Towards a Better Understanding of EHR Systems using Architectural Views

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Abstract: The content of this paper addresses the issue of understanding electronic health records (EHRs) systems under a developer perspective on the existent confusion about this concept. The current standard definition of EHR is discussed in terms of the main characteristics, data models and functional decomposition for clinical research. The key components of these models are identified and specified under two considerations namely, direct care and support. Also they are organized in architectural views describing an EHR system infrastructure for records management. The value of this work is the architecture centric approach by creating graphical representations of the system architecture based on top level standard descriptions.

1 INTRODUCTION

All healthcare and scientific authorities worldwide are realising the importance of developing global infrastructures for exchange of patient and healthcare data, services and provide wider opportunities for clinical research. In European countries health policy is influenced by the developments at the international level and by the standards set by the World Health Organisation (Ribeiro et al., 2010). Enabling EHR systems implementations provides many benefits, including improved access, quality and efficiency of patient care, as well as promoting research and coordination of services at lower costs (Vdovjak et al., 2012) (Bonney, 2012) . Nowadays an integrated system in the health care domain represents one of the most challenging problem. Its realization is not only difficult, but also poorly understood by system developers. The literature very clearly indicates that a clean, simple and easy to operate concept of an EHR system does not exist (EHR-IMPACT, 2008). Among the requirements and constraints that have to be satisfied we can mention a higher diversity and complexity, increased quality, productivity and reuse content, standardization. Due to the escalating complexity level of EHR systems and the technology trends, a coherent and integrated strategy for EHR systems development is required.

Architecture-based development of a system is a solution to solving these problems. There are well-known benefits of the introduction of this concept in the life-cycle development of software systems. Architecture is considered the first asset in an architecture-centric development process and from this point of view an analysis at this level should reveal requirements conflicts and incomplete design descriptions from a particular stakeholder perspective. Many research efforts have been concentrated on ensuring that these major issues are addressed at the architectural level.

This paper introduces the EHR vision shedding also light on the existent confusion about this concept. In literature several types of health records have been used with approximately the same meaning. The current standard definition of EHR is discussed in terms of the main characteristics and their variability of levels in sharing patient health information. Thereafter, the key components of an EHR system are identified and discussed under various considerations.

In particular, the rest of this paper is structured as follows: Section 2 presents an overview of the EHR definition and architecture-based software systems development concepts. The major concepts that could be included in data and functional models with the focus on architectural structural and behaviour views are detailed and graphically represented in section 3. Conclusions state the value of

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architecture-centric development of integrated EHR systems.

2 EHR OVERVIEW

The idea of EHR was born as an alternative to an existent healthcare system (Waegemann, 2003). The added value of EHR services aims to improve patient safety, quality and efficiency of patient care, and reduce healthcare delivery costs. (Hoffman and Podgurski, 2008). The major value of integrated EHRs is that they collect data once, then use it multiple times to serve different needs of the administrator to obtain data for billing, a nurse to report an adverse reaction, and a researcher to analyze the efficacy of medications (MITRE, 2006).

EHR has been a key research in medical informatics for many years. The literature provides several concepts that are used with approximately the same meaning including Personal Health Record (PHR), Electronic Medical Record (EMR), Electronic Patient Record (EPR), Electronic Health Record (EHR) and Computerized Patient Record (CPR). Most of them refer to the electronic collection of medical information, performed by the patient himself or herself, by a particular healthcare institution, or by a global, integrated system. Overall it is a systematic collection of electronic health information about individual patients or populations in a digital form. In particular, electronic health record is defined as *"digitally stored health care information about an individual's lifetime with the purpose of supporting continuity of care, education and research, and ensuring confidentiality at all times"* (Iakovidis, 1998). An idealistic definition and concept, probably not yet brought to real life is that *"EHRs are repositories of electronically maintained information about individuals' lifetime health status and healthcare, stored such that they can serve the multiple legitimate users of the record"* (EHR-IMPACT, 2008). EHR contains all possible health relevant data of a person and other health-related information, always established beyond an institutional framework (regional, national, global), web-based, and participation of citizen in creating the record (Edwards, 2007). HIMSS Analytics differentiates between EMR and EHR in order to reduce confusion (Garets and David, 2006).

EHR complexity resides in a multitude of interdependent elements which must be organized. To handle this complexity, a software architectural (SA) approach is necessary as it helps to consider separation of concerns realized through different levels of abstraction, dynamism and aggregation levels and (static/dynamic, local/global, functional/extra-functional) (Dobrica and Ovaska, 2010). As is often the case in the field of eHealth, the knowledge acquired in software engineering is not really exploited, although it helps to manage complexity. In particular, they can be used to develop EHR systems architecture. SA description is designed to address the different perspectives one could have on the system. Each perspective is a view (Bass et al, 2011).The information relevant to one view is different from that of others and should be described using the most appropriate technique. Several models have been proposed that include a number of views that should be described in the software architecture. The view models address the static structure, the dynamic aspect, the physical layout and the development of the system. In general, it is the responsibility of the architect to decide which view to use for describing SA.

3 EHR SYSTEM MODELS

A clear distinction is made between the EHR and an EHR system. The standard ISO/TR 20514:2005 discusses about two different views of the scope of the EHR, which are Core EHR and Extended EHR. Core EHR is limited to clinical information and is defined by the requirements for its record architecture. It is based on *the adoption of the system-of-systems approach*. This allows more modular health information systems to be built, ranging from a *simple environment* with just the EHR, a terminology service and some reference data, to a much bigger and more *elaborate environment* including many additional services such as decision support, workflow management, order management, patient administration, billing, scheduling, resource allocation, etc. Extended EHR is a superset of the Core EHR and includes not only clinical information, but the whole health information landscape.

Currently there is a standardization effort towards consensus on EHR system functionality (ANSI/HL7 EHR CRFP, 2009) in the definition of an EHR system functional model and functional profiles for various dedicated functionalities including clinical research (EHR-CR) (ANSI/HL7 EHR CRFP, 2004). The EHR system functional model is decomposed in three important sections: Direct Care, Supportive and Information Infrastructure. These sections gather functions which are grouped in several important categories and sub-categories. An UML Component diagram as shown

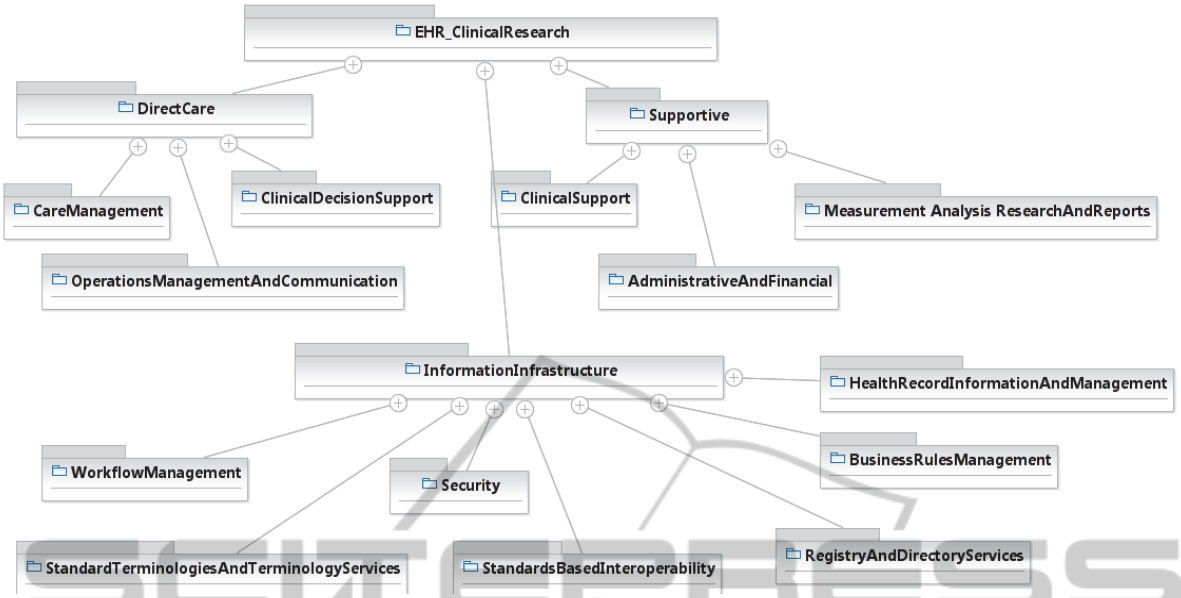

Figure 1: EHR – CR functional model.

Fig. 1 presents the EHR functional model for a better understanding of the domain, concepts and relations among them.

EHR-CR data model may be graphically represented as an UML Class Diagram. Complex data types specified by names, attributes and operations are interconnected based on composition, aggregation, generalization or other association relationships. The static aspect is represented and realized by attributes and behaviour/ dynamic aspect is visible and realized by using operations of classes. HL7-CR Direct Care Data Model includes classes such as *Electronic Health Record, Patient, PatientRecord, Demographic Information, PatientDeographics, KeyDemographic Information, PatientHistory, etc*. PatientRecord Class includes attributes such as ID, Name, Demographic Information, LabResults, Current medication lists and Problem List. Behavior is given by operations like create, identify, maintain and, calculatePatientAge.

A standardized solution of EHR Records Management based on a HL7 needs to pay attention to six key infrastructure components: security, health record information and management, standard terminologies and terminology services, standards-based interoperability, business rules management and workflow management. A conceptual structural view, based on UML component diagram is represented in Fig. 2.

4 CONCLUSIONS

In this paper we analyzed the recent standards on EHR-related concepts to facilitate exchange of EHRs between EHR systems. The aim was the understanding of standard requirements in order to develop compliant EHR systems. Our method was based on architecture-centric software systems development. The current standard definition of EHR concept has been discussed in terms of the main characteristics, data models and functional decomposition for clinical research. The key components of these models have been identified and specified under various considerations namely, direct care and support. Also they have been organized in architectural views describing an EHR system infrastructure for records management. The value of this work is the architecture centric approach by creating graphical representations of the system architecture based on top level descriptions of standards.

Our approach based on architectural views has an immense potential to improve the understanding of EHR systems as well as reduce time and risks in development stages. However, for this approach's success it is necessary to create a cooperation culture among stakeholders.

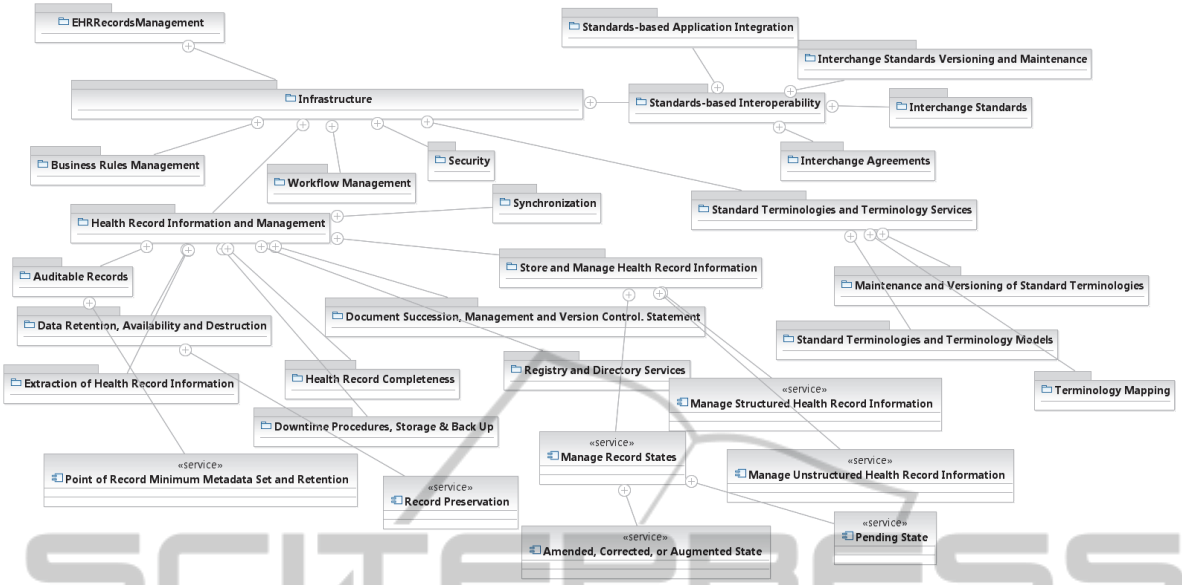

Figure 2: HL7 EHR records management profile.

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