# Development of Clinical Information System for Persistent Lifelong Electronic Medical Record

**Ilkon Kim[a], Jihyun Yun[b]**

[a] *Intelligent Health Information Sharing System Development Center, Daegu, Korea*
[b] *Dept. of Computer Science, Kyungpook National University, Daegu, Korea*

**Abstract**

*In order to improve the patient healthcare, it is required to cooperate among different clinical information systems. Enabling patient care records to be shared among hospitals is essential not only in delivering the quality of medical care services but also in saving medical expenses. The referred or emergency transported patients are required to carry their referral initiation forms. In this case, patient care records are usually exchanged paper-based and systems are not well organized. A clinical information system for persistent lifelong electronic medical record can help a physician make the appropriate treatment plan, and avoid making a wrong diagnosis. In this paper we develop a clinical information system for persistent lifelong electronic medical record. Our approach is focused on patient-centric care, more importantly, design mechanisms are based on HL7 standard and XML.*

***Keywords:***

Patient information sharing; Hospital information system; HL7; XML

## Introduction

The major issues with medical records are their electronic format, accessibility, sharability, confidentiality, security, acceptability to clinicians and patients. Enabling patient care records to be shared among hospitals is essential not only in delivering the quality of medical care services but also in saving medical expenses. The referred or emergency transported patients are required to carry their referral initiation forms. A clinical information system for persistent lifelong electronic medical record electronic medical record can help a physician make the appropriate treatment plan, and avoid making a wrong diagnosis.

However the development of effective electronic medical records system has been hampered by (1) the need for standards in the area of clinical data, (2) concerns regarding data privacy, confidentiality, and security, (3) challenges of data entry by physicians, and (4) difficulties associated with the integration of record systems with other information resources in the healthcare setting.

In this paper we solve the problems by (1) adopting HL7 standards, (2) applying network security, (3) supporting HL7 interface engines, and (4) considering clinical document repository. In order to improve the patient healthcare, we focus on patient-centric care to develop a clinical information system for persistent lifelong electronic medical record.

## Sharing Medical Information

Healthcare records are widely distributed and have strong local autonomy [1]. Frequently, patient information is not available when and where it is needed. This lack results in multiple requests to patients for personal data, unnecessary duplication of tests and other investigations, and ultimately delays in the patients receiving appropriate care. Synapses [2,4] and SynEx [3,11] developed as part of two European Commission-funded projects, which share electronic health-care records through the Internet. Synapses concentrated on the specification of a Federated Healthcare Record (FHCR) server, which provides integrated access to a record's distributed components. The Synapses server provides the functionality of a federated database system. Individual patient data could be distributed across numerous hospital and community health sites, which might necessitate forwarding a query to a server located elsewhere. A Synapses server at an external site would then act as a federating device, hiding the details of its local feeder systems from the remote.

The SynEx project concerned integrating a number of components – the Synapses record server being just one – to form an information system from which client applications could access a wide range of data in support of the health-care business. In SynEx, the record server was further developed as a component within an open, distributed-computing environment in an enterprise-wide manner and using XML technologies, with support for Web-based clients.

On the other hand, the recognition of the need for interconnection led to the development and enforcement of data-interchange standards, which include a standard medical vocabulary, standards for hospital information systems, standards for the computer-based patient record, and standards for data interchange. The HL7 is to provide a standard for the exchange of data among hospital-computer applications [5,6]. The HL7 standard is message based and uses an event trigger model that causes the sending system to transmit a specified message to the receiving unit with a subsequent response by the receiving unit. Messages are defined for various trigger events.

The HL7 organization is also developing standards for the representation of clinical documents (such as discharge summaries and progress notes). These document standards make up the HL7 Clinical Document Architecture (CDA)[5,7]. The HL7 CDA Framework became an ANSI-approved HL7 standard in November 2000. The CDA is a document markup standard that specifies the structure and semantics of clinical documents. A CDA document is a defined and complete information object that can include text, image, sounds and other multimedia content and gateway for Electronic Medical Record to support sharing and interoperability of Electronic Health Record.

In this paper we consider a clinical document repository, which integrates individual patient records of CDA format. The CDA generates XML based clinical documents and these clinical documents to be enclosed by HL7 messaging are stored into clinical document repository as document centric data of native XML databases.

An electronic medical record is a structured information collection about an individual patient. Extracts of individual patient records, obtained from a system and brought together in a structured format, can be shown to the other healthcare system. Figure 1 shows this scenario. A patient from hospital A transfers to hospital B. In hospital B, the doctor may need the past clinical record for diagnosis. In this case, if the patient record in hospital A has been stored in a clinical document repository, hospital B requests a transfer of the patient's clinical information and receives it. Alternatively, hospital B directly requests hospital A to send the clinical information.

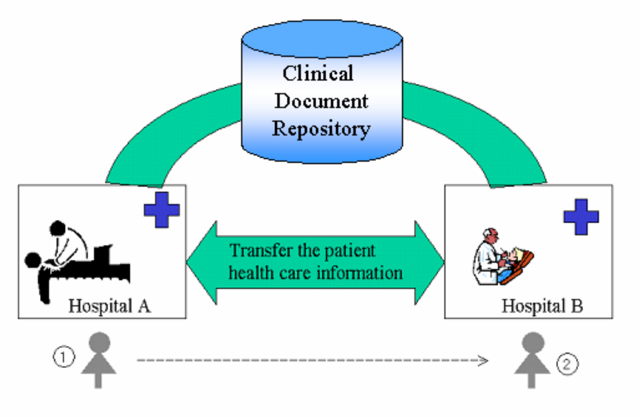


Figure 1 – A target scenario

In hospitals and other distributed health care environments, myriad data needs to be collected by multiple healthcare professionals who work in a variety of settings; each patient receives care from a host of providers-nurses, physicians, technicians, pharmacists, and so on [10]. Communication among the members of the team is essential for effective healthcare delivery. Communication among the different hospitals is often also required. Data must be available to decision-makers when and where they are needed.

In many institutions, furthermore, clinical and financial activities are supported by separate organizational units. Hospital administrators must integrate clinical and financial information to analyze costs and to evaluate the efficiency of healthcare delivery. Similarly, clinicians may need to review data collected at other healthcare institutions, or they may wish to consult online databases of biomedical information. Local-area networks that permit the sharing of information among independent computers and wide-area networks that permit the exchange of information among geographically distributed sites provide good communication infrastructures. The actual integration of information requires additional software, adherence to standards, and operational staff to keep it all working as technology and systems evolve.

The Figure 2 shows a health information sharing system which has four objectives, (1) local, remote, and mobile sharing of clinical, (2) persistent management of chronic patient, (3) clinical document sharing of emergent patient, (4) persistent, unique, personal identifier management.

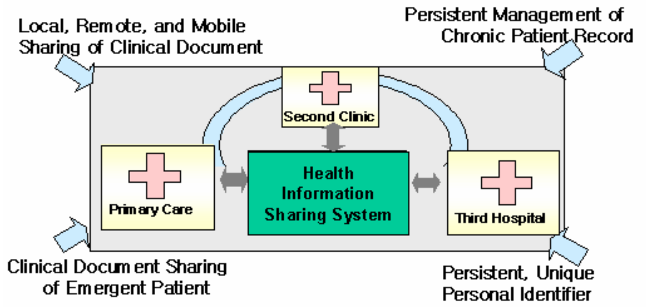


Figure 2 - Health Information Sharing System

## Clinical Information System Architecture for Persistent Lifelong Electronic Medical Record

In our developing system, it is composed of transport layer, HL7 interface engine, CDA composer, CCOW (Clinical Context Object Workgroup), MLM (Medical Logic Module) and CDR.

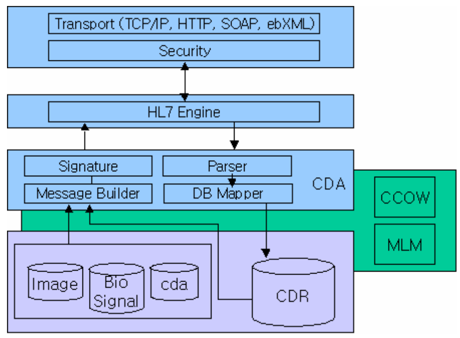


Figure 3 - Inter-hospital communication with HL7

Figure 3 shows the entire outline. Inter-hospital communication uses the HL7 interface engine. The HL7 interface engine basically supports the data integration in infra environment, and is sharing the HL7 RIM (Reference Information Model). The HL7 message is encoded with XML and transmitted through security module. While CDA building, security-signatures are attached each document. Being placed in the lowest layer, CDR is mapping patient records into CDA. Finally CCOW and MLM is applied between CDA and CDR.

Figure 4 shows the HL7 interface engine internal entities.

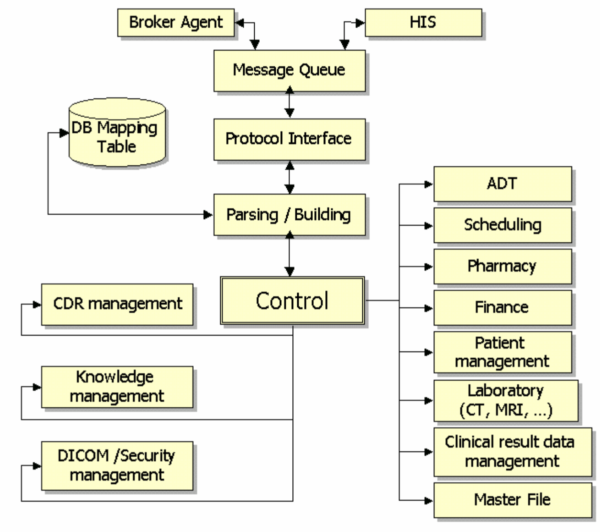


Figure 4 - HL7 interface Engine

The important specific functions are as follows.

- Message queue is
  - to input the message from the Broker Agent, HIS
  - to send the message into the Protocol Interface
- Message mapping in referencing the DB Mapping Table is
  - to generate the message by fitting the message into the HL7 message standard form with composing fields
  - to manage and store the mapping table information separately
- Message Parsing is
  - to analyze the message XML tag by referencing the message mapping table
  - to make action message work according to the message type
  - to store the message in the Database to record history
- Message Building is
  - to build the HL7 message by referencing the message the mapping table
  - to use the autonomous building function without the user directed controlling
- Message Control is
  - to execute the action which the message actually wants, according to the message type, ADT(Admission-discharge-transfer), scheduling, pharmacy, laboratory information management etc.

## Specification of Components

The CDA is part of the HL7 version 3 family of standards. This family, which includes both CDA and the evolving version 3 message standards, all derive their semantic content from the shared HL7 Reference Information Model (RIM) and are implemented in eXtensible Markup Language (XML). The process for generating an XML-based implementation from the RIM is part of the version 3 development methodology [7]. The exact style of HL7's XML representation was a carefully considered balance of technical, practical, and functional considerations.

A CDA document is a defined and complete information object that can include text, images, sounds, and other multimedia content. The document can be sent inside an HL7 message and can exist independently outside a transferring message [6,8]. There is a critical interdependence between clinical documents and document management systems. If CDA documents are viewed outside the context of a document management system, it cannot be known with certainty whether or not the viewed document is current. Clinical documents can be revised, and they can be appended to existing documents. In practice, it is impossible to guarantee an explicit forward pointer from an outdated version to the newer version. Document management systems and HL7 messages that carry CDA documents convey critical contextual information that minimizes the risk of viewing superseded information.

The Medical Logic Module (MLM) contains sufficient knowledge to make a single decision. It is an independent unit in a healthcare knowledge base. Each MLM contains maintenance information, links to other sources of knowledge, and enough logic to make a single decision. The health knowledge contains contraindication alerts, management suggestions, data interpretations, treatment protocols, diagnosis scores etc. For example, when a doctor prescribes the patient penicillin, the MLM checks for contraindications. If the patient has a recorded allergy to penicillin, an alert is generated. This decision support system in clinical institutions has been used successfully for many years, and is useful in preventive medicine. The syntax of each knowledge base is different and cannot be shared. Accordingly, Arden syntax attempts to define a complete health knowledge base for clinical decision support [5,8]. The HL7 standard interprets it as knowledge of the decision support. An MLM with Arden syntax can be used to share knowledge in a heterogeneous system, enabling common clinical treatment can be made.

With an emphasis on the point-of-use of applications, CCOW is to define standards that enable the visual integration of healthcare applications. Applications are visually integrated when they work together in ways that the user can see in order to enhance the user's ability to incorporate information technology as part of the care delivery process. CCOW has focused on specifying the Context Management Standard. Context management entails the coordination and synchronization of applications so that they are mutually aware of the set of common things - known as the context - that frame and constrain the user's interactions with applications. The context is primarily comprised of the identity of real-world things, such as patients, and real-world concepts, such as encounters, that establish the common basis for a consistent set of user interactions with a set of healthcare applications. The elements of the context may be provided directly by users as they interact with applications, or may be provided automatically by underlying programmatic sources. Specifically, the Context Management Standard defines a protocol for securely "linking" applications so that they "tune" to the same context. The context is represented as a set of subjects, each of which generally identifies a real-world entity such as a patient or a real-world concept such as an encounter. Linked applications remain automatically synchronized even when a context subject changes, for example, due to the user's inputs (e.g., the user selects a different patient). The user inputs of particular interest are those that are used to identify something, such as medical record number for patients, or an account number for a clinical encounter. CCOW specifies technology-neutral architectures, component interfaces, and data definitions as well as an array of interoperable technology-specific mappings of these architectures, interfaces, and definitions. It is the intent of CCOW that its standards may be implemented using broadly accepted and/or industry standard computing technologies, with emphasis on those that are most relevant to the HL7 membership. It is also the intent of CCOW that its specifications provide all of the details needed to ensure robust and consistent implementations of compliant applications and system services. However, CCOW does not intend for its specifications to serve as an implementation or the design of an implementation.

The hospital information system supports a variety of functions, including the delivery and management of patient care and the administration of the health organization. From a functional perspective, the HIS consists of components that support the following distinct purposes: (1) patient management, (2) departmental management, (3) care delivery and clinical documentation, (4) financial and resource management and (5) managed-care support. For this legacy system to be used in a web environment, we use XML and Web services. The fundamental concept of Web service is simple; web services allow us to make Remote Procedure Calls (RPCs) against an object in the Internet or a network. Web services differ from previous technologies in that their use of platform-neutral standards such as HTTP and XML allows us to hide the implementation details entirely from the client. The client needs to know the URL of the service, and the data type used for the method calls, but doesn't need to know whether the service was built in Java and is running on Linux, or is an ASP.NET web service running on Windows [9].

As web services work based on XML and HTTP or SOAP, it is appropriate that our system have the advantage of being accessed and developed simply. To locate web service providers, we use UDDI (Universal Description Discovery and Integration) specifications, which define XML Schemas that provide information about web services that allow clients to consume web services.

We suggest implementing agents in the .NET framework of Microsoft. This provides a useful and easy user-interface development environment, and contains a variety of utilities for developing web services. This system enables physicians to manage each component effectively and make it possible to use it on Internet.

## Conclusion

In this paper we show the system architecture of clinical information system for persistent lifelong electronic medical records.

For effective treatment it is required to communicate among hospital or clinical institutions and share patient records. Enabling patient care records to be shared among hospitals is essential not only in delivering the quality of medical care services but also in saving medical expenses. A clinical information system for persistent lifelong electronic medical record can help a physician make the appropriate treatment plan, and avoid making a wrong diagnosis. Our developing system aim to focus on patient-centric, patient information is available when and where it is needed. As many legacy systems are heterogeneous and they are not easy to be integrated, we design CDR (clinical document repository) center and adopt HL7 standard - CDA, HL7 messaging, CCOW and MLM. We also consider the security, which is network security and document signature. To communicate among the healthcare institutions, we use HL7 messaging and exchange the patient records to be generated as CDA format. To support physicians' decision, CCOW and MLM are applied between CDA and CDR.

To apply it in real world some sensitive issues still remain, such as legal problems of patient record management or conformance between hospitals. For the future work, we will extend this system more useful and apply it in real world.

## Acknowledgments

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**Address for correspondence**

Ilkon Kim, PhD

Intelligent Health Information Sharing System Development Center, 101 Dongindong 2-ga, Jung-gu, Daegu, 700-422, Korea

E-mail : ikkim@knu.ac.kr

Contact URL : http://www.ihis.or.kr/