Implementation of Medical Information Exchange System Based on Registry Server Model

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The systems of Medical Information Exchange among hospitals have widely been important issues in healthcare industry due to the non-interoperability of medical information in Korea. In this paper, to be able to consider more effective ways of sharing patients’ medical information, we developed a new Medical Information Exchange System (MIES) based on Registry Server Model which the system enables us to interoperate different types of data made by various different systems. To develop MIES based on Registry Server Model, we deal with the standardized data transfer methods and the terminologies suggested by Center for Interoperable EHR (Electronic Healthcare Record) of Korea to guarantee the interoperability of each participating system in each hospital. By applying the EHR standard to the proposed MIES, we assure that a patient’s medical information can be effectively exchanged under the different system environment. To ensure the information security, reference is made to the security guidelines suggested by the Center for Interoperable EHR of Korea. This study aimed at essential security systems for implementation of online services, such as encryption in the communication section, server security, database security, protection against web attacks, contents security and network security. The proposed MIES designed as centralized the Registry Server Model independently to guarantee the security for the sharing patient’s medical information to minimize.

Key words: Electronic health record, VPN, Web service security enhanced, Health level 7 standard, CDA R2

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1. Introduction

When the patient transferred to other facilities or select a new hospital, the patient is expected to bring his/her own records and submit to the newly assigned doctors1). In this case, records for the
patient are provided in various forms and informations by each doctor. Thus, the accuracy and usefulness of those records is limited when those ones are used. To overcome these barriers, some web-based information sharing systems have been developed in some General Hospitals to communicate with their affiliated clinics to eliminate manual procedures recently. However, this kind system is not proper for the nation-wide standard model but for the affiliated medical facilities\(^2\).

EHR is an information system that integrates EMR (Electronic Medical Record) maintained by individual hospitals to effectively exchange treatment histories of a patient scattered around medical facilities\(^3\).

EHR provides various benefits, in terms of improved medical service quality, reduced medical costs, better accessibility and enhanced safety for patients. Based on electronic treatment information and the clinical decision support system, EHR can incorporate drug interactions to reduce prescription errors and constantly monitor side-effects of pharmaceuticals for safer medical services. Moreover, by making individual treatment information available regardless of time and location, EHR increases patient’s right to know, improves the ability to manage diseases, and alleviates the asymmetry between the medical staff and the patient\(^3\). EHR can also intensify personal information protection by implementing managerial, technical and physical measures against misuse and abuse of treatment information\(^4\).

The primary aim of this paper is to build a Medical Information Exchange System (MIES) which makes it possible to exchange medical information among medical information systems of various hospitals, rather than one-to-one information transmission, and also guarantees the interoperability on medical information systems of the participating institutions. The MIES developed in this study have been tested by Seoul National University Bundang Hospital (SNUBH) as a secondary care center and 33 nearby Physician’s Clinics. Figure 1 shows the delivery process model of Referral from Physician’s Clinics to General Hospital. The requester institution sends a referral message to the Registry Server when referring patients, and stores the CDA document at the CDA Repository in Physician’s Clinic. Then requester institutions send Referral Message to requested hospital. Requested hospital request the Registry information to Registry Server and retrieve the CDA document after check the registry information. And also Referral Reply and Information Release Request are delivered as reverse way. This paper focuses on the system architecture and technical approach of the MIES for medical information exchange process.

2. Methodology of the MIES

To enhance the reliability and effectiveness of the medical information data exchange among the different medical institutions, the following factors should be considered very importantly: well screened items, data transmission methods, standardized terminologies and data and system securities.

Having considered the above issues, this study carefully applied ebXML data transmission standard suggested by Center for Interoperable EHR of Korea for a message transmitting system between non-identical systems. Furthermore, the
Web Service approach is adopted in this study to connect the EMR system of each hospital to the newly designed one. In addition, the international standard of the CDA R2 is used to enable nationwide transfer of medical records for information exchange purposes. We implemented centralized EHR Registry Server which contains information to share. And it will enable users to retrieve and distribute the CDA document from CDA Repository with patient index (Figure 2).

The EHR Registry Server is the center to store and manage the information on service-user hospitals, patients, their medical information and their consent to release of medical information.

2.1 System Architecture

The Medical Information Exchange System (MIES) is designed to exchange CDA documents within designated medical facilities through the CDA Transfer Server with a help of Central Registry Server. The essential functions of this server are managing the index information of the patients subject to information exchange, and facilitating the exchange of CDA documents via the CDA Transfer Server with the index information.

The MIES which consists of two servers needs to be connected to an adaptor. This adaptor plays a role of intermediary to transmit the CDA document and messages. The Registry Server stores the patient information according to predefined schema and generates the index for patient, which used for searching CDA documents. Using the produced index information of the patient, the CDA Transfer Server extracts the relevant CDA documents from the CDA Repository of the requester hospital for transmission. Then, the transmitted data is stored at the requested hospital’s Repository (Figure 3).

2.2 Application Methodology of CDA

To share the medical information among the different medical institutions, it is necessary to determine the items to be exchanged. The determined items are defined in the CDA format in reference to the structure of the CDA R2-based data architecture.

As a result, three templates can be generated: Referral Form, Referral Reply, and Information Release Request. In this study, LAB test result, medication order and health summary are summed up into an integrated template, and reproduced in a standardized XML format.
A CDA document consists of two parts: a Header and a Body. The former contains the personal information on a patient, while the latter contains the medical information on the patient.

In this paper, the CDA Body is constructed in the Structured Body type and is written out in the XML format. The Body encompasses items regarding LAB test result, medication order and treatment summary and is constructed in accordance with the CDA standard, as shown in Figure 4.

2.3 Application Methodology of Data Transfer

The Document Registry Framework (DRF) suggested by Center for Interoperable EHR of Korea is put to use to connect the Registry Server, which registers and manages the information categories subject to exchange, and the Repository, which stores and manages the CDA documents (Figure 5).

A CDA document is stored at the repository upon creation, and the registration is stored at the registry in the form of a message. To retrieve the generated CDA document, the Document Consumer obtains CDA ID and information on location of the Repository from the Registry, and finally gets the CDA document in need, from ebXML.

The DRF is provided in the WSDL format, along with the API of the transmitting module, in order to be applied to various platforms easily (Figure 6). The system developed in this study is a “.NET”-based platform, and the API is applied by using the “Visual studio. net.”

2.4 Application of Standard Terminology

A standardized terminology code is applied to transfer information on the diagnosis and the
medication for consistency. To notate the diagnosis of a patient, ICD-10 codes are used and marked into the Entry in a CDA document. The medication is represented in the Entry level of CDA document by using the EDI (Electronic Data Interchange) codes and the EDI main ingredient codes. A standardized terminology needs to be employed to transfer medical information from one system to another, and definitions are set forth at the CDA Entry level.

For diagnosis code ICD-10, codeSystem was set 2.16.840.1.11383.6.3 at the Entry Observation (Figure 7).

The EDI medication code is employed without alternation for medication and the codeSystem is set 2.16.410.1.10000.4, along with the information on ingredients, dosages and manufacturers of the drugs in use (Figure 8).

2.5 Application of Security

The security guidelines proposed by the Center for Interoperable EHR of Korea was used to ensure the information security. In this study, we aimed at essential security systems for implementation of online services, such as encryption in the communication section, server security, database security, protection against web attacks, content security and network security.

For that purpose, the VPN is implemented to encode packet in each middleware section. To protect the database and the server, an encryption solution is applied. A web firewall is implemented as well to block web attacks. Especially, to secure the data, all the transmitted data are sent out after encoding and decoded after receiving by using the public-key cryptography.

The communications between web services mounted on the middleware are conducted by managing the certification codes for each hospital middleware, thereby blocking access to the services if certification failed.

When sending a message, each packet is encoded for transmission within a VPN-controlled section.

The message calls the Web Service on the Registry Server: the paging call is verified against the Web Service Security Enhanced (WSE) for passage.

In case of Web Service, the Token in SOAP-type is checked for verification. Specifically, the ID and the password are checked. The password is encoded and stored in the database for future verification. Once certified, the encoded message is decoded and delivered to the final recipient.

Furthermore, access control is accomplished by monitoring user’s IP and Mac address on internal network in the security policy.

3. Experimental Results

The MIES is composed of three categories of services: Registry Server which manages information exchange and the registration information of the CDA documents, the CDA Transfer Server which, using the registration information, locates the CDA document in need from the relevant Repository Server and transmits it, and the CDA viewer which shows the CDA documents through
connection with information systems of hospitals concerned (Figure 9).

3.1 Registry Server

The Registry Server stores the meta-information for exchange of the medical information on a patient subject to referral. It provides two types of services: messaging service which enables reception and transmission of the meta-information, and the registry service which registers and manages information on exchange.

3.1.1 Messaging Service

The messaging service is composed of the service for transmission, the service for storing and inquiring the transmitted message. When transmitted, each message is molded in the XML schema.

The meta-information contains data on the sending and receiving medical institutions, medical staff in charge, reservations, diagnosis and meta ID. Especially, the meta ID is transmitted as a message produced by the OID rules. This OID is unique to each message, and serves as an index to search the relevant CDA document\(^6,7\).

When receiving a message, it is delivered via the messaging Web Service which is known as the CDAREgService. This Web Service uses the message decryption for decoding, and use the message parser for interpretation, and store the meta data to Database.

3.1.2 Information Exchange Registry Service

For a patient or a hospital to subscribe to this service, it needs to sign up for the service at the MIES Server for certification. The registration procedure is provided by Web Service at the EHR Registry Server. The procedure is tailored for each information exchange stage, and contains information on Referral, Reply, and Request. In addition, two other services are provided: one that verifies the consent to the release of the medical information, and the other that stores the registry information.

A certification message is sent out in a XML format, which activates the Registry Service from the MIES Server. The final authentication undergoes the processes such as verification of consent, certification and EHR registration. The certification message conveys the information on the ID code of the medical institution and on the patient’s social security number. These two pieces of information are used to check whether the EHR registration has been done or not. During transmission, the certification information remains encrypted.

When the consent information is absent, the Registry Web Service remits an “Authentication Fail” message to the original sender. Upon receipt, the sender sends back the registry information. When the registry information arrives at the MIES Server, its Registry Service activates and registers the information (Figure 10). Once the information on the patient and the hospital are registered, the Registry Service sends an “Authentication Success” message to the original sender, and the sender is now able to access the information exchange service and to start the medical information exchange process.

3.2 CDA Transfer Server

When a hospital transfers a patient to another institution, the requester institutions send a referral message to the Registry Server and the CDA Server.
document is stored at the CDA Repository. To transmit the stored CDA document, the Transfer Server searches the CDA documents produced at the requester institution and the receiving institution, and sends the relevant information to the requested institutions.

To search a document stored at the CDA Repository of a hospital, the index unique to the document is required to facilitate this process. Thus, a unique ID is assigned to each CDA document, and the unique ID is transferred in the form of meta ID upon message transmission.

When requesting for transfer of a CDA document, the requester hospital sends to the requested hospital, the OID generated during the messaging Web Service. The link service, which searches the CDA record, is registered at the registry through the CDA SearchService, and the CDA Document is stored at the CDA Repository.

The requested hospitals find out the location in the Registry in reference to the meta ID of the received message. Upon receipt of a request, the DRF Server searches the indexed document stored at the CDA Repository by the meta ID and transfers to the requested hospital.

### 3.3 CDA Viewer

When a hospital or a clinic refers or replies to the referral, the CDA document contains medication information, LAB test results and the patient profiles.

The requester hospital needs program to make the CDA document for XML Style Sheet (XSLT) and to access the medical information exchange service. And the transmitted CDA document is viewed on CDA viewer application (Figure 11).

### 4. Conclusion

We developed a CDA standard-based medical information exchange system which electronically exchanges the medical information items defined in accordance with the CDA document standard, adopting the standard transmission method and security devices. The security and standardization approaches cover all processes.

To provide the better personal information protection and security, the MIES, based on the standard suggested by Center for Interoperable EHR of Korea, established a Registry Server and a CDA Transfer Server separately, there by separating the patient information from the medical information. The Registry Server maintains only the patient profile and the indexes of the medical information, which reduces the burden arising from management of the entire medical data. Each CDA document is maintained in the CDA Repository of each medical institutions.
Table 1  Comparison of Prototype of the Information Exchange System and the MIES

<table>
<thead>
<tr>
<th></th>
<th>Prototype of Information Exchange System</th>
<th>MIES (System Based on EHR Standard)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Subject institution</strong></td>
<td>Clinics, secondary hospitals (SNUBH)</td>
<td>Clinics, secondary hospitals (SNUBH)</td>
</tr>
<tr>
<td><strong>Number of affiliated clinics</strong></td>
<td>9</td>
<td>33</td>
</tr>
<tr>
<td><strong>Number of Cases</strong></td>
<td>Appr. 1250 (2007.07.19~2008.6.20)</td>
<td>Appr. 5100 (2008.06.21~2009.03.20)</td>
</tr>
<tr>
<td><strong>Information exchanged</strong></td>
<td>Diagnosis, Medication orders, LAB test result</td>
<td>Diagnosis, Medication orders, LAB test result, surgery history, and medical images</td>
</tr>
<tr>
<td><strong>Documents exchanged</strong></td>
<td>Medical Referral and Reply form</td>
<td>Lab, Medication, Health Summary Medical Referral and Reply form, request for release of medical information</td>
</tr>
<tr>
<td><strong>CDA Level</strong></td>
<td>CDA R2 without Entry</td>
<td>CDA R2 with Entry</td>
</tr>
<tr>
<td><strong>Standard terminology</strong></td>
<td>No applicable codes</td>
<td>–Diagnosis : ICD-10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>–Medication : EDIcode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>–Item definition : LOINC</td>
</tr>
<tr>
<td><strong>Parties of exchange</strong></td>
<td>One – to – one exchange via gateway between hospitals</td>
<td>One-to–Many Exchange via EHR Registry Server</td>
</tr>
<tr>
<td><strong>Transmission method</strong></td>
<td>Web Service</td>
<td>Web Service (Message) &amp; ebXML (CDA)</td>
</tr>
<tr>
<td><strong>Encryption</strong></td>
<td>Secret key cryptography</td>
<td>public–key cryptography</td>
</tr>
<tr>
<td><strong>Platform</strong></td>
<td>.NET</td>
<td>.NET &amp; JAVA</td>
</tr>
<tr>
<td><strong>Security</strong></td>
<td>SSL, Server vaccine, SSL and firewall</td>
<td>encryption in the communication section, server security, database security, protection against web attacks, content security and network security, SSL implementation of VPN</td>
</tr>
</tbody>
</table>

The interaction among the heterogeneous systems is made possible with middleware. We constructed MIES based on the exchange standard suggested by Center for Interoperable EHR of Korea so that any system can be accessed.

Table 1 shows comparison of the old “prototype of the information exchange system” and the new “MIES” developed in this study. The “Prototype of Information Exchange System” has been tested to try medical information exchange between nearby some clinics and SNUBH at the first.

Currently, various Hospitals demand applying application of this instant system for an effective information exchange in Korea. To meet the demand, it is being pursued to build an advanced system enabling information exchange among the multiple Hospitals and clinics.

Applying the international standards to exchange of information among the different medical information systems, this study will expectedly contribute to medical information exchange not only between domestic medical institutions, but between international medical institutions.

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