Patient Tracking System Using RFID

By Joseph Chao

University of California, Los Angeles

December 7, 2007

ABSTRACT

A patient tracking system (PTS) is a potential method for tracking the location of patients throughout a hospital. One such system is described that implements RFID technology. This system will allow for increased efficiency within the hospital workflow, improved space allocation, and faster treatment for emergency patients. The PTS described employs active RFID tags, readers, and field generators, as well as positioning software, in order to determine the approximate location of any patient in a hospital. If the tags were to be embedded with vital signs sensors, the PTS can also allow for real time tracking of patients' vital information.

TABLE OF CONTENTS

Slowly but steadily, hospitals around the world are beginning to integrate radio-frequency identification (RFID) in order to enhance operational effectiveness. RFID provides an efficient means of accurately identifying patients, locating misplaced medical equipment, logging and checking medication, as well as many other processes [3]. Because many of these processes are currently being executed by personnel via barcode technology or human-readable labels, errors occur far too frequently, given the potential consequences. The accuracy and efficiency of RFID technology not only prevents such errors but increases the speed at which these tasks can be completed.

RFID, however, bears far greater implications in the hospital environment than simply making menial tasks easier. Of all the potential applications of RFID in hospitals, the technology available is best suited for tracking purposes [3]. An integrated tracking system embedded in a hospital's infrastructure can allow real-time position tracking of personnel and real-time position and vital tracking of patients. With an appropriate middleware backbone, a tracking system such as this would not only provide drastic increases in the efficiency of the hospital, but allow for the tracking of infection should an outbreak (e.g., the SARS epidemic) occur [5].

A potential patient tracking system (PTS) is outlined in this paper, with discussions regarding the technology necessary for the system and the implications that it would bring to healthcare in general.

In the next section of this paper, a case study performed on a Taiwanese hospital during the SARS epidemic will be examined. Afterwards, an overview will be given of the technology involved for the patient tracking system, followed by a discussion of the system as a whole. The paper ends with conclusions and a list of references.

SARS CASE STUDY

In 2003, an outbreak of severe acute respiratory syndrome (SARS) reached near pandemic levels. Centralized around Southeast Asia, where the population-to-hospital ratio is very high, emergency rooms were flooded with potential SARS cases. In Taiwan, the government subsidized research in applications of RFID in hospitals in an effort to control and monitor the spread of the SARS virus [4].

The hospital involved in this research was the Taipei Medical University Hospital (TMUH). What was developed was an RFID-based patient tracking system utilizing a system of tags, readers, and field generators to track not only the location of patients, but monitor their temperature as well. This was accomplished with the development of thermometer embedded active tags, specifically designed for this study [4].

With the integration of this system into TMUH, potential SARS cases could be determined by the temperature of the patient, who, when passing through the field of a reader or generator, would have his or her location pinpointed by a software system, and appropriate care would be given. This allowed for ease in determining which patients were actually potential SARS cases and ensured that they received attention promptly. Because of overcrowding, the ability to give priority to those patients with elevated temperatures proved to be invaluable.

There are three basic ways that RFID tags and readers can interact in the hospital environment. Fixed readers can interrogate mobile tags, mobile readers can interrogate fixed tags, and mobile readers can interrogate mobile tags. The case of fixed readers interrogating fixed tags in neglected due to its limited utility [2].

One technology that has been developed already is the mobile PDA reader, which is given to hospital personnel. With this, doctors and nurses are able to scan both mobile and fixed tags. A nurse could use the mobile reader to log medication inventory, while doctors use theirs to scan patient information.

The scheme used primarily in the PTS is that of fixed readers interrogating mobile tags. The basic skeleton for the PTS is a system where patients and personnel, who each possess their individual RFID tag, have their location and vital information tracked by readers and field generators placed strategically around the hospital. As mentioned before, the backbone of this skeleton is a software system that sorts through the data obtained by the readers and provides the information to appropriate staff.

Operating Frequency

The choice of operating frequency in hospitals is always a delicate one, since interference with medical equipment can be a problem. Washington Hospital Center, one of the first hospitals to implement RFID, adopted an ultra-wideband (UWB) frequency in order to circumvent the interference issue [1].

UWB sends low power signals through a spectrum of frequencies, rather than one strong signal at a fixed frequency. Because the signal at each frequency is weak, it does not interfere with medical equipment. Typically, UWB operates from 3.1 to 10.6 GHz [7].

One requirement of UWB is that the tags need to be either active or semi-active. This does not affect the PTS, however, since the tags used will have to be active regardless.

Tags

In hospitals who are using RFID today, patients are given their own RFID embedded ID bracelet upon checking in. This bracelet stores a unique patient ID number as well as other relevant information, such as medical histories. Implementing a PTS requires some further development of this existing system.

As mentioned, the tags used in the PTS will have to be active tags, not only because of the UWB operating frequency but because of the inherent benefits of active tags. A significant amount of information needs to be stored on each tag, and longer read-ranges will be necessary.

In the case of TMUH, special thermometer-embedded tags were developed. Tags with embedded sensors are also being developed for use in the food industry. As this type of technology grows, the patient ID bracelets can be embedded with not only thermometers, but other sensing equipment such as heart monitors. The information obtained from these sensors can also be written to the RFID tag and passed through to the reader, allowing for real time tracking of not only location, but vitals of all patients within the hospital.

A simpler approach for the time being, however, is to write not only ID information to the tag, but to indicate patient condition as well. This information can be written to the tag before the patient arrives at the hospital (i.e., in the ambulance). For example, a burn victim's RIFD bracelet will not only hold information storing his ID, but that he is a burn victim. Thus, the monitoring system will know that a burn victim has arrived at the hospital and will be able to track the patient's transportation throughout the hospital, while notifying the appropriate personnel for treatment. In order to incorporate this feature, the patient ID tags need to have read/write capability. The reusability of this type of tag also cuts costs for the hospital.

As implied above, personnel will be required to have RFID tags with them as well. These are already being used in the form of “smart” cards or badges. A unique personnel ID number can be written to these tags.

Readers

RFID readers will be positioned at major doorways and rooms within the hospital. These include the main entrance/exit, key operating rooms and theaters, important doorways, and any other key areas. The main purpose of these readers is to receive information from the tags that it interrogates.

An important feature that the readers must have is anti-collision capability, since potentially several tags will be communicating with the reader simultaneously. Each tag’s data must maintain its individual integrity.

Enough readers are needed to allow for positioning algorithms to determine the location of the tag being read. Having too many readers is not only unnecessary, but costly.

Field Generators

Because RFID readers are expensive, employing field generators is a good way to cut overall costs to the hospital. A field generator is a tag wakeup device that generates a 433 MHz wakeup frequency to active tags. Once a tag is woken up, it transmits its data, as well as the field generator ID number, to readers within range [7].

By using field generators implemented in strategic places around the hospital, a fewer number of readers is required. These generators would have to be allocated such that the entire hospital would be covered by the generators’ range.

Again, multi-tag read capability is required for the field generators. There are two options for the operation of field generators. They can either be set on a timer, which will activate the generator on set intervals. Each time the generator is activated it wakes up the tags within its range. Alternatively, the generators can be motion sensor activated.

Software

An important component to the PTS is the tracking software involved. This system takes the data obtained by the readers and uses positioning algorithms, similar to those used by cell phones, to determine the location of individual tags based on signal strength between different readers and the field generator ID.

In order to handle an overwhelming influx of data, certain rules can be set to limit the data being read. For example, a rule can be applied that only allows the information of patients with more critical conditions to be tracked.

With the location and condition of patients within the hospital, the software can then determine which personnel members to notify about specific patients. A virtual display of patient locations on a grid or digital map of the hospital can be monitored by staff members as well.

The way the PTS works is as follows:

Each patient is given a bracelet embedded with an active RFID tag, either upon checking in to the hospital or in transit via emergency transport. The data that would be written to the tag include the patient's identification, a note about the patient's condition, and other relevant information, such as an electronic medical history. Placed throughout the hospital are an array of RFID readers and field generators. As a patient moves or is moved about the hospital, a field generators will "wake up" the patient's tag. When the tag is woken up, it transmits all the data it contains, as well as the field generator ID, to readers within range (typically around 85 meters). An integrated software system that sorts data obtained from the readers determines the location of the tag (and thusly, the patient) via positioning algorithms based on the signal strength of the tag on adjacent readers, as well as the field generator ID. The location of the patient can be displayed virtually on a grid or digital map of the hospital, which staff members can monitor.

If the RFID tag were to be embedded with sensors such as thermometers or heart monitors, the patients' vital information can also be obtained via the PTS. The is the ultimate goal of the PTS is to be able to monitor not only location of patients but vitals as well, in order to most efficiently allocate personnel to those patients with critical conditions.

However, knowing simply the position of patients has its own benefits. Space in hospitals is always limited, so having a general idea of where patients are at all times will allow for more efficient allocation of rooms and beds. Tracking of emergency room patients will allow for faster treatment, since doctors will know ahead of time where the patient has been and what treatments have already been performed. A particular scenario where the PTS would be invaluable is during an outbreak. All patients infected could be tracked and contained with little confusion.

CONCLUSIONS

The PTS is an important potential application of RFID in hospitals. Efficiency is always an important issue in the hospital environment, and the PTS allows for the streamlining of the hospital workflow. The basis for the PTS, the tracking system developed in [4] and [5], has proven to be effective in dealing with high volumes of patients during an epidemic. And because the tags are rewriteable, the cost of maintaining the PTS is low. The direction that RFID technology is going makes the PTS a viable addition to hospitals around the world.

REFERENCES

[1] A. Scheck, “The Health Care Universe, All in an RFID Chip,” *EMN*, 2007

[2] A. Cangialosi, J. Monaly, “Leveraging RFID in Hospitals: Patient Life Cycle and Mobility Perspectives,” *IEEE Applications and Practice*, 2007

[3] P. Fuhrer, D. Guinard, “Building a Smart Hospital Using RFID Technologies,” *1st European Conference on eHealth*, 2006

[4] S. W. Wang, W. H. Chen, C. S. Ong, L. Liu, Y. W. Chuang, “RFID Applications in Hospitals: A case study on a demonstration RFID project in a Taiwan Hospital,” *IEEE*, 2006

[5] C. J. Li, L. Liu, S. Z. Chen, C. C. Wu, C. H. Huang, X. M. Chen, “Mobile Healthcare Service System Using RFID,” *IEEE*, 2004

[6] ActiveWave Standard Field Generator Datasheet, *ActiveWave Incorporated*, 2004

[7] S. A. Weis, “RFID (Radio Frequency Identification): Principles and Applications,” Available at http://www.eecs.harvard.edu/cs199r/readings/rfid-article.pdf