Advanced Point of Care System for reducing Adverse Drug Events using 13.56/900 MHz RFID, Wi-Fi, Text-To-Speech Technology in Ajou University Hospital

Ho-Young Byun[3], Kyung-Jin Lee[3], Sang-Hun Lee[2], Young-Ho Lee[4], Un-Gu Kang[4], Byung-Moon Lee[4], Hee-Jung Hwang[4], Rae-Woong Park[3,] Peom Park[1]

[1] Department of Industrial Information System Engineering, Ajou University, Su-Won, South Korea
[2] Humintec Co., Ltd, Su-Won, South Korea
[3] Department of Medical Informatics, Ajou University School of Medicine, Su-Won, South Korea
[4] Department of Information Technology , Gachon University of Medicine and Science, In-Cheon, South Korea

Abstract— **In hospitals, doctors and nurses may need real-time medical data anywhere and at any time. They waste over 30% of their working time searching for and reading information about patients[1]. Furthermore, it is very difficult to record patient information in real time during medical treatment. To overcome these problems, we propose a mobile system using a PDA and a Wi-Fi network. In the United States, adverse drug events (ADEs) are the eighth leading cause of death[2]. Thirty-eight percent of ADEs occur while the nurse or clinician is administering the drug[3]. To prevent ADEs, we propose an RFID system that reduces the risk of a fatal ADE by checking the Five Rights: 1. Identify the right patient, 2. Confirm the right medication, 3. Confirm the right dosage, 4. Confirm the right route, and 5. Confirm the right time[4]. We designed and produced software called A-POC (Advanced Point of Care), and tested it in the Department of pulmonary in Ajou University Medical Center.**

Keywords— **Pervasive Healthcare, Point of Care, Adverse Drug Events**

I. Background and overview

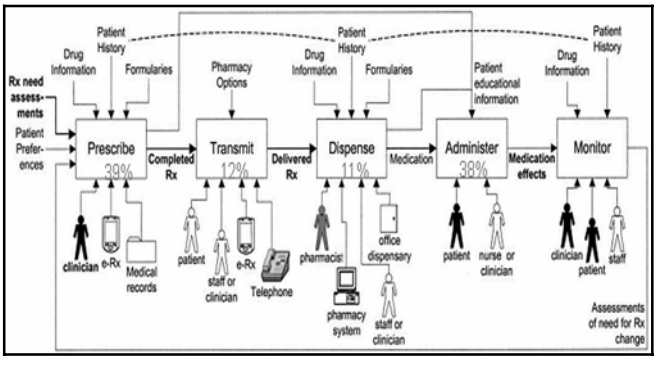

Fig. 1 The ADEs Rate by medication path(Bell, Cretin et al. 2004)

The death toll by medication error for a year in USA is about 44,000 ~ 98,000 [5] and the major factor of ADEs is the administration process by the patients, nurses, clinicians like the Fig.1.[6] For the reduction of ADEs-risk in the administration process we propose the method of checking drugs and medication orders through reading RFID tag before medication. Furthermore we designed and developed the mobile system using Wi-Fi network and PDA.

II. System configuration and design

A. System configuration

The system is made of 3 major parts: application service part, middleware part, legacy part like the Fig.2.

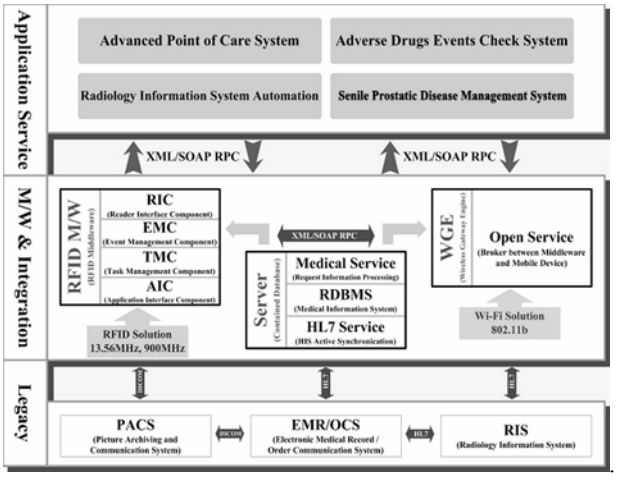

Fig. 2 System configuration structure

First, the legacy part is the ready-used information system in the hospital like the PACS (Picture Archiving and Communication System), the EMR/OCS (Electronic Medical Record/Order Communication System) and the RIS(Radiology Information System). These parts provide the basic informa-

tion to the advanced poin of care (A-POC) system. The information from legacy part is like the Table1.

Table 1 The information extracted from legacy part.

Data item	Usage in the APOC
MD information from EMR (ID, name / code, name of department)	For mobile rounding service
Disease information from EMR,LIS,RIS (Summary of Pathology and radiology report)	For mobile rounding service
Order information from EMR (Dosage, time of drug)	For checking the drugs
Patient information from EMR (NO, name, history, sex, age, status)	For rounding and checking the drugs
Picture information from PACS (CT, MRI, endoscope, microscope, gross image by JPEG compression)	For mobile rounding service

The text information of table 1 is came by XML message using HL7 standard and the medical images(CT, MRI, Microscope images) are came by DICOM standard. These text and image data are stored in the RDBMS(MS-SQL 2000^{TM}).

Secondly, the middleware part is for the providing and inserting the data which used in the application service. We used RFID middleware from ETRI^{TM} and wireless middleware. The communication which is the major role of the middleware between the RDBMS and application service is used the web service (XML-SOAP), the following Fig.3 is the message structure of XML-SOAP. Actually this message structure is motivated from PML (Physical Markup language) core specification 1.0.

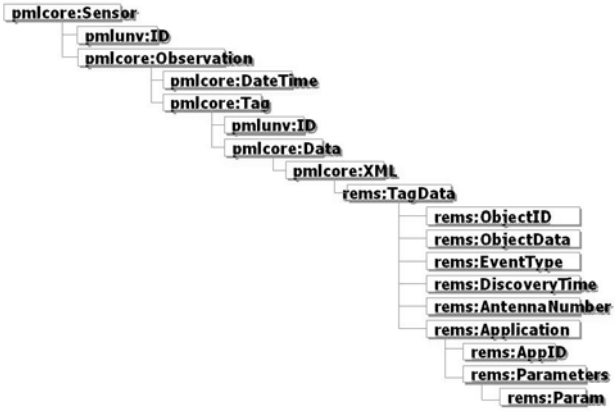

Fig. 3 Messgae structure between middleware and application.

Finally, we provide the application service, the major feature of the application service is the Text-To-Speech service (the creation of audible speech from computer readable text). The major problem of mobile device is the restricted scale of display, for the overcoming this reason we used the TTS technology from VOICETECH^{TM}.

B. RFID application service

1. To issue a RFID tag.

If a patient is sent to the ward, a nurse issues a RFID tag using APOC and the guideline of attaching the tags is like the Table 2. And from this point the patients can be identified by RFID tag, Physicians spend less time filling out charts, allowing them to spend more time working directly with patients, diagnosing and treating illnesses. As a result, they're able to identify those high-risk patients who need the most care.

Table 2 The guideline of attaching the tags.

Item	Guideline
Tagging-target	Patients (using the wrist type tag) in the maternity Beds in the ICU.
Tag size	10mm X 80mm 900 Mhz 50mm X 80mm 13.56 Mhz
Code used	Using the tag-id and internal RFID Object Name Server
Issuing policy	When assigned a bed

2. To check the 5- rights of medication administration and view a medical record.

During the medication process, by combining the information of drugs in A-POC program and RFID tag on a medicine it helps nurses avoid administering the wrong medication or dose, and helps reduce second-guessing and redundancies at the bedside. A-POC provides the information for the identifying the right patient, the confirming the right medication, the confirming the right dosage, the confirming the right route and the confirming the right time.

If the medication and the RFID tag information are unmatched, the alarm message is announced by Text to Speech engine. Besides the unmatched condition (medication time, name of administrator, name of patient and name of medicine) is automatically inserted to the A-POC system.[7]

The function of viewing medical record via APOC system is like the followings: First reading the RFID tag attached at a patient's wrist or patient's bed using RFID reader on PDA automatically, second searching patient's information through specific condition, third Predicting postoperative effects through patient's clinical condition, and lastly viewing the medical images of the patients in the mobile environment.

3. Software Deployment

The Physical software deployment is performed in the department of pulmonary like the Fig. 4. We used 1 server for a data providing service and middleware service, 1 PC for a issuing the RFID tag and synchronizing the PDAs and 6 PDAs for A-POC application software.

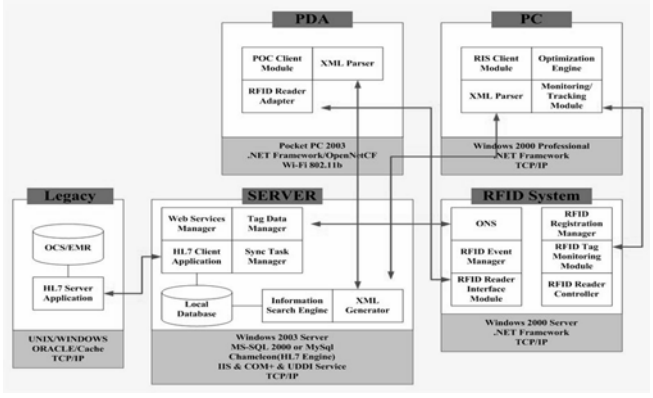

Fig. 4 Physical deployment of software

4. Hardware Specification

In this project there are many constraints for the whole-level usage of APOC: project cost, time, regulation problem and the rebellion of doctor and nurse. For these reason the reference site is limited to a ICU and a ward in Dept. of pulmonary. The followings are the specifications of HWs.

ICU				
Item	Detail	Description	Amount	Note
13.56 MHz RFID Set	RFID Tag	- Passive Tag	Over 100 EA	- Patients or beds
	RFID Reader	- CF Type - Range 10cm	3 Set	- PDA/PDA Phone
900 MHz RFID Set	Not determined			
PDA		- PPC 2003 - Wireless internet - CF slot	3 Set	- Residents/Nurses
Wireless LAN Set	Hub	- 802.11b - over 4port - Wireless internet	1 EA	
	Access Point	- 802.11b	2 EA	
Workstation		- Windows 2000 Prof.	1 Set	- RFID M/W Server
Terminal		- Windows 2000 Prof.	1 Set	- Client Application

Fig. 5 Used hardware in the ICU.

Dept. of Pulmonary				
Item	Detail	Description	Amount	Note
13.56 MHz RFID Set	RFID Reader	- CF Type - Range 10cm	3 Set	- PDA/PDA Phone
PDA/ PDA Phone		- PPC 2003 - Wireless Internet - CF Slot	3 Set	- Doctors
Wireless LAN Set	Hub	- 802.11b - Over 4port	1 EA	
	Access Point	- 802.11b	3 EA	
Application Server		- Server/Workstation - Windows 2003 Server - MySQL	1 Set	- Database Server - Web Server - Server Application Provider

Fig. 6 Used hardware in the pulmonary ward.

For a privacy and security, Wi-Fi network used a shared key association method with WEP(Wired Equivalent Privacy) encryption 40/104 bit of RC4 algorithm and in the RFID tag there are no direct writing / reading the patient information.

C. Test bed in the Ajou university hospital.

The total service flow of patient is like the Fig. 7.

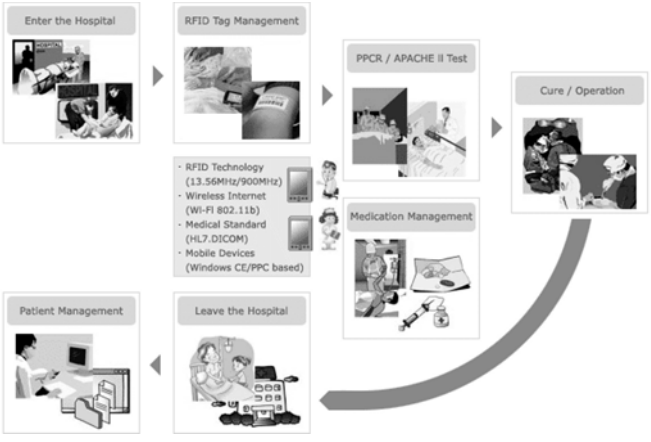

Fig. 7 Service flow diagram.

In the test period 3 beds in the ICU and 2 patients in a ward are the subjects of test operation like the Fig. 8.

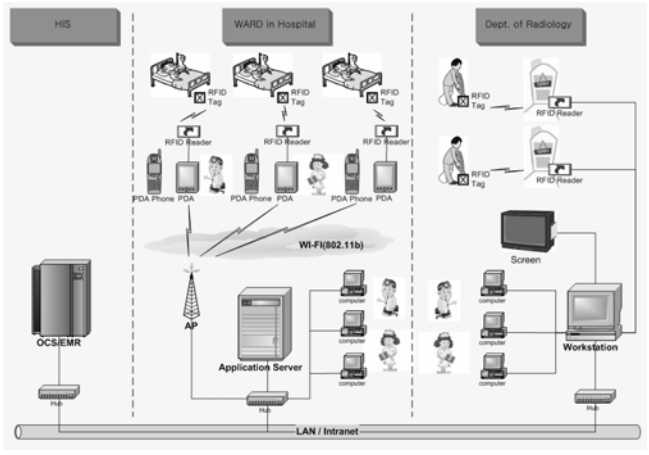

Fig. 8 Overview of test bed Fig. 8

Fig. 9 presents the main user interface and the bed-side care while rounding.

Fig. 9 The photograph of APOC and rounding.

III. Conclusions

Applying RFID technology to EMR, POC reduce the time of medical treatment and improve service quality and increase revenue. Implementation mobile system using Wi-Fi can get information at any time, any where to the clinicians. In short Any where and any time, doctors and nurses can obtain medical data, patients are offered medical services easily.

Table 3 Effects and Benefit

Item	Contents
Economical side	decrease overlapping works decrease medical trouble increase bed turnover rate
Hospital side	work any time/any where be easy to carry(potable) increase productivity and efficiency increase confidence through real-time management system
Patient side	increase service quality though TQM(Total Quality Management) decrease dangerous elements while in-hospital life

Acknowledgment

This research is supported by the Ubiquitous Computing and Network (UCN) Project, the Ministry of Information and Communication (MIC) 21st Century Frontier R&D Program in Korea.

References

1. Peom Park et al.; Development of Advanced Point of Care System Using Wi-Fi and RFID, CEWIT 2005, 7~8, 2005
2. Bates, D.; Spell, N.; Cullen, D.; The Cost of Adverse Drug Events in Hospitalized Patients, JAMIA, 227: 307-311, 1997
3. Bell, D.S., et al.; A Conceptual Framework for Evaluating Outpatient Electronic Prescribing System Based on Their Functional Capabilities, J Am Med Inform Assoc, 11(1), pp 60~70, 2004
4. To Err Is Human: Building a Safer Health System, IOM(Institute of Medicine), 2000
5. Ho-young Byun et al.;The research report of Wireless Gateway Engine, HUMINTEC™,27~29, 2005
6. Ho-young Byun et al.; The research report of RFID M/W, HUMINTEC™,12~15, 2004
7. Mijung-Lim et al.; Design of A-POC(Advanced Point of Care) System for COPD Patient's Tele-Monitoring and Emergency Measure, UbiCNS, E-poster, 2005
8. Information of Medical Administration at http://www.symbol.com, 2005

Address of the corresponding author:

Author: Peom Park
Institute: Department of Industrial Information System Engineering, Ajou University
Street: San 5
City: Su-Won
Country: South Korea
Email: ppark@ajou.ac..kr