EFFICIENT HEALTHCARE PROCESS BASED ON UBIQUITOUS TECHNOLOGY: SAMSUNG MEDICAL CENTER CASE[*]

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ABSTRACT

Recently, there are many efforts applying RFID(Radio Frequency Identification) technology into healthcare industry. This study introduces the Healthcare Information System based on ubiquitous technology including RFID. The results of the case show that the system improve the customer's satisfaction of overall process and reduce the waiting time for customers. It also improves the efficiency of the process and reduced trivial works of staffs. The system also provides the safety since the system can be shared with the staffs about any caution of the customers. Using emerging technology in a combination of RFID and mobile devices, this case gives great satisfaction to both the customer and staffs.

KEYWORDS: RFID, mobile device, healthcare

I.   INTRODUCTION

For the past few years, healthcare organizations over the world have also had a blueprint to adopt the Health Information System (HIS) based on the wireless network infrastructure. As a part of the wireless network, a mobile device has been employed in a large scale of hospitals due to its outstanding mobility.

Recently, Mobile healthcare is an important research direction for the application of wireless communication in healthcare systems. In particular, mobile networks not only provide mobility to patients, but also allow physicians so they can access patients' data anytime and anywhere. This brings important benefits to both patient and medical service provider.

Radio Frequency Identification (RFID) is a fast developing technology that uses radio waves for data collection and transfer; it can capture data efficiently and automatically without human intervention. RFID is believed to be the next generation innovation for automatic data collection and asset tracking. Although the technology is attractive, RFID is far behind earlier expectation. For a variety of reasons, adoption of RFID by healthcare has not fully developed because the cost benefit does not produce immediately [23]. Although costs are decreasing, many companies are still reluctant to invest in a technology not yet widely adopted [21]. [22] found that staffs believe the implementation of RFID in health care could lead to many benefits including improved patient care, improved patient security and safety, and improved organizational performance. RFID shows great promise in helping healthcare improve patient safety and achieve operational efficiency, but it also presents implementation challenges such as interference with medical devices, privacy concerns, prohibitive costs, and lack of global standards.

In this paper, we introduce the case of Samsung Medical Center (SMC), which is the best hospital providing hi-tech medical services using RFID and mobile device in Korea. They are trying to

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improve their hospital environment using emerging technology, such as mobile devices, RFID, and so on. In particular, SMC designed and developed a system to innovate on health checkup process.

The Samsung Medical Center is one of the most popular hospitals in Korea. The Samsung Medical Center consists of a hospital and a cancer center. The hospital is located in an intelligent building with floor space of more than 200,000 square meters and 20 floors aboveground and 5 floors underground, housing 40 departments, 10 specialist centers, 120 special clinics, and 1,306 beds. On the other hand, the 655-bed Cancer Center has 11 floors aboveground and 8 floors underground, with floor space of over 100,000 square meters. SMC is a tertiary hospital manned by approximately 7,400 staff including over 1,200 doctors and 2,300 nurses.

The results of the case show that the system improve the customer's satisfaction of overall process and reduce the waiting time for customers. It also improves the efficiency of the process and reduced trivial works of staffs. The system also provides the safety since the system can be shared with the staffs about any caution of the customers. Using emerging technology in a combination of RFID and mobile devices, this case gives great satisfaction to both the customer and staffs.

In this paper, we discuss about the current RFID technology and applications, then we discuss about the RFID technology in healthcare industry, especially, hospitals. The, we introduce the case of Samsung Medical Center, and the concluded a paper.

II.   BACKGROUND

A few studies have contributed toward reviewing research studies in healthcare or hospitals. [30] They discussed the potential benefits, implementation challenges and strategies of RFID in hospitals. However, their review is more industrial oriented and did not follow a formal framework. Other literature reviews also gave an overview of the state-of-the-art research on the potential use of RFID in hospitals but they are not comprehensive [19][27]. Lee and Shim [16] used case study to examine the RFID adoption decision process and proposed a model predicting the likelihood of adopting RFID within the healthcare organizations.

In [25], they utilized PDA*(Personal Digital Assistant)* to develop a remote access system for doctors to access the routine patient inspection records of each ward in the hospital's information system. The doctors can use their PDAs to read the badges of RFID for identification, and afterward they can use the system to speed up routine patient inspections. From the above researches, it is easy to find out that RFID does make significant contributions for promoting the quality of medical services and reducing the burden of responsible personnel.

To reduce time and cost in healthcare industries, RFID-based asset tracking and monitoring system can help prevent valuable assets and equipment from being stolen [27]. Other benefits include improving staff productivity, decreasing equipment rental, and improving regulatory compliance [4]. Staffs can save a lot of time searching for medical devices in their daily activities and can focus on their duties.

Regarding the medical process, most hospitals want to improve the patient workflow and the operational process so as to save costs and enhance patient satisfaction. RFID has the potential to significantly improve operations by actively monitoring asset and patient flow through the hospital [6]. Furthermore, the recorded data can be analyzed to improve hospital efficiency [5].

In general, there are a number of challenges posed by RFID implementation in healthcare industries as follows:

- Cost: RFID is still expensive, not plug and play, and has not yet proven its reliability in large-scale implementations.
- Environmental conditions: Tag reliability can be impacted by humidity, metal surfaces, liquids, and more. Current RFID tags cannot withstand extreme temperatures without temperature-resistant housing. For that reason, using them for items like surgical instruments is complicated.
- Limited application: It is still difficult to apply and read RFID tags on metal, fluids, and special textures. These currently limit tag application to cardboard, paper and plastic packaging.
- Technology incompatibilities: Interoperability between different RFID standards is not available at this stage, and will

III.   RFID IN HEALTHCARE INDUSTRY

In healthcare industries, especially hospitals, they are trying to find a way to improve efficiency of their process and reduce the cost of the operations in hospital. To achieve these goals, they have tried to adapt high technologies such as wireless networks, RFID, mobile technology, etc.

In general, RFID uses in the medical fields including tracking equipment, tracking patients, and tracking staff. Tracking expensive medical equipment, patients, and staff members are important processes in hospitals, they can improve their processes efficiently by RFID.

3.1 Why RFID needs in Healthcare Industry?

Hospitals are currently facing challenges of improving patient safety and reducing operational costs, which are often compromised by human and systemic errors. Also, achieving high operational efficiency in healthcare is another essential goal for performance evaluation of organizations [8]. In particular, five problems are identified as the common phenomena that lead to healthcare operation failures including medical mistakes [16], increased costs [30], stolen [16], drug counterfeiting [19], and inefficient workflow [10]. We are expecting to overcome these problems with RFID technology.

1) Medical mistakes: Medical errors have become a major cause of death. FDA also estimated that half of the drug errors are preventable by adopting the appropriate information technologies. Medical malpractice can come from patient misidentification which is recognized as a serious risk to patient safety [1], adverse drug events, infant missing or mismatch, and accidents.

2) Increased cost: Hospitals are actively seeking methods to reduce the rising healthcare expenses as well as not adversely affecting patient satisfaction.

3) Stolen: It is estimated that the theft of equipment and supplies costs hospitals $4,000 per bed each year, tracking medical devices, especially expensive assets, is of upmost importance.

4) Drug counterfeiting: Drug counterfeiting is caused a huge problem for people's health and the society [19]. Both consumers and manufacturers are looking for ways to keep drugs safe [21]. Item level RFID tagging is believed to be the best solution against counterfeit drugs.

5) Inefficient workflow: Inefficient workflows exist in every hospital because of the difficulty in allocating resources in real time. Most medical facilities practiced managing the large number of seriously injured patients expected during catastrophic events. During mass casualty events, as the demands on healthcare teams increase and the challenges are faced by managers, workflow bottlenecks begin to develop and system capacity decreases [10].

3.2 RFID Applications

RFID has been applied in a variety of healthcare practices. In particular, hospital applications are organized in five categories as follows.

1) Tracking: Tracking assets and equipment is the most widely used application in hospitals. RFID is moving beyond the perception of being solely an asset tracker and increasingly viewed as a technology that can improve care by tracking vulnerable patients. [3][2]. Further, RFID is used to accurately determine the location of victims and staff at the emergency site [1][8]. Compared to asset tracking, people tracking is more challenging since it involves patients, doctors, medical know-how and other organizational, privacy and social issues.

2) Identification and Verification: Misidentification is one of the major reasons of medical errors and it can be reduced by RFID. Positive patient identifications (PPI) applications include using a smart patient wristband that when scanned by a RFID reader reveals patient information such as name, date of birth, admitting orders, insurance information, and the surgical site [26].

3) Sensing: RFID tags can be applied to collecting sensor-derived data and doing computation by extending the chip's interface capability to a sensor. In hospitals, temperature sensing makes it very convenient to track tainted blood to aid in protecting a hospital's blood supply; chemical sensing can support advanced medical monitoring.

4) Interventions: RFID-enabled interventions can provide automated care, improve current procedure, guide pathway, enable automatic data capturing and collaboration, etc. Automated care is helpful for patients at home [18], and an assisted living system to support daily activities for visually sighted or brain injured people [7]. RFID interventions also can help alter current procedures and automate

manual process in hospitals [15]. Finding pathways for patients in the indoor environment can be accomplished by RFID, such as an indoor navigational system for blind or visually impaired people [14][20]. Also, currently data collection in hospitals is done manually. This process is time consuming and error prone. Fortunately, this problem can be solved by RFID. Collaborating with HIS, RFID can help build intelligent clinical diagnosis and treatment support system [13].

5) Alerts and triggers: Applications involving alerts and triggers are designed to protect patient from dangerous events or emergencies during the surgery, drug administration, etc. In the surgical environment, RFID applications are examined in surgery and believed to make patient care safer [32]. Drug administration can be improved by alerting care providers any critical situation.

IV.   SAMSUNG MEDICAL CENTER CASE

The Samsung Medical Center (SMC) is one of the most popular hospitals in Korea. SMC is a tertiary hospital manned by approximately 7,400 staff including over 1,200 doctors and 2,300 nurses.

4.1 Problems

Samsung Medical Center (SMC) is the best hospital providing hi-tech medical services using RFID and mobile device in Korea. It has over 200 customers to examine the health checkup every day. The customers carried their paper examination progress notes and staffs communicated each other only with memos on the notes to care the customers. It was very inconvenient to both customers and staffs. Furthermore, it was dangerous in that any miscommunication could be harmful to customers. Using emerging technology, such as mobile devices, radio frequency identification (RFID), and near field communication (NFC), the SMC designed and developed a system to innovate on health checkup process.

Since the system can track customers' moves from reception desk to every examination room, staffs are able to resolve customers' inconvenience without any delay. With mobile applications, both customers and staffs can check customers' health checkup progress.

4.2 The Samsung Medical Center (SMC) and emerging technology

The SMC was founded on Nov., 1994 under the philosophy of "contributing to improving the nation's health through the best medical service, advanced medical research, and development of outstanding medical personnel". It is a 2,000 sickbed-size tertiary hospital with over 1,300 doctors. Number of outpatient visits every day is over 8,000. Equipped with computerized physician order entry (CPOE), electronic medical record (EMR), picture archiving communication system (PACS), and other clinical automation system, it is defining a new hospital culture in Korea by being the best hospital in terms of hi-tech medical services. Recently, emerging technology, such as mobile devices, RFID, NFC, and etc., is in high demand, since they can contribute to improve healthcare service. This study aims to innovate on health checkup process using this emerging technology

4.3 Challenges of health checkup process at the SMC

The SMC has over 200 customers to examine the health checkup every day. The price is as expensive as about 1 million KW per person, even though the price is very various depending on checkup package types. Thus, the customers are basically very valuable to the SMC. However, the customers carried their paper examination progress notes and waited in front of the examination rooms without any information about waiting.

The staffs communicated each other only with memos on the notes to care the customers and pop their heads around door to check who are in waiting in front of the room. It was very inconvenient to both customers and staffs. Furthermore, it would be dangerous in that any miscommunication could be harmful to customers if staffs miss any notice on the paper.

4.4 Design and Implementation

A task force, composed of doctors, nurses, medical laboratory technologist, radiologists, nutritionists, psychology consultants and IT engineers, is organized in November, 2012 and has checked how to apply the emerging technology into the practice. Based on services and functions requested by

stakeholders (Table 1), a system using mobile devices, RFID, and NFC was designed and developed from December, 2012 and was implemented into the practice in April, 2013.

Table 1. Functions by stakeholders

	Mobile devices	**Active RFID**	**NFC**
Customer	- Enter web survey before visiting the department - Check his or her checkup progress	- (Open a locker) - Carry on the move (and automatically registered to next examination)	
Staff	- Identify oncoming customers - Scan customers near, check their checkup progress and guide next examination	- Issue the tag to customers - Identify customers waiting in front of the room and call for next examination	- Check customers' checkup progress and guide next examination

The first requested service is that customers can fill out the web survey with mobile devices, prior to visit the health checkup center. A small but important request from staffs is that they can identify oncoming customers with a few questions at the entrance, confirm the customers' arrival with mobile devices, and transfer the information to reception desks. At the floor, flow mangers among staffs wanted to check customers around her and guide their next examinations. Both customers and staffs requested to use smartphone app to check their health checkup progress, especially information of the next examination, time left to finish the day's checkup, etc.

Technically, RFID device is equipped with both passive tag for key of locker room and active tag for tacking customers on the floor. Wall-type RFID readers are installed on the wall or under ceiling to track customers' move from reception desk to every examination room. Portable RFID readers are connected with USB port to mobile device to sensor customers around floor managers. NFC technology on smartphone is utilized to read information of RFID tag which is carried by customer and to figure out health checkup progress with using smartphone app.

4.5 Business process on active RFID tag and mobile devices (Figure 1)

A customer for health checkup is guided by email or text message to complete the web survey prior to visit. No matter what devices he has, he can access the web site with just clicking on the email or pushing on the text message as long as the devices are connected to the web (Figure 1-①). When the customer visits for the checkup, a staff can identify the customer with a tablet computer (Samsung galaxy tab 7.0) at the entrance. Then, the information is transferred to the reception desk and the customer name is displayed at wall monitor. In order of waiting, a staff at the desk calls the customer and issues an active RFID tag, which has a tag ID matched to the customer's ID on the SMC's database (Figure 1-②), instead of a paper chart which scheduled checkup items are printed in and staffs can write any notice on.
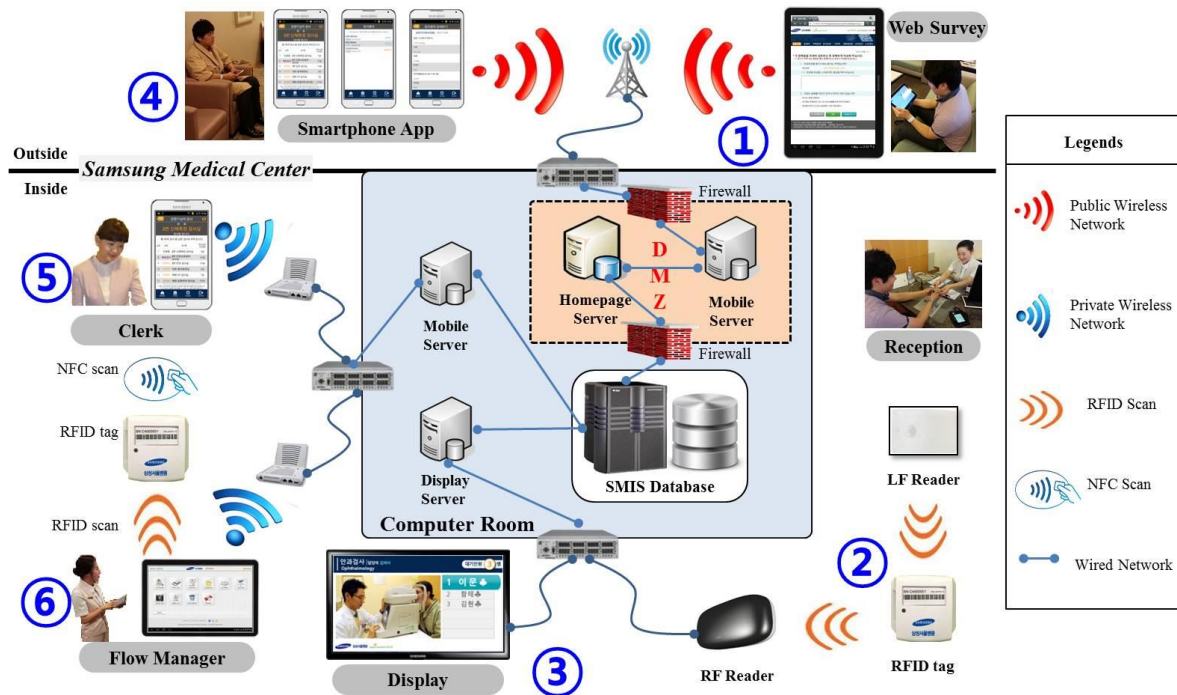
Figure 1. A system architecture and business process

All through the examinations, the RFID tag is put into his pocket. When he moves on the floor, the tag communicates with the RFID readers on the wall or under ceiling. A computer monitor is located in front wall of every examination room. At the moment he approaches to the examination room, where the scheduled checkup items will be performed, his name is displayed on the monitor (Figure 1-③). This means the customer has to wait here for next examination. At the same time, staff's computer in the room shows who is waiting outside.

Waiting his turn, he can also check the progress on his own smartphone (Figure 1-④). He can read off how many checkup items he has had, how many checkup items he has to take from now and how much time it will take. The staff also figures out the customer's progress, just touching the customer's RFID tag with his smartphone. This service is possible only on the smartphone which has NFC function (Figure 1-⑤).

A flow manager is a staff who finds customers in trouble and resolves the problem at hand. The majority of the problem is to guide them the next examination. A mobile application, which can be installed on Samsung galaxy tab 10.1 with Android OS, is developed. The mobile device is equipped with a portable RFID reader. When a "scan" button on the application is pushed by the manager, customers' names near her are displayed on the devices. When a name is selected, she can read off detail progress of the customer. If there is any memo about the customer, she can guide him in context of situation (Figure 1-⑥).

The customer goes home after returning the RFID tag to the reception desk when he finishes the day's health checkup.

4.6 Evaluation and benefits

To resolve the problems, SMC is developed a system and started a service. They also performed an evaluation of this service against customers as well as staffs in a hospital.

Table 2 shows the survey results from staffs and customers for the system. We have surveyed the system against 50 staffs and 100 customers according to the satisfaction levels including not satisfy(1), low satisfy(2), normal(3), satisfy(4), and very satisfy(5).

Most of the customers are over 40s in age. They are not in their best ages to use the emerging technology. In the SMC, emerging technology in a combination of RFID, NFC and mobile devices gives great satisfaction to both the customer and staffs.

Table 2. Survey Results

	Staffs	Customers
Efficiency	4.5	4.1
Convenience	3.8	4.6
Overall Satisfaction	4.1	4.4

RFID adoption in healthcare can not only reduce cost and improve efficiency by tracking assets, patients, and staffs, but also reduce medical errors to improve patient safety and save lives. Among several benefits from RFID, we describe benefits with SMC service.

1). Improved patient safety

RFID can quickly retrieving patient information and monitoring patient location in hospitals so as to improve the accuracy of patient identification [1] and any medication a patient is taking [31][29]. Finding the required equipment with minimal delay can save patient life [10]. Integrating RFID with existing HIS can improve decision making by accessing patient information in real time accurately. Further, RFID-based tracking system can improve personal safety and security by better access control.

In case of SMC, they also improve the safety since any caution of the customers such as allergy can be well shared by the staffs.

2). Reduced medical error

Alerting services can identify possible human errors and warn care providers in case of danger. Whereas communication among the staffs could not be monitored in case of progress papers, any notice for customers is colored on red not to miss during the process.

3). Time and cost saving:

RFID based asset tracking and monitoring system can prevent valuable assets from being stolen [27]. Other benefits include improving staff productivity, improving cost efficiency, decreasing equipment rental, and improving regulatory compliance [11][23].

Another satisfaction of this service is that the customers can be put on the waiting list automatically when they access to the examination rooms. But cost saving is not consider at this time.

4). Improved medical process

Hospitals want to improve the patient workflow and the operational process so as to save costs and enhance patient satisfaction. With automatic data capturing and storage capability of RFID, manual processes which are typically employed to record data can be automated. RFID has the potential to significantly improve operations by actively monitoring asset and patient flow through the hospital [6]. The main benefit to the staffs is that repetitive questions are drastically reduced from customers, because this RFID system enables customers to manage the checkup progress themselves with information on the displays or on the mobile devices. The staffs can also care the customers without asking the name since the RFID tags automatically transmit information to the staffs through the mobile devices.

5). Improved customer satisfaction

RFID technology brings benefits such as enhancing patient satisfaction [30]. Overall satisfaction of customers is more than 4.4 in Table 2, they do not have to carry or hold progress papers no more. They are also very proud that they feel they are treated with utmost devotion of the staffs, since staffs can identify customers near them and solve problems without any request. Another satisfaction is that the customers can be put on the waiting list automatically when they access to the examination rooms.

V. CONCLUSION

There are many efforts applying RFID technology into healthcare industry. The RFID system is an innovative tool in that the business process can be efficiently improved by ways not to be realized before. Adoption of the system may not ensure financial justification because IT system is usually cost-centric, and does not directly contribute revenue. However, the system helps to efficiently resolve any inconvenience as the SMC's RFID system does. It also affects to retain the existing customer and secure new client because of improving organization's brand image. Therefore, this innovative system is regarded to positively contribute management performance at second hand.

In the SMC, emerging technology in a combination of radio frequency identification (RFID), near field communication (NFC) and mobile devices has seamlessly integrated to innovate on health checkup process and gives great satisfaction to both the customer and staffs.

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