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DEVELOPING A PROCESS MODEL FOR DEPLOYMENT OF RADIO FREQUENCY IDENTIFICATION TECHNOLOGY (RFID) IN HOSPITALS: AN ACTION RESEARCH FRAMEWORK

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ABSTRACT
Radio Frequency Identification (RFID) technology is increasingly being explored for deployment in hospitals to improve their existing processes. In recent years, RFID pilots has lead to full scale implementation in hospitals, especially for tracking of expensive equipment as well as movable assets that are critical in surgeries. However, academic research is yet to emerge with a generic process model that can be adapted contextually for deployment of RFID in particular hospital settings. In this paper, we propose an action research framework for a pilot implementation of RFID in a large Indian hospital, the experiences of which will contribute to and result in the development of such a process model.

KEYWORDS
RFID, India, Processes, Hospitals, Healthcare, Framework

1. INTRODUCTION
Radio Frequency Identification (RFID) is a concept that has been in existence since 1940s (Landt, 2001). Historically, its first uses can be traced to World War II, when Britain’s aircraft batteries used radio waves to identify friendly airplanes returning from missions. 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. Hospitals are interested particularly in tracking high value equipment and to optimise their utilisation in emergency settings such as surgeries (Nagy et al., 2006).

In dynamic global economies, providing healthcare to an adequate standard, in time, is becoming rather complex and challenging (Hoskins, 2006). Furthermore, hospitals are strained for resources and equipment. Often surgical procedures are delayed due to missing equipment and staff time spent on tracking shared resources. In an emergency, it is not uncommon to find doctors often hunting for an IV stand or defibrillator, although the hospital may have numerous supplies. In large hospitals, significant expenditure is often incurred on equipment and towards inventory. Yet, medical staff spend hours searching for patient care assets, including medical devices (such as infusion pumps, portable x-ray machines and patient monitoring devices), as well as other mobile assets such as wheelchairs, laptops, stretchers and gurneys. Poor utilisation and slow device cycle times cause many high-value assets to go underutilised while these hospitals continue
to overspend on new and rental assets. Meanwhile, nurses sacrifice time with patients (especially in surgeries) to seek equipment they need and maintenance staff lose productive hours searching for specific items that need maintenance. As a result, the efficiency of processes in the hospitals reduce, costs and complexities continue to rise (Hoskins, 2006, Nagy et al., 2006). Managing the processes efficiently, enhancing quality of care and controlling costs is an essential need of worldwide societies in progress.

Latest academic research (Nagy et al., 2006) indicate that the use of RFID tags may lead to reduction in clinical errors, reduced costs and increased efficiencies in hospitals. Relatively inexpensive RFID technology may help optimise utilisation and support appropriate allocation of scarce material resources. However, there are limited academic reports in the area, and the available research is mainly in the context of developed nations, particularly the United States.

RFID may have much more potential in a developing nation such as India, where healthcare systems even in advanced hospitals are strained by inefficient utilisation and the shortage of expensive equipment. The need is therefore higher in finding solutions that enable optimum utilisation of assets, resources and increasing the quality of care. There is also enhanced interest in India, especially among super specialty hospitals, in catering to an international clientele. In their health policy statement that was released in 2002, the Government of India has also articulated this desire, in regards to hospitals (GOL, 2002). However, Indian hospitals are still a long way from meeting international standards for safety, efficiency and accountability. There are a multitude of small, medium and large hospitals that are struggling to assimilate and use expensive, higher technology equipment that is increasingly being demanded by both physicians and their patients. This creates significant shortages in hospitals, leading potentially to denial of the highest standard of care, even when, in theory, the device or equipment in question is part of the hospital inventory.

RFID in India is gaining interest in India, mainly driven by vendors such as Gemini Communications (Indian Express, 2007) who have successfully convinced varied government bodies and departments. The researchers have cited vendor initiated pilots and an ongoing pilot in a Cardiac hospital – which has been reported in the Section 3. This framework will be used to deploy RFID in a large hospital which expects it to be an innovative approach to addressing the issues of health care access, asset utilization and cost effectiveness prevalent in the Indian context. The researchers have not yet cited any academically initiated and published RFID deployment framework in a comparable Indian hospital.

Furthermore, current research (Nagy et al., 2006) indicated several research gaps such as lack of quantifiable results of technology applications, lack of standardisation, closing the loop and using the information, integration of hospital information systems to prevent labour cost shifting, supplier cooperation, battery life of RFID tags, interference and reliability, security, privacy and cultural issues. This paper proposes a generic process framework for successful implementation of RFID, thereby addressing some of the gaps in existing research as well as pioneering related academic research in the Indian context.

2. RFID IN HOSPITALS

RFID applications in hospitals in the past few years demonstrate the value of the technology in hospitals. Tracking is an activity in hospitals that is pivotal to its operations. There are varied items that would need to be tracked including people: doctors, nurses, patients, visitors etc; equipment that needs to be prevented from being stolen; medicines that need to be administered in time, in the correct proportions, from the correct packages and so forth (Pappu et al., 2004). A recent Frost and Sullivan report (Simpson, 2007) reports that RFID tracking can save hospitals time and money which could be expended in tracking lost equipment. Pilots had begun actively in hospitals in the US, UK and Germany for tagging patients in the hope of reducing the number of clinical errors. A survey in 2005 (Baker, 2005) revealed that 10 percent of health care organisations in the USA use RFID tags to track expensive equipment and 45 percent are expected to have systems in place. RFID has a major advantage that might justify any additional cost - it is automatic and so does not require manual intervention to work, which removes the potential for human error. In a frenzied operating room environment, inventory control cannot get in the way of taking care of the patient (Nagy et al., 2006). Page (2007) reports that pilot testing have given way to implementation of RFID, with hospitals moving ahead with dependable uses of RFID such as asset tracking.

O’Connor (2006) reports the pilot implementation of RFID in a Toronto area hospital, Hamilton Health Sciences Acute Care Center, Canada. The pilot implementation tagged 200 pumps, as well as diagnostic
equipment and other high value mobile assets in the nursing ward. Although the upfront costs were substantial, the full implementation is expected to bring high ROI, as it extends to infant tracking, adult patients or geriatric patient monitoring. The pilot has been successful in identifying the shortfalls and leading to broader implementation.

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. The President of the Dallas Fort Worth Hospital Council has declared that all hospitals in the region plan to deploy RFID systems (Godinez, 2007).

Baldwin and Larkin (2008) find that asset tracking systems can help hospitals keep tabs on their mobile inventories. They comment that RFID monitoring can fit into a hospital’s strategic priority. However, which tracking solution and infrastructure is needed can vary widely depending on the context. They comment that one RFID solution do not fit all hospitals, nor countries. Through the proposed generic framework, we offer a method in which RFID solutions can be deployed with best adaptation to the context.

3. RFID IN INDIA – THE RESEARCH CONTEXT

The use of RFID in India is rapidly emerging. RFID Association of India is a not-for-profit organisation that has been formed to promote the adoption of its applications in India, and collaborate with others to promote it globally (RFIDAI, 2008). The association entered into a Memorandum of Understanding with the RFID Association of Australia (RFIDAA) in July 2005, to provide a channel for the growing RFID cooperation between companies of both countries. In the same month, the RFID journal (Collins, 2005) reported that regulators in India had designated 865-867 MHz as the country’s UHF RFID spectrum, in line with the frequencies used by the United States and Europe. As the focus of this research is on hospitals, we highlight some current hospital trials.

Since 2006, the Bhagwan Mahaveer Jain (BMJ) Heart Center – a cardiac hospital in Bangalore, Southern India, is using passive UHF RFID tags to assist with maintaining patient records, monitoring patient flows and tracking assets throughout the outpatient department (Bacheldor, 2007). An average of 100 patients are tracked in a day, which includes returning patients as they check into the outpatient department. Patients checking into the outpatient department receive RFID tagged cards. The unique ID number on each tag is associated with that of the patient electronic records in the Clinical Information Processing Platform (CLIP) – a system that includes software and RFID interrogators and tags. The RFID interrogators or readers are positioned in the waiting room, consultation rooms and labs and they document whenever a patient enters, leaves and how long they stay in the area. The CLIP system is also integrated with hospital billing system, enabling the staff to use patient care and workflow information for accurate billing. The manual effort of paper registration and use of paper forms has been eliminated.

With respect to asset tracking using RFID, the hospital is attaching EPC Gen 2 RFID tags to stents, pacemakers, wheelchairs, gurney and other high value items, as well as certain mobile devices used in diagnostic labs. The CLIP AssetLIVE application, which uses a mapping technology, is used to track the location of these assets. The system, instead of tracking tagged objects in real time, documents their location by analysing RFID data reads and render their last known position in a graphic (Bacheldor, 2007). The hospital has benefitted from the technology in that it has increased patient throughput, reduced paper work and added visibility to supplies. However, the hospital is still in the process of finding if RFID is providing cost savings and improving workflow processes in the hospital, especially in the asset tracking area.

Amrita Institute of Medical Sciences (AIMS, 2008) is a 1200-bed specialist referral health centre, with an attached medical college (deemed university) hospital with 400 beds, in the state of Kerala, India. The health care infrastructure has over 50 clinical departments; 12 para-clinical departments; supports a patient volume of 800-1200 outpatients and leave an average of 750 inpatients daily. The Orthopaedics department in AIMS is a well-equipped resource for treating muscle, ligament, bone and joint disorders. The Department of Neurosurgery comprises six neurosurgeons, sub-specialized in the various facets of Neurosurgery and manages a wide spectrum of neurosurgical diseases.

The need for this research project has stemmed from the fact that the two departments Orthopedics and Neurosurgery share critical infrastructure and high value equipment which may be needed both routinely and in emergencies at the same time. However, there is also idle time during which this equipment may not be
fully utilised. In an emergency situation, these items have to be traced and RFID asset tracking is expected to enhance this process. In addition, evaluation can also be done as to whether these assets were utilised to their optimal capacity and thus enhanced hospital processes.

4. THE PROPOSED RESEARCH FRAMEWORK

4.1 Action Research - Justification

Action research is an iterative process, with researchers and practitioners acting together, diagnosing problems, actively intervening to achieve enhancement and reflective learning (Susman, 1983).Fraunholz (2001) who contextualized action research to trade sector concurs that it draws from the synergy created by the co-operation of researchers and practitioners in particular settings. Some early citations (Avison et al., 1999) recommend action research as a means of making academic research relevant, in order to explore theories and assumptions with practitioners in real situations and real organisations. During the last few years, the method has been applied in health care settings, which often deploy innovative technologies. It has endorsed as a suitable method in health settings, as reported in academic journals (Hampshire 2000, Dick, 2006).

Recently, the role of action research was demonstrated by the PRIDE project which developed, deployed and redesigned a technological innovation for use in primary health care setting of UK (Waterman et al., 2007). From their experiences, they maintain that “action research can be employed successfully to diffuse innovations that need a high level of adaptation in each new setting or where there is high complexity and mismatch between groups of people in an organisation, providing there is an established need for researching the said innovation further (Waterman et al., 2007:380)”. The participatory approach helped the researchers understanding the cultural context in which the innovation had to be developed, thus effectively helping them develop, test, redesign, and deploy the innovation.

Hospital environments are chaotic, with time being the most crucial asset. Consultation and involvement with staff was found to be an essential ingredient in developing this research framework. Even for a pilot implementation, using a vendor solution, sufficient involvement, training and adaptation was required. Therefore, we found the action research method by which the researchers can develop a generic framework, iteratively, using the context, was the best solution.

4.2 The Adapted Framework of Action Research

Action research is a continuous cyclical approach (Susman, 1983) which involves the cycles of situation diagnosis-action planning-action taking-evaluating-specifying learning. The cycle continues until the researcher and practitioners are satisfied of the outcome of the project. Fraunholz (2001) built a preliminary framework based on this cyclical approach, for the virtual management of projects in the German trade sector, re-labelling them as awareness raising-action planning-action taking-evaluating-specifying learning. From these fundamental research frameworks, we adapted the cycles of Action Research, relabeling them as illustrated in Figure 1 and explained as follows.

![Figure 1: The Iterative Process of Action Research](image-url)
In the process of learning via action research, Fraunholz (2001) cautions that the researchers need to ensure that learning occurs such that it will enhance the proposed models and facilitates theory generation, without being accused of influencing the context via consulting. However, the cyclical process of action research that facilitates meticulous documentation could facilitate the process. With this view, we propose the following:

**Phase 1** This phase was the starting point known as “Situation Diagnosis” (Susman, 1983). Fraunholz (2001) had renamed this phase as “Awareness Raising”, as the domain of trade sector required that a certain level of awareness had to be created among them, that they are performing sub optimally and that improvements are necessary. In the Indian context, within the hospital setting, the key stakeholders and medical practitioners are aware that certain processes, such as asset tracking, can be enhanced using RFID tracking systems. Nevertheless, the researchers feel that the level of awareness also need to be raised among the staff of the hospital, who are directly involved in the day-to-day processes of the hospital. By developing a process model in consultation with the key staff involved, will enable the researchers to identify the processes and build a model that can be enhanced using RFID. During this process, researchers, practitioners, hospital staff and other stakeholders will be involved in a discovery process which will effectively result in a model – that can be enhanced with RFID implementation. Therefore, the researchers propose to re-label this phase as a *Discovery and Modelling*.

During this phase extended literature reviews in the health care domain, with a particular focus on hospitals and their utilization of RFID will be conducted. The review is expected to identify extant best practices of RFID deployment and existing gaps in academic research. While the focus of this research is global, the Indian context will be studied closely, so as to identify any related variables that need to be considered for the framework. Subsequently, the researchers will focus on the context, or the current processes in the hospital that relate to the specific departments and assets concerned in order to model the processes. This modeling process will be iterative, in consultation with the key people who are involved in the processes of this hospital. As part of this phase, the researchers propose a requirements engineering exercise using cross functional teams within the departments involved. It is envisaged that the issues identified by the participants may fill the research gaps identified, such as inconsistencies or lack of knowledge of processes involved by all people negating the process enhancements envisaged. This requirements engineering exercise will also be part of the *discovery process*, which will lend itself to *modeling* the processes efficiently as well as contribute to identifying a suitable RFID implementation design. At the end of the phase, the researchers expect to have modeled the existing situation and have gathered requirements for improving the situation.

**Phase 2:** Susman (1983) called this cycle “Planning” and Fraunholz (2001) labeled the phase as “Action Planning”. In this phase, the researchers propose to draw from phase 1, and building on the learning, prepare a requirements gathered document (with specifications discovered by the staff) and propose an RFID implementation design, which can be communicated via a strategic plan document. The researchers will also identify metrics of performance and prepare for appropriate data collection processes that will contribute towards development of a theoretical model that will inform academic research. During this phase, the researchers will also identify a suitable RFID vendor, in consultation with the organisational stakeholders involved and obtain a solution which can be mapped against the requirements document, and the existing process model, to introduce any changes to the proposed design. A final specifications document which will guide the prototypical implementation, periodic evaluation of results and also communicated in the strategic plan of the hospital, will be developed. The researchers propose to label this phase as “Action Planning and Development” phase, maintaining that action is not only planned, but also developed through relevant documentation.

**Phase 3:** This phase is better known as “Action” by Susman (1983) and “Action Taking” by Fraunholz (2001) who suggested that this is the phase when the first change is introduced into an organisation, with the intention of enhancing the current processes. In this context, there are 2 stages of action that have been identified. In Stage 1, the RFID prototype based on the design (phase 2) will be rolled out, guided by the final specification document. Before any process change is implemented, the researcher will baseline the current asset tracking performance using RFID tags, based on the metrics of performance and associated analysis developed in phase 2. From the time of the roll out, it is expected that this activity will take a month of data collection. After the baseline, all relevant staff members will be trained by the vendor, as advised by the researchers. Changes will be suggested and introduced by the researchers, who will continue to make observations, which will thereafter contribute to the final theoretical model development. In Stage 2, based
on best practice and the existing process model of the organisation, the researchers will analyse processes to continuously refine/optimise them to derive maximum benefit from RFID technology. This includes *ex ante* process such as allocation and planning of asset use as well as *ex post* analysis such as financial controlling to reflect if assets are used cost efficiently and usage cost is allocated/budgeted correctly. The metrics of asset tracking performance employed to baseline performance prior to deployment of modified RFID tracking processes will again be collected, following full process deployment and enhancement, over an extended period of time (estimated to be three months). The data so collected will be compared with that collected pre-implementation and analysed. In parallel with the above analysis, affective measures of performance (i.e. measures based upon stakeholders' perceptions of ease of use and the extent to which they believe RFID asset tracking has affected clinical workflow) will be assessed using focus group techniques, during stage 2.

Given the iterative nature of this cycle, where the researchers have to take action, after reflecting on the change introduced, we re-label the stage as "**Reflective Action Taking**". We concur with Fraunholz (2001) that the aim of this phase is to ensure that the tracking system is optimised for use on a day-to-day basis.

**Phase 4:** Regarded as "evaluating" phase (Susman, 1983; Fraunholz, 2001) -- this phase involves the researchers and all others involved undertaking an evaluation, to determine if the result has been achieved and the introduced change was successful (Fraunholz, 2001). It involves extraction of all findings and documentation. Observations extracted from Phase 4 will be reviewed to extract key findings relevant to the process framework.

The final framework will be revised and built iteratively, drawing from key learning, inputs and analysis. Focus groups to validate the framework are envisaged at this stage. During this time, the researchers will communicate clearly to all key stakeholders and staff of the hospital that the researchers are trying to get objective feedback to validate the framework. As Fraunholz (2001) cautions, it is possible that the people involved are hesitant to be critical due to fear or may want to avoid another change altogether. In many occasions, any change introduced would be viewed as a tedious task, especially in a hospital environment, where time is of critical value. However, the researchers have ensured that the framework of implementation, from phase 1, will involve all the staff involved in the process, are taken into consultation, so that they are not only aware of the implications, but can also make positive contributions to the change. Rather than a directed change, a participatory change is proposed in this context. We re-label this phase as "**Consultative Evaluation**" to reflect that all people concerned are involved in this cycle.

**Phase 5:** This is regarded as the final phase of the action research (Susman, 1983) and labeled as "**Specifying Learning**". Fraunholz (2001) considers that this is an ongoing process which will occur during all the phases. However, the researcher had formally placed it at the final stage, as it is regarded as the most important phase, which will determine whether the research was successful. If the research was unsuccessful, it is recommended that the knowledge gained then feeds into the next iterative cycle for future research. Conversely, if the outcome is success, the next action would then be for the organisation to adapt the knowledge gained by the research.

In this context, if the outcome was unsuccessful, it would then feed into the next cycle for future research into RFID. If it is successful, the whole hospitals and all departments could then adapt RFID using the framework developed. Furthermore, the generic process model could then be used to implement RFID in other hospitals as well. This phase establishes a future strategy, no matter what the outcome was. While the researchers are essentially the key people in specifying the learning, the people involved may offer independent points of view, which can then be considered by the researchers for enriching the learning. According to Fraunholz (2001) the iterative process of data gathering and theory building will repeat, until it is proven that a clear hypothesis cannot be drawn, or there is a clearly defined hypothesis (or framework in this context). The researcher also confirms that there has to be documentation for each phase and each cycle, which will consist of participants, documents, models, aims, possible issues and key learning. Building on these recommendations, we propose that the phase continues to be labeled as "**Specifying Learning**" phase for this framework.

Furthermore, Fraunholz (2001) contextualized the Susman (1983) action research framework and provided a thematic diagram for the virtual management of projects in trade. We built on this schema, contextualizing it to the context of RFID deployment in hospitals, and provide the adapted framework in Figure 2. The framework indicates the aims of each phase, people involved and documentation proposed. Each phase will also have issues that will be identified and key learning, which will be documented at the end and drawn upon for specifying learning in the final iteration of the project and for the development of the deployment framework.
5. CONCLUSIONS AND FUTURE WORK

This research project is expected to develop a generic process framework for successful adoption of RFID facilitated processes in hospitals for enhancing efficiency. For this purpose, a prototypical design and implementation is planned for, in an Indian hospital within two surgical specialties: Orthopedics and Neurosurgery. Optimum utilisation of assets within these departments through an RFID asset-tracking pilot is expected to be in phases. A pre and post analysis of the pilot, will be conducted, identifying the processes that can be enhanced and to study the success of the implementation.

During the pilot process, the researchers will be involved as change agents, contributing to all phases for better efficiencies in implementation. Through cyclical processes of the action research, the researchers will build and enhance the process framework. The model and findings of this research will inform academia as well as health practices, addressing the some existing gaps found in the existing academic research as well as providing a new implementation framework for hospitals, which require methods to improve their quality of care, particularly in the context of India, a developing nation.

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