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# Application of RFID in an Integrated Healthcare Environment

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*Abstract*- Radio Frequency Identification (RFID) is an evolving technology that can utilize its capabilities within a healthcare environment to locate and track staff, equipment, and patients. RFID has the potential to significantly improve operations by actively monitoring asset flow through an organization and enabling this data to be analyzed for process improvement. It can also help to provide validation to existing process improvement initiatives set forth by an institution. Furthermore, RFID can be integrated into other operations including patient safety, clinical operations, billing, and theft prevention.[1]

## I. Introduction

RFID describes a system that uses wireless technology to accurately provide location information. Typically the location device is placed on an asset, on either a permanent or temporary basis, whose location needs to be identified and tracked. As the technology becomes more pervasive equipment manufacturers are now integrating RFID locators directly into their products.

As RFID has matured we are presented with the opportunity to integrate location services into a health care system. This integration holds the promise of improved efficiency, increases in patient safety and more efficient utilization of limited resources.

Typical uses in industry include asset location and tracking, inventory control, process analysis and management, and theft prevention.

## II. Technology

### a. Active vs Passive Tags

There are 2 main types of RFID tags that are currently deployed – active and passive. Passive tags need to be "illuminated" by the RFID infrastructure and their location is then calculated. Their advantages include the tags small size, absence of power requirements and their flexibility in being able to be molded into many different form factors. Their limitations are that they require a costly, dedicated infrastructure and have limitations on their resolution of location.

Active tags are powered units that emit a signal for the RFID infrastructure to pick up and calculate location information. Many active tags have memory locations for storing data and also can have communications ports for two-way transmission of data. Active tags also have greater potential for more accurate location with the downside of them being larger in size, are more costly, and they use battery power. Active tags may have the added advantage in that some systems can utilize an existing wireless infrastructure to implement a location solution.

### b. Levels of Granularity

The nature of the application defines the level of granularity and precision required in identifying the position of a tag. Some applications simply require that relatively static pieces of equipment are accounted for and need only be identified as being present in the system. Others are more dynamic in nature and require significantly more precise location information on a near real time basis. These factors affect the nature of the solution and the frequency at which location information is updated.

There are several methodologies used to locate active tags, each with distinct resolutions associated with them. The simplest method, and the least precise, uses the presence of a tag in the vicinity of a wireless Access Point (AP) to identify the tags as located in a particular location. As AP's have known mounting locations throughout an institution this method can provide tag location on a unit wide level. The actual resolution depends on the density of AP's in the system. The second method uses triangulation to more accurately identify location of the tag. This method requires several AP's and can increase resolution to around 30 feet. Again the density and layout of the AP's can affect the resolution that can be expected from the system. The third and most precise location method is to use specialized local transmitters that send signals that the tags can pick up. The umbrella of coverage that this type of system provides is programmable and can give resolutions down to a few feet. When a tag enters the transmitter's umbrella it sends a signal over the wireless network to the location server telling it that it has entered a specific location. This precision comes at a cost, as these transmitters need to be installed at special locations identified by the nature of the location application.

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c. Network Traffic

In addition to the technique involved in calculating tag position, the rate at which the tag identifies itself to the system can become an issue. The more often a tag "chirps" and sends it's location information to the server via the wireless network, the more network traffic an RFID system can generate. While the information transmission from an individual tag is limited in nature we need to keep in mind the effects of several thousand tags potentially utilizing the network. When looking at applications with a large number of tags, each sending out a short stream of information at regular intervals, the traffic must be analyzed and the wireless network engineered so as not to affect any other wireless applications that share it. In addition to the traffic generated there are power concerns related to the transmission frequency that need to be addressed. The more often a tag transmits, the shorter the battery life. A comprehensive battery management plan must be enacted to maintain the functionality of the RFID system.

d. Leveraging of Existing infrastructure

A major concern in the deployment of RFID systems is the cost of the infrastructure required. Many technologies require a dedicated network of receivers to provide location services. Dedicated units typically increase the costs of purchasing equipment, of the installation, and of the cabling required to connect to power and the network infrastructure. In locations without an existing wireless network these increases may be minimal. For facilities with an existing investment in wireless, a more cost effective solution is to utilize a technology that leverages this infrastructure as the medium to transmit tag information to a dedicated location server.

e. Comparison to other location technologies

There are currently other competing technologies that are utilized for location information. IR location is an active tag technology that uses an infrared signal from a tag to transmit location to a dedicated infrastructure of optical receivers. The optical nature of these tags limits them to line of sight applications. Simply blocking to the IR transmitter on the tag can result in loss of the positioning signal.

## III. Traditional Methods

As previously mentioned, the nature of the application dictates the resolution required to provide a useful solution. Also, the mobility of the equipment can make some solutions and setups more desirable than others.

a. Location/Tracking of Inventory

Inventory management is the most obvious use of RFID technology and has been used extensively in industry. In healthcare it can be an effective method to track equipment on both a unit level as well as for system wide inventory status and management. There are several levels of inventory management that can be addressed using RFID, the most basic being simple identification of an asset in the system.

There are other models of use that can effectively address clinical or regulatory requirements of an organization. A challenge in any healthcare organization is in locating a specific mobile asset for PM. For mobile equipment that have regular PM intervals, an RFID deployment can effectively provide the location of this asset for service. In addition to minimizing the amount of unfound equipment and maximizing regulatory compliance, an RFID system can increase the effectiveness of engineering staff as their time hunting for specific assets can be minimized.

In a clinical setting a model can be implemented where a caregiver can identify the location of the nearest unused piece of equipment. In this model, more efficient use of limited resources can be facilitated with the added benefit of potential cost savings through minimizing the purchase of redundant equipment. Caregivers will also benefit from this model as they are able to focus on their primary responsibilities rather than to hunt down needed equipment.

b. Location/Tracking of Staff

Staff tracking can give important information on workflow at both the unit level and in center wide operations. The location of staff in response to external stimuli like alarms can accurately be measured and a more complete model of flow throughout a system can be measured. An example of a system wide process that can be monitored is the response of a Code Team to an event.

This type data can be used as a baseline to measure the effectiveness of process improvement plans implemented by an organization. It can also identify bottlenecks and holes in a system and correlate them to specific times or events. This information can then be used as the foundation for future improvement plans.

c. Location/Tracking Patients

Patient location can be accurately monitored system wide through wearable RFID tags. Knowing patient location and availability can help in the scheduling of limited resources and can help keep those resources more active. Rather than waiting for an unavailable

patient, the resource can be rebooked with an available one.

There are also safety concerns that can be addressed with RFID. Children in Pediatric units can be tagged and monitored. In the event that a child enters a restricted area or wanders away, doors and elevators can be locked, alarms sounded and the child's location immediately identified. For patients with limited faculty, a similar system can be employed at doors and exits.

d. Theft prevention

RFID tagged equipment can trigger alarms at exits and lock doors, thus preventing unauthorized removal. RFID can provide a time stamp of the infraction. This log can be matched with surveillance video to identify individuals associated with a theft attempt.

## IV. Other Applications

There are other not so obvious applications that RFID can have a central role in. Many of these applications require integration into other hospital information systems and are more complex than providing traditional location services.

a. Patient Safety – Validation

Patient charts and imaging can be validated. In an OR for example, an RFID system can be integrated with PACS and the OR management system to insure that the images and information pertaining to a specific patient are in fact for that patient. This can help minimize medical errors related to such scenarios.

b. Incident audit trail

In the event of an incident with a patient, RFID can provide an audit trail of the equipment and staff involved. If the incident is related to equipment failure, RFID can accurately identify the offending piece of equipment even if the error is discovered long after the fact. If the error is related to an infusion pump, for example, we can accurately identify the pump in question and pull it from service.

RFID can also prove useful in validating that procedures were followed as well as help identifying breakdowns in a system where policies were not adhered to.

c. Dynamic Patient- Equipment association

RFID has the potential to actively associate and disassociate equipment from patients. This can be important when establishing which caregiver is to respond to a particular patient when a device alarm goes off. It can also help in creating an audit trail as to which piece of equipment has been used with which patient.

The most accurate level of location precision must be employed in this scenario. With current technology this can be accomplished using specialized local transmitters strategically located around a patients bed. When a tagged piece of equipment enters into the local umbrella that encompasses the patient's bed, we can say that this piece of equipment is associated with this patient. Similarly the equipment can be disassociated from the patient upon removal from the umbrella of coverage. This association and disassociation can be made available to other systems that manage data such as directed alarms. Challenges in this scenario are to positively identify to a caregiver when a device is associated and disassociated with a patient. This can be accomplished via audible tones from wireless communication devices, a status light on the tag or the device itself, or if the clinical device is connected to a network the integration of the RFID association into the devices server. The server can then identify whether the device is associated or not.

c. Equipment Status

Some of the RFID tags have communications ports that can relay information about device status. These communication ports can be used to transmit the status of the equipment. In the most basic use it can simply identify if the equipment is actually in use or not. This can be significant in a caregivers search for the nearest available piece of equipment.

d. Cost capture

RFID can assist in identifying specific assets for billing. A system can be employed that can accurately monitor the use of equipment and correlate it with a specific patient.

## V. Conclusion

RFID represents an enabling technology that allows a system to monitor and control the location of assets throughout an institution. Process controls can be developed to take advantage of this information in providing solutions to know problems. Furthermore, the data provided by such a system can be used to quantify previously unknown information and make recommendations for process improvement initiatives. RFID can also take an active role in the healthcare environment, beyond simply providing location services, by integrating directly into the caregiver's workflow thus freeing them to focus on their primary purpose of patient care.

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