Integral Medical Information Interchange with HL7 CDA- A Case Implementation

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Abstract

This paper presents an experimental system implementation to support patient information interchanging in patient referral between healthcare institutions. The system is implemented based on an agent-based architecture by adopting Health Level 7 Clinic Data Architecture, particularly with the adoption of HL7 v3.0 Standards, and Digital Imaging and Communications in Medicine v3.0 as well as leveraging the use of advanced information technologies. The HL 7 version 2.5 and HL7 version 3.0, respectively are adopted, respectively for message exchange for this research and system implementation.

The objectives of this research aim to enhancement the system interoperability and information compatibility among healthcare institutions involved in electronic patient referral.

We find HL7 V3.0 provides a thorough component-based reference information model with better transportability, scalability, integration, interpretability but it is also more difficult and complicate to implement but overall it is the trend and unique HL7 standard we need to adopt.

Keywords: Heath Level 7, Clinic Data Architecture, DICOM, Information Technologies, Web Services, Multiple Agents.

1. Introduction

The adoption of standards to develop an information interchange system has been regarded as a very important issue to enhance the interoperability and compatibility in all industries in facing this highly competitive age. Health care industry has no exception. Different industries may have developed different standards for different purposes. Regardless of the purposes in adopting standards, they are aimed to improve the efficiency and effectiveness of system development, maintenance, and utilization. In the US, the Administration Simplification Provision of the Health Insurance Portability and Accountability Act (HIPAA) had mandated the use of named health care electronic data interchange standards such as HL7 Standards and its attachment standards such as like CDA for the electronic conveyance of health care data since 1996. Under this addressed act, the professionals of health information systems, providers, payers are requested to adopt the HL7 Standards in sending or receiving detailed claim or encounter information such as patient order data in terms of diagnosis, laboratory results, observations, treatment modalities, and so forth (ASIG at HL7, 2004).

Therefore, in this research we attempt to build a patient information delivery system in patient referral to enhance the information interoperability and compatibility between health care institutions. The system is implemented by leveraging the use of the standards of medical informatics such as Health Level 7 (HL7) (Hammond, 2003), Health Level 7 Clinic Data Architecture (HL7 CDA), and Digital Imaging and Communications in Medicine (DICOM) and advanced information technologies such as Web services, software agents, and objected-oriented methodologies of system implementation. The HL 7 version 2.5 and HL7 version 3.0 are respectively used to conduct the different message implementation but for the same patient referral application. We use these two different implementations attempting to investigate the advantages, limitation, and constraints of these two versions of HL7 Standards.

2. The Standards of Medical Informatics Adopted

2.1 HL7-Health Level Seven and XML

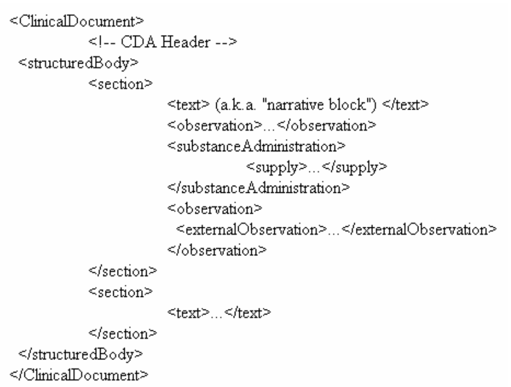
The HL7 (Health Level Seven, 2005) is developed by HL7 Standard organization which is one of American National Standards Institute (ANSI) accredited standards operating in the healthcare arena. The HL7's domain is clinical and administrative data. Its mission is set the standards for the exchange, management and integration of data that support clinical patient care and the management, delivery and evaluation of healthcare services so that the interoperability, compatibility, and quality of medical data and information can be ensured among healthcare information systems (Health Level Seven, 2006). Its newest version 3, which has been evolving over several years, uses an object-oriented development methodology and a Reference Information Model(RIM) (http://www.hl7.org/Library/standards.cfm) to create messages. It will be the most definitive standard to date. It adopts modern class-based concepts to model its information architecture and the use of rigorous analytic and message building techniques resulted in it has less flexibility with little option and significantly different information model from its past versions. As a result, the downward compatibility of Version 3 becomes very difficult even impossible. In contrast, the HL7 Version 2.5, which was approved as an ANSI Standard in June 26 of 2003 (Health Level Seven, 2003), is the version of HL7 Standards currently most widely implemented in healthcare and medical industries..

As the XML (eXtensible Markup Language) became a single standard for exchanging information, HL7 message is also able to be encoded in XML specification for its version 2.x standards. These XML-specified HL7 Standard version 2.x message is informally named as HL7 v2.xml, were formally approved by ANSI in July 2003 (Health Level Seven, 2003; Health Level Seven, 2004) and has been used by healthcare industry since then. However, HL7 v3.0 RIM is inherited to design in an XML messaging model. It is more consistent and capable of supporting more functionality, completeness, and better for imaging than any of the previous versions but it also looks more complicate in terms of modelling and implementation.

In this research, we attempts to use HL 7 version 2.5 and HL7 version 3.0 respectively to implement the same referral application. Two implementations were conducted in two different stages. We aim to make use of these two different version implementations to assess the advantages and constraints of two versions.

The HL7 Clinical Document Architecture (commonly shorted as HL7 CDA) is an XML document standard that specifies the structure and semantics of “clinical documents” (e.g., admission, discharge summary or progress note) for the purpose of exchange. The CDA can be a payload within an HL7 message, so it is also known as HL7 CDA message. The HL7 CDA is a defined and complete information object which can include text, images, sounds, and other multimedia data.

The Clinical Document Architecture, Release 2 (CDA R2), which became ANSI-approved HL7 Standard in May 2005 (Health Level Seven, 2004), is the most recent version of HL7 CDA. The basic architectural model of a CDA document is shown in Figure 1 (Dolin, et al., 2005).



```
<ClinicalDocument>
        <!-- CDA Header -->
  <structuredBody>
        <section>
                <text> (a.k.a. "narrative block") </text>
                <observation>...</observation>
                <substanceAdministration>
                        <supply>...</supply>
                </substanceAdministration>
                <observation>
                  <externalObservation>...</externalObservation>
                </observation>
        </section>
        <section>
                <text>...</text>
        </section>
  </structuredBody>
</ClinicalDocument>
```

Figure 1. Major components of a Clinical Document Architecture document

As we can see from Figure 1, the basic model of a CDA document, which consists of a header and a body, is rooted by '**ClinicalDocument**' tag. In general, the purpose of the CDA header is modeled to identify and classify the document and provide information on authentication, the encounter, the patient, and the involved providers (Dolin, et al., 2005). The body mainly contains the clinical report, organized into sections. The structured body contains one or more 'section' components. The clinical code can be drawn from a LOINC (Logical Observation Identifier, Names and Codes) (Huff, et al., 1998) value set or the clinical data in terms of clinical finding, procedure, observable entity, body structure, and so forth via a code drawn from SNOMED (Systematized Nomenclature of Medicine) (Wang, et al. 2002; SNOMED Clinical Terms, 2006) value set.

In this research, the message include the image is carried by a HL7 CDA message by adopting the Digital Imaging and Communications in Medicine (DICOM) Standard. It is structured as a multi-part document (DICOM Standards, 2004). The image definition, organizing and transmitting (imaging) adopt DICOM 3.0 Part 3 (NEMA, 2004) and Part 18 (NEMA, 2003). The Web Access to DICOM Persistent Objects (WADO) defined in the Part 18 provides a simple method to carry out the access of DICOM object by using HTML Web page or XML document through HTTP/HTTPs secure network protocol. As a result, in this research implementation, we adopt WADO to carry image object in a HL7 CDA document.

3. The Advanced Information Technologies

The modern advanced information technologies are in a variety forms, application domains, and applied techniques. In this research, the major information technologies adopted are software agent, Web services, and object-oriented methodologies for system development.

3.1 Software Agents

The Software agent, one of major studying and applied areas in artificial intelligence, usually bring great benefits in handling routine and repetitive tasks. One of the primary properties of software agents is autonomy, i.e. the ability to continuously monitor and react to changes without the need for human interference or assistance (Shoham, 1993; Jennings, 2000). Other critical properties of software agents are pro-activeness, sociability, and reaction. Software agents exhibiting these abilities can be self-integrated, independently functioning, or inter-coordinated to solve specific problems. They may be easily integrated with an institution's workflow system to play an effective role to seamlessly bridge the gaps between back-end information systems and front-end communication systems (Jennings, 2000).

3.2 Web Services and technologies

Web services are thought to be the paradigm shift of distributed object technology (Booth, et al., 2004). It makes the applications under Web environment proceed to the interoperable services, for examples, description, publishing, searching, and retrieval. Through the use of software components it is possible to loosely couple information systems effectively but irrespective of their platforms or languages as well. The technologies of Web services accelerate the integration of computer systems both in an organization and inter-organizations. It has become a de facto standard under current major IT vendors' supports and advocates.

W3C Web Services Architecture Working Group (W3C WSAWG) (Booth, et al., 2004) defines the architecture of Web services as a layer-plane architecture which can be illustrated as Figure 2. It consists of two layer-planes, which are core service plane and supportive plan. The core service plane provides the service specifications in terms of messages, descriptions, and processes of Web services. The supportive plane contains the rest of service specifications that are defined to support the layer operations of core service plane in terms of the issues of security and management. The core service plane consists of four layer components. The top layer is a process specification layer which is used for the description, aggregation, and choreography of a Web application. In the note released by W3C's WSAWG.

The service specifications of processes layer can be mostly accomplished by the specifications of Universal Description, Discovery, and Integration (UDDI) (UDDI Technical White Paper, 2004). The second layer is the descriptions of Web services language specifications which are commonly named as the Web Services Definition language (WSDL) (WSDL Version 2.0, W3C, 2004).

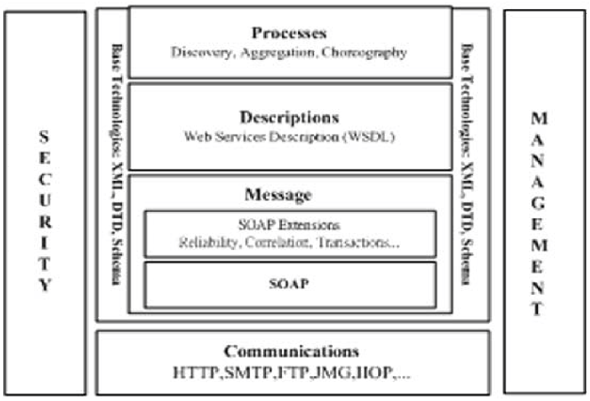

SECURITY
Base Technologies: XML, DTD, Schema
Processes
Discovery, Aggregation, Choreography
Descriptions
Web Services Description (WSDL)
Message
SOAP Extensions
Reliability, Correlation, Transactions..
SOAP
Base Technologies: XML, DTD, Schema
MANAGEMENT
Communications
HTTP,SMTP,FTP,JMG,IIOP,...

Figure 2. The layer-plane architecture of Web services

The WSDL is an interface definition language based on the XML (eXtensible Markup Language) standard. It provides a method of creating an explicit interface containing the return values, parameters, method names, protocols, and IP addresses so that external applications may remotely access the Web services components published on the web by referring to the information recorded in UDDI. The bottom layer of core service plane is a message layer which is supported by the Simple Object Access Protocol (SOAP) (SOAP Version 1.2, W3C, 2003) to define the protocol for object communications and accessing over the Web. The MIME-based extensive attachment in SOAP Version 1.2 provides a highly secure capability of carrying XML or non XML document in an SOAP object. Thus, HL7 CDA document can be thus securely transmitted and exchange by two communication parties.

4. Agent-Based Framework and System Implementation

In this research, a multi-agent system framework is designed for implementing the front-end information delivery and interchanging system, which is conceptually illustrated as it is shown in Figure 3. The design of the system framework is aimed to be able to carry out information interchange and transmission for a medical institution with other ones by the collaborations among different functional role-playing agents.

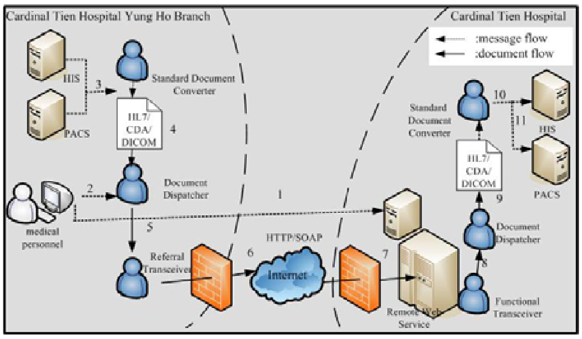


Figure 3. The agent-based system framework for information delivery front-end system

The agent-based system framework is implemented and deployed as a Web services component by leveraging the integrated use of the technologies of multiple software agents and Web technologies. It is mainly composed of three collaborative software agents, which are Standard Document Converter (SDC) agent, Document Dispatcher (DC) agent, and Functional Transceiver (FT) Agent. The front-end system implemented by these collaborative agents can be loosely integrated with institution's back-end systems such as health information system (HIS), radiology information system (RIS), and picture archive communication system (PACS) through SDC, which is another agent designed for data retrieval and conversion.

The SDC may periodically scan and retrieve the data records (e.g., patient data, infectious disease data, or insurance claim data) ready for transferred from the intermediary data repository implemented between the front-end system and HIS, RIS, and PACS. The data records stored in the intermediary data repository are extracted from HIS database (DB) and DICOM database when they are qualified for exchanging and transferring. The intermediary repository is implemented as the apart of databases. The SDC subsequently converts this data record into HL7 CDA document with embedded DICOM image's reference.

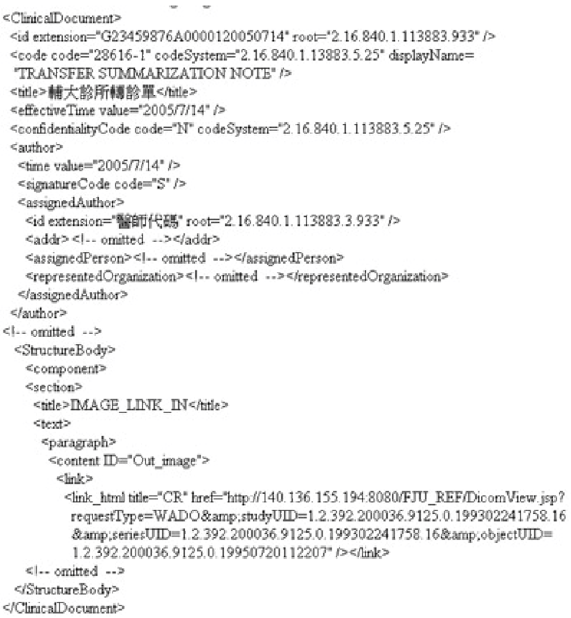
The Document Dispatcher （ DD ） is mainly responsible for activating the Functional Transceiver Agents, which can be Insurance Reimbursement Transceiver to conduct the patient data delivery and interchange to the peer hospital and clinic. The type of message uses LONIC code to identify in the header of HL7 CDA document.

The Functional Transceiver (FT) is mainly responsible for sending message to and receiving the return message (in HL7 CDA) from the external healthcare institutions, which can be another hospital/clinic, CDC, BNHI, and so forth. Again, which destination Functional Transceiver should be activated is dependent upon the type of message to be transferred.

The healthcare standards and advanced information technologies introduced and discussed in previous sections are adopted for the system implementation of this research. Two experimental referral systems are implemented based on this system framework. One is built in HL7 xml.2 standard message and the other is built in HL7 v3.0. Both experimental systems are developed on Microsoft Window 2003 Server running Java Virtual Machine. The databases and intermediary data repository are implemented on Microsoft SQL Server 2000 as well. The object-oriented technology of system development is adopted by using Java programming language with its Web services developed platform. The Web services are implemented by using Java Web Services Developer Pack Version 1.4 (JWSDP 1.4), which is a free integrated toolkit developed and provided by Sun Microsystems (http://java.sun.com/webservices/jwsdp/). We take the advantage of this toolkit to build and deploy the Web services and Web applications for the front-end message component of Functional Transceiver between two communication sites. The system experiment environment intends to emulate the real one which includes a main hospital at one city and its subsidiary clinics located in other cities. The messages are transferred over the Internet between these two sites. The experiment of these two systems and their experimental results are described in the following two sections, respectively.

4.1 Experiment 1- by Adopting HL7 xml.v2 plus CDA 2.0

The sample code for this implementation of using HL7 xml.v2 plus CDA 2.0 is shown as Figure 4.



```
<ClinicalDocument>
  <id extension="G23459876A0000120050714" root="2.16.840.1.113883.933" />
  <code code="28616-1" codeSystem="2.16.840.1.13883.5.25" displayName=
   "TRANSFER SUMMARIZATION NOTE" />
  <title>輔大診所轉診單</title>
  <effectiveTime value="2005/7/14" />
  <confidentialityCode code="N" codeSystem="2.16.840.1.113883.5.25" />
  <author>
    <time value="2005/7/14" />
    <signatureCode code="S" />
    <assignedAuthor>
      <id extension="醫師代碼" root="2.16.840.1.113883.3.933" />
      <addr> <!-- omitted  --></addr>
      <assignedPerson><!-- omitted  --></assignedPerson>
      <representedOrganization><!-- omitted  --></representedOrganization>
    </assignedAuthor>
  </author>
<!-- omitted  -->
   <StructureBody>
      <component>
      <section>
        <title>IMAGE_LINK_IN</title>
        <text>
          <paragraph>
            <content ID="Out_image">
              <link>
                <link_html title="CR" href="http://140.136.155.194:8080/FJU_REF/DicomView.jsp?
                 requestType=WADO&amp;studyUID=1.2.392.200036.9125.0.199302241758.16
                 &amp;seriesUID=1.2.392.200036.9125.0.199302241758.16&amp;objectUID=
                 1.2.392.200036.9125.0.19950720112207" /></link>
      <!-- omitted  -->
   </StructureBody>
</ClinicalDocument>
```

Figure 4. The CDA sample codes with HL7xml v2

The CDA Header code element presents this CDA document purpose. In figure 4, the code represent this is a transfer summarization note. The CDA header contains related medicine objects, such author, data enter, patient, represent organization and others. CDA body include related illness description and diagnosis information. The medicine image is indicated by "paragraph" and "link" elements. The DICOM file connected method complied with DICOM part 18: Web Access to DICOM Persistent Objects (WADO).

The selected user interfaces of this system, which are seen at the physician workstations at both sites, are shown in Figure 5. During the patient referral, the physician or nurse can submit and validate the required data including text, and images to be referred. These data include patient's demographics, medication summary, laboratory data, relevant images, and physician data from the system installed at the patient referring hospital/clinic site. By the way, the registration for the referred patient to the referred clinic/hospital also can be done during the time of proceeding referral as well. The patient's medical image files are transmitted simply by giving URL link address so that the referred physician may decide if to refer these images by using download images. The same image viewers are installed in patient's workstations at both sites. The clinical data are documented as an HL7 v2.xml CDA document.

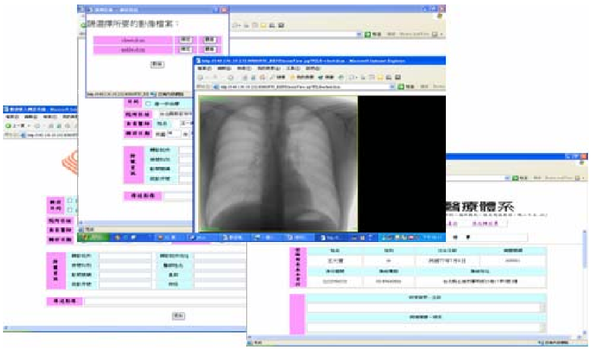
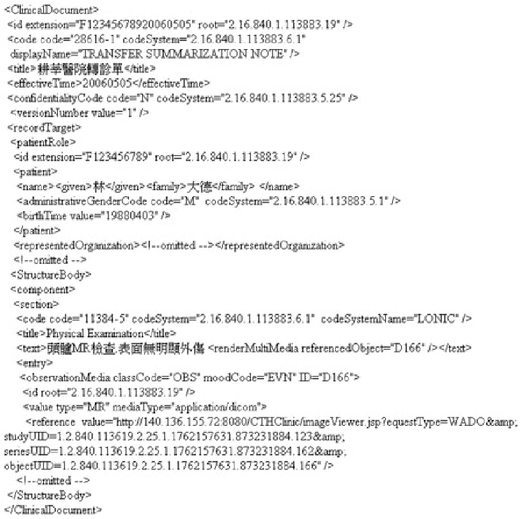


Figure 5. Patient data referred & seen by physicians

The advantages of the use of this system for transferring patient data during patient referral between hospitals/clinics are also very apparently. Without the aids of this system, the hardcopy of the laboratory data, medical image, and hand-writing patient record summary are only carried by human or sent by post mail. It takes from hours or even days to reach the patient referred-in hospital. Now, it can be done within minutes. The transaction data received can also be directly integrated into hospital's patient record. This can be significantly reduced the time of reproducing the patient data by hand. Meanwhile, it can reduce the cost and the waste of medical resource by sharing the medical record between medical institutions.

4.2 Experiment 2- by Adopting HL7 v3 plus CDA 2.0

Figure 6 shows CDA sample codes transformed by our system. In Figure 6, each medical information object related to this CDA Document is contained in CDA Header, which are referred to HL7 RIM and CDA 2.0. In CDA body, it used <section> and <text> to indicate each medical information, including medication, family history, assessment or physical exam section. The <renderMultiMedia> uses to indicate related multimedia like DICOM file, which is specified in the entry element. Similarly it is implemented in HL7 V2, the DICOM file connected method complied with DICOM part 18: Web Access to DICOM Persistent Objects (WADO).



```
<ClinicalDocument>
 <id extension="F12345678920060505" root="2.16.840.1.113883.19" />
 <code code="28616-1" codeSystem="2.16.840.1.113883.6.1"
  displayName="TRANSFER SUMMARIZATION NOTE" />
 <title>耕莘醫院轉診單</title>
 <effectiveTime>20060505</effectiveTime>
 <confidentialityCode code="N" codeSystem="2.16.840.1.113883.5.25" />
  <versionNumber value="1" />
 <recordTarget>
  <patientRole>
   <id extension="F123456789" root="2.16.840.1.113883.19" />
   <patient>
    <name><given>林</given><family>大德</family> </name>
    <administrativeGenderCode code="M"  codeSystem="2.16.840.1.113883.5.1" />
    <birthTime value="19880403" />
   </patient>
   <representedOrganization><!--omitted --></representedOrganization>
   <!--omitted -->
  <StructureBody>
  <component>
   <section>
    <code code="11384-5" codeSystem="2.16.840.1.113883.6.1"  codeSystemName="LONIC" />
    <title>Physical Examination</title>
    <text>頭顱MR檢查,表面無明顯外傷 <renderMultiMedia referencedObject="D166" /></text>
    <entry>
     <observationMedia classCode="OBS" moodCode="EVN" ID="D166">
      <id root="2.16.840.1.113883.19" />
      <value type="MR" mediaType="application/dicom">
       <reference  value="http://140.136.155.72:8080/CTHClinic/imageViewer.jsp?equestType=WADO&amp;
studyUID=1.2.840.113619.2.25.1.1762157631.873231884.123&amp;
seriesUID=1.2.840.113619.2.25.1.1762157631.873231884.162&amp;
objectUID=1.2.840.113619.2.25.1.1762157631.873231884.166" />
    <!--omitted -->
 </StructureBody>
</ClinicalDocument>
```

Figure 6. The CDA sample codes with HL7 v3.0

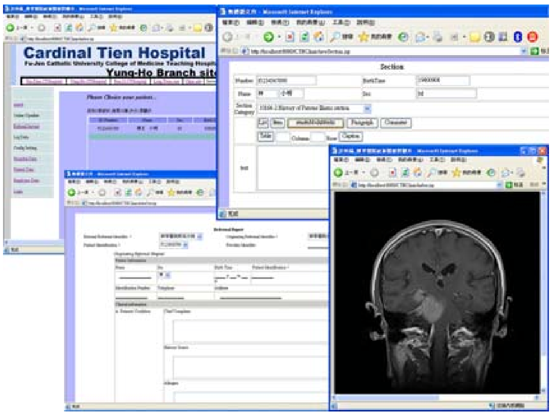


Figure 7. Patient data referred & seen by physicians

The way pf this implementation, not only original system's advantage is retained but also enhances the system expansibility and flexibility. This system's message transaction uses web services to accomplish. It provides highly transportability, scalability, and integration. The user interface not used original referral from, design involved object concept, which could add section and content flexibility in CDA body. Selected user interfaces are shown as Figure 7.

5. Discussion, Suggestions, and Conclusion

In this paper, we present two implementations for patient referral system based on our proposed multi-agent framework to support the information interchange and delivery over the Internet between medical institutions. One is build by adopting HL7 xml.v2 while the other is built by adopting HL7 v3.0 RIM for message transferring and exchanging. Both adopt CDA 2.0 for documentation and DICOM 3.0 for imaging. The advantages and limitations of two implementations are assessed. We found the implementation with HL7 v3.0 RIM could be more interpretable and interoperable than the implementation with HL7 xml V2. More significantly, the use of HL7 v3.0 RIM can transform medicine information into object so that it can be seamlessly integrated into object-based programming methodologies and system implementation paradigm and fully take the advantages of the technologies of Web services for message transferring and interchange. It would promote message interchange effectiveness and efficiency, and enhance system integrity, transparency, and scalability. Presently, the Chinese version of HL7 Standard specification in patient referral is defined based on International standard of HL7 v2.4. The adoption of HL7 3.0 has become a trend and unique HL7 Standards we need to take to develop a standardized medical information delivery system. To promote the use of HL7 v3.0, it is necessary to hasten to define a new Chinese version of HL7 Standard based on current international standard of HL7 v3.0 RIM for the adoption by Taiwan's healthcare to develop their standardized HL7 v3.0 messaging system.

Owing to the resource constraints, this system implementation couldn't take all advantages of HL7 v3.0 RIM. HL7 v3.0 is a very thorough and comprehensive specification but it needs other standardized coding systems, for instances LONIC, SNOMED, and others to fulfil the entire document implementation of an application. Presently, SNOMED is still not licensed in Taiwan. At present, we also don't have a unified and standardized drug coding standard for being applied by local system developers. Our healthcare authorities and business firms have to collaborate to overcome these problems, at the meantime to set up adoptable policies and strategies to speed up the promotion pace, otherwise the standardization of medical informatics might only be an ideal slogan.

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