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Enabling RFID Technology in Irish Hospitals

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Abstract

Hospitals represent a significant part of healthcare systems and account for no less than 60% of the entire healthcare service in most of developed countries. Therefore, improving service in hospitals is an important element to the process of healthcare reform. Better use of resources, more consistent quality, and a higher service level are the keys to rationalise the huge expenditure in healthcare systems due to higher growth in demand. Even though massive spending has been directed towards hospital improvement in Ireland, services provided in Irish hospitals are ranked relatively low comparing to the other European countries. Growth of population, aging, European Union regulations, and demanding patients place more pressure on healthcare researchers to provide innovation solutions for Irish hospitals. In the last two decades, the use of technology had a significant impact on hospital performance in terms of responsiveness, quality, and management practices. Radio Frequency Identification (RFID) technology has been successfully implemented in a number of hospital systems in many developed countries. It is an emerging technology for applications such as managing and tracking patients, equipment, and drugs. Integrating RFID technology into hospital systems allows a dramatic enhancement in hospital efficiency and effectiveness measures to happen. This paper gives a comprehensive review on the up-to-date applications of RFID technology in hospital systems. It includes a classification of RFID applications at different areas of hospitals. Inclusive analysis of the impact of RFID implementation on the overall performance of the hospitals is presented. As new technology, this paper looks into the challenges and problems facing the management in employing the technology. Recommendations on potential impact of using RFID in Irish hospitals are discussed.

1. Introduction

Healthcare sector is the biggest service industry in the world and responsible for an important part of the developed world's economy (Doeksen et al., 1997). Therefore healthcare reforms in terms of better service level and effective operational cost have been propelled continually by involved researches, decision makers, and governments. Hospitals are healthcare providers that represent a significant part of healthcare service and account for no less than 60% of the entire service industry in most of developed countries. Presenting new policies and technology at hospital systems has a great impact on the overall performance (McKee et al., 2002). Hospital reforms are addressed as an essential element to the process of healthcare reform since the improvement attempts at hospital systems will contribute significantly to the entire healthcare development.

In hospitals context, decision makers are trying to utilise resources optimally to enhance service quality and responsiveness, minimise medication errors, and streamline the workflows. Achieving this objective using conventional approaches is not possible and is gaining no improvement due to two reasons. First, the system of hospitals is deemed to be very complex and dynamic. Human errors, uncertainty, and safety regulations concern of patients and medical staff are factors that add considerable level of complexity to the system. Secondly, service demand in hospitals is continually growing especially in developed countries due to the demographic developments and changes of modern societies.

Ireland to comply with the European Union (EU) regulations is obliged to maintain a certain level of medical service quality and allows its residents a fair access to this service. While massive spending and effort have been directed towards hospital improvement in Ireland, services provided in Irish hospitals are still ranked relatively low comparing to the other developed European countries. The overall performance has witnessed a slight improvement due to that spending, however hospital services in Ireland are still criticised because of long

waiting times and delay in service access (Siciliani and Hurst, 2005). Irish population is expected to gain more growth and aging (Briefing, 2008) which cumulate further pressure on research to provide innovation solutions for Irish hospitals. In order for improvement effort to become more effective and have superior impact on system performance, new approaches should be presented. Researchers attempt to provide robust solutions in order to tackle the inefficiency of patients' flows and across various operations in hospitals (e.g. administration and logistics). Cost-effective approaches along with process improvement techniques can play a crucial role to restore quality level of hospital facilities with clear objectives of; minimum waiting time, leaser medical errors, and optimum resource utilization.

During last couple of decades, applying technology had a significant impact on hospital performance in terms of responsiveness, service quality, and management practices. Radio Frequency Identification (RFID) technology has been successfully implemented in a number of hospital systems in many developed countries. It is an emerging technology for applications such as; automating information transfer and tracking patients, drugs, and medical assets (Fisher and Monahan, 2008). Integrating RFID technology into hospital systems allows substantial contribution in hospital efficiency to take place (Kuo and Chen, 2008).

Most of Irish hospitals have adopted the usage of database applications to manage patients' information. Databases are considered as the foundation of information systems. They are also known as the essential base for many new information technologies and methods (e.g. RFID, simulation, and optimisation). The main goal of this research study is to review the potential benefits and challenges of enabling RFID technology in Irish hospitals. Specifically, the objectives of this study are to:

- provide a comprehensive review and classification of RFID applications in hospital systems,

- analyse the impact of RFID technology on the overall performance of hospitals, and
- discuss problems and challenges associated with RFID implementation.

2. RFID Technology

Although the fact that RFID technology was found during the end of World War II, its recent entry as economical and powerful entity tracking technology places it as an emerging technology with various applications in different industries (Ngai et al., 2008). It is used for identifying and tracking entities such as products, tools, equipment, and individuals via the radio frequency signals. The RFID technology has three basic components; Tags, Reader, and suitable IT infrastructure Figure 1.

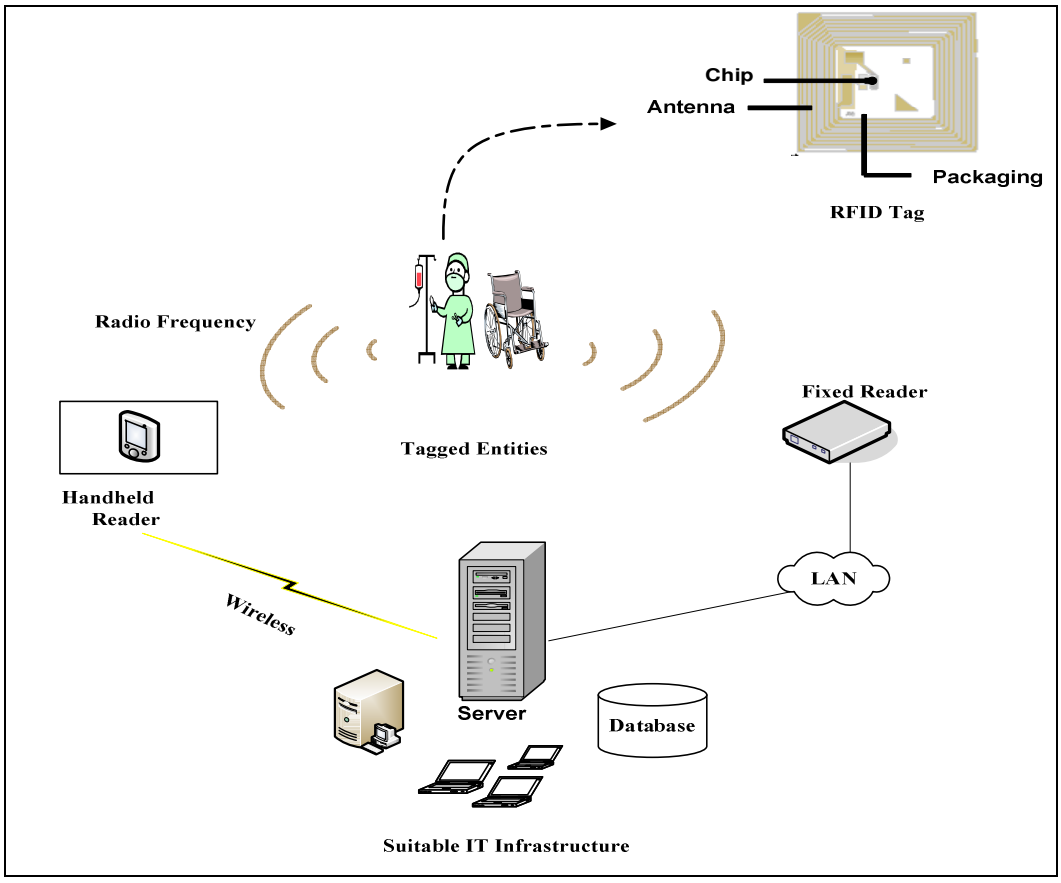

Figure 1. The main components of simple RFID system.

2.1 RFID Tags

The first component is a small tag contains an antenna and a tiny chip combined together in a way that easy to append to target entities. The main two types of RFID tags are; passive and active tags. A comparison of tag types is shown in Table 1 (Weinstein, 2005). Tags are presented in many forms such as bracelet, badges, asset, tags, and embedded microchips. Research development of RFID tags is directed to advance their functions for more applications. The key driver of passive tags development is to produce more memory capable and less expensive tags in more suitable forms and materials. While passive tags have limited applicability to communicate with smart technology platforms, active tags are the answer when emerging robust functions are required. Using Wi-Fi active RFID tags which response to standard Wi-Fi access points can reduce RFID infrastructure cost. They can also include sensors which allow them to update the stored information (e.g. update patients' temperature) (Want et al., 2006). The capability of wireless sensors and active RFID tags can be combined to enable better patient and medical equipment tracking (Huang et al., 2008).

Table 1. Basic types of RFID tags.

	Passive Tags	Active Tags
Power Source	• They use reader discharge to power a short response.	• They have their own power source and can last several years to run out
Range	• Short up to 5 meters	• Wide (could be tens of meters)
Storage Capacity	• They can store small data about 2 Kbits usually the basic identification information.	• They can store large data.
Development Target	• Enhancing the memory capability and reducing the cost	• Enhancing accessibility and sense functions
Cost	• Low cost	• High cost
Size	• Small	• Large

2.2 RFID Reader

The second component of RFID technology is the reader device which communicates remotely to adjacent tags and can be either as handheld or fixed devices (Domdouzis et al.,

2007). RFID Reader can be either passive or active based on the type of tags (Weinstein, 2005). Readers have been subject to many improvements that focus on supporting communication protocols and network technologies (Ngai et al., 2007).

2.3 IT Infrastructure

The third component for setting up RFID technology is the required IT infrastructure (e.g. a server, computers, and a suitable database application) to network RFID readers and to manage the data stream (Lahtela et al., 2008). Having an appropriate IT infrastructure plays an important role in the efficiency of RFID systems.

Though barcode systems are still used in many healthcare systems (Jossi, 2004), RFID technology is considered the next generation in this domain due to its superior capability (Al Nahas and Deogun, 2007). A discussion on how effective RFID comparing to barcode system was reported in (Hunt et al., 2007). Table 2 summarises a comparison between barcode and RFID systems.

Table 2. A comparisons between RFID and barcode systems.

	Barcode	RFID
Memory Capability	• Stores very limited information • Can't be updated or reused	• Has much better memory size • Can be reused many times
Usability	• Needs manual scanning for each Item. • Needs certain environmental conditions to work properly (e.g. normal light, clean, etc)	• Distantly tracks various items simultaneously. • Can work without a line of sight • Can penetrate any non-metallic material • Can work satisfactory in cruel and dirty environmental conditions
Cost	• Very economical	• Very high proportionate to a barcode label
Security	• having low security measures • Easy to be replicated	• Having a much better security level. • Difficult to be replicated

3. RFID Applications in Hospital Systems

RFID technology is considered as the new essential technology in hospital systems for its potential benefits to optimise service quality and cost (Wicks et al., 2006). RFID was applied at many functions including; tracking, identification, and sensing for various hospital

elements (e.g. medical equipment, medical material, patients, and staff). RFID is used in hospital either as a standalone technology or by integrating it in other tracking technologies.

Based on patient life cycle (from admission to discharge) and time motion perspectives, (Cangialosi et al., 2007) discussed where and how RFID can be applied in hospital systems. The study presented three RFID types: fixed RFID reader – for mobile objects, and mobile and handheld readers – for fixed and mobile objects. It also recommended a cautious implementation by starting with an extensive analysis of the current workflow, followed by identifying the key areas to begin with.

Case study analysis was done on various application of RFID in hospitals (Fuhrer and Guinard, 2006). The review suggested a future smart hospital where RFID can contribute positively to enhance productivity and improve service quality. A comprehensive summary of the future smart hospitals is shown in Table 3.

Automated identification process, which is more precise than the manual way is a key element for reducing medication errors and wrong procedure. Many applications in hospitals used RFID technology for automating the identification process. RFID technology was applied in a hospital clinical analysis laboratory to identify patient samples to automate identification process and reduce errors (Florentino et al., 2008). In this application, RFID along with a smart card system answered that the right samples were taken from patients. A process links RFID function with the hospital information systems for automating the whole process of inpatient medication was proposed (Lai et al., 2007).

RFID technology can be used along with other smart technologies for better functions. A prototype combines RFID and a smart sensor as an automatic system that allows quality control of blood and derivatives in the real time was discoursed (Abarca et al., 2009). The new system can track blood bags and monitor storing temperature and time of blood products to ensure effective procedure and good conservation.

Table 3. RFID applications for future smart hospitals.

Application	Proposed workflow	Possible Benefits
Patient Identification	On arrival, patients are given RFID based wristband that store only basic medical information with the possibility to retrieve all medical information from the main database via wireless connection by authorized staff.	Improper dosage of medication or inaccurate lab work will be eliminated by accurate patient identification.
Blood Tracking	Before a blood transfusion, both information on RFID chip on the patient ID bracelet and blood bag must be match.	The process of handling blood bags is easier and faster as well as blood transfusion errors will be minimised.
Smart Operating Theatres	The RFID attached to the patient wristband contains the necessary information and digital information and the electronic record of planed surgery will ensure the right procedure will be carried on the right patient.	Errors involved in surgical operations will be reduced.
Anti-Counterfeiting	Use RFID tracking system into packaging of prescription drugs.	The risk of using counterfeit drugs that may contain improper substances will be minimised.
Tracking Equipment, Patients, Staff, and Documents	RFID tags are attached to important equipment, patients, staff, and medical files.	The Efficiency of tracking medical assets and files and managing inventory system will be increased while the risk of losing important medical equipment will be reduced. The workflow of staff and patients can be improved with the possibility to supervise and guide them in the real time.

A case study conducted at Taiwan hospital that use active RFID tags to continuously detect, track, monitor the temperature of severe acute respiratory syndrome (SARS) patients was discussed (Wang et al., 2006). The study presented interesting recommendations for strategy, design, and implementation phases, include evaluating the current IT infrastructure and considering the difficulty faced throughout device and data management for better integration. It suggested also using team approach especially, medical staff for better staff motivation and less resistant to the new technology.

Five different pilots used in hospitals in five countries (Al Nahas and Deogun, 2007) were presented (Table 4). Real-time tracking of medical devices and easy identification for sleeping patients and babies are the most outcomes of the first pilot. The second system

developed a smart system where patients and clinicians, pill containers are tagged. Beds are enabled by RFID reader and an inbuilt display for showing and accessing medical records. Beds identify patients and nearby staff and verify the use of prescribed medicines. The system can be useful for preventing the error of taking incorrect medicine and for reducing the manual activities relating to medical data preparation. The third and fourth pilot showed the benefit of using RFID in identification process and the fifth pilot used RFID for safer anaesthetic drug administration.

Table 4. RFID systems in hospitals, enabling technologies, and specific applications (Al Nahas and Deogun, 2007).

System name	Enabling Technologies	RFID Applications
Harvard hybrid system.	Passive and active RFID and a hybrid system of bar code.	Identification of patients, NICU babies, and mother's milk containers; tracking equipment and staff.
Aarhus context-aware application.	RFID, finger-print recognition, and bedside displays.	Patient and clinicians identification, drug administrations (pills), and access to medical records.
Galway RFID/handheld application.	RFID, handheld devices, and IEEE 802.11b network.	Patient identification and access to medical records.
Intel transfusion system.	RFID, mobile RFID readers and programmers, and Cisco wireless network.	Transfusion; donors, recipients, and staff identification.
Auckland drug administration system.	Passive RFID.	Drug administration (syringes).

4. RFID Challenges in Hospital Environment

RFID Technology has potential efficiency and quality benefits in many hospital applications however, there are some restraining issues discourage its extensive implementation. In particular, return on investment (ROI), Technology, and Technology risks are fundamental challenges to widespread adoption (Wu et al., 2006). RFID challenges and related recommendations are illustrated in Figure 2. It is important to start RFID implementation by a pilot case in order to verify and evaluate its impact and also to better cope with the technology and its risks before going to further implementation in a larger scale.

4.1 ROI Challenges

The first issue delays the extensive adoption of RFID technology in a hospital system is the capability of providing an unobstructed analysis for the return on the investment (ROI). Even though the cost of infrastructure especially tags and readers and training required for applying RFID is reasonably reduced, wide implementation for the technology needs considerable initial investment. Looking into the expected investment in opposition to expected cost reduction and added value is the key of formulating the ROI (Wu et al., 2006). Few attempts to address the actual ROI of applying RFID technology were reported. Potential benefits of using RFID technology were addressed in the literature more than the actual ROI (Kumar et al., 2009). The same study recommended starting with pilot testing at most important areas before the actual implementation. A survey on 46 RFID projects (24 implemented and 22 not implemented facilities) in healthcare (Franklin, 2007) shows the applications in terms of importance as; asset tracking, patient tracking, patient identification, pharmaceutical tracking, infant tracking, and staff tracking. Integrating RFID technology with the existing IT infrastructure can help reducing the initial investment and then positioning the technology to more applications. Using improvement approaches such as lean principles (Correa et al., 2005) for analysing current processes and identify inefficiency when deploying RFID is very useful for systematically identify improvements areas. For instance, value stream mapping, one of lean tools is used to reviewing the sequence of a birth delivery process to rationalize where RFID should be implemented (Kumar et al., 2009). Simulation (Swisher et al., 2001, Eldabi et al., 2002) proved to be a robust tool to study the best implementation scenario to explain the impact of RFID implementation on the expected ROI before actual implementations.

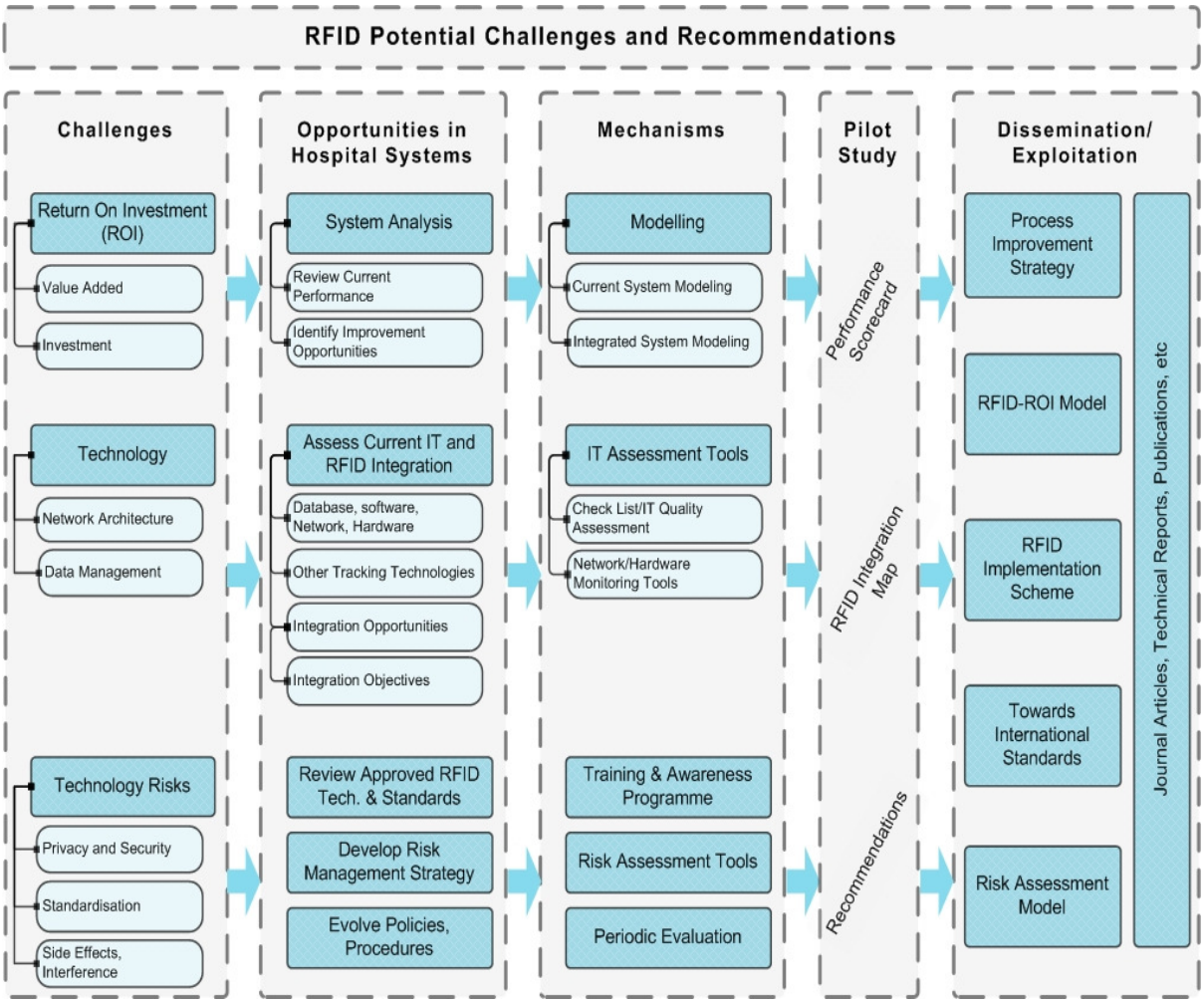

Figure 2. RFID potential challenges and recommendations.

4.2 Technology Challenges

Selecting the technology items carefully to trade off the cost and function is the second difficulty faces the embracing of RFID technology. In order to handle the immense amount of records generated by the RFID readers, a robust design of RFID network is required for data management challenges (Chawathe et al., 2004). For example, (Chen, 2007) presented a design for RFID network architecture that reduces the network and database loading by 41.8% and system loading by 83.2%. Pilot study will help dealing with technology implications and ensuring that RFID integration will be correctly aligned with the system objectives.

4.3 Technology Risks

One more challenge is the risks of applying such technology in hospital systems. Specifically, they include the risk of; information security and Privacy, Technology Standardisation, and side effects or radio interference. Effective risk management strategy, policies and procedures, periodic evaluation, and awareness programs are essential for managing these risks.

4.3.1 Information Privacy and security

RFID as other technologies might be hacked by unauthorized persons. Another concern is an improper access to patients' confidential data.

4.3.2 RFID Standardisation

The standard variation between RFID technology and other technologies existing in hospital systems hamper hospital administrators to invest widely in RFID application (Fisher and Monahan, 2008). Standards of RFID are various and complex (Juels, 2006). There is a need for unified worldwide standardization that facilities the use of RFID. In a global environment, local RFID standards and rules will hinder the manufacturers of medical equipments and hospitals intensively spend for RFID technology. Developing RFID Standards is in a process of development and the challenge is on the way to be resolved. Some international organizations (e.g. ANSI and ISO) are trying to develop RFID Standards for some applications (Roberts, 2006).

4.3.3 RFID Side Effects or Radio Interference

This risk also delays the wide use of RFID in hospitals. It is the risk that RFID devices may interfere with some electrical medical equipment or may have side effects on exposed patients and medical staff. While this may be a current concern, several RFID systems are approved to be used in healthcare applications. For example, Food and Drug Administration

(FDA) permitted the implantable VeriChip to be used as patient identification and for storing the basic medical data (Ip et al., 2008).

5. Conclusion

Healthcare service is the unique service that faces continual increase in the demand regardless to the economic situations. It struggles to reduce operational costs while keep improving service quality. Gaining a better control on hospital systems, RFID technology is presented as one of the best options to improve service delivery. RFID technology has a variety of applications in hospital systems that demonstrated the potential of enhancing system efficiency and minimising quality problems. This paper presents how RFID technology could be applied at different areas of hospitals to add value to the service level.

Most applications go for integrating RFID technology with the existing infrastructure rather than re-engineering approach. More researches are needed to study the actual ROI analysis for actual implantation phase.

RFID successful implementations are confronted with many challenges including strategic impact on investment, integration with current systems and technologies and risks associated with information technologies.

Extensive system analysis is a crucial step in order to identify the improvement opportunities by using RFID technology. This step includes a full assessment of current information technologies before integrating the RFID system. Modelling and simulation have proven to be effective tools to be used to support the justification of changes required as well as the impact of introducing the new technology in place. Risk assessment is also needed to assure that no pitfalls will surprise the critical hospital system due to the radio frequency or the magnitude of the data flowing from RFID devices into the data systems. Reports and publications have agreed that it is recommended to start the implementation procedure by a pilot case.

Researchers in healthcare industry and partner organizations need also to direct more effort towards unifying the complex standards currently introduced into a cohesive international standard.

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