

The Design of the HL7 RIM-based Sharing Components for Clinical Information Systems

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Abstract—The American Health Level Seven (HL7) Reference Information Model (RIM) consists of six back-bone classes that have different specialized attributes. Furthermore, for the purpose of enforcing the semantic expression, there are some specific mandatory vocabulary domains have been defined for representing the content values of some attributes. In the light of the fact that it is a duplicated effort on spending a lot of time and human cost to develop and modify Clinical Information Systems (CIS) for most hospitals due to the variety of workflows. This study attempts to design and develop sharing RIM-based components of the CIS for the different business processes. Therefore, the CIS contains data of a consistent format and type. The programmers can do transactions with the RIM-based clinical repository by the sharing RIM-based components. And when developing functions of the CIS, the sharing components also can be adopted in the system. These components not only satisfy physicians' needs in using a CIS but also reduce the time of developing new components of a system. All in all, this study provides a new viewpoint that integrating the data and functions with the business processes, it is an easy and flexible approach to build a new CIS.

Keywords—HL7, Reference Information Model (RIM), web service, process management.

I. INTRODUCTION

HEALTH Level Seven (HL7) is an American National Standard Institute (ANSI) accredited Standards Developing Organizations (SDOs) for the healthcare filed in 1987. There were many studies focused on the HL7 v2.x [1-3], and it was really helpful to refer to these studies for applications of the HL7 v2.x in Taiwan.

The HL7 v2.x message is a loosely coupled framework which limits the expressions of many attributes. It not only lacks of the ability to describe the laboratory data, quantification ratio data, and so forth, but it also includes a large number of unnecessary data and attributes. In addition, it is difficult to ensure the message transformation from local data to the HL7 messages is

successful or not during testing. Thus, there are different sights with the HL7 v2.x messages among the HL7 technical committee members. In 1994, the HL7 v3 was published to solve the shortcomings of the HL7 v2.x. However, surprisingly few studies have so far been made at the HL7 v3 in Taiwan.

The HL7 v3 improves the shortcomings of the v2.x [4](see the Table I). It is more flexible because it is a methodology named as Message Develop Framework (MDF) which based on the object-oriented model. The MDF specifies by the Use Case Model, Information Model, Interaction Model and Message Design Model. Furthermore, all of the HL7 v3 messages are based on Reference Information Model (RIM).

TABLE I
THE COMPARISON BETWEEN HL7 v2.x AND v3

HL7 v2.x	HL7 v3
1. No domain concepts	RIM
2. No data type definitions	The ANSI specified v3 Data Types
3. Vocabularies defined for specified items	Vocabularies defined for the information model
4. No a specifiable information framework	The RIM-based information framework

RIM = Reference Information Model

The RIM is presented by class diagrams, and there are six back-bone classes are stood for the information of clinical and health fields. The six classes include Act, Participation, Entity, Role, ActRelationship and RoleLink. Moreover, the Specialized Classes and Attributes are also defined for each class. For strengthening the semantic representations, some Vocabulary Domains are designed for Attributes. And for accessing data by a consistent approach, each Data Type contains one or more Properties. For example, the Data Type of the "birthday" Attribute is Timestamp (TS) and "address" Attribute is Address (AD). The Properties of AD are use (SET<CS>), useablePeriod (GTS), isNotOrdered (BL), formatted (ST), and so on. Consequently, some of the HL7 Data Types can be instantiated with Java generic type such as BAG and LIST.

It is useful and applicable to exchange messages based on the HL7 v3 Data Types for healthcare facilities[10] because that the Data Types define the clear meaning and semantic of the clinical and health data. On the other side, the HL7 special interest group (SIG) devoted to developing and designing free software and tools for assisting users who want to adopt HL7 v3 RIM in practice. Therefore, there have been some tools released in the HL7 websites.

It is a big challenge to have well communications among

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programmers, administrators, and physicians while developing a hospital or clinical information system. Moreover, the bad communications, unclear system requirements, implicit system specifications might cause the fail developing of systems. Therefore, this study introduces a general idea of the process management during designing systems. Connecting each stages of the business life cycle with each service components of the systems makes things simple. Then the systems can be revised flexibly according to different requirements in hospitals.

The integration of system, EHR, patients, and physicians is also an important issue. There were many researches focus on the developing and design of the clinical database and the architecture of CIS [8, 9] wanted to achieve the object of providing unified complete health records [6, 7]. But few researches think over the variation of the clinical business process.

This research tried to develop sharing components based on HL7 v3 RIM for the CIS. And it could be share components which based on the HL7 v3 implementation and application. The CIS will combine with the concept of business process management. Different CISs adopt the common manner to insert data into the clinical databases. Healthcare data in different databases have the unified format. The programmer can apply the required sharing components to match up business process. It not only decreases the system developing time but also help user to quickly find out required healthcare data.

II. MATERIAL AND METHOD

The whole system framework of the study is shown in Fig. 1. According to the developing process refer Fig1, there are three main portions in the study, they are the design and developing of CIS, the developing of RIM-based sharing components, and the design of the clinical database access.

A. The Design and Developing of CIS

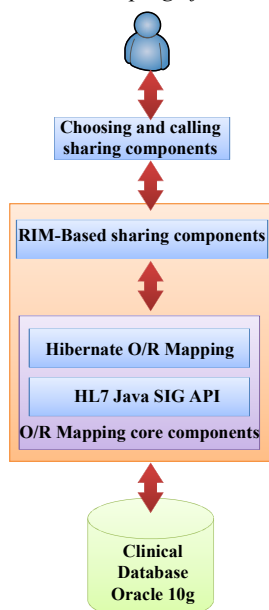


Fig. 1 The system architecture of the study

This research shows the basic ambulatory encounter workflow referred to Integrating the Healthcare Enterprise (IHE) EYE Care Workflow (EYECARE), the register and clinic scenarios in Taipei City hospital, the Ophthalmology's suggestion, and HL7 ambulatory encounter storyboard.

The CIS not only applies the business process concept, but also business process execution language (BPEL) to implement the integrated system process. BPEL is the generally accepted process execution language which is a combination of the Microsoft XLANG and IBM WSFL.

That makes the user interacting with porlets via the portal server possible, the websphere business modeling tool, portlet modules, and the application server are used in this research. The system operator modeled the business process by the way of a graphical interface. And business process and information technologies closed together.

B. The Developing of RIM-based Sharing Components

The design of sharing components in the study uses the ophthalmology scenarios which consist of many texts and figures. The Java API provide by HL7 SIG is deficient to implement sharing components. Thus, this research extend the API by implemented the definition of HL7 v3 RIM.

C. The Design of the Clinical Database Access

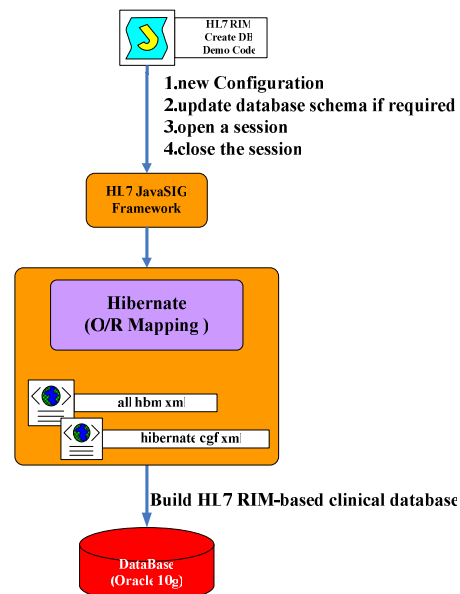


Fig. 2 The implementation of the clinical database

The design of the clinical data base is based on HL7 v3 RIM (see Fig. 2). Due to the relational databases are more popular presently, the database schema of the study is produced by applying HL7 SIG API and Hibernate 3. The core mapping components mapped objects into the Oracle 10g database.

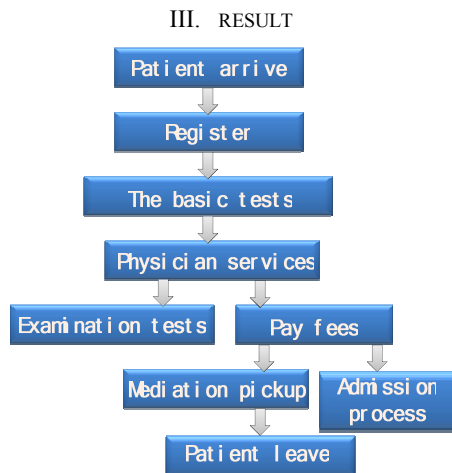


Fig. 3 The process in the ophthalmic department

It is complex to clarify the ambulatory encounter workflow in the ophthalmology department. The result of the examination mainly present in paper report. This research presented health records and outcome of examination graphically in order to ophthalmologists to arrange the examination for particular patients. The ambulatory encounter analysis for ophthalmology department is shown in Fig. 3.

A. The Design and Developing of CIS

門診	姓名	性別	年齡	診費
95-08-27-1021	林姓	男	55	118
95-08-27-1022	陳姓	男	55	118
95-08-27-1023	林姓	女	55	118
95-08-27-1024	劉姓	女	55	118
95-08-27-1025	黃姓	男	55	118
95-08-27-1026	楊姓	男	55	118
95-08-27-1027	王姓	男	55	118
95-08-27-1028	張姓	女	55	118

Fig. 4 The ophthalmic prototype system - examination and treatment

According to the ambulatory register flow analysis, after receiving the patient's identity from the counter, the system will confirm if there are the patient's health records or not in the system. If the system already has the patient's health record, the system will automatically make a clinic visit appointment for the patient. On the other hand, before make a clinic appointment, it should insert the patient's demographic to the clinical data base.

The artificial work in the process (such as entering the test result) is shown with porlets. Different physicians can use the CIS with the patterns of web pages they prefer. They can design their own porlets. It decreases the physicians' burden and time to be familiar with the new system.

The business related functions (such as register) in the CIS are served in web services. It makes the appearance and functions of the CIS are portability. But the processes are not the same in different department. Rather than make an appointment first in the ophthalmic department, the first process in the emergency department is to have a test. This research allows users design their business process depending on their requirements as portlets in the application server for making the process more elastic. All business processes are run together in an integrated developer environment. After accomplishing the integration, the business processes are deployment in the application server. When the application server executes, the customize web pages are emergence (see Fig. 4 and Fig. 5).

星期	看診時段	科別	醫師	診費
一	1上午診	新陳代謝	蘇祥雄	118 一樓十八診
一	1上午診	心臟內科	林日鈞	201 二樓一診
一	1上午診	一般內科	陳光止	202 二樓二診
一	1上午診	神經內科	吳代純	203 二樓三診
一	2下午診	一般內科	郭英明	205 二樓五診
一	2下午診	皮膚科	楊光武	207 二樓七診
一	2下午診	復健科	陳理興	208 二樓八診

Fig. 5 The ophthalmic prototype system - appointment reservation

B. The Developing of RIM-based Sharing Components

The extra HL7 v3 definition cannot directly apply in the database. This research analyzes the implied meaning of data types and defines the data type into the database according the database logic. For example, the String (ST) is stored in the database with string type. And that spent most of time and work in understanding the HL7 data type. There is no need to know the HL7 data type when directly using the sharing components in practice. But if there is any need to inherit, add, or override the sharing components, the HL7 data type should be understood.

C. The Design of the Clinical Database Access

After object-relational mapping by Hibernate 3, there are 37 tables (see Fig. 6). There are 2 Refined Message Information Model(R-MIM) and 15 CMET (list in Table II) related to the ambulatory encounter are developed as reusable sharing components in terms of web services. They are the media to the application program and clinical database. The application program can import data into relational database by calling the corresponding sharing components depend on the requirements according to the scenarios.

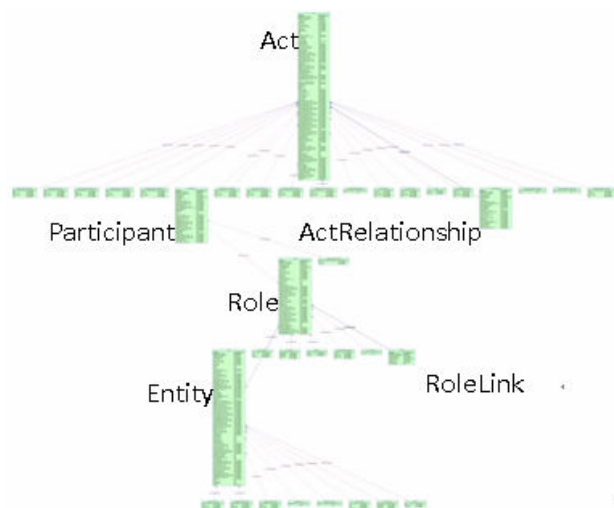


Fig. 6 The clinical database schema

TABLE II
SHARING COMPONENTS IN TERMS OF WEB SERVICES WHICH HAD DEVELOPED

	Web services
R-MIM	RegistryRequestControlAct AmbulatoryEncounterIntentActivate
actsCMET	Account Identified Appointment Encounter Identified Financial OrderOption
entitiesCMET	Device Universal Language Communication LivingSubjectIdentified NonPersonLivingSubjectConfirmable Organization Identified Person Identified AssignedPerson Universal Place Universal
rolesCMET	ServiceDeliveryLocation Identified

R-MIM = Refined Message Information Model

IV. DISCUSSION AND CONCLUSION

It is hard to understand meaning of the HL7 data type. However it is a necessary process before design the HL7-based clinical database. The developer can direct use the sharing components implemented in the study to import data into the database without studding HL7 data type logic. It really saves time and cost.

Sharing components developed in the study can be reuse or merge in the system. The study makes the data in the database confirms to HL7 message standard easier with the dynamic process and sharing components. Most of the CISs in Taiwan are still independent. Most of them cannot change the process of the system. The study addresses to handle dynamic process variations with web services. The web services help the highly changeable healthcare environment to arrange the new system process and work fast.

Dang, J. design the dynamic clinical process with Oracle BPEL. The IBM BPEL is used to develop reusable sharing components in the study. Both of them are able to deal with the process changes without modify system substantially in the hospital environment. The information technical personnel do not need to develop new system again and again. The physicians can be familiar to the system soon. It decreases the manpower and time cost when developing a new system. It increases the healthcare quality.

T. J. Eggebraaten proposed three solutions to design the clinical database. There are: (1) The design of database tables are based on RIM classes. The data types that had been used in RIM are the attributes of the table. But not all attributes have values, so it wastes the database space. (2) The HL7 data types are tables in the database. The tables are generated by the parent table's foreign key. Although it suits the set data type in RIM, and the data type hierarchy is clear. It is inefficiency when doing transactions. (3) The RIM classes are tables in the database. Each table references to other data type by the foreign key. For instance, Coded Element (CE) can find out the attribute values are code, codeSystem, and displayName by the foreign key. For all, it is a complex design, but it can provide better access efficiency to complex data type. The database table design are referred to (3) in this research.

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REFERENCES

- [1] E.-W. Huang, S.-H. Hsiao, and D.-M. Liou, "Design and implementation of a web-based HL7 message generation and validation system," *International Journal of Medical Informatics*, vol. 70, pp. 49-58, 2003.
- [2] "Performance analysis of a medical record exchanges model," *IEEE Trans Inf Technol Biomed.*, vol. 11, pp. 153-60., Mar 2007.
- [3] E.-W. Huang, D.-W. Wang, and D.-M. Liou, "Development of a deterministic XML schema by resolving structure ambiguity of HL7 messages," *Computer Methods and Programs in Biomedicine*, vol. 80, pp. 1-15, 2005.
- [4] M. CH, "Data interchange standards in healthcare IT--computable semantic interoperability: now possible but still difficult, do we really need a better mousetrap?," *J Healthc Inf Manag.*, vol. 20, pp. 71-8., Winter 2006.
- [5] J. Koehler, R. Hauser, J. Kter, K. Ryndina, J. Vanhatalo, and M. Wahler, "The Role of Visual Modeling and Model Transformations in Business-driven Development," *Electronic Notes in Theoretical Computer Science*, vol. 211, pp. 5-15, 2008.
- [6] John Møller-Jensena, Jesper Simonsenb, and R. K. Iversenc, "Measuring Effects on the Clinical Practice from a Configured EHR," in *Proceedings of the 4th Scandinavian conference on Health Informatics (SHI 2006)*, Aalborg University, Aalborg, 2006.
- [7] "Integration of health information resources into electronic health records using HL7," p. 1195., 2007.
- [8] "Toward vocabulary domain specifications for health level 7-coded data elements," *J Am Med Inform Assoc.*, vol. 7, pp. 333-42., Jul-Aug 2000.
- [9] T. J. Eggebraaten, J. W. Tenner, and J. C. Dubbels, "A health-care data model based on the HL7 Reference Information Model," *IBM SYSTEMS JOURNAL*, vol. 46, 2007.