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DESIGN OF AN ONTOLOGY AS A SUPPORT TO THE KNOWLEDGE AUDIT PROCESS IN ORGANIZATIONS

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Abstract

The objective of this article is to show an ontology that can serve as support to represent the results obtained throughout the knowledge audit process in organizations. This paper describes the form to represent what was obtained throughout the audit process and its advantages, as well as its advantages and the mechanism to reuse the information gathered from it. The design of the proposed ontology, the elements to be presented from knowledge audit, the way in which they can be represented with the help of the ontology, and their potential reuse for the development of applications are shown.

Keywords

Ontologies, Knowledge Audit, Knowledge Representation, Knowledge Inventory, Knowledge Flow.

1. Introduction

In the last couple of years, the process of generating, enriching, keeping, and sharing of knowledge, experiences and abilities that the employees within an organization have has been gaining on importance. It is commonly said that a great part of the success and competitive advantage that some companies have had is due precisely to the manner in which knowledge is managed. Undoubtedly, before defining the actions that a company must implement to manage its knowledge, it is important to identify the existent knowledge within the organization, who owns it, where it is stored and how it flows among its members; in other words, before implementing an initiative to improve knowledge management, a knowledge audit is recommended.

The aim of this paper is to show an ontology to support knowledge audit processes within organizations, the aspects of the audit that may be included in it and how they can be represented in this kind of formalism.

The structure of the article starts with the conceptual framework about knowledge in organizations; knowledge audit, its advantages and benefits; and ontologies and its main characteristics. The next section is focused on ontologies as a support for knowledge audit. After that, a proposal of an ontology as a support to the audit process of knowledge in the organizations is presented; the proposed ontology

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focus on aspects such as the knowledge inventory, knowledge nature, knowledge valuation, knowledge flow, knowledge management processes, reuse of the results of knowledge audit and its potential reuse for the development of applications. Next, the validation of the proposed ontology and practical implications, finally, the conclusions of the present paper are presented.

2. Conceptual framework

Some of the main topics related to knowledge in organizations, knowledge audit, ontologies and ontologies as a support to knowledge audit are explained in this section.

2.1. Knowledge in Organizations

In literature, there are several classifications of knowledge. It is very common the distinction between 'tacit knowledge' and 'explicit knowledge'. Polanyi (1967) defines: 'We can know more than we can tell'. This phrase was used to describe tacit knowledge. Tacit knowledge is the knowledge that a person possesses, it is described as knowledge embedded in the individual's experience and it has a personal quality, which makes it hard to formalize and communicate. In his words, it 'indwells' in a comprehensive cognizance of the human mind and body. This experience can be communicated and exchanged in a direct and effective way in the socialization process (Nonaka and Takeuchi, 1995). Explicit knowledge refers to the knowledge that is transferable in a formal and systematic way by means of a language, since it can be easily articulated and interchanged because it is independent of the individual's mind. Gualtieri and Ruffolo (2005) additionally explain that explicit knowledge can also be classified based on the following forms: "structured" (available in database), "semi structured" (available in intranet and internet web sites: HTML pages, XML documents, etc.) and "unstructured" (available as textual documents: project documents, procedures, white papers, templates, etc.)

Another particular classification establishes a separation among the declarative, procedural and heuristic knowledge (Vasconcelos et al., 2000). Declarative knowledge is related to the physical aspects of the knowledge and responds to the questions: "What?", "Who?", "Where?" and "When?". This type of knowledge serves to describe specific actions to perform certain tasks. Procedural knowledge describes actions for the following step and responds to the question: "How?". Finally, Heuristic knowledge describes the implicit reasoning and the individual's experience. This knowledge uses declarative and procedural knowledge to solve problems and there for to answer the question "Why?".

2.2. Knowledge Audit

Many of the mistakes of both earlier and more recent adopters of KM can be traced to the serious oversight of not including knowledge audits in their overall KM strategies and initiatives (Hylton, 2002b). A knowledge audit (an assessment of the way knowledge processes meet an organization's knowledge goals) is a means to understand the processes that constitute the activities of a knowledge worker, and see how well they address the "knowledge goals" of the organization (Lauer and Tannuri, 2001). Liebowitz defines a knowledge audit as a tool that identifies potential stores of knowledge. It is the first part of any KM strategy. By discovering what knowledge is possessed, it is then possible to find the most effective method of storage and dissemination. It can then be used as the basis for evaluating the extent to which change needs to be introduced to the organization (Liebowitz et al., 2000).

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The knowledge audit is a discovery, verification and validation tool, providing fact-finding, analysis, interpretation, and reports. It includes a study of corporate information and knowledge policies and practices, of its information and knowledge structure and flow. The knowledge audit examines knowledge sources and use: how and why knowledge is acquired, accessed, disseminated, shared and used. The knowledge audit will seek to give qualified insight as to whether the organization is ready, especially socially and politically, to become knowledge-based or knowledge-centered (Hylton, 2002b).

Capshaw (1999) believes that a knowledge audit should provide the following outputs: an assessment of current levels of knowledge usage and interchange; knowledge management propensity within the enterprise; identification and analysis of knowledge management opportunities; isolation of potential problem areas; and an evaluation of the perceived value of knowledge within the enterprise.

Knowledge audit is the indisputable first major step or stage in a KM initiative (Burnet et al., 2004; Henczel, 2000; Hylton, 2002b), yet it has not been sufficiently recognized as being of supreme importance to every KM undertaking. To effectively design KM systems both the organizational knowledge and the KM functions must be individuated by conducting the knowledge audit of the same organization, as these are needed to perform the business processes (Iazzolino and Pietrantonio, 2005).

2.3. Ontologies

An ontology, is a shared, formal conceptualization of a domain (Gruber, 1993; Borst, 1997). Ontologies are data models with two special characteristics, which lead to the notion of shared meaning or semantics: 1. Ontologies build upon a shared understanding within a community. This understanding represents an agreement of experts over the concepts and relationships that are present in a domain. 2. Ontologies use machine-processable representations (expressed in formal languages such as RDF (Lassila and Swick, 1999) and OWL (Dean et al., 2004)), which allows computers to manipulate ontologies.

Ontologies have been widely applied in the context of integration and representation of various knowledge resources in organizations (Berners-Lee et al., 2001). Machine readable metadata and semantic web are increasingly used to enhance the information access facility. Ontologies are the backbone of the semantic web, which facilitates sharing and reuse of knowledge not only between software agents and computers but also between individuals (Fensel, 2001).

3. Ontologies as a support to knowledge audit

There have been some proposals made to utilize ontologies as a support to knowledge audit, some have only been ideas and they just include some of the audit aspects.

Kingston (2001) proposes an approach that is based on the idea of building an ontology that represents all of the relevant aspects for knowledge modeling from multiple perspectives. Zachman (2002) proposes a modeling from different points of view, whose main idea is that for each “latest know-how” that wants to be adequately represented, it is necessary to represent a different number of perspectives about such knowledge, and possibly about the different levels of de-composition. If knowledge is re-collected and indexed considering modeling from multiple perspectives, and applying ontologies to represent it, you can find people who possess a particular resource of knowledge (or part of it), or all of the resources of knowledge that a certain person has, or all of the activities that a particular resource of knowledge could support (Kingston,

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2001). Kingston (2001) proposed this idea in the scope of the Artificial Intelligence researcher's publications, where within every publication, there should be a correspondence to the latest know-how. This is a proposal, which is not included in any methodology to audit knowledge, only suggests that it could be used as a support, and its applications are very specific within the indexation of documents and/or publications.

Lazzolino and Pietrantonio (2005) also suggest within their methodology of the first phase of organizational knowledge detection, a scheme based on ontologies to build a descriptive framework of the intangible assets of the organization. This scheme is not explained nor detailed. On the other hand, there is not an explanation of how to apply such an ontology or how to analyze and classify organizational knowledge within this methodology; besides, there exists no evidence of its application in its organizational knowledge detection phase.

On his behalf, Jackson (2004) utilized a real case study to demonstrate how the needs of the organizations can be directed by rigorous classifications of their knowledge as the base for the storage and access to knowledge on the Intranet. The topic about ontologies was utilized in its philosophical and technological sense in order to provide a set of methods to try to give a practical answer based on theory.

After reviewing and analyzing literature related to the use of ontologies in knowledge audit's methodologies, we have found very few cases of its usage. There are cases in which ontologies are applied to some phases. Explicitly, there is no ontology applied as an integral strategy to represent the results of knowledge audit, nevertheless, evidence exists of the benefits ontologies can provide in activities related to the inventory, flow, classification and valuation of knowledge; knowledge management analysis and knowledge reuse (Perez-Soltero et al., 2006).

4. Proposal of Ontology as a Support to the Knowledge Audit Process

After reviewing different literature about knowledge audit, as well as various methodologies to audit knowledge such as the proposals by (Liebowitz et al., 2000; Lauer and Tannuri, 2001; Burnet et al., 2004; Choy et al., 2004; Iazzolino and Pietrantonio, 2005; Cheung et al., 2005) the main elements that should be considered within an audit process that have been observed are:

- To determine the *knowledge inventory*,
- To analyze the *knowledge nature*,
- To carry out a *knowledge valuation*,
- To analyze the *knowledge flow* and
- To analyze how the *knowledge management processes* are brought about.

Additionally, we propose the inclusion of another element, which permits to *reuse the results* obtained from the process of knowledge audit (Perez-Soltero et al., 2007). In figure 1 you can find an ontological framework which schematically shows these elements, and how the ontologies could be an important tool to facilitate the representation and analysis of each one of them. The detailed information of the ontological framework can be found in (Perez-Soltero et al., 2006).

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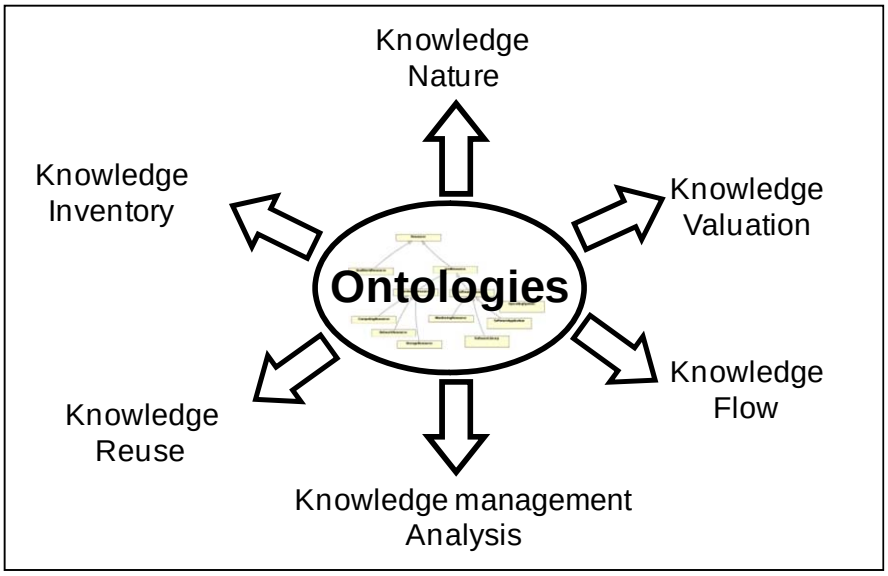

FIGURE 1: Ontological framework to support knowledge audit outcomes

Taking into account the aspects to be considered in the ontological framework as a support to knowledge audit, an ontology design is proposed. This ontology could be used as a support to the audit, the analysis of the identified latest know-how and the representation of the results of the audit.

It is important to say the proposed design includes all those elements described in the ontological framework, but it doesn't contain a detailed level in which way it covers all of the possible forms of classifying the latest know-how, such as those described in (Holsapple and Joshi, 2004; Nonaka and Takeuchi, 1995; Wiig et al., 1999; Vasconcelos et al., 2000). The forms of knowledge assessment such as those mentioned in (Bohn, 1993, 1994; Edvinsson and Malone, 1997; Norton and Kaplan, 1996), amongst others, are not mentioned. Neither is there a detailed listing in regards to the knowledge flow, and its valuation as those mentioned in (Anklam, 2005; Carver, 2001; Nissen, 2002, 2006), just to mention a few. The proposed design is conceived as a neutral ontology, since additional elements of valuation and classification can be added for the latest know-how and knowledge flow, which meet the specific needs of the domain where it is to be implemented.

Figure 2 shows the ontology design. It implements different classes and relations to represent the knowledge audit results.

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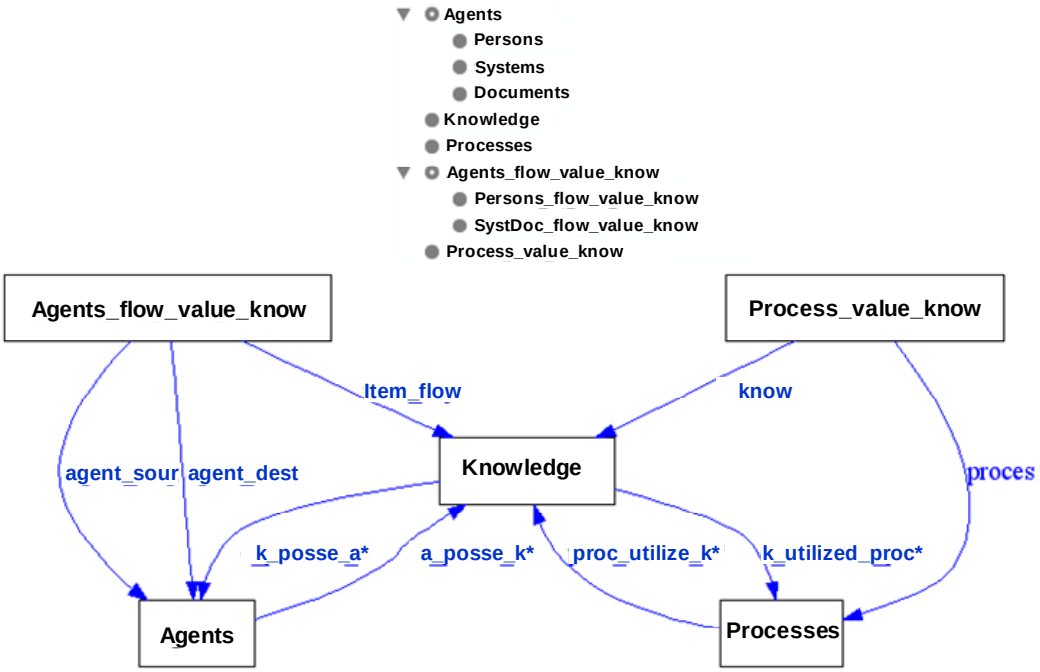

FIGURE 2: Design of an ontology to represent knowledge audit outcomes

At the top of figure 2 shows the classes of the ontology: ***Agents*** (subclasses: *persons*, *systems* and *documents*), ***Knowledge***, ***Processes***, **Agent_flow_value_know** (Subclasses: *Persons_flow_value_know* and *SystDoc_flow_value_know*) and ***Process_value_know***. At the bottom of this figure the relationship between these classes are shown.

Next, the ontology design is sectioned; the classes and relations between them are explained, emphasizing the aspects described in the ontological framework as a support of the knowledge audit.

4.1. Knowledge Inventory

In order to represent the elements related to a knowledge inventory, the ontology implements the classes ***Procceses***, ***Knowledge*** and ***Agents,*** where each one of them has different properties (more could be included according to needs). Figure 3 shows the existing relationships between such classes.

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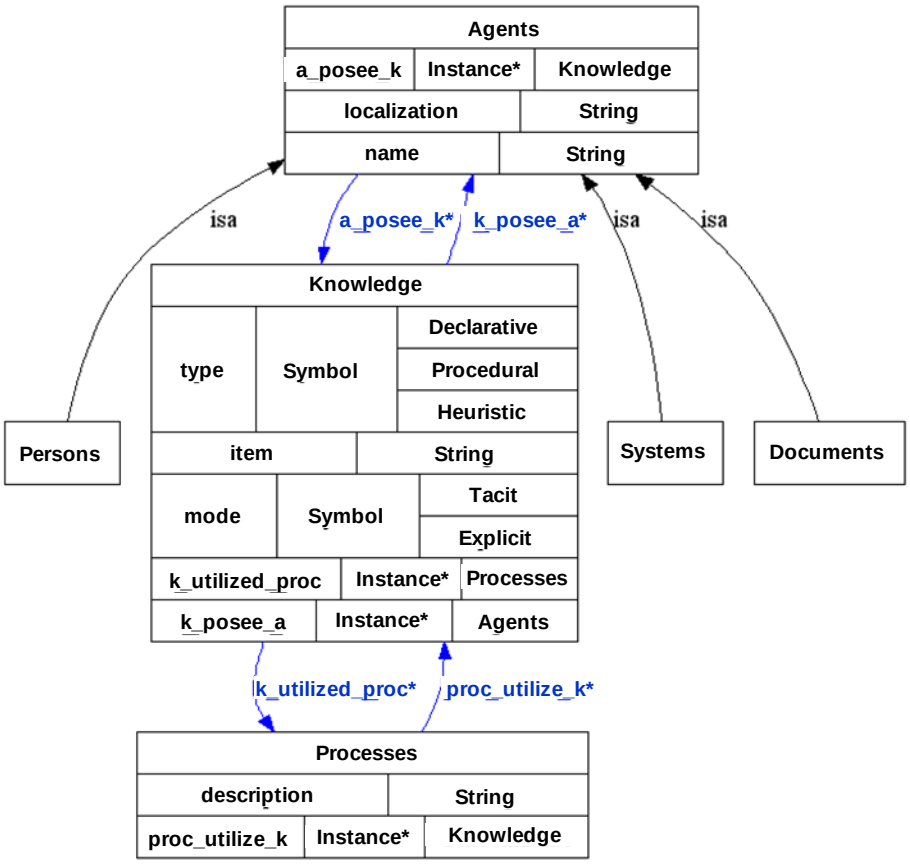

FIGURE 3: Ontology section related to knowledge inventory

The latest know-how can be represented in the ontology as instances pertaining to the ***Knowledge*** class (which has properties such as *name of item*, *type*, *mode*) or the ***Agents*** class (which has properties such as *name*, *localization*) to represent people, systems and documents; and the ***Processes*** class which will allow to represent the processes which are being analyzed in the knowledge audit. The relations between the classes allow us to know which processes a determined latest know-how belongs to, and which agent/agents have such knowledge.

The latest know-how can be recovered making searches within ontology, resides knowing to which processes the latest know-how pertains and which agent/agents know of such a knowledge. This class, upon being related with others in ontology, allows for the attainment of more specific information related to knowledge inventory, such as what tacit knowledge exists in a certain process, what persons utilize procedural knowledge more, what processes utilize explicit knowledge more, just to mention a few.

4.2. Knowledge Nature

In order to be able to represent the *knowledge nature*, the ontology contains the class ***Knowledge*** which has different properties (more can be included according to needs) that are shown in figure 4.

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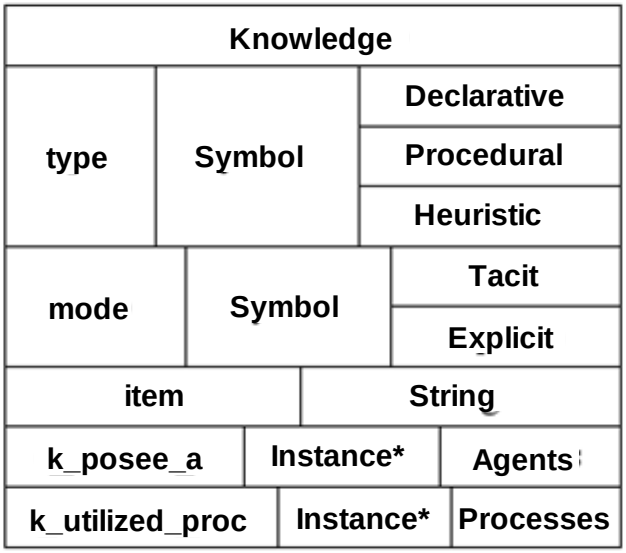

FIGURE 4: Ontology section related to knowledge nature

The information of the knowledge nature could be represented in the ontology as instances of the class ***Knowledge***. Some of the attributes of knowledge that can be included, are the name of the latest know-how, its type (declarative, procedural, heuristic), its mode (tacit, or explicit), etc.

The information of the knowledge nature could recover itself doing searches within ontology about the instances within the class of ***Knowledge***. With this class, you can obtain more specific information in regards to the knowledge nature, such as showing all of the existing procedural knowledge, what type of knowledge is the most used in the processes, just to mention a few.

4.3. Knowledge Valuation

In order to make the *knowledge valuation* easier, the ontology provides the classes of ***Agents_flow_value_know*** and ***Process_value_know***. Its attributes (more can be included according to the necessities) and relationships are shown in figure 5.

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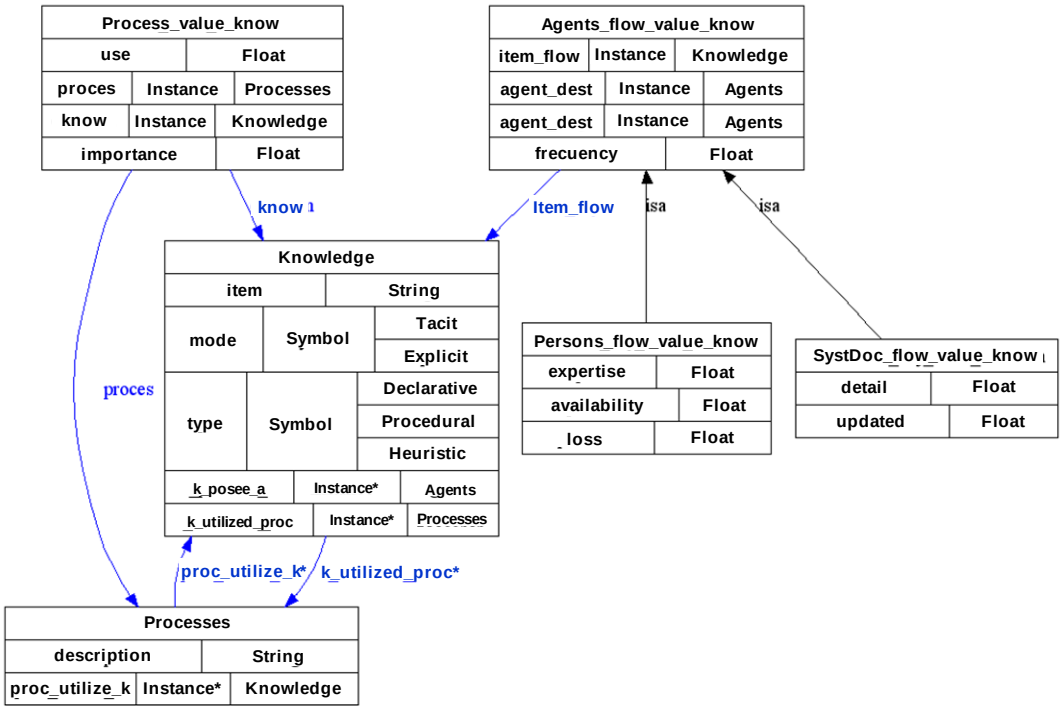

FIGURE 5: Ontology section related to knowledge valuation

The knowledge valuation could be represented in the ontology as instances of the following classes:

- Class ***Persons_flow_value_know,*** which has properties such as *availability* (describes the level of availability of the original agent), *expertise* (describes the level of expertise of the original agent) and *loss* (describes the level of impact if the knowledge the original agent has is lost).
- Class ***SystDoc_flow_value_know***, which has properties such as *updated* (describes the update level in which the information stored within the original agent is found), *detail* (describes the level of detail and explanation in which the information in the original agent is stored).
- Class ***Process_value_know***, which has properties such as *use* (describes the level of use that knowledge has in the key process) and *importance* (describes the level of importance that knowledge has in the key process).

The rest of the related classes within the ontology will allow us to recognize additional information related to the latest knowledge, processes and agents.

The information related to the knowledge valuation could be recovered by performing searches on the instances of class ***Persons_flow_value_know***, ***SysDoc_flow_value_know*** and ***Process_value_know*** of the ontology. Besides knowing what agent(s) possess such knowledge; these classes, upon being related with others in ontology, allow us to obtain more specific information related to knowledge valuation. Such information is the level of detail that a certain level has within a system or document, which knowledge has a greater impact within the process if it is lost, and what knowledge is of the most importance to a certain process, just to mention some.

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4.4. Knowledge Flow

In order to represent the *knowledge flow*, the ontology includes the classes ***Agents_flow_value_know***, ***Knowledge*** and ***Agents,*** where each of them has different properties (there can be more included depending on the needs). Figure 6 shows the existent relations between such classes.

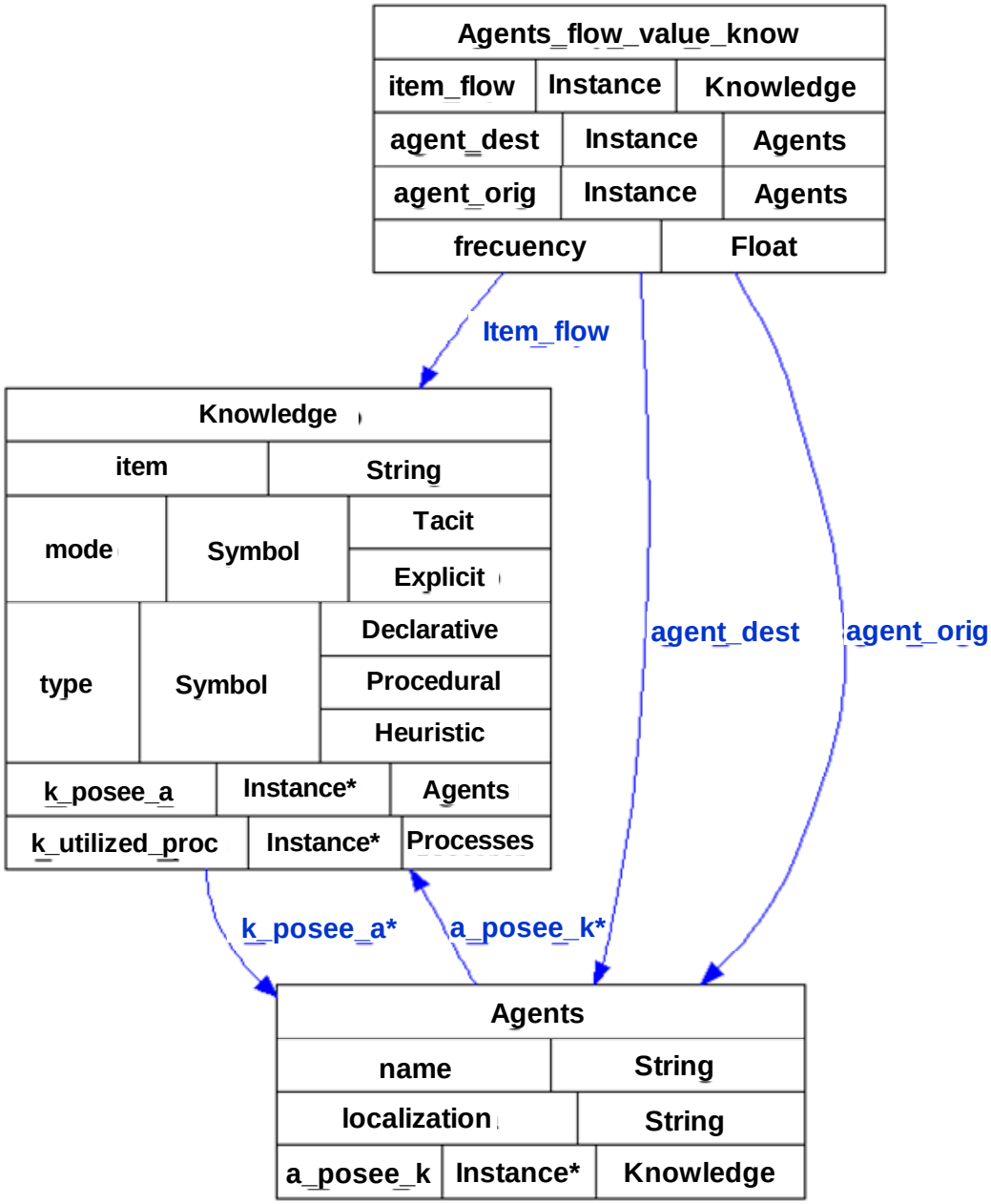

FIGURE 6: Ontology section related to knowledge flow

The information about the knowledge flows could be represented within the ontology as instances of the ***Agents_flow_value_know*** class (with properties such as *agent_orig*, *item_flow*, *agent_dest*, *frequency)*, where the agent (whether a person, system, or document) that originates the flow (*agent_orig*), the one who owns the knowledge that is flowing (*item_flow*), the destination agent (*agent_dest)*, and the frequency with which the destination agent turns to the original agent for the knowledge

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(*frequency*) are identified. In case the original agent is a person or a system/document, and the destination agent is a person, the frequency attribute will indicate the frequency with which the destination agent will consult the original agent.

In case that the original agent is a person or a system/document and the destination agent is a system/document, it would indicate the frequency the destination agent is updated with information that the original agent provides. The rest of the classes related with ***Agents_flow_value_know*** within the ontology, allow us to get additional knowledge related to the latest know-how, processes, and agents.

The information about the knowledge flow could be recovered by performing searches within the ontology, since they are stored as instances of the ***Agents_flow_value_know*** class. Besides, thanks to the ontology, we can determine what agent(s) posses such knowledge. This class, upon being related to others within the ontology, makes it possible to obtain the more specific information which is related to the knowledge flows, for example, which knowledge is provided by certain people, what knowledge certain person receives from other agents or what relevant knowledge is consulted the most frequently, just to mention a few.

4.5. Knowledge management analysis

In order to facilitate the *Knowledge management analysis*, and in this manner, detect problems/opportunities and find empty slots of knowledge, it is necessary to use all of the classes and their described relations within the proposed ontology. The knowledge management analysis should contemplate aspects which allow us to know how efficient we identify, store, recover, share and utilize knowledge within the processes of the organization and, in this manner, detect the problems/opportunities and empty slots of knowledge. Once the analysis has been concluded, initiatives that allow for the improvement of the management of organizational knowledge could be proposed. The ontology is proposed as a support tool, in order to realize this analysis plays a very important role, especially in the sections of the ontology related to knowledge valuation and flow (see figures 5 and 6). Next, there will be an example to show how the ontology can be a support tool of great use to understand the situation of the knowledge management within the processes of the organization.

If we analyze the instances of the ***Process_value_know***, ***Know***, ***Agents*** and ***Person_flow_value_know*** classes of the ontology, it can be determined what knowledge has the highest level of importance in a determined process, and what knowledge is tacit. Besides, we can determine the level of impact in a process depending on how much knowledge is lost, and how many people know it. This analysis can lead us to identify that the problem can be due to a deficiency in the management of such knowledge, mainly in the aspect of sharing. We will also be able to detect knowledge voids by simply identifying the people who participate in the processes that require such knowledge. A possible knowledge management initiative that could be proposed will consist of analyzing the convenience of explaining and storing such knowledge in some computer tool, in schemes that promote collaborative work, or in training courses for all of the people involved in the process, imparted by the owners of such knowledge, just to mention a few.

4.6 Knowledge reuse

Finally, the proposed ontology facilitates the *knowledge reuse* of the audit results in case that a knowledge management initiative requires a technological solution to be developed. Therefore, the ontology can be partly or fully reused, and it can also make use of the information in the form of instances or classes.

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Some scenarios where knowledge management initiatives could imply the reuse of the ontology could be the following:

Reuse of the ontology structure. In the development of a computer application to support the knowledge audits, the structure of the ontology could be reused adding new classes and more properties to the already existing classes, depending on the reach and level of detail of the audit. Inference mechanisms can also be included, so that they find the problems/opportunities within the knowledge management in a semi-automatic way.

Reuse of part of the ontology. For example, part of the ontology could be reused as part of a case based reasoning system on cases that documents how problems have been solved in the past in certain processes within the organization. Depending on the description of the problem that the user is looking for, the case based reasoning system could provide the user with the more relevant cases related to the problem trying to be solved. Once the user finds what cases are of real use to him/her, there can be searches within the audit ontology made to show what people, documents or systems can help and where they can be located. To perform this search within the ontology, diverse strategies can be utilized, for example, if there is an indication of what knowledge was necessary to solve such a problem, the search within the ontology will consist of obtaining all of those people, documents and/or systems that own the knowledge described in the case. In this type of search, we will be reusing the section of ontology that describes the knowledge inventory of the organization.

Reuse of the ontology completely. The development of a search tool of existing knowledge in the people, systems and documents requires the reuse of the ontology completely. When the user has some type of problem and does not know how to solve it, the tool can show him the different processes of the organization (he will select the one that interests him), the existing knowledge in the process (he will select what he wants to know) and who owns it. This tool can be joined with the case tool previously described, where all of the cases related with this process that have something to do with the knowledge that the user is looking for, are shown. Another form to reuse the ontology completely could be to support a management system of human resources of an organization and, in this manner, obtain relative information to the abilities, experience and knowledge that must be owned to solve problems that can be of use in other areas of the organization for the design of strategic training plans. All of this must be considered to meet the needs of knowledge or experience in the key processes of the organization.

5. Validation of the proposed ontology

A computer prototype was developed to validate the ontology. This computer tool uses the ontology introduced in Figure 2 to represent the data obtained from a knowledge audit. It was developed under Protégé 3.2.1 (Build 365). For more information on Protégé, installation and documentation, please refer to the website http://protege.stanford.edu/

The reason to implement the ontology using Protégé is that it is a very commonly used software tool in the field of ontological engineering, it is easy to use, free and it gathers the minimum requirements to support an implementation of the ontology in order to prove its functionality. On the other hand, Protégé used as an ontology implementing tool has the requirements needed to prove the advantages incurred in when using this ontology as a support to the knowledge audit process.

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The prototype was implemented in the Murcia University International Affairs Service (SRI-UM) as part of a knowledge audit process that took place in that organization. This organization was chosen due to the fact that it met with diverse characteristics, amongst them, that they possess diverse knowledge and that it is found in distinct forms (tacit, explicit; individual, group; declaratory, procedural, heuristic), an important requirement to be able to validate the ontology.

More specifically, the prototype was implemented in several of the SRI-UM core processes. To illustrate its functionality, the search process within the ontology with the information captured during the knowledge audit in the core process for accommodation of foreign students and professors "Vivir en Murcia" (VIMUR) will be shown.

Searching consists in obtaining ontology instances that qualify certain criteria. Several classes can be searched for simultaneously. Search results can also be stored for later usage or to be used as part of later searches. Here are two examples of searching the data gathered from the knowledge audit once input in the ontology captured in the prototype. For example, to perform a search for all instances of class ***knowledge*** that are a part of the accommodation program VIMUR. Figure 7 shows a search example displaying the entirety of knowledge assets that are a part of the process VIMUR.

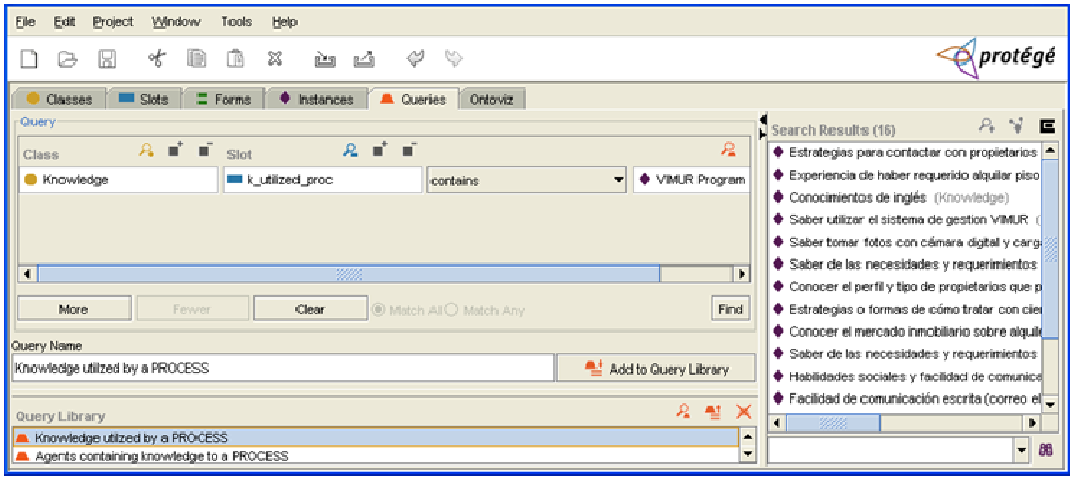

FIGURE 7: Prototype search screen showing all of VIMUR's knowledge assets.

Another search example could be used as a support in knowledge assets analysis. This analysis is performed on those knowledge assets that were valued as the most relevant/important ones for the key process VIMUR. In this case, the ontology was searched directly through the prototype and its results are shown on Figure 8.

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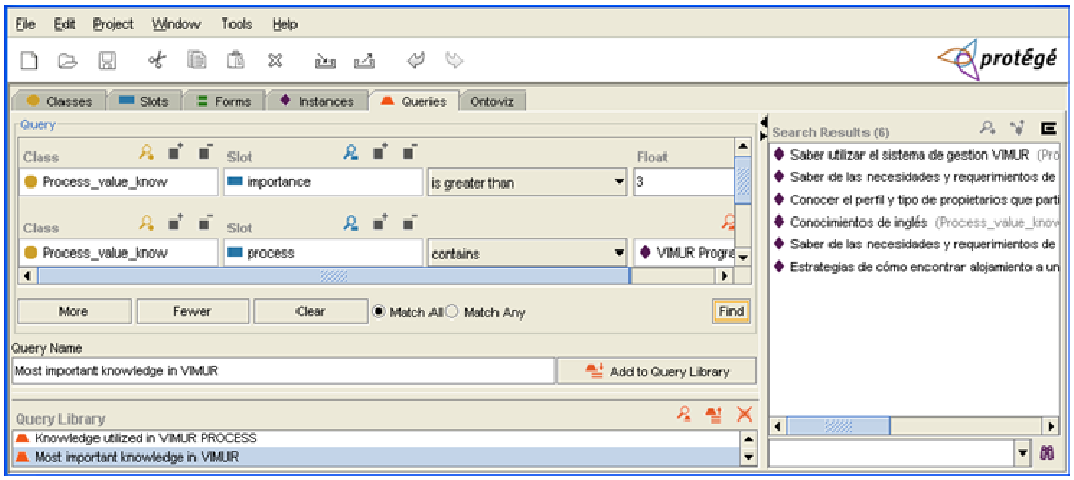

FIGURE 8: Prototype search screen showing the most important knowledge assets.

For length reasons, and the huge amount of possible search types available in the ontology, they are omitted. The search structure is similar to those previously shown.

Among the main aspects found during the knowledge audit and also detected with the prototype's help in the VIMUR process, high expertise in the English language, social skills and good verbal communication skills are required to properly conduct VIMUR's activities. Another key aspect is that this process is supported by computer systems, which are used as tools to carry out its activities from start to finish, which is why it is crucial to know how to use the different computer management systems. There are also tools that can be used to manage some aspects of the knowledge such as storage, sharing and usage. Another key element in this aspect is that a big part of the knowledge at VIMUR is obtained by facing and solving problems, and this experience is the key to get the activities carried out in a more efficient way. The main weakness observed in this process is that a single person runs it, and that is why it is important to get another member of the organization involved, besides of continuing the knowledge documentation in the computer management systems.

6. Practical implications

The preliminary results obtained from this investigation allow us to consider the feasibility of its practical application in organizations. Doing so requires a methodology that details how to audit knowledge step by step, as well as considering how to use the proposed ontology when gathering the information. In other words, it requires designing and developing a knowledge audit methodology supported by a software tool that covers all of the activities contained in the methodology, ranging from obtaining strategic information and identifying the key processes to start the audit on, up to developing the knowledge audit report.

As for the software tool that implements the functionality considered in the computer prototype, it should have a web-based search module, so everyone involved in the knowledge audit process can access it. The ability to automatically create forms and reports to automate the audit process as much as possible should also be included, in order to reduce costs and optimize time.

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7. Conclusions

The ontologies can serve as a support to the knowledge audit process within organizations including aspects from the representation of the results obtained throughout the audit up to serving as a mechanism to reuse information gathered from it. These results must be adequately represented in order to facilitate its efficient usage by the members of the organization or whoever wishes to use it in the given case that there is some technical solution wished to be implemented when there is some part of the knowledge management initiative proposed.

The design of the proposed ontology could serve as a support to knowledge audits to represent the knowledge inventory, the knowledge classification, the knowledge valuation, the knowledge flow, and the identification of knowledge gaps, to analyze knowledge management, and for the reuse of the audit results for the development of applications. This ontology could be enhanced with more classes, relationships, and properties, and reuse it in a complete or partial manner and adjusting itself to the necessities according to the level of detail that knowledge audit requires.

Finally, and as a part of the process of validation of the proposed ontology, a computer prototype was implemented in the Murcia University International Affairs Service (SRI-UM) as part of a knowledge audit process that took place in that organization obtaining good results.

References

Anklam, P (2005). Social Network Analysis in the KM Toolkit. *Knowledge Management Tools and Techniques Practitioners and Experts Evaluate KM Solutions*, Edited by Madanmohan Rao, ELSEVIER, pp. 329-346.

Berners-Lee, T, J Hendler and O Lassila (2001). The Semantic Web. *Scientific American*, 284(5), 34-43.

Bohn, R (1993). Technological knowledge – How to measure, how to manage, *Research Report 93-07*, Universidad de California, San Diego, Escuela de Graduados de Relaciones Internacionales y Estudios del Pacífico, La Joya, California.

Bohn, R (1994). Measuring and managing technological knowledge, *Sloan Management Review*, 36(1), 61-73.

Borst, WN (1997). Construction of engineering ontologies for knowledge sharing and reuse. *PhD Thesis*. University of Twente, The Netherlands, Enschede.

Borst, WN, JM Akkermans and JL Top (1997). Engineering ontologies. *International Journal of Human-Computer Studies*, 46, 365-406.

Budzak, D (2005a). Conducting a knowledge audit, Part I. *Inside Knowledge*, 9(3), 30-33.

Budzak, D (2005b). Conducting a knowledge audit, Part II. *Inside Knowledge*, 9(4), 32-36.

Burnet, S, L Illingworth and L Webster (2004). Knowledge Auditing and Mapping: A pragmatic Approach. *Knowledge and Process Management*, 11(1), 25-37.

Capshaw, S (1999). Whaddya know: find out with a knowledge audit the first step towards knowledge management, available at: http://www.aiim.org/inform/july99/p16.html (accessed January 15 2006).

Carver, J (2001). Knowledge Flow. Available at: http://www.seradigm.com (accessed April 12 2007).

Cheung, CF, KC Ko, KF Chu and WB Lee (2005). Systematic Knowledge Auditing With Applications. *Journal of Knowledge Management Practice*, August 2005.

Choy, SY, WB Lee and CF Cheung (2004). A Systematic Approach for Knowledge Audit Analysis: Integration of Knowledge Inventory, Mapping and Knowledge Flow Analysis. *Journal of Universal Computer Science*, 10(6), 674-682.

Dean, M, D Connolly, F Van-Harmelen, J Hendler, I Horrocks, DL McGuinness, PF Patel-Schneider and LA Stein (2004). OWL Web Ontology Language Semantics and Abstract Syntax. *Technical report*, World Wide Web Consortium (W3C), February 2004.

Edvinsson, L and MS Malone (1997). Intellectual Capital: Realizing Your Company's True Value by Finding its Hidden Brainpower, Harper Business, New York.

Fensel, D (2001). *A Silver Bullet for knowledge Management and Electronic Commerce*: Springer-Verlag Berlin Heidelberg.

Gruber, T. (1993). A Translation Approach to Portable Ontology Specifications. *Knowledge Acquisition*, 5(2), 199–220.

Gruber, TR (1995). Toward principles for the design of ontologies used for knowledge sharing. *International Journal of Human- Computer Studies*, 43(5-6), 907–928.

Gualtieri, A and M Ruffolo (2005). An ontology-based framework for representing organizational Knowledge, *Proceedings of I-KNOW 2005* pp. 71-78, Austria, July 2005.

Henczel, S (2000). The Information Audit As A First Step Towards Effective Knowledge Management: An Opportunity For The Special Librarian. *Inspel*, 34(3/4), 210-226.

Holsapple, CW and KD Joshi (2004). A formal knowledge management ontology: conduct, activities, resources, and influences, *Journal of the American Society for Information Science and Technology*, 55(7), 593-612.

Hylton, A (2002). A KM initiative is Unlikely to Succeed without a Knowledge Audit. Available at: http://www.annhylton.com/siteContents/writings/writings-home.htm. (accessed January 12 2007)

Hylton, A (2002b). Measuring & Valuing Knowledge: Role of the Knowledge Audit. Available at: http://www.annhylton.com/siteContents/writings/writings-home.htm. (accessed January 12 2007)

Iazzolino, G and R Pietrantonio (2005). Auditing the organizacional knowledge through a Balanced Scorecard-based Approach. *International Conference on Knowledge Management in Asia Pacific (KMAP 2005)*. November 2005.

Jackson, P (2004). Ontology and business: creating structure for storing and accessing organisational knowledge on intranets. In *Proceedings of the Twelfth European Conference on Information Systems* (Leino T, Saarinen T, Klein S eds.), Turku School of Economics and Business Administration, Turku, Finland. (ISBN 951-564-192-6)

Kingston, J (2001). Ontologies, Multi-Perspective Modelling and Knowledge Auditing. In *Proceeding of the II German/Austrian Conference on Artificial Intelligence*. September 2001.

Lassila, O and RR Swick (1999). Resource Description Framework (RDF) Model and Syntax Specification. *Technical report*, World Wide Web Consortium (W3C), February 1999.

Lauer, TW and M Tanniru (2001). Knowledge Management Audit – A Methodology and Case Study, *Australian Journal of Information Systems* (Special Issue on Knowledge Management), 23 – 41.

Liebowitz, J, B Rubenstein-Montano, D McCaw, J Buchwalter and C Browning (2000). The knowledge audit. *Knowledge and Process Management*, 7(1), 3-10.

Nissen, ME (2002). An Extended Model Of Knowledge-Flow Dynamics. *Communications of the Association for Information Systems*, 8, 251-266

Nissen ME (2006). *Harnessing Knowledge Dynamics: Principled Organizational Knowing And Learning*: IRM PRESS, ISBN 1-59140-773-7.

Nonaka, I and Takeuchi. (1995). *The Knowledge-Creating Company*: Oxford University Press.

Norton, D and R Kaplan (1996). *The Balanced Scorecard: Translating Strategy into Action*. Boston MA: Harvard Business School Press.

Perez-Soltero, A, G Sanchez-Schmitz, M Barcelo-Valenzuela, JT Palma-Mendez and F Martin-Rubio (2006). Ontologies as Strategy to Represent Knowledge Audit Outcomes. *International Journal of Technology, Knowledge and Society*, 2(5), 43-52.

Perez-Soltero, A, M Barcelo-Valenzuela, G Sanchez-Schmitz, F Martin-Rubio, JT Palma-Mendez and AA Vanti (2007). A Model and Methodology to Knowledge Auditing Considering Core Processes. *ICFAI Journal of Knowledge Management*, 5(1), 7-23.

Polanyi, M (1967). *The Tacit Dimension*. Garden City, N.Y.: Doubleday.

Vasconcelos, J, C Kimble and FR Gouveia (2000). A design for a Group Memory System using Ontologies. In *Proceedings of 5th UKAIS Conference*, University of Wales Institute, Cardiff, McGraw Hill, April 2000.

Wiig, KM, R Hoog and R Van Der Spek (1999). Supporting Knowledge Management: A Selection of Methods and Techniques. *Expert Systems With Applications*, 13(1), 15-27.

Zachman, J (2002). The Framework for Enterprise Architecture. Zachman Institute for Framework Advancement (ZIFA). http://www.zifa.com (Accessed May 09 2007)

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