Ubiquitous-Severance Hospital Project: Implementation and Results

Bung-Chul Chang, MD, PhD[1], Nam-Hyun Kim, PhD[2], Young-A Kim, RN, PhD[3], Jee Hea Kim[3], Hae Kyung Jung[3], Eun Hae Kang, MA[3], Hee Suk Kang[3], Hyung Il Lee, MA[3], Yong Ook Kim, MD, PhD[4], Sun Kook Yoo, PhD[2], Ilnam Sunwoo, MD, MS[5], Seo Yong An[2], Hye Jeong Jeong, PhD[2]

Departments of [1]Thoracic and Cardiovascular Surgery, [2]Biomedical Engineering, Yonsei University College of Medicine, [3]Division of Medical Information and Technology, Yonsei University Health System, Departments of [4]Plastic and Reconstructive Surgery, [5]Neurology, Yonsei University College of Medicine, Seoul, Korea

Objectives: The purpose of this study was to review an implementation of u-Severance information system with focus on electronic hospital records (EHR) and to suggest future improvements. **Methods:** Clinical Data Repository (CDR) of u-Severance involved implementing electronic medical records (EMR) as the basis of EHR and the management of individual health records. EHR were implemented with service enhancements extending to the clinical decision support system (CDSS) and expanding the knowledge base for research with a repository for clinical data and medical care information. **Results:** The EMR system of Yonsei University Health Systems (YUHS) consists of HP integrity superdome servers using MS SQL as a database management system and MS Windows as its operating system. **Conclusions:** YUHS is a high-performing medical institution with regards to efficient management and customer satisfaction; however, after 5 years of implementation of u-Severance system, several limitations with regards to expandability and security have been identified.

Keywords: Ubiquitous Hospital System, OCS, EMR, ERP, PACS

I. Introduction

Yonsei University Health Systems (YUHS) consists of 2 graduate schools, a medical school, a dental school and a nursing school, as well as Gwangju Mental Health Hospital and 3 general hospitals; Severance Hospital, Gangnam Severance Hospital, and Yongin General Hospital. These sites have approximately 3,200 patient beds and almost 8,000 employees.

In order to achieve its goal of becoming a future-oriented, world-class institution, YUHS embarked on the ubiquitous-hospital project to actively embrace Korea's medical service market liberalization and rapidly changing paradigms in the medical environment. The project is ambitious and mid- to long-term involving the introduction of intelligent systems, the expansion of infrastructure and security systems, and the actualization of digital management. Its goals are the integrated management of information for hospitals, increased operational efficiency through the standardization of user interfaces, business processes, and codes, and the establish-

ment of management support and scientific cost control and analysis systems.

To achieve these goals, YUHS needed to prepare for the integrated operation of 4 hospitals by implementing an integrated physician's order communication system (OCS) and electronic medical records (EMR) system, securing management information support through data warehousing, stimulating communication, and improving workflow, as well as reinforcing services for internal and external customers through mobile technologies. Even though immediate convenience is important, the foremost goal of medical information systems is to provide ease of clinical research with the main focus being on the patient. Medical information systems must also be user- and future-oriented allowing easy entry of patient information.

II. Case Description

1. History
The ubiquitous-hospital project is very extensive and therefore carried out in several stages (Figure 1). The first stage consisted of completing the infrastructure by integrating and interconnecting the core systems of medical institutions, i.e., OCS, EMR, picture archiving and communication system (PACS), and enterprise resources planning (ERP). The second stage involved implementing electronic health records (EHR) with service enhancements, while the third stage involved expanding the knowledge base for research with a repository for clinical data and medical care information and extending it to the clinical decision support system (CDSS).

YUHS finished the third stage with the opening of a clinical data repository in 2008, which involved implementing EMR,

as the basis of EHR, to manage individual health records from birth to death including health examination information complete with the clinical histories of family members. The scope of this work included applying user-defined XML templates, constructing .NET-based advanced architecture, and establishing a standard terminology system.

The EMR system of YUHS consists of HP integrity superdome servers embedded with Intel® Itanium® chips, using MS SQL for the database management system and MS Windows for the operating system. To maximize internal business efficiency and customer satisfaction, improvement of user convenience was given the highest priority. Despite initial concerns about safety when we switched to a Windows environment, the systems are now operating perfectly without any faults [1]. Prescriptions and patient records are integrated on one screen and data structuring is enabled through the use of standard forms.

2. Enhanced Customer Services at the YUHS
The YUHS is a customer-oriented institution developed to manage the care cycle from admissions to discharge and afterwards. Patients save both cost and time by making reservations and checking examination results on the internet at home. These enhancements have enabled the hospital to reduce waiting times, greatly improving customer satisfaction. The u-Severance system also utilizes smart cards for services such as parking, guide kiosks, u-stations, certificate issuance, and viewing of visitor information. For example, when patients use their smart card to enter the hospital's carpark, their entry time is recorded, while their appointment is reflected on the OCS. Furthermore, when they scan their smart card at a u-severance guide kiosk, their card is verified,

- HIS: hospital information system
- OCS: order communications system
- PACS: picture archiving and communications system
- EMR: electronic medical record
- PoC: point of care
- CDSS: clinical decision support system
- SEM: strategic enterprise management
- DW: data warehouse
- ERP: enterprise resource planning
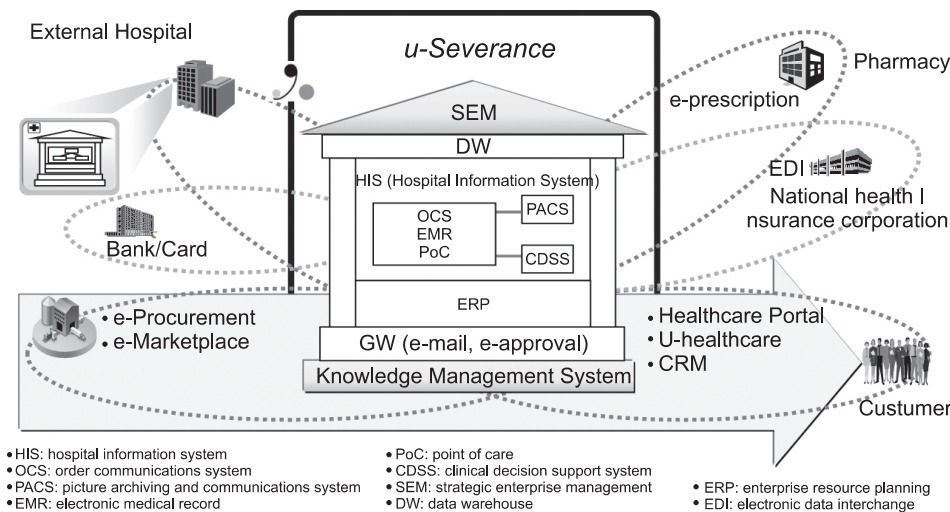- EDI: electronic data interchange

Figure 1. Overview of u–Severance System.

their registration number called-up, and the OCS accessed to bring up the patient's medical schedule. This significantly reduces waiting times for customers.

With the success of EMR, YUHS is also looking into making medical records available to patients and referral physicians online, to further enhance business efficiency and reduce costs. It is also exploring the possibilities of providing treatment statistics and index data online, as well as a clinical research system, and a more efficient collaboration and treatment delivery system. The benefits realized through the ubiquitous-hospital project have allowed YUHS to channel efforts toward reinforcing its status as a reliable and leading research institute and premier medical institution.

III. Results

The current U-Severance Information System consists of EMR & Electronic Nursing Records (ENR), Order Communication System & Medical Supporting System, Administration for Medical Services, ERP & Management Information System, and Disaster Recovery System. Each system is described in detail as follows. The hardware configuration of u-Severance system is also shown in Figure 2.

1. EMR & ENR

EMR can clearly distinguished procedures based on information regarding prescriptions and clinical record information. Various forms are necessary to input, save, and manage information without limitations. In the case of traditional information management, there is a shortcoming in that too many forms of similar types are produced. EMRs use Medical Record (MR) ITEM units for the management of information. For this project, all forms related to hospital staff activity were collected and re-sorted by classification (record sheet, result sheet, agreement, legal form). The management aspect and linearity of medical treatment records were accommodated through the generation of new forms based on MR ITEM. The MR ITEM concept was also applied to surgery nursing records, and anesthesia nursing records, as well as nursing informatics research forms. An additional merit to using MR ITEM is that the flow of record information is easily understood from the end user's point of view.

ENR is based on the Severance nursing process model and systematically organized as 3Ns (NANDA, NIC, NOC), providing a foundation for easy realization of the ENR system and allowing for efficient visualization of the activities of the clinical nurses. Systematic nursing procedures lead to high-
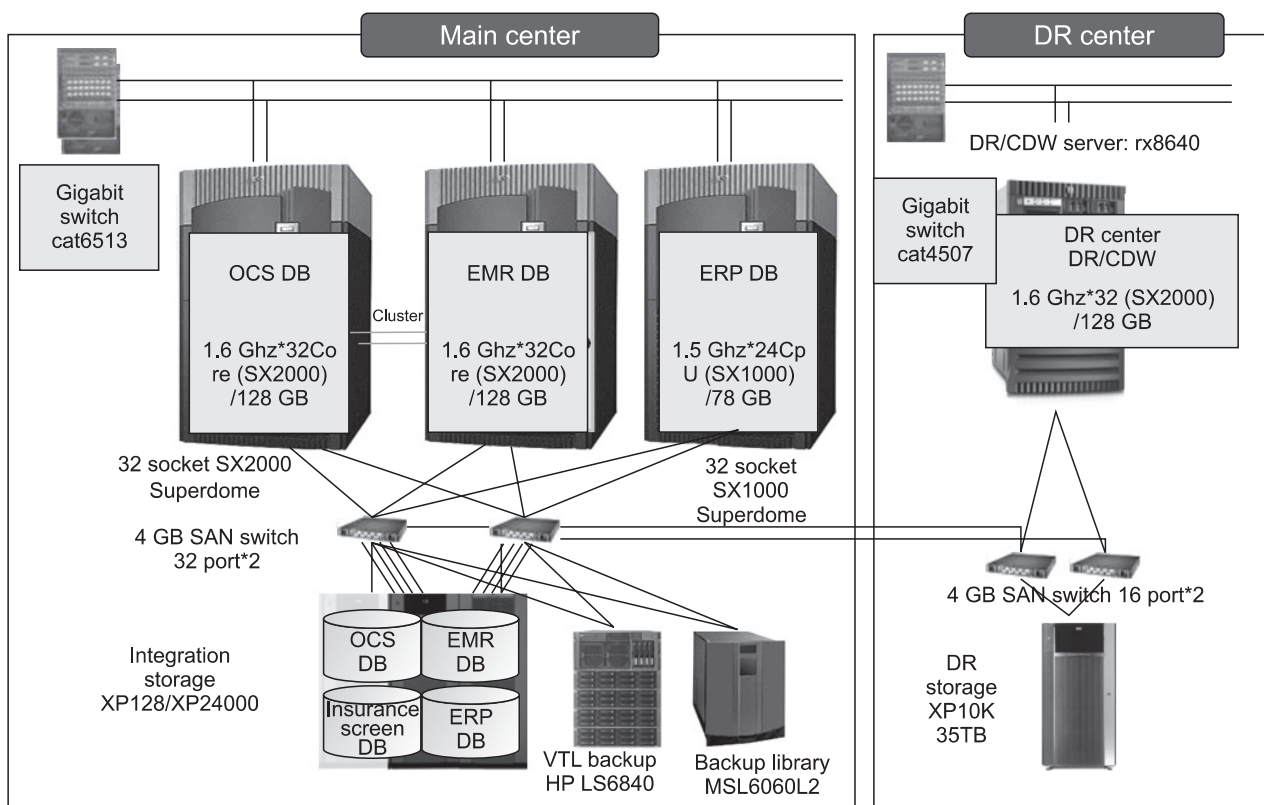

Figure 2. Hardware configuration of u-Severance system. EMR: electro medical record, ERP: enterprise resource plan, VTL: virtual tape library, SAN: storage area network.

quality record keeping. Through the systematization of inference algorithms it is easy to determine nursing diagnosis and interventions based upon information of hospital admission and discharge, test result, diagnosis, surgery, clinical observation information, etc.

EMR/ENR information is also useful for medical treatment statistics, indicator data, activity based cost analysis, etc. Access history of these systems, detailing who read what record when, should be saved for all medical records [2,3].

2. Order Communication System and Medical Supporting System

The OCS was flexibly designed to allow physicians to not only choose things from each examination group through a menu bar but also a user or user group can initiate 'User set' permitting examinations and drugs to be prescribed in a short period of time. Also, by entering 2 or 3 words of a product or chemical name or diagnosis, prescription order can be selected from a related pop-up list.

This system also functions for the convenience of patients and has improved the process of medical treatment. In the outpatient clinic, patients can check-in directly through installed card reader at department reception desks which alert patients when it is nearly their turn for medical treatment without making them wait in front of the doctor's office. The system is also capable of sending short messaging system (SMS) according to medical treatment department and doctor by text message. Although it is policy to pay in advance prior to treatment, this system allows patients who initiate a deferred payment agreement contract to pay after medical treatment through the post receipt patient service.

As part of the strategy to eliminate overcrowding in the emergency room (ER), emergency medical treatment follows a 2-4-12 rule policy, that is, a decision with regard to hospitalization, transfer, or discharge must be made within 2 to 4 hours after admission and all emergency medical treatment must be concluded within 8 hours of having a decision or within 12 hours of admission. The emergency process is especially unique in that if ER doctor initially diagnoses a person as an emergency patient, relevant doctors and nurses are notified by the system and all processes progress urgently permitting a quick decision. This decrease in time to treatment is particularly important in cases involving stroke, myocardial infarction, sepsis, or bleeding.

Hospitalization treatments are organized by critical pathway (CP) contributing to improvement in medical treatment quality and customer satisfaction by registering and applying CPs determined according to diagnosis [4,5]. The registra-

tion of a CP includes prescription by date, record, and nursing diagnosis. When there is a decision for hospitalization in the outpatient clinic, the system can guide the CP determined by the diagnosis and indicate the intended patient to whom the CP will be applied. When an intended patient is registered for hospitalization from the administrative office, a patient to whom a CP will be applied is automatically registered as a CP patient. Doctors can evaluate the CP by date and treat the patient at the same time. Records are integrated and managed and incomplete records can be monitored on one screen. A nurse can explain a planned medical treatment procedure to a patient in advance and carry out nursing care according to the schedule confirming the nursing diagnosis by date.

The Case Pack Delivery System (CPDS) used in the operating room arranges expendables for use in surgery in advance by diagnosing department or family doctor, processes claims, as well as manages returns, minimizing the quantity of expendable supplies in the operating room while standardizing claims and returns. With Drug Utilization Review (DUR) the system confirms administration and checks whether specific drugs are appropriate for the patient when prescribed. Modules include drug to drug interactions, checks for duplication of prescriptions, safety ranges of dosages, attention guidelines for pregnancy and breast-feeding, use in children, etc. CDR (Clinical Data Repository or Clinical Data warehouse) provides a variety of clinical information to doctors in order to support their clinical research.

3. Administration for Medical Services

Integration of patient IDs among affiliated hospitals permits the integrated management of the administration process. Insurance claim/evaluation was designed for a speedy process of insurance claims and ease of claims review. The open card system, automatic payment system, custom guide system, Interactive Voice Response (IVR), Kiosk, IVRFAX, etc., all work to advance medical services for customers.

4. ERP and Management Information System

YUHS introduced the ERP system with the goal of improving financial management by optimizing the flow of financial information among various. Accurate performance evaluation was not possible because there were no objective standards and evaluation of financial performance. In addition, analysis of calculating profits and losses were not made properly so it was difficult to understand the capabilities of equipment and decide whether their operation was necessary or not. Automation was not easy to fulfill and there were

too many indirect costs due to hospital features. An accurate activity analysis and reliable computations were needed, as well as high-quality customer service, convenience, and access to medical information [6].

From June 2004, YUHS has been pursuing an integrated information system to actively take advantage of e-Business opportunities. As the first condition for ERP, master data (i.e., goods and drug codes, personnel information, equipment, unit, and account information, etc.) were defined considering simplification through standardization of code systems and integration between hospitals. The scope of ERP was systematically established considering integration for the administration and research management fields [7,8]. As aspects of typical administration management task proficiency; a human resource system, a financial accounting system synchronized with goods, medical equipment prevention check and management, and accounting system for compilation of budget cost-analysis profitability were established. For research management a knowledge management system was established through digital management of research products, research objects, and clinical data links. A systematic change management system was also established to minimize confusion caused by accepting new processes and task re-distribution.

5. Disaster Recovery System

It is very important that the integrated medical information system of a large hospital have stability and a back-up for infra-structure, databases, and applications to protect against disaster. To achieve this, there are 4 disaster recovery systems, as well as a tripling and quadrupling of data, and storage of EMR data to a separate XML file

IV. Discussion

YUHS have provided better medical processes in a cost-effective way and enhanced the customer services by using the u-Severance system. The patient cycle is efficiently managed from admissions to discharge and afterwards. Efficient establishment of various types of clinical documents are facilitated with re-usability of medical information.

The u-Severance system has been in use for 5 years now and several limitations for expandability and security have been identified. Outpatient and inpatient databases (DBs)

were merged together in order to allow for information sharing between outpatients and inpatients. However, there is a need for separating the two DBs and create supplementation in order to prevent problems with one DB affecting the other. In addition, there is a need for further performance improvement by establishing a DB with XML documents and fine tuning. Other areas for improvement include improving MR ITEM structure for the integration of CDR and CDSS, upgrading .NET framework, enriching user interface, tightening up security and privacy, and integrating ID management.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

References

1. Yonsei University Health System [Internet]. Seoul: Yonsei University Health System; c2009 [cited 2010 Mar 1]. Available from: http://www.yuhs.or.kr/en/.
2. Eduljee A, Rocha RA. Practical evaluation of clinical guideline document models. AMIA Annu Symp Proc 2003: 836.
3. Tully MP, Cantrill JA. Insights into creation and use of prescribing documentation in the hospital medical record. J Eval Clin Pract 2005; 11: 430-437.
4. Pearson SD, Goulart-Fisher D, Lee TH. Critical pathways as a strategy for improving care: problems and potential. Ann Intern Med 1995; 123: 941-948.
5. Coffey RJ, Richards JS, Remmert CS, LeRoy SS, Schoville RR, Baldwin PJ. An introduction to critical paths. Qual Manag Health Care 1992; 1: 45-54.
6. AHIMA e-HIM Personal Health Record Work Group. Practice brief. The role of the personal health record in the EHR. J AHIMA 2005; 76: 64A-64D.
7. Markus ML, Tanis C. The enterprise systems experience--from adoption to success: glimpsing the future through the past. Cincinnati (OH): Pinnaflex Educational Resources, Inc.; 2000: p87-100.
8. Markus ML, Tanis C, Fenema PC. Enterprise resource planning: multisite ERP implementations. Commun ACM 2000; 43: 42-46.