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An Information Exchange Model Based on HL7 v3 and Ontology in the Public Health Emergency Alarm System

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Abstract:

Information exchange plays a vital part in the success of public health emergency alarm system. It includes collecting and integrating the monitoring information, sharing of data, commanding coordinately and so on. An information exchange model based on HL7 v3 and ontology is proposed in this paper. It adopts HL7 v3 and ontology techniques to tackle the problem caused by structural and semantic heterogeneities respectively. This approach promises a system capable of overcoming difficulties encountered by traditional information exchange in the public health emergency alarm system.

Keywords **—public health, information Exchange, HL7 v3, ontology.**

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I. INTRODUCTION

Although the probability of occurrence of a public health emergencies is smaller, it is still a high-hazard events. Early warning plays a vital role in dealing with these emergencies. It can help to reduce the degree of harm in events. Just as the SARS disease in 2003 which exposed the weakness of public health information system of China. Then our state promptly issued a "Public Health Emergency Regulations". It requires local governments should establish and optimize public health emergency alarm system. So far , many places have set up their own alarm system.

Major public health emergency warning information comes from the Center for Disease Control, health surveillance, health services and other health system. Only by collecting information through multiple channels together with integrating and comparing, can a system really improve its own sensitivity since the characteristics of public health emergencies.[5] But in reality, every information has their own data structure and communication standard, which makes information integration and comparison among systems very difficult, then leading to the existence of early warning systems is not smooth, early warning information lag, inaccuracies, etc. In order to solve the problem of information exchange in public health emergency alarm system, we propose an information exchange model based on HL7 v3 and ontology.

This paper is organized as follows. Section describes the knowledge about HL7 and ontology. Section focuses on the framework of this model. Section introduces how the information exchanges based on the model. Finally a brief summary will be given.

II. BRIEF INTRODUCTION OF HL7 AND ONTOLOGY

A. HL7

HL7(Health Level Seven) is a medical information exchange protocol of network model for Open Systems Interconnection (OSI) seventh layer (application layer), which was published by International Organization for Standardization. It aims at developing and researching protocols and standards for hospital data transfer, norming the format for clinical and management information, thereby reducing the cost of health care information systems interconnected. In addition, it also can improve data information sharing between healthcare information systems.[6-9] Currently, there are two HL7 versions, HL7 v2.X and HL7 v3.

At present, many countries and regions have been using HL7 standard in the field of public health events. For example, American national electronic disease surveillance and reporting system is developed based on HL7 v2.3 version, which stipulates the data exchange of public health information and disease notification. The prescription part of HL7 v2.4 is adopted as infectious disease notification purposes in Taiwan. The lateset version of HL7 v3 provieds a development standard, which recommends a HL7 Development Framework to define the steps of HL7 message development. We can use this method to develop an information model ,which is more localized for health events prewarning. For example, we can use this method to develop an information model in the field of health events report.[7] Although HL7 v2 version has been widely used and has got great success, its development process lacks clear methodology guidance and its data lacks consistency, etc. These defects limit the application and further development of HL7 v2. This paper will use v3 version. By adopting a unified standard HL7 messages, the CDC can easily integrate the various information monitoring.

B. Ontology

There are many different definitions about ontology. But in the computer information system, the definition that ontology is a clear specification of conceptualization proposed by Gurber is the most widely adopted.[2] The goal of ontology is to capture knowledge in related fields, to provide a common understanding of the domain knowledge, to identify commmon vacabulary recognition in related field and to give clear definition of the relationship between these words and vocabulary from different levels of formal patterns.

Due to the rapid development of medical information, medical industry and related industries need a clear set of normative concepts for knowledge sharing and interaction. Currently, both at home and abroad have carreid out research on ontology in the medical field.[1] For example, the foreign has Unified Medical Language System (UMLS) , Systematized Nomenclature of Medicine – Clinical Terms (SNOMED CT) and Medical Subject Headings (MSH) while China has Medical Knowledge Library established by Chinese Academy of Sciences (CAS) , Traditional Chinese Medicine (TCM) Language System and TCM Clinical Term Set established by Institute of China Academy of Traditional Chinese Medicine Information.

C. Combination of HL7 & Ontology

HL7 standard defines message transmission formats, solving the problem of heterogeneous information integration, to a certain extent. Since the information transmission environment in existing medical institutions lacks consistency of processing, and the generated results require users and vendors privately to negotiate. It is difficult to provide a complete “plug and play” solution, which makes the implementation of each HL7 gateway must munually map message for appropriate database format of information system. So each database form must be fully understood, which is time-consuming. Thus, it is necessary to combine the ontology and using synonymous or approximate relationship between different concepts to automatically accomplish the mapping of HL7 message field with a local database field. Then transfer the message in HL7 standard, which can not only address the communication problem for heterogeneous information, but also reduce the cost of developing HL7 gateway.

III. INFORMATION EXCHANGE MODEL

The purpose of the information exchange model based on HL7 v3 and ontology (referred to as model) is to address the problem of various information interaction in public health event alarm system, which can make full use of existing human resource, material and equipment of the public health system to play a role in information mornitoring system related to other public health emergencies. In additon, the model collect together the monitoring information to form a horizontal networks and establish a longitudinal network in CDC between the upper and lower, so that the various levels can coordinate with each other. Through HL7 message with a unified standard, we can integrate a variety of information as much as possible. Then we can make a reasonable forecast according to some forecasts model, combined with

expert advice, to reduce the degree of ingure in public health emergencies. Figure 1 is a general framework of this model. The model consists of two parts: ontology mapping service point and HL7 gateway.

A. Ontology Mapping Service Point

Ontology mapping service point is the main module of the information exchange model. It is mainly to receive a query of HL7 gateway and to return the corresponding message module and the mapping relationship between the field of database and the field of message module, including message template library, HL7 RIM ontology library, database schema library, mapper, query processing module and HCI interface.

1) Message Template Library HL7 is a message-based and event-triggered model. HL7 defines various trigger events and corresponding message format, so that it can use messages corresponding to all events which may trigger to make a template and establish a uniform template library. What's more, doing so can help to adapt to changes of HL7 standard . When HL7 standard changes, we just need to modify message template library of ontology mapping service, and don't need to modify the gateway of every medical institution.

2) HL7 RIM Ontology Library Reference Information Model (RIM) is an abstract information model for all messages in HL7 v3 standard. It can ensure the consistency of the concept and provide data and concept reuse. RIM's grass-roots includes six bracket class: Act, Entity, Role, Participation, Act Relationship and Role Link. In addition, the Domain Message Information Model (D-MIM)

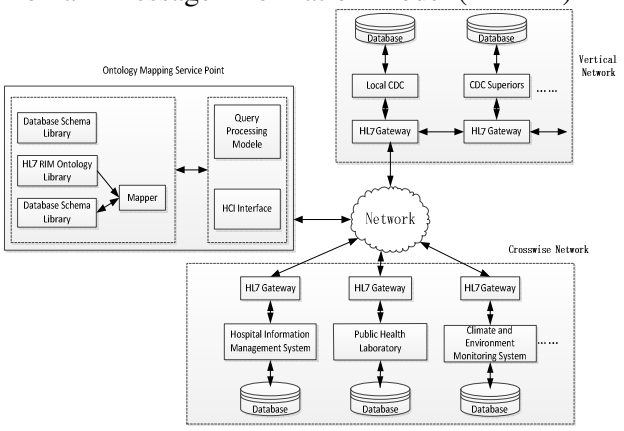


Figure1 Public health emergency warning system model based on HL7 v3 and ontology

class is derived from RIM while the Refined Message Information Model (R-MIM) class is derived from D-MIM. We can use HL7 and all its derived classes to build an ontology library, referring to a variety of medical ontology and term sets mentioned preceding part. For Example, B.Orgun built an HL7 RIM ontology library referring to SNOMEDCT.[4]

3) Database Schema Library Database Schema Library stores all database schema involved in information system in early warning system. Database schema includes database names, table names, the relationship between tables, field names and field types, which can be extracted through reverse engineering of relational databases. When a new detection source applies for joining, it should submit its database schema to ontology library.

4) Mapper Mapper is used to complete the map between database schema and HL7 RIM ontology to bulid the relationship of HL7 message field and specific database field. As figure 2 shows, the mapper works by inputing database schema and HL7 RIM ontology of one medical institution to the mapper, then outputing the map relationship between database schema and HL7 RIM, according to corresponding conversion rules, algorithms, and some external knowledge library. At present, DartGrid, VisAVis, D2OMapper and many other tools or systems is available for these kinds of work.

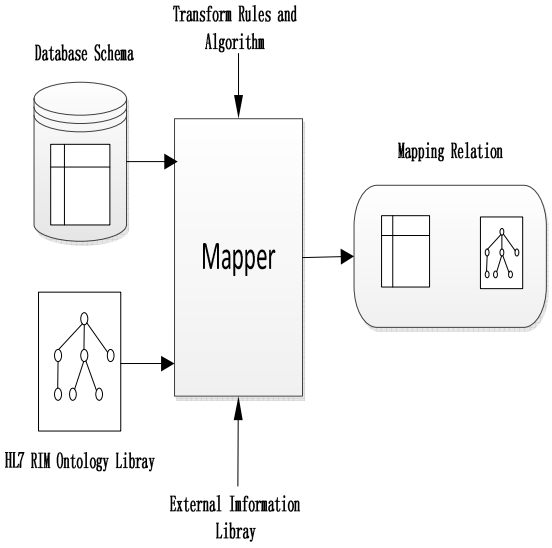


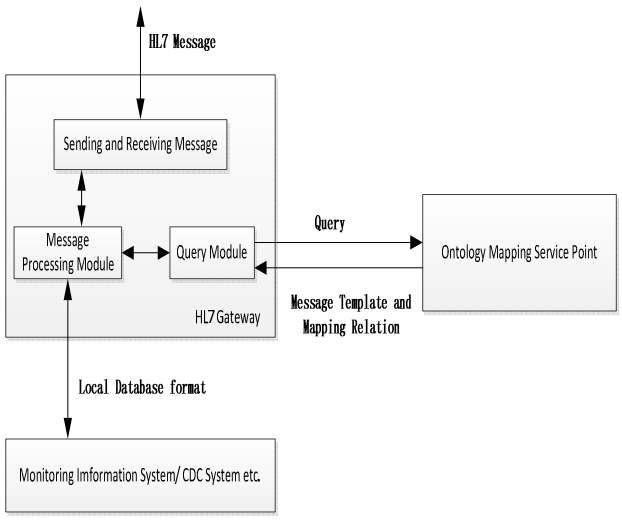
Figure2 The map between database schema and HL7 RIM ontology

5) Query Processing Module Query processing module receives the query of HL7, and returns mapping relationship between message template of gateway request , local database schema and HL7 RIM ontology.

6) HCI Interface The mapping relationship automatically generated by tools are not necessarily very accurate, so the system provides a HCI interface to provide a visual interface for users, which makes it easy to modify mapping rules and mapping relationship in order to improve the accuracy of maps.

B. HL7 Gateway

When an event occurs (unknown disease reporting or queries, etc.), information systems respond to events, and to generate and transmit a specific HL7 message. Then the receiving system extracts the desired content from the HL7 messages to achieve information exchange. But many of the current medical information systems was not according to HL7 standards when building their initial systems. In order to use HL7 protocol, we can construct an intermediate components which we call HL7 gateway to complete the conversion of local news and standard HL7 message. The structure of HL7 gateway is shown in figure 3. It includes HL7 message sending and receiving module, query module and message processing module.



Fugure3 HL7 gateway works

1) Message Sending and Receiving Module Message sending and receiving module is used to send and receive HL7 message.

2) Query Module By accessing ontology mapping service points, the query module gets a message template corresponding to a specific trigger event, and the mapping relationship between the fields of message template and the fields of database.

3) Message Processing Module The main task of message processing module is to complete the conversion between local database formats and HL7 messages. When HL7 messages need to be dealt with, we should first call query module to get message template and mapping relationship. When sending a message, we can extract the contents of the local database and fill in the appropriate contents to HL7 message, according to the mapping relationship, to constitute HL7 message. When receiving a message, we can extract the contents of HL7 message and base on mapping relationship to save the approriate contents to the database. To improve efficiency and reduce processing time, corresponding cache mechanism can be created to keep the mapping relationship and corresponding mapping relationship. If there is no corresponding information, we can call the qurey module to qurey the corresponding information.

HL7 standard does not require specific transport protocol to transmit messages. We can propose TCP/IP, E-Mail, Web Service and other transport protocols and services for transmission of messages, to build system conveniently.

IV. INFORMATION EXCHANGE

The combination of HL7 and ontology technology can better address the problem of structural and semantic heterogeneity in public health early warning system, thus completes the information collection and integration to the most degree. In addition, with standard HL7 messages, medical resources can be effectively coordinated, and the information between various medical institutions also can be coordinated.

1) Information Collection The existing information source monitoring which only need to achieve HL7 gateway can be easily added to the system. When information source mornitoring find

a public health emergency (eg unknown disease) need to be reported, it will start to notify the events through a standard HL7 message and send the HL7 message to the CDC, who can easily collect and integrate these information. As the number of the bulletin cases is more than the preset standard, CDC will send early warning signal to relevant departments through a unified HL7 message.

2) Coordination of Mecidal Resources When public health emergencies happen, the CDC often needs to master the situation of medical resources in various medical institutions, such as pharmaceuticals, blood, equipment and so on. HL7 standard which defines query message can transfer local query of the CDC to query message which meets HL7 standard. When query message arrives each HL7 gateway, it is combined with field mapping and transformed into local query, then returns the standard HL7 query results. The process can be simplified as shown in Figure 4. The CDC and other relevant departments can extract the results, according to the returned unified message, to deploy a variety of medical resources legitimately.

3) Information Exchange Between Medical Institutions Using standard HL7 message to achieve information exchange through HL7 gateway makes not only CDC and medical institutions , but also medical institution and institution can exchange information, such as patient's referral information, observations, doctor's order, etc. These information have great reference value for many other relevant institutions. For unknown diseases, relevant information can be uploaded to the CDC by monitoring source. The experts will confirm the current best treatment programs according to these information, then the treatment program will be sent to the relevant medical institutions through a unified HL7 message.

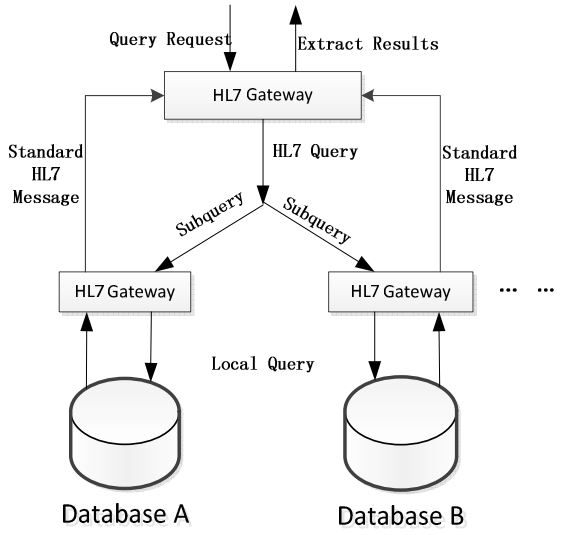


Figure4 Query simplified model

4) Coordination Command The CDC can make full use of horizontal and vertical networks by developing a specific coordination information model. The CDC superiors can obtain the situation of public health emergencies in each regional through the bullentin of the subordinate CDC, and do the work of coordination and command as much as possible. In addition, the relevant departments could grasp the situation in time and make a response.

V. CONCLOSION

Using the information exchange model based on HL7 v3 and ontology in public health emergency early warning system can break the existing "island of information" situation between department and department, system and system. It also can effectively integrate various monitoring systems into a unified information platform, and gradually expand the coverage of health monitoring sources, which provides a wealth of data for reasonable and accurate early warning. What's more, information in departments and regions can communicate smoothly with each other, which can minimize the degree of harm.

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