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The Archetype-Enabled EHR System ZK-ARCHE – Integrating the ISO/EN 13606 Standard and IHE XDS Profile

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Abstract. The EHR system ZK-ARCHE automatically generates forms from ISO/EN 13606 archetypes. For this purpose the archetypes are augmented with components of the reference model to achieve so-called “comprehensive archetypes”. Data collected via the forms are stored in a list which associates each value with the path of the corresponding comprehensive archetype node coded as W3C XPath. From this list archetype-conformant EHR extracts can be created. The system is embedded with the IHE XDS profile to allow direct data exchange in an environment of distributed data storage.

Keywords. EHR, ISO/EN 13606, archetype, form generation, archetype-conform EHR extract

1. Introduction

The project EHR-ARCHE[2] aims to support health care providers in finding those contents within electronic health records (EHR), which are relevant for their respective information needs, in consideration of the ever growing Information overload from chronically ill. It emanates from an IHE XDS [1] based distributed data storage architecture with a central metadata component. The EHR data are represented as fully-structured ISO/EN 13606 EHR extracts. The ISO/EN 13606 standard [2, 3] is based on the dual model approach, which means that the representation of the EHR data are described by a reference model (RM) and a set of archetypes (AT) [4].

In this paper we describe the EHR system ZK-ARCHE, which serves as the data source within EHR-ARCHE’s IHE XDS environment. Its purpose is to support the fast and convenient creation of archetyped EHR extracts, as well as their provision to the XDS-repository and registration within the XDS-registry.

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[2] See http://www.meduniwien.ac.at/msi/arche/

2. Method

The functionality of the system can be grouped in three main steps (see Figure 1): (a) After the user selects an archetype from the archetype repository, the system automatically generates a corresponding data collection form. (b) Data collected by means of the form are stored as archetyped EHR extracts. (c) The latter can then be transferred to the repository and registered. This step is supported by automatically retrieving the required IHE XDS metadata from the EHR extracts.

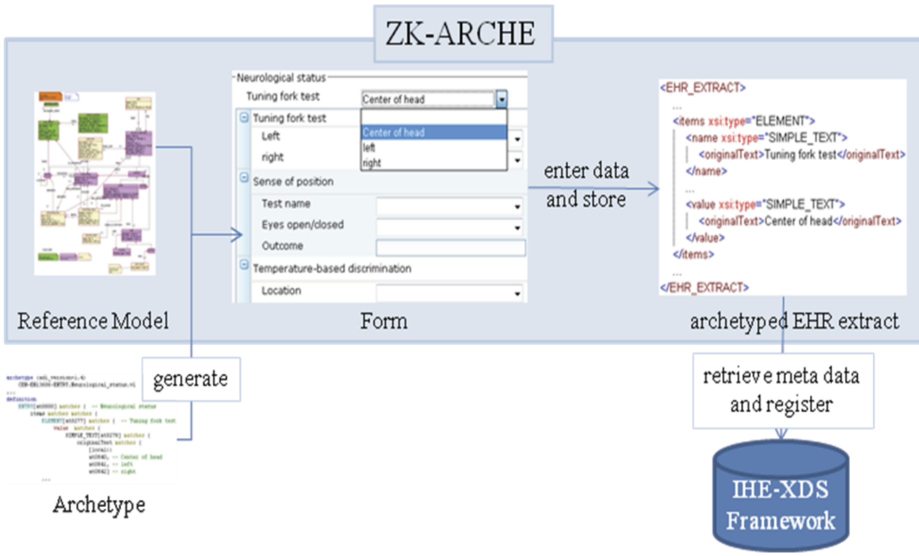

Figure 1. Functionality of the EHR system ZK-ARCHE

We developed the ZK-ARCHE system according to the classic Model-View-Controller (MVC) [5] pattern. In the following we describe how the different tasks are split up between the model, the view and the controller.

2.1. Model

The model is an instance of the Archetype Object Model (AOM). ATs only contain those attributes of RM classes, which they constrain, i.e. they represent a "differential view" of the RM. When processing an AT we therefore have to additionally consider the RM. As suggested in [6] we use a so-called "Comprehensive AT" for this purpose, which augments the AT with the mandatory attributes of the RM classes that are not constrained by the AT. In the Comprehensive AT all referred ATs (slots) are included and augmented like the referring AT. To ensure unambiguous node-IDs, the node-IDs of the referred ATs are extended with the ID of their AT as prefix. Predefined data (e.g. Unified Code for Units of Measure Object Identifier) are filled in and every node of the Comprehensive AT is associated with a relative W3C XPath.

2.2. View

The model is visualized as a data collection form to allow user input. The structure and input options of the form are generically derived from the model. The RM classes referred to within the model are transformed to form widgets as follows:

- The COMPOSITION represents the view's root class and corresponds to the whole form.
- SECTIONs are displayed as individual pages within a tab-box.
- ENTRYs and CLUSTERs group their sub-elements as defined by the AT.
- For the data values held by ELEMENTs we support entry fields of data types date, time, number, text including selection lists, and boolean. Data values that are not entered by the user (e.g., fixed values prescribed by the archetype or system-provided metadata such as instance identifiers of RECORD_COMPONENTs) are automatically completed and cannot be edited in the form.
- If the comprehensive AT prescribes an occurrence > 1 for a node, the corresponding widget may be dynamically duplicated via a button in the form.

All data are internally held in a list of key-value pairs (see Table 1). Each value included in the EHR extract is associated with a key that consists of the absolute W3C XPath of the AT-node holding the value. Emanating from this list it is possible to create a complete AT-conformant EHR extract; no additional information such as the Comprehensive AT is required. This technique is therefore also appealing for integrating archetypes into existing EHR systems. It was also successfully applied in [7].

Table 1. Sample entries in the key-value list, which holds the data to be stored in the EHR extract. The creation time of the EHR extract (1st row) is generated by the system. The service start time (2nd row) and heading of the lab findings SECTION (3rd row) are prefilled by the system respective by the AT and may be adapted by the user.

Key	Value
/EHR_EXTRACT/time_created[@xsi:type='TS']/time	2011-02-15T14:23:00Z
/EHR_EXTRACT/all_compositions[archetype_id='CEN-EN13606-COMPOSITION.discharge_summarization_note.v1/at0000' and @xsi:type='COMPOSITION'][1]/session_time[@xsi:type='IVL']/low[@xsi:type='TS'] /time	2011-01-17T06:54:04Z
/EHR_EXTRACT/all_compositions[archetype_id='CEN-EN13606-COMPOSITION. laboratory_report.v1/at0000' and @xsi:type='COMPOSITION'][1]/content [archetype_id='CEN-EN13606-SECTION.Laboratory_findings.v1/at0000' and @xsi:type='SECTION'][1]/name[@xsi:type='SIMPLE_TEXT']/originalText	Laboratory findings

2.3. Controller

The controller creates the model for a selected AT and derives the view from the model. Documents collected via the view are converted to the key-value list, from which the AT-conformant EHR extract can be directly generated. The EHR extract can either be stored locally or in an IHE XDS repository. When storing the document in the IHE XDS repository, 23 metadata required for registering the document are retrieved from the EHR extract and the EHR system. Some of these metadata, e.g., the EHR system

ID and the document ID, are set by the system or derived from the AT, e.g., classCode, language. Others, e.g., the service start and stop time, are entered by the user.

3. Results

ZK-ARCHE was implemented as a web application in Java using the Archetype Definition Language (ADL)-Parser [3] of the openEHR foundation and the ZK Framework[4]. As client it only requires a web-enabled browser without any plugins. For the communication to the IHE-XDS environment the “Sense” infrastructure from ITH icoserve [8] was used.

Within the EHR-ARCHE project we developed 128 ATs for the domain of diabetes treatment [9]. Hereby the ZK-ARCHE system provided valuable assistance by allowing the physicians involved in the AT design process to visualize each draft of an AT as data collection form on the fly. Twelve of the 128 ATs are of type COMPOSITION and include the other ATs via slots. They are the starting point of the form generation process. The largest AT contains 119 slots. It results in a form of initially 745 input fields, which may be dynamically extended (e.g. by adding further table rows). This AT consists of 22.122 lines of code in the ADL. The resulting Comprehensive AT has 35.998 lines of code, and thus enlarges the AT by 63%. The creation of the corresponding form takes 5 sec on an Intel Core 2 Quad Q9400 computer. Besides numerous test documents we also created 29 documents based on real anonymised patient information. They were all successfully stored as AT-conformant EHR extracts and uploaded into the IHE XDS environment.

4. Discussion

In [10] a method for the automatic creation of forms from openEHR ATs is described. It does not, however, address how to create AT-conformant EHR extracts from the collected data. Under the name of Opereffa an open source application is developed, which allows forms to be generated from openEHR ATs [11]. In [7] and [12] approaches of integrating openEHR ATs in existing EHR systems are presented. The tool LinkEHR [6] allows existing data to be mapped to ATs, to transform them into AT-conformant data. It supports the ISO/EN 13606, openEHR and HL7 Clinical Document Architecture (CDA) data models. However, automatic generation of forms for ATs is not in the focus of this tool. EHRflex [13] creates forms from ISO/EN 13606 ATs. Although it follows a slightly different approach, it provided helpful evidence on the implementation of our forms. Our ZK-ARCHE System extends the before mentioned tools and systems with its embedding into an IHE XDS environment. In [14] a health information framework is described, which integrates a commercial EHR system into an IHE XDS architecture. It supports the exchange of free text hospital discharge letters embedded in CDA documents.

For the creation of the Comprehensive AT some assumptions had to be made to simplify the implementation. Optional attributes of the RM, which are not constrained by the AT, are not included in the Comprehensive AT. Slots may only be filled with a

[3] http://www.openehr.org/projects/java.html

[4] http://www.zkoss.org/

single AT. ELEMENT nodes with unspecified data type in the AT (matches {*}) are interpreted as data type SIMPLE_TEXT. Without these assumptions the Comprehensive AT would further grow in relation to the AT.

Because of the direct derivation of the form from the Comprehensive AT, the form usability depends on the modeling of the AT. Complex structures in the AT result in an equally complex form. This problem could be solved by adding a GUI design tool to the system, which allows the generated forms to be manually edited. Alternatively, an intermediate layer for describing the visualization of an AT could be added, similar to the description of an archetyped EHR extract's visualization such as presented in [15].

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