Time Oriented Database System Using RFID

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Abstract

The recent focus on patient safety, care and security in hospitals has yielded a flood of new technologies aimed at improving quality of patient care. This has been due to the integration of Information and Communication Technologies in healthcare facilities. This has revolutionized the health systems and new fields of eHealth and health informatics have emerged. Health information systems are now combining physical process of healthcare delivery with medication information and applications that provide clinical decision support. One such technology is Radio Frequency Identification (RFID). Application of RFID technology in hospitals has risen dramatically during the last decade. This study focuses the use of RFID technology for managing patients and ensures better control and safety procedures. Existing patient's monitoring and management solutions are expensive and rely mostly on information recalled by hospital staff. Moreover, many such applications do not track treatment, drug dosage, and diet. The paper presents a system that integrates RFID with patient data management system addressing all these drawbacks together with the classical entities in a health information system or patient data management.

Keywords: *Patient Data Management, RFID, Healthcare, Temporal database, health databases, EHealth.*

1. Introduction

The evolution in Information and Communication Technology (ICT) during the last decade has had a profound impact on all walks of life including education, engineering, management, finance, and medical science [1]. The healthcare sector has reformed and healthcare organizations are facing a variety of new challenges such as increasing financial pressure, dearth of technical human resource, improvement in the quality of healthcare provided, and introduction of patient safety and security measures [2]. Most of these issues are mainly due to the lack of monitoring and visibility of the patients in the real working environment.

Radio frequency identification (RFID) is one of the proven technologies to resolve these problems [3]. With the help of RFID technology, one can monitor the status of patients and keep track of all the health services provided to them [4]. RFID can be integrated with the current databases and all the updates can be performed in the real time. The integration of RFID with the hospital information system and the central database will improve the information flow within the hospital by knowing the status of clinical staff, paramedics, patients, medical supplies, bed allocation and critical clinical equipment for improving patient care and safety [5]. Staff can be monitored as timestamps are recorded when they interact with the patient for e.g. giving medications on time, keeping track of patient's diet, treatment etc. [6] This ensures that all the procedures are carried out in a timely manner patient waiting time is reduced. The real-time visibility of patients within and between departments and the availability of rooms and beds can be easily determined through tracking boards. The location and status data with timestamps can be integrated into existing database application to help optimize workflows and increase efficiency [5].

Bar code solutions are also being used in variety of healthcare applications, including monitoring systems for medical dose management, labeling for pharmaceutical unit-dose medications, lab specimens, patient ambulatory systems, and blood samples [7]. Bar codes can be combined with RFID tags to create two-tiered identification, resulting in more robust point of care, patient-specific medical media. For example, pharmaceutical companies can locate and track each dose of medication produced in vast batches and hospitals can monitor the healthcare staff more efficiently and maintain healthcare records.

A huge amount of data related to patients, doctors, staff, pharmacy, medical equipment and other mobile assets is stored in a health database [6]. Patient is a key entity in that database because majority of the data revolves around the patient such as condition, treatment, follow-up, medication, and hospitalization [8]. The concept of time is also very important here because that data changes with respect to time and temporal aspect of data must be stored in the database environment [9]-[11]. This paper brings much needed solution for the challenges discussed above and provides increased visibility and improved operational efficiency in hospitals. The rest of the paper is organized as follows: Section 2 presents details about RFID technology, our approach is described in Section 3 while Section 4 lists the major outcomes and opportunities of this research. Conclusion is provided at the end.

2. Radio Frequency Identification Technology

The term RFID (radio frequency identification) describes a wireless identification technology that communicates data by radio waves [7]. It is sometimes referred to as contact-less technology. The identification information is encoded in a chip and packaged in a "tag" connected to an antenna which transmits this code. RFID labels can hold more data than barcodes, and can be read automatically by the reader without any user intervention. The entire system consists of the RFID tags, a RFID reader and a back-end database. The technology works through this communication between the RFID tags and RFID readers [12]. Many researchers have addressed issues that are related to RFID reliability and privacy ability [2] [3] [13]. The usage of RFID technology continues to increase due to better service and proven efficiency for all the stakeholders. It has been realized as a performance differentiator for many commercial applications, but its capability is yet to be fully utilized. Fig. 1 shows basic components of RFID system.

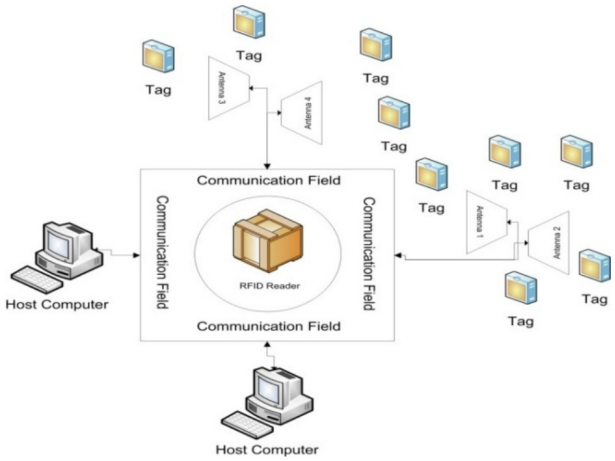

Fig. 1 Components of RFID systems [12]

RFID technology has evolved over a period of time. Initially it was not very successful due to high infrastructure cost and organizations preferred barcode applications as a low cost alternate. Now the cost of RFID has reduced substantially due to use of sophisticated technology which has increased in usage in commercial applications. It is evolving as a major technology enabler for tracking goods and assets around the world. It is a transformational technology in terms of its impact on business processes and systems. It can help hospitals locate critical equipment more quickly to improve standard of patient care, pharmaceutical companies to reduce counterfeiting of medical products and logistics providers to improve the management of moveable assets. With the ability to store several kilobytes of data in addition to the unique identifier, it could be viewed as a massive distributed database that has the potential to become ubiquitous i.e. billions of tags used throughout the world on a variety of objects that are sold, purchased, stored, moved and even produced [14].

2.1 Frequency bands used by RFID

There are many types of RFID systems each operating at a different radio frequency. The choice of radio frequency depends on the requirements of the real environment [14]-[17]. It is not a type of technology where 'one size fits all' applications. Four frequency bands are being used for RFID:

- **Low Frequency (125/134 KHz)** – Most commonly used for short reading range applications such as access control, animal tracking and asset tracking.
- **High Frequency (13.56 MHz)** – The scheme is used where medium data rate and reading ranges up to about 1.5 meters are acceptable. It can be implanted inside thin things such as paper.
- **Ultra High Frequency (850 MHz to 950 MHz)** – It can identify large number of tags at the same time at a brisk reading rate.
- **Microwave (2.45 GHZ)** – It has a reader rate that is even faster than the UHF tags. It produces best results in services such as vehicle tracking.

2.2 RFID Tags

RFID tags in use can be classified into two categories based on the presence of internal batteries:

- **Active RFID tags:** These tags are powered by batteries. Active tags can transmit signal to RFID reader located at a large distance (100+ meters). This allows for continuous monitoring of the tags that are used to equipment tracking.
- **Passive RFID:** On the other hand, Passive tags do not contain batteries. Instead, they draw their power from the radio wave transmitted by the reader. The reader transmits a low power radio signal through its antenna to the tag, which in turn receives it through its own antenna to power the integrated circuit (chip).

2.3 RFID Chips

There are two basic types of chips available on RFID tags:

- **Read only chips:** These chips are programmed with unique information stored on them during the manufacturing process. The information on read-only chips cannot be changed.

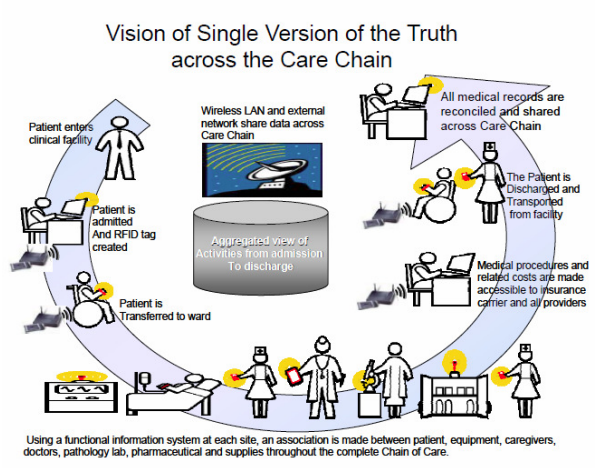

Fig. 2 Data flow in RFID [18]

- **Read-Write chips:** The user can add or edit the information stored on the tag when the tag is within range of the reader. These chips are more expensive than the read-only chips. They are used in applications where data stored in a tag is updated upon the delivery of a service.

2.4 RFID and Healthcare Industry

RFID technology is extremely useful in location of institutional assets. It applications in healthcare are increasing day by day to improve the efficiency of the healthcare systems by tracking information in real time. Integration of RFID based information into existing healthcare management applications will optimize the workflow processes used in healthcare delivery [19]. In general, RFID application in healthcare sector may be divided into two broad categories, inventory management and workflow or process optimization. These applications co-exist within the organization and track the availability of resources at the right place for the right person [20].

Figure 2 shows the use of RFID in a healthcare system in order to facilitate the patient care mechanism and create a single version of truth across the care chain that is visible to all the stakeholders. When a patient enters the healthcare facility for admission, a RFID tag is allocated and then all the information pertaining to this RFID tag is maintained in a centralized database. All the services provided to the patient are tracked through the RFID by creating an association with staff, equipment, doctors, lab, pharmacy and supplies. This information is also visible to the insurance companies through web interfaces to facilitate them in tracking the expenses as per need.

3. Our Approach

The paper highlights the application of RFID technology in healthcare domain and focuses primarily on patient's data. RFID mechanism has been integrated to healthcare management system. The architecture and hardware used for this integration has been described in consequent sections. The ontological model for Patient Data Management (PDM) has been developed which has served as basis for development of workflow model of PDM and the conceptual model (scheme) for the healthcare management system.

3.1 Architecture of RFID

RFID will connect to our patient data management system through the USB port. The form based front end of the PDM application is connected with the backend database through the RFID tag. As soon as the RFID tag of any object is detected by the reader, it is displayed on a textbox on the screen and all the information pertaining to that tag is displayed below it. The dataflow is shown in fig. 3.

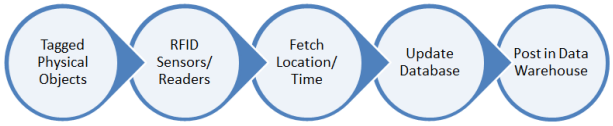

Fig. 3 Data flow in RFID

3.2 RFID Device

The RFID device used for this purpose is SC403 (see fig. 4). It is an access control device. The device has lock control, alarm, exit button, and door sensor. This device is suitable for offices, hospitals, industries, and houses. The Wiegand-in interface is used to connect external reader to construct master and slave system.

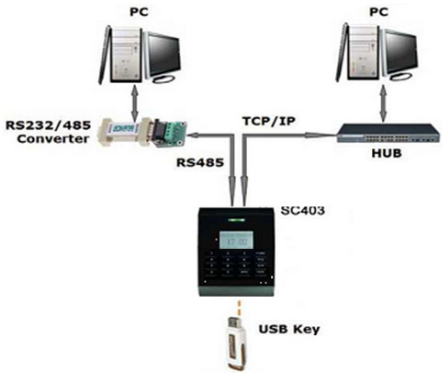

Fig. 4 RFID device connectivity

The device can also be connected with a control panel by Wiegand-out interface to perform reader function. Operations can be performed through the device as well as using the PC software and later uploaded to the device through TCP/IP, RS232/485 communication. USB host option is used for downloading and uploading of data including user templates or records.

3.3 Requirement Analysis: Work Flow Model for Patient Data Management (PDM)

Another important task in this research is to carry out the requirement analysis for patient data management systems. An ontology which covers patient, health, and hospital information must be developed. This step includes the integration of ontological knowledge base with the existing information system. It requires the creation of ontological categories based on the information regarding patients in a hospital database. Moreover, time related aspects are significant in most of the health and medical domains. The basic idea is to distinguish temporal and non-temporal data components [21]. Some attributes are temporal in nature. The values of such these attributes may change with the passage of time and the changes must be saved for possible retrieval later. Similarly, data regarding the doctors and paramedical staff who are looking after the must be present in the database. Fig. 5 shows the ontology for patient data management. Moreover, the work flow of patient data management in the hospital environment is shown in fig. 6.

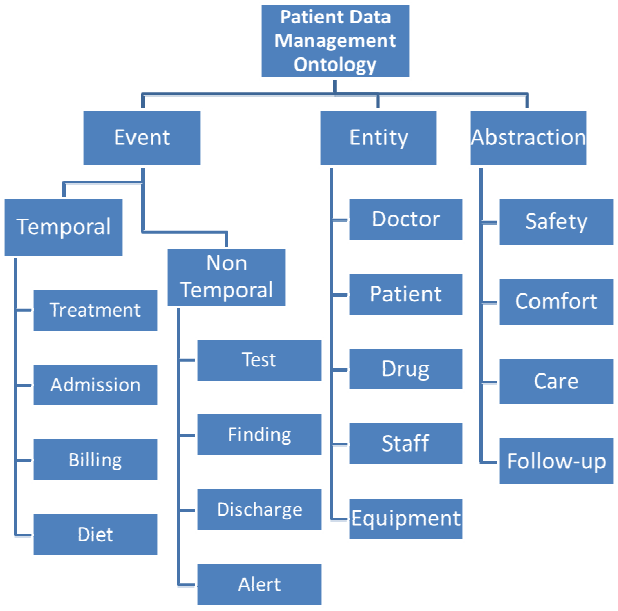

Fig. 5 Patient Data Management (PDM) Ontology

3.4 Patient Database Design

The ontological development and work flow model identify the important entities in the healthcare setup which are later used to construct logical diagram of the database (see fig. 7). Following tables have been used:

- Patient: This is the main table in which all the information related to the patient is recorded first. Admit, Checkup, Diseases, Surgical table are all connected with this table.
- Disease: Disease table stores the disease history of patients along with the time period when they were suffering from the disease.
- Surgical: Surgical table stores the information regarding surgical procedures carried out on a patient together with the reasons and outcomes.
- Checkup: Checkup table store patient problems, diagnosis, comments of doctor, status of ailment, as well as reference numbers of doctor, OPD, tests etc.
- Test: Test table maintains record regarding tests carried out on patients, referring doctor, result and copy of report.
- Token: Token table contains patient checkup date, token number, status, admission etc.
- Admit: Admit table stores patient admission date, discharge date, discharge report and summary of treatment.
- Pharmacy: The table maintains record of medicine administered, quantity, dosage, dispensing date, and a list of possible side effects. The table is connected with disease information table.
- Disease information: The table stores the disease name, ID, and the pharmaceutical record pertaining to the disease.
- Doctor name: The table stores doctor name, ID, and login and logout. The table connects doctor with patients through the Checkup table.

4. Outcomes and Opportunities

The main outcomes of this research include

- Understanding of problems related to information management in healthcare sector.
- Development of information workflow and process model for hospitals.
- Temporal Database schema design [9].
- Overview of RFID technology and its role in healthcare sector.
- A prototype software application based on RFID.

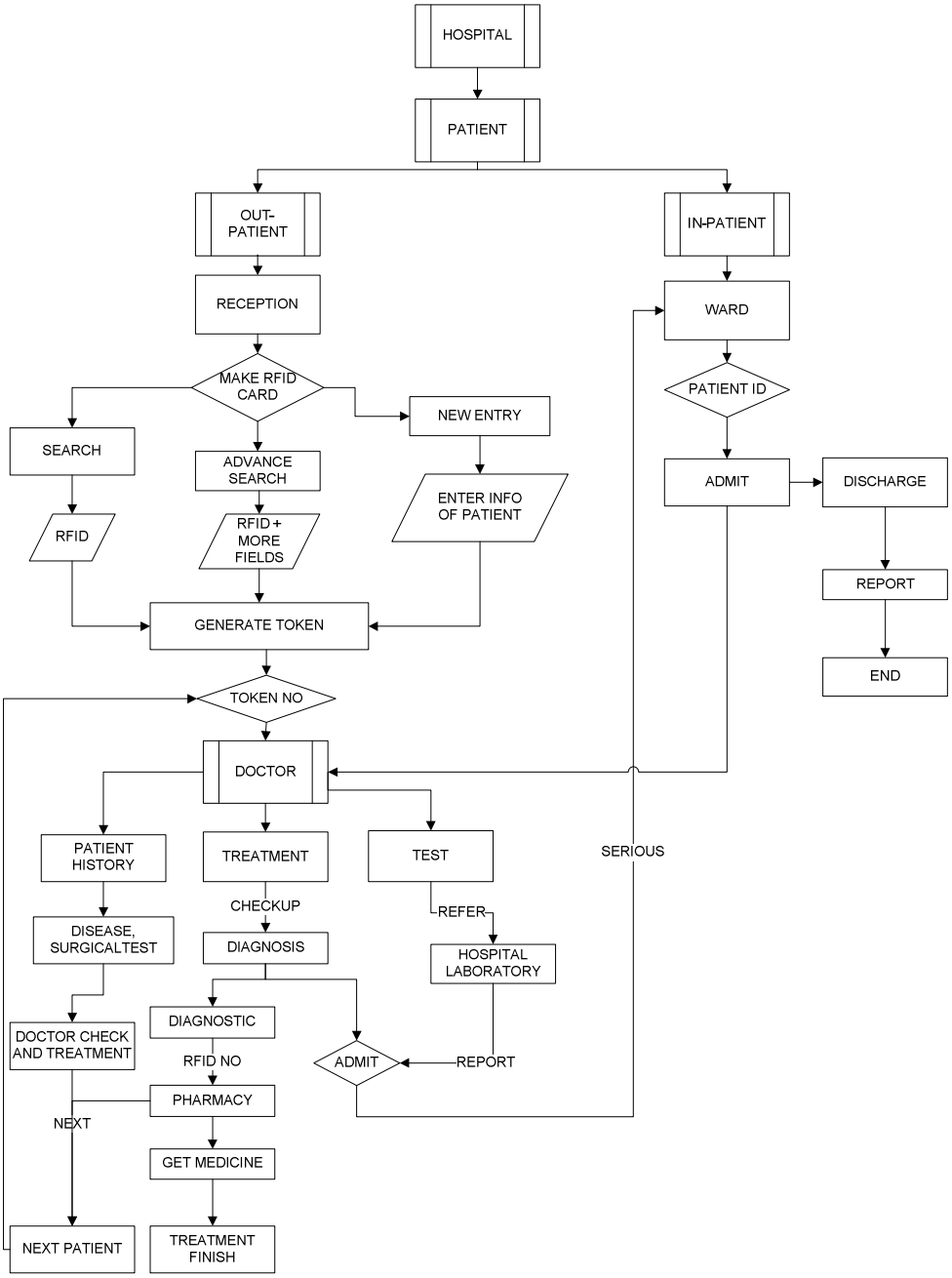

Fig. 6 Requirement analysis: Work flow for Patient Data Management

The key opportunities of the RFID based system are in real-time tracking of patients, staff and medical supplies at hospitals. Some of the main benefits are RFID based systems are listed below:

- Checking and monitoring staff duties in different wards and ICU's.
- Increased patient safety as well as real time updates.
- Monitoring of patient's diet.
- Reduction in the time required for retrieval of information.
- Dynamic par level adjustment.
- Appropriate removal of medicines and other products that are expired.
- Reduction in patient billing errors related to the supplies.
- Real-time tracking of inventory.

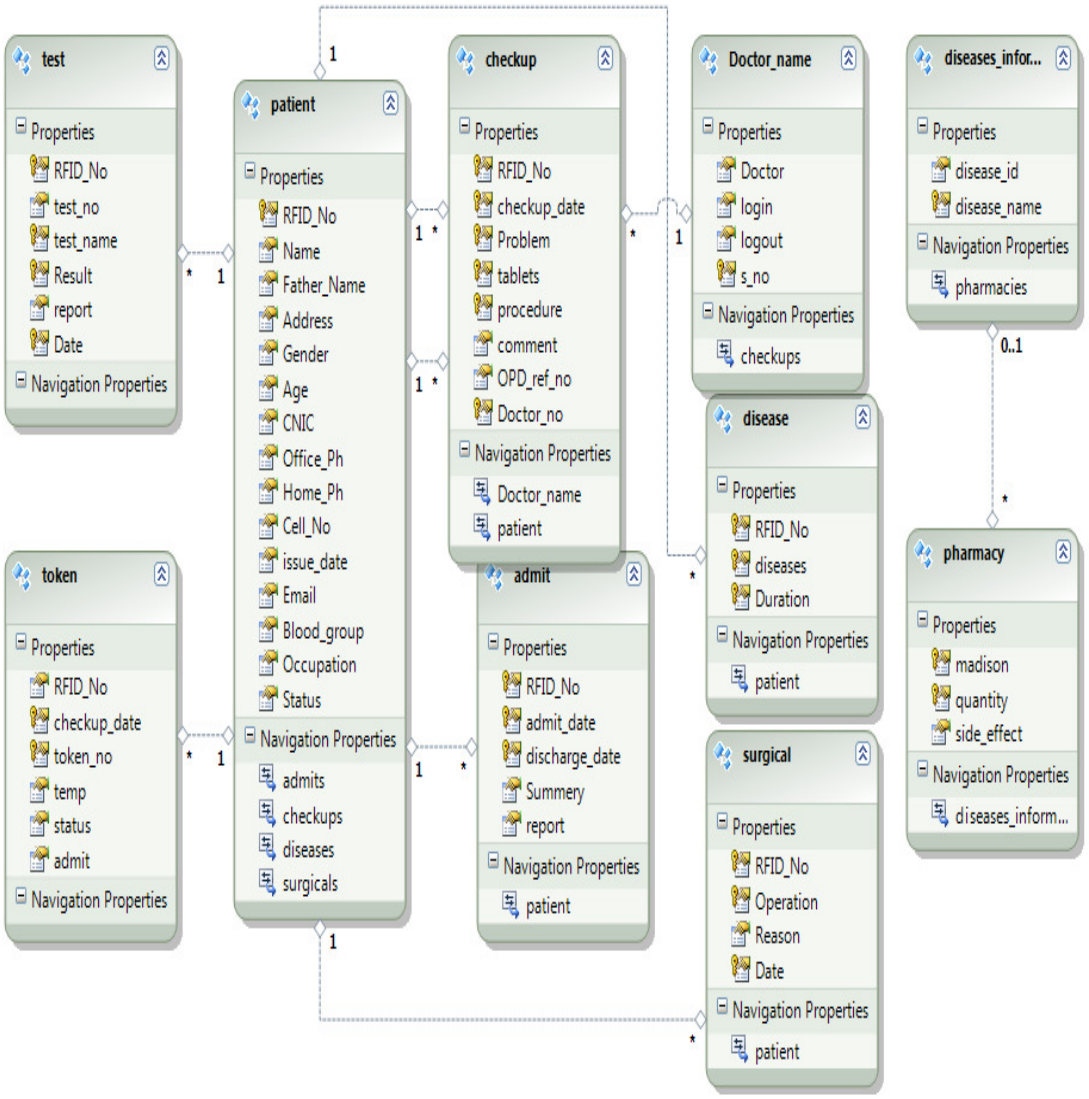

Fig. 7: Logical diagram of Patient Management system Using RFID

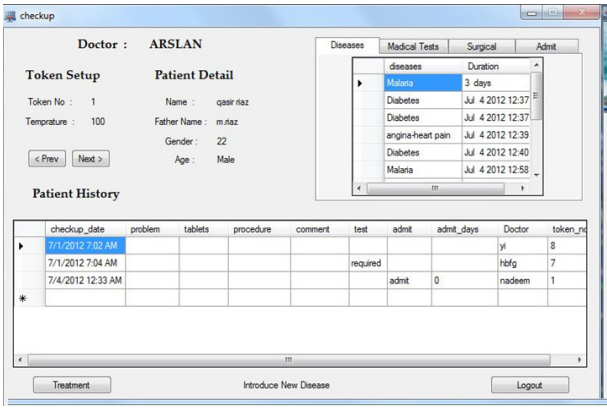

Fig. 8: Patient checkup screen

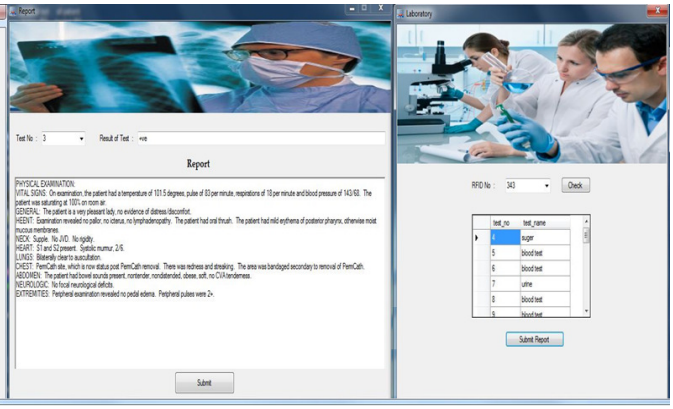

Fig. 9: Patient's report

5. Conclusion and Future work

The paper investigated the application of RFID technology in healthcare domain, primarily focusing on the patient's data. The architecture of health information system as well as a database integrated with RFID technology has been presented together with its implementation. The application is extremely useful in a hospital setup for monitoring and tracking patients and enhances patient's safety by having accurate and timely information. It will also reduce medical and clinical errors and thereby increase efficiency and productivity of healthcare organization.

The work can be extended to other related areas in a hospital environment. For instance, RFID tags can be used for safety and security of newly born babies, hospital supply chain management, track patients having serious infections, TB control program, Polio vaccination program etc. Moreover applications that share data among different healthcare providers can be built to facilitate healthcare professionals using web applications or distributed architecture. Finally, the work may be extended to develop mobile based applications for patient management.

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