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A review of challenges and barriers implementing RFID technology in the Healthcare sector

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Abstract

The healthcare industry is progressively involved in adopting new technologies to provide improved quality of care given to patients. The implementation of RFID technology has globally impacted several industries and this revolution has improved the aspects of service delivery in the healthcare industry as well. The RFID technology has the potential to track medical assets and interact with almost any of the medical devices, pharmaceutical materials, IT equipment, or individual patients, deployed in hospitals all over the world. The motivation behind this paper is to investigate the advantages and obstacles to implement RFID technology in the healthcare sector highlighted in the literature. Further, we highlight the most possible methods or technologies to be adapted to overcome the limitations of implementation.

Keywords: RFID technology; Ambient Intelligence healthcare; RFID Healthcare management systems; Asset-tracking;

1. Introduction

The productive utilization of resources will lead to improved quality time spent in treating the patients such that the hospital employees can reduce the time spent on looking for medical supplies and devices. Healthcare data

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handling and integration is a major task in the healthcare environment. A typical patient service involves various activities such as identifying patients and type of service to be provided, history of the treatment given and accessing patient data. Conventional methods involve human intervention in identifying and managing patient data, which maybe prone to errors leading to fatal outcomes. Radio Frequency Identification (RFID) [1] is being rapidly used by the healthcare sectors to track medical supply stock, identify patients, and oversee work force [1]. RFID has the capability to capture data without any human intervention and it consists of consists of a transponder (tag), a transponder reader, and a database software application [2]. The transponders are again classified into active (those that have their own energy source) and passive (those that depend upon transponder reader for its energy source) [3] [4]. The transponder's reader collects data from the tag using radio frequency signals and the data collected includes the identification proof, data encrypted in the tag, and its physical location [5].

This technology the efficiency of medical asset tracking cost effectiveness of healthcare service providers and improving patient safety [26] [52]. The utilization of RFID technology impacts all the players in the hospital environment including patients, doctors, nurses, technicians, administrators, other medical care providing staff, insurance companies, and government regulatory agencies. Introducing RFID technology for healthcare assets, patient and staff tracking can help in reducing medical errors [1] [7] and workload of healthcare service providers thereby improving the efficiency of patient care [1] [7] [13]. RFID technology implementation in healthcare systems had led to enhanced and remarkable transformation by eliminating problems in the healthcare sector such as the long-established paper based process, low discernibility of patients, staff, medical equipment, and data. However, there are several other important factors that need to be considered such as cost management, people management in busy healthcare sectors adapting to changes in operations, ethical and legal considerations before implementing this technology in the healthcare environment [6] [50]. When adopted, the RFID innovation in the healthcare services sector can possibly give colossal advantages such as enhanced effectiveness such as reduction of operational cost, reduced labor cost; quality advantages such as improved patient care, and reduced medical errors; and intensified management advantages such as overall improvement of the process, regulatory agency compliance, and coordination between the healthcare service providers and medical insurers [27].

The healthcare industry has started investing more time and resources in various technologies to improve the care provided for patients. However, there are several obstructions when technology is implemented to deal with sensitive patient data. Inspired by the significance of having a useful and viable RFID based solutions in healthcare, in this paper, we present the challenges and barriers faced by the healthcare sector in implementing the RFID based solution to improve various services provided by the healthcare sector. When utilized meticulously, RFID will serve several purposes in the healthcare industry such as tracking patient and medical staff, Medical asset and tool tracking, inventory tracking, laundry Tracking, and Medical wearable tracking. The purpose of the paper is:

- To provide an insight into the existing RFID utilization in the healthcare sector and review the existing literature on RFID technology.
- To investigate the challenges, obstacles, and issues faced by the healthcare industry to implement RFID in their organizations.
- To identify possible solutions to overcome the challenges related to security, data visibility, and other occupational based pitfalls and to successfully adopt the technology.

The rest of this paper is organized as follows. Section 2 sums up the related work in literature. Section 3 presents the potential implementation challenges faced by the healthcare sector to implement RFID technology. Section 4 concludes the paper.

2. Literature Review

In this section, we summarize the initiatives, existing articles, and publications found in articles related to RFID, various stages of its implementation, and challenges faced in implementation. RFID in the supply chain industry is well known to trace and track the products but has not been well adapted in the modern healthcare industry [28]. The authors [28] present the benefits, areas of applications, and implementation challenges of RFID in the healthcare industry, especially in hospital environments. Further, the hospital environment consists of a combination of various technologies such as patient data management, sensor networks, and RFID technologies. Ho et. al [29] proposed a project in integrating sensor networks and RFID technologies to build a system elderly to monitor the in-home

medication intake for elderly people as this model is aimed at focusing to support the care for the elderly population. The developed model has two phases namely the learning and development phase in which compatibility of sensor networks in interacting with RFID system falls under the learning phase and the latter phase builds a system that consists of sensors and high frequency RFID system components. In this paper, the authors further studied the challenges in implementing a user friendly healthcare system by combining both these technologies.

Internets of Things (IoT) and smart technologies have paved the way for endless possibilities and opportunities in the healthcare sector improving facilities provided to the patients as well as enhancing the security of the entire healthcare ecosystem [30] [51] [53] [54] . IoT can mechanize patient consideration work process with the assistance of medicinal services portability arrangement and other new advancements, and cutting edge medical insurance offices. A state-of-art of RFID application for body centric system and information retrieval about the user is designed in [30]. Carr et. al focuses on factors influencing the adoption of RFID in healthcare organizations [31]. Various direct and indirect relationships and risk factors were analyzed to identify the usefulness of the factors for the healthcare sector. However, the analysis by the authors couldn't find relevant information to support the relationship between various factors and to practically put it in use. The aging population has caused a major concern regarding the housing, economic growth, quality of life as it requires high quality and long term care for the elderly people [32]. Jang et al [32] identified a study to determine quality characteristics of ubiquitous healthcare (u-healthcare) for healthcare service that impacts the healthcare service providers' aims and came up with a research model, to identify an individual's intentions of use for u-healthcare. In addition, the study carried out guides the decision makers and policy makers to plan and execute systems for long term care.

One of the most promising applications of RFID is its asset tracking capability. Álvarez López et al [45] and Booth et al [33] examined the implementation of RFID technology in the integrated healthcare environment to track medical staff, patients and medical equipment by effectively observing resource courses through an organization and empowering this information to be examined for process improvement. The authors emphasize that the utilization of RFID technology in hospital operations will improve the safety of patients, enhance medical care given, improve clinical services, regulate the billing process, and prevent theft of hospital assets or equipment [26] [33] [52]. Ngai et al [34] proposed an RFID based Healthcare Management System (RHMS) which was built and implemented in a quasi-real world setting. The result of the proposed model shows the system design to develop the RHMS. A mobile healthcare service system using RFID technology to identify people and instruments both inside and outside the hospital premises while treating an acute infection spreads in the society is discussed by Li et al [35]. The system for the control of SARS infection and the methods to receive the patient's location and details of their health condition in order to take control measures is discussed [35]. This proposed model highlights different ways to provide healthcare services to regions across various geographic locations thereby transforming electronic healthcare to mobile healthcare. Lingle's [46] article for the Packaging world, articulated the factors for an organization's reluctance in accepting RFID implementation is presented in figure 1. The biggest challenges identified are cost, followed by operational complexity, lack of technical expertise, knowledge in utilizing RFID data and other miscellaneous reasons.

Ethical issues in tracing and tracking of individuals and equipment is a major concern while implementing RFID technology. Though RFID is a promising technology to track and handle assets, there might be a security issue if the information is accessed by a malicious hacker. Ambient Intelligence is a comprehensive technology that includes a combination of smart technologies such as IoT, Artificial Intelligence, Pervasive computing, Intelligent Networks, Human-Computer Interface (HCI) [36] [53] [54]. Ambient intelligence is a system based environment that reacts and responds when humans are present in the environment which suits well to be adopted as a framework for smafrt healthcare technologies. Ambient intelligence has several attributes such as the awareness of the presence of individuals, awareness of contexts, recognizing gestures and spoken commands, adapting to the needs and wants of the individuals. Kosta et al [37] assessed five scenarios based on AmI (Ambient Intelligence) focusing on the healthcare industry, assistive technology and day to day life activities involving homecare. The authors discuss the factors of mobile devices evolving as an interaction tool with the environment. As a result of dealing with humans and their interaction with the environment or system, a huge amount of data is collected. Metras [38] presents an overview of the combination of RFID and ambient intelligence technology in which RFID uses tags to collect data from the user and the latter focuses on data on servers (both centralised and distributed) accessed by users with the help of URL addresses stored in tags. This technology is still emerging, and the legal and ethical issues in adapting

ambient technology such as ransomware attacks are a major cause of concern. Since RFID deals with a huge amount of sensitive patient data, the combination of ambient intelligence and RFID is still questionable.

A medical error might involve wrong diagnosis or treatment for an ailment, infection, and syndrome and is the third leading cause of death in the US [39]. Minimizing medical errors must be one of the primary goals of healthcare organizations to ensure patient safety. The current state of Hospital Information Systems (HIS) is unable to track the details about the patient's credentials, operational location and time accurately [40]. Integration is a major issue in healthcare and becomes the significance cause of serious medical errors which may sometimes lead to fatal outcomes. Wu et al [40] analyses by reviewing existing literature and several interviews with experts in the medical field that the serious factor of medical error is the medicine provision in healthcare. An RFID backed system will ensure self-regulated patient identity; verify various drugs administered to the patient at various treatment stages, and regulate the patient registration system [40]. Any forms of errors can be eliminated on the verge of its initial state thereby reducing or completely purging medical errors. When most of the research work found in the literature focuses on the benefit of RFID technology to healthcare, Ting et al [41] discuss the management based issues in developing RFID projects across the healthcare industry. A case study on Humphrey and Partners Medical Services Limited, a medical organization was conducted to analyze and determine a development framework and important issues to consider before implementing an RFID based project.

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This research review's purpose is to gain insight and understand RFID technology development and the existing threats and security risks in implementing the RFID technology on a large scale in the healthcare industry. We consider this to be significant because it was a result of analyzing many healthcare industry expert interviews, high quality research articles present in literature, and healthcare organization's annual reports on RFID technology implementation and utilization [45]. There has been much research and study conducted to analyse various factors influencing the implementation of RFID technology on a large scale in the healthcare sector. It is more important to conduct research on the results obtained from existing work to identify the pitfalls and shortcomings for the successful adoption of this revolutionary technology for the enhanced benefit of customers.

3. Challenges in Implementing RFID for healthcare organizations

The social and hierarchical elements add to the achievement or failure of RFID frameworks in emergency clinics that must be additionally dissected. As discussed below many categories of challenges faced by the healthcare sector in implementing RFID technology.

Tracing the social implications ought a major concern as the ramifications of RFID frameworks, for example, safety concerns for nursing and other emergency clinic staff, to be considered from the beginning, particularly during the plan and execution of the innovation [8]. Though RFID technology has been in the market for more than a few decades,

there are several challenging factors that have to be addressed before a large scale and efficient implementation of this technology in the healthcare sector.

Some of the other prominent challenges identified in implementation are presented below in a detailed manner.

- **Cost effectiveness** (for maintenance & testing): Though RFID has revolutionized the asset tracking practice, it can be costly. RFID (software or hardware) will need more extravagant equipment to maintain it throughout its lifetime. Though the price has reduced over the years since its introduction in the market, business organizations are hesitant to adapt to this technology because of the raising costs [9] [10] [15] [45] [47]. Irrespective of the type of tags, i.e., active, semi-passive and passive, the costs of the tags impacts the cost management of a business organization.
- **The trouble with metals and liquids**: RFID tags use electromagnetic waves as a medium of communication. Though RFID uses cutting edge technology, it does not work efficiently through metals or liquids as they inhibit the electromagnetic wave propagation [18].

- **Difficulty in training**: RFID technology has been extensively produced and used in the USA to provide state of art healthcare services in the USA [11]. However, when implemented in developing countries with business support from local distributors, there is a lack of technical support and skill [12]. Insight about various RFID tags and frequencies can be a challenge if there is a lack of technical skill and support. Though the Asian healthcare sector is huge, due to lack of technical support, the full scale implementation of RFID is still emerging.
- **Ethical Issues**: The major issue is the breach of privacy, as anyone who uses the reader device for RFID can get access to the patient data and there is a high risk for the fraudsters to misuse the sensitive medical data [13] [14]. RFID chips can be implanted in a person in two ways, either as an external tag to be worn or as an injected internal chip implant or otherwise a sub-dermal implant [16]. In either case, the consent of the individual is important. However, this consent alone cannot guarantee safety from any of the negative effects caused because of the implantation of the electromagnetic powered RFID tag. This technology will thereby reduce the freedom of people in society as it tracks every movement of the person and keeps the legal authorities informed in the digital world.
- **Narrow channel bandwidth**: Lui et. al [48] have highlighted the fact that when compared to WiFi devices and other FMCW radios, channel bandwidth of RFID is limited. The authors [48] claim that there might not be enough details for vital sign tracking with RFID technology. However, it is suggested in the paper that "*software defined radios*" such as USRP can be introduced to produce more signal characteristics for a better understanding of the vital signs.
- **Microchip Implants for healthcare:** Werber et al. [54] analyze the fact that only very few studies deal with "*RFID subcutaneous microchip*". The authors [54] developed a model for analyzing the acceptance rate of the RFID –SM model by conducting empirical studies. The results obtained proved that an anticipated convenience proved to be of higher significance in terms of the adoption of any new technology including RFID-SM. However, such researches are still in their infancy and hence a wide spread adoption of modern technologies might take a while.

4. Future Perspective

The RFID technology has been in the market for a long time and deals with a huge amount of data on a daily basis. As a part of a future perspective, Machine learning techniques can be combined with the RFID technology features to provide a personalized diagnosis and care for patients depending upon their medical history, age, gender, drug vulnerability [58]. Conventional systems are known to operate in an effective manner whenever a regulation – based system is in effect. But, in healthcare ecosystems, the data is continuously changing or combined or added to the existing records. In such cases, machine learning transcends in performance by appending new rules to get the desired outcome. This, in turn, will give good monetary gains and proves to be cost effective for systems such as healthcare that requires constant updating of records or data. Figure 2 shows our proposed future framework combining RFID technology and machine learning features for effective and stable healthcare data management.

5. Conclusion

RFID seems to be promising in the method in which health care services are provided to patients with cutting edge technology. In this paper, we discussed the features of RFID in the healthcare sector and highlighted the current challenges faced by the healthcare industry while implementing the RFID technology related to asset tracking and patient data management. Several other pot barricades of implementation were identified and discussed.

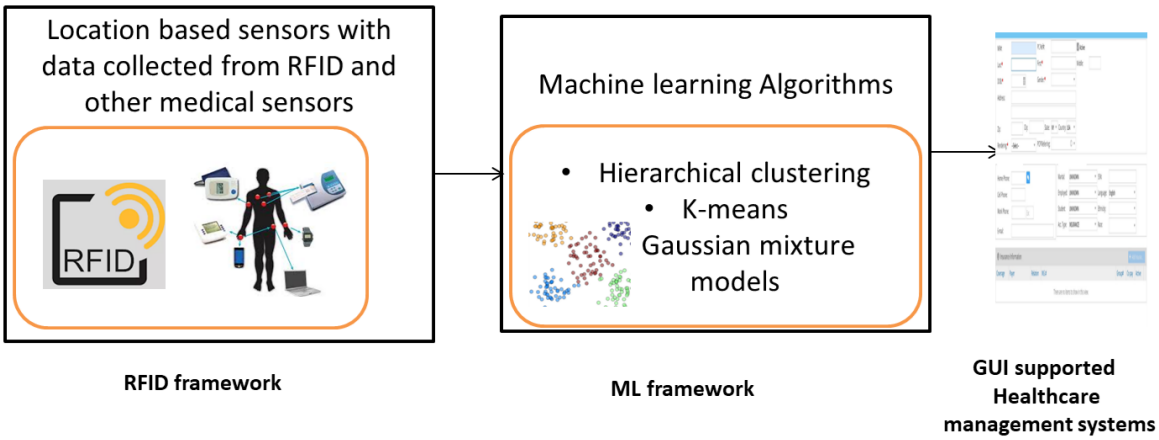

Fig. 1. The proposed future framework of ML supported the RFID framework for smart healthcare

These challenges when addressed throw light on emerging opportunities in efficient handling and management of RFID data and provide guidance in large scale implementation and global adoption.

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