Semantic interoperability in healthcare information systems: a top-level ontology based solution.

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Abstract. The amount of medical information has generated challenges for interoperability between health information systems (HIS). In the enterprise engineering context, is desirable the enterprise integration through interoperability of its systems. The semantic interoperability SI in HIS is the ability of such systems for exchanging data between themselves despite the different terminologies adopted. In seeking for ways to cope with issues of SI, one can find much research initiatives on subjects like vocabularies, thesauri, terminology, information models and ontologies. This paper describes the research carried out within a thesis in the construction phase, which general objective is to determine a top-level ontology based solution to provide semantic interoperability in HISs. This thesis is classified as a qualitative applied research. We hope to formulate a top-level ontology based solution to provide the semantic interoperability between the ontologies and terminologies which the healthcare information systems use.

Keywords: Semantic interoperability, health terminology, health ontologies, top-level ontology.

1 Introduction

The enterprises have operated in a complex environment where large information's volumes are generated every day. The information generated is presented in different formats and are stored in several information systems (IS) adopted by organizations. Such IS must be able to exchange information between IS different. The same organization is common to find a lack of integration and alignment between two or more departments, therefore it is possible to find in the same company over a system that deals with the same information, but these systems are unable to communicate and integrate between itself.

In order to deal with the complexity of business environments, modern organizations have employed practices of enterprise engineering, which allows them to build a set of best practices. In the enterprise engineering context, is desirable the enterprise integration where the organization will be able to interact with the business environment in which it is inserted furthermore the enterprise´s departments will be able to interact among each other, through interoperability of its systems. In the last few years, the adoption of the enterprise engineering becomes focus in various

organizations. The term enterprise engineering refers to the set of methods, models and tools applied to analyze, design and continuously maintain an enterprise in an integrated manner.

The scenario in the healthcare field would not be different. The healthcare field produces in daily basis a large information volume in multiple formats. The amount of medical information in addition to its complexity and variability, has introduced challenges to the research community. To organize and store the biomedical information, it is requires the adoption of IS. In this connection, the study on information retrieval and knowledge organization systems (KOS) for healthcare area has grown considerably in recent years. [26]

The major challenge faced by the health authorities is the integration between different types of information, according to its content and its nature. In fact, the lack of consistent standardization is one of the factors that prevent interoperability among HIS. To provide efficient and good quality healthcare services, the adoption of solutions for interoperability is necessary with the aim to allow the integration of HIS and sharing of information between the various health entities public or health entities private. Proposals for semantic interoperability (SI) between HIS could be information models or ontologies.

Although several researchers have been studying the relation between the registry of health information and your representation by ontologies as a solution for semantic pattern, a literature review revealed that these studies have not concluded whether the health entities (hospitals, clinics, laboratories) has been adopting the most appropriate standards for semantic interoperability on HIS. Moreover, it has not been possible to identify studies that show that terminologies, ontologies or models of information are more appropriate for achieving semantic interoperability between the various HIS adopted by a healthcare entity or between HIS from distinct healthcare entities, which support the EHRs.

So, one can observe that there are some gaps to be filled and, according to this observation, one can defined the following questions that reveal our **research problem** for the thesis project:

- A top-level ontology based solution could provide the semantic interoperability between the ontologies and terminologies which the HISs uses?

This thesis focuses on studying the issues related to the problem of SI between different HISs adopted by the healthcare entities. The **general goal** is to determine a top-level ontology based solution to provide semantic interoperability in HISs. In face these **specifics goals** are:

- To verify ontologies and terminologies, which are recommended by health authorities to provide semantic interoperability and which are usually adopted by healthcare entities.
- To analyze the mechanisms adopted by these ontologies and terminologies in trying to provide semantic interoperability and the advantages and disadvantages found in each one.
- To identify what level of semantic interoperability these ontologies and terminologies are providing to interoperate with another.
- To list the gaps from semantic interoperability found in these ontologies and terminologies to interoperate with another.

- To specify, based on a top-level ontology, a recommendation for a solution able to provide semantic interoperability concerning the gaps found.

This thesis is an initial state from the construction phase, the problem research, the general and specific goals were establishment. The methodology was proposal and isn't approved by the qualify exam. The next steps consist in to elaborate the theory background and to test methodology. After that, we are able to development the kernel of this thesis. The remaining part of the paper is organized as follows: section two approaches the related works with this proposal and the brief literature review needed to understand our proposal. The methodology is described in the section three. Finally, section four presents our final remarks.

2 Related works and literature review

One of the most important stages of a research project is the literature review. The literature review refers to the mapping of those who have written and what has been written on the topic and/or research problem. Moreover, delimits theoretical basis adopted to address the issues and the research problem. This section provide an overview of the important concepts to better understand this research and also review the related works existing about the research object.

2.1. Enterprise Engineering

The Enterprise Engineering Manifesto refers to enterprise engineering as emerging discipline that deals with development theories, models, methods and other artifacts for analysis, design, implementation and governance of companies in a theoretically rigorous and practically relevant way.[22].

The Enterprise Engineering (EE) theory is required to give experience meaning, and to provide the basis for appropriately understanding enterprises. It is the aim of EE to be theoretically, conceptually, and methodologically complete, in pursuing the next three generic objectives: Unity and integration, Mastering complexity and Employee involvement. [23].

A suitable classification scheme present in the EE theories (EE-theory) refers to the four classes distinguished: philosophical, ontological, technological and ideological. Each class refers one or more EE-theory presents in the Figure 1 below [24], where the arrows indicate the entire class of theory side of the arrow is based on a number of theories opposite class.

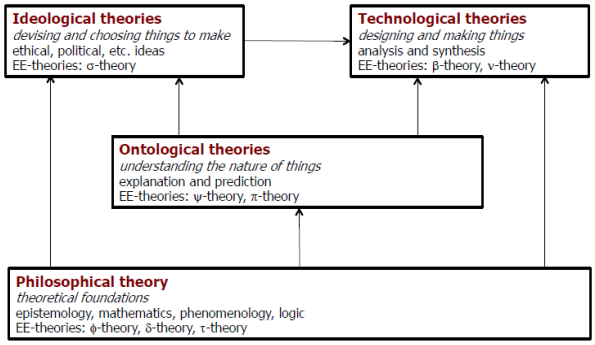

Figure 1: EE-theories versus Classes of theories. [24]

The EE-theory will be more detailed in the theoretical foundation of the thesis, and will be analyzed to determine what or which EE-theories are suitable for this research. The EE theory and concepts in this research are related to understand the healthcare enterprises and your relation with the environment which it's included. The related works listed above will be investigated to better contextualize this thesis in the enterprise engineering. We believe that the EE-theory related to ontological theories could be used to orient our work, than the enterprise ontology will be investigated [18, 20]. With regard to enterprise to have integrated systems and information, emerge the problems of enterprise applications interoperability [50]. The state of the art about interoperability is discussed in the section 2.3.

2.2. Knowledge organization systems and Ontology

The Knowledge Organization Systems (KOS), originate in the organization of knowledge and are known as models of knowledge representation and documentary languages [15, 59]. In the literature different types of KOS are described: Ontologies, metadata schemas, taxonomies, classification structures, web directory, thesauruses, dictionaries, folksonomies [51, 59].

The understanding about KOS is important to this thesis because the object of study is the ontology, which is identified as a type of KOS [58]. The term ontology is used in many research fields such as philosophy, computer science and information science, with different meanings [1]. For this research, it is important to understand the concept of ontology and the ontologies that theories have to offer and the related concepts. Related work that must be visited are described and justified below.

The concept about KOS and the relation with the ontology emphasis on ontologies as viable alternatives for knowledge organization will be approached from the aforementioned studies and in [63, 51, 15, 3, 59, 37].

An overview on the state of the art regarding ontologies, encompassing definitions for the term and discussions about its meaning, types of ontologies, proposed for applications in different fields of knowledge and proposals for building ontologies covering methodologies, tools and languages are included in [7].

The concept about ontology will be investigated by [1] that provides a recent clarification about Ontology. The differentiation between ontologies of information systems from ontologies for information systems is discussed in [27]. The principles for the design of ontologies used for knowledge sharing are discussed in [36]. According to [34] ontologies have well defined characteristics and common components. The basic components of ontology are: classes, relationships, axioms and instances. The basic ontology components will be explained in the future.

The ontologies can be generally classified into generic, domain, task and application ontologies, according to their level of dependence on a particular task or point of view. [39, 40]. An important contribution of [64] is his study on the use of "philosophical ontology" and "top-level ontology" to assist in troubleshooting integration among systems, facilitating the communication process and reducing the cost of propagating errors when correct them in the early stages of development.

We need to understand the conceptual basis for the top-level ontology and formal ontology we will be analyze the papers below [31, 39, 40].

Some important top-level ontology has been identified and should be further developed in the near future [6]. There are currently multiple top-level ontologies under development, e.g., the Descriptive Ontology for Linguistics and Cognitive Engineering (DOLCE), and the Basic Formal Ontology (BFO). In the context of this thesis we will consider the latter, BFO, and to increase knowledge of the BFO, the following research works will be investigated: [12, 34].

A lot of proposals for evaluating ontologies are listed in the paper [5], this contribution explain that a standardized methodology does not seem to exist. The methodology listed in this paper will be studied with the aim of selecting the most suitable for this research. The EE-Theories also will be investigated to help the investigator to choose a evaluating ontology methodology [24, 20, 18, 23].

The research [4] analyse that the evaluation methodologies available to evaluation of ontology aren't focus on the ontology content. The author understands the evaluation of ontology content to be the activity of verifying whether the ontology really represents the knowledge of a domain, according to the assessment of experts. He present qualitative research about the content evaluation of an organizational ontology, developed within a large Brazilian energy utility company. The evaluation process will be analyzed to contribute towards improvements in both modeling and evaluation processes in ontology development.

The design and evaluation of ontologies for enterprise engineering are discussed in [38], this work present a logical framework for the TOVE (Toronto Virtual Enterprise) ontology to represent activities, states, time, resources, and cost in an enterprise integration architecture. The DEMO methodology (Dynamic Essential Modeling of Organizations) consists of several model types, each expressed in a specific diagram could be applied to provide the enterprise interoperability [8, 18, 20].

2.3. Interoperability and semantic interoperability

The need for interoperability in the area of information technology (IT) does not refer to something new, but has become a necessity as the web brought down

organizational barriers, connecting corporate databases previously isolated. The interoperability is researched for several authors, this section list the related works that support the theoretical background. In its turn in the literature in the field of Information Science and Computer Science, several researchers define interoperability, in a simply way, as the ability of a IS has to share and exchange information with other IS. The interoperability enables the user to search for heterogeneous information resources stored in different locations, using a single and without knowledge of how resources are stored interface. [11, 28, 48, 52, 54].

However, problems related to sources of information handled by the system, which may present syntactic, structural and semantic differences, may preclude interoperability between different IS. [52, 54]

In this sense, interoperability is linked to cooperation, normalized by specifications, policies and standards that enable the integrated information exchange. Interoperability between systems is possible only when the underlying languages employed to create models have conceptualizations that overlap in some extent. In addition, for two or more ISs interoperate, communication skills, information exchange, the use of mutually operations, independently of the architectures, platforms and semantics used must be developed. This way the enterprise interoperability is worry about the interoperability between organizational units or business processes, in consequence between the IS, whether from an intra or inter organizational point of view. [48, 43].

There are seven possible levels of interoperability, listed below, which we will define in the next stages of the thesis: Technical interoperability; Organizational interoperability; Semantic interoperability; Interoperability political and human; Intercommunity Interoperability; Legal Interoperability; International Interoperability. The focus of this thesis is the semantic interoperability. [25, 62].

A review from the European Interoperability Framework, support by the papers like [25, 16, 43] becomes important to verify which the standards are recommended by the authorities to provide interoperability. The European Interoperability Framework (EIF), is a framework development by European Commission to support the European Union (EU), is a set of recommendations which specify how governments, enterprises and citizens communicate with each other within the EU and across Member States borders [25]. Others researches like [2, 11, 13, 28, 48, 52, 54, 55, 60, 62] will be visited. To review a interoperability theories, the fundamentals concepts and aspects related to semantic interoperability.

2.4. Ontology applied to semantic interoperability

The semantic interoperability problems involve the adoption of solutions able to ensure uniform interpretation between systems, such as: metadata schemas, classifications, thesauri and ontologies. [62]. The interoperability problem that can be treated from ontologies is the semantic heterogeneity. The possibility to integrate two different vocabularies, V1 and V2, associated with two ISs who work in different areas is to establish semantic relationships between terms of V1 and V2 terms. To do this, you must define the meaning of each term of V1 and V2 in a language that is

more expressive than the V1 and V2 own. This language must explicitly express the meanings of terms and avoid the ambiguities inherent in natural language. At this point, ontologies can be used to advantage [26].

The major papers listed above in the section 2.2 and 2.3 will be visited to give the fundamentals concepts related to ontology applied to solve problems about semantic interoperability.

Solutions for semantic interoperability based in information models aim to structure information for purposes of communication between systems, creates templates to represent the information of medical records. These templates consist of a set of basic clinical variables used to represent the information in medical records. Another alternative for semantic interoperability solutions that has been widely accepted for knowledge representation is the use of formal principles based on philosophical foundations. Under ideal conditions, the terms in a vocabulary would be defined free of ambiguities and overlaps in a structure called an "ontology" [39].

In the early 1990s, ontologies have become widely applied in medicine and biomedicine as a way to structure the large volume of data generated. Since then, these areas have housed research on interoperability of ISs from ontologies, as evidenced by numerous international initiatives produced with this technology [55]. Ontologies have been widely adopted in the medical field in order to deal with the massive information produced in medicine. [6, 2].

The paper [29] presents the state of the art in terminologies and ontologies applied to biology and medicine. It's present a descriptive framework and compare systems in terms of their architectural elements, expressiveness and coverage, as well as analyze the nature of the entities they denote. This paper examine the follow terminologies and ontologies: International Classification of Diseases (ICD), Medical Subject Headings (MeSH), Gene Ontology (GO), Systematized Nomenclature of Medicine - Clinical Terms (SNOMED CT), Generalized Architecture for Languages, encyclopedias and nomenclature (openGALEN), Foundational Model of Anatomy (FMA), Unified Medical Language System (UMLS) and Open Biomedical Ontologies (OBO) Foundry.

There are several approaches to organizing and sharing information in medicine: information models, like Health Level Seven International (HL7) and Open Electronic Health Records (OpenEHR); terminologies, like MeSH; and thesaurus, like National Cancer Institute (NCI) Thesaurus (NCIt) [6]. In their paper are proposed a method for separating and classifying the information available in medical records, drawing on Karl Popper philosophical theories. This method was tested by using descriptions of clinical cases within the scope of a biomedical project that deals with the human T cell lymphotropic virus.

To analyse how openEHR archetypes impact on health professionals and semantic interoperability the paper [32] will be visited. These authors believe that semantic interoperability is essential to enable EHRs. They evaluated that the openEHR archetypes approach enables syntactic interoperability and semantic interpretability, however, they concluded that openEHR archetypes and domain knowledge governance together create the knowledge environment required to adopt EHRs.

In the work from [47], the authors address the semantic interoperability of two EHR standards: OpenEHR and ISO EN 13606. Both standards follow the dual model

approach which distinguishes information and knowledge, this being represented through archetypes.

Several researches are being made to enable the integration of ontologies. There is a brief summary description of these surveys in [30] and a deeper coverage in [61]. Several contributions have been made in the biomedical field for the development of semantic standards such as medical terminologies, ontologies and coding systems [29] presents the difference between terminologies and ontologies in the biomedical context.

In Brazil, health minister from the federal government establishment a ordinance number 2.073 [49] from August, 31 in 2011, regulating the use of standards for interoperability and health information for HIS in all levels of government, and the private systems and the health care sectors. These standards are:

- openEHR for definition of the Electronic Health Record (EHR).
- The HL7 to establish interoperability, aiming at integrating the results and the of tests requests, between systems.
- In terms of clinical coding and mapping of national and international terminology in use in Brazil, to support semantic interoperability between systems, terminology SNOMED-CT will be used.
- To define the clinical document architecture is used the standard HL7 CDA.
- For the representation of information on imaging is used DICOM standard.
- For coding of laboratory tests will use the LOINC (Logical Observation Identifiers Names and Codes) standard.
- For encoding data identifying the labels of products relating to human blood, cells, tissues and organs of products, the ISBT 128 will be used.
- Towards interoperability of knowledge models, including archetypes, templates and management methodology, we will use the ISO 13606-2 standard.
- To the intersection of identifiers of patients of different information systems, the specification of integration IHE-PIX (Patient Identifier Cross-Referencing) will be used.
- Other classifications that will be used to support interoperability of healthcare systems: ICD, ICPC-2 (Primary health care), and TUSS CBHPM (Brazilian classification hierarchical medical procedures) and procedures tabled from the Brazilian health entity called Sistema Único de Saúde (SUS, in English is Health Unique System).

The ISO EN 13606 has been selected as the official EHR standard for national projects such as in Sweden and in the Region of Madrid in Spain to address the semantic interoperability of EHR standards. [47]

During the development of this thesis, these terminologies and ontologies are best studied and detailed in order to analyze the mechanism to provide the semantic interoperability and to verify if these solutions are able to provide the semantic interoperability.

Several studies have presented the state of the art terminologies and ontologies applied to biology and medicine, some of them present a critical analysis of this terminologies and ontologies, and they are: [26, 6, 43, 53]. Other studies focus on delving into one or more ontologies or terminologies [30]. The information models in

medical system are studied object from the thesis [7], which focus on the representation of patient data through information models and biomedical ontologies. The studies cited above also identify the application of ontologies for semantic interoperability troubleshoots.

Many studies are focused in the evaluation on health ontologies and terminologies, we will visit the papers below to give us the [44] Using BFO for Ontological Error-Detection in UMLS, others papers analyzing the openEHR, the HL7 and the ISO EN 13606, its will be investigated [13, 17]. The literature from our research object is very rich, and during the contrition phase we intend to pursue further studies that can contribute to this work.

3 Research methodology

The initial phase known as the decision phase of this thesis has completed where the theme was chosen, the research problem and the general and specifics objectives were determined. A brief literature review in order to identify the state of the art about the theme and related research works were also performed. Now, the research is in the initial state of the constructive phase where the plan of research (methodology) has being elaborated and the implementation of the research will be conducted. [56]

This thesis, accordance with its nature and approach of the problem is classified as a qualitative applied research. The figure 2 presents the mapping where the research problems issues were associated to the specifics goals and they were classified considering the objectives and the technical procedures. [33, 44, 46].

		Research Classification	
Next steps	**Specifics goals**	**Considering the objectives**	**Considering the technical procedures**
Step 1	To verify which ontologies and terminologies are recommended by health authorities to provide SI and which are usually adopted by healthcare entities.	Exploratory survey	Bibliographic and Documental research
Step 2	To analyze the mechanisms adopted by these ontologies and terminologies to provide SI and the advantages and disadvantages found in each one.	Explanatory study	Explanatory case study
Step 3	To identify what level of SI these ontologies and terminologies are providing to interoperate with another.	Explanatory study	Explanatory case study
Step 4	To list the gaps from semantic interoperability found in these ontologies and terminologies to interoperate with another.	Explanatory study	Explanatory case study
Step 5	To specify, based on a top-level ontology, a recommendation for a solution able to provide semantic interoperability concerning the gaps found.	Descriptive research	Experimental Case Study

Figure 2: Next steps versus the research classification. Prepared by the authors.

3.1. Steps to research development

In order to achieve the general aim of this thesis and to propose answers for the questions of the research problem, we defined specific objectives. These specific objectives guide the necessary steps to complete the survey. The next steps are detailed below.

- **Step 1:** To verify which ontologies and terminologies are recommended by health authorities to provide semantic interoperability and which are usually adopted by healthcare entities.

To develop this specific goal (Step 1), two types of technical procedures was selected, the bibliographic research and the documentary research, which employed techniques of the Content Analysis [8] to the collection, processing and analysis of information. According to the method of the Content Analysis the analysis was divided into three phases: i) Pre-Analysis; ii) Exploration of the material; and iii) Treatment of results, inferences and interpretations.

The pre-analysis has four main tasks: i) to select the documents to be submitted to analysis, characterized by the construction of a corpus analysis; ii) the formulation of hypotheses and objectives; iii) the boundaries of indexes and indicators fundamentals for interpreting the results; and iv) the choice of categories of analysis. To build the corpus of analysis should be considered the following rules: i) rule of exhaustiveness; ii) rule of representativeness; iii) rule for uniformity; and iv) rule of relevance [8].

The universe of the research consisted of technical and scientific articles and theses. The coverage area is Information Science and Computer Science. The representativeness of the corpus is ensured by the choice of databases used for the literature review because they represent a significant portion of the literature related to the theme. The searched databases, national and international, are listed below: CiteSeerx, BioMed Central publishes, ScienceDirect, PhilPapers, Pubmed, ACM Digital Library, SciELO, Portal Capes, BRAPCI (in Portuguese, Base de Dados Referencial de Artigos de Periódicos em Ciência da Informação).

The documents selected for the corpus analysis are written in Portuguese (to include studies in Brazil and because both researchers and the University are Brazilian) and English (the fact that most scientific texts of Information Science and Science the relevant computing is written in English).

The literature survey is being held since October 2013, where the references listed in this article are already part of the expected result in this goal. The literature survey will be conducted until early June 2014. As the search strategy some terms were used like: i) In Portuguese, ontologia, interoperabilidade semântica, ontologia de alto nível, ontologia biomédica; ii) In English, ontology, semantic interoperability, top-level ontology, biomedical ontology, enterprise engineering, knowledge organization system, enterprise ontology.

After the stage of pre-analysis in the constructive phase, the selected documents are exploited and are compiling a record containing the topic, summary, and reference observations. At the end of step 1, it is hoped to retrieve the list of ontologies and terminologies that are recommended by health authorities in different countries to obtain the semantic interoperability of heath records. Besides it is expected to obtain the list of ontologies and terminologies that are effectively utilized by healthcare entities. Some results from the step 1 are already listed in the section 2.4.1 and 2.4.2.

- **Step 2:** To analyze the mechanisms adopted by these ontologies and terminologies to provide semantic interoperability and the advantages and disadvantages found in each one.

An ontology for IS should be evaluated for their ability to perform the function for which it was designed. An ontology evaluation consists in two dimensions: a content

evaluation and a technical ontology evaluation. The first one is related to the knowledge representation, the goal is to detect inconsistencies or redundancies before these can spread out in applications. The second targets to ensure smooth and correct integration with industrial software environments [31].

The basic components of ontology are classes (organized in taxonomy), relationships (representing the type of interaction between the concepts of a domain), axioms (used constrain the meaning of terms) and instances (used to represent specific elements, ie the data itself) [36]. Furthermore, to understand the mechanisms that ontology should have to provide semantic interoperability, a theoretical survey on interoperability will be held on databases of scientific papers.

Many studies on development methodologies and evaluation of ontologies are identified in the paper [5], the methodologies listed in this paper will be studied with the aim of selecting the most suitable for this research. Beyond that, the ontology content evaluation methodology proposed by [4], mainly because our focus is in the structure and in the content.

We should adopt a methodology for evaluating ontologies and terminologies. Some key issues for the evaluation of ontologies like the listed below will have to be replied [7].What is the mechanisms for interacting with ontologies? What is the formalism of knowledge representation used? Is the ontology well documented? Was the ontology evaluated on the technical point of view?

Besides these issues, criteria focused on the concepts and definitions that make up the ontology should be analyzed: [7]

- Check the structure or architecture of ontology: Are the settings built following the design criteria?
- Check the syntax of the definitions: Are there structures or keywords in syntactically incorrect settings?
- Check the contents of definitions: What is defined by the ontology? What isn't? What sets incorrectly? What can be inferred and what cannot?

Besides the enterprise engineering, the DEMO methodology will be analyzed by the researcher to understand the enterprise interoperability mechanisms [8, 18, 20].

As a result of the literature search is expected to define a set of mechanisms necessary for ontology to ensure semantic interoperability and define a set of questions focused on the evaluation of ontologies.

- **Step 3:** To identify what level of semantic interoperability these ontologies and terminologies are providing to interoperate with another.

The technical procedure applied in this step is an explanatory case study. The development of this step consists in to perform an ontology mapping between the ontologies listed above like a result of the step before.

As a result of this step is expected to map the common and non-common mechanisms found in the ontology evaluated. This mapping will propose a methodology to integrate such medical ontologies, providing a link to a first ontology (e.g. Ontology A) concept with the concepts of the second (e.g. Ontology B).

The method to the mapping is not chosen yet. In the article [47] is presented the state of the art in ontology mapping, 35 works have been reviewed. This paper will be analysed to choose the appropriate of ontology mapping method for this thesis.

- **Step 4:** To list the gaps from semantic interoperability found in these ontologies and terminologies to interoperate with another.

After the results obtained in step 3, this step consist only in identify the gaps of the mechanisms in the ontology A that aren't a correspondent in the ontology B. This step is complementary to the previous step.

- **Step 5:** To specify, based on a top-level ontology, a recommendation for a solution able to provide semantic interoperability concerning the gaps found.

Based on the literature review, some mechanisms that can be used to provide compatibility of ontologies have been identified: Integration of ontologies, Combining ontologies; Aligning ontologies and ontology mapping [50].

The last step of the research consists of to build a theoretical basis for recommendations to establish a semantic interoperability in the adoption of ontologies for the health record of patient, beyond the suggestion practices to obtain interoperability between ontologies. The result of this step is providing a top-level ontology based solution to provide semantic interoperability in healthcare information systems. In the section 2.2, was listed some important top-level ontologies based in authors like [6,12,34]. We intent to propose a mapping based on the Basic Formal Ontology (BFO) and to increase knowledge of the BFO, the following papers will be investigated: [12,34].

4 Final Remarks

This paper describes a proposal of a doctoral thesis for the School of Information Science on Federal University of Minas Gerais. This thesis has determined the theme, the research problem and the general and specifics objectives. Furthermore, this paper presents a short review of the literature, which identifies the state of art about the main theme and the research work related. The thesis starts its construction phase, at this stage all the theoretical background will be explored in depth and the research methodology will be specified and tested.

Basically, we study a proposal for semantic interoperability between different adopted by the healthcare information systems. Through a literature search on the basis of scientific data, we intend to list the main patterns of semantic interoperability adopted by governments of different regions. We also look forward to define a set of ontology needed to ensure semantic interoperability and further define a group of questions focused on the evaluation of ontologies mechanisms.

We will carry out a mapping between the ontologies taken to health information and the mechanisms of semantic interoperability that we have identified. Based on this mapping, we will propose a top-level ontology based solution to integrate these different medical ontologies. Then, we hope to reach recommendations for representation of healthcare entities in order to seek for new ways to deal ting with issues of semantic interoperability in HIS.

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