RFID-BASED IMPLEMENTATION OF AN E-MONEY AND IDENTITY CARD

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Abstract. RFID technologies, which proved itself to be reliable, exist since 1940s and today are used by various industries in multiple areas, and there are many extensive research about this subject which enable these technologies to develop. In this paper, an "e-money and identity card" application is preferred. At 13.56 MHz (HF) operating frequency passive mifare tags and SMX1300 demo kit are used. A software is developed using C# programing language at Visual Studio 2010 .NET platform for this application in which a purchase of a product can be done with id cards by using RFID technology. RFID-based implementation is designed for elementary schools and high schools. System offers many benefits to parents of students. Parents can keep their children under control. Students' entry and exit times at school can be controlled by their parents. Parents can identify prohibited items at school canteen for their children. In this way, students' diet can be under control. The students' parents can determine daily spending limit for their children.

Keywords: Antenna, radio frequency identification (RFID), radio frequency , reader, tag

1 INTRODUCTION

Radio Frequency Identification (RFID) technologies are used on moving or still, live or inanimate objects(Kavas, A., 2007). In this section, the literature related to the use of RFID is reviewed. RFID is not a new technology and its research has been ongoing for decades. RFID technologies have exist since 1940s. It was first used during World War II by England Army (Manish, B. and SHAHRAM, M. 2005). In the 1970s, nuclear material started to be used within the scope of monitoring activities and the scope of commercial applications (Üstündağ, A. 2008). After years of progressive, Tuna (Tuna, H., 2005) identified the cattles on the internet with RFID transporter chipsand Dağoğlu (Dağoğlu, M., 2006) performed contour loading and access system, patient monitoring system, personnel monitoring system. Furthermore, Pala (Pala, Z., 2007) solved a city's parking problem through RFID technology and Oranlı (Oranlı, G., 2007) evaluated to adopt RFID technology in a firm operating at banking industry by using Fuzzy Analytical Hierarchy Process. Additionally, Yaman (Yaman, T., 2008) investigated the potential benefits of RFID technology at shopping cart and Gunduz (Gunduz, M. B., 2008) designed and tested an electronic log-book and a passenger information system. Birgün (Birgün, S., Aytaç Özmen G., 2011) conducted an implementation which purposed to select the best RFID system for Air Force Command and Aydın (Aydın, Ç., 2011) purposed to design an antenna operating at 2.45 GHz RFID frequency with wide band.

In this study, membership of an identity system and an electronic money system has been done for schools. To achieve this goal, the study used RFID, local area network (WLAN) and database technologies. Students used to go shopping at school canteen with the money. But now, they start to use their identity cards. So there is no need to carry any money. The

RFID-based implementation has a lot of functions. It has provided many benefits for parents and school administration. For example, students' entry and exit times at school, their diet and daily spending limit can be controlled.

The paper organizes in 5 section. The second section provides information about RFID technology. Description of the technology, system components, and the working principles of these are examined. In the third section, Materials suitable for RFID - based implementation of an e-money and identity card is determined. In the fourth section, RFID - based implementation of an e-money and identity card is developed. In the fifth section, benefits and challenges of RFID - based implementation are explained. Finally, it is emphasized that the appropriate parts of the system to be developed.

2 RFID TECHNOLOGY

In recent years, automatic identification procedures (Auto-ID) have become very popular in many service industries, purchasing and distribution logistics, industry, manufacturing companies and material flow systems. Automatic identification procedures exist to provide information about people, animals, goods and products in transit. An RFID system is always made up of two components. Figure 1 shows them. The first component is the tag (also known as a transponder) which is located on the object to be identified. The other component is the reader (also known as an interrogator). A reader typically contains a radio frequency module (transmitter and receiver), a control unit and a coupling element to the transponder. In addition, many readers are fitted with an additional interface (RS 232, RS 485, etc.) to enable them to forward the data received to another system (PC, robot control system, etc.). (Finkenzeller, K., 2003).

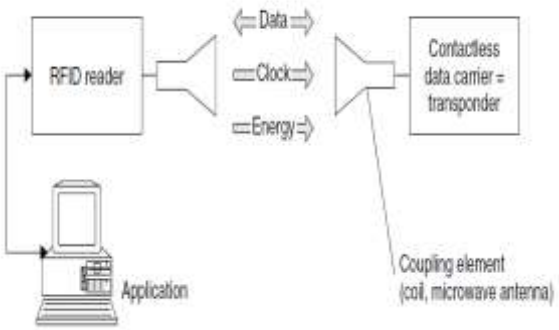

Fig.1 Components of an RFID system (Finkenzeller, K., 2003)

One of very important feature of RFID systems is the power supply to the transponder. Transponders are classified as active or passive depending upon the type of power supply they use. Figure 2 shows various samples of transponder. Passive transponders do not have their own power supply, and therefore all power required for the operation of a passive transponder must be drawn from the (electrical / magnetic) field of the reader. Conversely, active transponders incorporate a battery, which supplies all or part of the power for the operation of a microchip. One of the most important characteristics of RFID systems is the operating frequency and ranges of the frequency. The different transmission frequencies are classified into the four basic ranges. Nearly all RFID systems operate on one of four frequency bands: low frequency (LF), high frequency (HF), ultra high frequency (UHF), and microwave (MF). (For farther details, please took at referance 12)

Fig.2 Samples of transponder (Agim website 2013)

3 MATERIALS SUITABLE FOR RFID-BASED IMPLEMENTATION OF AN E-MONEY AND IDENTITY CARD

Initially, the correct frequency, the correct tag and the correct reader are identified. 13.56 MHz frequency range and 1K mifare passive transponders are selected for this application. Serial RFID Mifare Reader/Writer (it is called SMX1300) is used. Figure 17 presents SMX1300 Mifare RFID Reader. SMX1300 is a compact, ready-to-use, serial, 13.56 MHz RFID Mifare Reader/Writer. It is integrated with RS232, PCB Antenna, Buzzer and 5V regulator circuit in case direct 5V supply is not available and user can supply 9V-12V DC. SMX1300 has similar dimensions with the SM132-USB Reader/Writer. The SMX1300 supports all variants of the MIFARE Classic, MIFARE 1K and MIFARE 4K RF identification protocols. All protocol layers of the ISO/IEC 14443 A are supported. (SonMicro Electronics, Turkey)

Fig.3 SMX1300 Mifare RFID Reader (SonMicro Electronics, Turkey)

Figure 4 shows memory organisation for 1Kbyte. 1Kbyte are organized in 16 sectors with 4 blocks each. A block contains 16 bytes. The last block of each sector is called “trailer”, which contains two secret keys and programmable access conditions for each block in this sector.

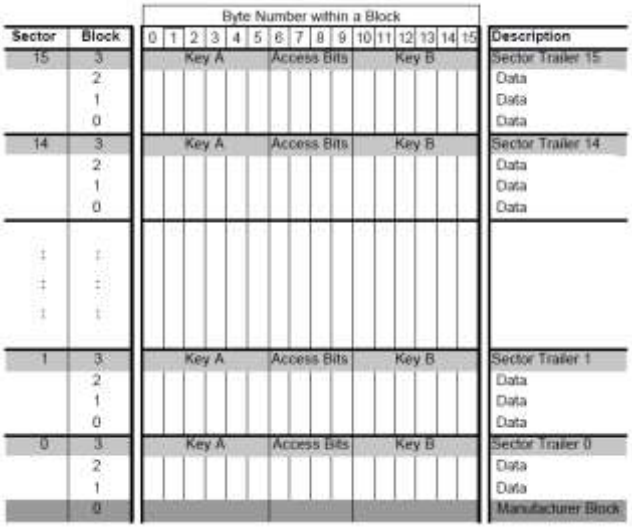

Fig.4 Memory organisation (Philips, Turkey)

Manufacturer Block : This is the first data block (block 0) of first sector (sector 0). It contains the IC manufacturer data. Due to security and system requirements this block is write protected after having been programmed by the IC manufacturer at production.

Data Blocks: All sectors contain 3 blocks of 16 bytes for storing data (Sector 0 contains only two data blocks and the read-only manufacturer block.) The data blocks can be configured by the access bits as read/write blocks for e.g. contantless access control or value blocks for e.g. electronic purse applications, where additional commands like increment and decrement for direct control of the stored value are provided. An authentication command has to be carried out before any memory operation in order to allow further commands (Sonmicro website 2013).

Value Blocks : The value blocks allow to perform electronic purse functions (valid commands: read, write, increment, decrement, restore, transfer).

Memory Access: Before any memory operation can be carried out, the card has to be selected and authenticated as described previously. The possible memory operations for an addressed block depend on the key used and the access conditions stored in the associated sector trailer. The access conditions for every data block and sector trailer are defined by 3 bits,which are stored non-inverted and inverted in the sector trailer of the specified sector. The access bits control the rights of memory access using the secret keys A and B. The access conditions may be altered, provided one knows the relevant key and the current access condition allows this operation.

Communication Protocols: SMX1300 have two communication interfaces; UART and I2C. Commands are kept same for both protocols but communication frames are different. The communication between the host and the module can take place at 9600bps, 19200bps, 38400bps, 57600bps or 115200bps N, 8, 1. Module communicates at 19200bps,N,8,1 as default. Once the baud rate is changed using the change baud rate command, successful communication will only occur with the new baud rate. The host first sends the command and the module executes the operation and replies with a response to the command. The host can analyze the reply to check if the operation was successful or if any error occurred during the operation (Sonmicro website 2013). Table 1 is the UART frame for the commands sent by the host. Table 2 is the UART frame for the response packets sent by SMX1300 module in response to the commands.

Header	Reserved	Length	Command	Data	CSUM
1Byte	1Byte	1Byte	1Byte	NBytes	1Byte

Table1- UART frame send by Host. (SonMicro Electronics, Turkey)

Header	Reserved	Length	Command	Response	CSUM
1Byte	1Byte	1Byte	1Byte	NBytes	1Byte

Table2- UART frame send by SMX1300 module (SonMicro Electronics, Turkey)

Table 3 lists the commands supported by SMX1300 module and the corresponding code.

Code	Command	Description
0x80	Reset	Resets the Module
0x82	Seek for Tag	Continuously checks for presence of a tag
0x83	Select Tag	Selects a Tag
0x84	NA	Not Implemented
0x85	Authenticate	Authenticates the selected Block
0x86	Read Block	Reads from the specified Block
0x89	Write Block	Writes the data to the specified block
0x8D	Increment	Increments a value block
0x8E	Decrement	Decrements a value block
0x91	Read Port	Reads from the Input port
0x92	Write Port	Writes to the Output port
0x93	Halt	Halts the PICC

Table3- Commands to control SMX1300 module. (SonMicro Electronics, Turkey)

4 RFID-BASED IMPLEMENTATION OF AN E-MONEY AND IDENTITY CARD

This application is designed for elementary and high schools. It has solved many of the problems in schools. It has helped parents. In traditional school system, parents do not have too much information about their children's time in school. For example, what do their children eat, which product do they buy at school canteen, what time do they enter and exit at school , how much money do they spent etc. This application responds to all of these questions. They can also lose their money at school. The system is designed to solve all of these problems. The system consists of two parts: Hardware and software.

Hardware: In applications, 3 piece readers, 6 piece transponders and 2 piece computers are used. The first reader is placed in school principal's room , the other is placed in school canteen and the last reader is placed in the school entrance gate. 3 piece transponders are used for products of school canteen and the other transponders are used for students and school personnel members as ID cards. RFID system, which has a high frequency of 13.56 MHz is preferred. SMX1300 RFID Mifare Reader/Writer and 1K mifare passive transponders are used in the system. UART is used for communication interface. The data blocks of the cards are prefered to write data. The value blocks are not used in the system. The data are written in the blocks in the decimal system. ID cards write the passwords in the 10^{th} data block and ID cards write the total amount of money(card balance) in the 2^{nd} data block. Product cards write the product prices in the 2^{nd} data block. Product prices, total amount of money and passwords are recorded in the system database, too. The 2^{nd} data

block contains 16 bytes. The total amount of money (card balance) is written in the first byte, the second byte and the third byte, respectively. Figure 5 presents the process of communication between reader and tag.

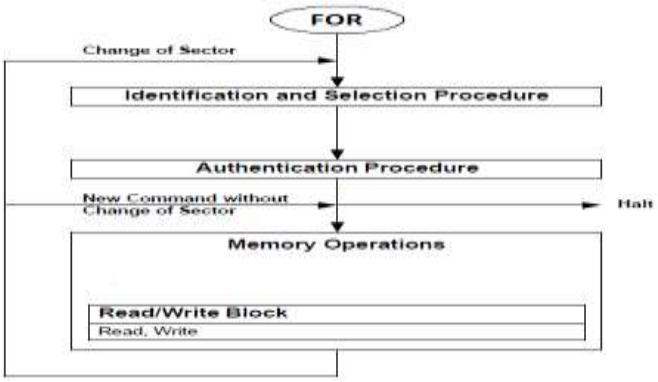

Fig.5- The process of communication between reader and tag (Philips, Turkey)

The access bits control the rights of memory access using the secret key-A. The access bits is created using students' passwords and in this way, the access bits are transformed into a complex structure and thus reliability of the system is increased much more.

Software: Implementation class library is written in C# for Visual Studio 2010 applications. Database system is also prefered SQL Server 2010 environment. Applications are run at Windows 7 operating systems. Database structures used in the system are foloowing: Student-staff database structure is shown in figure 6. School canteen database structure is shown in figure 7.

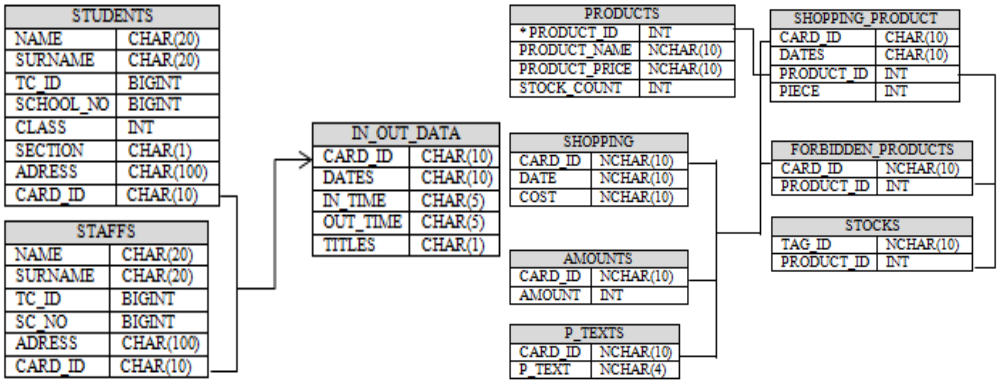

Fig.6- The database structure of the student-staff system

Fig.7- The database structure of the system of the school canteen

The details of database structures used in the system are shown in table 4.

The database tables of student-staff system database system		The database tables of school canteen database system	
STUDENTS:	School students' information is stored.	**PRODUCTS:**	Product-related information in the school canteen is kept.
STAFF:	School teachers' and school staffs' information is stored.	**STOCKS:**	It stores product id and Tag id about products.
IN_OUT_DATA:	Entry and exit times for school students, school teachers and school staffs are stored.	**FORBIDDEN_PRODUCTS:**	It stores prohibited products related information.
		AMOUNTS:	It stores the amount of money the amount of ID cards.
		SHOPPING:	It stores total money and date of shopping about shopping.
		SHOPPING_PRODUCT:	It stores product information about shopping.
		P_TEXTS:	It stores the password for the ID card.

Table4- The details of database structures used in the system

The system consists of two separate software interfaces of implementation. The first software interface is e-money system for school canteen. The other is identity card system for school personnel members and students.

Membership system: Identity card software interface is used in school principal's room. Identity card program is installed first to a computer at school principal room.

Fig .8- Student-personnel system software interface

Figure 8 presents the opening the software interface. Two types of case can be accessed in the system. The first is "*password entry*" and the other is the *"Entry without password",*too. Password is only known by the school principal. Entry without password only allows for search operations. Password entry allows for search operations, delete operations, update operations and insert operations . Initially, student and staff credentials are recorded in the system by the school principal and ID cards are gived students and staffs by the school principal. Figure 9 shows student operations software interface.

Fig .9- Student operations software interface

Each student and personnel in school has to educate its ID card to RFID reader board by entering and exiting the front door of the school. So personnel members' and students' entering and leaving clocks are recorded by the system. If school principal wants to know the students' and staff's entering and leaving times, school principal will report it.

School canteen system: E-money software interface is used in school canteen. E-money program is installed to a second computer at school canteen. This part includes canteen shopping. At first, ID cards are introduced in the system by the owner of the canteen. The password can be created for ID cards during this introduction. Figure 10 shows password settings software interface.

Fig.10- Password settings software interface

Later, school personnel members and students load into money their ID cards at canteen. Figure 11 presents Counter loading software interface.

Fig.11- Counter loading software interface

Before students start shopping, parents should determine a daily limit and the banned products for their children. There is no need to do such a thing for the personnel. Figure 12 shows students settings software interface.

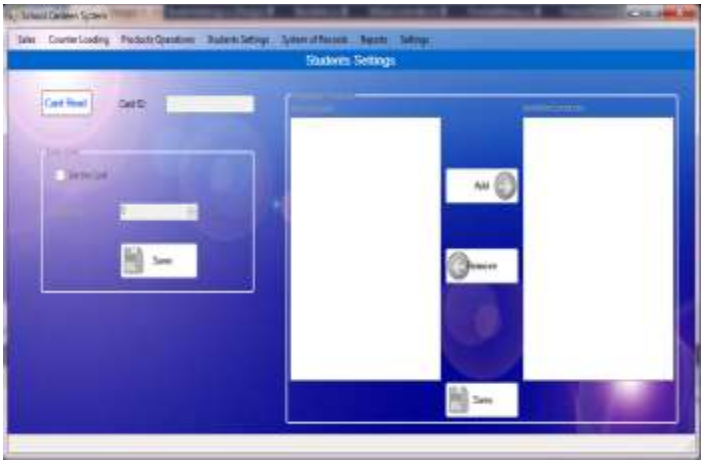

Fig.12- Students settings software interface

Eventually, they can begin to go shopping. Figure 13 shows sale software interface. The system controls banned products during shopping and remove them from the list of shopping. Also the owner of the canteen can remove some products from the list of shopping, too. The system controls the daily spending limit and card balances during sales and provides the necessary warnings. Parents can report their children's shoppings list and the total amount of money spent on in a certain time interval.

Fig.13- Sale software interface

The owner of the canteen records information of all kind of canteen items (product price, product name and so on.) in the system database. Then delete operations, update operations can be done for the products. Each product in the school canteen includes an RF card. This card is written into the product price. Product price is written in both the system database and product card. So the owner of the canteen can sell the products of canteen more quickly with RFID-based product card. In addition, the owner of the canteen can check stocks of canteen and the owner of the canteen can report student shoppings and information about the stocks of canteen.

5 THE BENEFITS AND CHALLENGES OF THE IMPLEMENTATION

The benefits and challenges of the proposed RFID-based e-money and identity card system are examined from different perspectives. The benefits and the main challenges of the RFID based e-money and identity card system are as follows:

Benefits: System offers many benefits to parents of students. The e-money and identity card system can effectively improve the relationship between parents and school management. Students' entry and exit times can be controlled by their parents. So that students can not do absent. The entry and exit of personnel members can be also controlled by school principal. Entry and exit times can be reported at certain time intervals by the system. The identity cards can be used as an e-money and an ID card. There is no need for students to carry money. The school personnel members, students or parents can load money in their card at the school canteen at any time. Students must firstly determine the password if they want to start shopping at school canteen. The elder students use a password during shopping. Because they know the number system. But first grade students, who can not know the number system, do not use a password during shopping. This increases the reliability of the system and makes it useful. Parents can identify prohibited items at school canteen for their children. In this way, students' diet can be under the control. Furthermore, parents can report student shoppings at certain time intervals. In this way, they can see what their children buy, which products and how often buy. Parents can determine daily spending limit for their children. The ID card balance can also be reset by the owner of the canteen when the owner of ID card returns the money back.

Challenges: Manufacturers does not manufacture product with rfid card. This makes it difficult for the usefulness of the system.

6 CONCLUSIONS

As a result, thanks to the proposed system is presented a lot of conveniences for school management. Parents can keep their children under control.

Consideration for inclusion in their student cards grading systems in the future. Students are able to learn their notes with the identity cards. It is considered on the system sofware which is fully adapted to the web-based software. So that the parents or students themselves will be able to load money their ID cards from online. Readers which use in the implementation transfer data with serial communication. In the future, considered wireless communication instead of serial communication. In order to increase the reliability of the data between the reader and the cards are planned to develop a crypto software.

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