Comparative Analysis of RIM and Other Models Used For Mapping Legacy Databases Schema for HL7

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***Abstract*— This problem of making interoperable health records is solved by using Health Level 7 standard for HIS being developed today, but how do we make the existing systems HL7 compliant? And save billions of dollars and time already spent on designing and development of the existing systems. On other hand the most important and crucial data that exists in these HIS.**

***Keywords*— RIM, databases, HL7 compliant, schema, legacy, Hospital, Information, System**

I. INTRODUCTION

Ever since the beginning of time, mankind has strived hard to make life better. Since the time of cavemen, when men first discovered fire, life has changed and evolved today comparing it with life then. The technology and the advances in technology present today are witness to this evolution.

Men learned to use this discovery in order to make their lives easier and better. And because of this discovery they learned to use other objects around them as a form of tool, fire being the first tool. The entire human race has evolved in search of more and more better discovery, leading to invention of many tools, and from tools to technology. As is said "***necessity is the mother of invention***"

Because of the quench and quest for knowledge, we have learned the basics of research. Research we use today to find better and optimum solutions as per our needs and requirements. From lunar lullabies to walking on the moon, men has invented and improved the new and better techniques to enhance the luxury of life with leaps and bounds.

The most important factor in improving quality of luxurious life is health. If one does not have health, than everything else seems of no importance and useless. As it is said and is believed, "***health is wealth***". And this is why research plays an important role in health, as it is the primary concern of every single individual.

Since health is of such important concern, bio-medical scientist and researchers have involved the use of technology to finding better cures. And have succeeded in doing so, as they have been able to finding cures through vaccines of many incurable diseases computed using new and improved methods provided by the enhanced technology.

Not only the introduction of technology and computers, bio-medical scientist and researchers were able to find better cure, but as well encouraged the healthcare providing institutes in creating hospital information systems to keep past records of a patient's history. And in doing so have helped medical practitioners in identifying the cause of patient's visit using their past medical history and family background.

This improvement forced the private healthcare providing institutes have developed their Health Information Systems (HIS) based on learning from the open source software community (OSSC). Many of these HIS are based on international standard provided by the OSSC, such as HL7, DICOM and etc.

Following the international standards for their HIS, allow them to store the past and present medical records of a patient in electronic form, also known as Electronic Health Record (EHR). However, these EHR's are used in the treatment of a patient for diagnosis and treatment on their next visit to the hospital.

II. PROBLEM STATEMENT

We are able to identify the epidemics and illness on national level, using the Hospital Information Systems created to facilitate a single health providing institute. And prepare ourselves, to fight the epidemics in certain areas, especially affected by natural disasters.

However the statistical figures provided b HIS are not accurate, because of the fact that though many recent HIS have been developed using the Health Level 7 (HL7) standards. HIS that collaborates and exchange information with other HIS, and with HIS on national level in many countries. However HIS developed before the created of HL7 standard do not provide any kind of interoperability of any kind.

This problem however is solved by Health Level 7 standard for HIS being developed today, but how do we make the existing systems HL7 compliant? And save billions of dollars and time already spent on designing and development of the existing systems. On other hand the most important and crucial data that exists in these HIS.

Numerous research papers on this topic have been published on how these legacy systems can be made HL7 using the HL7 Reference Information Model (RIM). Which one should be used in which scenario is yet unknown? Therefore we will be conducting a ***comparative analysis of RIM and other models used for mapping legacy databases schema for HL7***.

III. INTERNATIONAL STANDARDS

A. International Standards in Healthcare

Creating effective standards requires collaboration among other standard developing organizations. Most of the standard developing organizations (SDO) have established formal agreements, pacts intended to evade surplus in standard formation and work results, creating an open interaction all over the industry. Some of the standards created by various

organizations in collaboration and accepted by majority worldwide are as following;

B. HL7

Health Level 7 (HL7) is non-profit open source organization, formed in 1987, involved in developing the international healthcare standards for interoperability. Its name is a reference to the 7th level of the Open System Interconnection model, commonly referred as Application layer of the OSI model [1].

The purpose of HL7 is to create standard for health informatics and for exchanging, sharing and integrating EHRs. The standards are developed in collaboration with subject matter experts and information scientists in the field of healthcare and information technology. HL7 also collaborates with other standard development organizations (i.e. ANSI and ISO) to encourage the use of abetting and well-matched benchmarks in healthcare and data infrastructure domains.

HL7 encompasses the complete lifecycle of standard specifications for documentation (e.g. HL7 CDA), application development (e.g. HL7 CCOW), messaging, adoption, and adherence to support hospital workflows. Some of the standard specifications documented by HL7 are as following:

C. ICD-10-CM

International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) is international standard presented by Centers for Medicare and Medicaid Services (CMS) and the National Center for Health Statistics (NCHS) [3]. ICD-10-CM is morbidity classification for standard investigative classification for all universal epidemiological, health managing reason and medical use. Including the examination of common health and monitoring of incidence and categorization of diseases and other health related problems.

It is used to categorize diseases and supplementary health related issues documented on various types of health and essential record, including decease records. In addition to enabling the storage and recovery of diagnostic information for treatment centers, epidemiological, and quality purpose [4].

D. ICD-10-PCS

International Classification of Diseases, 10th Revision, Procedure Coding System (ICD-10-PCS) is a system of medical categorization used for routine codes in America [5]. It was developed as a substitute for the ICD-9-CM volume 3.

The objective of developing ICD-10-PCS was to develop fresh procedure coding system, advance correctness and competence of coding, condense guidance efforts, and improve interactions with general practitioner [6]. The crucial characteristics were:

- comprehensiveness
- an exclusive coding for all considerably diverse procedures
- expandability
- a systematic arrangement that permits incorporation of innovative procedures as unique codes
- Typical terminology—the coding system comprise definitions of the terminology applied. While the significance of the specific words can be different in general usage, the coding scheme does not contain numerous meanings for the identical term. Each term is allotted a precise meaning
- multiracial—the scheme has a multiracial organization with every code character possessing the equivalent meaning within the exact procedure segment and across procedure segments to the scope achievable

E. DICOM

Digital Image and Communications in Medicine (DICOM) is developed by American College of Radiology (ACR) and National Electrical Manufacturers Association (NEMA) as a standard in 1980's[5]. It is almost a universally accepted standard among medical imaging apparatus vendors and healthcare IT institutes, because of its capability to store, print and transmit information over network using HL7 standards, providing interoperability among medical imaging devices.

F. Interoperability in Health

Interoperability is a wide concept with variety of definitions that exist both in academia and industries. Few definitions of interoperability are as follows:-

According to IEEE [7],"interoperability is the ability of two or more systems that is used to exchange information and to use these information that has been exchanged"

In the field of eHealth applications "Interoperability means that the ability to communicate and exchange data accurately, effectively, securely and consistently with different information technology systems, software applications, and networks in various settings and exchange data such that clinical or operational purpose and meaning of the data are preserved and unaltered"[6].

"Interoperability in health care information is the capability of health information systems to work together within and across organizational boundaries". It is necessary that heterogeneous arrangement consent on the information they want to exchange and what standards to use [8].

When different enterprises are integrated it is necessary that all the systems and technologies share whole information with different structures and formats. Such type of sharing and of information transparently is very difficult requirement which raises the very complex issues of compatibility and interoperability [9].

According to Medical Records Institute [9] it is:

"Electronically maintained information about and individual's lifetime health condition and health care"

IV. BACKGROUND

A. The HL7 Evolution

Health Level 7 (HL7) is non-profit organization created for developing standards as a compiled collection messages and formats related to clinical standards. HL7 was created as a standard interface to allow multiple heterogeneous applications in communicating with each other, and allow clinicians and/or medical practioners to share patient's data with each other [10].

HL7 was standard first developed in early 80's, but was released in 1990's as HL7 v2.1. However it was not widely accepted until 1998. But since 1998 the standard has grown to be accepted on global level in the field of Health Informatics, and is implemented in all applications under development today.

The HL7 community realized that the HL7 v2 still needed more refinement, and hence HL7 v3 standard was made publicly available for test purpose. The final and stable version of HL7 v3 standard has still not been released; however the beta version of HL7 v3 has been published in 2006.

The released version of HL7 v3 covered the following aspects that were felt necessary in HL7 v2, which are as following:

- Lack of consistency
- Lack of formal methodologies
- Lack of well-defined application and user roles
- Lack of precision

Not only does HL7 v3 cover the aspects mentioned above, but it also covers new standards defined by the clinician's community. And is specifically designed not to be backward compatible with any version of HL7 v2, so that only one standard may be implemented by the vendor to reduce the cost, maintainability and reduce time on the application.

B. Message Exchanging Model for Hospital Information System

The hospital information systems today are mostly based on information communication among various departments, such as finance, scheduling, pharmacy and etc. Allowing medical practitioners to exchange data with each other within the hospital using the same system. By means of using a single database server as a source of all information to store this information and/or data [11].

However, Jihyun Yun and Ilkon Kim discuss another method of exchanging the same data by means of using HL7 standard within the system. The proposed solution of using XML, not only allows the exchanging of system within the same HIS, but as well allows the exchanging the relevant patient information among various hospitals by means of XML as a layer on top of HL7's v3 RIM model.

The proposed solution of XML with HL7's v3 RIM, together combined with SOAP will allow them to serve the patients information in a decentralized manner. And serve the results in a lesser amount of time, and solves the problem of exchanging and information storage in a relational database system.

C. HL7 RIM-based Design of Sharing Components for Clinical Information Systems

Majority of HIS are developed based on the workflow of the healthcare providing institutes that will be using them [12]. Creating a difference in information flow for the system of every HIS developed till today. These systems are capable of sharing information within the same system, but incapable of sharing information across various heterogeneous HIS.

Although these HIS of each individual healthcare providing institute are developed based on the standard clinical information, that are followed worldwide. Based on this clinical standard provided by HL7, researchers and system developers have been able to design systems, which are capable of sharing information using HL7 RIM model and clinical standard on their databases schema to store, retrieve and update the information.

D. Real-Time Integration of Clinical Data Systems Using Advanced Database Technology based on HL7

Although a number of researchers have worked on creating real-time systems as prototype for data integration using XML and HL7 standard. These prototypes are an effort to creating not only real-time systems, but as well an effort towards creating information available and accessible on mobile phones, in order to obtain cater patients [13].

These prototypes are proposed as solution to mapping the clinical convention of manual paper based storing and retrieving patient's data. Such that the clinician responsible for entering patient's information in the system may not feel much difference than doing it manually, and same as for when retrieving to update the information.

V. RESEARCH FINDINGS

A number of prototype and solutions exists designed to map the existing legacy systems database on to comply with HL7 standards. So these legacy systems may be able to interact with other heterogeneous system, and exchange patients information across multiple networks as per required by the health practitioner.

A. Using RIM

Following are few of the solutions that have been developed either as prototypes or as systems that exists today.

B. What do identifiers in HL7 identify? An Essay in the Ontology of Identify

On the basis of the documentation of HL7, it is distinguished on the general ontological categories that if an organization wishes to develop solutions using semantic ontology [14], can identify entities from the following:

- Database entities.
- System documents ox any existing HIS.
- Individual diagnosis and/or measurement results.
- Individuals process for modifying the results.
- Each object, such as building and patient's information.
- Surgical operations or acts of observations.
- The type of individual which instantiate.

C. Semantic Interoperability of Exchanged Message in Healthcare using Artemis Message Exchange Framework

Artemis has developed an Electronic Data Interchange framework for mapping standard XML format using OWL ontology using semantic web [15]. It is a solution to most of the challenging problem of interoperability in healthcare domain.

The EDI is a proposed solution to tackle the existing problem, using engineering approach in the domain healthcare and semantic interoperability. The solution uses OWL ontology as a wrapper to the existing HIS message exchange and web services, generating target ontology instance according the graphically defined mapping.

It is a generic platform to mediate between any incompatible healthcare standard that exist in healthcare institutes. Although at the backend uses HL7 v2 and HL7 v3 message functionality.

D. Automated HL7-RIM and Relational Database Mapping

All the existing HIS have one thing in common, the identifiers by which the users and patients are identified. These can easily be mapped to HL7 v3 RIM model, using the proposed solution [16].

It can identify the field in the database, to the most relevant field which needs to be mapped according to the HL7 v3 RIM standard. Once this mapping is completed, it requires the system administrator to confirm the mapping and manually map the fields which the system does not find a relevant mapping to.

The proposed solution also, gives the option to the system admin to manually map all the fields as per requirements. And then confirms to save the mapping for the system to work.

E. Using Knowledge Game as and Interactive Mapping Tool for HL7 RIM-to-Relational Database

With the increasing healthcare facilities all around the world, the numbers of Hospital Information Systems are increasing. And with this increase in Hospital Information System, there exists a challenge of heterogeneous data among other hospital information system. Data needed for exchanging patient's information in order to facilitate the patient by providing better cure.

F. Automatic Filtering to Enhance the Usability of HL7 Information Models

A number of tools exist today, that help in identifying the possible solutions to make the existing system compatible and work with HL7 standards [17]. And since HL7 information models are very large with the wealth of knowledge they contains, makes them very useful for the potential audience.

Using these information models classes of HL7, the tools proposed can extract 80% of information from the Domain Message Information Model (D-MIM), a subset of R-MIM in the Reference Information Model (RIM), within 3 iterations within an average time per iteration. Extracting knowledge with a precision of 80%, almost the same as if done manually by a human being.

G. The HL7 approach to Semantic Interoperability

HL7 organization itself is trying to evolve its standards, by working with Semantic Groups for Health Life Sciences [18]. Keeping the existing framework it has developed with years of experience and information gathered. Instead, it can use the existing health and life science semantic framework developed by the semantic group at World Wide Web Consortium (W3C), as all the needed components and methodologies exists.

With the expertise in the clinical information of HL7 models, combined together with Semantic Web will enable HL7 to resolve much complex issues. Especially covering the entire domain of Health and Information Technology; sometimes referred as health informatics.

H. Microsoft BizTalk Server

BizTalk Server enables administrative simplicity and provides a complete solution framework for patients, and medical practitioners. Enabling integration of existing Hospital Information Systems (HIS) applications and legacy databases using Health Level 7 (HL7) accelerator [19].

Since HL7 v3 messages are programmed with XML, BizTalk server offers its support. Providing the ability to process and validate data with flexible and dynamic mapping tools using HL7 accelerator for BizTalk Server. Allowing users to map the legacy database schema to HL7 requirements that can flawlessly translate data essentials between standards, as well as data modeling necessities found in HL7 v3 messaging specifications, as seen in the image below.

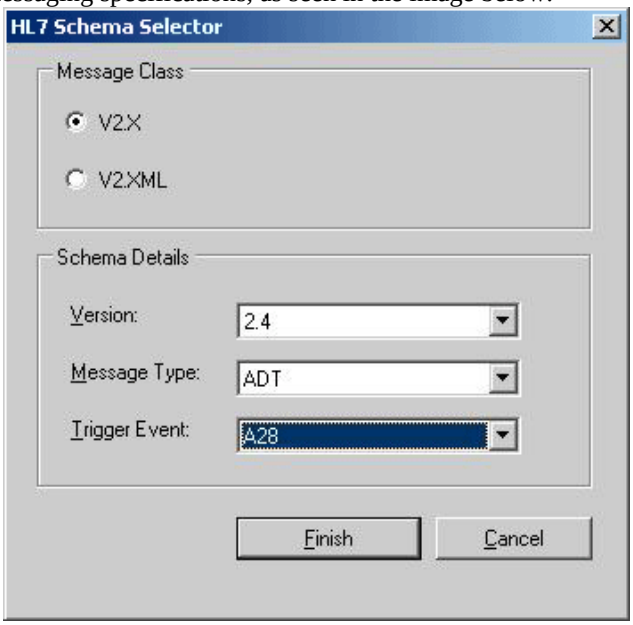

Figure 1: Adding HL7 schema to a project, via HL7 schema selector

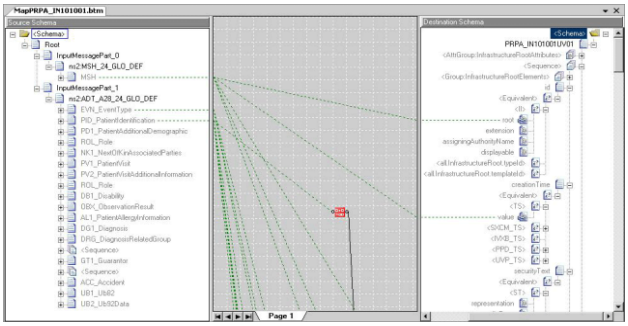

Figure 2: Small sampling of the actual mapping using HL7 accelerator

BizTalk server can effortlessly extend and accommodate the challenges raised by the interoperability between organizations using different HL7 standards. As HL7 v3 evolves and more of its parts are finalized as standards, the schema may become more complex for users to map according their legacy database running the existing HIS.

VI. Proposed Solution

Based on many of the solutions discussed in this paper, the best optimum solution for legacy database has been proposed by Health Life Horizon in their research paper "Interactive Mapping Tool for HL7 RIM-to-Relational Database Using Knowledge Game".

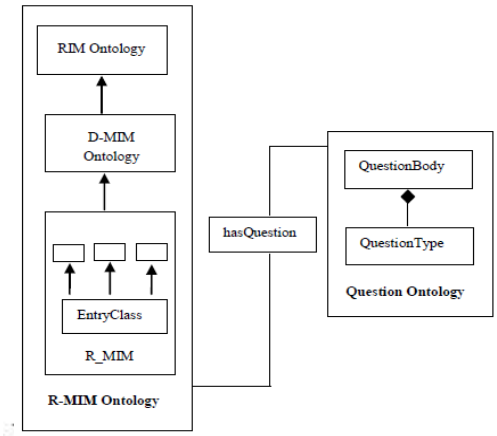

Figure 3: Preview of R-MIM and Question Ontology

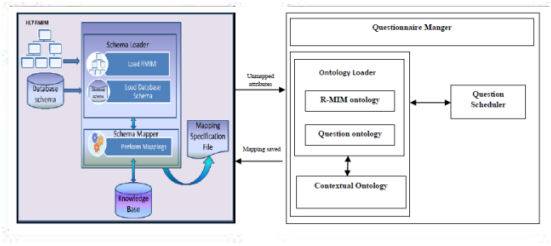

Figure 4: Database to R-MIM Mapping

However, the proposed solution in Figure 3 and Figure 4 lacks the capability of updating the knowledgebase, with the techniques used by Database Administrators (DBA) to make their HIS HL7 compliant.

In order to update the knowledgebase, so that it may aid other DBA's in making existing HIS HL7 compliant if same scenario occurs already faced by some other DBA. We need to introduce the Service Oriented Architecture, such that it updates the knowledgebase on a centralized server, after a successful mapping has been implemented.

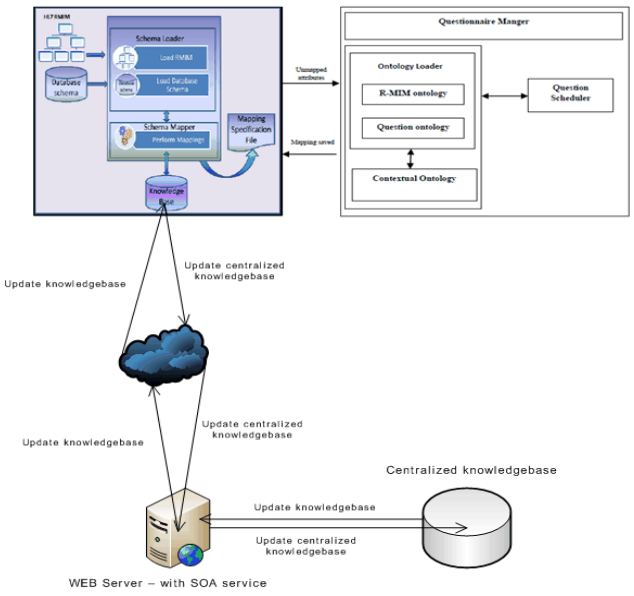

Figure 5: Database to R-MIM Mapping and updating centralized database, using SOA

In figure 5 we have introduced a centralized knowledgebase system using the Service Oriented Architecture (SOA). So that, when the client using the proposed solution in [18] starts mapping the legacy database schema of the existing HIS, the knowledgebase is updated before it begins asking questions, in order to automate the database mapping as per questions answered.

If the mapping as discussed in [18] is not done automatically and the user has to do it manually. The updated mapping will generate a series of questions in a sequence as per the mapping done manually by the user. This generated sequence will then be sent back to the centralized knowledgebase and it will be updated.

Because the centralized knowledgebase will be updated each time a user has to manually map the legacy schema with the new generated sequence of questions. This will help other clients to solve and map their HIS's legacy schemas if they face the same scenario encountered by some other user.

VII. Conclusion

Although this solution will help majority of the DBA's in making their legacy databases HL7 compliant and mapping as per HL7 standard. There is exist no verification and validation of the series of questions which will update the centralized knowledgebase, that a user has correctly mapped the legacy database.

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