Hospital Automation RFID-Based: Technology Stored In Smart Cards

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***Abstract*— RFID is a technology being adopted in many business fields, especially in the medical field. This work has the objective to present an automation system for a hospital's clinical analysis laboratory. This system initially uses contactless smart cards to store patient's data and for the authentication of hospital employees in the system. The proposed system also uses RFID tags stuck to containers containing patient's collected samples for the correct identification of the patient who provided the samples. This work depicts a hospital laboratory workflow, presents the system's modeling and deals with security matters related to information stored in the smart cards.**

***Index Terms*—Hospital Automation, Laboratory Automation, RFID, Smart Cards, HealthCare .**

I. INTRODUCTION

As the process of industrial and commercial automation, hospitals are also being included in the context of automation. Thus, solutions that can automate hospital processes have been searched, in order to make them more secure and with a lower operational cost.

In this context, there are several works looking forward to providing technologies to support the emerging demands in the process of hospital automation, as:

- Murakami, et al, (2006) developed a Glucose's Continuous Monitoring system in Patients Critics of the Intensive Care Unit;
- Várady, P., et al, (2002) developed a Patient's Tracking System Based on Open Architecture using Standard Technology;
- Varshney, (2006), shows the monitoring of patients using the wireless LANs Oriented Infrastructure.

The research in the area of hospital automation has the objective to solve recurring operational problems. This paper presents the development of the information system using RFID technology (Radio Frequency Identification), with the goal of improving the operation of the analyses laboratory of UFRN (Federal University of Rio Grande do Norte) hospitals' network. The UHAB (University Hospital Bezerra Ana) was chosen, to be the case of study for the project.

In order to elicit the requirements for the deployment of the system, interviews were conducted with doctors, nurses, biochemical and other professionals who knew about the logistics of the hospital (stackholders). Thus, it was found that the use of smart cards can be crucial in the process of employees and patient's authentication of the hospital. The authentication, improves the usability of the system, for example: the module of the doctor starts when the doctor`s smart card is read. This process reduces the authentication's time cost, making the system more efficient. According to Bardram (2005), the process of authentication with login and password typing in hospital environments is ineffective because generally users need to identify themselves in multiple machines. Another contribution of this work was to ensure the correct link between blood samples and the patient. This process proposed the use of RFID tags in the clinical laboratory analysis. Thus, the developed system avoids some problems of identification that were always found in the previous systems.

This paper presents the methodology and technologies used in the automation process at the clinical laboratory of UHAB.

II. RFID -RADIO FREQUENCY IDENTIFICATION

Recently, it has been known that the popularization of technology for automatic identification (Auto-ID) in industry, trade and academic, become the focus of several researches. This interest meets the emerging demands in the automation process, which creates the need for more efficient applications to obtain and control information.

The RFID technology (Radio Frequency Identification) is used for automated identification of objects. The superiority demonstrated by this technology in relation to other existing identification systems, presents two main characteristics: it has identification fields and it does not need a direct view to the object. These aspects are the motivation for choosing this technology in the development of the system which is described in this paper. A direct view or contact is not necessary, contributing to the increase of the usability level. Thus, this facilitates the process of reading, and the identification fields allow patients data storage, such as: allergies, blood type and exam results.

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A. RFID for hospital automation

Several cases in scientific literature are found where the technology of smart cards and RFIDs are successfully applied in hospital environments. According to Panescu [Panescu 2006], the RFID technology has great potential to be widely used in hospital systems for tracking inventory, location of patients and combating of medicines counterfeiting. Booth at al. [Booth et al. 2006] also cites the use of RFID in tracking patients and employees. However he also discuss the application of this technology in radiographs and records to ensure the correct identification of the patient and also in the use of RFID tags to link a patient with a device. Chan [2003] [Chan Chan et al. 2001] demonstrate the use of smart cards to store medical records of patients. Attiaoui [Attiaoui et al. 2002] follows the same line by proposing the use of smart cards for storing medical records of patients.

B. As Tags

The tags are transponders that have an identifier of the object with which it is associated. The tags typically consist of an antenna and an electronic microchip (Figure 1). The antenna is responsible for making communication between the tag and the reader. There are two main energy classifications of a tag. They can be passive, obtaining energy through the magnetic field generated by readers through antennas, or they can be active, with a battery that provides the energy required to perform processing and modulation of the signal.

A passive tag was chosen for the project due to its low cost and independence of the life of a battery. An important aspect about the passive tag refers to the reception of energy, which happens only when the reader is sending data. Then, when the tag is responding, it does not receive energy from the reader. The energy used is provided by capacitors that store energy for later use.

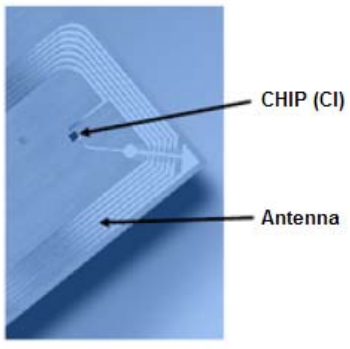

Fig. 1- Tag components

C. Readers

The passive tags require a transmitter that sends power to them in the form of radio waves and also a device capable of reading the information and providing the data to a user or to the network. The reader, in such cases, is the device responsible for such functions. They are responsible for operations of low level communication with the tags and for making the data available for the network interface.

Every kind of reader and tags communication occur wireless. The reader's communication with another device is realized through network interfaces. It can also communicate with middleware through of many protocols, such as: Bluetooth (IEEE 802.15.1), ZigBee (IEEE 802.15.4), and Ethernet (IEEE 802.3).

D. Application of the RFID technology

The automatic recognition of objects is a RFID technology feature that can be applied in many ways: use intelligent shelves, tracking of animals, selling products at retail store and at libraries. We proposed the application of RFID technology to control the requisition of laboratory tests, through smart cards and tag (see fig. 4), in order to promote the automation of the processes performed at the clinical laboratory of the UHAB.

E. Smart cards

Smart card is a portable computer with a capacity to store programmable data. The contactless smart cards have no physical contact with the reader and its operation is similar to the RFID tags. It can be just a storage device (memory cards), or it may also have a microprocessor (mixed cards) for some operations. The memory cards have only data storage capacity and offer lower cost, being therefore, used in a larger scale. Due to the need only for storage of data, the project of automation of the laboratory adopted the use of the memory card. Fig. 3 illustrates a reader and some cards which are currently at HUAB. As shown in Fig. 3, the cards are personalized with the name of HUAB, the goal is to give a better presentation to the card and facilitate its recognition when it is presented in the Hospital.

The contactless cards optimize the authentication of users. There are three kinds of standards for the smart cards, as shown in Table 1. The pattern that was used was ISO 14443B, which is used by the hospital smart cards.

Standard	Type of Card	Approximate reach
ISO 10536	*Close coupling*	0 up to 1 cm
ISO 14443 (A e B)	Proximity coupling	0 up to 10 cm
ISO15693	Vicinity coupling	0 up to 1m

Table 1 – Standard types and Range

F. Card`s Memory Area

The data stored in the card is for identification and authentication in the system. The data in the card are: the card's ID, the user's ID and name, blood type, whether it is diabetic or not, whether it is hypertensive or not and so about the allergies. The information does not occupy much space a 2 Kbits card was chosen and the memory is divided into 32 blocks of 8 bytes, as it is shown in Table 2.

Blocks 0 to 5 are reserved for the information of the card. Block 6 is the manager's memory version and block 7 is the user's ID. The data in shaded blocks are encrypted. Table 3 shows as the data format being stored in the card.

Block	Size : 8 bytes
0	Serial Number (64 bits)
1	Configuration block
2	e-purse
3	Debit Key
4	Credit Key
5	Application Issuer Area
6	Application Area 1 : protected by kd
7	
8	
9	
10	
11	***Modifiable limit***
12	
13	Application Area 2 : protected by kc
14	
-	
31 (2K)	

Block 6 to 12 are write lockable

Table 2- Card's memory structure

Bloco	8 Bytes
6	Version's identifier
7	User's identifier
8	User's data
9	User's data
10	User's data
11	User's data
...	User's data
31	User's data

Table 3 - Blocks that can be manipulated

III. Eliciting of Requirements: Organization and Operation of the Hospital Laboratory

The laboratory is the department responsible for receiving the examinations of analyses, and those requested by a doctor.

The exams are divided into two groups: internal and external. The internal examinations are from patients who are admitted in any of the hospital beds, and the others are external patients. The laboratory of the hospital is divided into two departments: reception and analyses. The reception of the laboratory is responsible for registering, printing and inputting the results of the examinations in the system. The laboratory holds important information for the hospital statistics.

Every process performed in the system for automation of the laboratory must be stored, so it can be audited in a future time. Therefore, a module of administration was developed to allow the registration of peripheral information in the system and also to allow the monitoring of the actions of the system (audit).

In general, the laboratory has the following flow of activities:

- At midnight, the numbering of patients is reseated. When the first patient arrives with the examination request, number one is assigned to this patient. The second patient number two and so on. In exam tubes or containers for collection of examination, labels with the number referring to the patient who gave the sample with their initials are fixed. This numbering is important to make the correct input of the corresponding results for the patient. When the sample is collected, the receptionist of the laboratory records in a particular book each examination, the name of the patient along with the number.
- At the laboratory, the biochemical receives the book of examinations to be performed on that day.
- During the examinations, the book will be completed. At the end of all the examinations, the book is passed to the receptionist of the laboratory, so the results can be added to the system. You can notice that the biochemical interaction is minimal, and may even be zero if the function of printing examinations is also attributed to the laboratory receptionist. However for the system to be also general it should give the biochemical the ability to view the requisition of examinations received and print examinations, among other features. In this case, there is a lower probability of errors to occur because the biochemical enters the data directly into the system.

There is a serious risk in the process, which is the possibility of data to be entered in the wrong order. For example: the result of the examination of a patient can be assigned to another. This type of misunderstanding can generate problems to a patient. Thus, it was found that the use of RFID tags can contribute significantly to minimize the errors, since the tubes can be identified with tags that provide a univocal character in the process.

A. *Proposed Solutions*

The deployment of the system at the laboratory was implemented on two main points. On the first one, the system receives and records the requests of both direct examination of the doctors stations and the laboratory reception. These procedures can now be performed through the use of smart cards with RFID. On the second one, the system makes the identification through:

- RFID tags attached to the tubes of collections for clinical examinations;
- Bracelets for identification with RFID placed on the arm of hospitalized patients.

B. *Principal Modules*

Currently, the system can be divided into three main modules according to the function:

- Module of the doctor: The user has the option to request exams, to check the situation of exams and check results of examinations;
- Module of the laboratory receptionist: This is the module of higher complexity, where you can register requests, print spreadsheets, verify results, issue monthly reports and register pending examinations;
- Module of the Administrator: The user performs audit, and holds peripheral entries to the system.

C. *Physical Architecture of the System*

The architecture of the system is composed of workstations, local area network and a server. Smart cards

and a reader are
connected to the workstations and a printer is connected to the laboratory reception computer for the exams printing (see Figure 2).

All details of the system are stored on the server, except for a few local settings that are saved in a XML file. These settings are the IP (Internet Protocol) address and port of the server database. The Figure 3 shows the devices in the system.

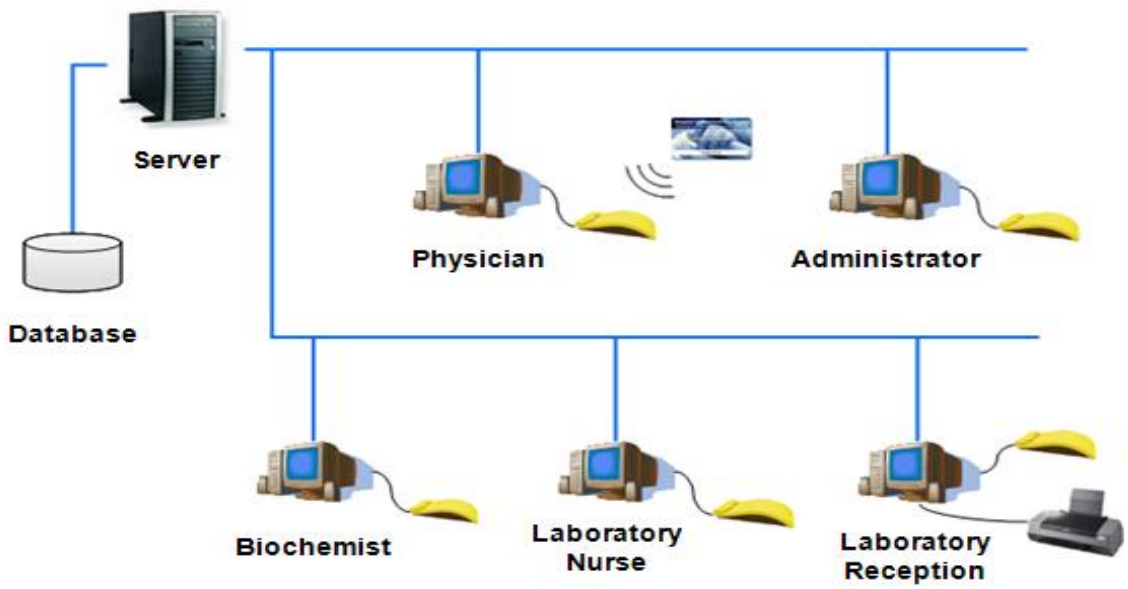

Fig. 2 – Systems architecture

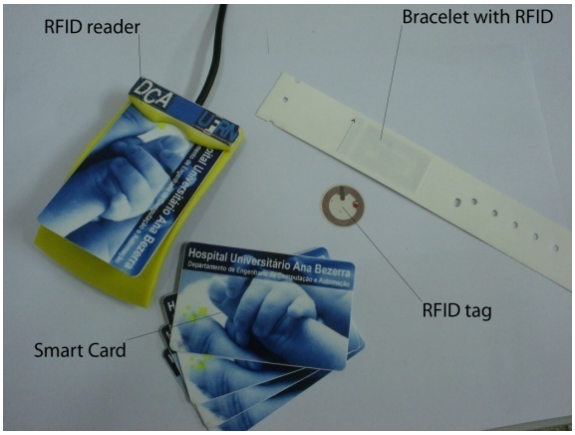

Fig. 3 – System devices

IV. Conclusions

The hospital automation has emerged with several demands, many of those devoted to information systems. This work presented solutions that use RFID technology as a mechanism of interaction between users and the system. The use of smart cards and RFID tags improved the operational processes, because the solution proposed implemented the development of the system by changing the form of interaction with the user, but ensuring the same data entry. Thus, some problems have been solved, especially improving the quality and control of the automation of the clinical laboratory. Part of it is already installed. Now we are in the process of training and installing the second part of the system (patient control and check in/out).

Acknowledgements

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References

[1] Booth, P., P.H. Frisch & S. Miodownik, 'Application of rfid in an integrated healthcare environment', Proceedings of the 28th IEEE EMBS Annual International Conference, 2006.
[2] Chan, Alvin T.S., 'Integrating smart card acess to web-based medical information systems', Communications of the ACM, 2003.
[3] Chan, Alvin T.S., Jiannong Cao, Henry Chan & Gilbert Young, 'A webenabled framework for application smart card in health services', Communications of the ACM, 2001.
[4] Attiaoui, Walid, Pr. Mohamed Ben Ahmed, Pr. Moncef Tagina & Dr. Bouthe¨Ina Chetali, 'Integrating usb smart card with flash memory to web based medical information systems: Application for the pathology of cancer', IEEE, 2002.
[5] Panescu, Dorin, Healthcare applications of rfid identification, em 'Ieee Engineering In Medicine And Biology Magazine', IEEE Computer Society, 2006.
[6] Murakami, Alexandre ; Gutierrez, M. A. ; Lage, Silvia Helena Gelas ; Rebelo, Marina De Fátima De Sá ; Ramires, José Antonio Franchini. A Continuous Glucose Monitoring System in Critical. IEEE Computers in Cardiology, v. 32, p. 10-14, 2006.
[7] Varday, P., Benyo, Z. And Benyo, B. An open architecture patient monitoring system using standard technologies. IEEE Transactions on Information Technologies in Bio-medicine, Vol. 6, No. 1, pp.95–98, 2002.
[8] Varshney, U. Patient monitoring using infrastructure-orientedwireless LANs. International Journal of Electronic Healthcare, Volume 2, Number 2 / 2006, 149 – 163, 2006.
[9] Bardram, Jakob E., 'The trouble with login on usability and computer security', Proceedings on Ubiquit Computing 2005.