Hospital Automation System RFID-Based: Technology Embedded In Smart Devices (Cards, Tags and Bracelets)

Gustavo H. P. Florentino¹, Carlos A. Paz de Araújo¹, Heitor U. Bezerra², Hélio B. de A. Júnior², Marcelo Araújo Xavier³, Vinícius S. V. de Souza³, Ricardo A. de M. Valentim³, Antônio H. F. Morais³, Ana M. G. Guerreiro², Gláucio B. Brandão³

Abstract- RFID is a technology being adopted in many business fields, especially in the medical field. This work has the objective to present a system for automation of a hospital clinical analysis laboratory. This system initially uses contactless smart cards to store patient’s data and for 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 gave away the samples. This work depicts a hospital laboratory workflow, presents the system modeling and deals with security matters related to information stored in the smart cards.

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 were searched, in order to make them more secure and with a lower operational cost.

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

- [1] developed a Glucose’s Continuous Monitoring system in Patients Critics of the Intensive Care Unit;
- [2] developed a Patient’s Tracking System Based on Open Architecture using Standard Technology;
- [3] 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 information system using RFID technology (Radio Frequency Identification), with the goal of improving the operation of the analyses laboratory of FURN (Federal University of Rio Grande do Norte) hospital’s network, it was chosen the UHAB (University Hospital Bezerra Ana), to be the case of study for the project.

In order to elicit the requirements for the deployment of the system were conducted interviews with doctors, nurses, biochemical and others professionals who knew about the logistics of the hospital (stockholders). 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 of the system, becoming more efficiently. According to Bardram [4], 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 on 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 the popularization of technology for automatic identification (Auto-ID) in industry, trade and academic, becoming the focus of several researches. This interest meets the emerging demands in the automation process, which creates demands 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 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 directly view or contact is not necessary, contributing to increase the level of usability. Thus, this facilitates the process of reading, and the
identification fields allow store patients data, such as: allergies, blood type and exam result.

A. RFID for hospital automation

Several cases in literature are found where the technology of smart cards and RFID is applied successfully in hospital environments. According to Panescu [5], the RFID technology has great potential to be widely used at hospital systems for tracking inventory, location of patients and combat of medicines counterfeiting. Booth [6] also cites the use of RFID in tracking patients and employees. However he also discusses 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 [7] Chan and Chan [8] demonstrate the use of smart cards to store medical records of patients. Attaiaoui [9] follows the same line by proposing the use of smart cards for storing medical records of patients.

A. As Tags

The tags are transponders that have an identifier of the object on which it is associated. The tags typically consist of an antenna and an electronic microchip. 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 passive tag refers to the receipt 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.

B. Readers

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

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

C. 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, in order to promote the automation of performed processes at the clinical laboratory of the UHAB.

D. Smart cards

Smart card is a portable computer with a capacity to storage programmable data. The contactless smart cards have no physical contact with the reader and have similar operation as the RFID tags. Being that a great advantage, because there is no direct contact with RFID and reader, thus, the wear and tear of the cards and reader is avoided, because of that reducing cost of this technology. Smart Cards can be only a storage device (memory cards), or may also have a microprocessor (mixed cards) for some operations. The memory cards have only data storage capacity and offer lower cost, and is 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. Figure 4 illustrates a reader and some cards which are currently at UHAB. As can be seen in Figure 4, the cards are personalized with the name of UHAB, the goal is to give a better presentation to the card and facilitate the recognition of this, 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 at show in Table 1. The pattern that was used was ISO 14443B, is used by the hospital smart cards.

![Table 1: Standard Types and Range](image)

<table>
<thead>
<tr>
<th>Standards</th>
<th>Card types</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>ISO 10536</td>
<td>Close coupling</td>
<td>0 a 1 cm</td>
</tr>
<tr>
<td>ISO 14443</td>
<td>Proximity coupling</td>
<td>0 a 10 cm</td>
</tr>
<tr>
<td>(A e B)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISO15693</td>
<td>Vicinity coupling</td>
<td>0 a 1m</td>
</tr>
</tbody>
</table>

E. Area of Memory of the card

The data stored in the card is for identification and authentication on 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 or not hypertensive and so it allergies. The information does not occupy much space, was chosen a card with 2 Kbits of memory divided into 32 blocks of 8 bytes, as it is show in Figure 1.

Blocks 0 to 5 are reserved area for the information of the card. Block 6 is the manager's memory version, in block 7 is the user’s id and the data in shaded blocks are encrypted. Figure 2 shows as the data format being stored in the card.
II. 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 registration, printing and inputting results of examination 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, it was developed a module of administration which allows to register the information peripheral to the system and also to allows monitor the actions of the system (audit).

In general the laboratory has the following flow of activities:

- At midnight, is reseated the numbering of patients. When the first patient arrives with the examination request, is assigned to the patient number one. The second patient numbers two and so on. In exams tubes or containers for collection of examination are fixed labels with the number referring to the patient who gave the sample with their initials. This numbering is important to make the correct input of the corresponding results for the patient. When you the sample is collected his, 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 are added to the system. You can check that the biochemical interaction is minimal, and may even be zero if the function of printing of examinations is also attributed to the laboratory receptionist. However for the system to be also general, should give the biochemical the ability to view the requisition of examinations received, 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 error 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 to 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 of 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. **Principals 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 report and register pending examinations;
- **Module of the Administrator:** The user performs audit, and holds entries peripherals to the system.

C. **Physical Architecture of the System**

The architecture of the system is composed by 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 3).

![Fig. 3 – Architecture of the system](Image)

All details of the system are stored on the server, except 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 4 shows the devices in the system.

![Fig. 4 – Devices of the system](Image)

III. **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 system developed changing the form of interaction with the user’s system, but ensuring the same data entry. Thus, some problems have been solved, especially improving the quality and control the automation of the clinical laboratory is some and installed, now we are in the process of training and installing the second part of the system (patient control and check in/out) information in the system.

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**REFERENCES**