IN-TEH
intehweb.com

Design and Development of an RFID-based HIS - A Case Study

C.H. Wu, W.H. Ip, S.K. Kwok, G.T.S. Ho and C.Y. Chan
The Department of ISE, The Hong Kong Polytechnic University, Hong Kong
Corresponding author E-mail: jack.wu@polyu.edu.hk

Abstract: *The Healthcare industry involves critical activities where small mistakes could cause huge loss of life and incur massive financial losses. Improving operational efficiency and enhancing data correctness of patients are the prime targets of using hospital information system (HIS). Radio Frequency Identification (RFID) technology, with a unique ability to perform automatic data collection without any human intervention, has gained great interest in the healthcare industry. In this research, an RFID-enabled HIS is proposed for improving operations in a hospital. This research presents the fundamentals of RFID, the benefits and its challenges, and also demonstrates three improved signature applications. It aims at providing the healthcare industry with a comprehensive understanding of RFID and its suitability for healthcare applications. The proposed system is considered to be suitably operational, practical, and affordable for healthcare organizations not only in China and Hong Kong, but also in other countries.*
Keywords: *RFID, hosptial information system, drug dispensing system, body checking system, emergency transfusion system.*

1. Introduction

Healthcare is a vital and unique part of society, however safety, cost, administration and standards have aroused extensive concern in the international community. According to the World Health Organization, medical errors affect one in every ten patients worldwide. Medical errors have been implicated in nearly 80 percent of adverse events that have occurred in complex healthcare systems. The major medical errors are caused by defective systems, inefficient procedures and human mistakes (Palmieri, P. et al., 2008). Hospitals spend tremendous amounts of resources in exploring and improving their services, facilities, operational systems and in reducing medical errors. Generally, Hospital Information Systems (HIS) can help. However, an effective and efficient HIS can be achieved by adopting new technologies, improving surgical and medical procedures, and providing comprehensive training to staff across the healthcare spectrum. Hence, technology is considered a very useful tool to help improve the overall performance of hospitals.

Radio Frequency Identification (RFID) stands for Radio Frequency Identification, which uses radio signals to identify specific objects. Although the power of RFID technology is not fully realized, great potential has emerged. With the unique capability of identifying multiple individual items without a line-of-sight constraint, RFID provides real-time data collection and target identification. It enables tracking of physical objects throughout their lifecycles without direct human involvement. The basic technology of RFID derives from World War II, where it was used to "Identify Friend or Foe" (Kwok, S. et al., 2007). The majority of applications in the first wave of RFID have been in the supply chain. In 2004, Wal-Mart and the U.S. Department of Defense (DoD) announced a schedule by which their suppliers were required to attach RFID tags on pallets and cases of goods shipped to particular distribution centres.

The healthcare industry is deemed to be the next target for RFID following manufacturing and retail marketing (Wang, S. et al., 2006). Continous tracing and tracking of patients, equipment and pharmaceutical products is considered as a very significant application in the healthcare industry. The main objectives of this research are designing a RFID-enabled HIS to study how it can be successfully applied to a hospital, and how it can ensure better medical services, improve efficiency and effectiveness, reduce operation costs, and ensure a patient's data correctness. A China-based hospital, Dagang Oil Field General Hospital (DOFGH) in Tianjin, China, is selected for the case study to demonstrate that how the new system works.

2. RFID – The Background

RFID technology with the special ability of multiple object identification without the constraint of line-of-sight, provides a perfect way for real-time data collection and object identification. Thus, a increasing number of organizations are utilizing this special technology for business automation and management optimization.

2.1. Basic of RFID

RFID is a promising, emerging and advanced technology which can automatically identify a physical object without line-of-sight interaction (Kwok, S. et al., 2007). RFID technology captures and transfers data from an item of equipment to a reader via radio signals within a certain read range. In recent years, the applications of RFID technology has manifested various and sophisticated trends beyond ships and airplanes identification. A typical RFID system is an integrated collection of components including a tag, antenna, reader and software. An RFID tag is attached to an item which needs to be tracked and identified. The tag can transmit information concerning the object to the RFID reader via an antenna. Then, the reader reads the information stored and forwards it over a suitable communication channel, such as a network, to an application software running on a computer.

Nowadays, an increasing number of organizations utilize RFID technology to optimize their business, including the U.S. DoD, Metro AG, Wal-Mart, Gillette and Tesco. The top 100 suppliers of Wal-Mart were all required to adopt RFID technology in 2005 (Romanow, K. & Lundstrom, S., 2003) and one of Wal-Mart's distribution centres in Texas was dedicated to handling all the company's RFID tagged pallets and cases. Metro AG has implemented their first item-level RFID project in a store located at Rheinberg and Dusseldorf (RFID Journal, 2003). They attached RFID tags to every Gillette razor blade, Kraft cream cheese and Proctor and Gamble (P&G) shampoos. With the RFID-enabled systems, it not only enhances stock replenishment operations but also benefits customers, because the shopping carts are allowed to update shopping lists automatically with a self checking function.

The application types of RFID usually rely on radio frequency (RF), which can be normally classified into four types: Low Frequency (LF, 125 to 134 kHz), High Frequency (HF, 13.56 MHz), Ultra High Frequency (UHF, 860 to 960 MHz) and Microwave (2.45 GHz). LF is mostly used for access control and animal tagging and it is not very susceptible to liquids and metals. HF is the most suitable for applications in transcontinental connections without the requirement of a long reading range. UHF tags are the cheapest to produce and they are used extensively in supply chain applications, such as pallet and case tracking. UHF tags can be read at long range. However, compared to LF, an HF or UHF tag is more susceptible to opaque materials. Microwave tags have higher transfer rates than UHF tags but are more susceptible to opaque materials than UHF tags.

2.2. RFID in Healthcare Industry

More and more organizations have started utilizing RFID technology to improve their efficiency and effectiveness. The healthcare industry has no exception. The healthcare industry contributes around 14 percent of the world's gross domestic product (Garfinkel, S. & Rosenberg, B., 2006). Most healthcare organizations are facing patient identification problems. In general, an HIS can be separated into two parts – the Management Information System (MIS) that satisfies the administrative requirements, and the Clinical Information System (CIS) that satisfies the clinical requirements. HIS needs to enable authorized users to collect, store, process, communicate and retrieve patient and administrative information, with the aid of computers and communication facilities (Association, 2008). However, as investigated, a typical hospital has an error of at least five percent in the records of the master patient index. One of every twenty patients has an error in his or her medical record number.

The high rate of medical error, raises public concerns, therefore creating the need for the healthcare industry to adopt functional and innovative technology to improve the current system so that operational efficiency and effectiveness can be enhanced. Ultimately, healthcare services need to be improved and patient's data correctness needs to be guaranteed. Thus, RFID technology is becoming an important tool in the healthcare industry.

Survey results on RFID applications in healthcare are provided on the website of RFID in Healthcare, where most of the hospitals were reported to apply RFID in tracking and tracing patients and staff. More than 50% of the applications involved tracking individuals (such as patients and medical staff) and medical equipment. The most common application is in tracking and tracing patients, and in patient identification. In fact, there have been many sucessful applications of RFID in item tracking and tracing, such as work-in-process, equipment, food, books, small children and animals (Brown, D., 2007; Gandino et al., 2007; Kelepouris, 2007; Kwok et al., 2008). Currently, there are mainly eight types of RFID applications in healthcare, including tracking individuals, patient identification, tracking equipment or assets, tracking and matching blood samples, becoming part of an electronic medical record, tracking items in the general supply chain, tracking pharmaceuticals and in product authentication.

Although RFID technology offers tremendous benefits to the healthcare industry, there are still some challenges to be faced, such as interference concerns, privacy and ethical issues, and standards.

A hospital, is a special and critical environment, where various radiation-emitting devices, including microwave sterilizers, MRI units, and X-ray, and pacemakers machines are regularly used (Garfinkel, S. & Rosenberg, B., 2006). Some electromagnetic interference has the potential of preventing the operation of RFID devices. It has been proven that long range RFID readers are riskier than short-range readers. RFID readers should be kept away from critical healthcare equipment. It is better to

use a short range reader than long range reader if possible (Garfinkel, S. & Rosenberg, B., 2006).

After using RFID, it becomes possible to collect more detailed information outside the hospital, hence the privacy issue appears. However, it is difficult to define precisely. Some experts (Brown, D., 2007) see the privacy issues in two scenarios: the first one occurs when tags are transferred to the unsuspecting and uninformed public; the second one occurs when people themselves are embedded with chips or find themselves required to carry tagged documents.

Since there is a growing trend in applying RFID technology in the healthcare industry, new standards should be developed for these new capabilities. The central challenge for the healthcare industry is not only in the development of the security protocols, encryption methods, reducing the physical size or in more ubiquitous devices, but in the development of the standards and policies and human computer interfaces that help to provide the appropriate visibility, use, and control of information (Garfinkel, S. & Rosenberg, B., 2006).

3. Research Method

Presently, the application of RFID for the healthcare industry is at the emerging stage, therefore, it is appropriate to adopt an exploratory case study approach. According to (Gerring, J., 2007), a single case can shed light on a larger class of cases, and thus contribute to a larger group. Partington, D., (2002) stated that case study research is about engaging theories with the complexities of the real world, and making sense of them.

In this research, the approach is based on a case study. Firstly, a survey has been conducted to investigate the social attitude towards the RFID technology applied in a hospital. A survey has been conducted by targeting different groups of interviewees. More than 100 interviews were successfully completed, involving interviewees of different ages, genders, occupations and current city or country of residence. The interviewees included patients, medical staff, hospital management, project managers and system programmers of China Health Informatics Limited (CHI), professors, the CEO of the system development company, other professionals and so on. All useful data and information was then collected to establish a case study database. All feedback and information collected have thus been analyzed in order to propose solutions.

To protect sensitive business information, the data provided by DOFGH and CHI in this research is rounded up and some is provided based on estimation.

4. A Case Study of RFID-enabled HIS

DOFGH was founded in January 1964, and developed gradually to meet the needs of the oil industry in Tianjin, China. After 40 years of development and growth, DOFGH has a healthcare system network of four grade-one hospitals, four community health service centres and 21 community health service stations. As an integrated hospital, DOFGH is involved with prevention, teaching, research, injury first aid, healthcare, rehabilitation and community health. Currently, the hospital has 781 beds and employs 1,700 persons, including 1,423 healthcare professionals, 687 specialists and so on.

4.1. Analysis of the Needs of Patients and Medical Staff

In order to investigate the patient requirements and medical staff needs, a survey was conducted. More than 140 interviews were successfully completed, involving interviewees of different ages, gender, education levels and occupations. The findings are presented, and explain how the public views the current medical services, and the recognition of RFID technology and hospital information system are discussed, and conclusions drawn.

Based on the survey responses, as illustrated in Fig. 1 and Fig. 2, one can observe that almost half of the interviewees had no knowledge of RFID and the hospital information system, but there are a number of people who have an interest in the new technology.

The collection of data was by personal interviews, e-mail surveys, Windows Live Messenger surveys, Tencent QQ surveys, and web page surveys which are available at http://www.my3q.com/survey/337/michelle_chau/29185.phtml.

There were nine aspects of improving current hospital services highlighted; they are waiting time in the Out-Patient and Emergency Department, time spent on collecting medicines from the pharmacy, time spent on the admission and hospitalization procedure, fees, hospital environment, accuracy of the diagnosis, medicine and services provided, medical service quality and the quality of drugs, and recreational facilities. In this research, the desire for improving current hospital services is clear. The top three are: accuracy of the diagnosis, medicine and services provided (78%), quality of drugs (64%), and waiting time at the Out-Patient and Emergency Department (54%), as shown in Fig. 3.

On the other hand, there were nine aspects highlighted for improving the medical staff's work, including workload, efficiency and effectiveness, time spent on manual record work, salary, equipment, training, communication among colleagues, recreation facilities, and financial assistance. Among the current medical staff and post medical staff, the top three aspects of most concern were: efficiency and effectiveness (70%) which is shown in Fig. 4, time spent on manual record works (55%), workload (49%).

According to the responses concerning confidence in using the new RFID-enabled HIS in the hospital, 24% were certainly confident in using the new RFID-enabled HIS and 60% mentioned that they would be confident in

using the new system if they could know more about the system. However, it is also found that 16% of respondent had no confidence in using it (Fig. 5). Referring to the safety concerns in using RFID, 52% believed RFID is safe to humans.

To summarize, one can understand that this research can be considered as a demand pull project. The survey results showed that the hospital should have a new customizable and sustainable system, which can change and improve the current operation processes, and fulfill the highly rated expected improvements for patients and the medical staff. The focuses are on the effective usage of hospital information, efficient collecting of information, and the operation of the dispensary, so as to enhance the hospital effectiveness, efficiency and accuracy.

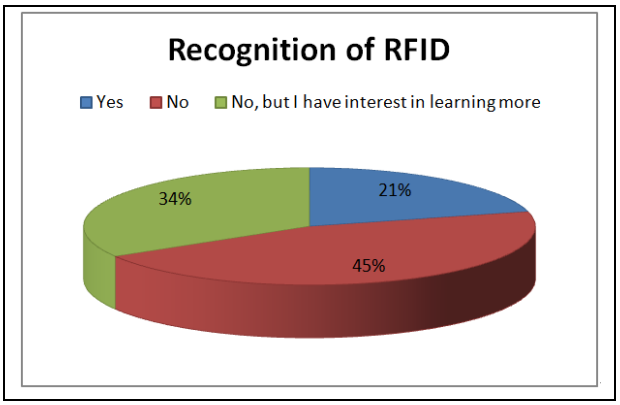

Fig. 1. Recognition of RFID reported by interviewees

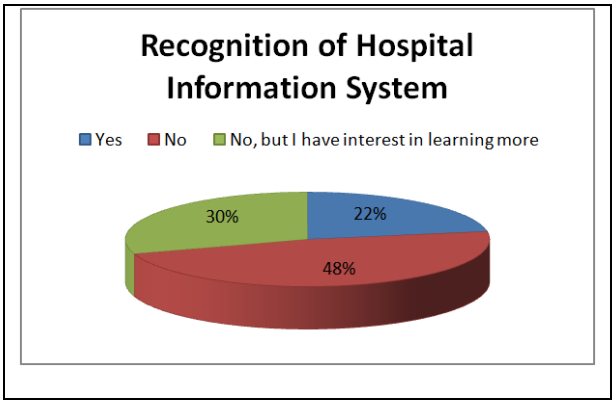

Fig. 2. Recognition of HIS reported by interviewees

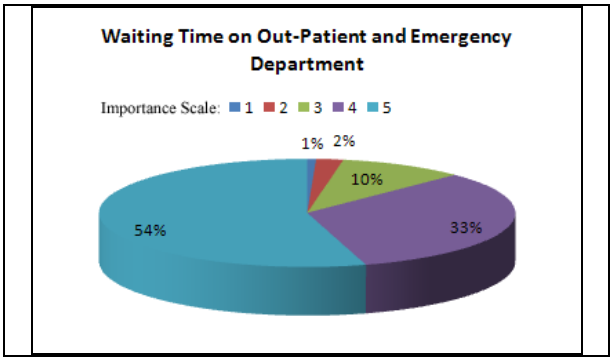

Fig. 3. Fifty-four percent of respondents rated 5 for waiting time at the out-patient and emergency department

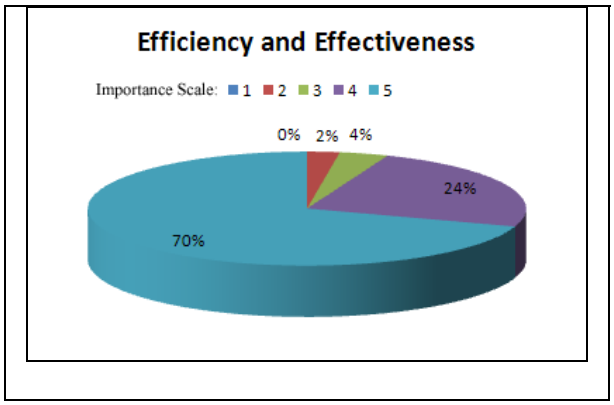

Fig. 4. Seventy percent of respondent rated 5 for efficiency and effectiveness

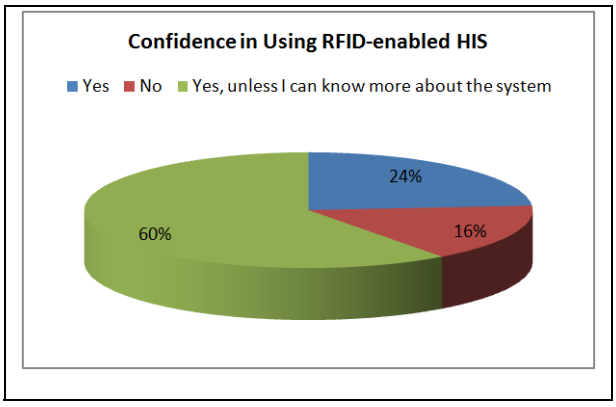

Fig. 5. Sixty percent of respondents wanted to know more about the system before using RFID-enabled HIS

4.2. The Design of the RFID-enabled HIS

RFID-enabled HIS consists of RFID wristbands, RFID tags, PDA handheld devices, RFID reader and antenna, WIFI network platform and software. The RFID wristband includes patient information, such as name, blood type, allergies and other critical information for identification, which can be associated with treatment and payment. The specifications are an NXP chip, 14443a agreement and 1k bytes capacity. The RFID reader, which contains a receiver, transmitter and microprocessor, is used to send and receive RF to and from the tag via antennas. A PDA, which has an RFID reader installed inside to read the patient's RFID wristband, is the handheld device designed for medical staff, so that medical staff can retrieve useful information quickly and view a patient's medical record by using PDA in a real-time manner. Ultimately, medical staff can issue prescriptions, confirm drug prescriptions, check medical records and so on anytime and anywhere. Moreover, PDA can also work as an intercom for emergency situations. The specifications of the PDA used in this case study were handwriting enabled, consistent with the sealing standard, Microsoft® Windows® CE 5.0 (CE.NET) embedded operating system, consistent with IEEE802.11b (WLAN). With the aid of the WIFI network, the locations of tagged assets, medical equipment and patients become visible to the managerial team and medical staff. Thus, the staff can

retrieve patients' medical records by using the PDA and locate the patients immediately if an emergency occurs.

The proposed hospital information system provides data switching between the information centre and the system front-end application. The architecture of the RFID-enabled HIS was also established to integrate with the existing system. As illustrated in Fig. 6, it shows that data was collected, processed, stored and transformed into useful information for medical services in the hospital. The hospital-wide RFID-enabled HIS infrastructure was designed as depicted in Fig. 7. The RFID readers should position at strategic points and RFID tags attached to patients or equipment.

By using the new system, relevant medical processes will be changed to incorporate RFID technology. For doctors, they can retrieve and update the diagnostic information of patients in various stages; input consultations; enter prescriptions and so on. For nurses, they can query the inspection reports selected, such as type-B ultrasonic, CT, and other different testing reports; execute medical advice; record and check the vital signs of patients etc. Both doctor and nurses can check the patient basic information, such as name, gender, address, diagnosis and other basic information. They can also check and search surgery schedule, check diagnosis list; check examination reports and so forth.

4.3. Solution for Improvement: Out-patient and Emergency Transfusion System

Currently, the existing HIS has contributed to paperless workflow and environmental issues have been addressed with the implementation of HIS to the management of patient information, however, some critical safety issues have not yet been enhanced. Although HIS has made a great contribution, transfusion accuracy has yet been enhanced. Regarding the existing transfusion workflow which contains human verification, thus frequent accidents in the wrong transfusion of fluid due to human error can happen. This scenario will happen more easily during an emergency. Therefore, there is a need to ensure all transfusions can be performed correctly, i.e. the right fluid transfused to the right patient.

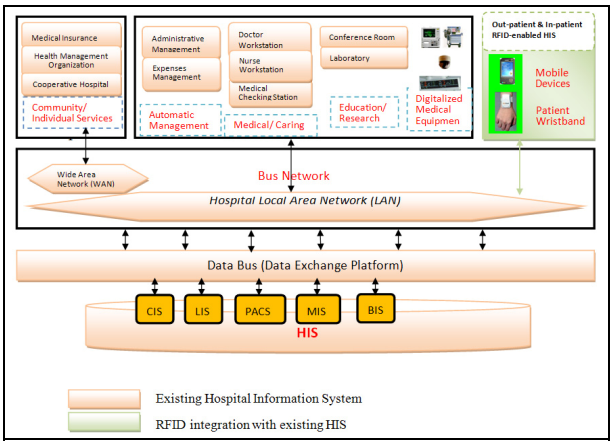

Fig. 6. RFID Integration with Existing HIS

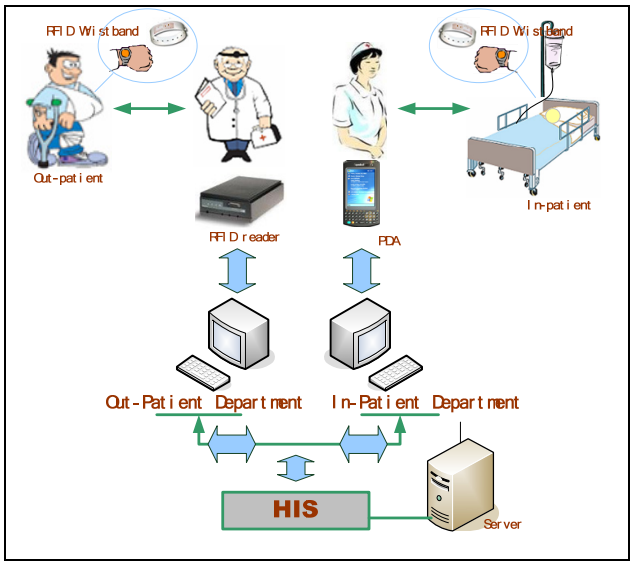

Fig. 7. Infrastructure of RFID-enabled Hospital Information System

The Out-Patient and Emergency Transfusion System is integrated with the existing transfusion procedure inside the hospital, so that medical staff can carry out the same procedure but with an unprecedented accuracy. This system makes use of RFID and PDA to assist in the transfusion procedure, and to ensure the accuracy of any transfusion performed in the hospital. The generic workflow is illustrated in Fig. 8. By using this system, all the transfusion procedures, including the transfusion fluid, the patient and medical staff who perform transfusion are strictly monitored. It also can provide a proactive alert when the staff attempts to make a wrong transfusion.

4.4. Solution for Improvement: Automated Body Checking System

Currently, patients always have to queue up for a physical examination with a long waiting time. However, the physical examination also increases the workload of nurses at the front desk as they need to cope with the repetitive operational procedures, such as payment handling, record printing and so on. As a result, patients

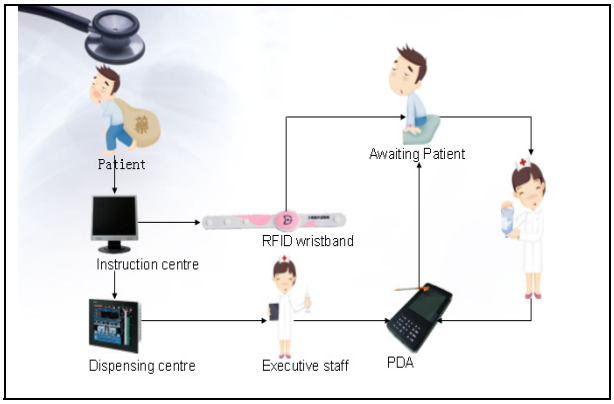

Fig. 8. Generic Flow Chart of Out-Patient and Emergency Transfusion System

are required to wait at the reception and for the physical examination.

The new workflow for checkup system is shown in Fig. 9. At the beginning of the checking, the system will identify if there is patient record, if not patient needs to register, and if yes then the wristband information will be initialized. An RFID wristband will be dispensed to the patient and he or she will go to the checkup kiosk located near the entrance of the checking centre and will be identified via the RFID wristband. The patient can choose the check mode, print the checking procedure and pay for bill. After settling the bill, the RFID wristband of the patient will be scanned by the automated checking kiosk and the patient will follow the instructions shown on the checking procedure. Once it is done, the record will be recorded in system in a real-time manner. A doctor can query the body check record, issue a recommendation, and authorize the generation and print the report.

4.5. Solution for Improvement: Drug Dispensing System

In the existing system, dispensers check the drugs according to the delivery notes from suppliers, and the drugs are then placed on predefined shelves. The dispenser prints the drug labels and sticks them on the corresponding packets. A doctor prescribes the medicine for the patient and meanwhile the patient information will be stored in the central computer system. After that, the dispenser gets the patient information from the system and collects the drugs from the shelves based on the prescription. Another dispenser will check the collected drugs. Finally, the patient obtains the medicine after name calling and identification. It is proven that human errors can happen in the complex dispensing processes. Fig. 10 shows the workflow of the new RFID-enabled Drug Dispensing System.

(1) Stock in and Drug Tagging: A supplier ships the ordered drugs to the dispensary and the drugs are placed on their predefined shelves. Then, RFID tags are tagged to the containers. Each drug associated with a specific RFID ID is recorded in the computer system.

(2) Prescription: An RFID card with relevant information is given to each patient. Then, the dispenser puts the drugs on a reader which is used to capture the tag information from the drug container and prints a drugs label if it matches with the system record.

(3) Vetting: A reader installed in the shelves will alert the dispenser if the wrong drugs are selected.

(4) Verifying: Reconfirming of correct drugs with the system prescription by scanning the RFID tag.

(5) Issuing: Confirming the details of drugs received by the RFID card and the drug dispensing system will validate whether the correct drugs will be issued to the patient or not.

4.6. Evaluation of the RFID-enabled HIS

The RFID-enabled HIS simplifies the traditional workflow. It enables the least manual involvement and

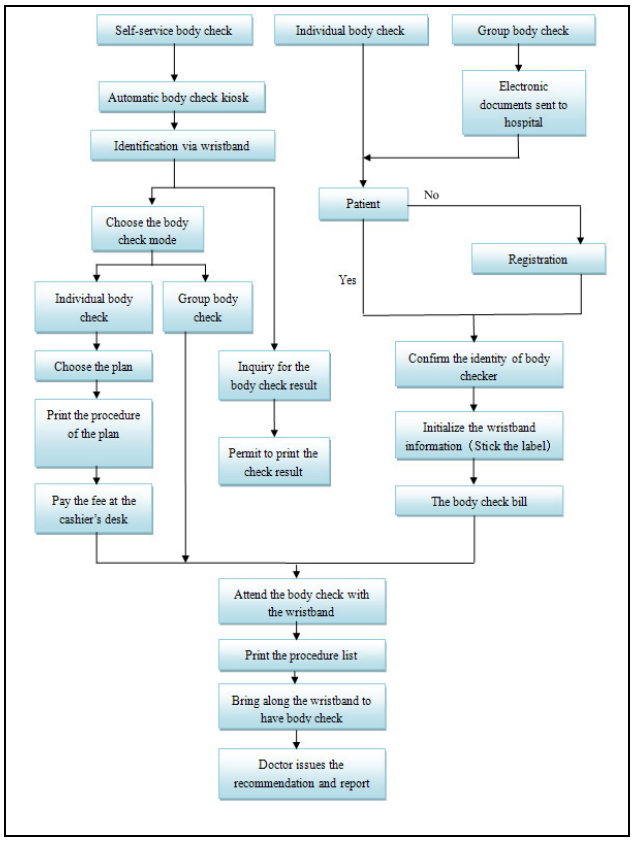

Fig. 9. Flow Chart of Automated Body Checking

streamlines the operation flow. For doctors, the waiting time for the patients' test results is saved, by about 15.8%. For nurses, the time spent on handling manual records and paperwork has decreased by 87%, which significantly enhances working efficiency, so that they can serve more patients. Such saving of time is extremely significant for hospitals as it can accelerate the processes when an emergency occurs. After a 3-month pilot run of the new system in DOFGH, the accuracy of the procedures was improved by at least 80%. It is expected that the time for retrieving patients' medical records and locations will be decreased by approximate 80% and 50% respectively.

With the aid of the RFID-enabled HIS, the first and perhaps the most obvious benefit is that the medical error

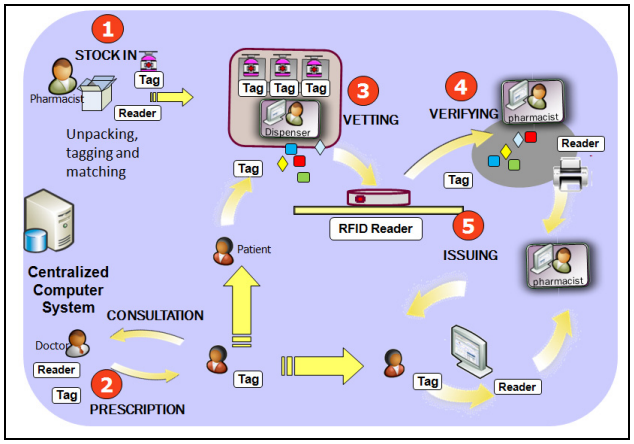

Fig. 10. Work Flow of RFID-enabled Drug Dispensing System

rate and medical malpractice rate have been reduced by 5.7%. By making use of RFID technology to automatically identify a patient, the accuracy of patient identification has been enhanced by 13.2%. Both the errors of misdiagnosis or delay in a diagnosis have been cut down remarkably.

After making use of the RFID-enabled HIS and the RFID wristbands, one can see that the manual procedures between the HIS information centre and patients have been eliminated. The related digitalized patient information can be directly retrieved. Ultimately, simplifying the retrieval processes can increase the working efficiency of medical staff and release their pressure.

Before using the RFID-enabled HIS, an out-patient took about two hours to wait for the lab test result. However, due to the improved workflow, which has automated on-site ordering, retrieval from the on-line storage and automated transfer to the analyzer, it now takes only 7 minutes. On the other hand, medical staff can save time so that they can focus on analyzing abnormal and critical issueses. Due to these improvements, patients' satisfaction increased from 76.6% to 81.4%.

5. Limitation of the Study

The findings proved that RFID technology can help DOFGH to enhance efficiency and effectiveness, and improve patient satisfaction. Nevertheless, the implementation of RFID-enabled HIS still has some constraints, as follows.

(1) Electromagnetic Interference: Some of the radio frequency (RF) transmitting devices used in the case study, such as PDA, mobile phones or other wireless devices, have interfered with medical equipment. It could potentially cause malfunction of the equipment and fatal errors.

(2) Opaque materials: Metal, liquid, sodium and graphite, could affect performance of an RFID tag in this application. A lot of medical equipment contains metallic materials and some containers hold various fluids such as blood, which will reduce the read range.

(3) Change Management: Some medical and operational processes need to be changed to incorporate the RFID-enabled HIS. Resistance from medical staff, especially physicians, would be a major inhibitor for a hospital to make changes. Some changes in nurse to patient interaction, doctor to nurse interaction and nurse to pharmacist interaction may be difficult to establish. Change management is more difficult to handle than the implementation of the new system.

6. Conclusions

To meet the challenge of patient's data correctness and improvement of efficiency and effectiveness, is perhaps the greatest motivating factor for applying RFID technology in hospitals. Three signature applications have proven that RFID technology, although in its infancy, is able to boost the efficiency and effectiveness, and ensure the patients' data correctness in the hospital in this case study.

In this research, an RFID-enabled HIS is designed and tested in a hospital – DOFGH. In order to determine the user's requirements of the RFID-enabled HIS, a survey was carried out. Based on the results obtained from the survey, the patients expected aspects of improving current hospital services such as accuracy of diagnosis, medication and services, quality of drugs, and reducing waiting time at the Out-Patient Clinic and Emergency Department. The most expected outcome of medical staff or post medical staff were efficiency and effectiveness, time spent on manual record work, and workload.

After testing the RFID-enabled HIS solutions in DOFGH, involving the Out-patient and Emergency Transfusion System, Automated Body Check System, and the Drug Dispensing System, the advantages and capabilities have been demonstrated. It can tremendously reduce or eliminate medical errors, incorrect patient identification, wrong manual procedures, missing information, and improve patient satisfaction. It generates benefits in enhancing efficiency and effectiveness, and reducing operation cost in correcting errors.

Besides this hospital, the RFID technology can be adopted by any hospitals. Although it is feasible that adopting RFID offers tremendous benefits to hospitals and healthcare organizations, including improving existing workflow, enhancing efficiency, and increasing data accuracy, there are still some constraints in using RFID-enabled systems in real applications, such as electromagnetic interference, dealing with opaque materials and overcoming resistance to change management, and these need to be considered carefully in future applications.

7. Acknowledgements

The authors wish to thank the Department of ISE and the Research Committee of The Hong Kong Polytechnic University for support in this research work.

8. References

Brown, D. E. (2007). *RFID Implementation*, McGraw-Hill, NY.

Gandino, F., Montrucchio, B., Rebaudengo, M. and Sanchez, E.R. (2007). Analysis of an RFID-based Information System for Tracking and Tracing in an Agri-Food Chain. In *Proceedings of the 1st Annual RIFD Eurasia*, pp. 1–6.

Garfinkel, S. and Rosenberg, B. (2006). *RFID : applications, security, and privacy*, Addison-Wesley, NJ.

Gerring, J. (2007). *Case Study Research: Principles and Practices*, Cambridge University Press, NY.

Kelepouris, T. (2007). RFID-enabled traceability in the food suplly chain, *Industrial Management & Data Systems*, Vol. 107, No. 2, pp. 183–199.

Kwok, S.K., Tsang, H.C., Cheung, C.F. and Lee, W.B. (2007). *Advanced Radio Frequency Identification (RFID) Technology: Counterfeit Prevention, Physical Asset Management and Business Applications*, Hong Kong: Department of Industrial and Systems Engineering of The Hong Kong Polytechnic University, Hong Kong.

Kwok, S.K., Cheung, C.F., Lee, W.B., Tsang, Albert H.C. and Tang, M.C. (2008). Development of an RFID-enabled mobile smart library system, *International Journal of Enterprise Network Management*, Vol. 2, No. 2, pp.185–197.

Palmieri, P.A., DeLucia, P.R., Peterson, L.T., Ott, T.E., Green, A. (2008). The anatomy and physiology of error in adverse health care events, *Vol. Advances in Health Care Management*, Iss. 7, pp. 33–68.

Partington, D. (2002). *Essential Skills for Management Research*, SAGE Publications, London.

RFID in Healthcare. (n.d.). A survey of RFID appliactions in Healthcare, Available from: http://www.health-rfid.com/inventarisatie_en.html, Accessed: 2010-06-20

RFID Journal (2003). Metro opens store of the future, Available from: http://www.rfidjournal.com/article/view/399, Accessed: 2010-03-30

Romanow, K. and Lundstrom, S. (2003). *RFID in 2005: The What Is More Important Than The When With Wal-Mart Edict*. AMR Research Alert.

Wang, S.W., Chen, W.H., Ong, C.S., Liu, Li and Chuang, Y.W. (2006). RFID applications in hospitals: a case study on a demonstration RFID project in a Taiwan hospital. In *Proceedings of The 39th Hawaii International Conference on System Sciences*, pp.1-10