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Maximising the Benefits of Radio Frequency Identification Technology (RFID) Integration in Clinical Contexts: a Linear Conduit

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Abstract: Radio Frequency Identification Technology (RFID) has been explored for various process enhancements in clinical contexts, particularly hospitals, for asset tracking. The technology has been accepted in such environments, as it is inexpensive and, in principle, uncomplicated to integrate with other clinical support systems. It is perceived to offer many benefits to currently resource critical/strained clinical environments. This research investigation focuses on the exploitation of the potential of the technology, to enhance processes in clinical environments. In this paper, the researchers aimed to uncover if the technology, as presently deployed, has been able to achieve its potential and, in particular, if it has been fully integrated into processes in a way that maximises the benefits that were perceived.

This research is part of a larger investigation that aims to develop a meta-model for integration of RFID into processes in a form that will maximise benefits that may be achievable in clinical environments. As the first phase of the investigation, the key learning from a clinical context (hospital), which has deployed RFID and attempted to integrate it into the processes, to enable better efficiencies, is presented in this paper.

The case method has been used as a methodological framework. Two clinical contexts (hospitals) are involved in the larger project, which constitutes two phases. In Phase 1, semi structured interviews were conducted with a selected number of participants involved with the RFID deployment project, before and after, in clinical context 1 (hereinafter named as CC1). The results were then synthesised drawing a set of key learning, from different viewpoints (implementers and users), as reported in this paper. These results outline a linear conduit for a new proposed implementation (CC2). On completion of the phase II, the researchers aim to construct a meta-model for maximising the potential of RFID in clinical contexts. This paper is limited to the first phase that aims to draw key learning to inform the linear conduit.

The Context

RFID implementation was deployed as a pilot in the Clinical Context 1 (named as CC1 for this research) – a private hospital, based in Sydney, Australia. The hospital has a well developed web based clinical information system. One of the key modules of this system is the clinical support resource management system that books, tracks and manages patient orderlies to efficiently move patients and equipment between wards, operating theatres and clinic appointments. This module was to be integrated with a real time location system or RTLS (using RFID technology), to enable a more efficient real time view of hospital resources. The pilot project had the objective of evaluating the capabilities of the RFID solution within the private hospital, with a view that the key learning would be used for deploying a similar system within the emergency department of a public hospital.

Active RFID tags were attached to high value and high utilisation assets including a group of critical equipment and patient transport equipment (such as wheel chairs) and selected patients within the premises including the operating theatre and radiology departments. The tags were also attached to selected wheelchairs and loan assets such as infusion pumps and ECH machines. The tracking of the RFID tags

took place through the 5 in-patient floors of the private hospital, theatre complex and Radiology department, storage area in level 4 and the Sterilization Department. The impact on workflows was then monitored in two areas: Clinical Support that is involved with patient movements/transport and Sterilising Services that is involved with sterilisation and supply of critical/high utilisation equipment, on a regular basis to relevant areas.

The project was deployed as a pilot and the RFID tracking system was then not integrated directly with the clinical support resource management system during this implementation. Rather, the real time location system was deployed with its own web based interface, which was then used by the orderlies/SSU unit members to locate resources within the hospital. The rationale were that (1) this typical implementation would cause minimal disruption, (2) users could manually locate resources if necessary, and (3) the system could be tested for effectiveness, user friendliness and with refinements deployed fully in the hospital, covering all areas.

The success of this pilot was evaluated on a set of criteria such as (1) demonstrating the real benefits to hospital staff (users) and processes; (2) increase in process efficiency and asset utilisation; (3) reduce staff frustration in finding equipment (4) demonstrate the capability to assist with patient risk management ie real time confused patient location; (5) ability to track patient/assets on each floor of the hospital; then each wing and each room; (6) demonstrate the reliability and discrimination of the system (7) assist in specifying number and location of access points to minimise infrastructure investment trade-off with location accuracy and (8) successful level 1 integration with the hospital infrastructure. A post implementation review demonstrated revealed certain limitations, which were being addressed at this time, for further full deployment.

The lead researcher in this investigation conducted post implementation review with the project team and end users (hospital staff) involved, with a view to: understand the process integration of RFID in the clinical context and the achievements of the technology in this context as well as validating the review that was conducted immediately post deployment of the pilot. The interviews focused on the processes that were targeted for enhancement, the actual changes to processes observed; and the extent to which the technology has aided in reshaping the clinical processes and enhancing process efficiencies. Specifically, users/ user managers, project/strategic managers and technology implementers were interviewed on the effectiveness of the RFID tracking system – on its perceived and experienced benefits in regard to cost and time savings, better efficiencies and process enhancements for better quality of patient care.

Background and Literature Review

Radio Frequency Identification is a concept that has been in existence since 1940s (Landt, 2001) and can be traced back in history to World War II, when Britain's aircraft batteries used radio waves to identify friendly airplanes returning from missions. In the past few years, it has been explored as a means for various process enhancements in clinical contexts – particularly in asset tracking, aimed at realising better return of investment (ROI). Hoskins (2006) recounts that in hospitals, poor utilisation and slow device cycle times cause many high value assets go underutilised, while hospitals continue to overspend on new and rental assets, affecting the ROI. Hospitals are interested particularly in tracking high value equipment and to optimise their utilisation in emergency settings such as surgeries (Nagy et al., 2006). Conversely, providing healthcare to an adequate standard, in time, is becoming increasingly challenging. Hospitals are strained for resources and equipment (Hoskins 2006, Nagy et al., 2006). Surgical procedures often are delayed due to missing equipment and staff time spent on tracking shared resources. Doctors hunting for Defibrillators, to nurses or orderlies spending hours searching for patient monitoring devices or bariatric wheel chairs, stretchers and gurneys, hamper the day-to-day processes in a hospital and thus affect quality of patient care. In large clinical contexts, significant expenditure is incurred on equipment and inventory re-ordering or rentals. And yet they continue to be unavailable in times of need. Managing these processes efficiently, to enhance quality of care while realising ROI/controlling costs, particularly in the milieu of economic downturn, is now imperative for progressive societies.

Health care providers globally are beginning to recognise the benefits of adopting RFID into their operations, to enhance efficiency and provide better services (Cavoukian, 2008). In particular, the technology has been trialled to track medical equipment and supplies more efficiently, enabling the authenticity and administration of drugs, and improving patient safety via the use of RFID bracelets. The technology has been accepted in such environments, as it is inexpensive and, in principle, uncomplicated to integrate with other clinical systems, and so may offer many benefits to currently resource critical/strained clinical environments. A Frost and Sullivan report (Simpson, 2007) reported that RFID tracking can save hospitals time and money which could be expended in tracking lost equipment. Page (2007) reported that pilot testing of RFID applications have given way to implementation of RFID, with hospitals moving ahead with dependable uses of RFID such as asset tracking. Recent RFID systems demonstrated potential applications including patient identification, drug administration, access to medical records, transfusion, and people and equipment tracking (Nahas et al.,

2007). The Heart Hospital Baylor Pano, Texas, has implemented an RFID network, which automates tracking and cataloguing of the hospital's high end equipment (Godinez, 2007). According to the hospital authorities, staff in the hospital has embraced this technology well and is very satisfied with its performance.

Healthcare providers in a number of countries hope location technology such as this will improve patient care. An incident in Birmingham Heartlands Hospital, illustrates the effectiveness of this technology (Thomas, 2008) in reducing clinical errors. In this hospital, a child went into the operating theatre to have grommets inserted, but emerged without tonsils. This triggered the development and implementation of the Safe Surgery System to minimise mix-ups using RFID tags to identify every patient and to check the list of tasks before surgery. Subsequently, the patient photo is integrated into the electronic patient record. The patient is given an RFID wrist tag – a short-range, low-cost radio tag that transmits a small amount of information when activated. The tag system works in conjunction with personal digital assistants (PDAs) allocated to each clinician, and when the patient arrives in the operating theatre, staff then scan the tag to verify the patient's identity and check that all tasks have been done. Since the system's introduction in March 2007 there have been no mistakes in the operating theatre, and the efficiency of patient throughput has improved by 14 percent (Thomas, 2008). The incident demonstrates how the RFID system has reshaped the process and made it more effective.

A study "Trends in RFID 2008" based on 100 telephone interviews conducted in early 2008, with IT professionals and clinical/nursing directors at hospitals with more than 300 beds by Spyglass Consulting Group, a market intelligence and research firm in California (Cox, 2008), revealed that hospitals are aggressively deploying a range of RFID systems. According to the report, the benefit is no longer being able to find equipments, but rather the wireless identification and location data is being used to streamline and repair a range of healthcare workflows and business processes.

Early applications of RFID such as infant tracking is now giving away to staff tracking, combined with time and motion studies to optimise workflows in areas such as radiology and surgeries (Cox, 2008). The author reported few instances where RFID has been beneficial with reshaping processes within hospitals, resulting in reduced errors, cost savings and better patient care. Harrisburg Hospital in Pennsylvania deployed a range of RFID applications from a patient tracking system for surgical patients to a 433MHx wireless infrastructure able to track wheelchairs and a range of portable medical gear. In Christiana Hospital, Newark, Delaware, the emergency department has 76 treatment rooms that handle 100,000 patients annually. Nurses were losing track where patients were in the treatment process, as they were moved among diagnostics and treatment facilities. This resulted in patient stay spiking above normal levels and resulted in 4-5% leaving without treatment. The hospital combined a tracking system with infrared sensor network for locating hardware assets. A web based application showed tagged patients, staff and medical assets and created a visual workflow for patient progress. The data is filtered through various subset views so departments can expect and manage the number of patients and streamline their progress. According to the report, the length of patient stay has been reduced (Cox, 2008).

Chen et al., (2008:286) imply that while an increased number of vendors, hospital administrators and caregivers are advocating the relative advantages of RFID, the adoption seems to have slowed, which can be attributed to technology resistance, expensive system costs and disparate standards. Their research which addressed RFID adoption in hospitals from the expectation-confirmation perspective, revealed that Healthcare providers who have a high perception of the usefulness in front-end interoperability and of performance expectancy affirm a positive confirmation experience with the use of RFID technology. However, for its continues use and progress, *hospital administrators and equipment vendors need to address those factors that have been revealed as significant such as increasing the perceived frontend inter-operability by using experienced consultants and integrators to implement systems that are proven to be interoperable at the front-end. They may also intervene via training and education to increase caregivers' performance expectancy of RFID* (Chen et al., 2008:286).

Methodology

This research investigation focused on leveraging the potential of the technology, to enhance/reshape processes in clinical environments. The lead investigator aimed to find if the technology has been able to achieve its potential and if it has been integrated into the processes such that the full potential is exploited. Specifically, the study expected to reveal cost savings, time savings and process efficiencies experienced as a result of deployment of RFID. It also expected to capture issues that emerged as significant, as a key learning to inform the linear conduit.

The research questions that lead this phase of investigation were:

1. to what extent has RFID technology been able to assist in reshaping clinical processes and enhancing their efficiencies?

2. can the benefits achieved through the application of RFID technology be further enhanced through improved process integration in the clinical context?

Study Design

The research has been undertaken based on case method. A selective sample of users involved in the RFID pilot project were interviewed to confirm/ validate the interviews conducted after implementation and to draw key learning from different perspectives. For the purpose of tracking process changes, it was necessary to map the workflows within two departments that were identified prior to the RFID deployment (the pilot) as key areas of implementation. These were Clinical Support and Sterilising Service Unit. The process that involves the users (mainly patient care orderlies) is described as under.

Clinical Support Services

1. A request is entered on-line by the nurse using the Web Based Hospital Information System,
2. The operators and the Clinical Paging Unit receive the request and assigning an order to a Patient Care Orderly into the system
3. The order triggers a pager text message with the order description. This includes the patient, equipment required and what needs to be done (transport the patient or deliver the equipment)
4. The orderly then received a text message and reviews the request using the workstations (if necessary) and then goes into the storage rooms to search for the assets that are required to complete the work order.
5. If the equipment requested is not found in the department storage area, the orderlies then commence search from the top level (10), down to every level. It is noted that there are occasions when the equipment was not located in the building, the orderly then had to search across the public hospital next door and then to the clinical buildings etc, until the assets were found. However, this is not a regular occurrence).
6. When the assets were found, the orderlies then assemble the order, deliver it or take the patient for transport to the wards (occasionally transports the patient via ambulance) and then return the assets to the storage area.
7. Subsequently, the orderlies update data records and then the asset becomes available for the next order.

Sterilising Services

1. First stage of the workflow is initiated by the daily morning route executed by the technician on duty to collect all the devices in storage behind the lift area on each of the levels in the hospitals
2. all the equipment collected is then returned to the sterilising room at level 3.
3. the second stage of the workflow is initiated by the requesting nurse when they enter the requisition on-line using the hospital information system.
4. the request is then automatically printed on the printer located outside the storage room at level 3
5. the technician on duty collects the printed docket from the printer and proceeds to assemble the order
6. the technician scans all the items of the kit and enters the assignment information into the Instruments Tracking System and
7. once all the parts have been entered into the system, the technician delivers the order to the requesting nurse within the in-patient floor. The equipment is then left on the front desk; it is not delivered directly to the patient.

(It was noted that in some rare cases, the requests are actually received directly from the nurse over the phone. In these instances no tracking information is recorded within the systems).

A set of questions was designed for the semi-structured interviews which included strategic/project managers, technology implementers and users. The strategic project managers were interviewed on the need for deployment of RFID, and if these objectives were based on cost and time savings as well as process enhancements. The perceived/experienced risks, emerging issues and mitigation plans were also revealed during the interview. The focus of the interview was to examine the cost savings, time savings and process reshaping that has been experienced – to be ratified with the objectives. The technology implementers were also interviewed on perceived/experienced issues, cost and time savings and particularly the potential of the technology which has been realised or not realised, to explore the reasons. The users, which were the major group in this study, were interviewed based on the work flow and process flow, focusing on their perception on how their workflows and process of patient care have improved. They were also able to comment on time savings and cost savings experienced.

Results

User/User Manager View

The Sterilising Services experienced major time savings as a result of the RFID pilot. According to the users, the time taken to search the equipment in particular has been reduced significantly. Most of the equipment are of high utilisation nature, and need to be sterilised and reused continuously. Due to the high utility nature, these equipments would need to be loaned, or purchased and stocked in excess, to optimise staff time spend in tracing them. According to this set of users, the department has experienced better efficiencies in the process of day-to-day work, through time savings and "monetary saving" through better equipment recycling. From the process flow diagram, a step has been eliminated, enhanced by the computer based RFID tracking.

However, the user manager expressed that the tracking system must be made more efficient to detect smaller devices, which have high utilisation, but may get lost "under a patient bed" etc. Another concern was that the RFID tracking system was not yet integrated with the Clinical Support System, which meant that the users did have to understand/cope with a new interface, which caused some reluctance. And this was particularly due to staff being in shifts and part time, which meant that they were not interested in learning a new interface, rather than the one that was tested. Therefore, technology integration did emerge as a major factor for continued use of the tracking system, instead of manual tracking.

The Clinical Services users/user managers expressed that although the orderlies were advised to trial the system, the system was not being used effectively. The reason was that the orderlies usually received the order for equipment, with patient details on a pager. For using the RFID tracking system, they had to then look up a computer at the workstation. However, orderlies were staff always on the move, and may not be near a workstation. This meant that they had to find a closest workstation first, then spend time looking up the system for the equipment (such as a bariatric wheel chair, considered high value/scarce equipment). During this time, the orderlies found it easier to manually look for the equipment which may be available on a corridor and then transport the patient to the destination. On further investigations, it was revealed that due to the lack of integration of the tracking system, the orderlies also had to learn the new interface, which they were reluctant to do, in the time they were in the hospital – without disrupting their routine work. According to the set of users, the system would be potentially more efficient and effectively reshape their work flows, if the pager message also came with the "location of the equipment" as it already has the required equipment and patient location. Therefore, when the pilot becomes a full implementation, integrated with the hospital information system, the users feel that it will definitely enhance their work flows, enhance quality of care for the patients, resulting in time and cost savings.

Technologist/Implementer View

The technology implementers also felt that there were cost, time and efficiencies experienced. However, the interviews revealed that the technologists were supportive of the user view in that they indicated that the implementation of the pilot was driven by technology and not the users. In such environments, users being the major catalysts of success, to effectively reshape processes, the take up of the tracking system effectively would mean that the user friendliness of the system needed improvement. This effectively could only be achieved on deployment of a full implementation covering all the hospitals, rather than some areas. The efficiency of tracking equipment and small devices, accurately from a location, was not possible until a full deployment was completed. In addition, the integration with the clinical resource support system, which eliminated the need for users to learn another interface (particularly that the users are mainly part time and casual staff) was imperative for the continued use of RFID tracking system, which would then bring in significant time and cost savings and reshape the processes more efficiently. The technologists also revealed that there is potential for the RFID tracking system to be integrated into other areas such as bedside applications/monitoring and extending into remote monitoring in a large multi-hospital environment, where patients do tend to "wander away". The extension into patient monitoring and after care, support would bring in better efficiencies for the hospital.

Strategic/Project Managers View

The strategic project managers who were involved in the deployment of the pilot and will be involved in the future implementation on a large scale (particularly emergency services), also felt that the pilot revealed significant potential of the technology in time and cost savings and process efficiencies. The constraints of non-integration with the clinical resources support system and having to educate the users on a new user interface were already noted. According to the strategic manager, the full scale implementation was only possible after the potential was demonstrated/ experienced to certain level. This objective was achieved. The emerging issues of technology integration (i.e. the integration with the hospital information system that will eliminate the need to educate users on another interface) and accuracy of location was already considered for the future full

scale implementation. The strategic managers expressed that the technology does have potential to be deployed for tracking resources and patients in the future, which will definitely reshape the processes within the hospital, making it more efficient. The staff time would be recorded more efficiently, their work processed enhanced and result in time and cost savings. Therefore, the full scale implementation is now being planned.

Key Learning and Outlook

RFID tracking systems have illustrated potential time/ cost savings and improving efficiencies within this context (CC1). Technological integration with the hospital information systems and user education are the major factors to be addressed for a complete and large scale implementation. The potential of integrating and expanding the technology into other areas, with the involvement of users/technologists and user managers must be considered for maximising the benefits of RFID in this clinical context.

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