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Towards ISO 13606 and openEHR Archetype-Based Semantic Interoperability

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Abstract. Semantic interoperability of clinical standards is a major challenge in eHealth across Europe. It would allow healthcare professionals to manage the complete electronic healthcare record of the patient regardless of which institution generated each clinical session. Clinical archetypes are fundamental for the consecution of semantic interoperability, but they are built for particular electronic healthcare record standards. Therefore, methods for transforming archetypes between standards are needed. In this work, a method for transforming archetypes between ISO 13606 and openEHR, based on Model-Driven Engineering and Semantic Web technologies, is presented.

Keywords. electronic healthcare records, archetypes, semantic interoperability

1. Introduction

One of the basic needs for any healthcare professional is to be able to access clinical information of patients in an understandable and normalized way. This information is usually distributed among several independent and heterogeneous systems that may be syntactically or semantically incompatible. Nowadays, there are different standards for representing electronic healthcare records (EHRs), and each one defines its own information models and manages the information in a particular way. The recent European Commission recommendations [1, 2] state that semantic interoperability of EHR systems is an essential factor for improving the quality and safety of patient care, public health, clinical research, and health service management. Semantic interoperability means ensuring that the precise meaning of exchanged information is understandable by any other system or application not initially developed for the same purpose.

From the technical perspective, the dual model architecture [3] is gaining relevance to develop EHR systems. This architecture is based on two modeling levels: information and knowledge. The information level is provided by the reference model and the knowledge level by the archetype model. Archetypes define clinical concepts and are usually built by domain experts. They constitute a tool for building clinical consensus in a consistent way. Consequently, they are considered basic to deliver fully interoperable EHRs [4]. Therefore, the development of methods and techniques for

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adapting archetypes to different standards would constitute a step forward to pursue interoperability.

In this work, the semantic interoperability of two dual-model based standards, ISO 13606 (http://www.centc251.org) and openEHR (http://www.openehr.org) is addressed. This research has been performed in the context of a project that pursues the semantic management of EHR-related information and knowledge. In previous work, we combined Model-Driven Engineering and Semantic Web technologies to propose an architecture for promoting semantic interoperability [5] and a methodology for representing clinical archetypes for Semantic Web [6]. The approach presented in this paper to transform ISO 13606 archetypes into openEHR ones and vice-versa will be based on such technological infrastructure.

2. Motivation

The openEHR standard provides a full specification for the creation, storage, maintenance, and querying of EHRs. Data are organized in this standard in *COMPOSITIONs*, which can be included into an optional *FOLDER* hierarchy. A *COMPOSITION* contains *ENTRYs*, which can be grouped in *SECTIONs*. *ENTRYs* are classified according to their type of information in *ADMIN_ENTRY*, *OBSERVATION*, *INSTRUCTION*, *ACTION*, etc. and they contain *ELEMENTs*, which may be grouped in *CLUSTERs*. openEHR also allows for the definition of data structures such as table (*ITEM_TABLE*), tree (*ITEM_TREE*), list (*ITEM_LIST*) and a single *ELEMENT* (*ITEM_SINGLE*). In addition to this, it provides other structures to represent the *HISTORY* of *EVENTs*.

Archetypes are defined in this standard using the Archetype Definition Language (ADL). An ADL archetype has different sections: header, description, definition and ontology. The header includes the name of the archetype, language, specialization information and so on. The description section includes audit information, such as original author, purpose or lifecycle status. The definition section contains the structure and restrictions associated with the particular clinical concept. Finally, the ontology section includes the terminological definitions and bindings associated with the archetype terms. Figure 1 shows an extract of the definition section of the openEHR ADL archetype for measuring visual acuity. Here, this section says that visual acuity is represented by means of a table, whose *row head* can be *Left*, *Right* or *Both eyes*.

```
definition
  OBSERVATION [at0000] occurrences matches {1..1} matches {  -- Visual acuity
    data matches {
          ...
              ITEM_TABLE [at0003] occurrences matches {1..1} matches {  -- Table
                rows cardinality matches {0..1; unordered} matches {
                  CLUSTER[at0004] occurrences matches {0..1} matches {  -- row
                    items cardinality matches {2; ordered} matches {
                      ELEMENT[at0005] occurrences matches {0..1} matches {  -- row head
                        value matches {
                          DV_ TEXT matches {
                            value matches {"Left","Right","Both eyes"}
                        }}}...
```

Figure 1. Extract of the definition part of the visual acuity openEHR ADL archetype

On the other hand, the ISO 13606 standard was developed to exchange EHR extracts, so it does not provide proper methods for version management, workflow management, interfaces to other systems etc.

In this standard, data are also organized in *COMPOSITIONs*, which can also be contained in *FOLDERs*. A *COMPOSITION* includes *ENTRYs*, which can be also grouped in *SECTIONs.* Finally, *ENTRYs* include *ELEMENTs*, which can be grouped in *CLUSTERs*.

Both standards follow the dual model approach, but they differ in how they structure the EHR domain, because they have different reference models. Both reference models are indeed very similar since they share the main structure organization. Nevertheless, openEHR has richer data structures and data types. Consequently, the transformation into ISO 13606 requires an in-depth analysis of the structural differences of both standards.

Figure 2 shows the corresponding ISO 13606 representation of the archetype shown in Figure 1. An *OBSERVATION* is here represented by an *ENTRY,* and an *ITEM_TABLE* is represented as a *CLUSTER*. This contains another *CLUSTER,* whose components are *ELEMENTs*.

```
definition
  ENTRY[at0000] occurrences matches {1..1} matches {  -- Visual acuity
    items matches {
          ...
              CLUSTER[at0003] occurrences matches {1..1} matches {  -- Table
                parts cardinality matches {0..1; unordered} matches {
                  CLUSTER[at0004] occurrences matches {0..1} matches {  -- row
                    parts cardinality matches {2..2; ordered} matches {
                      ELEMENT[at0005] occurrences matches {0..1} matches {  -- row head
                        value matches {
                          SIMPLE_TEXT occurrences matches {1..1} matches {
                            originalText matches {"Left","Right","Both eyes"}
                        }}}...
```

Figure 2. Extract of the definition part of the visual acuity ISO 13606 ADL archetype

Regarding transformation rules, any type of openEHR *ENTRY* is transformed into an ISO 13606 *ENTRY.* Other data structures as table, list, or tree are represented in ISO 13606 as a combination of *CLUSTERs* and *ELEMENTs.* On the other hand, the openEHR types *FOLDER*, *COMPOSITION*, *CLUSTER*, *SECTION* and *ELEMENT* have equivalent conceptual structures in ISO 13606, so they can be directly mapped.

As a consequence, two different situations may happen when transforming openEHR content into ISO 13606. First, there might be an equivalent ISO13606 data structure or data type. In this case, their properties can be directly mapped. For instance, the property *subject* of the openEHR *OBSERVATION* has the same semantic meaning as the property *subject_of_information* of an ISO 13606 *ENTRY*. Both of them identify the person to whom the information in an *ENTRY* or *OBSERVATION* is related. Their data types are, respectively, *PARTY_PROXY* and *RELATED_PARTY*. Hence, the first data type has to be transformed into the second one.

Unfortunately, this does not happen with every openEHR property. Properties of openEHR *OBSERVATION* such as *data*, *state*, *protocol* or *language* are not defined in ISO 13606 *ENTRY*. Therefore, they have to be transformed into 13606 *CLUSTERs* or *ELEMENTs* while the name of the original openEHR property is kept and used to identify the corresponding ISO13606 data structure.

3. The Solution

In [4], a semantic interpretation of the reference and archetype models of ISO 13606 and openEHR was presented. That research work proposed an ontological infrastructure for semantic interoperability based on common, integrated, standard-independent ontologies. That work produced a series of ontologies for both standards, including a common, integrated archetype model ontology. These ontologies have been used in this work to support and simplify the transformation processes and facilitate the development of standard-independent technologies.

Later, a methodology for transforming ADL archetypes into OWL was developed by applying Model-Driven Engineering (MDE) techniques [6]. That effort made it necessary to develop metamodels for both the ADL and OWL representation of archetypes. Thus, ADL archetypes were transformed into OWL archetypes by means of model transformations. That methodology has been applied to both ISO 13606 and openEHR, and a web tool for transforming ADL archetypes into OWL is available online at http://klt.inf.um.es/~cati/.

Our technological approach to transform openEHR↔ISO 13606 archetypes is based on the use of MDE. Hence, mappings between the metamodels of the ISO 13606, openEHR, and the integrated archetype model ontology were developed. The last one provides a common representation for both standards and has been used as a mediator in the transformation process, which is depicted in Figure 3. There, the solid arrows represent the mappings defined between the metamodels and the dashed arrows show the possible transformations between the integrated metamodel and the specific ones.

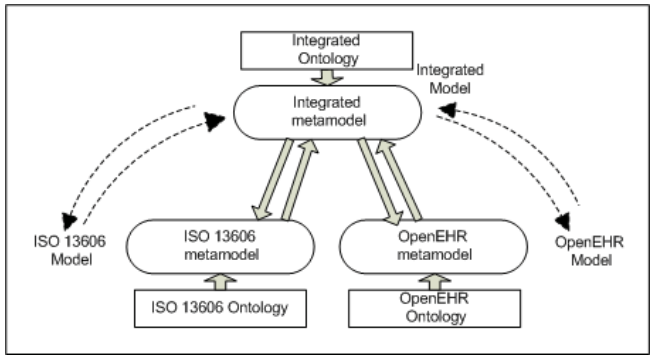

Figure 3. A sketch of the transformation process

The transformation of openEHR archetypes into ISO 13606 is a process defined by the following workflow (the opposite transformation would be similar):

1. The ADL input archetype is transformed into its MDE representation, that is, a model conforming to the openEHR metamodel (openEHR model).
2. The openEHR model is transformed into the common, integrated archetype representation (Integrated model).
3. The Integrated model is transformed into ISO 13606 (ISO 13606 model).
4. The ISO 13606 model is transformed into ADL.

A Java software transformation tool has been developed to perform such transformations and executes the previous workflow. The tool is currently being tested.

4. Conclusions

Semantic interoperability of clinical standards is a major challenge in the eHealth across Europe [2]. It would allow healthcare professionals to manage the complete electronic healthcare record of the patient regardless of which institution generated each clinical session. Clinical archetypes are fundamental for the consecution of semantic interoperability, but they are built for particular electronic healthcare record standards. Therefore, methods for transforming archetypes between standards are needed. In this work, the similarities and differences between two dual model-based EHR standards, namely, ISO 13606 and openEHR have been discussed. This analysis has been performed in order to define mechanisms for transforming openEHR archetypes into openEHR and vice versa. As a result of this work, a process for transforming such clinical archetypes has been defined, constituting an important step towards the consecution of semantic interoperability. This process is based on the use of an integrated ontology defined for ISO 13606 and openEHR standards. This transformation process might be adapted and applied to other dual model-based clinical standards. As further work, this result will be included in ArchMS [7], an EHR standard-independent archetype management system developed in our research group, capable of managing both ISO 13606 and openEHR archetypes.

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