Applying RFID to Patient Care: Challenges and Opportunities

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INTRODUCTION

The application of Radio Frequency Identification (RFID) to patient care in hospitals and healthcare facilities has become more widely accepted in recent years. RFID and other wireless technologies are the next evolutionary step in patient/object/asset identification and tracking. RFID can potentially deliver many benefits to the healthcare industry. The appropriate application of RFID technologies can reduce many manual operations performed in patient care. When RFID is applied to existing workflow models of patient care, the number of manual steps involved in checking and processing patients can be reduced. RFID can automate the admitting, screening and treating processes for patients, enhance communications between caregivers and support teams, and reduce medical errors (Wicks, Visich, and Li, 2006). In addition, to reduce the number of medical errors, some hospitals have started to use RFID chips on wristbands that can be embedded with data and scanned with a reader to identify patients and what surgical procedure is needed (Hancox, 2006).

However, despite the promised benefits, over 90% of the hospitals in the U.S. still have not adopted the technology (BearingPoint, 2006). As such, this paper examines the current information process used to process patients from admission to discharge, and then it considers where RFID can be applied in a hospital setting to improve patient care and hospital operations. Next the paper investigates the challenges associated with deploying RFID technology in a hospital environment. It is expected that the results of this study will be useful to hospital administrators contemplating RFID deployment in identifying challenges and opportunities.

OVERVIEW OF RFID

RFID is a communication mechanism utilizing radio energy to enable a remote device to communicate with the base station. RFID relies on storing and retrieving data using devices called RFID tags. A tag contains writable memory, which can store data for transfer to various RFID readers some distance away. An RFID system may consist of several components: tags, tag readers, edge servers, middleware, and application software. The purpose of an RFID system is to enable data to be transmitted by a tag which is read by an RFID reader and processed according to the needs of a particular application. The tag contains a transponder with a digital memory chip that has a unique electronic identifier. The interrogator (i.e., reader), which consists of an antenna packaged with a transceiver and decoder, emits a signal activating the tag so the interrogator can read from and/or write to it. Automatic tag reading allows vast amounts of data to be stored and transmitted at once, streamlines and speeds up operations while improving accuracy and productivity. Automatic tag reading also does not require direct contact or line of sight between RFID tags and readers.

Active RFID tags contain their own power source, usually an on-board battery. *Passive* tags obtain power from the signal of an external reader. *Semi-passive* tags are a variant of passive tags where a battery is included with the tag, but the tag must be excited by a reader in order to transmit data (RedPrairie, 2005). See Table 1.

Table 1. Comparison of different RFID systems (RedPrairie, 2005)

Characteristics	Active	Semi-Passive	Passive
Power Source	Battery	Inductive	Inductive
Memory	Up to 288 bytes	Variable	Up to 288 bytes
Read Range	<1500 ft.	<100 ft.	<15 to 30 ft.
Class	Read only Write once, read many Multi read/write	Write once, read many	Read only
Frequency	125KHz, 134KHz, 13.56MHz, 868-930MHz, 2.4GHz	915MHz, 2.4GHz	303MHz, 433MHz

RFID IN HOSPITALS

In the context of hospitals, hospitals offer a wide range of services and functions. This study proposes identifying where RFID can be applied from the perspective of the patient. Specifically, the different stages of the patient life cycle—from admission to discharge—are identified, and where RFID may be applied to improve operations is explored.

Patient Life Cycle: From Admission to Discharge

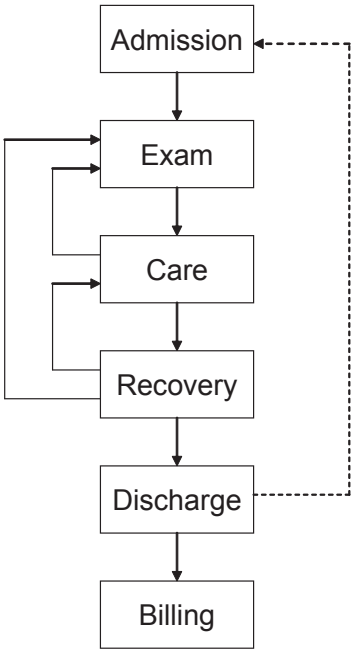
Many hospitals track their patients using manual systems. These systems are typically paper driven utilizing everything from whiteboards, cards, and charts to self-adhesive notes. One useful tool to examine where opportunities of improvement may lie is the patient life cycle. The cycle has six stages (see Figure 1):

Admission: Admission to a hospital usually involves paperwork being filled out by the patient and hospital staff. The information recorded includes: insurer/ability to pay, patient name/contact information, and reason for admittance. Once this information is obtained, the patient is assigned an identification (ID) number that is written on the chart and a wristband which is then attached to the patient.

Examination: After formal admission, the patient is delivered to the appropriate department for diagnostics and treatment. As the patient is treated by the medical staff, the wristband, orders, and charts are visually inspected to confirm procedures, medications, transportation, and later the ultimately discharge from the hospital. This process is performed to assure the correct patient is being treated.

When a patient is first treated, a visual inspection of the patient is performed. If a visual inspection does not provide the cause of the problem, additional tests are performed. Test results are reviewed to determine possible causes. If enough information is obtained, the treatment is started, otherwise, more tests are performed until enough information can be evaluated to provide care. At this point, the patient is either discharged or assigned to additional care.

Figure 1. Patient life cycle



Patient Care: When it is determined that a patient needs further care, he or she is assigned a bed and transported to his or her room by an orderly. On regular intervals the following procedures are carried out:

- Blood work is drawn and analyzed (by phlebotomist).
- Blood pressure, pulse, temperature, and O_2 saturation are recorded.
- IV fluid levels are recorded and replaced as needed.
- Other evaluations of the patient are recorded (e.g., pupils, motor skills, awareness, pain sensations).
- Other specimens are obtained and sent to labs.

As needed, the patient is removed from his or her room and transported to departments where procedures, treatments, tests and examinations are performed. To document the treatments, caregivers record actions taken and results on the patient's chart.

Recovery: As the patient improves, he or she is encouraged to walk around for exercise. The patient's movements are recorded of when they left and returned. Meals, medical supplies, and medications consumed by the patient are continuously recorded.

Discharge: Hopefully, the patient reaches a point where the physician determines that hospital care is complete. At this stage, the patient is issued post-hospital care instructions, and the patient is processed for discharge from hospital. When leaving the hospital, the patient is typically transported on a wheelchair to the curbside or transported back home using a non-emergency medical transport service.

Billing: Billing information is processed and statements sent to appropriate parties (e.g., insurer) for payment.

Benefits of Using RFID

Given that less than 10% of hospitals in the U.S. have adopted RFID (BearingPoint, 2006) and that hospitals still predominantly use paperwork, there should be many opportunities of using RFID to improve operational processes in hospitals. In many hospitals, records and charts are recorded in paper form with some information entered into computer terminals to be printed out and placed in the chart. Procedures, inventory control of assets and consumables, and billing information are all still recorded manually and later entered into a computer.

In an environment where RFID is integrated into the hospital information system, a patient can be tracked from the time they enter the hospital to the time they leave. This process starts when a patient is issued an RFID wristband (during *admission*). Once tagged, the patient can be monitored as they enter and exit rooms. As care is provided to the patient, handheld scanners and terminals with wireless capabilities may be used to input information about procedures performed and the condition of a patient. For example, an emergency room (ER) staff scans the patient as he or she is admitted and all materials used in the care of the patient (during *examination*). Medicines and materials would be associated with a patient and recorded automatically. The collected data enable other medical staff in the next shift to review what was administered to treat the patient. By automating these systems, harmful drug interactions can be identified automatically and notification sent to the physicians.

When properly integrated into an existing medical system as part of a systems solution, RFID can be used in conjunction with automation to check for errors and perform routine record keeping. When scanners are connected to the network using wireless networking and docked networking, a caregiver can update a patient's chart in real time to provide hospital staff with the most current information (during *care*). Vital signs, test results, and procedures can be viewed and checked instantly by medical staffs or by automated routines. If a patient were to be administered a drug, real time tracking could show what medication was dispensed and when it was delivered and taken by the patient. At any time during this physical process, software can check for errors and notify hospital staff if the wrong medicine was dispensed or administered to a patient (Wicks, Visich, and Li, 2006).

With all this information recorded centrally, it makes sense to utilize existing network technologies to allow closer monitoring of the patient by medical staff (during *care*). This would allow nurses to use workstations to record and look up patient information in real-time. Doctors and nurses could look up patient records using handheld devices, wireless notebook computers, or even cell phones. If a patient's condition worsens or improves, physicians can be notified automatically by event triggers written into the patient tracking software. No longer would the doctor need to see the patient or the printed chart to assist the patient. Doctors could quickly identify a patient, retrieve comprehensive medical records, review patient's recovery status, and check past medical logs which have been recorded by nurses via RFID terminals.

As the patient recovers, he or she is frequently encouraged to exercise and walk around the hospital (during *recovery*). As a patient moves about, his or her movements can be tracked by RFID readers scattered throughout the facility. Such information can be logged and can give the tending physician an idea of how much physical activity the patient has engaged in. In addition, when the patient becomes well enough to leave the hospital, the discharge process can be streamlined (during *discharge*) since most information related to his or her care has already been captured using RFID. Moreover, a record of the entire care process captured by RFID is also useful if the patient ever returns for additional care. If the patient returns, his or her medical history could be retrieved to view past diagnosis and treatment. If RFID were extended to a hospital-issued card (e.g., a tagged hospital card or subcutaneous implant) to be kept with the patient, such a card can expedite the subsequent admission process.

While the patient was being cared for at the hospital, equipment and consumables can be tracked and recorded as they are issued or used on a patient. Such tracking is necessary for inventory and billing needs (for *billing*). With fully recorded information, the hospital can automate billing generation for patients and insurance companies. The medical care industry is cost driven where cost recovery determines the profitability of a hospital. By more closely tracking the consumables using RFID, hospitals will be able to avoid excess inventory, reduce out-of-stock periods, and improve the efficiency of medical service supply chain. With a more complete care history, it will also be easier to identify billing fraud.

CHALLENGES OF ADOPTING RFID IN HOSPITALS

RF Interference with RFID Tags

As with any wireless technology, there is the possibility of interference from external sources. Solutions include (1) suppressing interference sources and (2) requiring closer proximity between the RFID tag and the scanner. In any case, there may be situations where it is not practical to scan RFID tags because of the environment. An example of this would be the MRI scanner in the radiology department. The electromagnetic (EM) fields present in the bore of the magnet are significant and would block most RF communications. There is also the issue

that one would not want ferrous materials near such a device for safety concerns. This problem can be solved by scanning the patient as they enter the room before being placed on the scanner table.

Partial Implementation

Given that RFID cannot be ubiquitously deployed in a hospital overnight, many hospitals are considering partial implementations of RFID. A partial implementation first requires a careful analysis of the workflow of a hospital to determine what activities are compartmentalized. The best areas to implement RFID would be where activities are compartmentalized from the rest of the hospital. For example, if a patient is given a wristband that is dual use or tri-use (i.e., containing bar code, RFID tag, and printed text), then the wristband would allow other departments to perform their work regardless of whether or not those departments have RFID scanners.

RFID Security and Privacy

RFID is secure in that tags are extremely difficult to counterfeit and impossible to read without a reader. In fact, some consider the tags physically tamper-proof (Finkenzeller, 2003). However, a common security concern lies with the radio transmission of the tag when it is interrogated by a reader. Since tags emit omnidirectionally, those with specialized high-gain antennas can intercept tags' radio transmissions over a long distance. An example is where an individual sits in the parking lot and uses a high-gain antenna to listen for radio transmissions of RFID tags in a building (Anteniese, Camenisch, and de Bedeiros, 2005).

One solution is to reduce the transmit power of the tag so that transmission distance is only a few inches. But if an operator is required to be so close to the tag to read it, then the process becomes no different from that of bar coding, and the advantages offered by RFID are negated. The long-term solution is to encrypt the data on the tags. It is possible to read/write tags to store encrypted data on the tags, thus making the data intercepted by third parties difficult to use. This solution still makes it possible for a third party to read what is stored on the tag, but it does require the third party to have additional knowledge to make use of the information.

In addition, there is also the issue of the tag remaining active after it is no longer needed by the hospital. If a patient were to walk out of the hospital with his or her wristband on, the tag in the wristband would continue to transmit data when interrogated by a reader. The solution to this would be to deactivate the tag once it is no longer needed (Juels, Rivest, and Szydlo, 2003).

Operational Issues

The development of RFID as a viable alternative to bar codes is a challenge. Range and accuracy are two technical challenges that RFID must overcome to achieve expected benefits. The effective read/write range of passive RFID readers is quite short, and readers must be within a few feet of the object to accurately read the tag or write to it. Active tags allow for longer ranges. The proximity of reads can be an issue if there are multiple objects too close together making it difficult to read tags. The materials on which the tag is affixed may also affect readability. However, as RFID technology improves, the issues of range and accuracy will be solved. For example, the new-generation Gen2 tags provide greater performance, even when used on containers with liquid and metals, and result in more simultaneous reads (Symbol Technologies, 2006).

CONCLUSION

When implemented properly, RFID can significantly aid the medical staff in performing their duties. This paper first presents an overview of RFID technology, then it examines the patient life cycle from admission to discharge. Based on the patient life cycle, it considers where RFID can be applied in a hospital setting to improve patient care and hospital operations. It is found that RFID offers the ability to reduce manual entry of records, increase security for the patient and hospital, reduce errors in administering medication, assist staff by reducing manual labors involved in tracking materials, and serve as a component of an automatic audit system. In addition, RFID enables a fully automated solution for information delivery at the patient bedside, thus reducing the potential for human error. Finally, the challenges associated with deploying RFID technology in a hospital environment are also presented.

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