Implementing the OpenEHR electronic medical record in content management systems: Similarity between archetypes and content

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ABSTRACT
This article describes doctoral research motivated by the challenges arising from efforts to achieve semantic interoperability in Electronic Health Records (EHRs) via the OpenEHR standard. The research carried out the implementation of OpenEHR information models that provide semantics to archetypes. By evaluating the implementation of EHRs in CMSs compared to implementations made from scratch, the research analyzes the necessary requirements for the implementation of EHRs in CMSs. This theoretical effort allowed to establish a theoretical argumentation, of general scope, regarding the concepts of archetype and types of CMS, which shows the similarity between the concepts of archetype and content. This result establishes a close relationship between these two concepts from different domains, expanding the understanding and possibilities of building this type of software in content management systems, in general.

Keywords: Electronic Health Record, Interoperability, OpenEHR Archetypes, Content Management System.

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INTRODUCTION

The electronic patient record (EHR) made by archiving in individual forms presents problems (Massad, 2003) such as illegibility, ambiguity, reading mistakes, absence and loss of information, among others. Thus, the Electronic Health Record (EHR) was proposed to organize and streamline the registration and access to clinical information.

However, increasingly, patient records are distributed in databases of different hospital and clinic information systems. Hence the worldwide effort to achieve interoperability between these systems, aiming to exchange data, make information available among professionals and to the patient himself. The OpenEHR standard[2] aims to enable interoperability between EHR systems (Beale; Heard, 2008), representing clinical knowledge via metadata patterns called "archetypes". Manageable by medical experts represent complex concepts such as "blood pressure" or "family history", allow the reuse of clinical knowledge, well specified and validated by reference organizations (Nardon et al., 2008).

For the construction of reusable archetypes, the standard specifies a reference model, stable core that defines the generic building blocks for the archetypes, and a model of archetypes that express domain knowledge (Beale, 2002). Thus, for the creation of EHR software that expresses clinical information, it must first be ensured that such specifications are implemented. The results of this effort are described in a previous study (Pessanha; Bax, 2015).

Thus, once this possibility is verified, the gains brought to the management of clinical information by its implementation in content management systems (CMS) are analyzed. As an initial result, necessary for the development of this step, is the analysis of the requirements for the implementation of OpenEHR archetypes as content in CMSs. Only after the accomplishment of the previous stage, by extensively listing such requirements, a comparative analysis between these two key concepts for this research is viable.

Such combined efforts made it possible to obtain a comprehensive result, whose scope extends to CMSs and archetypes in general, namely: the similarity between the concept of archetype and the concept of content in CMSs. This result establishes a theoretical connection between these two concepts, previously devoid of any formal approximation, clarifying advantages arising from the implementation of EHRs in CMSs.

It is in the context specified above that this research presents contributions to the generic problem of health information management.

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2 OpenEHR, institutional page: <http://www.openehr.org/pt/home.php>

STRUCTURE OF THE ARTICLE

The order of presentation and themes of each section was defined as follows: Section 1 introduction; Section 2 describes the factors that motivated the development of the research; Section 3 deals with *the design science research methodology*; Section 4 exposes the aspects related to semantic interoperability in EHR; Section 5 presents the dual model and ontologies, foundations for the OpenEHR standard; Section 6 lays out the OpenEHR standard, details of the formulation of the CIR ontology, which serves as the basis for its reference model and its knowledge model or archetypes; Section 7 presents the analysis concerning the implementation of EHRs in CMSs and the elements and analysis that allowed us to conclude about the similarity between the concepts of archetype and content. Finally, Section 8 presents the conclusions of the research.

MOTIVATION

One of the great motivators for the adoption of archetypes in the construction of applications is the prospect of reusing well-specified clinical knowledge validated by reference organizations. Therefore, it is essential for EHR programs that seek interoperability to adapt to standards aimed at this end, such as OpenEHR.

According to Kobayashi and Tatsukawa (2012), current OpenEHR implementations provide resources for approximately 25% of *software developers.* In this way, expressing archetypes in Python (something that does not yet exist) makes it possible to manage clinical information on this platform[3]. The details of this result, in particular, are detailed in (Pessanha; Bax, 2015).

Finally, to carry out an analysis that shows, to the proponents of such systems, the possibility and advantages of using a CMSs framework for the implementation of PEP/RES type systems, according to the OpenEHR standard.

METHODOLOGY

The need to deal with issues of a practical and theoretical nature, nested and interdependent, led to the adoption of *design science research*[4] as a guiding paradigm for the methodological trajectory of this research. In the specific case of information systems, we work with the creation of new knowledge through the design of algorithms, interfaces, methodologies, among other practical results.

3 TIOBE Index, institutional page:<http://www.tiobe.com/index.php/content/paperinfo/tpci/index.html>
4 We chose to use the original term "*design* science *research*", since the translated term has not been adopted, at the time of writing this work, to have been adopted in the academic literature researched.

Thus, one works with formal as well as material or empirical knowledge. In fact, this research sought, at first, to express OpenEHR archetypes in Python, in an empirical effort. Next, we worked on the possibility of implementing OpenEHR RES in CMSs, in a broad theoretical effort of analysis.

As its essential characteristic, *design research* emphasizes the link between two natures of problems, practice and knowledge, showing that scientific knowledge can be produced through the *design* of useful artifacts (WIERINGA, 2009).

Thus, the context of this research, permeated with problems of different natures, nested and influencing their solutions in a chained way, is consistent with the *design research methodology*.

SEMANTIC INTEROPERABILITY IN RES

The scenario in which EHR systems are found is characterized by heterogeneity, as a result of informational complexity arising from the various medical specialties, terminologies, cultures, languages, as well as the various existing systems. Factors that explain the importance of achieving semantic interoperability for EHR systems.

The semantic aspect must be considered, i.e., the various interpretations that data receive in different contexts of information systems. This makes the integration of health information systems a complex process. Integration is the arrangement of an organization's information systems into a single system. Interoperability is the ability of information systems to work together, both internally and externally to organizations, promoting effective service delivery (HIMSS, 2010). Thus, interoperability implies information systems aggregating their strengths without altering their autonomy and characteristics (Sheth, 1999). At the semantic level, the meaning of the shared information is guaranteed by the sharing of a common vocabulary.

According to Kalra (2007), the international community considers semantic interoperability between EHR systems essential for the future of health services, and the use of terminologies, ontologies and archetypes composes this challenge. Nardon (2002) points out that, from a technical point of view, the challenge of interoperability and the complexity of information makes the development of such systems more difficult than that of other information systems.

KNOWLEDGE REPRESENTATION AND ONTOLOGIES: DUAL MODEL

By implementing, at a single level, complex and highly demanding systems such as EHR systems, a system that is difficult to maintain, has a short service life and is high cost (Beale, 2007). The two-level approach of A.I. knowledge representation proved to be adequate to avoid these consequences.

THE DUAL MODEL

The development of such systems requires the abstract specification of the domain and then codified into an appropriate language. Thus, a system concentrated in knowledge and unrelated to specific code, external to the system, is generated. This brings advantages such as **ontological or knowledge engagement** (meaning that the logical sentences that describe the specification have a more direct relationship with the domain being modeled), readability, inference, semantic fidelity, reusability, and portability of knowledge.

ONTTOLOGIES

When searching for domain knowledge, detached from implementation, the ontological level used in the description of the knowledge system becomes important. Guarino (1995) proposed, for such systems, an Ontological level, where the meaning associated with a language of knowledge representation could be formally restricted.

Ontologies can be seen as a contemporary response to a need for knowledge-based systems. One purpose is to favor the sharing and reuse of knowledge stored in different systems. The latter, before the predominance of the Internet, could not be shared or reused. In general, it was organized in isolated knowledge bases, in different languages, without integrating interfaces, and therefore without interoperability.

A definition of ontology from Computer Science states that: "an ontology is an explicit specification of a conceptualization" (Gruber, 1995, p.1). For this author, all formally represented knowledge is based on a conceptualization: objects, concepts, and their supposed relationships. This conceptualization is a **simplified and abstract view of the world** one wishes to represent.

Guarino (1995, p.2) defines ontology as: "a logical theory that explicitly and partially explains a conceptualization". Thus, an ontology provides an understanding of a shared conceptualization of a domain, a common vocabulary free of ambiguity. Ideally, any instance that makes use of a domain's data and metadata should adhere to the corresponding ontology.

An ontology requires a domain-specific vocabulary and a set of logical axioms that will ensure the semantics to the desired meaning of the vocabulary terms. Thus, two ontologies can have different vocabularies and refer to the same conceptualization, that is, to the same domain.

The organization of concepts as well as semantic integration, enabling interoperability between systems is done through the development of ontologies, which contextualize the data and give them meaning. If the term "allergy" is recorded in an EHR, it implies that this data has the same meaning as the term "allergy" in the ontology, hence the need for a correct and consistent mapping between the information model and the terms of the ontology (Cannoy; Yier, 2009).

As for terminologies, the **application of ontologies to the domain of RES** makes them logically more coherent and intuitive to common sense, even if they are intended for interpretation by *software* (SMITH; CEUSTERS; TEMMERMAN, 2005).

SEMANTIC INTEROPERABILITY IN RES: THE OpenEHR standard

Making EHRs interoperable is a prerequisite for supporting distributed health systems (Chen, 2009). To this end, it is necessary to use reference models, clinical data structures and terminologies, preserving the semantics of the knowledge domain, updating and retrieving data in a consistent and unambiguous way.

Given the need for theoretical robustness in clinical information models, seeking interoperability, computability, scalability, economic feasibility and performance, an ontology was used to develop the formal basis of the OpenEHR model.

THE GENERATION OF INFORMATION IN CLINICAL AND BUSINESS PROCESSES

The ontology of clinical information described by Beale (2007) starts from two types of process: the clinical process, which describes the interaction between the clinical investigation system and the patient; and business, which contains the clinical and administrative context.

And, aiming at the serialization and exchange of messages between information systems, the types of information created in these processes are listed in five distinct types that can be created during the patient care process (Figure 1): **observations**, information created by an act of observation; measuring, questioning, or testing a patient or related substance; **opinions**, inferences made by the researcher; **instructions**, observation-based instructions; **actions**, recording of intervention actions that occurred via instructions or other cause; **Administrative events**, logging events in the administrative context.

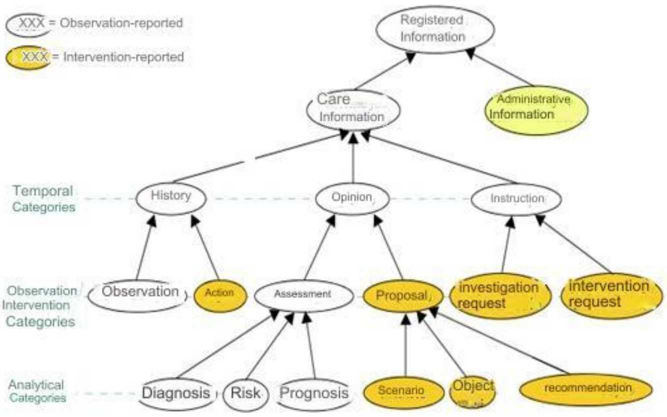
Figure 1 - Information Created by the Clinical Investigator

Source: Translated by Beale (2007)

THE CIR ONTOLOGY AND THE OPENEHR STANDARD REFERENCE MODEL

Based on these categories, Beale (2007) proposes an initial ontology, which situates the types of information with respect to the categories of administrative information (*admin information*) and care *information*. This ontology, plus necessary categories, results in the **ontology of clinical information** or CIR (*Clinical Investigator Record) ontology*, as shown in figure 2:

Figure 2 - The Ontology of Clinical Information (CIR)



Source: Translated by Beale (2007)

For an understanding of the CIR, it can be categorized as an ontology of information. Which deals with any type of information, entities that have a commitment to some type of medium such as written, audiovisual, etc. In short, something of the reality that is being recorded and has characteristics such as the type of registered entity, notes, test results, diagnoses, structure of the records made, relationships between recorded information, etc.

Thus, the CIR ontology is defined to deal with health information. Archetypes are not descriptions of real things, but records of something that aroused the interest of the health professional during the clinical process. Thus, guided by the categories defined in the CIR ontology, health professionals, when entering information via forms, will do so in a more intuitive way and with a lower learning curve, as their categories correspond to information generated during the workflow of these professionals.

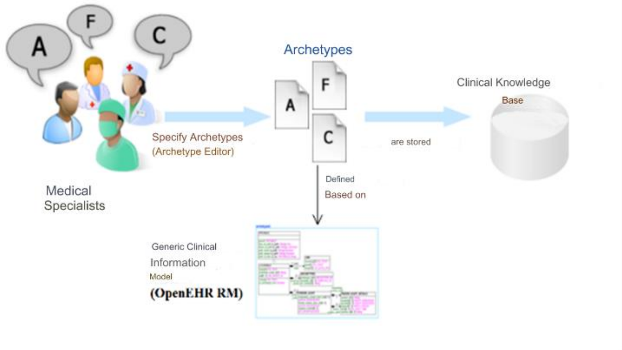
Since the **OpenEHR reference model**, based on the CIR ontology, is generic, how can specific clinical concepts, such as the patient's blood pressure, be represented? It can be seen, however, that there is a concept of the CIR ontology focused on the expression of measurements about the patient: **observation**. Therefore, blood pressure will be defined as an observation. But then the question arises: how to express the particularities of this observation? The answer to this question will lead to the knowledge model proposed by the OpenEHR standard, or archetype model.

THE KNOWLEDGE MODEL OR ARCHETYPE MODEL OF THE OPENEHR STANDARD

Taking as constituent elements the clinical information models, which allow the representation of general clinical concepts, we arrive at the **knowledge model** of the OpenEHR standard, which aims to represent particular clinical concepts (unlike the reference model, which represents general clinical concepts and resides within the software).

Particular clinical concepts are represented as a set of constraints on the generic information model. Through two-level modeling, the medical staff determines the characteristics of the health record that are most appropriate to their needs, creating the archetypes that will compose the clinical knowledge bases, as shown in Figure 3.

Figure 3 - Construction of Archetypes by Medical Experts



Source: Translated by Gutiérrez and Carrasco (2013)

From the perspective of the restriction to the reference model, the archetypes can be seen as Martínez-Costa *et al.*:

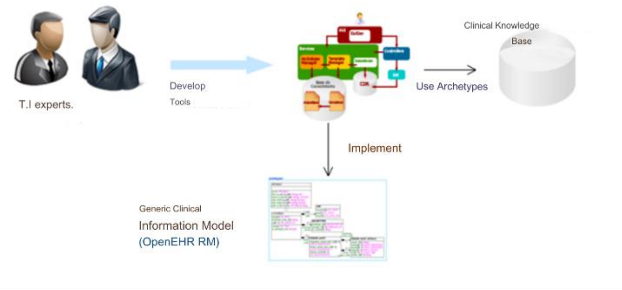
> Archetypes apply constraints to objects, which can be considered descriptors of the ontological levels of the domain, defined in a reference model. Archetypes bridge the gap between the generality of the concepts defined in the reference model and the variability of clinical practice, thus becoming a tool to represent these concepts (MARTÍNEZ-COSTA *et al.*, 2009, p.151).

The **archetype model**, therefore, can be seen as **a metadata representation** developed to organize and standardize data from knowledge domains. Through archetypes, clinical concepts are captured structurally **outside** of the *software*.

Archetypes can be described as a formal and reusable model of a domain concept that, represented by an archetype, can be reused in various scenarios that require its application.

Once the archetype repositories have been created, they can be used by information technology specialists to create EHR programs (Figure 5) respecting the division proposed by the dual model.

Figure 4 - Construction of Applications by IT Specialists



Source: Translated by Gutiérrez and Carrasco (2013)

In addition to fostering greater reuse of knowledge, the use of archetypes can be seen as a possible solution to the heterogeneity of health information. Thus, EHR systems based on the archetype model can be updated under the supervision of medical teams, even without generating system disruptions.

METADATA-ORIENTED FRAMEWORKS: CONTENT MANAGEMENT SYSTEMS (CMS)

CLINICAL INFORMATION, METADATA, AND CMSS

When looking for a technological solution that allows working with OpenEHR archetypes, it must be taken into account that we are not working with data processing, but with information at a higher level of complexity, coming from the various medical specialties, demographics, terminologies, etc.

Therefore, there is a need for a thoughtful architecture, not only to deal with data, but to manipulate information at a level of complexity and granularity that comes from the nature of clinical information. Every clinical document shares specific information and several common properties such as terminologies, persistence, coherence, completeness, ability to be read by a human being, authenticity, validity, among others.

The second level involves the use of metadata structures that can be processed between senders and receivers of clinical information, seeking to enable semantic validation of such information. In the case of OpenEHR, these **metadata** structures are called **archetypes**, which can be seen as a representation of metadata designed to organize, standardize, and share data from knowledge domains. Without loss of generality, metadata is understood in the context of this research as:

> Metadata is what you need in addition to the data itself to understand and use that data. Metadata acts as instructions that come along with the data. On the other hand, metadata is what will not be seen if you only look at the data itself. Metadata exists in addition to or behind the data. They add context and a more extensive interpretation to the data (BOIKO, 2005).

According to Pessanha (2014), such metadata is of fundamental importance for the construction of knowledge artifacts, being an indispensable part of the very nature of archetypes. This finding is reinforced by the comment made by Nadkarni (2011, p.1) to Marco's (2000) observation when he states "When we talk about metadata, we are really talking about knowledge.":

> From a practical perspective, this means that if you have metadata accompanying data, it means that you can do things with the data that would be much more difficult, or perhaps, impossible to do if that metadata didn't exist. Nadkarni (2011).

The same Nadkarni points out, according to the previous paragraphs, the adequacy of electronic health records in the category of metadata-oriented systems:

> Systems in biomedical settings—such as Electronic Health Record systems, clinical trial data management systems, and basic research laboratory information management systems—are ideal candidates for the application of metadata-based techniques. (NADKARNI, 2011).

In the context of archetypes containing highly complex structured information, the concept of knowledge capitalization (Arancon et al, 2008) naturally associates metadata-oriented systems and content management systems:

> Knowledge capitalization covers a group of applications devoted to managing content, documents, and information, structured in such a way as to allow users easy access to knowledge and addition or modification of data. Currently, different solutions are available for such purposes, under categories such as Content Management Systems (CMS), Document Management Systems (DMS), wikis, dynamic web portals, search engines, etc. (ARANCON et al., 2008).

CONTENT MANAGEMENT SYSTEMS (CMS): DEFINITION AND CHARACTERISTICS.

Content management refers to the system and processes where information is created, managed, published, and archived. A content management system (CMS) provides the necessary infrastructure for multiple people to effectively contribute to content and collaborate throughout its lifecycle (SUH et al., 2003).

From this characterization of CMSs, it is possible to verify their insertion in Information Science as information management systems. According to Han (2005, p.356): "[A] ideal CMS is an **information management system** that preserves, organizes, disseminates, and manages locally developed documents and external documents with associated metadata."

Thus, when positioning the archetypes next to the CMSs, they are also positioned next to information management, therefore, next to Information Science. And, due to the importance of metadata in CMSs, according to Boiko, it can be included in the category of metadata-oriented systems:

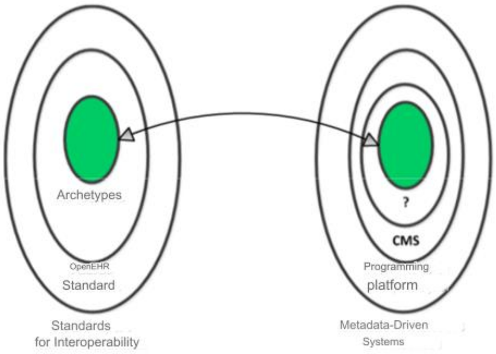
Metadata is critical, not only to enable the CMS to integrate with other disparate data sources, but also to enable the CMS to unify and make more efficient and automated use of the functionality and information it manages. [...] If management is the art of naming information, metadata is the set of names. In other words, content management is all about metadata. The metadata system behind a CMS is what defines the system. The set of names and relationships contained in the metadata-oriented framework is the skeleton in which content is allocated. Without this structure, the contents become shapeless and flabby like a human body without bones (BOIKO, 2005).

ARCHETYPES AND CONTENT: CONCEPTS FROM THE CMS AND OPENEHR DOMAINS.

Once the perception of the CMS as metadata-oriented was achieved, it was possible to understand archetypes as metadata structures, as well as to verify that an EHR system can fall into this category.

The above scenario allows the correlation between a metadata structure, the archetypes, and their counterpart in a metadata-oriented system, in this case, the CMSs. Such correlation between elements belonging to different domains (Figure 6) opens up possibilities for the construction of RES/PEP software and the management of its knowledge artifacts with a better cost-benefit ratio than that proposed by the OpenEHR architecture.

Figure 5 – Correlation Between Elements of Standards for Interoperability Versus CMSs



Source: Pessanha (2014)

It is necessary, therefore, to find in the architecture of CMSs, the concept whose properties and functions are similar to those of the archetype concept. **It is essential to obtain the similarity between these concepts if the management of archetypes via CMSs is sought**.

The concept of content, defined by Boukar due to its similarity with the central notion of archetypes (information plus metadata), is presented as a support for its representation in the domain of CMSs:

To manage content, it is necessary to contextualize the information. In practice, content is information enriched with data. Basically, content is a suite of structured data that a computer can organize into a system for its collection, management, and publication. [...] It is information plus a layer of datasets [metadata] in a specific context (BOUKAR, 2012).

Similarly, Boiko defines content as a function of information and metadata, reinforcing the perception of conceptual equivalence with archetypes:

> Content, therefore, is information that is labeled with [meta]data and gathered into collections that a computer can organize, systematize, manage, and publish. Such a system, a content management system, is successful if it can apply [metadata-oriented] methodologies to its data without losing the interest and meaning of the information along the way (BOIKO, 2005, p.495, emphasis added).

The same Boiko (2005) clarifies that a content management system can be seen as a balanced interaction between entities such as authors, types of content, publications, workflow, among others, whose balance is maintained by the metadata, between the forces of these entities that define it. It is the metadata that holds the system together and gives it its shape. This high degree of abstraction of CMSs is in line with the characteristic of independence of hardware and software on which the system is built. Rather, it presents itself as an organizational process to collaboratively align competitive forces in order to gather and provide valued content.

Thus, the central role played by the concept of content in CMSs and its relationship with metadata can be seen, as metadata and content types are strongly related to each other. Most of the metadata is stored in the elements of the content types that are defined. Content types can be seen as portions of information or functionality wrapped in metadata. Thus, the close similarity between the concept of content types and the concept of archetypes is evident, not only in terms of the concepts of information and metadata, but also in terms of the concept of reuse.

It was argued that the concepts of archetype and content can, in their respective domains, be considered similar, it is now necessary to verify if such similarity persists in the functional aspect that involves the archetypes.

The question to be asked is: If content is the conceptual similar, in the domain of CMSs, to the concept of archetypes, does the former have an analogous instantiation mechanism, which allows its *reuse* in the system defined in this domain? The answer to the previous question can be answered by the concepts of the domain of the CMSs called, content model, content types and content components, whose importance in the system is highlighted by Boiko:

> At the heart of any content management system are groupings of information that are reusable across your various publications. Each of these groupings, which I call content components, originates from a group that I call the content type. Dividing your information into types is the first and greatest step in becoming able to manage the creation and distribution of your information (BOIKO, 2005).

These three concepts must be understood in an abstraction hierarchy in which the content model is presented as the most abstract level (analogous to a data model), and which deals strictly with how information is stored. Next is the type of content (analogous to classes in Object

Orientation), which refers to what the information is, finally the types of content (they would be like the instances of the types of content), enabling the creation and storage of content of various types, such as a news item, a media file, a form, among others.

> [...] When you create and store content, you're creating portions of content that can be of various types. These portions are called components. Components are portions of content that follow the content model defined for a particular content type (BOIKO, 2005).

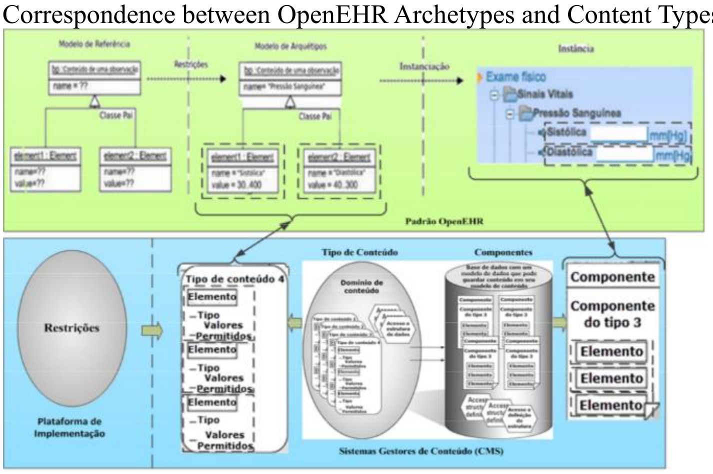
Since we seek to identify a functional isomorphism between elements of the domains of the CMSs and the OpenEHR standard, the conceptual scheme and the discussion presented allow us to confirm, in response to the question previously posed, the relationship between content types and archetypes, as well as between content components and instances of archetypes.

Seeking to present this correlation in a more intuitive way, Boiko uses an analogy with object-oriented programming that applies to both the OpenEHR/archetypes domain and CMS/content:

> As a programmer of object-oriented languages, the content architect creates content classes (called content types) and content instances (called components). The class/type defines the general structure and the instance/component the specific content within the general structure of the system (BOIKO, 2005).

Thus, content types divide the information you need to deal with into manageable chunks of convenient size. To this end, content types are defined in order to establish a set of content objects that can be created, maintained, and distributed. In the CMS, content is stored in the form of components, which are instances of particular content types.

Figure 6 – Correspondence between OpenEHR Archetypes and Content Types in CMSs



Source: Pessanha (2014)

CAVEATS REGARDING THE REPRESENTATION OF OPENEHR ARCHETYPES AS CONTENT

Once the similarity between the concepts of archetype and content, instance of archetype and content component has been discussed, it should be noted that, despite the guarantee that, as previously stated, every CMS has a content model, this does not necessarily imply an immediate facility to express oneself and use any archetype published as content.

The requirements for the expression of the instances of the classes of the reference model and of the archetype(s) with which one wishes to work must be confronted with the possibilities of content modeling expressed by the content model and the data model of the CMS with which one intends to work, as the latter is built on a particular development platform to meet established requirements and, Such requirements may not be compatible with those necessary for the expression of an archetype.

IMPLEMENTING RES/PEP VIA CONTENT MANAGEMENT SYSTEMS (CMS)

The possibility of representing archetypes via content in content management systems opens up possibilities for the agile development of PEP/EHR systems not implemented "from scratch". Consequently, it avoids the expenditure of time and effort in implementing the steps and components necessary for the solution that follows this path. Expressing archetypes as content in a CMS makes prototyping interfaces more intuitive and less expensive. Combined with the natural content management capacity of CMSs, it allows us to deal with one of the problems that, according to Lusk (2002), most lead to failures in systems of this nature:

> Many electronic medical records fail due to unintuitive data entry interfaces. [...] Many systems are inflexible and do not allow physicians to design an interface that satisfies their needs. A good electronic medical record system gathers information from other existing information systems and presents it in an intuitive and consistent format, acting as a universal interface for images, text, and access to legacy documents (LUSK, 2002).

The same author points out that the ideal electronic medical record should have an intuitive interface that models physicians' natural habits for entering and reviewing information. It must be adaptable to allow for the necessary variations in documentation, it must provide an easy entry of highly detailed information from any patient, efficient *workflow* for documentation, reducing the use of paper, as well as versioning, retrieval, security, scalability, robustness, *logging* and reporting. Such requirements can be met by systems built more efficiently and more cost-effectively on this type of platform.

RESULTS: CONTENT MANAGEMENT SYSTEMS AS A FRAMEWORK FOR THE IMPLEMENTATION OF RES/PEP SOFTWARE

Having obtained, through computational implementation, the certainty of the OpenEHR expression in python (Pessanha; Bax, 2015), the use of a systemic framework capable of meeting the stages of the construction of an RES/PEP software in the OpenEHR standard was analyzed, eliminating problems of traditional implementation.

The analyzed framework was restricted to content management systems. What allowed us to make the relationship between this particular type of software and the knowledge artifacts of the OpenEHR standard was the fact that archetypes are metadata structures, whereas CMSs are classified as metadata-driven systems.

The importance of metadata for this type of software is crucial, as it allows you to organize and standardize the knowledge of the domains worked as content. Content management systems enable the efficient and automated use of knowledge domain information through its representation via content.

The analysis carried out, having the concept of metadata as a background, made it possible to establish the argument of **conceptual similarity between archetypes and contents**, in a theoretical connection, previously non-existent, between the domain of content management systems and standards for the interoperability of clinical data.

CONCLUSIONS

Once the similarity between archetypes and content has been verified, future work should consider the construction of knowledge artifacts, in the form of content in CMSs, confronting the requirements of OpenEHR archetypes with the possibilities of different CMSs.

Such a result will enable proofs of concept, paving the way for future implementations of RES/PEP software as well as the comparison of the results obtained through the use of content frameworks with those obtained through "pure" coding.

Implementations and tests in CMSs, such as those proposed above, also make it possible to carry out tests involving the use of design patterns (Schmidt; Stal; Rohnert; Buschmann, 2000) such as MVC, an acronym for the *Model-View-Controller* pattern, which describe a reusable general solution to some recurring problem in the development of object-oriented software systems, which can be used in many different situations.

CMSs, while in principle they may allow the application of design standards, do not impose them a priori. This makes room for verification of possible performance gains of archetypes such as content applying the MVC pattern. A positive result would add value by allowing a tested, well-documented, and commonly known solution to be used in future RES/PEP developed on top of this type of platform.

In theoretical terms, the conceptual similarity between archetypes and contents positions the guiding theme of this research, that is, the use of standards for semantic interoperability in electronic health record systems, together with analogous research in the field of Information Science. More specifically, with Information Management research. Thus, the challenge of semantic interoperability in EHR is also seen and treated from the perspective of Information Science theory and techniques.

This adds value to the already existing search for solutions from the perspective of Computer Science.

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