A Case Study for Developing an RFID Based Smart Health Centre in Iraq

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Abstract— **Radio Frequency Identification is a technology being adopted recently in many businesses, especially in the medical field. This paper proposes a system for the automation of the Health Centre of Nahrain University in Baghdad, Iraq. This system initially uses an RFID tagging system coupled with a web-based database to provide multiple benefits, including the identification of patients, error reduction in drug administration, an easier and faster use of the Electronic Health Record, enhanced security and control features when accessing confidential data.**

I. INTRODUCTION

Improving safety, quality, and value of health care is the focus of most hospitals and medical facilitates [1]. RFID has application in the health care industry for tagging patients to ensure that medical records are correctly associated with the people they describe, and that the correct medications are administered. These records can also provide information about a patient's allergies, and is therefore critical for this association to be made correctly [2].

Prior to RFID, bar codes have been successfully used in health care. It is estimated that 70 percent of all medication containers had bar codes in 2006 [1]. Bar codes can also be used for identifying patients and staff. However, bar codes require line-of-sight scanning. Wrinkling, tearing and wetting of bar codes adversely impact their readability. In addition, bar codes cannot be used for real-time tracking. On the other hand, RFID does not require line-of-sight for scanning. RFID tags are resistant to tearing and moisture [1].

The suggested application is RFID Health Centre system to be applied in Nahrain University, whereby each patient is uniquely identified by an RFID transponder. This unique identifier can be used to retrieve all the patient's records from a centralized database. Traditional RFID systems store patient details on the transponder itself, severely limiting the amount of data which can be stored. The system proposed by this paper uses the RFID tag simply as a mean to uniquely identify the patient, before retrieving the data from a centralized server.

II. RFID

The birth of radio-frequency identification technology was in October 1948 after the publication of a paper by Harry Stockman titled "Communications by Means of Reflected Power." The popular system Identification, Friend or Foe (IFF), for aircraft, was one of the first applications of RFID technology [3]. All RFID systems are generally comprised of three main components as shown in Fig. 1.

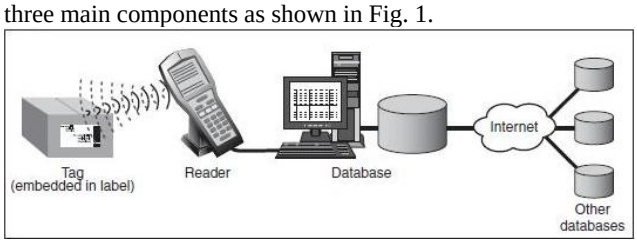

Fig. 1. Components of an RFID system

A. RFID tag, or transponder

Which is located on the object to be identified and is the data carrier in the RFID system;

B. RFID reader, *or transceiver*

This may be able to both read data from and write data to a transponder;

C. Data processing subsystem

This utilizes the data obtained from the transceiver in some useful manner.

RFID is fundamentally based on wireless communication. A reader transmits a signal that is received by an antenna integrated with a small RF chip. In general, the chip is activated only when an RFID reader scans it. When the chip wakes up, it sends the unique identifier number, which the reader passes along to applications. Typical carrier frequencies (the reader's transmitting frequency) in today's applications range from 125 kHz to 2.45 GHz (with 5.8 GHz also being considered) [3].

The function of the RFID technology in this system is to hold a unique identifier, which will be used to reference the patient's records within the centralized database.

Tags can be active, passive or semi passive, the designation being determined entirely by the manner in which the device derives its power [4]. Active tags have an internal battery that supplies power to all functions and allow greater communication range than can be expected for passive devices, better noise immunity and higher data transmissions rates when used to power a higher frequency response mode.

Passive tags operate without an internal battery, deriving the power to operate from the magnetic field generated by the reader. Passive transponders have shorter read ranges than active tags and require a higher-powered reader. However passive tags offer advantages in terms of cost and longevity.

They have much greater lifetime and are generally lower in price than active transponders [4].

Semi Passive tag which has a battery used only to power the tag IC, and not for communication [4].

A reader typically contains a transmitter and receiver, a control unit and a coupling element. Readers typically operate at one radio frequency; the reader often includes a serial communication (RS-232, USB, and so on) capability to communicate with a host computer [3].

The RFID reader used in this system is the ELA816 card reader, which is a small range reader (typically 5-15 cm reading range). This reader operates at a frequency of 125 kHz.

The ELA816 card reader is designed to provide access control; it is connected to an access controller meaning it is positioned at main gates or at specific doors to allow authorized personnel to access. The ELA816 card reader will be used to operate in a host based reader system. Once the RFID tag passes over the card reader, the reader will handle all the RF and digital functionality required in communicating with the RFID tag. Then the ELA816 card reader will pass the Tag number to the host computer. The communication between the host and the reader is over a serial cable (RS-232). The output format of the RS232 packet is shown in Table I.

TABLE I

ELA816 RFID READER OUTPUT FORMAT

1Byte	1Byte	16Byte	1Byte	1Byte	2Byte
0D HEX	SYNC	Card Data	Key Data	30 HEX	Checksum

III. RFID Health Centre System in Nahrain University

Many hospitals, health centres and other medical facilities have been using the identification technologies to improve the patients' care, optimize the workflows, reduce the operating costs, reduce costly thefts and help avoiding severe mistakes (such as patients' misidentification) [5].

The RFID Health Centre system in Nahrain University consists of the following seven sections that provide services to patient; (reception, account, physician, dentist, laboratory, pharmacy and administrator sections).

The equipment list needed to build such a system is as follows:

- Seven RFID readers (this is related to the size of the Health Centre) that communicates with the tag that is carried by the patient.
- Passive RFID tags which will carry specific data (only unique identifier).
- Centralized computer (Server) which is connected to network, each PC of this network (Client) has a specific application, requirements and operations on using the system.
- The physicians, dentists, caregivers and other staff members wear a "smart badge" storing their employee ID number.

The structure of the system can be described as client-server architecture. The client consists of the host specific application connected to the reader while the server includes the web server and database.

This project merges many different technologies and programming languages including RFID, Apache web server ver. 2.2.8, PHP scripting language ver. 5.2.6, MySQL database ver. 5.0.51b and Visual Basic 6.0.

A. Client-side Application

The primary function of the client side application is to communicate with the RFID tag. Once the RFID card passes over the reader, the application waits for a response. The application checks for errors, when the response arrives. If no errors are found, the application extracts the tag number from the response string and stores it. The application generates the Uniform Resource Locator (URL) from the tag number and sends this URL to the server over the network. The system incorporates a web-browser in which the results of the query can be viewed.

Fig. 2 shows the implemented connection between the RFID reader and the host computer using serial port through RS232 and the used RFID tags.

Fig. 2. Interfacing with ELA816 Card Reader

The flow chart of Fig. 3 illustrates the interfacing with the ELA816 RFID reader.

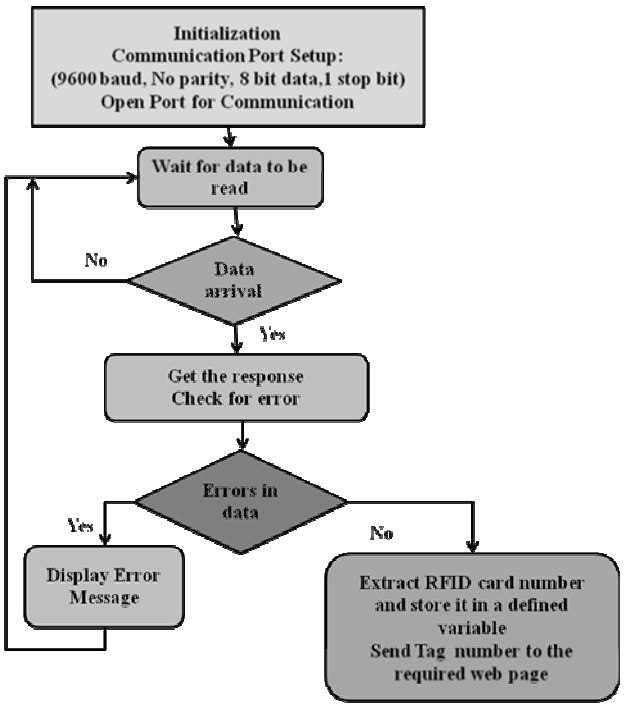

Fig. 3. Illustration of the interfacing with the RFID card reader

B. Server-side Application

The Server-side of the application consists of a MySQL database, accessed using the PHP scripting language. The server software must be secure, store all the patient information in an efficient manner and allow the patient information to be easily viewed and updated through the generation of dynamic web pages.

C. RFID Database System

On the web-server side of the system, My Structured Query Language (MySQL) is the language chosen to create and communicate with the relational database. MySQL is a fast, easy-to-use Relational Database Management System (RDBMS). Its speed and small size makes it ideal for web-development [6]. A relational database is a database divided into logical units called tables, where tables are related to one another within the database. A relational database allows large complex data to be broken down into logical, smaller, manageable units. Tables are related to each other through a common key (data value) in a relational database. These tables are all related to a patient. Therefore it is very important that the relationship between the various tables is well established. The information contained in these tables comprises personal, medical and dental information. Each patient has three profiles that define his medical conditions which consist of: ***Personal***, ***Medical*** and ***Dental*** profiles. That is to say, given the patient's tag number, one should be able to find all information within the database relating to the patient (i.e. Tag number is a reference to patient profiles), as given in Fig. 4.

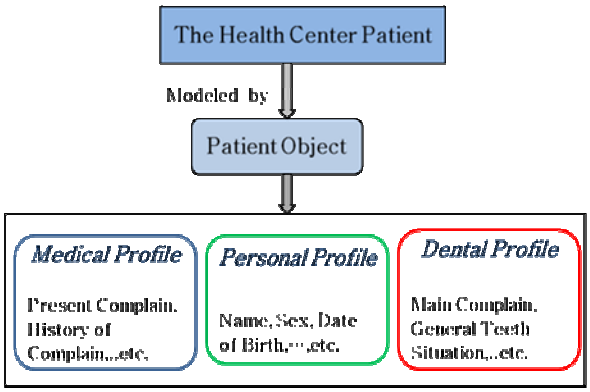

Fig 4. The structure of MySQL database

D. Application of PHP5

Hypertext Pre-processor [7] (PHP) is a scripting language used to interact with the database. PHP invokes SQL commands, and dynamically generates web-pages to display the results. PHP is an embedded scripting language, which means that PHP code is embedded in HTML code. PHP is used to move data into and out of the MySQL database. PHP is also suitable for more complicated tasks such as parsing and verifying data that the user has entered into a HTML form. PHP is used to interact with the MySQL database and to generate dynamic web pages as shown in Fig. 5.

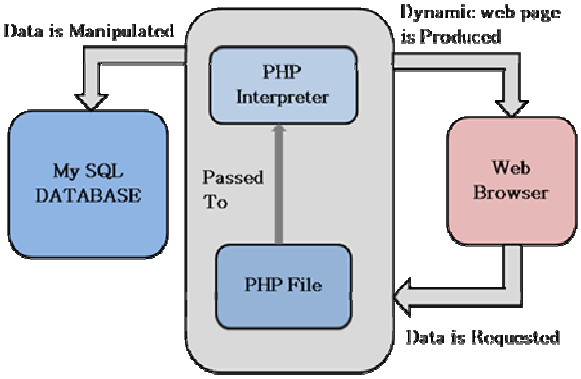

Fig 5. PHP and MySQL database interaction

E. System Structure

On arrival, each patient receives a card with an embedded RFID tag. The patient's medical histories and other important information are stored in centralized database. Each patient's records are associated with a unique identifier. This identifier is stored on a RFID card.

Physician, dentist, pharmacist, biologist, accountant, receptionist and administration personnel are allowed to access the database using user name and password. According to the specific application that fulfils section requirements, the RFID card is read and the identifier is passed over computer network to the centralised server. The server searches the database and dynamically retrieves patient information to a web page containing the relevant patient information. Then

medical personnel and other staff member are authorised to view and update the patient details.

F. Design and Implementation

The block diagram in Fig. 6 shows how the patient may progress inside the health centre and its various sections that the patient might go through.

1) Client Login System: The login system on the server-side simply takes the username and password, queries the database, and links to the appropriate page depending on the query result. If the user is a physician, it links to Physician Section page, a dentist to Dentist Section page, the administrator to Administrator Section page, pharmacist to Pharmacy Section page, a biologist to Laboratory Section page, an accountant to Account Section page, receptionist to Reception Section page while an unauthorised user will have to re-enter user name and password. The client application must present a login GUI where the users can enter their login details.

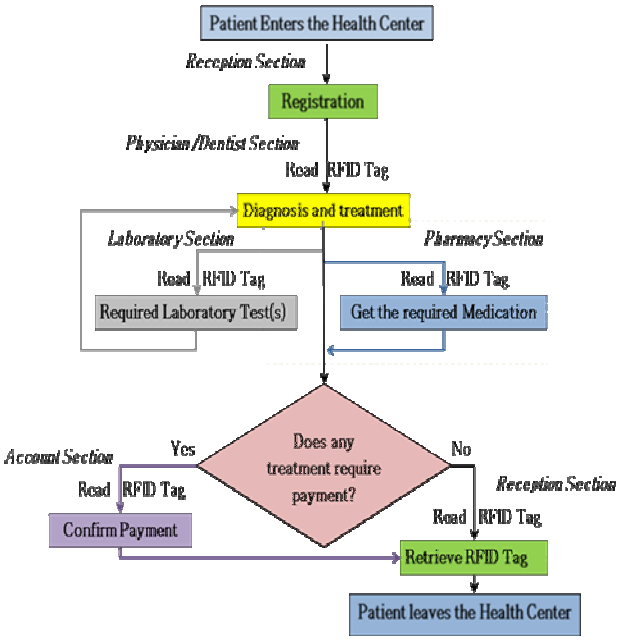

Fig. 6. Patient progress in the Health Centre

2) Reception Section: At the reception section, the receptionist is authorized to:

- Add new/Update patient profile: the patient will fill some personal information then he/she will be given RFID card to be a reference to his/her record while in the health center, see Fig. 7.

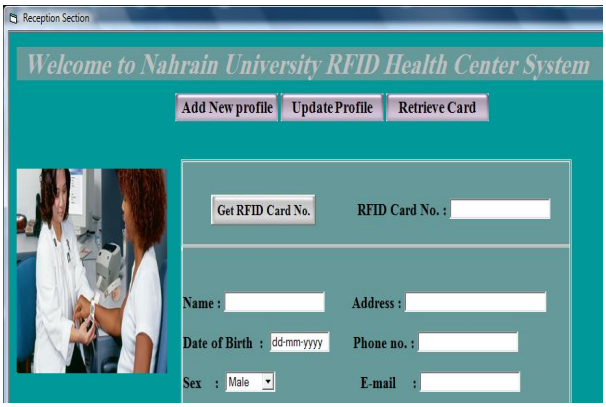

Fig. 7. Adding new patient personal profile

- Retrieve RFID card: when the patient leaves the health center he/she should return the card to be used again by another patient (the cards are reused because of their limited numbers).The receptionist would be informed if the patient has to pay for treatment and the card would not be retrieved until the accountant sends a confirmation that the patient has no payment, then the card will be retrieved.

3) Physician Section: If the patient visits the physician, the physician will have to read his/her RFID card number to retrieve the patient information (name, sex, age) with a digital photo of the patient. The physician is authorized to:

- Add new / Update medical profile: the patient complain, history of complain and all other medical information can be added in this form, see Fig. 8.

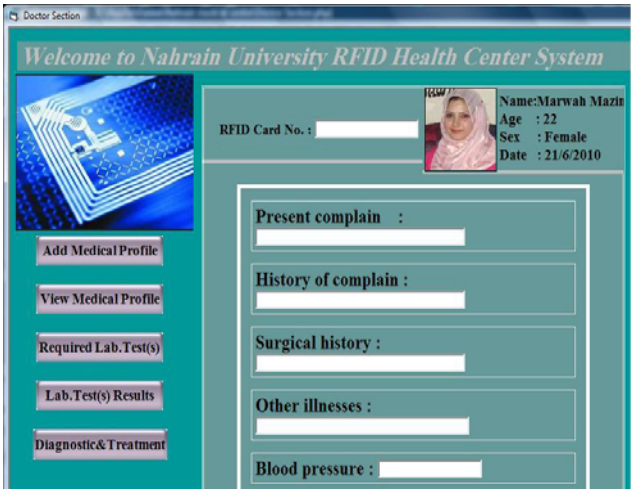

Fig. 8. Add new medical profile

- Send required test(s): if the patient may require a laboratory test, the physician should only choose the required test(s) to be examined and press send to send it to the laboratory section. Fig. 9 shows two selected tests to be sent.

Fig. 9. Send required test(s) to laboratory section

- Diagnostic and treatment: after adding daignostic the physician can select the required medication with its description needed for treatment then the patient should go to the pharmcy section to get the medication. Fig. 10 shows the fields where the physician can add diagnostic and a list of medications avaliable in the pharmacy along with its description to be added.

Fig. 10. Add Diagnostic and Treatment

4) Dentist Section: If the patient visits the dentist, the dentist will have to read his/her RFID card number to retrieve the patient information (name, sex, age) with a digital photo of the patient. The dentist is authorized to:

- Add new/Update dental profile: the patient complain, general description for teeth and all other dental information can be added in this form.
- Diagnostic and treatment: after diagnosis the dentist can select the required dental treatment, scheduling a next time visit. Fig. 11 shows the fields where the physician can add diagnostic and the dentist can add a list of all the performed dental treatments.

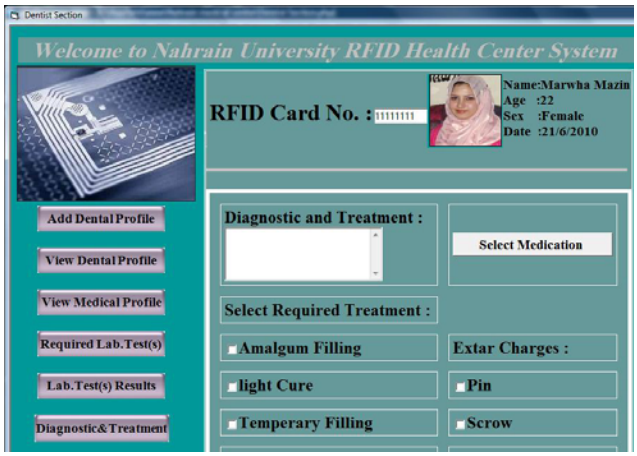

Fig. 11. Add diagnostic and select applied dental treatment

5) *Laboratory Section:* If the patient needs a laboratory test(s) he/she would go to the Lab. section, where the biologist would have to read his/her RFID card number to retrieve the patient information (name, sex, age) with a digital photo of the patient and to view what test(s) should be examined. Fig. 12 shows that after reading the patient RFID card, the patient would need two tests and how much they cost.

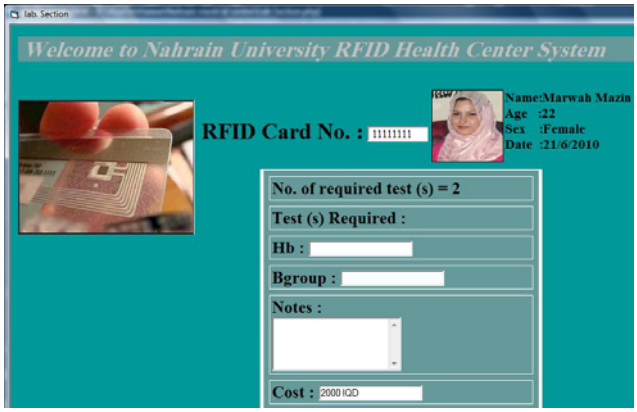

Fig. 12. Required laboratory tests to be examined

6) *Pharmacy Section:* If the patient needs a medication, he/she would have to go to the pharmacy, the pharmacist will have to read his/her RFID card number to retrieve the patient information (name, sex, age) with a digital photo of the patient and get the required medication with its description as shown in Fig. 13.

Fig. 13. Required medication with description

7) *Account Section:* If the patient is to have any dental treatment and/or needed a laboratory test(s), he/she would pay for treatment/laboratory test(s). Fig. 14 shows the account section page where the accountant should read the RFID card to retrieve the patient information, no dental treatment required to be paid for while there are two laboratory tests that should be paid for. On payment by the patient, the accountant will confirm this to the reception.

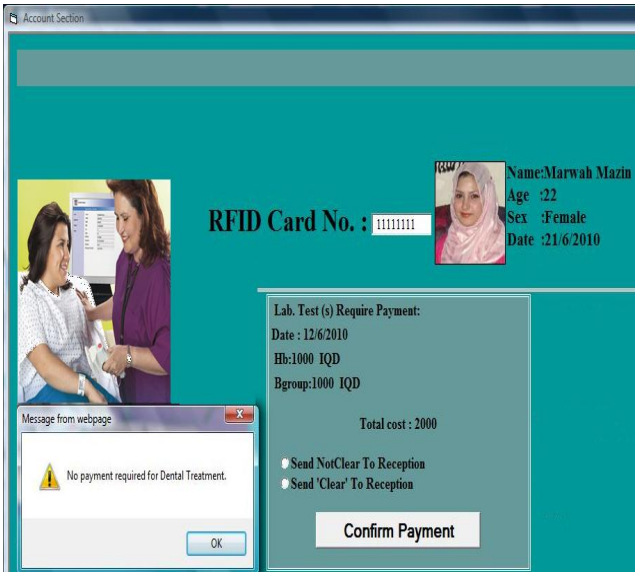

Fig. 14. Treatment required to be paid for with payment confirmation

IV. Conclusions

The proposed system successfully merges the technologies of RFID and web-based database systems. The RFID tag provides a secure and robust method for holding the patients identifier. The web-based database allows for the centralization of all patient records. This increases the security of patient data, as records can only be retrieved with an appropriate username and password, combined with the patient's tag number.

Further work will focus on incorporating extra functionality to the system such as adding video conferencing. This would allow physicians to converse with remote specialists, increasing the level of service offered to the patient.

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