Chapter 4
Interoperability of EHR Systems Based on Semantic Representation and Transformation Models

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ABSTRACT
The semantic interoperability of electronic healthcare record systems is a major issue given that it would increase the quality of healthcare and patient safety. In this chapter, different solutions based on the use of semantic models for representing clinical knowledge are presented. The aim of the research presented here is to contribute to the achievement of semantic interoperability by making explicit the meaning of the exchanged data and knowledge items. In particular, this work is focused on dual model-based electronic healthcare records standards and presents methods and tools for the representation and transformation of clinical archetypes and for the automatic generation of standardized applications.

INTRODUCTION
A healthcare record is the set of non-redundant, ordered, and complete information concerning the relation between an individual and any healthcare centre, and it is a basic tool to achieve quality in healthcare. Healthcare records can be queried in different situations and due to different reasons, and they can play different roles in the healthcare process. However, their main use is to support clinical care. The lifelong clinical information of
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any person supported by electronic means configures the Electronic Healthcare Record (EHR). An EHR is then a healthcare record digitally stored in one or more information systems. It contains information about one patient although it can contain references to other people. As pointed out in Blobel (2006), EHR systems must support life-long EHR, be technology and data format independent, facilitate sharing of EHRs via interoperability at data and knowledge levels, integrate with any/multiple terminologies, support for clinical data structures and prioritise the patient / clinician interaction.

As a consequence of the technological development, there are currently many different Health Information Systems (HIS) in daily practice in healthcare institutions. Most of these systems are built on different information models, so the exchange of information between clinical information systems has become a major challenge for the last decades. In this context, the adoption of EHR standards will facilitate the achievement of the information exchange goal. In fact, it is more a requirement than a goal given the increasing fragmentation of healthcare and the increasing mobility of citizens around the world, who need effective and quality healthcare.

Nowadays, there are some advanced standards and architectures for representing and communicating electronic healthcare records, among which HL7 (HL7, n.d.), OpenEHR (OpenEHR, n. d.) and ISO EN 13606 (ISO 13606, 2013) should be pointed out given their relevance. So far, the availability of such standards has not solved the problem, because each standard defines its own information models and manages the information in a particular way. However, they play a fundamental role because they are currently the targets of the interoperability methods that are currently being developed by the community. In particular, this chapter will be focused on the interoperability of EHR standards that follow the dual model architecture approach (Beale, 2001).

This architecture is based on the meta-modeling of healthcare records, which distinguishes two conceptual levels, information and knowledge. Therefore, our effort will be mainly put on the interoperability at knowledge level. It should be noted that the following three levels of interoperability are usually identified in healthcare:

- **Level 1**: Technical and Syntactical interoperability. Example: Dr Smith is able to receive patient clinical data but he cannot understand them, because they are in French.
- **Level 2**: Partial semantic interoperability. Example: Dr Smith is able to understand some important data because they are codified according to an international coding system. However most of them are in French.
- **Level 3**: Full semantic interoperability. Example: Dr Smith is able to access patient data, to understand them and to integrate them in the hospital information system.

In this chapter, we will describe solutions for representing and transforming knowledge between dual model based EHR systems, and for the automatic generation of applications from clinical knowledge units. All these solutions intend to support the achievement of interoperability level 3 by following the technological recommendations of the Semantic Interoperability for Better Health and Safer Healthcare report (EC Roadmap, 2009), which identifies the use of standards and technologies.
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