Chapter 5
On the Integration of Clinical Archetypes with Ontologies and Rules

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ABSTRACT
This chapter presents an approach to translate definitions expressed in openEHR Archetype Definition Language (ADL) to a formal representation using ontology languages. The approach is implemented in the ArchOnt framework, which is also described. The integration of those formal representations with clinical rules is then studied, providing an approach to reuse reasoning on concrete instances of clinical data. Sharing the knowledge expressed in the form of rules is coherent with the philosophy of open sharing underlying clinical archetypes, and it also extends reuse to propositions of declarative knowledge as those encoded for example in clinical guidelines. Thus, this chapter describes the techniques to map archetypes to formal ontologies and how rules can be attached to the resulting representation. In addition, the translation allows specifying logical bindings to equivalent clinical concepts from other knowledge sources. Such bindings encourage reuse as well as ontology reasoning and navigability across different ontologies. Another significant contribution of the chapter is the application of the presented approach as part of two research projects in collaboration with teaching hospitals in Madrid. Examples taken from those cases, such as the development of alerting systems aimed at improving patient safety, are explained. Besides the direct applications described, the automatic translation of archetypes to an ontology language fosters a wide range of semantic and reasoning activities to be designed and implemented on top of a common representation instead of taking an ad-hoc approach.
1. INTRODUCTION

Clinical practice can be represented as an iterative care delivery process that starts with observations of the status of the patient. Such observations lead to informed opinions on the part of a health care professional, including assessment of the current situation, goals for a future situation and plans for achieving the goals. Such plans then turn into detailed instructions for clinical practice that eventually trigger the appropriate actions. At this stage, we may need to repeat the whole iteration until the problem is solved. These four kinds of information are breakpoints where communication between independent healthcare systems is frequently lost because of data ambiguity and incompatibility.

In the last years, the paradigm of archetypes (Garde, Knaup, Hovenga, & Heard, 2007) has brought a new way to define the models of electronic health records and to normalize the information transfer between such heterogeneous healthcare systems, making them more interoperable. Archetypes are formal clinical specifications, expressed in terms of constraints on a generic reference model. They can be combined together through templates, and used at runtime to extract data, to enable querying, and to support legacy data transformation. Thus, archetypes serve as a shared language for common and specialised clinical concepts. In other words, the reference model encloses the stable features like the set of classes that make up the blocks constituting an electronic health record and the basic syntax of statements, while archetypes allow for sharing a wide variety of combinations of those classes corresponding to record fragments created for specific clinical situations. For example, Blood Pressure, Medication Order and Transfusion are clinical statements that have already been specified as archetypes, so they can be used or refined as reference data structures for the interchange of clinical data.

However, improving interoperability requires different systems to have the ability to exchange every possible information related to healthcare, including propositions of declarative knowledge as those encoded for example in clinical guidelines. The archetypes paradigm and the underlying two-level model (which are detailed in the Background Section) allow reaching this understanding at syntactic, structural and semantic levels (Garde et al., 2007). Nevertheless, when it comes to clinical rules, archetypes and the languages used to define them show themselves insufficient, at least to guarantee a seamless exchange of the underlying semantics.

The consideration of semantic interoperability introduces the need for computational semantics. For example, a health care information system that receives some observation entry like Body Temperature (no matter from where but conforming to some archetype specification) should be able to deliver it to the appropriate professional, who would eventually proceed to deal with the assessment of the observation. This is clearly a significant advance for the interoperability of health systems, but it could be further enhanced with semantics attached to the archetypes. If the archetype is linked to knowledge representations, then the system would be able to act upon the information directly (e.g. by triggering an alert or notification), or to suggest the clinician some courses or action or relationships with other existing information. This additional processing on the data requires shared representations as those that can be found in formal ontologies (Gruber, 1993). A further step would be that of being able to infer knowledge on how to assess, evaluate
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