Development and Implementation of a Smart Medical Cabinet using RFID Technology in Developing Countries

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***Abstract*—Drug management system in health sector such as hospitals and pharmacy in developing countries takes a lot of time and generates a lot of inconveniences for the patients due to inefficient method employed for inventory, identification, tracking and administration of drugs which is subject to manipulation. This paper presents the development of a RFID moveable asset tracking system.**

A smart medical cabinet through the use of RFID technology is designed to automate most of the processes involved in the day-to-day running of the pharmacy to track the movement of drugs within the hospital environment thereby offering a better and more secure inventory system. This system is made up of both hardware and software components. The hardware components include: a RFID active tag, RFID tag reader, web server and a database server. The tag readers are mounted in the smart shelves that houses the drugs to be administered to patients in the hospital or the pharmacy

***Index Terms*—Radio Frequency Identification (RFID), RFID tags, RFID readers, RFID moveable asset tracking.**

I. Introduction

ASSET tracking enables organizations to know exactly what assets they own, lease or control, as well as how those assets are being used throughout their life cycles; that is from acquisition stage all the way through disposal stage. The need for proper, effective tracking and identification methods (both for assets and human tracking) cannot be overemphasized with the increasing operational risks in the health sector and the technological advancement going on in the biomedical sciences industry. Identification has become paramount in every aspect of our day to day activities.

In the past various modes of identifications have proven efficient in their own way ranging from the typical use of paper to the plastic tagging of products that carry particular information about the product. But with the advancement of technology, the need for more efficient modes of identification has become more expedient.

This has led to the invention of modern identification methods such as Barcode. Although there are several modes of identification, the Radio Frequency Identifications (RFID) system is becoming widely acceptable across various industries. RFID is preferred to the barcode technology because of its ability to transmit larger amounts of information without being in line of sight. It ability to read/write information about assets which enables the use of interactive applications such as computing the bills at a payment point within the shortest time possible gives RFID technology a major advantage over other identification modes such as barcodes [1].

II. RFID Technology and its Operation

Over the years, RFID gained a great interest in industry and academia. It was invented in 1935 but was only applied in the military activities for tracking planes during World War II. It was later used by the United States of America to track nuclear materials and subsequently used by agricultural department to track and identify medicines and hormones to be given to cows [2]. Further research opened up its usefulness in many other areas of lives which led to the use of RFID technology in a variety of applications such as smart parking lot access, material tracking information systems, libraries management systems, hospital management systems, Pharmaceutical manufacturing, supply-chain management and Airline baggage Identification.

RFID is a wireless technology that operates in an unlicensed ISM RF Band using tags and tag readers to communicate with a backend database system in order to make feasible automatic identification through the use of radio-waves. Different categories of RFID technology are available but the requirement of the application involved determines the appropriate RFID frequency band and the

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type of tag to be employed [1].

The basic architecture of an RFID system consists of a tag that includes an antenna and a chip, a reader equipped with antenna and a transceiver, and a workstation to host the middleware and database.

Basically there are two types of RFID tags namely active and passive tags. The Active tags are tags with internal battery power source used to generate a signal in response to RFID reader. The trade-off is larger size, more cost and limited operational life, depending on battery type employed and operating temperature while Passive tags have no internal power source, thus, they obtain power directly from the RFID reader transceiver. These types of tag are much lighter in weight than active tags, less expensive and offers unlimited operational lifetime. The drawback is that they have shorter read ranges than active tags and require a highly powered reader [3]

Each of these tags has its unique frequency ranges and characteristics with different advantages and disadvantages. However, a lower frequency indicates a lower read range and slower data read rate with increased abilities to read accurately from a distance and through varieties of substances such as fog, metal, liquid or ice as compared to the barcode that is short of these abilities [4].

RFID tags are made up of integrated circuit/chips and an antenna. The IC/chip is a tiny computer used for storing and processing information, modulating and demodulating a radio- frequency (RF) signal, and other specialized functions while the antenna is used for receiving and transmitting the signal which helps to enable the chip to receive power and communicate. They are impressed on a mount which is often a paper substrate or Polyethylene Therephtalate (PET) thus inserted between a printed label and its adhesive support.

RFID Readers are radios that transmit and receive analogue waves which are converted into a string of zeros and ones bits of digital information. The main function of the reader circuit is to provide 125 KHz carrier frequency, transmit that to the tag and detect the magnetic coupling from the tag such that tag and the server can exchange information. The reader is made up of a transceiver, control unit and a memory unit. The block diagram below shows the basic features of the RFID reader circuit.

Fig. 1. various forms of RFID tags

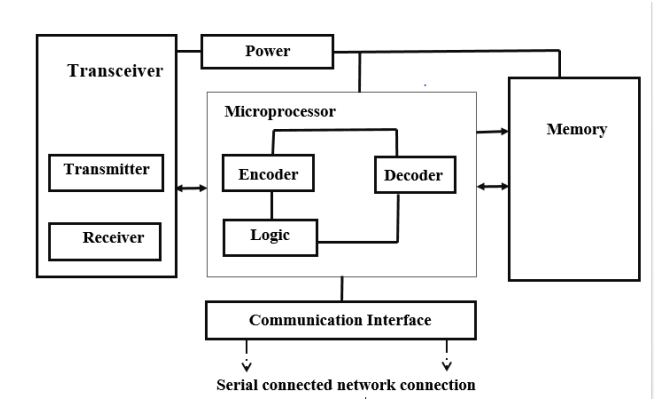

Fig. 2. Block diagram of the RFID reader

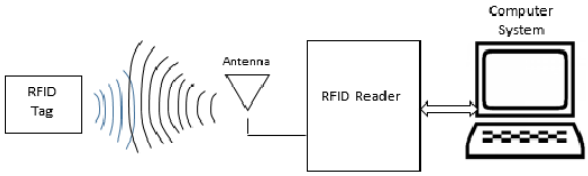

Fig. 3. Block diagram of the RFID tag reader system

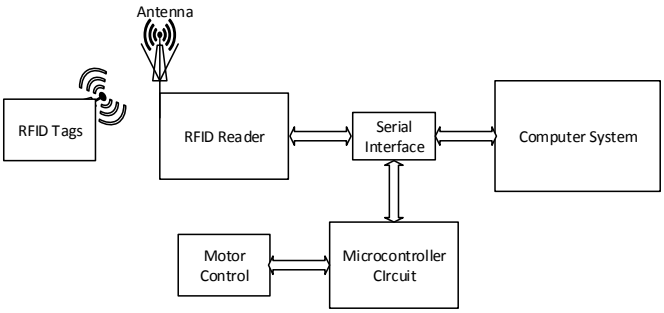

Fig. 4. Block diagram of a Full RFID system Architecture

Some of the operational frequencies and characteristics used in RFID system are depicted in table 1

Table 1, RFID operation frequency ranges and related applications

Frequency Band	Commonly used frequency	Communication Range	Applications
Low Frequency	125 to 135 KHz	20 to 100cm	car immobilization and access control systems
High Frequency	13.56 MHz	10 to 70 cm	contactless credit cards and building access control systems
Ultra High Frequency	868 to 928 MHz	10 cm to 3m	Supply chain management
Microwave	2.45 & 5.8GHz	3m	fleet identification and electronic toll applications

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Each frequency range has its advantages and disadvantages. For instance, Europe uses 868 MHz for its UHF applications while the US uses 915 MHz for its UHF applications. Japan does not allow the use of the UHF frequency for RFID applications [5]. Low Frequency tags (LF) are less expensive to manufacturer than the Ultra High Frequency (UHF) tags. UHF tags offer better read/write range and can transfer data faster than other tags. High Frequency (HF) tags work best at close range but are more effective at penetrating non-metal objects especially objects with high water content.

III. THE PROBLEM STATEMENT

Even with the advancement in technology, a great percentage of hospitals in developing countries still embark on the crude method of drug inventory and tracking such as the use of paper. The crude method requires that the nurse or doctor to manually enter the details of the drugs administered. This crude process has proven to be time consuming and highly inefficient as drugs are taken away from the clinic without been properly entered into the books or even recorded at all. The need for a more efficient system can no longer be denied hence the introduction of the RFID technology. Although there are several accounts of healthcare operational failures which lead to prescription errors, inflated medical costs, losses from theft, drug counterfeiting and inefficient workflow. The advent of RFID technology offered an enhanced and more secured drug management and administrative system which tracks drugs inventory and provide assistance with billing and the tracking of patient care.

IV. THE RFID VERSUS BARCODE TECHNOLOGY

Barcode and RFID are both identification technologies designed to hold data that can be accessed with some type of reader. In reality, the two complement each other and can be used simultaneously in many applications. In addition, both technologies are often assumed to be synonymous; this is due to the act of bringing the card close to reader circuit. The method of data exchange between them accounts for most of the differences between them and helps determine where each identification technique is best applied. Table 2 shows the comparison between Barcode and RFID technology.

V. SYSTEM DESIGN

The system design stage requires complete analysis of the system specifications. This is divided into 3 parts in order to achieve accuracy and full functionality of the system.

- The Software Division
- The Hardware Division
- The Electrical Division

The software division of this project was achieved using Visual Basic.net, .txt files, C# and LabVIEW. VB.NET is a multi-paradigm, high level programming language, implemented on the .NET framework. The VB.net program was used to construct an interactive Graphic User Interface (GUI) that displays the information required.

Table 2, Comparison between Barcode and RFID technology.

COMPARISSION OF BAR-CODES AND RFID TECHNOLOGY		
	BAR CODES	**RFID**
Durability	Exposed – risk of wear and tear or damage due to handling	Better protected, can be encased, with stands harsh environments
Technology	Optical	Radio frequency
Line of sight	Required	Not required
Read range	Inches to a few feet	Tens to hundreds of feet
Read rates	Slow –one at a time	Fast –up to 1,000 in a single pass
Reusability	No	Yes
Security	Low–easily copied or faked	High –encryption is harder to replicate
Memory Capabilities	Static –read only and limited data capability	Dynamic –high capability; reads, writes, updates, triggers other actions.

The Hardware division includes the selection and setup of the RFID tags and readers, the setup of the Servo Motor and construction of the smart shelf.

ISO 18000-6C standard tags were used and operate at the UHF band. Both the reader and the tags are designed to operate with the UHF Frequency standard between frequency bands of 902 - 928MHz. The Tag memory are divided into four storage areas, each storage area is made up of one or more memory words. The four storage areas namely the EPC,TID, User and Password area.

Servo motor are small sized highly energy efficient motors used to allow precise control of angular, velocity and acceleration in the operation of remote-controlled robots. They are also used in industrial applications, pharmaceuticals and food services industry.

The electrical division includes the use of a Microcontroller and a servo motor to automate the cabinet, hence making it a smart shelf.

VI. TESTING AND RESULTS

The interior of the smart cabinet consist of

1. The servo motor
2. The USB and coaxial cable
3. The RFID antenna
4. The RFID UHF reader

VII. CONCLUSION

In healthcare sector of most developing countries, RFID has a great potential to improve on patient safety and supply chain management of organizations. RFID is the major technology behind Internet of Things (IoT) which allows

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networking of physical objects embedded with electronics software, sensors which enable it to exchange data with manufacturer, operator and/or other connected devices. The deployment of this technology will unlock real value to the health care services with amazing benefits to all interested parties by providing premium care to patients and optimizing available resources for sustainable operations of the very important sector of the economy.

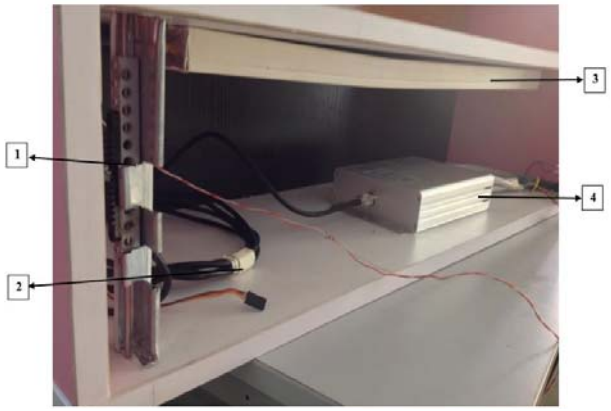

Fig.5, Interior of the RFID smart cabinet

Fig.6, Main interface displaying the information of the 4 drugs in the cabinet

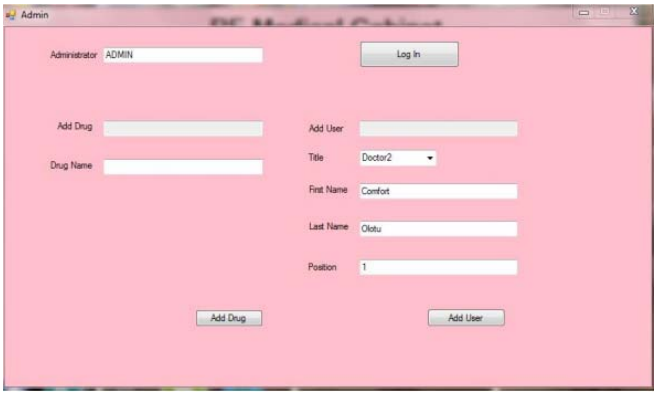

Fig.7, Administrative interface when a new authorized personnel is being registered

Fig.8, Administrative interface when a new drug is being registered

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