

# Ontological Evaluation in the Knowledge Based System

Tania C. D. Bueno<sup>2</sup>, Sonali Bedin<sup>1</sup>, Fabricia Cancellier<sup>2</sup> and Hugo C. Hoeschl<sup>1</sup>

1 Instituto de Governo Eletrônico, Inteligência Jurídica e Sistemas – IJURIS, Rua Lauro Linhares, 728 – sala 105 – Trindade - 88036-0002 - Florianópolis – SC – Brasil {hugo, sonali}@ijuris.org, www home page: <http://www.ijuris.org>

2 WBSA Sistemas Inteligentes SA, Parque Tecnológico Alfa, Centro de Tecnologia IlhaSoft , SC 401 Km 1 - Módulo 10 - Térreo B - João Paulo - 88030-000 - Florianópolis, SC – Brasil {tania, fabricia}@wbsa.com.br www home page: <http://www.wbsa.com.br>

**Abstract.** In the last few years, several studies have emphasized the use of ontologies as an alternative to organization of the information. The notion of ontology has become popular in fields such as intelligent information integration, information retrieval on the Internet, and knowledge management. Different groups use different approaches to develop and verify the effectiveness of ontologies [1] [2] [3]. This diversity can be a factor that makes the formalization of formal methodologies of evaluation difficult. This paper intends to provide a way to identify the effectiveness of knowledge representation based on ontology that was developed through Knowledge Based System tools. The reason is that all processing and storage of gathered information and knowledge base organization is performed using this structure. Our evaluation is based on case studies of the KMAI system [4], involving real world ontology for the money laundry domain. Our results indicate that modification of ontology structure can effectively reveal faults, as long as they adversely affect the program state.

## 1 Introduction

Testing the application is an important stage of the system development process. These tests aim at the verification of all the functionalities of the tool, inferring that the results are the ones expected when the system was conceived. However, it is

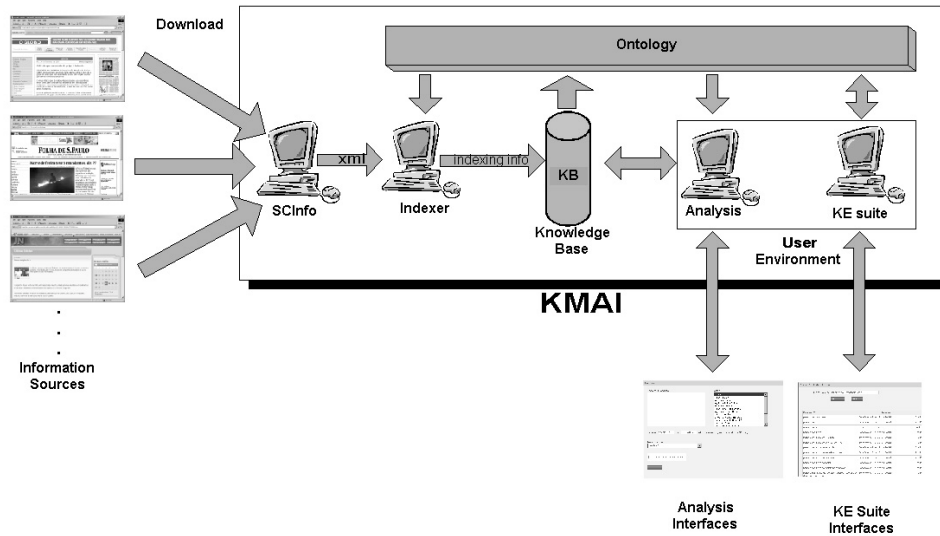
particularly difficult to engage in ontology evaluation where the entire system design assumes a high degree of interaction between the user and the system, and makes explicit allowance for clarification and retrieval. This is the case of KMAI - an intelligent knowledge management platform [5].

The only approach towards the formal evaluation of ontologies is OntoClean [6], as it analyses the intentional content of concepts. Although it is well documented in numerous publications, and its importance is widely acknowledged, it is still seldom used due to the high costs for applying OntoClean, especially on tagging concepts with the correct meta-properties. Open response tests, especially those making use of nonsense words, require an extensive training of the listeners. However, additionally to the word and phoneme scores, possible confusion between phonemes is obtained. This allows for diagnostic analysis. Redundant material (sentences, rhyme tests) suffers from ceiling effects (100% score at poor-to-fair conditions) while tests based on nonsense words may discriminate between good and excellent conditions.

In earlier works, we used a methodology called Mind Engineering [7] to identify and organize ontologies using a collaborative web tool called Knowledge Engineering Suite (see item 2.2). This tool is a module of KMAI system. Mind Engineering allows building a knowledge base, improving the construction of the ontology of the domain and the automatic representation of cases in knowledge-based systems, either in the juridical area or any other knowledge management domain [8]. Our methodology of testing is focused on the verification of the results expected from the system when using ontologies for the retrieval of the information and observes the principles of the methodology used in the ontology development. The tests are affected from the terms that are part of the domain ontologies created for a specific application.

Despite the fact that testing provides a proof of correctness for only those test cases that pass, it remains popular partly due to its low, incremental cost. Our evaluation is based on two case studies involving real world applications based on ontology. Our results indicate that specification based assertions can effectively reveal faults, as long as they adversely affect the state of the program.

Therefore, our paper is organized as follows: In section 2, we present KMAI System and Knowledge Engineering structure. In section 3, we describe the participation of the ontological structure in KMAI System and aspects of ontology application. In turn, these aspects will be applied to our recall measures. In section 4, we introduce the ontology evaluation process. Section 5 develops recall measures for ontology in KMAI system. We end with a brief conclusion and future work.



**Fig. 1.** The participation of the ontology structure in the KMAI System.

## 2 The KMAI System

The KMAI System embraces the whole cycle of strategic information production, from the collecting process to the retrieval by the user. Part of the visualization of the system is in figure 1. It begins in the election of the digital sources to be monitored (Knowledge Engineering), separating structured from non-structured data (about 90%) and submitting them to differentiated treatments. Data obtaining is made through Collecting Agents connected to collections, each one representing a source of information, which can be from specific websites to documents storage directories (textual documents, spreadsheets, e-mails and reports in general) digitally existent in the organization.

The vision of the storage structure is physical, containing the items collected in files organized by domains. The collections are converted for a common pattern that allows communication with structured databases. The chosen format was XML (Extensible Markup Language). Text Mining is devoted to extract concepts, statistics and important words of a group of documents to minimally structure them.

In that phase, three types of information are extracted: metadata (common document information, such as title and author), indexes (terms that describe the content of the document) and concepts (terms that describe the context of the document). These concepts are based on the ontologies defined in the Knowledge Engineering Suite (see item 2.2). Therefore, the cycle of information production is completely assisted in a digital and intelligent way.

The retrieval process is cyclical, as the user describes the subject to be searched on and the system shows the related information, organized by the degree of similarity with the subject described, enabling the increasing of more specific

information referring to the present elements on the subject searched, for instance, periods of time or informational sources.

## 2.2 Knowledge Engineering Suite

This Module of KMAI System allows the building of the relationship tree, always considering the similarity between all the *indicative expressions* filed and the ones already existing on the base. These relationships allow the system to expand the search context. The organization of the tree allows the dynamic definition of the weights of the *indicative expressions* according to the query made by the user. The fields of ontology editor are presented with all available relationships. They are the following: -synonyms; -related terms; “this is a type of”; “this belongs to this type”; “this is a part of”; “this is part of this”. The editor still presents the existing relationships and allows to including them to another *indicative expression*. Each relationship has a weight related to the defined *indicative expression* in the query made by the user.

## 3 The Process of Ontology Construction

The ontologies structure is the heart of the KMAI System. The reason for it is that all processing and storage of gathered information and knowledge base organization is performed using this structure. It also plays an important role in the quality of the results presented to the user.

The participation of the ontology structure in System KMAI occurs in three moments (see figure 1). At the first moment, the system extracts information from different previously selected sources. Each one of these documents is indexed based on the ontologies defined by the specialists and knowledge engineers during the knowledge engineering process. It means that the system will mark the documents with all indicative expressions found in the text, storing them in an organized way in the knowledge base. Thus, it is possible to make a pre-classification of the cases in the base according to what was defined in the knowledge organization promoted by the ontologies.

In a second stage, ontologies are important in the analysis interface available to the user. The process begins at the moment in which the user types the input text for the search. It is at this point that the indicative expressions defined by the user that coincide with the ones presented in the ontology are identified. These expressions identified in the entry case determine the stream of relations that will be used by the system. It means that there is a dynamic relation between the way the user enters the indicative expression in the analysis interface and the way the relations in the Knowledge Engineering Suite are defined for this expression.

The first versions of the Knowledge Engineering Suite worked with key expressions, an approach that resulted in some rigidity in the ontology organization. The weight of the information that was typed by the user in the search text was not considered. For this new approach, the importance of the indicative expressions to be

considered is defined by the user. The system gives priority to the expressions and search for the corresponding derivations for each case, according to the knowledge base. A priori, there is no hierarchy in the organization of ontologies in the knowledge base. The weight of relations will be based only on what is required by the search, where the context intended by the user is defined.

The third moment when the ontology takes part is in the Knowledge Engineering Suite, available in the system and integrated in its architecture. Through the Knowledge Engineering Suite, the user is able to update the knowledge base with new expressions. At each new update in the ontology, the system re-indexes all the texts stored in the knowledge base, so that users may use this new ontology organization to search for documents previously indexed. It allows the verification of old documents that are related to a context that is important at the present moment. This way, it is possible to define a dateline about a subject, locating its start point.

It is important to highlight that this structure of contextualized ontologies allows automatic information indexing by the system and a knowledge acquisition that gives more qualitative answers in the retrieval process.

#### 4 Ontology Evaluation

In KMAI System, the *indicative expressions* are organized in sub-domains, the following of relevance in the domain. The retrieval process is based on similarity between the number of terms, ontology and relationships presented in the text. These relationships are based on relevancy of the connection (synonyms – 0,99; related terms – 0,75; “this is a type of”- 0,30; “this belongs to this type”- 0,30; “this is a part of”- 0,30; “this is part of this”- 0,30), see item 2.2.

In this perspective, the recall tests identifies if the ontology relationships improve the quality of the results in the KMAI System. Thus, the ontology is inserted in the analysis for evaluation in two ways: textually, in the analyzer search, where the document is presented orderly based on the similarity of the ontology and ontology relationships, or yet in the form of graphs that allow the evaluation of the quantity of the documents where that ontology and its relationships appear.

The process of test and evaluation of the ontologies define the effectiveness of relationships considering the amount of documents retrieved.

The first test is performed by the Knowledge Engineer during the ontology construction phase. First of all, the relations of synonyms are created, for instance: “money laundering” is synonymous with “dirty money” and “laundering operations”. After that, the search function of the system is performed to verify the number of documents found and then the engineer starts to create “type of” and “part of” relations (e. g., combating money laundering, Offshore Financial Centers, Global Programme Against Money Laundering). To check if the relation falls within the context, a small increase in the number of documents retrieved has to be observed. Otherwise, if the number of documents retrieved is higher than 70% of the documents retrieved through the synonyms, then the relation will be considered not

adequate; in the aforementioned example, “Offshore Financial Centers” is an expression too wide for the term “money laundering”. The last relations to be inserted are the related terms (e.g. crime against the financial system, ideal financial heaven, organized crime) with weight 0.75. In this case, if the relation brings a search result above 150% of the documents retrieved by the first step, the term should be considered as inadequate for that set of relationships. In the example given, the expression “organized crime” presented a search result higher than 150% and the engineer should create a separate relation for that *indicative expression* with synonymous and other relations, if the term is considered important for the domain he is working on.

Thus, after the definition of the search domain, the process is developed in some stages, such as the following description. As an example, we will call the *indicative expression* A and B in the description of the process: a. Previous analysis of the A terms; b. Analysis of B terms; c. Elaboration of the relation of the terms A and B; d. Representation of error.

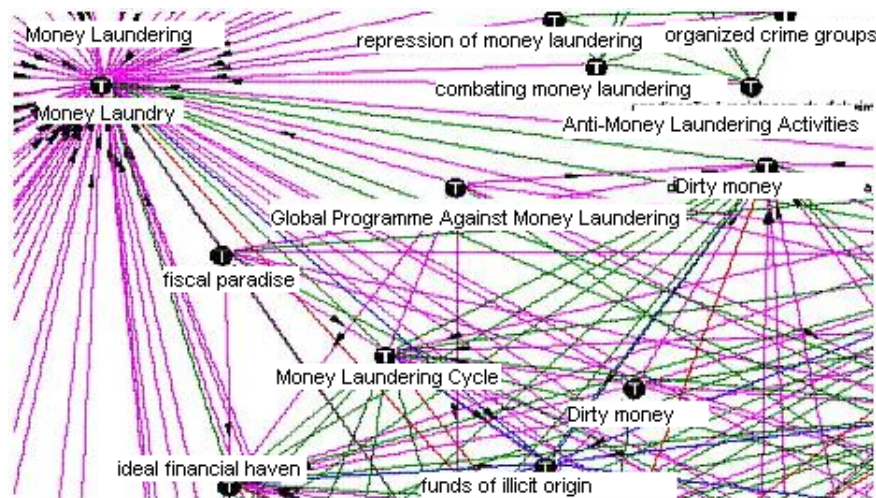


Fig. 2. Part of Money Laundry Ontology.

#### 4.1 Previous analysis of the A terms

Initially, a previous analysis must be performed of the “indicative expressions” pertinent to this domain, aiming at verifying if they are relevant and if the retrieval represents a considerable number of news.

It is important to remark that, previously, the system must contain registered sources and knowledge base news of a minimum period of thirty days. These key-terms can be part of the ontology target of the analysis, and does not affect the expected final results.

The analysis of the representation of these words will be made initially in the first page of retrieval of the system, where there will be news in which these words are contemplated.

#### **4.2 Analysis of B terms**

In this stage, the same analysis previously accomplished will contemplate other words, chosen randomly or because they are part of the ontologies, as previously said. Also the aim here is also the retrieval of news, but using a set of news, from the first test.

#### **4.3 Elaboration of the relation of the terms A and B**

After the individual evaluation of the terms A and B, with the registry of the results got, it takes the construction of the relation. This construction is accomplished by the association of term B as synonymous of term A, inserting both as an ontology in the system. From this insertion, automatically the relation of synonymy will be created, which is one of the types of semantic relations found in the system. This relation for synonymy will imply simultaneously the retrieval of the news pertaining to terms A and B, in one same analysis.

At this stage of the test, a result is expected such as the retrieval of the same news that was part of the individual analyses, considering that key-terms A and B were inserted as synonyms. It is important to point out that here, the test with ontology formed of a few terms will result in an evaluation with bigger indices of trustworthiness, achieving 100%, considering that the evaluation of a lesser number of retrieved news becomes faster.

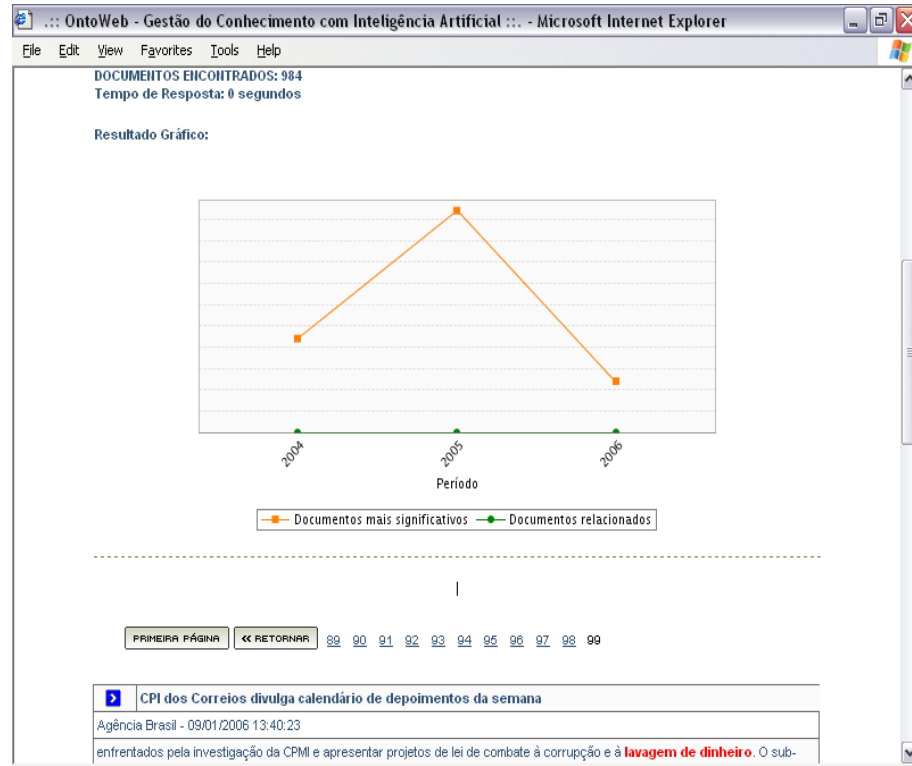
From the insertion of the “indicative expression” it is already possible to infer that, if an ontology is not well constructed will result in the retrieval with low indices of precision or, in many cases, a completely inefficient retrieval, compromising the performance of the system.

Taking domain SOCCER as an example, which is the object of this test and considering the insertion of the indicative expression "The King of Soccer", the term is verified by the system in the domain, after the insertion of the term and normalizes the grammatical accent. Thus, for the domain SOCCER, "Pelé" will be related as synonymous the term “The King of Soccer”, with or without grammatical accent. But, “pele” in Portuguese means “skin”. In this case, when the analysis of the system retrieves news about skin, or dermatology, or allergies, however, and something about Pelé, the football player, it is considered that the error presented is not of the system, but an error of the ontology construction. When the ontology was not constructed in the correct form to represent the expected knowledge, we proceed to the elimination of the “indicative expression” and initiate the construction of new “indicative expression” and its relationships, for a new stage of tests.

#### 4.4 Representation of error

The following stage of tests is related to the representation of error, considering that the ontology is correctly constructed, already identified and the errors of relationship are corrected. The test consists of the construction of the relationship of the ontology constructed to a term that does not represent any relation with the ontology.

For example, we take the indicative expression “money laundry (lavagem de dinheiro)” (see fig. 2), this expression is related to money laundry ontology in KMAI system. In this way, the system recovered 4,516 documents, in the period of two years, from one source (*Agência Brasil*).



**Fig. 3.** The Result of Money Laundry ontology in the KMAI System.

It was observed that documents with a low degree of similarity were retrieved due to the terms “bank secrecy” and “kidnapping”. When testing the term “bank secrecy” the result was within the context of money laundering; however, other terms like “kidnapping” were totally out of the subject. The term “bank secrecy” retrieved 984 documents, for the same two-year period, and the documents with a low degree of similarity contained the term “money laundering” (see Figure 3). When testing the term “kidnapping”, 1,422 documents were retrieved, with the most similar not



referring to the “money laundering” crime; only the fifth, the sixth and the seventh documents connected “kidnapping” to “money laundering”.

As another example, we define the term “soccer play”, synonymous with the term “Fabricia” (see item 2.2). After that, the user will precede the search on soccer and will retrieve, in bigger similarity, a notice as a result that consists of information on “Fabricia”. However, they do not have a real relation with soccer, or soccer game. The system makes automatically this relation of synonyms and presents, the relations of “soccer” and the relations of “Fabricia” as results. The retrieval, considering this relation, will demonstrate if the system is working correctly. Another possible verification is related to the results, or either, the verification of the results got to see if they are the results expected.

It is possible to point out when the evaluation of the result is made, that an external factor call problem of the oracle can make it difficult and affect the analysis. The problem of the oracle is related to the absence of documentation and knowledge of the domain object of the test. In the case the responsible for the test does not know the domain and it were not part of the team that constructed the ontologies, he does not have any conditions to evaluate the result. Additionally, the absence of documentation that bases the knowledge of the domain can affect in the results and in many cases deprive the system of characteristics related to its initial conception. The team responsible for the construction of the net of ontologies, also responsible for the tests suggests considering that the knowledge of the domain is basic for the analysis of the results.

## 5 Results

The procedure adopted to do the recall test in KMAI was made to invite some users who are experts in the domain, but work in different areas, to make some questions. Experts in the money laundry domain were chosen because knowledge engineers that don’t work with them couldn’t identify the retrieved texts that belong to the domain with precision. For each question, a complete ontology was elaborated. Then, the query was formulated with the “indicative expression” that is part of the domain ontology. Each user made their own evaluation according to their specific knowledge about the domain.

Since KMAI measures the similarity with all documents and, due to conceptual premises, any document that has a similarity superior to 50% would be returned and the recall test has a particular aspect. Only the set of documents that contains the most similar ones were considered to calculate the recall. For instance, the 4,516 documents returned by the query “money laundry” are all pertinent to the context, because all documents have more than 50% of similarity. However, to verify the relevance of each *indicative expression* that composes the money laundry ontology we use the process described in item 4.4 and observe that when the expression was changed, a significant variation in the graph appears, superior to the number of the

existing documents about the subject in the knowledge base. With this, it was possible to identify the less significant expressions and the most ambiguous ones.

## 6 Future Work

We need instead to develop a specification from the available documentation. The specification must then be validated as correct by domain experts. Once a formal specification has been obtained or created, the next task is to convert it into assertions. To facilitate this task, it is better to write the specification using a formal language and structure that matches the one of the programme.

## References

1. Duineveld, A. J. et al, 1999. WonderTools? A comparative study of ontological engineering tools. Twelfth Workshop on Knowledge Acquisition, Modeling and Management. Voyager Inn, Banff, Alberta, Canada.
2. Eriksson, H. et al, 1999. Automatic Generation of Ontology Editors. Twelfth Workshop on Knowledge Acquisition, Modeling and Management. Voyager Inn, Banff, Alberta, Canada.
3. Benjamins, V.R., 1998. The ontological engineering initiative (KA)2, Formal Ontology in Information systems. IOS Press, Amsterdam.
4. KMAI System. Available at: <http://www.kmai.com.br> Access on: 02 janeiro 2006.
5. Ribeiro, Marcelo Stopanovski. KMAI, da RC<sup>2</sup>D à PCE. Gestão do conhecimento com inteligência artificial, da representação do conhecimento contextualizado dinamicamente à pesquisa contextual estruturada. [2004]. Dissertação (Mestrado em Engenharia de Produção) – Universidade Federal de Santa Catarina, Florianópolis, 2003.
6. Völker, Joahna, Vrande i , Denny and Sure, York. Automatic Evaluatioversn of Ontologies (AEON). Lecture Notes in Computer Science. Springer-Verlag GmbH. Vol. 3729/2005. Pag. 716 – 731.
7. Bueno, Tania C. D. et al, 2005. Knowledge Engineering Suite: A Tool to Create Ontologies for Automatic Knowledge Representation in Knowledge-Based Systems. Lecture Notes in Computer Science. Springer-Verlag GmbH. Volume 3591/2005. Page: 249.
8. Hoeschl, Hugo. C. et al, 2003. Structured Contextual Search For The Un Security Council. Proceedings of the fifth International Conference On Enterprise Information Systems. Anger, France, v.2. p.100 – 107.6. Bueno, Tânia C. D. et al, 1999. JurisConsulta: Retrieval in Jurisprudencial Text Bases using Juridical Terminology. Proceedings of the Seventh International Conference On Artificial Intelligence And Law. ACM, New York.
9. Faatz, Andreas, Steinmetz, Ralf. Ontology Enrichment Evaluation. Lecture Notes in Computer Science. Springer-Verlag. Vol. 3257/2004. Pag. 497 – 498.