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Integration of Health Information Systems Using HL7: A Case Study

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Abstract. Interoperability is a prerequisite for health information systems (HIS) that will reduce waste of unnecessary costs, errors, delays, and futile repetition. Many previous studies had proposed different approaches in the attempt to solve interoperability challenges. In this paper, we report our experiences in using Health Level 7 (HL7) standard and adopting the Common Gateway Model for exchanging heath data. The benefits and challenges of using standards for data interoperability are also described.

Keywords. interoperability, electronic health record (EHR); health information system (HIS); health level 7 (HL7); BizTalk

1. Introduction

Many published studies describe that interoperability can improve the efficiency of healthcare delivery while reducing the costs and time associated with accessing and analyzing health information. A number of countries in the world are developing interoperable Electronic Health Records systems (iEHRs) [1-6]. However, several problems appear because of variation in the hardware, software, coding methods, terminologies/nomenclatures used, and their definitions between EHR systems. Additionally, different types of users can potentially interpret the same data (e.g. words or terms) in different ways. These are the barriers to achieving health data interoperability [7, 8]. Many previous studies had proposed different methods in the attempt to solve interoperability problems [9-11]. Kuo et al. [12] categorized interoperability methods into three models: (1) point-to-point oriented, (2) standard oriented, and (3) common-gateway model. Using point-to-point oriented model, data exchange parties have mutually agreed–upon coding terminologies, messaging protocol and business process. In other words, health data can only be exchanged between organizations with contract. The main benefit of this model is that the data exchange process is very flexible and straightforward. The drawback is that it will cause huge variation among data exchange parties. If many different parties are involved in data exchange, many interfaces and data formats are required to be developed, which will create significant variation in EHR development (e.g. it needs $N(N-1)/2$ exchange interfaces for N different EHRs).

In standard oriented model, health organizations must follow a unique standard (terminology and message standard) for health information exchange. The benefit of

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using this model is that it has less variation in EHR implementation. However, it is difficult for all parties to agree on a standard to use in practical application, especially when there are many health organizations involved in the data exchange.

In common-gateway model, a messaging broker/bus provides a common, standardized point of communication between multiple systems engaged in information sharing. When health organizations want to communicate information, standard message structures, such as HL7 standards, are defined to contain the information supplied in requests, responses, and submissions by the information exchange parties. Each system needs only to know how to convert its data to standard message structures and connect to the messaging broker/bus. Information exchange parties do not need to set up mutually agreed–upon data structure, coding terminologies, and business process. This allows health organizations to develop their information systems locally and reduce development complexity and cost for each system.

2. A Case Study

In this section, we describe our experience in utilizing a hybrid data exchange model to facilitate automation in patient data exchange at the British Columbia Women's Hospital, Provincial Health Services Authority (PHSA).

2.1 Background of Provincial Milk Bank Project

BC Women's Milk Bank stands as the first hospital-based human donor milk bank in Canada [13]. It is the only human milk bank in BC and one of the sixteen human milk banks in North America. The program collects human donor's milk from healthy mothers who are capable of producing extra mother's milk for their babies. Similar to blood banks, milk banks collect and pasteurize mother's milk to support many mothers who are unable to produce sufficient breast milk for their babies, especially for sick or very tiny babies. In 2012, the Ministry of Health initiated a grant to support planning of expanding the Milk Bank at BC Women's Hospital to automate and optimize the Milk Bank service. The expended program will increase the capacity of collecting, pasteurizing, and distributing human donor's milk throughout the province. With the increased capacity and data collection, an electronic system is in need to improve quality outcomes and provide automated solution in replacement of paper-based manual process. The Milk Bank Management System (MBMS) is chosen and implemented in BC Women's Hospital as the electronic system to manage and distribute mother donors' milk. An automated data sharing between the web-based system and the provincial patient index depository, Enterprise Master Patient Index (EMPI), is then proposed to optimize the efficiency and accuracy of data entry during the donor screening process.

2.2 Hybrid of Common Gateway Model and Standard Oriented Model

In order to leverage the existing data collection in the EMPI database and enable the database to communicate with the Milk Bank Management System, we applied the Common-Gateway Model using Microsoft BizTalk Broker and Heath Level-7 (HL7) standards to design and develop interfaces for querying and exchanging data.

The Milk Bank Management System is required to collect basic donor information including donor's Personal Health Number (PHN) and BC Provincial ID Number and combine secondary information including the application, message, and operator information to construct a HL7 v2 message. The HL7 v2 message is used as a query to retrieve donor's detailed demographic information from the EMPI database. EMPI uses given unique PHN and BC Provincial ID numbers to find matched patient in their database. The detailed demographic information from the provincial EMPI database contains the most up-to-date patient information such as patient legal name, gender, current address, date of birth, and phone number, etc. However, EMPI is designed to generate XML format messages in HL7 v3 standard, which is different from HL7 v2 none-XML format. We see the advantages of adopting the Common-Gateway Model to map different structured messages and to facilitate smooth communications between the two systems.

In this case, the BizTalk Broker is the middleware to enable automation of message exchange between the EMPI database and the Milk Bank Management system through the use of tailored adapters (Figure 1). The receiving adapter accepts the HL7 v2 message from the Milk Bank Management System and translates the message to HL7 v3 format in the sending adapter. Then, the sending adapter sends the transformed message to the EMPI database. EMPI receives and runs the transformed message as a query in the database, constructs the retrieved demographic information in HL7 v3 format, and sends the message back to the BizTalk broker. The BizTalk broker again receives and converts the returned message from EMPI and sends the demographic information back to the Milk Bank Management System in HL7 v2 format [14].

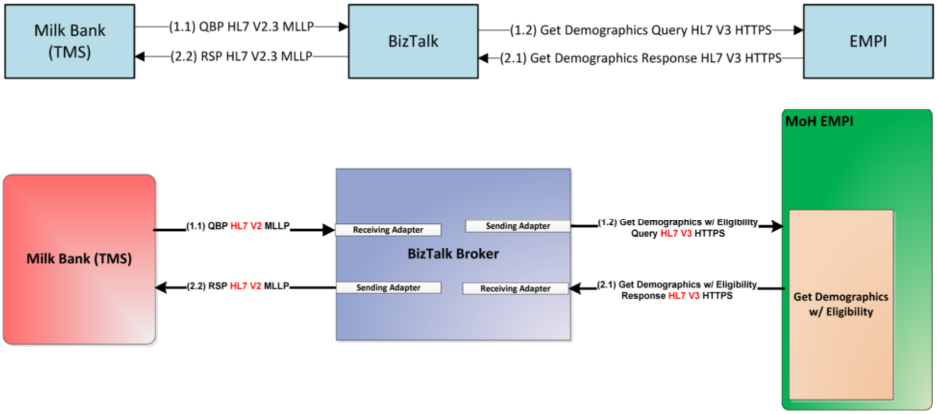

Figure 1. The message flow from the source application (TMS) through BizTalk Broker to destination application (EMPI), and EMPI sends the response back through BizTalk Broker to TMS. Mapping logics sit in the Sending Adapters within BizTalk Broker.

3. Results

The Milk Bank Management System is coded to construct HL7 v2 messages. There were originally debates whether it is more efficient and effective to construct HL7 v3 message in the Milk Bank Management System itself and adopt the Point-to-Point Model instead of the Common-Gateway Model for data exchange. However, the decision is to use the HL7 v2 message standards from the Milk Bank Management

System through a broker due to following reasons: 1) Comparing to HL7 v3, HL7 v2 is a more commonly used standard for health information exchange world-wide. There may be future plans to integrate the Milk Bank Management System with other EHR or healthcare systems. 2) Currently, there are several systems integrated. More systems will be integrated with EMPI that share similar business requirements such as Cerner clinical information system for the provincial initiated Clinical & Systems Transformation (CST) project. The interface analysis work can be reduced by leveraging from currently implementations with EMPI. 3) By adopting the Common-Gateway Model, the BizTalk Broker provides an advantage in interface management and monitoring [14].

R = Required
C = Conditional
O = Optional
B = Backward Compatibility

HL7 Field Mappings

Source HL7 v2.4
MSH Message Header

Field #	Field Name	Milk Bank (TMS) Length	Req\Opt	Data Type	Repeating	Notes	Mapping	Value	Mappings
1	Field Separator	1	R	ST		Milk Bank sends "|"			
2	Encoding Characters	4	R	ST		Milk Bank sends "^~\&"			
3	Sending Application	180	O	HD		Milk Bank sends "PHSA_BCWMB"	Copy To		Y
4	Sending Facility	180	O	HD					
5	Receiving Application	180	O	HD					
6	Receiving Facility	180	O	HD					
7	Date/Time of Message	26	O	TS		Milk Bank sends: System date and time the message was formatted in sending system. YYYYMMDDHHMMSS	Copy To		Y
8	Security	40	O	ST					
9	Message Type	7	R	CM		Milk Bank sends "QBP^Q21" for Get Demographics Query message	Copy To		Y
	1-ID			ID					Y
	2-Trigger Event			ID					Y
	3-Message Structure			ID					
10	Message Control ID	20	R	ST		Unique number that represents the query ID. This number needs to be retained in addition to the v3 mapping for sending back in the response message.	Copy To		Y
11	Processing ID	3	R	PT					
12	Version ID	60	R	VID					

Figure 2. Many organizations use templates to streamline the mapping process such as an excel file [15].

The mapping is done by doing gap analysis on the two different message formats and recording the mapped requirements on a standardized excel spreadsheet [15]. Each interface requires a mapping document that clearly outlines the inbound message structure and data type as well as the logic/translation rules that are required to translate the message to the outbound message format. These mapping documents act as a guide to construct the codes and configurations in the BizTalk Broker in order to translate the messages (Figure 2).

Once the logics are applied to the broker, the process is automated to translate or filter the information. An acknowledgement message (ACK) is sent back to the sending system from the receiving system to indicate the message transmission is successful. On the other hand, a negative acknowledgment (NACK) is sent to the sending system from the receiving system to indicate a message is suspended or failed in the transmission [14, 16] (Figure 3). This response mechanism helps message error handling, and the ACK/NACK message contains code that may imply why the error occurs. For example, a successful transmission is indicated by the code "AA", meaning the message is received, and there is no error handling needed. These error handling codes are standardized by HL7, but can be customized by implementation.

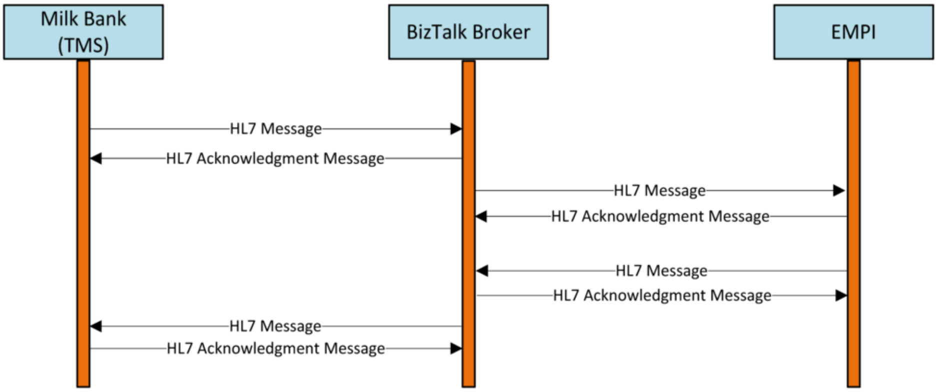

Figure 3. The HL7 Acknowledgement Message indicates the message transmission status. An ACK message indicates successful transmission; a NACK message indicates transmission has failed.

As a result, there are approximately 10 HL7 messages exchanged between the two systems per day. The estimated message exchange volume is around 2000 messages a year. The average time for querying one donor's demographic information is less than 3 seconds. Multiple queries and responses can be exchanged simultaneously. Moreover, Hypertext Transfer Protocol Secure (HTTPS) for data retrieval provides secured data transfer from the EMPI database to the BizTalk broker. The Minimal Lower Layer protocol (MLLP) via virtual private network (VPN) for data exchange between the Milk Bank Management System and the BizTalk broker enables a simple and fast form of message transport.

4. Discussion and Conclusion

While in the previous workflow in section 3, the donor's demographic information is collected manually, and it is solely dependent on the data that the donor provides. The new workflow allows real-time demographic data retrieval from the provincial patient demographic data repository, Enterprise Master Patient Index (EMPI). Therefore, the integration of the two systems substantially decreased the service's data collection time in comparison to previous manual entry during donor screening. Also, the broker provides an extra safeguard for message exchange as it automatically filters out corrupted data. Furthermore, up-to date donor demographic information exchange ensures the quality of the Milk Bank's data collection. The decreased time and effort as well as the enhanced data exchange security and quality successfully promote the expansion of the BC Women's Milk Bank program. As a result, the expansion strategically delivers better values for patients and encourages healthier population provincial wide.

Despite the many benefits in adopting the Common-Gateway Model and using of HL7 standards, we uncovered some challenges and future opportunities for the integration implementation. First of all, although HL7 standards provide a systematized framework for data exchange, its v2 format allows room for negotiation whereas v3 format has a stricter structure. In other words, customized data can be negotiated by heterogeneous systems, and the integration can be done on an "implementation by implementation basis" in the v2 format. Choosing the appropriate version from different HL7 standards can significantly influence the interface implementation and the quality of data exchange. For example, with simple data exchange, HL7 v2 is typically cheaper and faster to implement whereas HL7 v3 implementation usually takes longer and is less straightforward. On the other hand, with more complicated data exchange, HL7 v3 introduces the Reference Information Model (RIM) that addresses the drawback of data interoperability from the HL7 v2 standard.

Also, the Milk Bank Management System produces a low volume message feed. It is not likely to receive a significant number of new donors on a daily basis. That is to say, comparing to other high-volume data exchange interfaces, the data exchange is only active on an ad hoc basis. The analysis and implementation effort could possibly be reduced by adopting a different approach. This brought our attention to address relatively simple interfaces by alternative methods such as using FHIR instead of HL7 v2/v3. Unlike other HL7 standards, the Fast Healthcare Interoperability Resources (FHIR) standard published by Health Level Seven International in February, 2014, is easier to implement, and messages can be parsed for real-time data retrieval, which offers "A Robust Health Data Infrastructure" [17]. Further analysis and testing can be done to determine whether FHIR is a more suitable approach to address implementations such as the Milk Bank Management Integration project.

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