Using OpenEHR in SICTI an electronic health record system for critical medicine

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Using OpenEHR in SICTI an electronic Health record System for critical medicine

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Abstract. SICTI is a software tool for registering health records in critical medicine environments. Version 1.0 has been in use since 2003. The Biomedical Engineering Group (Núcleo de Ingeniería Biomédica), with support from the Technological Development Programme (Programa de Desarrollo Tecnológico), decided to develop a new version, to provide an aid for more critical medicine processes, based on a framework which would make the application domain change oriented. The team analyzed three alternatives: to develop an original product based on new research, to base the development on OpenEHR framework, or to use HL7 RIM as the reference model for SICTI. The team opted for OpenEHR. This work describes the use of OpenEHR, its strong and weak points, and states future work perspectives.

1. Introduction

The issues of quality control in medicine, precision on per-patient cost and statistical analysis of management indicators increasingly require using digitally-based health records systems in medical institutions.

Critical Medicine is, by its own nature, an area that demands timely response and management of vast volumes of information on each patient. Electronic health records systems are, therefore, a natural solution for this area.

Design and conceptual representation of each piece of information used in Critical Medicine stands as a major challenge for the development of these systems. Electronic health record software is posed to continuous change in medical knowledge, featured by the steady inflow of concepts, the expansion and deepening of already known concepts, and the increasing complexity [1] stemming from new interrelationships among evolving knowledge fields. Thus, the conceptual model will need to show capability for representing knowledge that is yet unveiled at the time of development.

Traditional modelling approaches distribute responsibility into layers, where “business” or “domain” rules end up hard-coded and assume database models known a priori. These approaches do not offer flexibility enough as demanded by electronic-based health-recording systems.

Version 1.0 of SICTI[2] was developed on a database model which differentiates clinical meta-data from clinical data. Clinical metadata is used to validate system input at runtime. OpenEHR develops a similar and much more complete version of this idea by proposing a “two level modelling”[3].

Development of models based on successive refinement of high level models is now more frequently used for health systems. Following the process of refining and specializing, specific clinical area models are derived from more generic or abstract ones. For example, the HL7[5] initiative, aimed at the exchange of clinical data, bases its development on a refinement of its Reference Information Model (RIM).

The OpenEHR initiative presents models and tools oriented to solving not only data exchange but also to store, validate and provide semantic interoperability between systems. The “two-level

modelling" technique differs from HL7's techniques by allowing for dynamic business rules and knowledge models redefinition without needing to recode business or persistence layers.

2. Objectives

The Project pursues two objectives: (1) to upgrade the existing SICTI version by covering new clinical processes and, (2) to use medical information standards and flexible modelling techniques for representation and persistence of clinical data. This second objective is essential in order to achieve the first one, because the medical field is continually creating requirements which can only be met with flexible models.

Finally, we aim to provide the local and regional critical medicine units with SICTI, a system which would allow better documentation management and systematized data in order to support clinical decision. It is expected that SICTI will evolve into an independent venture from the University environ.

3. About the OpenEHR initiative

The *open*EHR Foundation is a non-profit company created with the purpose of promoting and publishing formal specifications of requirements for representing and communicating electronic health record information. OpenEHR foundation is committed to the development of an open and interoprable for clinical systems, from which the most important current endeavour is the electronic health record (EHR). This objective is achieved by doing research on clinical requirements and creating specifications and implementations. The specification is composed of modular support information, service and clinical information models.

The OpenEHR framework covers the following requirements:

(1) capacity to register any clinical information including complex lab results, images, diagnostic information, care plans or evaluations.

(2) allow for archetyping of all clinical systems allowing for content, semantics and user interfaces definition by clinical experts and not software engineers.

(3) correct integration with terminology services.

(4) easy integration with messaging systems, in particular with those based on HL7 Version 2.

(5) open to HIS systems and other databases.

(6) distributed versioning of EHR, demographic and other information.

(7) a base for component-based, flexible and future-proof architectures.

OpenEHR work is oriented to two activity areas: technical and clinical ones. The technical area is where engineering work is performed, whose actions include specification development, implementations, testing and conformity. The clinical area is where organizations and individuals that compose the health sector provide their knowledge by developing ontologies, archetypes, templates as well as by enabling for clinical training.

This two activity areas are, namely, the two levels indicated in the "two level modelling" approach. The first level features the information models, whereas the second level is where conceptual clinical information is represented via restricted formal structures called archetypes.

The information models are built as a stable reference model which allows for future proof information systems. Archetypes are general purpose artefacts which can be re-used and structured into hierarchies. Archetypes are used on run-time referred from templates, which are archetypes trees. Each archetype bounds a specific part of the reference model.

OpenEHR projects can be grouped into four branches:

(1) conceptual and implementation specifications.

(2) open source implementations. Each implementation corresponds to a certain point in the life cycle of the conceptual specifications.

(3) clinical knowledge structuring and representation, which involves archetype development.

(4) tools to create and edit archetypes, templates and terminology sets.

All these projects evolve about specification development, without which the remaining part would make no sense. Figure 1 depicts high-level modules developed for the specification project. This project includes requirements, architecture, implementation and conformity specification.

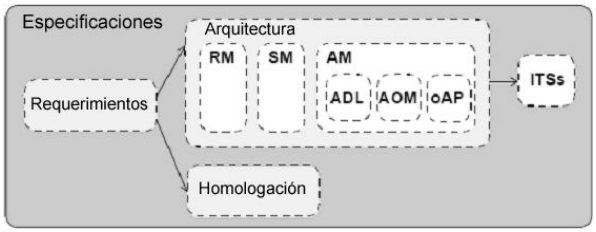


Figure 1. **OpenEHR specifications**

Architecture specification[6] is composed of the Reference Model (RM), the Archetype Model (AM) and the Services Model (SM). The archetype model is as well composed of the Archetype Object Model (AOM) and the openEHR Archetype Profile package (oAP). Archetypes represented by the AOM are written with the Archetype Definition Language (ADL), based on Frame Logic theory [7].

Archetype and template use makes this methodology innovative and interesting. It results in adaptative and flexible systems capable of dealing with continuous change in the clinical field. These two artefacts are central, so some lines appear to explain what they are and what their use is: (1) archetypes are formal specifications used for creating data structures and validate real data input. Since archetypes refer to the reference model, validated input is sure to conform with the reference model and in line with restrictions defined by the archetype; (2) templates are specifications for localized restrictions. Templates are definitions for interfaces put archetypes together and define restrictions. Each template defines which archetypes to chain together; and establishes values for optional fields in archetypes, specifies language and terminologies to be used and adds further restrictions upon the restrictions already defined in archetypes.

4. The SICTI project

The project starts by making a broader requirements analysis than that done for SICTI Version 1. New areas included are: (1) request, register and follow-up of lab exams and treatment indications, (2)

clinical and nurses' evolution registering, (3) enable for hydric balance automatic report generation, (4) clinical variable evolution graphs generation and (5) broaden the set of statistics produced.

Then, the team faces three possible development models.The first one, based on absolute original research and modelling approach, the second, by basing the development on the OpenEHR framework and, the third, using the HL7 reference information model and refinement techniques. Table 1 presents dimensioning that was considered for comparison. A short explanation of each area and criteria for evaluating follows:

- Data Model: RIM from HL7, RM from OEHR and a possible "original" one. Evaluation is focused on the capacity of the model to represent different clinical domains.
- Persistence solution. Evaluation refers to the maturity of persistence layers and database solutions in order to register and retrieve clinical data.
- Terminology integration. Integration of clinical terminology is particularly necessary for this kind of systems. Evaluation refers to the capacity and simplicity of each model to integrate terminology into the system.
- Adaptability. The openness of the models to represent different clinical realities without having to undergo structural changes.
- Maturity refers to the time and systematic development of the different initiatives.
- Re-usability refers to the possibility of implementing different systems based on the same model. Two level designs from OpenEHR and refinement and specialization from HL7 are compared.
- Cost refers to accessing to code, support, specifications, manuals, communities. Maintenance, low reusability and required reengineering costs are included.

Table 1 Compare: OEHR, "original" and HL7

	OEHR based	Original Development	HL7 V3
Data Model	+++	+	++
Persistence solution	+	+	+
Terminology integration	+++	+	++
Adaptability	+++	+	+
Maturity	++	+	+++
Reusability	+++	+	++
Costs	+++	++	++

Based on this analysis the team opts to develop SICTI based on OpenEHR, setting aside HL7 and the possibility of a fully "original" research and development. Development then concentrates in validating the two level design methodology and tools.

SICTI Business layer development starts with OpenEHR version 0.95; then, version "1.0 release candidate". None of these versions is fully implemented in Java. The team develops the lacking routines and modules.

The team also derives a simplified ADL [8] syntax in XML for archetype design. An archetype parser is also defined to read and load these archetypes into the archetype object model. Once parsed and loaded the AOM provides an interface to use the loaded archetype for validation.

A simple prototype is developed running on JBoss and validating inputs from a web page. The archetype concept and methodology is therefore successfully tested. Changes introduced to archetypes generate behaviour changes in the prototype without having to change code in the business layer.

5. Prototype

Development numbers:

A. 25 archetypes, 3 templates and 16 dictionaries were developed.
B. Four forms with 60 inputs in 6 JSP files..
C. 38 Java classes implemented which include dynamic web interface generation from information registered in templates and archetypes.
D. 15 classes were replaced in order to create our parser. Three grammar files to be used by the parser were also defined.
E. 54 AOM classes already coded by acode.se were used. Some routines were missing and were coded by the team.

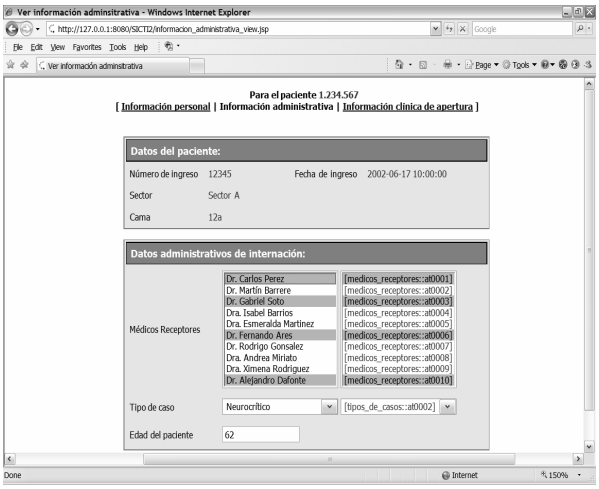
The prototype development where some parts of the java code available was replaced by our code exposed limitations of the current specifications implementation but also required a deeper understanding of the mechanisms designed. This work enabled us to identify potentialities not exploited nor suggested yet.

6. Technological transference

Tertiary work implies teaching, research and reaching out to society. In the case of NIB, this translates into development of equipment for clinical installations expected to go beyond the University environment [9][10].

With the OpenEHR based prototype is developed and functional, the NIB expects to pick at least three medical institutions with whom to develop a pilot run of a whole year, covering all service areas of their intensive care units. As a result, these institutions would obtain an application absolutely adjusted to their environment in turn this would provide an important environment to test adaptability and validity of the methodological approach proposed by OpenEHR.

Figure 2. SICTI prototype interface



SICTI version 1.0 is at use in four Intensive Care Units in Uruguay (IMPASA in Montevideo, CAMEDUR in Durazno, Public Hospital in Rivera, GREMEDA in Artigas). This version has allowed these health centers reduce their dependence on paper documentation, as well as to standardize information sets relevant to care and procedures carried out on patients, and to produce statistical reports to monitor basic management processes.

7. Future Work

From this work the team has identified a group of areas to explore and deepen the research work. The first one is linked to the development of a persistence model to support the openEHR reference model (RM). Options range from using object oriented databases, using relational databases and paths based on XPath [11], which allow for identifying any piece of information in the reference model.

Another line to explore is the use of paths to define non hard-coded solutions for decision-making support as well as to generate statistic bases on service quality and management. The fact that OpenEHR can reference all its information through paths makes this solution possible.

8. Conclusions

This work performed by NIB within the SICTI project has proven and validated the OpenEHR initiative and methods.

The knowledge gained on OpenEHR has allowed the team to understand in depth the "two level modelling" concepts, as well as on the associated issues the team has to face in order to implement OpenEHR. This expertise has allowed us create codes for routines not implemented by acode.se and supplementary codes respecting the OpenEHR framework structure.

To sum up, we have gained knowledge on how to develop a real system based on OpenEHR, with its full potential being its capability to build documentation fast and efficiently.

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