REAL-TIME RFID-ENABLED HEALTHCARE-ASSOCIATED MONITORING SYSTEM

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Keywords: Radio frequency identification, Infectious diseases, Healthcare-associated infectious diseases.

Abstract: In healthcare context, the use of Radio Frequency Identification (RFID) technology has been employed to reduce health care costs and to facilitate the automatic streamlining of healthcare-associated infectious disease outbreak detection. RFID is playing an important role in monitoring processes in health facilities such as hospitals, nursing homes, special accommodation facilities and rehabilitation hospital. In this paper, we present a design of healthcare system using a real-time RFID-enabled application, called "Healthcare-associated Infectious Outbreak Detection and Monitoring System (HIODMS)".

1 INTRODUCTION

Infectious or communicable diseases have been an ever-present threat to human society since the great Plague of Athens in ancient times. The changing face of healthcare poses new challenges for the detection, treatment and prevention of infectious diseases. Historically local public health organizations, hospitals and clinics have been at the forefront of infectious disease outbreak detection and treatment. Healthcare-associated infections encompass almost all clinically evident infections that patients acquire during the course of receiving treatment for other conditions within a healthcare setting. Most infections after 48 to 72 hours of hospitalization are considered Healthcare-associated acquired. Healthcare-associated infections (also known as hospital-acquired infections) are referred as nosocomial. Most common healthcare-associated infections are: i) respiratory infections (pneumonia) and Catheter-associated urinary tract infections, ii) surgical wound infections, result from contamination of the surgical wound, and iii) infections associated with intravascular cannulas or central venous catheter.

Healthcare-associated infectious diseases (such as Tuberculosis, Legionnaires' disease and gastroenteritis) can affect any person regardless of age, gender, or race and common among residents of long-term care facilities (e.g., nursing homes, special accommodation facilities and rehabilitation hospitals). Patients with weakened immune systems are likely admitted to the healthcare facilities (e.g., hospitals) and sometimes do not realize that they are already incubating the virus while in hospital. Also visitors, staff, and residents constantly come and go, bringing in pathogens from both the hospital and the community (Larry et al., 2003). Tuberculosis (TB) poses specific risks to health care staffs, which can be responsible for spreading the disease to patients in their care. Legionnaires' disease has been reported from many hospitals since the first outbreak and water cooling towers are identified to the cases of the disease, which apparently causing pneumonia. A new study by the School of Medicine, University of Pittsburgh has determined that environmental monitoring of institutional water systems can help to predict the risk of hospital-acquired Legionnaires' disease (ScienceDaily, 2007). A viral gastroenteritis outbreak presents a growing challenge in health care and long-term care facilities. Influenza Epidemics in the United States result in an average of 136,000 deaths and 114,000 hospitalizations per annum (Thompson, 2003).

Chowdhury B., Wang X. and Sultana N. (2009).
REAL-TIME RFID-ENABLED HEALTHCARE-ASSOCIATED MONITORING SYSTEM.
In *Proceedings of the 11th International Conference on Enterprise Information Systems - Software Agents and Internet Computing*, pages 163-166
DOI: 10.5220/0001997601630166

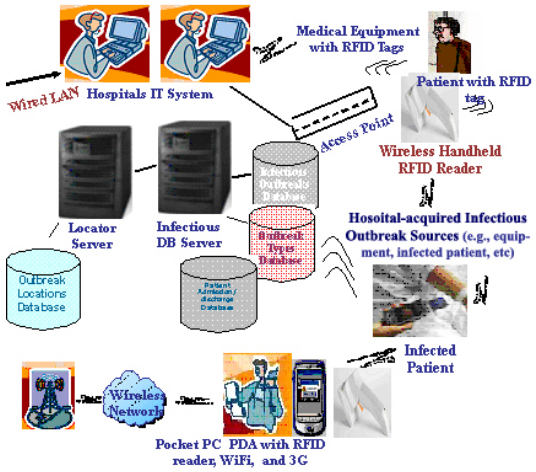

Figure 1: Main components of RFID-enabled HIODMS Architecture.

The risk of acquiring an infection while hospitalized is very real and can be responsible for spreading the highly contagious disease to other patients, medical professionals, equipment, air, water and fomites. The impact of healthcare-associated infections is enormous: the patient may need longer hospital treatment, re-admission, or even further surgery, and use of hospital and community resources (Jenney et al., 2000). Healthcare-associated infections are one of the top ten leading causes of death in the United States, recent data suggests that the rate of hospital-acquired infections has increased over the past two decades (Spelman, 2002). In most countries, healthcare infectious outbreaks are a notifiable disease where the patient needs to be accurately identified, isolated and monitored while infected with the virus. The Institute of Medicine strongly recommended that monitoring leads to reduction and prevention of healthcare associated infections.

Information systems plays a vital role in developing an effective approach and facilitate infected or healthcare-associated patient's information, (e.g., patient medical history, diagnosis) and associated equipments or assets to address this emerging or re-emerging outbreaks threat (Buehler et al., 2004). Mobile or wireless technology is expected to provide real-time information about vital signs and other physiological indicators of one's health and fitness. Such monitoring systems are expected to find greater use in such applications in long-term health care facilities. In this paper, we demonstrate an application of real-time monitoring system can be facilitated by the use of the wireless technology such as Radio Frequency Identification (RFID). We integrate RFID technology with a multi-layer architecture for a Healthcare-associated Infectious Outbreak Detection and Monitoring System (HIODMS) via both wireless and wired network.

Following section demonstrate the RFID-enabled HIODMS architecture. Section 3 illustrates the application of the RFID-enabled HIODMS and the security issues.

2 RFID-ENABLED HIODMS ARCHITECTURE

The main components of RFID-based HIODMS (as shown in Figure 1) are: patient tags (RFID encoded wristband), a reader (fixed and handheld), and health care provider IT systems (i.e., Real-Time RFID-Based HIODMS). RFID is one of the emerging wireless technologies that play an integral role to halt the spread of such outbreak diseases, prevent and control further outbreaks by isolating infected patients and associated medical equipments or assets in real-time. Each unique patient tag can be passive, semi-passive or active. Passive patient tags can be used for both reading and writing capabilities by the reader and do not need internal power. They get energized by the reader through radio waves and have a read range from 10mm to almost 10 meters. We suggest the use of passive patient tags with the read range of one meter, and RFID-based PDA readers (e.g., Motorola MC9090-G) for the real-time Healthcare-associated Outbreak Management System application. The reason to select a 13.56 MHz (High Frequency) solution is for the low cost, better read range, and faster read rate.

The passive patient tag antenna picks up radio waves or electromagnetic energy beamed at it from a PDA-based RFID reader device and enables the chip to transmit healthcare-associated infected patient's unique ID, and location to the reader device, allowing the patient to be remotely identified. The reader converts the radio waves reflected back from the patient tag into digital information then pass onto HIODMS for processing. Patient's basic infection information is stored in the backend server for processing data. The patient database can also be linked to other health centres databases for retrieving patients past history using Internet via a wireless network. In addition to monitoring healthcare-associated infected patients, the system can also track associative equipments or assets (e.g., wheelchairs), staff member, and surgical equipments in real-time to isolate them and prevent further outbreaks. RFID-based HIODMS enables healthcare

staff to follow an infected patient through the hospital, from admission to discharge. In case of isolation, if an infected patient enters an unauthorized area in the healthcare settings, the RFID based system issues an alert to the healthcare staff with information that indicate the identity and location of the particular patient.

An application of RFID-based HIODMS consists of five layers, namely: physical device layer, middleware layer, health IT infrastructure management layer, data layer, and graphical user interface layers. The physical device layer consists of the actual RFID hardware components that integrate with HIODMS for capturing data automatically. In this layer we used passive HF read/write RFID readers and patient tags. The middleware layer or framework acts as the standard mechanism to get a quick connectivity between healthcare-associated outbreaks detection tags and RFID-based HIODMS as shown in Figure 1. The IT infrastructure management layer is responsible for managing and controlling healthcare organization's IT components such as computers, back-end servers, networks, and printers. In addition, this layer enables data mapping, formatting, business rule execution and the service interactions with back-end databases. The data layer composed of a Relational Database Management System and it interacts with a back-end database (e.g. SQL server). Finally, the graphical user interface (GUI) layer is comprised of an extensible GUI, which helps in detecting, monitoring and managing hospital-acquired various infectious outbreaks (i.e., wound infection) information, generating various reports and analyzes the health information at various stages in the entire value chain.

3 RFID-ENABLED HIODMS APPLICATION AND SECURITY

In this paper, we demonstrate some interfaces of the RFID-enabled HIODMS application as shown in Figure 2, which can be integrated with the healthcare IT System for capturing healthcare associated infectious diseases (e.g., wound infection, Gastroenteritis, Tuberculosis) data automatically and wirelessly. The system is developed in Microsoft Visual Studio.net 2003 environment using Visual C++.

The RFID-based HIODMS application registers a reader and issues a unique wristband (patient ID) to every patient at registration/admission in healthcare facilities (e.g., hospitals), and also issues

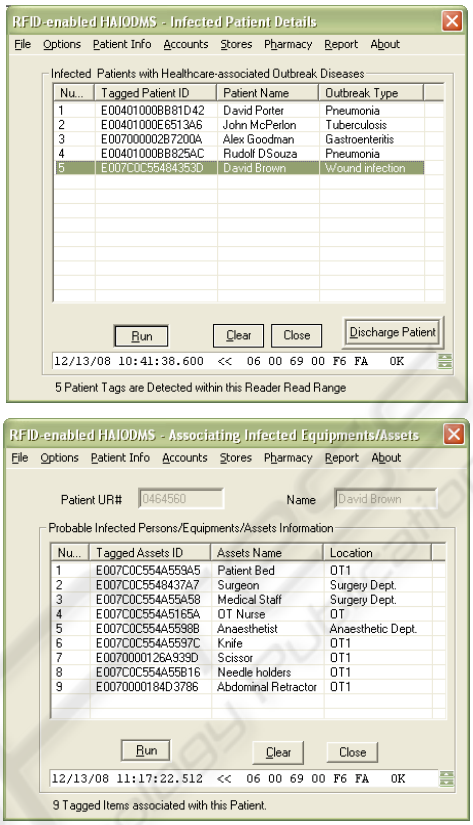

Figure 2: Two examples of RFID-based HIODMS application.

RFID tags to hospital equipments/assets (e.g., beds, and surgical instruments) relating to the particular patient. The RFID then uses the patient ID as a key to information and perhaps other information (e.g. name, DOB, drug allergies, and blood group) stored in the health providers back-end databases (i.e., SQL server). The patient tag is used to identify patients all the way from observation, investigation, and treatment to discharge while in hospital. In case of healthcare-associated infectious outbreak (e.g., wound infection), this tag is used to identify exact outbreaks area or location, time, and list of associated hospital equipments/assets in real-time as shown in Figure 2. For example, an RFID patient tag contains a unique tag ID, which a HIODMS application uses to retrieve an infected patient record stored in the database. When a patient appears with a wristband within a reader read range, the application reads and lists the tagged patient IDs, names and displays the patient admission information automatically on a selection of a particular infected patient. The application then transfers these healthcare-associated outbreaks data to the SQL server for permanent storage and further analysis over the mobile network in real-time.

While RFID provides promising benefits such as healthcare organizations business process automation, some significant challenges (e.g., security concerns, process, and manage RFID-based infectious data) need to be addressed before these benefits can be realized. To overcome this challenge, sophisticated security measures are needed. Without security, illegal activities can cheat RFID systems easily for the air interface between infected patient/equipment tags and RFID readers, and the interface between RFID readers and the back-end database system. In addition, healthcare-associated infected patient's privacy is also an issue, since anyone can intercept communication between the patient tags and readers, or between readers and the back-end system, and then they can obtain information about an infected patient. To remove security vulnerabilities and protect patient's privacy, a number of existing RFID security measures can be considered and adopted as a measure of security.

In our RFID-enabled HIODMS, communication between patient tags and readers, readers and back-end database is one-way. Our patient tags are passive, inexpensive and have a minimum amount of memory. We require very little information in the patient tag (e.g., Tag ID only). When the outbreak infected patient tag comes in to contact with the reader within a range of one meter. The Pocket PC (PDA-based RFID reader) reads and processes the patient/equipment tag identification number. Within this proximity and with the mobile/wireless environment, there will be no scope to intercept communication between patient tags and a reader. In a worst case situation, if an intruder intercepts and gets the patient/equipment tag ID, he or she gains nothing because the tag does not contain any additional information.

To achieve the secure transfer of integrated patient/equipment data from Pocket PC to back-end database server via wireless network, we use a Hash Function-based Mutual Authentication Scheme (Lee, 2005). This scheme, utilizing a hash function, is widely used for secure communication between mobile/wireless devices (such as PDA-based IODM system) and back-end SQL servers in a RFID-based healthcare environment.

4 CONCLUSIONS AND FUTURE WORK

We presented a RFID-enabled monitoring system (HIODMS) to help healthcare providers to overcome challenges of hospital-acquired infectious outbreak diseases by providing accurate, automatic and real-time information on patients, associative medical equipments or assets as they move to the value chain. Using HIODMS, health care organizations have a chance to track rapidly and accurately of outbreak patients, their location, and associative assets identification; to improve patient's safety by capturing infected patient data; to prevent or reduce medical errors, to increase efficiency and productivity, and to save costs in real-time via wireless network.

In future research, the application based on HIODMS can be expanded to include a variety of tracking or sensor (such as temperature) features using RFID. RFID patient tag (wristband) can transmit not only its unique identification number, but also the ambient temperature, which can help healthcare facilities IT departments to remotely monitor the room's temperature or to receive alerts via mobile phone or emails. We also plan to extract the healthcare-associated infectious outbreaks data provided by this proposed RFID-based HIODMS to analyze the diseases behaviour and outbreak patterns using data mining techniques. We then could predict the next step towards controlling these serious hospital-acquired diseases, enhancing preparedness, and providing rapid response health measures.

REFERENCES

Barraclough, B.H., 2001. *Safety and quality in Australian healthcare: making progress*, The Medical Journal of Australia, Vol. 174, p. 616-617.

Buehler, J., Hopkins, R., Overhage, J., Sosin, D., Tong V., 2004. *Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks: Recommendations from the CDC Working Group.* Morbidity and Mortality W. Report,53, p.1-13.

Spelman, D.W., 2002. *Hospital-acquired infections,* The Medical Journal of Australia, Vol. 176 (6), p.286-291.

Jenney, A.W., Harrington, G.A., Russo, P.I., Spelman, D.W., 2000. *The cost of surgical site infection following coronary artery bypass surgery*. Journal of CHEST –CHICAGO-, Vol. 118, p. 397-402.

Strausbaugh, L.J., Sukumar, S.R., and Joseph, C.L., 2003. *Infectious Disease Outbreaks in Nursing Homes: An Unappreciated Hazard for Frail Elderly Persons,* School of Medicine, Oregon Health and Sciences University, Portland, Oregon.

Lee, S., 2005. *Mutual Authentication of RFID System using Synchronized Information*, M.Sc. Thesis, School of Engineering, Information and Communications University, South Korea.

ScienceDaily, 2007, *Environmental Tests Help Predict Hospital-acquired Legionnaires' Disease Risk,* ScienceDaily, 23 August.