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Clinical Contents Harmonization of EHRs and its Relation to Semantic Interoperability

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Abstract

This paper describes solutions proposals in the field of clinical content harmonization of electronic health records and semantic interoperability establishment. First the Czech national project "Information Technologies for the Development of Continuous Shared Healthcare" will be mentioned and its approach to creation of semantic interoperability platform. Afterwards an approach using openEHR architecture will be described. Finally a technique of creation of electronic health records with harmonized clinical content will be stated.

1. Introduction

Sharing and reusing the data among different institutions in the Czech healthcare environment is at relatively low level. The majority of healthcare information systems in the Czech Republic communicate with each other using a national communication standard called DASTA [1], which is based on the national nomenclature called National code-list of laboratory items (NCLP) [1]. These standards are developed and administered by the developers of healthcare information systems that are either specialized companies, university IT centers or research institutions in the Czech Republic. The development of the standard is supported by the Czech Ministry of Health. DASTA is specialized mainly in transfer of requests and results of laboratory analyses. The current version of DASTA is XML based and provides also the functionality for sending statistical reports to the Institute of Health Information and Statistics of the Czech Republic [2] and limited functionality of free text clinical information exchange. Unfortunately, the DASTA has almost no relation to international communication standards such as HL7 [3] or European standards like EN13606 [4].

The use of international standards such as HL7 v2, HL7 v3, EN13606 or DICOM [5] is induced mainly by the local requirements within healthcare institutions to communicate with modern instruments and modalities. Here, the major role is played by the HL7 version 2 and DICOM standards; however, it represents only a minor part of the overall communication within the Czech healthcare system.

Many papers, especially in last few years, deal with the problem how to establish semantic interoperability among various EHR systems [6], [7], [8]. As stated in [9] the semantic interoperability has 4 prerequisites. They are a standardized EHR reference model, standardized service interface models, a standardized set of domain-specific concept models and standardized terminologies. The problem of clinical content harmonization has similar objectives – unambiguous semantics of common information model connected to international nomenclatures and ontologies. We can say that having EHRs with harmonized clinical content (HCC) and message development process we could achieve semantic interoperability.

Achievement of semantic interoperability and especially an EHR with HCC in our work will be based on results of projects "Information Technologies for the Development of Continuous Shared Healthcare" (ITDCSH) [10], ARTEMIS [11], openEHR foundation [12].

2. Materials

A national research project of the Academy of Sciences of the Czech Republic, ITDCSH had in its main goals the creation of an interoperability platform for structured healthcare data exchange, serving as a basis for lifelong healthcare support, which would be based on international communication standards. For this purpose the HL7 standard v3 was chosen from the set of HL7, DICOM [5], openEHR [12] and ENV 13606 [13].

This unique project (in the context of Czech healthcare environment) served primarily as a demonstration of possibilities, tasks and issues. It was not possible to cover the whole area of medicine as an interoperability domain. Our department has a long history of interdisciplinary research oriented on the field of cardiology. Therefore, the cardiology was chosen as the medical domain for the pilot realization of the semantic interoperability platform. A set of important medical concepts in the field of cardiology named Minimal Data Model of Cardiology (MDMC) [14] was prepared by the representatives of Czech Society of Cardiology and statisticians specialized in medical data processing. This set of concepts served as a basis for information models of two EHR systems used in our solution.

2.1. Terms and definitions

At this point it is advisable to summarize some terms of key importance for the rest of the text:

electronic health record (EHR) is defined as "a repository of information regarding the health status of a subject of care, in computer processable form" [9].

EHR system is defined as "a system for recording, retrieving, and manipulating information in electronic health records" [4].

clinical content is a part of set of concepts that underline the EHR and which refers to medical domain concepts such as physical examination, laboratory, medication, rather than demographic information, billing or bed management.

archetype according to [9] (from the technical point of view) is "a computable expression of a domain-level concept in the form of structured constraint statements, based on some reference information model".

semantic interoperability according to [15] is "the ability of information systems to exchange information on the basis of shared, pre-established and negotiated meanings of terms and expressions".

openEHR template is a directly, locally usable definition which composes archetypes into a larger structure logically corresponding to a screen form. Templates may add further local constraints on the archetypes it mentions, including removing or mandating optional sections, and may define default values.

HL7 template are used to apply constraints on R-MIMs (refined message information models) generated from generic reference information model.

HL7 v3 message is an instance of classes of R-MIM which are composed in a hierarchy defined by hierarchy definition model (HMD).

LIM template is a pattern defining tree-like structure of instances of LIM (Local Information Model) [16] classes. Each LIM template represents one integrated part of the EHR system the LIM describes, e.g. physical examination, medication and ECG data.

2.2. Possible content stored in an EHR

In the following text we put an example of concept groups that may appear in an EHR as described in [17].

1. A collection of concepts that together form fixed attributes of a higher level concept that is not recorded as its component parts alone - e.g.:

   - a blood pressure measurement with its two pressure measurements, patient position, cuff size etc.

   - a body weight with details about the baby's state of undress and the device used for measurement

2. A generic concept (with other fixed attributes) that is a value or a collection of values which form a subset of a larger (or very large) known set - e.g.:

   - a diagnosis - the value - with fixed attributes such as the date of onset, the stage of the disease etc

   - a laboratory battery result which includes an arbitrary set of values - the collection - with fixed attributes such as the time of sampling, or a challenge applied to the patient at the time the sample was taken (e.g. fasting).

3. A collection of these higher level concepts that are usually measured together and might be considered themselves concepts - e.g.:

- Vital signs - with temperature, blood pressure, pulse and respiratory rate
- Physical examination - with for example observation, palpation and auscultation (and other findings)

4. A collection of these aggregations which might form a record composition or a document - e.g.:

- A clinic progress note containing symptoms, physical examination, an assessment and a plan
- A laboratory report that contains the results as well as interpretation and details about any notifications and referrals that have been made
- An operation report detailing the participants and their roles, a description of the operation, any complications and followup monitoring and care required

2.3. Archetypes

Archetypes play a key role in development of future proof EHR systems [18]. As defined in the section 2.1 archetypes are structured constraint statement based on some reference model (RM). In the paper [19] we can find example of archetype that represents "weight at birth" based on HL7 RIM as well as on openEHR reference model. The archetype binding to a RM is realized in archetype definition that is formalized in Archetype Definition Language (ADL) [20] particularly in the part called *definition*. Language that is used for this binding is called contraint ADL – cADL.

The openEHR foundation presents an application called Clinical Knowledge Manager accessible from their web site [21]. Its purpose is to concentrate archetypes in one repository in order to be reviewed by the community and create a repository of archetypes that could serve as a basis for development of EHRs with HCC.

In the Figure 1, the structure of archetype representing blood pressure concept is depicted. The part *data* contains values of the actual pressure, i.e. systolic, diastolic, mean arterial pressure, pulse pressure and textual comment on blood pressure reading. *State* is a list of information describing conditions of the measurement, e.g. the position of the patient at the time of measuring blood pressure. *History* covers separate measurements and adds temporal data in the implicit form, i.e. base measurement in the history, another reading after 5 minutes of rest, 10 minutes etc. Finally, the *protocol* holds technical data such as size of a sphygmomanometer's cuff if it is used or a specification of an instrument used to measure the blood pressure. For the sake of further computerized processing, archetypes are defined in ADL.

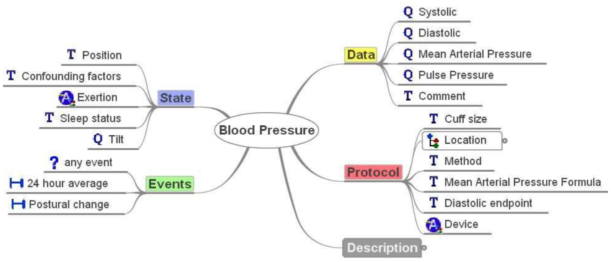

Figure 1: Blood pressure archetype example.

2.4. Communication standards

Communication among EHRs can be understood as data exchange in form of messages which have well defined syntax that is supported by all participants. This ensures so called *syntactical interoperability* where the structure and provenance of information or knowledge is understood by a clinical system – data are in machine readable form.

In Czech healthcare environment two kinds of communication could be recognised – passive and active. *Passive communication* is realized between healthcare institution and registries gathering data of patient with particular diagnosis (e.g. joint replacement, organ transplantation and oncology). *Active communication* is actively initiated by a request or query. Messages in active communication process have typically form of application forms, various documents (e.g. medical treatment summary), structured forms (e.g. laboratory results) etc.

Despite the long term effort in the field of communication standardization there still does not exist one universally accepted communication standard. There are two commonly used standards: HL7 v3 (international) and EN 13606 (European). The HL7 standard served as a basis for the solution described in section 4.1 and EN 13606 is indirectly connected with the proposal in the section 4.2 since it defines archetypes and templates for messaging as well as the reference model originating from openEHR.

2.5. HL7 v3 RIM

The Reference Information Model (RIM) [22] is used to express the information content for the collective work of the HL7 Working Group. It is the information model that encompasses the HL7 domain of interest as a whole. The RIM is a coherent, shared information model that is the source for the data content of all HL7 messages. As such, it provides consistent data and concept reuse across multiple information structures, including messages.

3. Methods

3.1. Semantic interoperability and Semantically enriched Web Services

In order to achieve semantic interoperability of EHR information, there are four prerequisites, with the first two of these also being required for functional interoperability [9]:

- a standardized EHR reference model, i.e. the EHR information architecture, between the sender (or sharer) and receiver of the information,
- standardized service interface models to provide interoperability between the EHR service and other services such as demographics, terminology, access control and security services in a comprehensive clinical information system,
- a standardized set of domain-specific concept models, i.e. archetypes and templates for clinical, demographic, and other domain-specific concepts, and
- standardized terminologies which underpin the archetypes. Note that this does not mean that there needs to be a single standardized terminology for each health domain but rather, terminologies used should be associated with controlled vocabularies.

An elaborate work regarding semantic interoperability can be found in [6], where the development framework (not the implementation itself) for semantically interoperable health information systems is described. However, this paper will orient on the realization and validation of the interoperability platform.

Procedure of semantic interoperability achievement among EHR systems storing clinical information in various proprietary formats was studied in project ARTEMIS. The resulting solution contained an idea of wrapping and exposing the existing healthcare applications as Web Services [19]. The semantic interoperability was achieved by using OWL [23] (Web Ontology Language) mappings of archetypes based on reference models of, possibly, different standards (openEHR, HL7 RIM). These archetypes semantically enrich the Web Services messages. The interoperability was realized through a mediator that transformed the source message using mapping definitions into appropriate form to be accepted by the destination system and its Web Service.

3.2. Clinical content harmonization

EHR systems with harmonized clinical content are the most appropriate ones to achieve semantic interoperability. Their clinical content that refers the same domain is ready for exchange with minimum transformations and mappings during its delivery. However, the actual implementation of communication is out of scope of this area.

4. Results

This section presents results of various approaches to semantic interoperability approaches; one based on HL7 v3 messaging and the other one on openEHR architecture especially the construct called templates.

Some results in process of clinical content harmonization of EHR are shown. Particularly the clinical concepts mapping to coding systems (table 1), modeling these concepts using standardized reference model (here HL7 RIM; see figure 6) and finally finding archetypes that cover modeled concepts.

4.1. Semantic interoperability platform based on HL7 v3 messages

Primary result of the project ITDCSH is a proposal of semantic interoperability platform based on international communication standard, which is shown in Figure 2.

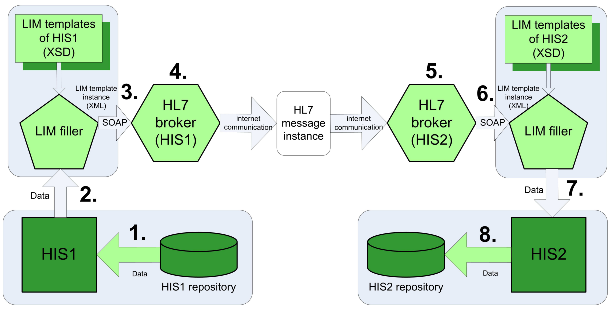

Figure 2: Proposal of semantic interoperability platform based on international communication standard.

The proposal consists of LIM filler module, HL7 broker and original HISes. Numbers in the Figure 2 represent the data flow in a situation when HIS1 sends data to HIS2. First of all, the requested data are gathered from HIS1. This is done by the LIM filler that has a connection to the HIS repository. Next, the LIM filler takes the suitable LIM template which contains the correct concepts to represent the communicated data. LIM filler adds data values to empty classes in the LIM template, thus creating a LIM message. HL7 broker receives the LIM message via the SOAP protocol used by the LIM filler module. Again, another transformation is performed; in this case the HL7 broker produces appropriate HL7 message instances, which are sent in a secure way to the receiving HL7 broker. Now the process of data transformation runs backwards. The HL7 broker attached to HIS2 creates LIM messages recognized by the LIM filler of HIS2 and sends them via SOAP. The receiving LIM filler recognizes the incoming LIM message and extracts the data into form suitable for storage in HIS2 repository. Finally, the data are stored in the HIS2. In this example we left out the requesting and confirmation mechanisms for simplicity reasons.

LIM fillers and HL7 brokers components were developed to support data transformations of a given HIS. Both components will be described in more detail in the following text.

4.1.1 LIM filler module: For reasons mentioned earlier, it is necessary to convert data from local EHR into LIM message, which is an instance of LIM template, on each side of communication. This task is performed by the module called LIM filler. LIM filler is adjusted for each local EHR to produce LIM messages according to local EHR structure.

LIM filler module can be EHR plug-in or standalone application, which takes the data from local EHR and fills them into LIM template. It works in two modes. In the first one, it creates the LIM messages on user’s demand and sends them to the HL7 broker. In the second mode, it polls the HL7 broker for new messages. In case of new message it downloads it, extracts the data from the message and acts according to particular storyboard or just stores the data of the patient in the local EHR.

LIM filler must respect security aspects of the communication protocol. It communicates with the HL7 broker through the secured HTTP channel using SOAP protocol. The LIM messages must be digitally signed by both parties involved and the signatures must be checked before extracting the data from the LIM message.

4.1.2 HL7 broker: Fundamental part of the solution is a component called HL7 broker. The HL7 broker serves as a configurable communication interface to the "world of HL7" for each of EHR systems. The configuration is performed via an XML file containing the LIM model of a particular EHR and mapping of classes from this model to the actual HL7 messages. The configuration says how to convert data represented in the form of LIM message into the form of HL7 v3 messages. Only the prepared artifacts from current HL7 v3 ballot were used, no new HL7 messages were created.

Communication between EHR system and HL7 broker is implemented using Web Services (33) based on SOAP (34) over HTTPS protocol. The HL7 broker provides several methods (`sendLimMsg()`, `ackLimMsg()`, `getLimMsg()`) for transfer of the data between EHR system and HL7 broker. The data are transported in the form of a LIM message described by the LIM template. Several LIM templates are defined, e.g. administrative data, ECG or laboratory results. There are two communication modes - querying and passive one.

In the query mode the EHR system receives the LIM message (the query) from the HL7 broker. The query LIM message contains only several values assigned to concepts, which serve as parameters of the query. After the information is retrieved from the local database of EHR, it 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. Such data should be flagged as external - received using HL7 standard.

The result of a query in the EHR, initiated by the received query LIM message, could consist of 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.

4.1.3 Implemented storyboard: The HL7 storyboards were used to implement querying mentioned above. For example we can mention a storyboard from the "Patient Administration" domain called "Patient Registry Find Candidates Query" (artifact code PRPA_ST201305) that was implemented in order to search for patient administrative data. UML sequence diagram representing activities performed according to the "patient query" storyboard with added HIS1 query and HIS2 responses is shown in Figure 3.

Queries that are produced by incorporated HISes and passed to HL7 broker are composed of empty LIM templates with only some attributes containing values, which are recognized as parameters of a query. Using wildcards like the * symbol is allowed in parameter values to denote arbitrariness. For example, when you search for patient with name "Wil*" you get all patients whose name starts with "Wil".

Our solution enables composing queries to all domains covered by the LIM templates. As mentioned above, the query is done by using specific LIM template which is partially filled in. That means one

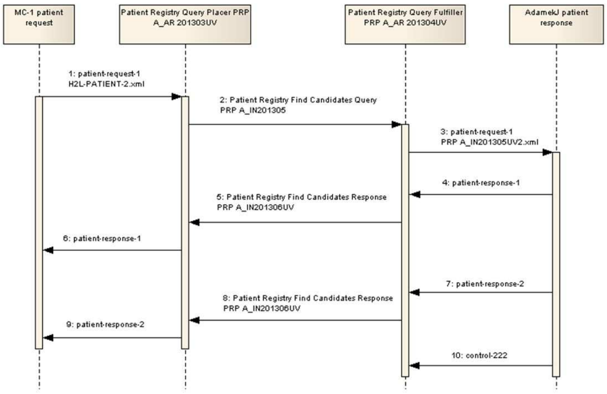

Figure 3: Sequence diagram of the Patient Registry Find Candidates Query.

can use the "Administrative information LIM template" to query administrative data of a patient or using the "Physical examination LIM template" to get data referring the physical examination of a patient. Finally, the HL7 broker executes the appropriate storyboard that leads to acquisition of data queried by the LIM filler module.

4.1.4 HL7 message instance: In order to consolidate reader's apprehension of HL7 messaging and queries described in previous text we put an example of "Patient Registry Find Candidates Response" (artifact code PRPA_IN201306) in the XML form. It holds data acquired after search for Mr. John Smith and is depicted in Figure 4.


```
<?xml version="1.0"?>
<hl7:PRPA_IN101306UV02 xmlns:hl7="urn:hl7-org:v3">
  <hl7:id root="48f5eb3d5d7399.80032341" extension=
    "48f5eb3d5d7462.58285204"/>
  <hl7:creationTime>151008150608</hl7:creationTime>
  <hl7:versionCode code="V3PR1"/>
  <hl7:interactionId root="1234.1234.1234" extension=
    "PRPA_IN101306UV02"/>
  <hl7:processingCode code="D"/>
  <hl7:processingModeCode code="T"/>
  <hl7:acceptAckCode code="AL"/>

  <hl7:Acknowledgement>
    <hl7:typeCode code="AA"/>
    <hl7:TargetMessage>
      <hl7:id root="48f5eb0f8d9773.81740782" extension=
        "48f5eb0f8d9887.41094918"/>
    </hl7:TargetMessage>
  </hl7:Acknowledgement>

  <hl7:ControlActProcess>
    <hl7:classCode code="CACT"/>
    <hl7:moodCode code="EVN"/>
    <hl7:priorityCode code="R" codeSystem=
        "2.16.840.1.113883.5.7" codeSystemName=
        "ActPriority"/>
    <hl7:QueryAck>
      <hl7:queryResponseCode code="OK" codesystem=
        "2.16.840.1.113883.5.1067" codeSystemName=
        "QueryResponse"/>
    </hl7:QueryAck>
    <hl7:Subject1>
      <hl7:typeCode code="SUBJ"/>
      <hl7:contextConductionInd value="true"/>
      <hl7:RegistrationEvent>
        <hl7:classCode code="REG"/>
        <hl7:moodCode code="EVN"/>
        <hl7:id root="2.16.840.1.113883.19.420.2"
            extension="cust1"/>
        <hl7:statusCode code="active"/>
        <hl7:Custodian>
          <hl7:typeCode code="CST"/>
          <hl7:contextControlCode code="AP"/>
        </hl7:Custodian>
        <hl7:Subject2>
          <hl7:typeCode code="SBJ"/>
          <hl7:IdentifiedPerson>
            <hl7:classCode code="IDENT"/>
            <hl7:id root="2.16.840.1.113883.19.420.1"
                extension="6501010001"/>
            <hl7:statusCode code="active"/>
            <hl7:Person>
              <hl7:classCode code="PSN"/>
              <hl7:determinerCode code="INSTANCE"/>
              <hl7:name>
                <hl7:prefix>Ing. CSc.</hl7:prefix>
                <hl7:prefix>Doc.</hl7:prefix>
                <hl7:given>John</hl7:given>
                <hl7:family>Smith</hl7:family>
              </hl7:name>
              <hl7:telecom use="MO" value="Tel:
                (+420) 377259020"/>
              <hl7:telecom use="H" value="Tel:
                (+420) 737151760"/>
            </hl7:Person>
            <hl7:Subject>
              <hl7:typeCode code="SBJ"/>
              <hl7:QueryMatchObservation>
                <hl7:classCode code="OBS"/>
                <hl7:moodCode code="EVN"/>
                <hl7:code code="V16847" codeSystem=
                    "2.16.840.1.113883.11.19723"/>
                <hl7:value>100</hl7:value>
              </hl7:QueryMatchObservation>
            </hl7:Subject>
          </hl7:IdentifiedPerson>
        </hl7:Subject2>
      </hl7:RegistrationEvent>
    </hl7:Subject1>
  </hl7:ControlActProcess>

  <hl7:Receiver>
    <hl7:typeCode code="RCV"/>
    <hl7:Device>
      <hl7:classCode code="DEV"/>
      <hl7:determinerCode code="INSTANCE"/>
      <hl7:id root="1.2.203.25666011.99.1.2"
        extension="UI-1"/>
    </hl7:Device>
  </hl7:Receiver>

  <hl7:Sender>
    <hl7:typeCode code="SND"/>
    <hl7:Device>
      <hl7:classCode code="DEV"/>
      <hl7:determinerCode code="INSTANCE"/>
      <hl7:id root="1.2.203.25666011.99.1.2"
        extension="MC-1"/>
    </hl7:Device>
  </hl7:Sender>
</hl7:PRPA_IN101306UV02>
```


Figure 4: Dump of communication according to storyboard PRPA_ST201305 - XML representation of Patient Registry Find Candidates Response.

4.2. Semantic interoperability platform based on openEHR archetypes and templates

Archetypes are distinct, structured models of domain concepts, such as "blood pressure". They sit between lower layers of knowledge resources in a computing environment, such as clinical terminologies and ontologies, and actual data in production systems. Their primary purpose is to provide a reusable, interoperable way of managing generic data so that it conforms to particular structures and semantic constraints. Consequently, they bind terminology and ontology concepts to information model semantics, in order to make statements about what valid data structures look like. ADL provides a solid formalism for expressing, building and using these entities computationally. Every ADL archetype is written with respect to a particular information model, often known as a "reference model", if it is a shared, public specification.

Archetypes are applied to data via the use of *templates*, which are defined at a local level. Templates generally correspond closely to screen forms, and may be re-usable at a local or regional level. Templates do not introduce any new semantics to archetypes, they simply specify the use of particular archetypes, and default data values.

A third artifact which governs the functioning of archetypes and templates at runtime is a local palette, which specifies which natural language(s) and terminologies are in use in the locale. The use of a palette removes irrelevant languages and terminology bindings from archetypes, retaining only those relevant to actual use. Figure 5 illustrates the overall environment in which archetypes, templates, and a locale palette exist.

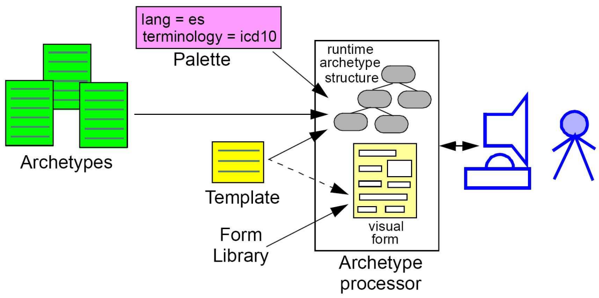

Figure 5: Archetypes, templates and palletes.

According to [24] templates include the following semantics:

- archetype 'chaining': choice of archetypes to make up a larger structure, specified via indicating identifiers of archetypes to fill slots in higher-level archetypes;
- local optionality: narrowing of some or all 0..1 constraints to either 1..1 (mandatory) or 0..0 (removal) according to local needs;
- tightened constraints: tightening of other constraints, including cardinality, value ranges, terminology value sets, and so on;
- default values: choice of default values for use in templated structure at runtime.

At runtime, templates are used with archetypes to create data and to control its modification.

The main advantages [25] of the openEHR approach are the functional and semantical interoperability. The functional interoperability represents the correct communication between two or more systems. This is also covered by other approaches like the HL7 v2.x. The openEHR approach also offers the semantic interoperability. It is the ability of two or more computer systems to exchange information which can be comprehended unambiguously by both, humans and computers.

4.3. Harmonizing clinical content of EHRs using international nomenclatures, openEHR architecture and HL7 v3 RIM

Concepts of clinical content of an EHR are usually "hiden" in object model, database schema or in meta-models developed during the information system creation. The process of enabling the creation of EHRs witch HCC has following steps:

1. *map clinical concepts* to an international coding system or ontology (SNOMED CT, LOINC, etc.)
2. *find archetypes* in a repository or knowledge base, that sufficiently cover encoded concepts
3. *underlying reference model* may be openEHR RM or HL7 v3 RIM thanks to OWLmt Mapping Engine [26] that is capable of transforming one to the other by using pre-defined mappings

In [17] the controlled and uncontrolled archetype development is described as well as techniques for ensuring maximal reusability of created constructs, curtailing their complexity and minimizing their number are proposed. Such practice would perfectly support the second step mentioned in previous enumeration.

The example of partial implementation of the step 1 is shown in the Table 1.

Description of encoded concept	Code	Coding system
Measurement of the breath frequency in one minute	9279-1	LOINC
Measurement of the heart beats in one minute	8893-0	LOINC
Measurement of blood temperature	8328-7	LOINC
Measurement of intravascular diastolic pressure	8462-4	LOINC
Amount of proteins in blood sample	2885-2	LOINC
Subjective complaints of the patient are described	10154-3	LOINC
Treatment of Ischemic Heart Disease	C0585894	UMLS CUI
Detection of Left ventricular hypertrophy	C0149721	UMLS CUI
Coughing after administration of ACE inhibitors	C0740723	UMLS CUI
Sequelae of cerebrovascular disease	I61	ICD10
Angina Pectoris	I20	ICD10
Hyperplasia of prostate	N40	ICD10

Table 1: Mapping concepts of MDMC to LOINC, UMLS and ICD-10 coding systems.

The step 2 was accomplished using the archetype repository [21] and some found archetypes are put down in Table 2 together with matching classes from the model partially depicted on Figure 6.

LIM class	Archetype ID
Subjective Complaints Description (Observation-cls)	openEHR-EHR-CLUSTER.issue.v1
Patient Height Measurement (Observation-cls)	openEHR-EHR-OBSERVATION.height.v1
Body temperature measurement (Observation-cls)	openEHR-EHR-OBSERVATION. body_temperature.v1
Heart rate measurement (Observation-cls)	openEHR-EHR-OBSERVATION. heart_rate-pulse.v1
Breath frequency measurement (Observation-cls)	openEHR-EHR-OBSERVATION. respiration.v1
Waist circumference measurement (Observation-cls)	openEHR-EHR-OBSERVATION.waist_hip.v1
Laboratory examination (Act-cls)	openEHR-EHR-OBSERVATION.lab_test.v1
Smoking state determination (Observation-cls)	openEHR-EHR-OBSERVATION. substance_use-tobacco.v1

Table 2: Some archetypes matching the concepts modeled in a reference model.

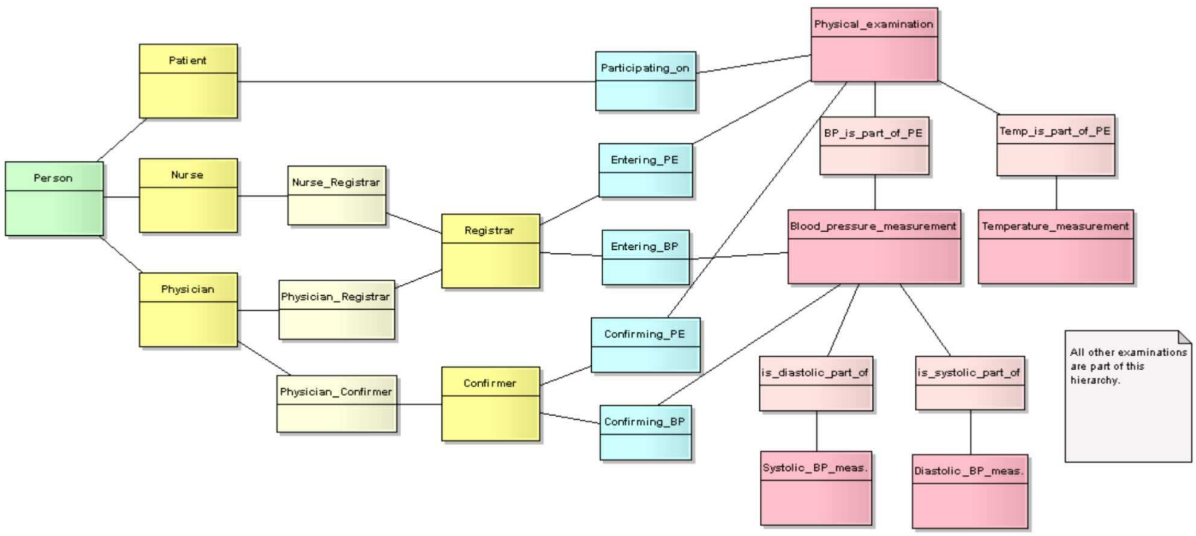

Figure 6: Selected part of HIS1 LIM.

5. Discussion

The development process of message interchange, recommended by HL7 v3 (see Figure 7), was altered by splitting the implementation effort between HIS developers and HL7 standard implementers. This new approach might help developers to overcome the initial frustration which is caused by the overwhelming size of the HL7 standard (RIM, amount of artifacts etc.). The development of individual LIM, closely related to internal information structure of the particular HIS, with the simple communication interface between HIS and HL7 broker based on LIM messages, SOAP and Web Services, seems to be more manageable for smaller developer teams than a strict adherence to HL7 v3 methodology.

Message interchange based on openEHR templates is a very interesting and relatively unexplored field, as the openEHR approach is primarily oriented to describe the development of future-proof EHR systems. This kind of messaging is based on a simple idea – instead of rendering the definitions contained in templates as screen forms, it is used to carry structured data in a form of a message. Such concept is close to document interchange via HL7 CDA, but with major one difference – a higher degree of data structuring.

The communication via HL7 v3 messaging standard or openEHR templates is in real life result of huge effort of many people – domain experts, developers, medical stuff etc. Therefore, having EHRs with HCC available would reduce the complexity of communication frameworks and various translator and mapping modules. The data interchange would be much straightforward and that is worth studying rigorously.

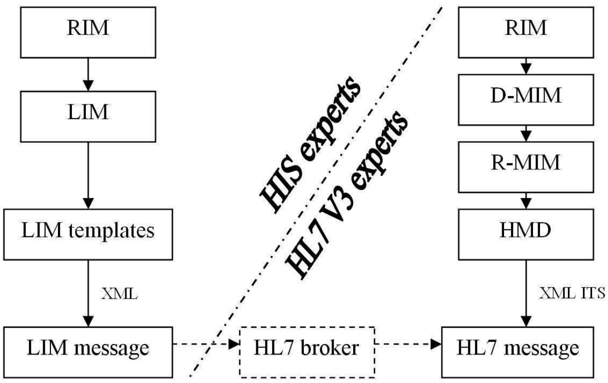

Figure 7: The messaging development process, recommended by HL7 v3 on the right and our solution on the left side.

6. Conclusion

During the development and implementation of the platform for semantic interoperability it was necessary to use the simulated patient data as the use of real patient data is not allowed for such a purpose due to legislative reasons. Results of performed tests were not affected by the fact that the data were simulated and are valid for real patient data as well.

Using LIM models and LIM fillers resulted in considerable universality of the solution, which does not depend on communication standards being used, although the LIM is based on HL7 v3 RIM. This independency is supported by the fact that contemporary modern communication standards have some important characteristics in common: basic reference model, user defined models derived from that reference model using strict methodology, and finally, some kind of templates helping in creating a new message or document. Comparison of contemporary communication standards can be found in [27].

The HL7 v3 implementation process was divided between HIS developers and HL7 implementers by utilization of LIM models. This approach resulted in better distribution of the experts' and developers' tasks.

The UMLS Knowledge Source Server was used to find the appropriate mappings of MDMC concepts to international nomenclatures and 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. We managed to map most of MDMC concepts to LOINC and more than 50% are included in SNOMED Clinical Terms [28]. During the mapping we had to cope with some problematic concepts with too small or too big granularity, concepts with different synonyms differing slightly in their meaning or concepts which cannot be found in any available classification system [29].

After evaluation of the outcomes of the project ITDCSH we can say that the HL7 v3 is usable in a restricted form in the Czech healthcare environment. It has no support by the governmental institutions and only a limited support by the software vendors. The main step for wider use of HL7 v3 in the Czech Republic should be the implementation of functionality, which is currently provided by the DASTA national standard, the inclusion of NCLP on the list of HL7-supported code systems, or better the mapping of the NCLP to an established international nomenclature like SNOMED CT. The next fundamental step would be obtaining the translation of the international nomenclature in the Czech language.

References

[1] Ministry of Health of the Czech Republic (homepage on the internet), Data Standard of MH CR - DASTA and NCLP. http://ciselniky.dasta.mzcr.cz.

[2] Institute of Health Information and Statistics of the Czech Republic (homepage on the internet). http://www.uzis.cz.

[3] Health Level Seven, Inc. (homepage on the internet) Health Level 7. http://www.hl7.org.

[4] European Committee for Standardization (CEN), Technical Committee CEN/TC 251: European Standard EN 13606, "Health informatics - Electronic health record communication".

[5] NEMA - Medical Imaging & Technology Alliance (homepage on the internet), DICOM. http://dicom.nema.org.

[6] D.M. Lopez and G.M.E. Blobel, "A development framework form semantic interoperable health information systems". Int. J. of Medical Informatics 2009; 78:83-103.

[7] B.G. Blobel, K. Engel, and P. Pharow, "Semantic interoperability - HL7 Version 3 compared to

advanced architecture standards". Methods Inf Med. 2006; 45(4):343-53.

[8] D. Kalra and B.G. Blobel, "Semantic interoperability of EHR systems". Stud Health Technol Inform. 2007;127:231-45.

[9] Technical report. ISO/TR 20514 – Health informatics – Electronic health record – Definition, scope, and context. ISO. 2005.

[10] EurMISE.org. The project of the "Information Society" programme. http://www.euromise.org/research/news.html.

[11] Software R&D Center, Middle East Technical University. Artemis Project Homepage. http://www.srdc.metu.edu.tr/webpage/projects/artemis/home.html.

[12] openEHR (homepage on the internet), openEHR – future-proof and flexible EHR specifications. http://www.openehr.org.

[13] European Committee for Standardization (CEN), Technical Committee CEN/TC 251: European Standard ENV 13606-1, "Health informatics - Electronic healthcare record communication".

[14] M. Tomeckova et al., "Minimal data model of cardiological patient". (in Czech). Cor et Vasa 2002; 4: 123.

[15] K.H. Veltman, "Syntactic and Semantic Interoperability: New Approaches to Knowledge and the Semantic Web". The New Review of Information Networking 2001; 7: 159-84.

[16] M. Nagy et al., "Applied Information Technologies for Development of Continuous Shared Health Care". CESNET08 Conference: security, middleware, virtualization; CESNET,z.s.p.o; 2008. p. 131-38.

[17] S. Heard et al., "Templates and Archetypes: how do we know what we are talking about?" http://www.openehr.org/publications/karchetypes/ templates_and_archetypes_heard_et_al.pdf.

[18] T. Beale, "Archetypes: Constraint-based domain models for future-proof information systems". In: Baclawski K, Kilov H, editors. Eleventh OOPSLA Workshop on Behavioral Semantics: Serving the Customer. Northeastern University, Boston, 2002, pp. 16-32.

[19] V. Bicer et al., "Archetype-Based Semantic Interoperability of Web Service Messages in the Health Care Domain". Int'l Journal on Semantic Web & Information Systems. 2005; 1(4): 1-22.

[20] T. Beale and S. Heard, "Archetype Definition Language (ADL)". The openEHR foundation. Rev. 1.3.1, 2004.

[21] openEHR foundation. Clinical Knowledge Manager. http://www.openehr.org/knowledge/.

[22] HL7 Inc. (homepage on the internet), HL7 Version 3 - January 2009. http://www.hl7.org/v3ballot/html/welcome/environment.

[23] Ed.: D.L. McGuinness and F. van Harmelen, "OWL Web Ontology Language". W3C Recommendation. 2004. http://www.w3.org/TR/owl-features.

[24] T. Beale and S. Heard, "The Template Object Model (TOM)". http://www.openehr.org/releases/1.0.1/architecture/am/tom.pdf, 2007.

[25] M. Goek, "Introducing an openEHR-Based Electronic Health Record System in a Hospital". Masters Thesis. Department of Medical Informatics, University of Goettingen, Germany. 2008.

[26] Artemis projectt. OWLmt – OWL mapping tool. 2005. http://www.srdc.metu.edu.tr/artemis/owlmt.

[27] M. Eichelberg, T. Aden, J. Riesmeier, A. Dogac, and G.B. Laleci, "A Survey and Analysis of Electronic Healthcare Record Standards". ACM Comp Surv, 2005 Dec; 37(4): 277 - 315.

[28] College of American Pathologists (homepage on the internet), SNOMED Terminology Solutions. http://www.cap.org/apps/cap.portal?_nfpb=true&_pageLabel=snomed_page.

[29] P. Hanzlicek, P. Preckova, and J. Zvarova, "Semantic Interoperability in the Structured Electronic Health Record". Ercim News 2007, 69:52-3.