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Combining Archetypes with Fast Health Interoperability Resources in Future-proof Health Information Systems

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Abstract. Messaging standards, and specifically HL7 v2, are heavily used for the communication and interoperability of Health Information Systems. HL7 FHIR was created as an evolution of the messaging standards to achieve semantic interoperability. FHIR is somehow similar to other approaches like the dual model methodology as both are based on the precise modeling of clinical information. In this paper, we demonstrate how we can apply the dual model methodology to standards like FHIR. We show the usefulness of this approach for data transformation between FHIR and other specifications such as HL7 CDA, EN ISO 13606, and openEHR. We also discuss the advantages and disadvantages of defining archetypes over FHIR, and the consequences and outcomes of this approach. Finally, we exemplify this approach by creating a testing data server that supports both FHIR resources and archetypes.

Keywords. HL7, FHIR, archetype, semantic interoperability

Introduction

As the need of semantic interoperability and exchange of EHR increases, new standards and methodologies emerge to deal with new requirements and take advantage of new technologies. One of the standards under developed that is receiving more attention is Fast Healthcare Interoperability Resources (FHIR) [1]. FHIR is an HL7 specification for the electronic exchange of healthcare information. FHIR takes advantage of the lessons learnt with HL7 v2 and HL7 V3 to provide a specification for the interoperability of healthcare information aiming at easing the implementation. FHIR is based on a set of basic modular components called Resources, which describe the clinical or administrative contents of the health records that can be exchanged. Resources are reusable patterns defined and represented in a common way, based on a set of data types. Resources also contain a common set of metadata and a human readable part. These Resources can be used by themselves, extended, or combined to satisfy the majority of common user cases.

This approach is similar to the dual model approach used by EN ISO 13606 [2] and openEHR [3]. In fact, archetypes and FHIR Resources are closely related. Both

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define reusable patterns to describe clinical information. The main approach difference is that archetypes are maximal datasets, as they are expected to represent all the clinical content, while FHIR resources only contain the most common used clinical information, but can be extended with additional items for a specific use case. This similarity allows us to explore the use of the archetype methodology applied to FHIR. In fact there is an ongoing effort from openEHR and FHIR communities to create joint archetypes that contain at least all parts FHIR resources do [4]. These agreed archetypes will ease the transformation between selected openEHR archetypes and FHIR resources. Our approach is slightly different, as we apply the dual model methodology over FHIR Reference Model (RM).

The objective of this paper is to demonstrate that archetype methodology can be applied to FHIR and describe which are the advantages and disadvantages of this approach.

We will demonstrate the usefulness of our approach by generating FHIR archetypes and use them for the automatic generation of data transformation programs between archetype-based standards and FHIR, and vice versa. In addition to the mappings, we will also demonstrate how archetypes and resources can be used seamlessly in a FHIR-like data server. We will discuss the advantages and disadvantages of using archetypes for FHIR resource extension and mappings between standards.

1. Methods

In order to create FHIR archetypes we have to define a Reference Model (RM) first. We will assume that each one of the FHIR resources is a reference model entity, and therefore archetypes will be defined by constraining them. We will derive a reference model archetype from each one of the Resources already defined in FHIR. Once we have created the reference model and imported it into an archetype editor with support to multiple reference models, in our case LinkEHR[5], we are ready to define extended resources as archetypes completely compliant with FHIR RM. The process for the creation of FHIR archetypes is described in **Figure 1**.

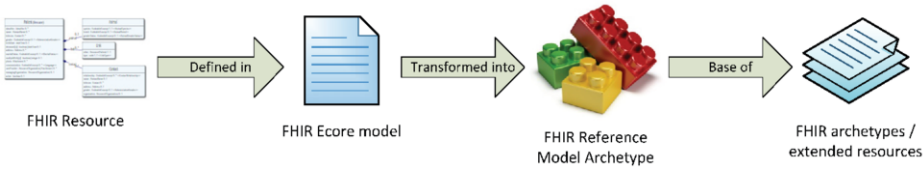

Figure 1. Steps needed for the creation of FHIR archetypes

To support FHIR RM we propose the use of what we call a "Reference Model archetype", i.e. an archetype that contains an explicit and exhaustive definition of a given business class. For its generation, we analyzed FHIR ecore definition [6] and created an iterative process that transforms each one of the types defined in the ecore model into archetypes. These archetypes contain the corresponding attributes defined in the ecore and references to each one of the types inside them. If a type could be derived into other types an alternative of references was created for each one of the subtypes. Only one reference was created for each individual type. In order to reduce the size of

the RM archetypes, any further use of the same type in the archetype was transformed into references to the first reference to avoid the repetition of archetype structures. In each one of the iterations, every reference from the RM archetype was solved with the corresponding archetype. The iterative process ends when the RM archetypes selected as archetypable entities (i.e. the types we want to be able to generate archetypes from) do not contain any references to other types (a restriction of RM archetypes is that they must be completely defined on their own).

The set of all RM archetypes created with this method defines the FHIR RM. This allows us to generate archetypes based in FHIR RM.

2. Results

2.1. FHIR archetypes

Including the RM archetypes into LinkEHR Editor allows the creation of derived archetypes compliant with FHIR model. The editor shows the valid types and attributes that can appear at a given point in the archetype. **Figure 2** shows side by side an excerpt of a cancer questionnaire archetype created with the tool and the original FHIR Questionnaire resource. The created archetypes can be seen as extended FHIR resources.

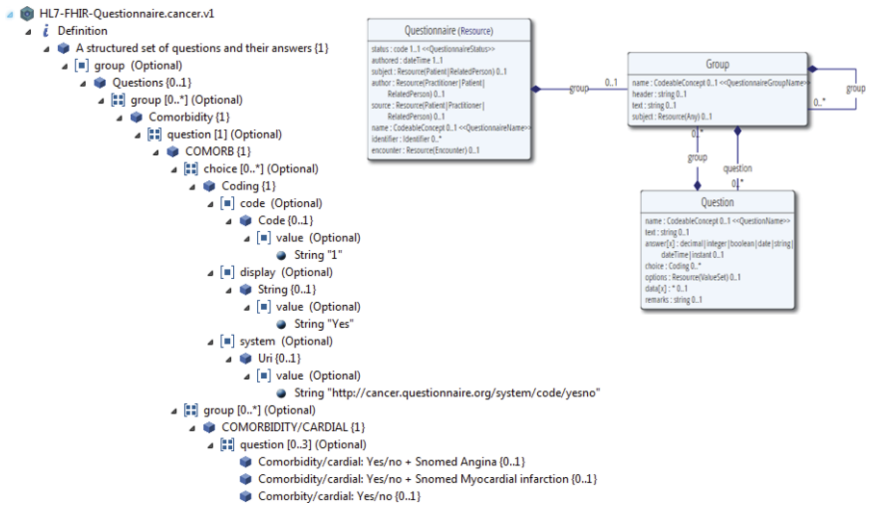

Figure 2. Comparison of a cancer questionnaire archetype and a FHIR Questionnaire resource

2.2. Mapping to a FHIR archetype

An advantage of including FHIR reference model into LinkEHR is the possibility of generating data transformation programs from the archetypes. This transformation programs are generated on the fly from the defined mappings between source data and target archetypes. This mapping process is described in [7]. For the mapping process, first we have to define a FHIR archetype with the desired constraints. Then LinkEHR mapping process completes the FHIR archetype with the underlying RM, which in the

end assures that all the mandatory parts from both the archetype and the reference model will have a value. This comprehensive archetype can then be mapped to a selected archetype from any other RM or to an XML source. When all required information for an archetype has a mapping, LinkEHR automatically generates an XQuery transformation program that will transform the source into an XML compliant with both the archetype and the reference model constraints. This XQuery program can be used by a FHIR server to provide FHIR outputs from a non-FHIR server. Mappings from FHIR instances to data in any other archetype-based reference models are made in the same way, as long as target model has been loaded in LinkEHR.

2.3. FHIR+Archetypes data server

In addition to the mappings, we explored the use of a FHIR server to support archetypes as if they were resources. The approach that FHIR uses for storing and querying data instances can be similarly used for archetype-based approaches. Both approaches could use the Resource name or the archetype identifier to know which clinical model to retrieve. Also, every resource can be queried by a set of predefined search parameters such as identifier or language. Each one of the resources defines an additional set of query parameters that can be used to obtain lists of data instances (e.g. for searching Patient resources by gender or family name). Search parameters are defined with an XPath pointing to a given entity. Archetypes do not define any set of default query parameters, but allow the query of data by arbitrary paths [8][9]. Moreover, these paths can come not only from the archetype, but also from the underlying reference model. Archetypes were included into the FHIR server as resources by creating a profile defining a set of search parameters and their corresponding XPaths for each archetype in the server. Query parameters contained in the profiles are reference model dependent (based on model node identifier), and thus can be defined based on reference model paths. Using this, we created a FHIR server that also supports search of archetypes based on a given set of parameters.

3. Discussion

FHIR can be used in archetype based systems, using all already available methodologies and tools. By using this approach, archetype based systems can easily provide FHIR services to extract, store, and query an archetype based system. This can be beneficial for both FHIR and archetype based systems as allows FHIR enabled applications to use already defined clinical models but also helps archetype based systems to get more visibility in the HL7 world.

Using FHIR archetypes has some key advantages, such as being able to check if a resource is valid against the reference model. This is especially useful with FHIR Draft Standard for Trial Use (DSTU) status, which means that all aspects of the FHIR specification can potentially change. The proposed methodology for the creation of archetypes from the FHIR specifications is based in an automatic process and allows us to regenerate the RM when a new FHIR version is released. We can also check if a generated FHIR archetype is still compliant with the model after the specification is updated.

Other key advantages of using archetypes are knowledge reuse, multilinguality (FHIR based archetypes could be used to provide translation of resources to other

languages without the need of creating extensions to the profiles), the ability to generate derived artifacts (such as schematron rules [10], mindmaps, sample formularies or implementation guides), and use of AQL [9] to query FHIR archetype-based data.

We can also use archetypes for mapping existing systems and standards from and to FHIR. A mechanism such as the one demonstrated on the FHIR/archetype server could be useful for the seamless inclusion of FHIR in current systems, using mapped FHIR resources as the inputs and outputs of an archetype based system. Generated FHIR archetypes can also be mapped directly to data sources to generate valid FHIR instances from current systems. This kind of approach has been successfully tested for other non-dual model native standards such as HL7 CDA [11] or CDISC ODM [12].

There are also some disadvantages that we have to take into account when using archetypes with FHIR. One of the issues we had to deal with was that our current transformation is based on XQuery. This could be problematic as JSON is used heavily in FHIR. However, this is not a big issue as direct transformations between XML and JSON already exist.

There are more difficult issues to solve when dealing with FHIR archetypes, mostly due to the separation between the narrative definition and the formal definition of FHIR resources. This affects both the resources definition and the generation of valid instances from the resources and will require further future work.

In conclusion, the advantages of a joint use of FHIR and archetypes outweigh the disadvantages. Using FHIR based archetypes allows us to reuse all the tools and methodologies developed for dual model standards, and profiling archetypes as FHIR resources will help to the rapid adoption of both FHIR and dual model approaches.

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