Harmonization of Clinical Content in EHR: HL7 Messaging vs. OpenEHR Approach

Nagy, Miroslav
2010

Harmonization of Clinical Content in EHR: HL7 Messaging vs. OpenEHR Approach

Post-Graduate Student:
MGR. MIROSLAV NAGY

Department of Medical Informatics
Instutite of Computer Science of the ASCR, v. v. i.
Pod Vodárenskou věží 2
182 07 Prague 8, CZ

nagy@euromise.cz

Supervisor:
RNDR. ANTONÍN ŘÍHA, CSC.

Department of Medical Informatics
Instutite of Computer Science of the ASCR, v. v. i.
Pod Vodárenskou věží 2
182 07 Prague 8, CZ

riha@euromise.cz

Field of Study:
Biomedical Informatics

This work was partially supported by the project of the Institute of Computer Science of Academy of Sciences of the Czech Republic AV0Z10300504 and by the project of the Ministry of Education, Youth and Sports of the Czech Republic No. 1M06014.

Abstract

This paper sums up the last stage of the project called "Harmonization of Clinical Content in Electronic Health Record (EHR)", which is being solved as author's PhD project. The aim of this project was the clinical content modeling of EHR and transportation of medical data via communication standards (HL7 v3 and CEN EN 13606). An experiment was conducted where archetypes and openEHR templates were used to send patient's information to another EHR-S. The results were compared to the previous solution based on HL7 v3 messages, which was described at the PhD Conference '09. At the end of the paper the author discusses contemporary semantics description of real clinical data by means of ICD-10 code-list, which covers the qualitative point of view quite well. However, the quantitative view on semantics of clinical data is much more difficult and the inevitability of medical ontologies usage is emphasized.

1. Introduction

Contemporary initiatives in e-Health aim to carry a proposal that would enforce clinical data usage in an electronic form. Benefits of the electronic document interchange in healthcare are becoming obvious to the broader professional and laic audience. The basic prerequisite for this to carry on is a high quality source of clinical data, i.e. well structured EHR.

Defining a structure of clinical data stored in various EHRs is the most important issue, which, at the same time, causes most problems with interoperability among EHR systems (EHR-S). Therefore an indispensable amount of effort is made to unify the modeling process in order to make the semantic interoperability real.

One of the most significant initiatives in standardization of EHRs is the CEN EN 13606 norm and specifications of the openEHR Foundation. Relations between these two are described in [1] and they can be summarized as follows. Currently there is no standard available for a Shared-EHR system which supports the creation, storage, maintenance, and querying of Shared EHRs. OpenEHR is the only open specification currently available and it is a candidate for this purpose. On the other hand, CEN EN13606 is an appropriate standard for the exchange of Shared EHR Extracts, which are comprehensive collections of data designed to transfer clinical data from one EHR to another.

2. Materials

2.1. Two-level modeling

In order to use the openEHR archetypes we have to define them, as well as the basic modeling paradigm of openEHR - the two-level modeling paradigm. According to [2] an archetype (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". Each archetype [3] is a set of constraints on the reference model, defining a subset of instances that are considered to conform to the subject of the archetype, e.g. "laboratory result". An archetype can thus be thought of as being similar to a LEGO instruction sheet.

Under the two-level approach [4], [3], a stable reference information model constitutes the first level of modeling, while formal definitions of clinical content in the form of archetypes and templates constitute the second.

2.2. Ontologies

Ontology has many definitions depending on the angle of view you look at it. For the purpose of this paper we can take the definition from [5]. In the context of computer and information sciences, an ontology defines a set of representational primitives with which to model a domain of knowledge or discourse. The representational primitives are typically classes (or sets), attributes (or properties), and relationships (or relations among class members). Ontologies are typically specified in languages that allow abstraction away from data structures and implementation strategies.

In our department, a research in the field of knowledge modeling was accomplished resulting in creation of modeling concepts and tools. It will be demonstrated in the Results section.

2.3. MDMC and its mapping to SNOMED CT

The Minimal Data Model of Cardiology (MDMC) [6] is a set of approximately 150 attributes, their mutual relations, integrity restrictions, units, etc. prepared according to needs of statisticians. Prominent professionals in the field of Czech cardiology agreed on these attributes as on the basic data necessary for an examination of a patient in cardiology.

Description of encoded concept	SNOMED CT Code
Drug allergy (disorder)	416098002
Diabetes mellitus (disorder)	73211009
Vascular disorder of lower extremity (disorder)	373408007
Cerebrovascular accident (disorder)	230690007
Normal menopause (finding)	237123000
Body weight (observable entity)	248345008
Hip circumference (observable entity)	284472007
Respiratory rate (observable entity)	86290005
Atrial fibrillation (disorder)	49436004
ECG finding (observable entity)	271921002

Table 1: Some of the MDMC concepts mapped to SNOMED CT.

We started encoding the concepts of the MDMC using SNOMED-CT codes in order to describe the semantics in a standardized way. These coded terms were used to avoid ambiguity in the next part of our work where we integrated the HL7 v3 standard and openEHR artifacts into EHR systems based on MDMC.

Some example concepts from MDMC and their mapping to SNOMED CT can be found in the Table 1.

2.4. Clinical Knowledge Manager and Ocean Archetype Editor

The notion of archetypes has been known for several years. As a result there already exist some archetypes describing most common concepts and their sharing started to have sense. For this purpose a Clinical Knowledge Manager (CKM) is available at http://www.openehr.org/knowledge/. It is a repository designed to share (serves as a library of archetypes and templates), supports the full life cycle management of archetypes and provides governance of the knowledge artifacts.

In case that the CKM repository does not contain certain archetypes, there is a tool for designing new archetypes. The Ocean Archetype editor is a tool developed by OceanInformatics and supports creating archetypes and binding terms they contain to coding systems. After creating an archetype it can be exported in an abstract syntax, i.e. the ADL format [7].

2.5. Clinical Data Source and LIM templates

As a source of clinical data the ADAMEKj EHR-S [8] was used. ADAMEKj was developed in the Department of Medical Informatics ICS AS CR with the aim to collect outpatient genetic and clinical data in cardiology. The domain model of the application is based on the MDMC. The user interface was inspired by the former ADAMEK [9] application.

The ADAMEKj LIMFiller module was used to retrieve data from the ADAMEKj EHR-S into the form of LIM messages [10]. LIM messages were then used for further transformations - to fill the archetypes with data.

LIM templates [10] were developed in the project called ”Information Technologies for the Development of Continuous Shared Healthcare”(ITDCSH). For the purpose of this paper we describe the LIM template for Patient's Physical Examination. The LIM template is depicted in the form of XML-Schema in the Figure 1.

```xml
<?xml version ='1.0' encoding ='UTF-8'?>
<xs:schema targetNamespace="urn:lim" xmlns:xs="XMLSchema" xmlns:limDt="urn:lim">
  <xs:import namespace="limDt" schemaLocation="limDt.xsd"/>
  <xs:element name="lim">
    <xs:complexType>
      <xs:sequence>
        <xs:element name="header" minOccurs="1" maxOccurs="1" type="limDt:header"/>
        <!-- Šablona: Fyzikální vyšetření -->
        <!-- begin hl7class type="Act-cls" -->
        <xs:element name="Fyzikální_vyšetření" minOccurs="1" maxOccurs="1">
          <!-- LOINC: 129545-1     PHYSICAL FINDINGS  FIND PT   ^PATIENT  NAR  OBSERVED H&amp;P.PX 2     -->
          <!-- begin hl7class type="ActRelationship-cls" -->
          <xs:element name="Měření_výšky_je_součástí_fyzikálního_vyšetření" minOccurs="0" maxOccurs="unbounded">
            <!-- begin hl7class type="Observation-cls" -->
            <xs:element name="Měření_Výšky" minOccurs="1" maxOccurs="1"/>
            <!--
                LOINC: 8308-9   BODY HEIGHT^STANDING   LEN   PT   ^PATIENT   QN      BDYHGT.MOLEC  2
                UMLS: CUI C0005890
            -->
          </xs:element>
          <!-- begin hl7class type="ActRelationship-cls" -->
          <xs:element name="Měření_váhy_je_součástí_fyzikálního_vyšetření" minOccurs="0" maxOccurs="unbounded">
            <!-- begin hl7class type="Observation-cls" -->
            <xs:element name="Měření_hmotnosti" minOccurs="1" maxOccurs="1"/>
            <!--
                LOINC: Weight Measured     3141-9     BODY WEIGHT   MASS     PT   ^PATIENT  QN   MEASURED     BDYWGT.ATOM  2
            -->
          </xs:element>
          <!-- begin hl7class type="ActRelationship-cls" -->
          <xs:element name="Měření_tlaku_je_součástí_fyzikálního_vyšetření" minOccurs="0" maxOccurs="unbounded">
            <!-- begin hl7class type="Act-cls" -->
            <xs:element name="Měření_tlaku" minOccurs="1" maxOccurs="1">
              <!-- begin hl7class type="ActRelationship-cls" -->
              <xs:element name="Je_diastolickou_součástí" minOccurs="0" maxOccurs="unbounded">
                <!-- begin hl7class type="Observation-cls" -->
                <xs:element name="Měření_Diastolického_Tlaku" minOccurs="1" maxOccurs="1"/>
                <!--
                    LOINC BP Diastolic     8462-4     INTRAVASCULAR DIASTOLIC     PRES PT    ARTERIAL SYSTEM    QN       BP.ATOM   2
                -->
              </xs:element>
              <!-- begin hl7class type="ActRelationship-cls" -->
              <xs:element name="Je_systolickou_součástí" minOccurs="0" maxOccurs="unbounded">
                <!-- begin hl7class type="Observation-cls" -->
                <xs:element name="Měření_Systolického_Tlaku" minOccurs="1" maxOccurs="1"/>
                <!--
                    LOINC: 8508-4   INTRAVASCULAR SYSTOLIC PRES PT    BRACHIAL ARTERY    QN       BP.MOLEC  2
                -->
              </xs:element>
            </xs:element>
          </xs:element>
          <!-- begin hl7class type="ActRelationship-cls" -->
          <xs:element name="Měření_teploty_je_součástí_fyzikálního_vyšetření" minOccurs="0" maxOccurs="unbounded">
            <!-- begin hl7class type="Observation-cls" -->
            <xs:element name="Měření_Teploty" minOccurs="1" maxOccurs="1"/>
            <!--
                LOINC: 8328-7   BODY TEMPERATURE   TEMP      PT    AXILLARY  QN       BDYTMP.MOLEC  2
            -->
          </xs:element>
          <!-- begin hl7class type="ActRelationship-cls" -->
          <xs:element name="Měření_pulsu_je_součástí_fyzikálního_vyšetření" minOccurs="0" maxOccurs="unbounded">
            <!-- begin hl7class type="Observation-cls" -->
            <xs:element name="Měření_Pulsu" minOccurs="1" maxOccurs="1"/>
            <!--
                LOINC: 8893-0   HEART BEAT     NRAT      PT    PERIPHERAL ARTERY   QN   PALPATION     HRTRATE.MOLEC 2
            -->
          </xs:element>
          <!-- begin hl7class type="ActRelationship-cls" -->
          <xs:element name="Měření_dechové_frekvence_je_součástí_fyzikálního_vyšetření" minOccurs="0" maxOccurs="unbounded">
            <!-- begin hl7class type="Observation-cls" -->
            <xs:element name="Měření_Dechové_Frekvence" minOccurs="1" maxOccurs="1"/>
            <!--
                LOINC: Respiratory Rate     9279-1     BREATHS   NRAT     PT    RESPIRATORY SYSTEM     QN       RESP.ATOM     2
            -->
          </xs:element>
          <!-- begin hl7class type="ActRelationship-cls" -->
          <xs:element name="Měření_obvodu_boků_je_součástí_fyzikálního_vyšetření" minOccurs="0" maxOccurs="unbounded">
            <!-- begin hl7class type="Observation-cls" -->
            <xs:element name="Měření_Obvodu_Boků" minOccurs="1" maxOccurs="1"/>
            <!--
                UMLS: CUI: C0562350
            -->
          </xs:element>
          <!-- begin hl7class type="ActRelationship-cls" -->
          <xs:element name="Měření_obvodu_pasu_je_součástí_fyzikálního_vyšetření" minOccurs="0" maxOccurs="unbounded">
            <!-- begin hl7class type="Observation-cls" -->
            <xs:element name="Měření_Obvodu_Pasu" minOccurs="1" maxOccurs="1"/>
            <!--
                UMLS: CUI: C0455829
            -->
          </xs:element>
          <!-- begin hl7class type="Participation-cls" -->
          <xs:element name="Pacient_se_účastní_fyzikálního_vyšetření" minOccurs="1" maxOccurs="1"/>
        </xs:element>
      </xs:sequence>
    </xs:complexType>
  </xs:element>
</xs:schema>
```

Figure 1: LIM template for Physical Examination - XML Schema simplified for clarity.

2.6. OpenEHR templates

In the set of documentation released by openEHR explanation of the term archetype and template can be found as follows [11]:

Archetypes are a key element of the openEHR methodology. They are reusable, structured models of clinical information concepts that appear in EHRs, such as 'test result' , 'physical examination' and 'medication order', and are expressed in terms of constraints on the reference model. All data in openEHR EHRs are instances of reference model entities, configured by archetypes. Archetypes also act as mediators between data and terminology. They are language- and terminology-neutral.

Templates are (usually) locally defined models of screen forms, and ring together a selection of archetypes, terminologies, language and other details relevant to the particular local use of archetypes. For example, concepts such as 'referral' and 'prescription' are modeled as templates, which in turn use archetypes for more fine-grained concepts.

Archetypes are encoded in the Archetype Definition Language (ADL) and openEHR Templates (OETs) in the Template Definition Language (TDL). TDL forms a super-set of ADL. Each OET must have a root archetype that contains other relevant archetypes connected through so called slots. Templates may add further local constraints to the archetypes it mentions, including removing or mandating optional sections, and they may define default values.

As mentioned in [10] openEHR Templates can be used as a basis for a user interface definition or after filling with data they can be used as some sort of messages or documents suitable for data transfers. The second usage will be studied in this paper.

3. Methods

In the next section an experiment will be described, which aimed to compare the two approaches - one based on HL7 v3 messaging (described in more detail in [12]) and the other on openEHR archetypes and templates.

3.1. How to create an Archetype?

A basic procedure of Archetype creation can be found in "Help pages"supplied with the Ocean Archetype Editor. Some of advices are cited in the following two paragraphs.

The first aspect to consider is that an openEHR health record consists of just a few 'classes' which contain information about the patient or data subject. The 'container classes' are:

EHR - this is the top level class and contains all information about the data subject.

Extract - this class contains all information that is to be transferred to another EHR.

Folder - this class allows information within an EHR to be organized.

Composition (or document) - this is the class that contains information committed to the EHR by a clinician.

Section - this class allows information within a composition to be organized.

Entry - this class contains meaningful information that is to be processed by the machine and read by the clinician.

These classes contain no clinical or demographic concepts at all - and it is this feature which differentiates the openEHR approach. The classes do have attributes which ensure that it is clear how the information in the EHR was collected, by whom, and who took responsibility for it - as well as meeting many other complex requirements. The clinical or demographic requirements are met through designing archetypes for the purpose.

The usage of each one of above-mentioned classes is explained in more detail in the "Help pages", which we leave out from spatial reasons. For the purpose of this text we put only an explanation of usage of the Section class: "In summary, if you are attempting to standardize the organization of information within a document, progress note or any other Composition, then you probably need to create an SECTION archetype."

3.2. Experiment: Comparison of openEHR Template approach with HL7 v3 messaging

In the following text we describe the experiment conducted in order to compare the communication schema based on HL7 v3 messages with the data exchange using openEHR templates and archetypes. The main motivation of accomplishing such a comparison was the difficulties encountered during implementation of the communication among EHR-Ss using HL7 v3 messages. The main shortcoming was the usage of HL7 balloted storyboards. Storyboards describe the dynamic aspect of the communication and define the factual form and thus the content of messages is exchanged. And here we come to the main problem. HL7 storyboards are ”short-message”oriented, which was not exactly matching our needs. Nature of our communication was rather document-oriented, which caused complicated transfer of LIM messages (e.g. physical examination) via several HL7 v3 messages originating in several storyboards.

Usage of openEHR templates on the other hand makes our data exchange straightforward. Another possible solution was incorporating HL7 CDA documents, which might be a future work for our team. The openEHR approach was right choice for us because the openEHR approach is infiltrating the CEN EN 13606 standard, which is gaining its popularity and is in center of interest in various research projects [13]. Therefore, we also tested the applicability of the openEHR approach while we already have had implemented data exchange via HL7 v3 messages. The data exchange via openEHR templates forms an alternative solution.

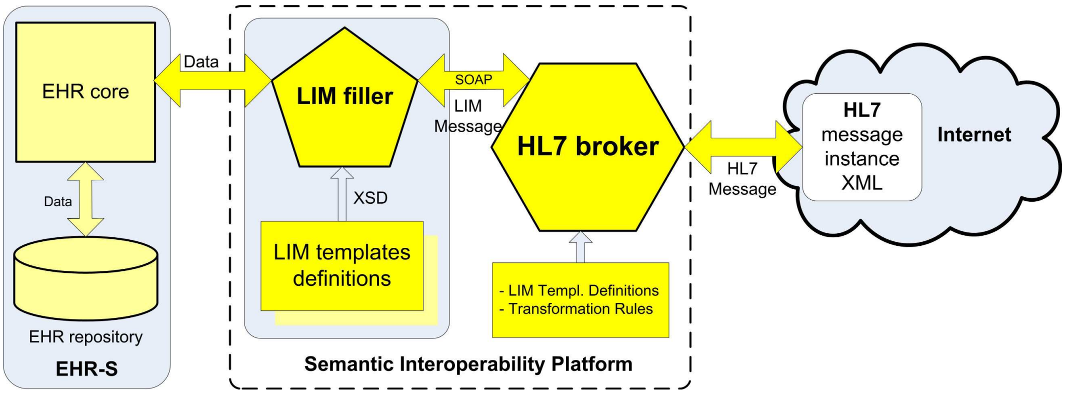


Figure 2: Former communication schema based on HL7 v3 messaging.

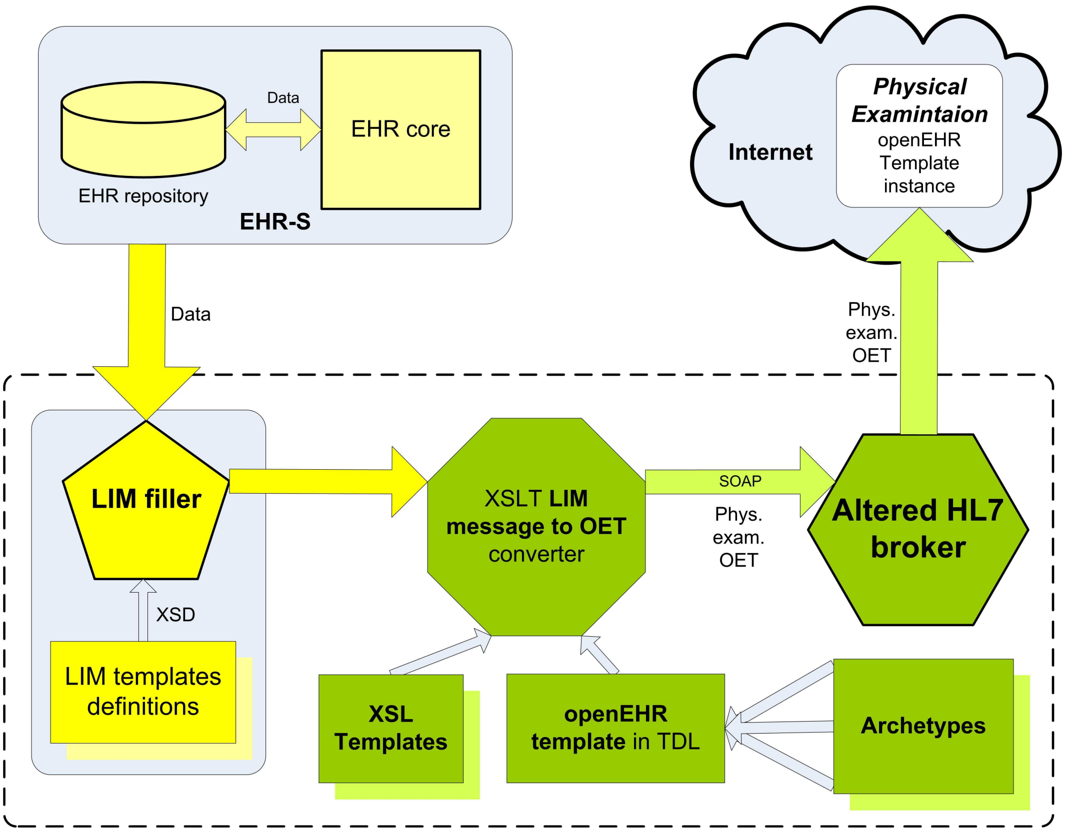
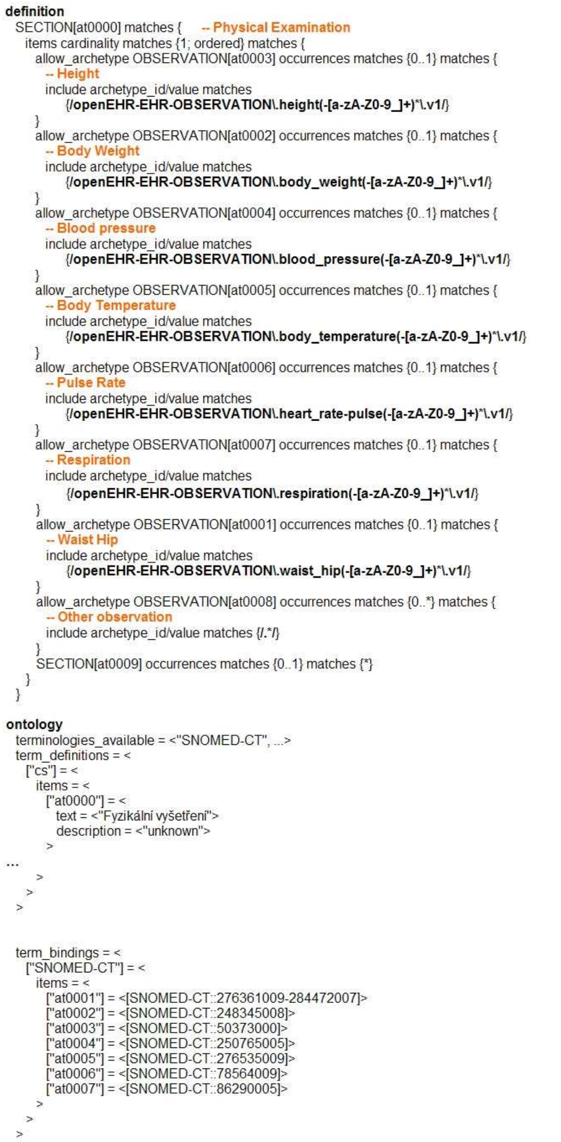


Figure 3: New communication schema based on openEHR templates and archetypes.

In the former solution (see Figure 2) we used all ”possibilities” that the HL7 v3 standards offers (RIM, storyboards, balloted messages). Since the HL7 v3 storyboards are ”action-oriented” it was quite difficult to transport most of defined LIM templates. The nature of data we were dealing with was much more suitable for HL7 CDA [14]. Our task was more or less as the CDA’s - transferring ”documents”, rather than short messages.



```
definition
  SECTION[at0000] matches {     -- Physical Examination
    items cardinality matches {1; ordered} matches {
      allow_archetype OBSERVATION[at0003] occurrences matches {0..1} matches {
        -- Height
        include archetype_id/value matches
            {/openEHR-EHR-OBSERVATION\.height(-[a-zA-Z0-9_]+)*\.v1/}
      }
      allow_archetype OBSERVATION[at0002] occurrences matches {0..1} matches {
        -- Body Weight
        include archetype_id/value matches
            {/openEHR-EHR-OBSERVATION\.body_weight(-[a-zA-Z0-9_]+)*\.v1/}
      }
      allow_archetype OBSERVATION[at0004] occurrences matches {0..1} matches {
        -- Blood pressure
        include archetype_id/value matches
            {/openEHR-EHR-OBSERVATION\.blood_pressure(-[a-zA-Z0-9_]+)*\.v1/}
      }
      allow_archetype OBSERVATION[at0005] occurrences matches {0..1} matches {
        -- Body Temperature
        include archetype_id/value matches
            {/openEHR-EHR-OBSERVATION\.body_temperature(-[a-zA-Z0-9_]+)*\.v1/}
      }
      allow_archetype OBSERVATION[at0006] occurrences matches {0..1} matches {
        -- Pulse Rate
        include archetype_id/value matches
            {/openEHR-EHR-OBSERVATION\.heart_rate-pulse(-[a-zA-Z0-9_]+)*\.v1/}
      }
      allow_archetype OBSERVATION[at0007] occurrences matches {0..1} matches {
        -- Respiration
        include archetype_id/value matches
            {/openEHR-EHR-OBSERVATION\.respiration(-[a-zA-Z0-9_]+)*\.v1/}
      }
      allow_archetype OBSERVATION[at0001] occurrences matches {0..1} matches {
        -- Waist Hip
        include archetype_id/value matches
            {/openEHR-EHR-OBSERVATION\.waist_hip(-[a-zA-Z0-9_]+)*\.v1/}
      }
      allow_archetype OBSERVATION[at0008] occurrences matches {0..*} matches {
        -- Other observation
        include archetype_id/value matches {/.*/}
      }
      SECTION[at0009] occurrences matches {0..1} matches {*}
    }
  }

ontology
  terminologies_available = <"SNOMED-CT", ...>
  term_definitions = <
    ["cs"] = <
      items = <
        ["at0000"] = <
          text = <"Fyzikální vyšetření">
          description = <"unknown">
        >
...
      >
    >
  >


  term_bindings = <
    ["SNOMED-CT"] = <
      items = <
        ["at0001"] = <[SNOMED-CT::276361009-284472007]>
        ["at0002"] = <[SNOMED-CT::248345008]>
        ["at0003"] = <[SNOMED-CT::50373000]>
        ["at0004"] = <[SNOMED-CT::250765005]>
        ["at0005"] = <[SNOMED-CT::276535009]>
        ["at0006"] = <[SNOMED-CT::78564009]>
        ["at0007"] = <[SNOMED-CT::86290005]>
      >
    >
  >
```

Figure 4: Definition and Ontology sections of `openEHR-EHR-SECTION.physical_examination.v1` archetype, which is a root archetype in the Physical Examination OET.

4. Results

Which form of the communication was better? HL7 has a much better documentation, thus a straightforward development process. OpenEHR templates and the TDL are not documented well, yet, but they are much more simple than the HL7 v3 modeling methodology and suitable for smaller developer teams.

4.1. Physical Examination OET

In the Figure 4 we can see an example of the openEHR Template (OET) containing archetype `openEHR-EHR-SECTION.physical_examination.v1` which we created using the Ocean Archetype Editor tool. This archetype was developed to be a root archetype of composed OET. The archetype is derived from the SECTION class from the openEHR Reference Model. According to the Archetype Building Guide: A SECTION is an organizing class, contained within a COMPOSITION. Archetypes of Sections standardize the organization of information within a Composition. Examples of Sections are: Physical examination - organized by System, History - organized by presenting complaint, social history, review of systems etc.

The slots of the `openEHR-EHR-SECTION.physical_examination.v1` archetype contain following archetypes found in the CKM repository:

- openEHR-EHR-OBSERVATION.height.v1
- openEHR-EHR-OBSERVATION.body_weight.v1
- openEHR-EHR-OBSERVATION.blood_pressure.v1
- openEHR-EHR-OBSERVATION.body_temperature.v1
- openEHR-EHR-OBSERVATION.heart_rate-pulse.v1
- openEHR-EHR-OBSERVATION.respiration.v1
- openEHR-EHR-OBSERVATION.waist_hip.v1

Finally, concepts covered by archetypes slots were encoded in the ontology section by codes from SNOMED-CT (the lower part of the Figure 4).

4.2. Components of the Experiment

The data flow in the experiment depicted in Figure 3 is as follows. The former LIM Filler module attached to ADAMEKj EHR creates the LIM message containing data about a physical examination. The LIM message is then transformed by XSL templates into the OET instance conforming to the `openEHR-EHR-SECTION.physical_examination.v1` archetype, described in the previous section. Both the LIM message and the OET instance are encoded in XML. The OET instance is sent via SOAP to the former HL7

Broker, which was reconfigured for the purpose of this experiment. The HL7 broker then sends the OET instance to the recieving system. In this experiment the HL7 broker does not transform the OET instance in any way. It serves as an inbox/outbox for the communicating EHR-S.

4.3. Archetype modeling methodology

To propose a modeling guideline or some sort of methodology for archetypes' creation, the content of EHR they describe must be clarified. According to "EHR information model" these are commonly used types of clinical information: *Basic information* (e.g. date of birth, sex, height, weight, pregnancy), *Problem list*, *Medications list*, *Therapeutic precautions* (allergies and alerts), *Patient preferences*, *Patient consents*, *Family history*, *Social history/situation*, *Lifestyle*, *Vaccination record* and *Care plan*.

This is a high level structure of EHR which can be found in a more or less complete form even in contemporary systems. The ADAMEKj also corresponds with this structure. This fact suggests an idea that if the modeling process of EHR adheres commonly agreed guidelines or methodologies, which are independent on the implementation aspects (i.e. used approach - object oriented programming, archetypes, relational database etc.), much better interoperable EHRs can be implemented. This implies creation of ontologies of various domains in medicine.

Within the frame of research in the EuroMISE Center a so called knowledge base (KB) tree of the MUDR EHR [15] was created. This tree was based on concepts of the MDMC. Another KB tree was created for the domain of dentistry. MUDR KB trees can be considered as some kind of ontologies, because they comprise vertices interconnected with various kinds of edges. The tree structure is formed only by the edge of the *superior* type. From the modeling point of view MUDR KB trees do not depend on any kind of implementation technology. After creation of the KB tree in the "MUDR Knowledge Base Editor" tool, it can be imported to MUDR or it can serve as a basis for further modeling process. Hence, the process of enabling the creation of EHRs with harmonized clinical content formulated in [10] can be extended by the *ontology creation* step at the beginning of the process.

Although ontology creation process can end up with various ontologies describing more or less the same domain, they can be aligned and merged [16] thank to the research conducted in the field of knowledge modeling.

5. Discussion

The most important thing, in order to achieve information consistency among various openEHR archetype based EHRs, is the archetype creation methodology. Such a methodology should guarantee consistent archetype creation. This means that two authors describing the same concept via archetype should end up with approximately the same structure of the definition part of the archetype. However, such an aim is really hard to accomplish.

After we mapped all concepts from the MDMC to SNOMED-CT we fixed their meaning. This helps in the further work, however the CKM repository does not support searching archetypes using SNOMED-CT codes. Only archetype identifiers are supported.

In the experiment we use the clinical data in form of LIM messages only from technical reasons. The more straightforward solution would comprise an archetype-specific "filler"module.

The usage of openEHR approach was a reaction to the situation in the e-Health community. The considerable amount of experts and professionals deal with archetypes, therefore we realized the experiment based on openEHR approach. For example NEHTA recommends to use archetypes in Australian e-Health [17].

The advantage of HL7 v3 being an ISO standard is gradually being eliminated by the activities of the openEHR Foundation. The archetypes were added to the CEN EN 13606 norm as Part 2. The implementation of communication via OET was considerably simpler than searching for correct storyboard in HL7 v3 ballot.

Despite the clinical content of the ADAMEKj EHR (concepts of MDMC) was modeled using HL7 v3 RIM classes, we used the openEHR approach as the first choice mainly thank to the stricter policy on data structures compared to HL7 CDA. The openEHR template contains only structured data conforming to given archetypes, the CDA document consists mainly from the free-text part which is annotated by structured pieces of information.

The WHO's ICD-10 coding list is commonly used in the real world of healthcare. The advantage it brings is obvious: even when the well structured EHR is not common, the information about patient's diagnoses are encoded in ICD-10 codes and they are processable by any other system or professional. However, the ICD-10 covers only diagnoses, i.e. true/false statements (boolean data type) if patient suffers from given disease. This can be considered the *Qualitative point of view*.

The modeling of the *quantitative* attributes is more complicated. It comprises of the description of the attribute, stating its data type (real number, integer, image data, etc.), eventually its units definition. Such a complex "meta-information"about a given attribute cannot be covered by a coding list. Much more sophisticated tools have to be incorporated e.g. ontologies.

6. Conclusion

Without ontologies there is no progress in achieving semantic interoperability. Communication standards can only *support* (!) the semantic interoperability among heterogenous EHR-S, *not guarantee* it.

The first step in creating ontologies might be the usage of the MUDR Knowledge Base editor tool, which was successfully applied in the creation of Dental KB [18].

Standardized clinical terminology would bring benefits to physicians, patients, administrators, software developers and payers. It would help also health care providers because it would give them more reliable and complete pieces of information, which belong to the healthcare process and would lead to better, less error prone and safer care of patients.

Since the evaluation of the comparison experiment described in sections above is not fully complete at the time of writing this text, we have given a brief outline of the evaluation only. We were interested in the standardization degree (data model, design and development process), the amount of implementation work, possibilities of interconnection with classification systems and tooling support (e.g. openEHR tools: Ocean Architect Editor, EHRflex [19]).

References

[1] P. Schloeffel, T. Beale, G. Hayworth, S. Heard, and H. Leslie, "The Relationship between CEN 13606, HL7, and OpenEHR", In: J. Westbrook, J. Callen, G. Margelis, J. Warren (Eds). HIC 2006 and HINZ 2006: Proceedings. Brunswick East, Vic.: Health Informatics Society of Australia, pp 24-28, 2006.

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

[3] T. Beale and S. Heard, "Architecture Overview", The openEHR Foundation. 2008. (Available at: http://www.openehr.org/releases/1.0.2/architecture/overview.pdf).

[4] T. Beale, "Archetypes: Constraint-based Domain Models for Future-proof Information Systems" In: Eleventh OOPSLA Workshop on Behavioral Semantics: Serving the Customer. K. Baclawski, H. Kilov (Eds). Northeastern University, Boston, 2002, pp. 16-32.

[5] T. Gruber, "Ontology", Encyclopedia of Database Systems, Ling Liu and M. Tamer Özsu (Eds.), Springer-Verlag, 2009. (Available at: http://tomgruber.org/writing/ontology-definition-2007.htm).

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

[7] T. Beale and S. Heard, "Archetype Definition Language - ADL 1.4" The openEHR Foundation. 2008. (Available at: http://www.openehr.org/releases/1.0.2/architecture/am/adl.pdf).

[8] M. Nagy, P. Hanzlicek, P. Preckova, P.Kolesa, J. Misur, M. Dioszegi, and J. Zvarova, "Building Semantically Interoperable EHR Systems Using International Nomenclatures and Enterprise Programming Techniques", CeHR 2007: Conference Proceedings. Amsterdam: IOS press; 2008. p. 105-10.

[9] R. Mares, M. Tomeckova, J. Peleska, P. Hanzlicek, and J. Zvarova, "User interface for patients' database systems - an example of application for data collection using minimal data model of cardiology" (in Czech), Cor et Vasa 2002; 4: 76.

[10] M. Nagy, "Clinical contents harmonization of EHRs and its relation tosemantic interoperability", PhD Conference '09. Matfyzpress 2009; pp. 65-74.

[11] The openEHR Foundation, "Introducing openEHR", The openEHR Foundation 2007. (Available at: http://www.openehr.org/releases/1.0.2/openEHR/introducing_openEHR.pdf).

[12] M. Nagy, P. Hanzlicek, P. Preckova, A. Riha, M. Dioszegi, L. Seidl, and J. Zvarova, "Semantic Interoperability in Czech Healthcare Environment Supported by HL7 version 3", Methods Inf Med, 2010; 49(1):186-195.

[13] D. Moner, J. Maldonado, D. Bosca, C. Angulo, M. Robles, D. Perez, and P. Serrano, "CEN EN 13606 Normalisation Framework Implementation Experiences", In: B.Blobel, E. Hvannberg, V. Gunnarsdottir (Eds). Seamless Care - Safe Care, IOS Press 2010. pp: 136-142.

[14] R.H. Dolin, et al., "The HL7 Clinical Document Architecture", J Am Med Inform Assoc. 2001;8 (6):552-69.

[15] P. Hanzlicek, J. Spidlen, and M. Nagy, 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).

[16] A. Burger, D. Davidson, and R. Baldock, "Anatomy Ontologies for Bioinformatics: Principles and Practice", Springer London 2008.

[17] National E-Health Transition Authority, "Review of Shared Electronic Health Record Standards", Version 1.0 - 20/02/2006. (Available at: http://www.nehta.gov.au/component/docman/doc_download/68-review-of-shared-electronic-health-records-standards-v10).

[18] M. Nagy, P. Hanzlicek, J. Zvarova, T. Dostalova, M. Seydlova, R. Hippmann, L. Smidl, J. Trmal, and J. Psutka, "Voice-controlled Data Entry in Dental Electronic Health Record", Studies in Health Technology and Informatics, 2008. 136: pp. 529-534.

[19] A. Brass, D. Moner, C. Hildebrand, and M. Robles, "Standardized and Flexible Health Data Management with Archetype Driven EHR System (EHRflex)", In: B.Blobel, E. Hvannberg, V. Gunnarsdottir (Eds). Seamless Care - Safe Care, IOS Press 2010. pp: 212-218.