HL7-based Data Exchange in EHR Systems

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Abstract

This paper describes procedures of development of an electronic health record for shared healthcare which include implementation of communication standard HL7 v.3, its application in the environment of existing hospital information systems (HIS) and modeling the semantics of the transferred data. The main part of the solution is so called HL7 broker that serves as a mediator in the communication between the two incorporated systems and implements procedures defined in the HL7 v.3 standard. Data models which describe the systems communicating wit communicating with7 broker are based on the original data models implemented in HISes and are in the proper form, demanded by the HL7 standard. In order to achieve the semantic interoperability of incorporated system the creation of mapping of existing data models to international nomenclatures was necessary. Finally the possibilities of usage of international standards and nomenclatures in comparison to the national ones are discussed.

1. Introduction

My contribution describes the results of the project called ”Information technologies for development of continuous shared health care” supported by Czech national programme ”Information Society” that are covered by the thema of my doctoral thesis – semantic interoperability among systems of electronic health record (EHR). One of goals of the project was to design and implement environment of communicating systems, which would create a base for lifelong EHR of the patient. There are participating two different EHR systems - MUDR EHR [1] and hospital information system (HIS) WinMedicalc 2000 [2]. International standards and nomenclatures were utilised in order to achieve semantic interoperability of concerned systems.

2. Incorporated medical systems

In order to fullfil the main goal of the project an analyzis of the semantics of both participating EHR systems had to be done. The MUDR EHR focuses on efficient, reliable and modular way of data storage and is intented to be part of a more complex system as it does not contain modules engaging in catering services, human resources, drug supply etc. WinMedicalc 2000 is a full featured HIS and for the purpose of the project the interest was limited on its EHR part.

The abbreviation MUDR stands for MUltimedia Distributed Record, which is a pilot solution of structured electronic health record, developed in the Department of Medical Informatics ICS AS CR. MUDR EHR uses a special graph structure called knowledge base and data files to represent the stored information [3]. The WinMedicalc 2000 stores its data in a relational database and thus uses Entity-Relationship model [4] to represent its information model. Preparation of the semantic content of both EHRs in the field of cardiology started from the same modeling basis - the set of important medical attributes for the diagnosis of cardiological patients named the Minimal Data Model for Cardiology [5]. In the MUDR EHR, the modeling process resulted in creating of a part of the knowledge base - the knowledge domain called PATIENT, consisting of basic administrative data, allergy information, family history, social history, subjective information, physical examination, laboratory examination, personal history, treatment information and history of cardio-vascular diseases.

The model of WinMedicalc 2000 system consists of basic administrative information, cardiological

examinations (e.g. ECG examination, Holter monitor, stress test ECG etc.), laboratory examination, physical examination and family history. Each of these data (except administrative information) are connected to a clinical event, that binds together the object and subject of the event, i.e. the patient and the physician. Clinical event contains further information such as place where the event took place (e.g. ward, emergency room). Moreover, WinMedicalc 2000 system covers a broader scope than just clinical data (e.g. catering services, bed management), but these are out of the concern so they are left out.

3. Solving communications

After an initial survey in the field of international communication standards the HL7 v.3 [6] was chosen to enable the data exchange among EHRs. Due to the complexity of the HL7 standard it would be in real life too exhausting to comprehend the whole standard. Therefore the implementation is divided in several parts. The communication was based on:

- creating *local information models* (LIMs) describing the semantic structure of EHR (for this purpose a modelling application named MODELAR was developed)
- establishment of *HL7 brokers* for each information system
- implementation of supporting modules (we call them *LIM fillers*) as parts of the participating systems

A sample communication scenario (see Fig. 1) is based on situation when HIS2 enquires particular data from HIS1 and it is already known which data are going to be transferred. The first step is to retrieve data from the database of HIS1. The LIM filler on the side of HIS1 transforms this data into a LIM message described by a relevant LIM template. LIM templates are described by XML-Schema language and are embedded in the LIM filler. Data proceed in a secure way to the HL7 broker via the SOAP protocol bound to HTTPS protocol using web-services technology. The HL7 broker transforms the data into HL7 message instance according to mapping definitions between the LIM model of HIS1 and HL7 balloted messages. The instance of HL7 message is sent to the receiver of the data which is stated in the header of the LIM message. The accepting HL7 broker transforms the incoming HL7 message into a LIM message according to HIS2. The HIS2 gradually polls (by using web-services) the broker for new data, which in this case will be successful, otherways it gets a message that says that there are no messages. The LIM filler on the side of HIS2 transforms the received LIM message into internal form suitable for storage into its database. The last step of the communication is the storage of received data into HIS2's database.

Hospital information systems contain sensitive data thus the access control and security is one of key issues. In proposed solution a secured HTTP connections are used. The access control is managed by HIS themselves as it was this way before the HL7 communication extensions. All extensions of the HIS developed in the frame of this project are transparent to the hosting HIS as much as possible.

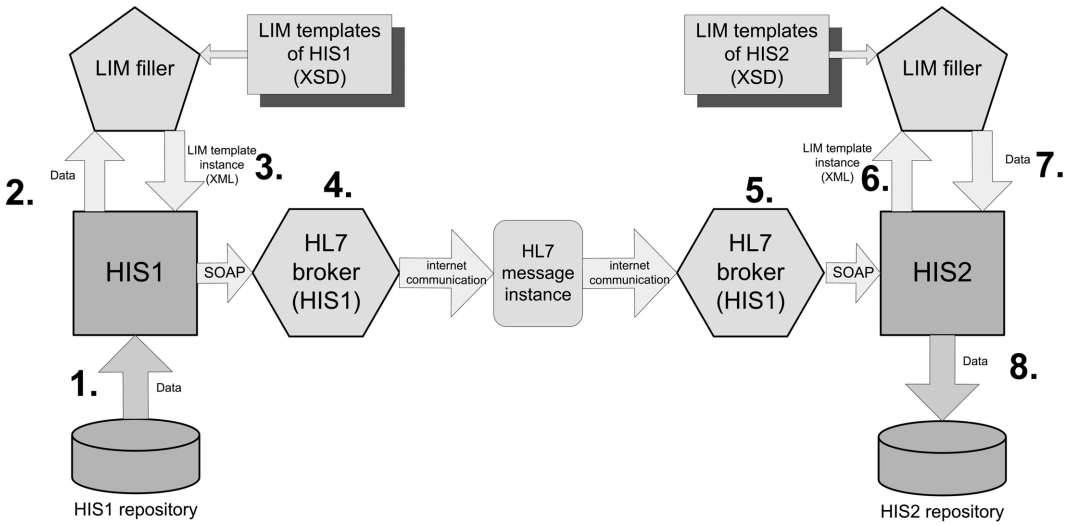

Figure 1: Communication scenario between HIS1 and HIS2.

Connecting a HIS to HL7 communication environment brings a need of dealing with data originating outside of the system. On the other side the system must deal with a new user type or role – the HL7 user. There was a need to store the foreign data separately and mark it clearly that it originates in HL7 communication. In case of querying data from other HIS over HL7 there had to be done an access control exception for testing purposes since the main goal of the project was to design and test the communication possibilities of the HL7 standard. The access control and overall manipulation with data originating from different hospital is gowerned by law, which is still not in the suitable from. Incoming queries have right to read all data about particular patient that are intended to be shared, which are for testing purposes almost all of them. In real life usage a sophisticated access control policy would be needed.

3.1. Describing EHR semantics

The HL7 v.3 standard methodology introduces a reference model (Fig. 2) that should serve as a basis for all semantic objects modelled during the whole process of implementation of communication among EHR systems. Both MUDR and WinMedicalc 2000 systems have been described on a semantic level by classes derived from those in the reference information model. This produced so called local information models (LIMs) of each EHR which are conceptually very close to HL7 D-MIMs (domain message information model). Classes from these models represent collected variables. Moreover, beside the similar concepts both LIMs use also the references to established code systems (LOINC [7], NCLP [8]), giving the possibility of the precise specification of semantics.

3.2. HL7 broker

The main motivation for creating the HL7 broker was to disengage vendors of EHR systems from comprehending and implementing all parts of the HL7 standard, thus saving financial resources. The HL7 broker serves as a configurable communication interface for the EHR system. The configuration is made by a XML file containing the LIM model of a particular EHR.

After creating LIM models for both EHR systems involved in the project, the next step was to produce so called *LIM templates*. These templates consist of classes defined in LIM model which are arranged in a tree structure. Each LIM template represents one integrated part of the EHR system the LIM model describes, e.g. physical examination, medication, ECG data. Having LIM templates the configuration of HL7 broker by mapping classes from LIM models to fragments of balloted HL7 messages could be completed.

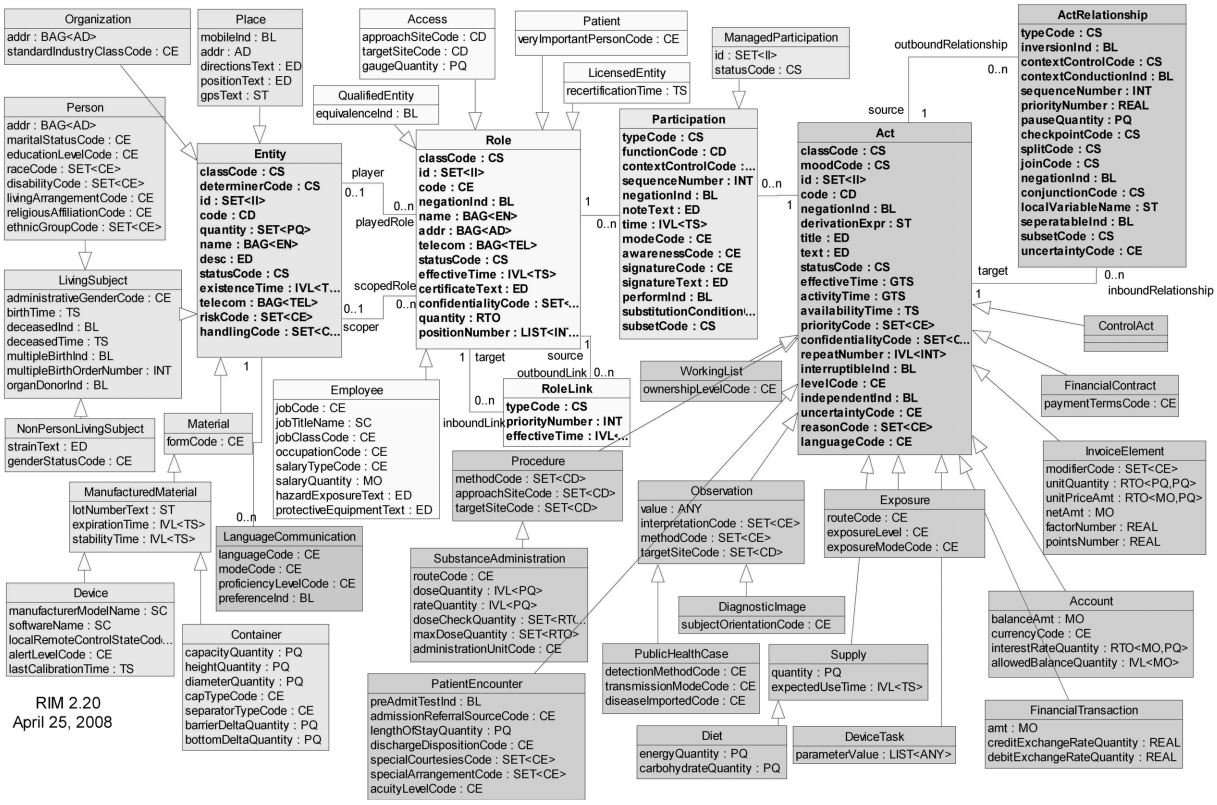

Figure 2: Reference Information Model defined in the HL7 v.3 standard.

The HL7 broker plays a role of an entry point to a HL7 network or some sort of a gateway. The HL7 network consists of HL7 brokers which communicate with each other. The HL7 brokers support peer to peer communitaction and broadcasts are possible as well. New HIS is added into the HL7 newtwork after implementing all three steps mentioned at the beginning of this section. The HL7 broker connected to the new HIS is added to the set of existing HL7 brokers.

3.3. EHR communication modules

Both EHR systems had to be extended by programatic parts supporting the communication with a particular HL7 broker. We call these parts LIM fillers as their main task is to fill in LIM templates with actual data, thus creating LIM message instance.

Secondary task of a LIM filler is communication with the HL7 broker via SOAP protocol. Therefore, a SOAP client had to be implemented on both EHRs. Each filler was created independently but on a similar basis as a pluggable module.

3.4. Classifications and code lists

Uniqueness of term definitions and their precise denomination are necessary for semantic interoperability. We have found that current classification of medical terms is not optimal. Insufficient standardization in medical terminology represents one of the prevailing problems in processing of any kind of medical-related data.

Various classification systems, nomenclatures, thesauri and ontologies have been developed to solve this problem, but the process is complicated by the existence of more than one hundred incompatible systems. The most extensive current project that supports conversions between major classification systems and records relations among terms in heterogeneous sources is the Unified Medical Language System (UMLS) [9].

During the development of MUDR EHR and MDMC, the UMLS Knowledge Source Server was used to evaluate the applicability of international nomenclatures in the Czech medical terminology. During the analysis, we found that approximately 85 % of MDMC concepts are included in at least one classification system. More than 50 % are included in SNOMED Clinical Terms [10].

Each information system uses its internal code-lists. There are plenty of them in the information systems and standards. To avoid necessity to implement them in the HL7 broker, a web application enabling each information system developer to define and maintain their own code-lists has been developed. The same mechanism can be used to import the HL7 code-lists. Each code-list is characterised by its name, technical name, version, administrator and user of the code-list (HL7, WinMedicalc, MUDR).

The web application allows the user to define relations between values of individual code-lists describing the possibility to convert value from one code-list to value from the another one. The allowed relation types are equivalence, generalization or specialization.

The entered data about code-lists can be utilized by SOAP method `Translate(val, A, B)`, where `val` is the value from code-list `A` and `B` is the destination code-list. The method returns the value from `B` which is equivalent or generalization of the value `val` from `A`. This method can be used by core of HL7 broker to convert values from messages according to required code-lists.

3.5. Communication interface between MUDR EHR and HL7 broker

Communication between electronic health record and HL7 broker is similar in both participating systems, therefore in the following text the MUDR EHR part will be described.

Communication between MUDR EHR and HL7 broker is based on SSL secured SOAP protocol. The HL7 broker provides several methods (`sendLimMsg()`, `ackLimMsg()`, `getLimMsg()`) for transfer of the data between MUDR EHR and HL7 broker. These methods are exposed by the web-service of the HL7 broker as operations and are described in web-services definiton language (WSDL) file in the following form:

The data are transported in the form of a message described by the LIM template – *LIM message instance*. Several LIM templates are defined, e.g. administrative data, ECG or laboratory results. There are two communication modes - *querying mode* and *passive*.

In the query mode the MUDR EHR receives a special LIM template with a query from the HL7 broker. This LIM template contains only several entered values serving as an identifier of the demanded information – query parameters. After information retrieval from the local database of MUDR EHR, the information is sent back to the HL7 broker in the form of LIM message.

The passive mode is used to import the content of the LIM message (with all the required data) into the target EHR.

```
...
<portType name='svc-porttype'>
  <operation name='ackLimMsg'>
    <input message='tns:ackLimMsgRequest'/>
    <output message='tns:ackLimMsgResponse'/>
  </operation>

  <operation name='getLimMsg'>
    <input message='tns:getLimMsgRequest'/>
    <output message='tns:getLimMsgResponse'/>
  </operation>

  <operation name='sendLimMsg'>
    <input message='tns:sendLimMsgRequest'/>
    <output message='tns:sendLimMsgResponse'/>
  </operation>
</portType>
...
```

The combination of both modes enables the EHR application triggered by the user request to ask for the data from the other EHR via HL7 broker, wait for the incoming data and store them into its own database structure. Such data should be flagged as externally received.

The result of a query in the EHR initiated by the received LIM template could consist of a several LIM messages according to the query specification. In this case the individual messages will be sent to the HL7 broker in sequence with the last message marked as the final one.

4. Results

Communication between participating EHR systems is realized via the HL7 v.3 communication standard. Local information models describing semantical structure of both EHRs were created in order to support semantic interoperability. Each LIM is derived from the HL7 RIM. The message exchange is realized via HL7 brokers which communicate with corresponding EHRs by using web-services technology based on SOAP protocol.

5. Discussion

The majority of healthcare information systems in the Czech Republic uses so called Data standard of the Ministry of health (DASTA) [8] and National code-list of laboratory items (NCLP)[8], as a communication platform. These standards are developed by the producers from many companies, faculties, research institutions in the Czech Republic. DASTA is based on a predefined limited set of structured data, especially from the field of laboratory examinations, which is possible to transfer by the standard messages. The benefit of the DASTA is its simplicity, allowing an easy implementation of the interface and realization of a communication among information systems. This simplicity however limits its use, in case the information not covered by the actual standard version is to be transferred. The communication of structured general clinical information is not covered satisfactorily by the DASTA and it is usually limited to transfer of the free text messages. On the other side, the possible extension of the standard by another data is much easier on the national level than on the international one.

HL7 v.3 offers the general methodology and tools for the realization of communication between information systems in healthcare and covers this area with a large scale of generality. The large extent of the standard and existing relations to other standards and classifications are a bit demotivating for the developers with the minimal experience with standards of this scale. On the other side, this extensiveness and universality allows to represent the majority of the situations and entities appearing in the data exchange process in healthcare. Thanks to references to external classifications and nomenclatures the HL7 standard provides the method to accurately specify the semantics of the communicated data without the need for ad hoc agreement of communicating parties about the exact meaning of individual elements in the transferred messages.

NCLP and DASTA have only a minimal relations to international classifications and standards. The communication of Czech hospital information systems with other healthcare information systems on the european or international level is not possible without the adherence to the international standards and classifications. Unfortunately, their use in the national environment is very limited without existing Czech localization of a high quality. Such translation would be very expensive and time consuming, but on the other hand it would significantly extend the integration possibilities of Czech eHealth activities into the international context.

6. Conclusion

The structured form of information stored in EHR is an inevitable prerequisite for semantic interoperability establishment among various EHR systems. The research work in the scope of the project ”Information technologies for development of continuous shared health care” demonstrated one possible concept of solving the problem of distributed medical environment. The developed concept is based on international standards and nomenclatures which can be applied as a system for shared lifelong electronic patient’s health documentation.

References

[1] Hanzlicek, P., Spidlen, J., Nagy, M.: Universal Electronic Health Record MUDR. In: Duplaga, M., Zielinski, K., Ingram, D. (eds.) Transformation of Healthcare with Information Technologies. pp. 190–201. IOS Press, Amsterdam (2004)

[2] Medicalc Software s.r.o.: WinMedicalc 2000, http://medicalc.cz/winmedicalc

[3] Spidlen, J.: Databazova reprezentace medicinskych informaci a lekarskych doporuceni (In Czech). Master Thesis at Faculty of Mathematics and Physics, Charles University in Prague, pp. 32–34, (2002)

[4] Chen, P.: The Entity-Relationship Model – Toward a Unified View of Data. ACM Transactions on Database Systems, vol. 1, no. 1, pp. 9–36. (1976)

[5] Tomeckova, M.: Minimalni datovy model kardiologickeho pacienta (In Czech). Cor et Vasa, vol.44, No. 4, pp. 123. (2002)

[6] HL7 Int. Ballot HL7 v3 – May 2008, http://www.hl7.org

[7] Regenstrief Institute Inc.: Logical Observation Identifiers Names and Codes, http://loinc.org

[8] Ministry of Health of the Czech Republic: Datovy standard MZ CR v.4, http://ciselniky.dasta.mzcr.cz

[9] National Library of Medicine – National Institutes of Health: Unified Medical Language System, http://www.nlm.nih.gov/research/umls

[10] International Health Terminology Standards Development Organisation: Snomed CT, http://www.snomed.org