RFID in Hospitals

MAE 295C

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Introduction

In a hospital emergency room, immediate treatment is the most important factor to saving lives. Unfortunately, emergency rooms around the country are dealing with overcrowding. This is due to many factors, mostly lack of personnel and equipment and an overcrowding problem in hospitals in general. Any delay in treatment can lead to a worsening condition, or even death, yet the average ER wait time is still around four hours. By increasing the efficiency of a hospital by just a small amount, hundreds of lives, along with thousands of dollars, could easily be saved. This paper proposes a system implementing RFID into hospitals for patient tracking and information for just this purpose.

Proposal

RFID is an emerging field that can provide huge benefits to the medical field. A well designed RFID system can lead to reduced labor costs and reducing the amount of time spent on paperwork, without too much of an initial cost. This paper proposes a system that will allow for patients to be tracked while on hospital grounds, and have their medical information present on them at all times. This will be accomplished using various RFID technologies, with an effort to keep costs at a minimum to ensure that almost all hospitals will be able to integrate this technology, regardless of size.

Current Alternatives

Currently, no hospitals use RFID to the extent proposed in this paper. While some hospitals do employ some sort of RFID, its main purpose is to track equipment, and occasionally hospital staff. Other alternatives to storing the required medical information are also available, but none provide any of the functionality or ease of use as RFID.

Birmington Heartlands Hospital (UK)

One hospital that has utilized RFID is the Birmington Heartlands Hospital in the UK. When patients enter the hospital, a digital photograph of the patient is taken. This, along with the required care the patient will receive is then stored on the wrist tag. Hospital staff members are then able to obtain the patient's information by scanning RFID reader equipped PDA's. They can also access the patient's medical records via the hospital's wifi. Operating wards were also equipped with readers, bringing up patient and operation details on a screen in the ward. These improvements both increased efficiency and ensured that all patients were treated correctly, minimizing the risk of surgery being performed on the wrong patient. Installing the necessary equipment at this hospital cost an estimated $158,000, while saving approximately $547,000 a year from increased minor operations. The benefits of RFID are clear, recouping initial costs in one-third of a year.

Even with all of these advantages, several drawbacks do exist. The wireless tags are not updateable, and therefore must be updated with each visit. While the tags are so cheap that cost is not a prohibiting factor, this increases the amount of time spent during check-in. Also, with this system, check-in is not automated. Patients are unable to be located using this system, so lost time searching for patients cannot be avoided. Finally, if the hospital's WiFi access was down for any reason, patient details would not be able to be accessed by this method. If an emergency hit, this could prove to be disastrous.

Scroll ID®

The Scroll ID® is a laminated piece of paper containing all important medical information encased by a metal tube. Medical history and allergies are stored, along with identification including insurance carrier and current personal doctor. All of these details are essential to immediate treatment of any injury, and the ability to obtain this information quickly is a huge advantage of this product. Another advantage is the relatively cheap cost ($25).

The main drawback to this method of storing information is keeping the tube on your body at all times. It would be very easy to misplace the Scroll ID® or simply leave it at home. Another drawback is

the lack of updates. While customers are provided with four free updates, they aren't instantaneous, and may lead to complications if sudden changes occur, but the medical history isn't updated. Also, many people wouldn't take the time to resubmit all of their medical information every time something changed. This is a consumer based solution, so people must actively go out and purchase one to receive the benefits of the Scroll ID®. Many people are not willing to spend money on something they aren't sure they'll ever need, and some are just unaware. A hospital based solution is preferred, on the other hand, as hospitals foot much of the initial costs, and are able to reach a larger amount of people.

While both of these approaches do have their merits, the best solution would be something incorporating the two. The Scroll ID® provides all the information needed when an accident occurs, while the approach adopted in the Birmington Heartlands Hospital is great once a patient has been admitted. By combining the two, a solution encompassing the entire process can be created, saving both time and money in the process.

Detailed Plan

The proposed plan is to combine two different forms of RFID tags into a credit card form that will easily fit into a wallet. The first tag used will be the Aeroscout® T2 Tags, combo WiFi/RFID cards that will allow the tags to quickly be located. The second tag will be the HP® Memory Spot tag, a very close range tag that has large amounts of storage, currently up to 512 KB. This tag provides the data storage necessary for storing essential medical information. The three main sources of information stored would be identification, important medical history, and any other relevant information. Identification consists of a picture, height, weight, name, DOB, emergency contact, insurance carrier, current doctor, etc. The medical history would detail any previous major operations, current and previous medications, and any allergies. Finally the other relevant information would include all other crucial information, like glasses, diabetes, pacemakers, immunizations, etc. The tag would also store any hospital data, such as any pending tests or surgeries, test results, medication prescriptions, and things of the sort.

The hardware requirements aren't very steep, only requiring a reader for the Memory Spot tag. Most hospitals already utilize some sort of wireless network throughout the building, and the T2 tags are able to communicate over this network right out of the box. Range enhancers can be purchased as well, if an extended range is required. These can be placed in parking garages or nearby restaurants to extend the tracking ability from the T2 tags, and are much cheaper than any typical RFID reader. Hospitals will require Memory Spot read/write devices, so they can update the patient's medical information quickly at the time of change. The information can easily be synced at check-in, check-out, or any time in between. Portable readers are also being developed, so they can be carried around by paramedics and these tags may be read at the scene of the accident. One piece of optional equipment is the Aeroscout® Exciter, a device which creates a choke point that allows the tag to be turned on or off. By placing these devices on the doors, the tag can conserve energy and broadcast only when on hospital premises.

These cards will most likely be distributed by medical insurance carriers, and distributed to their clients at either a small premium or at their own cost. If the insurance carriers do decide to do this at their own cost, hospitals will likely be willing to subsidize this due to the large amount of money saved on their part. With these cards, patients will be able to check-in to a hospital almost immediately, bypassing any paperwork needed. The identification data can instantly be read to a computer, and the all the appropriate forms can be filled out electronically. Once a doctor becomes available, he/she may pull up medical information instantly, which will speed up the diagnostic process. As soon as a diagnosis is made, the doctor can then update the card to include any required tests, surgeries, or prescriptions. Prescriptions could be filled out almost instantly, and the chance of performing incorrect tests or surgeries on a patient is close to zero. Check-out would also work in much the same way, with all relevant information being read from the card and filling out all the forms electronically. This system alone would save untold hours and allow the hospital to both treat and discharge patients much more quickly.

The T2 tags contain 100 bytes of storage, plenty to hold critical identification information such as name, height, weight, sex, ID#, etc. The T2 tags also have a locator built into them. These tags interact with a central server connected to the hospital's wireless network and locations are determined using a Relative Signal Strength Indication (RSSI) algorithm. By including a locating device on these cards, patients can be easily located, regardless of where they are in the hospital. This way, patients will be allowed to wander yet still be monitored. The range can also be extended to include parking lots or nearby restaurants, so patients are allowed even more freedom. If this is implemented, a simple programming rule can be created to contact the patient if he/she steps outside of the locators range. Also, with the tags being relatively inexpensive, they can be easily adapted to use with both staff members and expensive equipment at little to no extra development cost to the hospital.

By sending paramedics into the field with handheld Memory Spot readers, even more lives may be saved. When paramedics arrive at a scene of an accident, they cannot administer some treatment until the patient's medical history is known. By carrying these readers onto the scene, they can quickly pull up a patient's history without no matter where the patient is. Since the information is stored on the card and not on a network, the paramedics can obtain the information even if they are unable to contact medical control due to whatever reason. By knowing the patient's allergies and current medications, they can then administer the best treatment while transporting the patient to the hospital to undergo more extensive treatment.

This proposal would ensure that the patient would receive the best care possible through all stages of an accident, while ensuring they receive the best care no matter the situation. Also, the time saved by hospitals will be enormous, allowing them to see more patients, and thus make more of a profit. It will also introduce more traceability in hospitals as patients, staff, and equipment can all be monitored with relative ease.

Technology

Aeroscout® T2 Tags

The T2 tags are special combination WiFi/RFID cards specifically designed for locating purposes. These tags are able to operate wherever a WiFi network is available, making them extremely easy to integrate into any application. They also have a very good battery life, lasting around three years on a single ½ AA battery broadcasting once every 30 seconds. It also works with choke points, so choke points can be placed at the entrances and exits of hospitals to turn the tags on and off. This would help to conserve battery life greatly, keeping the tags broadcasting only when necessary, and could increase the battery life of the tags to decades, depending on how often a person spends in a hospital. Unfortunately, the biggest drawback to this tag is its unwieldy shape and size. The T2 tags weigh in at 2.44" x 1.57" x 0.67". While the 2D profile is much smaller than a regular credit card, the thickness is too large to fit inside any wallet. The components can be spread out to utilize the entire space allowed, but the thickness would still be much too large. There is hope, however, as the tag comes with a variety of features that prove useless for this application. These include call button messaging, an onboard motion sensor, and telemetry functionality. The battery can also be replaced with a slimmer battery, while improving battery life. ½ AA batteries typically run at 3 V with a storage capacity of 850 mAh, while a much slimmer lithium coin battery, such as the Sony CR2477 battery, can operate at 3 V with 1000 mAh. Miniaturization can also continue to occur as technology progresses, and the individual components on the tag will undoubtedly become smaller. By removing any extraneous features, replacing the battery, rearranging the tag to better use the available space, and through miniaturization, the tag will hopefully be able to change into a much more convenient shape.

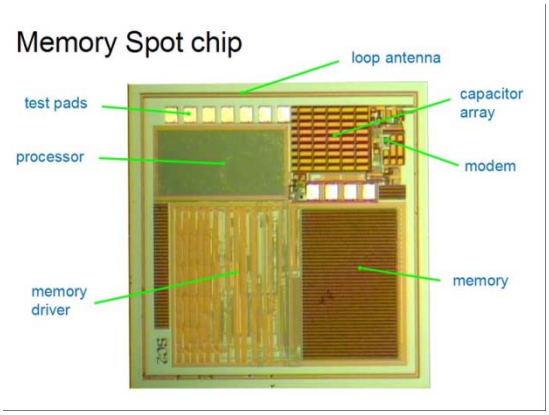
RSSI Algorithm

The T2 tags use a Relative Signal Strength Indication (RSSI) algorithm to determine their location relative to the access point. The process begins with a wireless map of the floor plan being created. This is the most labor intensive part of the entire proposal, and involves taking multiple measurements to determine the wireless coverage of the area. While the actual method can get more complicated, involving ray-tracing and object reflectivities and absorptivities, the actual way the floor map is obtained is not important to this proposal. Here, a sample of a wireless map is shown, with the access point being the white dot in the middle. Darker areas on the map indicate stronger wireless coverage. Once a wireless map is obtained, then the tags can be located using Monte Carlo sampling techniques. The

most effective method for this application will most likely be a simple sequential Monte Carlo filter with boundary information. Through a very complicated series of mathematical equations, this predicts the location of the tag using previous RSSI readings while taking possible boundaries, such as walls, into consideration. While the accuracy isn't too great, these tags serve their purpose well, giving a rough estimate of where an object is located. Great precision isn't necessary, as long as patients can be found quickly when needed. Also, when creating a wireless map, any problems with lack of coverage can easily be solved by installing additional access points. Adding any additional access points or installing new furniture can lead to new wireless maps, however, so care must be taken when this is considered.

HP® Memory Spot

The HP memory spot is very similar to existing RFID technology in that it's a passive unit powered by an electric field generated by some reader. The main difference is that the memory spot contains an onboard processor, essentially making it a tiny computer. It can hold 512 KB, more storage than any RFID tag currently on the market. This increased amount of storage also allows the Memory Spot to use encryption for security issues, although its limited range and lack of damaging information defeat the purpose. The chips are 4 mm x 4 mm with a 1 mm read range, so tiny that they can be attached onto the T2 tags without any negative impact. Also, since the read ranges on each tag are so different, they should not interfere with each other while broadcasting. The data transfer rates of the Memory Spot are amazing, clocking in at 10 Mbps, blowing any current RFID tag out of the water. The 512 KB storage limit is also not a problem, as one HP® engineer said, "We can easily see how to get to several times the current capacity on a small chip." The only drawback to this chip is the fact that it is still in development, and may not be available for commercial use for another 2-3 years.



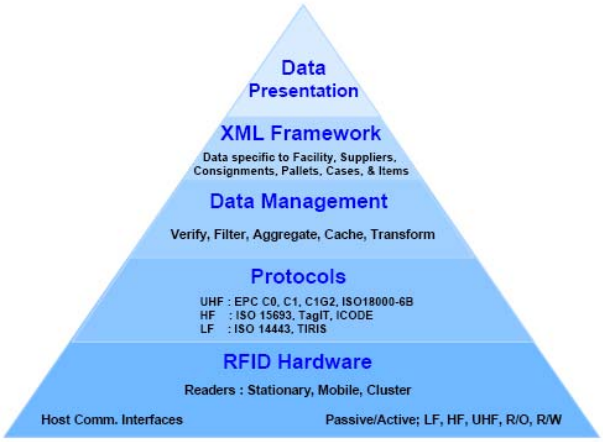
Standards

The standards used in this proposal were not very important. The T2 tag used the common WiFi standard 802.11 b/g, along with an RFID component that transmitted at 125 kHz. The ISO standard was not specified, but is most likely ISO/IEC 18000-2:2004 due to its frequency. Since no RFID readers are going to be used, the exact standard being used is irrelevant.

The Memory Spot is still in development, and as such, no standard has yet been approved. The chip operates at 2.45 GHz, but will require an entirely new standard as this is a completely new technology. The exact same situation applies with the reader for the Memory Spot.

Middleware

There will need to be two middleware's for this proposal, one to interface with the T2 tags and one to interface with the Memory Spot tags. To accomplish both of these tasks, WinRFID will be used. A simple diagram of how WinRFID works is detailed to the right.



WinRFID - multi-layered architecture

The T2 tags are the more complicated case. The middleware must be able to access the routers used in the hospital for read only access. Since the information on the tags never changes, read/write functionality is unnecessary. WinRFID will need to use both the 802.11 b/g protocols to communicate with the T2 tags and obtain their RSSI measurements. Once the data is obtained, it is then stored in a database and position is determined using the RSSI algorithms as discussed before. Finally, the data will need to be presented preferably in both a graphical form utilizing the hospital floor plan and a searchable database form if locating a specific patient is required. The middleware must also have various processing rules in order to deal with any "collisions" from tags transmitting at the same time, to deal with any user defined alerts that may exist, etc.

For the Memory Spot tags, the middleware is much less complicated. It must be able to connect with the Memory Spot read/write machine, using whichever protocol is eventually adopted for the Memory Spot. The middleware will then either read off the data from the tag or rewrite data on the tag, either syncing the tag with a hospital database or manually inputting any changes. Since most of the data read off the tags will mainly be used for filling out registration forms, data presentation is unimportant.

Cost Analysis

Initial cost for 1000 tags –

Item	Cost Per
HP® Memory Spot tag and reader	$20,000
Aeroscout® T2 tags	$60,000
WiFi Access points	$2,000
Wireless mapping labor	$100,000
Total Cost	$182,000
Savings (1 year)	$547,000
Cost-benefit	+$365,000

Since the Memory Spot is still in development, the costs there are completely random guesses. However, looking at the possible savings it's clear that regardless of how much the tags and reader end up costing, the hospital will still receive a huge cost-benefit by implementing this system. The savings value was obtained from the amount of savings by Birmington Heartlands Hospital from their RFID approach. It's possible that this system may save even more money per year.

Conclusions

An RFID based system integrated into the workings of a hospital was proposed. The system uses a combination of Aeroscout® T2 tags and HP® Memory Spot tags to allow all of a patient's information to be stored and accessed at any time, given the correct reader device. Tracking can also be done on hospital premises, giving patients more freedom and reducing the amount of time looking for patients, hospital staff, or equipment. Additionally, if hospitals plan on adopting this plan, the integration should be simple and painless, since much of the proposal relies on existing WiFi architecture already existing in almost every hospital today. The only labor intensive step in the entire procedure is mapping the wireless coverage. This can easily be accomplished in a couple days to a week, using a team of engineers to take the precise measurements needed..

This paper showed the benefits of implementing RFID into hospitals today, and the ease of which this could be accomplished. The technologies needed to realize this proposal are either currently on the market or 1-2 years away, making complete RFID integration a very real possibility. With such a huge cost benefit of at least +$365,000, hospitals must at least consider integrating RFID. The bottom line is that RFID can save hospitals both time and money, saving lives in the process.

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