RFiD IN HOSPITALS: ISSUES AND SOLUTIONS

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OVERVIEW

While visibility and trust are key antecedents to *effective* channel relationships, information sharing and communications are the backbone of supply chain *efficiencies*. Until this point, companies have been focusing on personnel-centric, relationship-building tactics, such as strategic alliances and partnerships to realize these. Now, there is a technology which can achieve these AND MORE, with less emphasis on the vagaries of the individuals themselves, who manage the interactions between channel members.

In today's dynamic business environment, successful companies must have both an efficient and effective supply chain in place. As manufacturers move towards "manufacturing right the first time," supply chains must be capable of delivering the most cost-efficient service, in a manner determined by the customer; in other words the supply chain should simply "do the right things right!". Thus, the combination of customer-driven best practices, and increased supply-chain cost efficiencies, allows firms to establish programs leading to increased operating profits and higher customer satisfaction/retention. However, for successful implementation of any such supply chain strategy, real-time data and item visibility is imperative – which is where Radio Frequency Identification or RFiD comes in.

INTRODUCTION

> *"WalMart intends to have its top suppliers put RFID tags on pallets and cases beginning Jan. 1, 2005. We believe the future belongs to those who see the possibilities long before they become obvious to everyone."*
>
> **Linda Dillman, CIO, WalMart**

Ever since WalMart first announced publicly, on November 4th, 2003, that it was going to require its Top 100 vendors to become "RFiD Compliant" by the January 1st 2005, the market has been buzzing with action and excitement – this despite the fact that the technology WalMart was talking about has been around since World War II! Coming close on the heels of WalMart's announcement, was the following one made by the U.S. Department of Defense:

> *"U.S. Military to Issue RFID Mandate. Exclusive: Following in WalMart's footsteps, the U.S. Department of Defense plans to ask its top 100 suppliers to put RFID tags on shipments."*

So, what is it that makes WalMart's announcement so critical? How does the one made by the DoD change things for vendors of both organizations? Are other firms going to be affected by this technology too; if "yes" who are they and in what manner? This study is intended to provide answers to these questions and many more, which are being constantly debated in Board Rooms and on Shop-floors alike. The study focuses, specifically, on the implementation of RFiD in hospitals, and looks into various issues involving three principle areas (people, equipment and medicines/drugs), which are impacted by it. Finally several cases of implementation are examined, and implications of the technology are discussed.

RADIO FREQUENCY IDENTIFICATION (RFiD)

RFiD technology is based on the simple idea that an electronic circuit or tag, self powered (using a battery) or powered intermittently through radiation from a distance, can transmit information in air that can be read by a reader located at a distance. These tags are nothing but plain antennae bonded to a silicon chip kept inside a plastic or glass case.

Tags operate differently depending on the frequency of operation. The most commonly used tags operate at 13.56 MHz as shown in fig. 1. The Reader and the Tag are equipped with coils which have a mutual inductance to each other. The Reader coil carries an alternating current producing a magnetic field in the vicinity. This magnetic field charges up the small tag coil, and switches on the circuitry inside the tag. The tag then responds by transmitting data back to the reader. These tags however, have a drawback of having a short range [1, 2]. Also, they cannot distinguish easily between several tags grouped closely together.
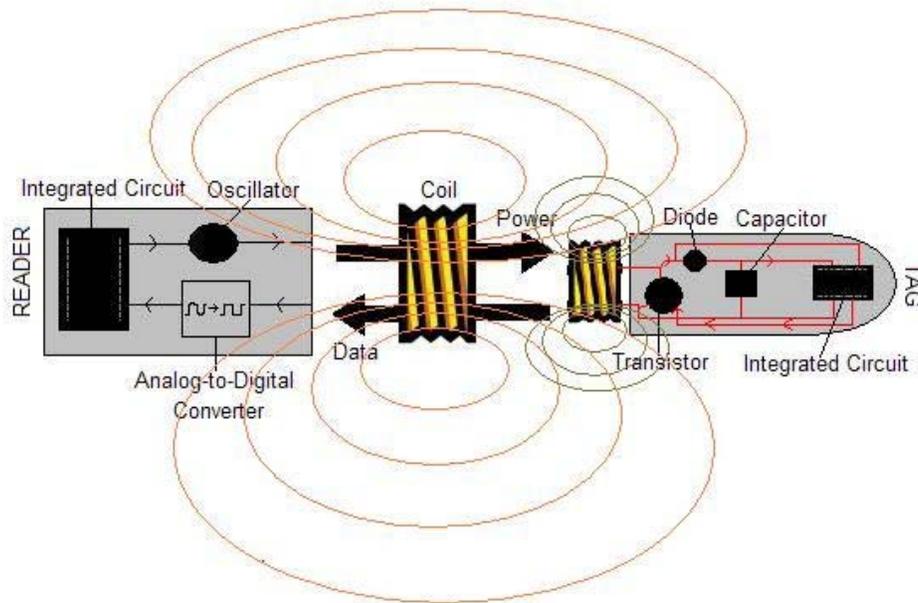

Figure 1: A Schematic of Power and Data Flow in a 13.56 MHz RFiD System [1].

The higher frequency tags, mostly 915 MHz, are shown in operation in fig. 2. The reader emits an electromagnetic wave which charges up the tag. The tag in return transmits the data back to the reader. These tags have a greater range than their lower frequency counterparts and can read a multitude of tags more easily than them [1, 2].
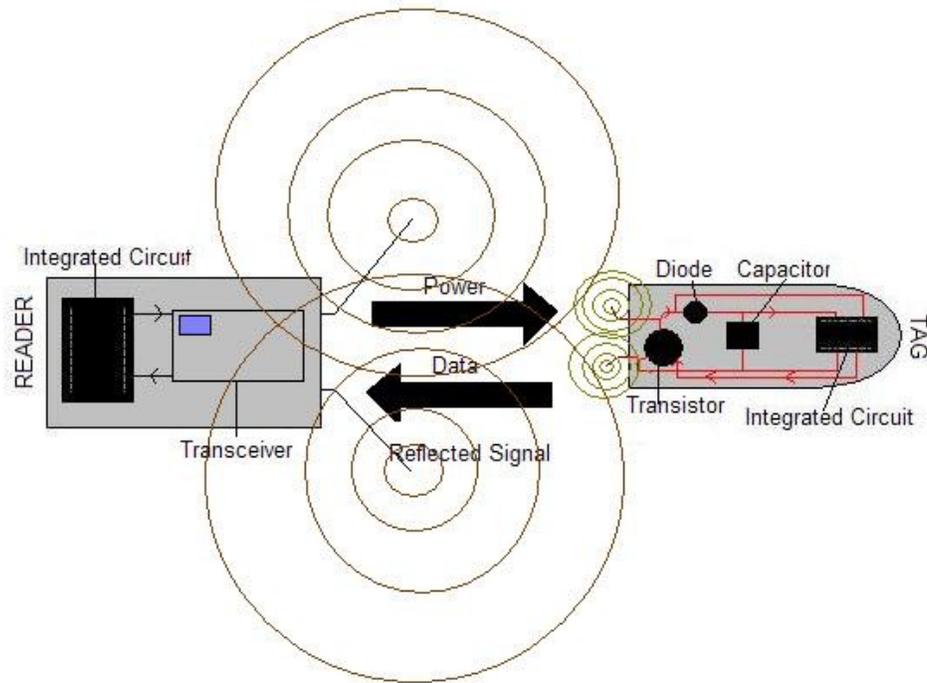
Figure 2: A Schematic of Power and Data Flow in a 915 MHz RFiD System [1].

The higher frequency information exchanges, however, see a very high attenuation in the presence of fluids or metals [2]. This is where the lower frequency technologies seem more reliable than their newer counterparts. Later sections in this paper, studies the role and usefulness of both technologies in a hospital scenario.

NEED FOR TRACKING IN A HOSPITAL

There is always a crowd of things and people going around in a hospital that need to be tracked. There are doctors, nurses, patients, and visitors who need to be kept track of in times of emergencies. There is equipment that needs to be prevented from getting stolen and then there are medicines that need to be given to the right patients, in the right amount, at the right time, and from the right packages. Also, it is important that the hardware chosen (along with its specific construction) operates well outside the frequencies used by other medical instruments and systems used in a hospital to avoid the potential for interference. All these issues are considered in detail in the following few paragraphs.

People

o *Doctors* – Situation: There is an emergency and all the doctors are elsewhere in the hospital. The nurse pages the doctor about the emergency. The doctor responds in some time, but it is too late by then! This is exactly the scenario that needs to be avoided. If the position of the doctors can be tracked on a real time basis, a better arrangement and distribution solution can be had to ensure

the availability of at least one doctor in every area of the hospital to take care of such emergencies. Doctors can wear bracelets or badges containing RFiD tags.

o *Nurses* - Usually there are far more nurses in a hospital than doctors, hence even distribution is seldom a problem in their case. However, it is still equally important to keep track of the nurses. For example, keeping track of close contact with patients having infectious diseases is of utmost importance for the health of the hospital staff. In Singapore and the other south-east Asian countries, RFiD became an important tool in fighting against SARS. All hospital staff was tracked for close contact with a SARS patient and then were appropriately treated [3]. Also, in case of a medical error it may be important to track the nurses who were responsible for giving the medications to the patients. Like doctors, the nurses can wear the tags as bracelets or badges.

o *Patients* - Each year, between 44,000 and 98,000 patients die because of medical errors [4]. Currently, only 3-4 percent of the approximately 64,000 hospitals in the U.S. have an integrated Hospital Information System (HIS) to manage patients' records and care. In addition, 60 percent of those hospitals with an HIS are using bar code technology to ensure patients receive the right treatment [5]. The number of fatalities can be significantly reduced by incorporating RFiD in the hospitals for increasing the accuracy of reads. If every patient is required to wear an RFiD tag, all his/her records can be placed in a central computer and can be accessed by all authorized doctors and nurses on their handheld computers simply by scanning the tag he/she is wearing. Every life saved will more than cover the cost of implementing the RFiD systems. Using RFiD will also help track patients easily on a real-time basis. While it may be difficult at times for the patients to wear a bracelet or a badge, wearing an anklet with an embedded RFiD tag could provide a practical option.

o *New born babies* - Each year, a significant number of babies are stolen from the hospitals. Also there are quite a few errors in matching the babies to the correct parents. Putting an RFiD tag on each baby will help track the position of the babies in the hospital on a real-time basis as well as help in accurately matching them to the correct parents. Babies can wear locked RFiD tags on their ankles.

o *Visitors* - When there are patients in the hospital, there will always be visitors to see them. Often times these visitors might wander away into the restricted areas of the hospital. Putting an RFiD tag on each visitor can help eliminate this problem by linking them to a unique patient. An alert will be triggered each time the visitor wanders away from close proximity of the patient they are there to see. The visitors can wear badges or bracelets containing RFiD tags.

Equipment

o *Medical instruments* - It is estimated that the theft of equipment and supplies costs hospitals $4,000 per bed each year and with over 975,000 staffed beds in the U.S., this represents a potential loss of $3.9 billion annually [6]. If each of these instruments is embedded with an RFiD tag for real-time tracking, not only can they be prevented from getting stolen, but can be located very easily at times of emergencies.

o *Surgical tools* - After an operation, the surgeons always fear about a surgical tool being left sewn-up inside the patient's body. Having a small RFiD tag on each of the tools will enable the doctor to track each and every piece of

equipment and eliminate this fear from the doctor's mind. The doctor can therefore concentrate more on the operation itself.
- o *Other miscellaneous items* - Items that are used by patients on a rotation basis need to be tracked for tracking a contamination. For example, a bed sheet in a hospital is randomly allocated to a bed after its routine visit to the laundry. If the bed sheets (and all other similar items) have an embedded RFiD tag, all the dangerous infections can be tracked and the infected sheets can either be sterilized or simply disposed off!

Medicines and Drugs
- o *Combating the growth of counterfeit drugs* - The Food and Drug Administration (FDA) estimates that up to 40 percent of medicines shipped from countries such as Argentina, Colombia, and Mexico may be counterfeit [7]. Clearly counterfeit drugs are a huge problem to our society and should be eliminated. RFiD is commonly believed to be the best medicine against counterfeit drugs. Item level RFiD tagging can help eliminate this problem. The RFiD tags located on the packages can be tailored to capture specific information required by the laws of the different states or countries. The requirement of all the information contained in the RFiD tags will reduce counterfeits significantly.
- o *Reverse logistics and recall management* - Sending drug shipments back because they are out of date or incorrect can be made a lot easier by incorporating RFiD in the supply chain. RFiD provides seamless visibility in the entire supply chain, forward or reverse.
- o *Prescription adherence* - About 40 percent of patients don't take their medication as prescribed, according to Information Mediary Corp. (IMC) [8]. By using RFiD tags on the packages of the medicines, the time of opening up the packages can be tracked. This information can be linked to the patient to prevent any bad effects arising out of not taking the medicines on time.
- o *Drug Testing* - The effects of the drug can also be tested efficiently and more accurately using RFiD tags. Each test person's data is captured into a computer including the times that they took the medication, the amount of medication he/she received etc.

Miscellaneous items
- o *Specimen bags, slides and test tubes* - There can be medical errors related to inaccurate matching of a sample (e.g. DNA) to the correct owner/patient. The importance of positive patient identification (PPI) in reducing medical errors becomes clear when considering that between 44,000 and 98,000 patients die in the United States each year from medically related errors [?]. The leading cause of death due to medical errors is caused by patient misidentification, and specimen or medication misidentification. This can not only be reduced, but eliminated altogether by the use of RFiD. RFiD tags can be placed on test tubes, slides and bags meant for holding test specimens and can be uniquely and accurately linked to a patient's records.
- o *Blood bank* - If all the blood bags in bank are tagged with RFiD tags, real-time information about the availability and location of a certain blood group can be had right from the patients bed side using a hand held device. This can help save a lot of time and confusion at times of emergencies.

- o *Medical waste* - The medical wastes coming out of a hospital are extremely hazardous. These wastes can be easily tracked by the waste management agency with the help of RFiD. All hospitals have to do is, put an RFiD tag on all outgoing waste bags. The waste management agency can then easily detect the presence of medical waste in a surrounding and appropriately treat it before it becomes dangerous to the population.

CURRENT USE OF RFiD IN A HOSPITAL ENVIRONMENT

SUBJECT	HIGH FREQUENCY (e.g., 13.56 MHz)	ULTRA HIGH FREQUENCY (e.g., 915 MHz)
Doctors, Nurses, Patients, Visitors, Babies, Staff	RFiD tags used in wristbands for controlled access to rooms and hallways.	RFiD tags used as Wristbands and Badges to track people.
Equipment		
Medicines and Drugs	RFiD tags on packets, to prevent counterfeits and track consumption time.	
Specimens and Test Tubes	RFiD tags on test tubes to identify the patient they belong to.	

Table 1: The Present State of RFiD Implementations in the Hospitals.

The use of RFiD has already begun in several hospitals across the country. Many companies are already focusing their time and energy towards the realization of this goal (table 1 presents a summary of the current state of the technology). It is a well established fact that none of the RFiD technologies being considered in hospitals, do not interfere with telemetry instruments like the X-Ray and the CAT scan machines. The effect of these technologies is however unknown in case of an MRI machine.

AGILITY HEALTHCARE SOLUTIONS - AgileTrac
As reported in the RFID Journal, in a five-year, $ 3.9 million deal, Agility Healthcare Solutions will design and implement an RFiD system at 3 Virginia hospitals operated by Bon Secours Richmond Health System. This system will track the mobile medical equipment around the hospitals. Agility will also be responsible for the operation and the management of this RFiD system. According to Agility, Bon Secours will get a return on its investment within the first full year of operations, by deploying its "AgileTrac" program.

Exact location of more that 10,000 tagged equipment will be tracked on a real-time basis using this RFiD system. The tags will operate at 303 MHz. By transmitting at 303 MHz, the readers will operate well outside the frequencies used by other medical or scientific telemetry systems found in hospitals. Using this frequency also

gives the readers a long-range read capability. Hundreds of readers deployed across the three hospitals, have built-in 802.11b capabilities to connect to a wireless LAN. This allows the readers to communicate with the central inventory management system also hosted by Agility. Using Wireless LAN also allows the hospitals to reconfigure frequently.

EXAVERA TECHNOLOGIES - eShepherd

According to the RFID Journal [5], Exavera Technologies has released its eShepherd system that combines RFiD and Wi-Fi technology to track people inside a hospital. Exavera claims that this system can bring enormous savings to hospitals and healthcare centers. According to rough estimates in the report, Exavera, based in Portsmouth NH, claims that an average-sized hospital with 250 beds can save nearly $4 million a year for an investment of just $400,000 that covers the equipment and installation. These savings come mainly by ensuring that patients get correct treatments and medications.

Some estimates show that as many as 98,000 people die in the U.S. each year because of medical errors. In cases where a patient does not die from an error, the mishap ends up costing the hospital an average of $4,700 per Adverse Drug Event (ADE). Many of those errors could be avoided by using the RFiD technology. Exavera believes its technology will deliver an integrated hardware and software platform that all hospital departments can use to intercommunicate.

The eShepherd system combines RFiD with Wi-Fi and VoIP to deliver a single system to track patients, staff and hospital assets. The unit can connect to the hospital's LAN through a central router, and it can handle telephone calls over the wireless network. The unit also includes an RFiD reader to read RFiD tags placed on patient bracelets, staff ID badges and hospital equipment. Exavera will offer RFiD tags operating at either 433 MHz or 915 MHz for the U.S. market and 868 MHz for the European market, as well as 2.4 GHz. According to Exavera the devices have read ranges of up to 45 feet with the passive tags worn by patients and up to 90 feet with the active tags that would be worn by staff.

Nurses and doctors wearing RFiD-tagged badges will also carry handheld devices that will allow access to a patient's record whenever they detect proximity to a patient. The eShepherd system will help ensure that patients get the correct treatment. In addition to reducing medical errors, the system will also improve various process efficiencies. By carrying handheld devices, doctors will be able to view any patient's complete record whenever they need to, instead of having to repeatedly walk to a central filing area to retrieve them. The system can also be used to locate equipment, staff and patients on a real time basis. Currently, the eShepherd system is being tested in two New England hospitals, one with 25 beds and the other with 99. The 25-bed trial, deployed in an 8,000 square-foot wing of the hospital, required just two VeraFi Wi-Fi router transceivers, according to the company.

Exavera's systems include middleware to link its systems to the proprietary existing electronic health records systems such as those sold by IDX, Meditech, Siemens

Medical and GE. Exavera says its eShepherd system will help hospitals meet security and privacy regulations set by the Health Insurance Portability and Accountability Act of 1996 (HIPAA) and requirements regarding positive patient identification established by the Joint Commission on Accreditation of Health Care Organizations (JCAHO).

UNIVERSITY OF MEMPHIS FEDEX CENTRE

Memphis-based systems integrator American Project Services (APS) has teamed up with the University of Memphis' FedEx Center for Supply Chain Management and the Shelby County Regional Medical Center's Trauma Emergency Department to deploy an RFiD network [10]. The ultimate aim of the project is to track the time taken by patients at each location in the trauma center. This data will be provided to the center, which will use it to further streamline its service and improve patients' experience.

The first phase of the project was to validate the RFiD technology and the results produced thereby. RFiD tags were attached to patients as they entered the facility. The technology worked faultlessly, with 100% accuracy. Also, by automating the collection of data, the APS trial showed that RFiD technology could track patients without altering the study's results. Using bar-codes or other manual data-entry systems distorts the data because they constantly remind the working staff that they are being monitored, and research has shown that people perform differently when they know they are being watched.

The trial used tags and readers from Alien Technology. Operating at 2.45 GHz, the 2-inch by ¾-inch by ½-inch tags includes a battery to enable a longer read range. The read range was up to 30 meters, compared with the 3 meters capable with passive tags. The tag comes with a 12-byte unique ID number that was used in the trial. 25 RFiD readers were deployed throughout the approximately 250,000-square-foot facility, which includes three X-ray rooms, two CAT scan rooms, two ICUs, an operating room and several general areas. Only the MRI room was not covered. During the trial, an RFiD tag was attached to an ankle of arriving patients as soon as they entered the center. Only each tag's unique ID was tracked, and no patient or injury data was recorded.

MAXELL - Test Tubes

As reported in the RFID Journal [11], Maxell Corp. is doing research on a way to put its RFiD "coil-on-chip" tags to the base of plastic test tubes. The company is also trying to develop an RFiD reader that will read and write to a tray-full of tagged tubes. Maxell believes that there will be a large market for its system for use in medical diagnostics and pharmaceutical trials.

Maxell's Coil-on-Chip tags, measuring 2.5mm square, operate at 13.56 MHz. The antennae are mounted directly onto the surface of the silicon chip. These tags are embedded to the bottom of a test-tube, which can be as small as 3mm in diameter. Depending on the model, Maxell tags can store 128 bytes to 4 kilobytes of data. The tags use a proprietary protocol developed by Maxell.

This frequency allows a very small read-write range. Maxell has therefore designed the system so that a tray of test tubes can be placed on top of the reader, keeping the distance between the reader and tags within acceptable limits. Maxell says it is still developing its RFiD test tube system, but it hopes to ship its first samples soon to customers that have already approached the company looking for RFiD test tube solutions.

BENEFITS ATTAINED THROUGH THE USE OF RFiD
- Continual real-time tracking of all people inside the hospital.
- Monitor and track unauthorized people wandering into restricted areas.
- Easy access to patient's medical records through his RFiD tag.
- Real-time tracking of expensive and critical instruments.
- Restrict the access of drugs to authorized staff.
- Accurate matching of test specimens to the patients, reduction in medical errors.

CONCLUSIONS
Over the years, RFID technology had proved its ability in many applications such as toll collection, access management and manufacturing. While its application in the hospital and healthcare environments is still very limited, results coming from the field indicate tremendous potential. However, one needs to remain cautious and not be caught up in the hype surrounding this technology; there still are a number of unanswered questions on issues such as privacy, security and cost (such as in the retail environment, where consumers tend to view it as yet another intrusion by 'Big Brother'). Thus, organizations should learn just as much about the physics behind it as they do about the economics, and about the companies promoting them. There is little doubt in the fact that the future of RFiD technology is very promising, especially in hospital environments, where preventing even one of the approximately 98,000 deaths would more than justify its investment.

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ABOUT THE CONSORTIUM

The *Consortium for the Accelerated Deployment of RFiD in Distribution* is dedicated to fostering the rapid adoption and implementation of RFiD technologies in Distribution, by providing a forum where practitioners and academicians can contribute to solutions and standards, thereby speeding up its acceptance and application.

We seek to become the enabling force for identifying relevance and deployment strategies for various applications of RFiD technologies through simplification, integration, proliferation and education, through a multi-university and multi-industry effort.

RESEARCH AREAS INCLUDE

"High-Level" Projects: Transportation; Inventory Management; Facility & Asset Management; Distribution; Security; Logistics Networks

"Mid-Level" Projects: Adapters; Alarms and Sensor Networks; Embedded Systems

"Low-Level" Projects: Source Code for Readers; Event Management Systems; Filtering & Hand-Off Algorithms

SPECIAL INTEREST GROUPS INCLUDE

Pharma SIG; Healthcare Industry SIG; Airlines SIG; Retail SIG; Food Industry SIG; Electronics SIG

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