The International JOURNAL of TECHNOLOGY KNOWLEDGE & SOCIETY

Ontologies as Strategy to Represent Knowledge Audit Outcomes

Alonso Perez-Soltero
Gerardo Sanchez-Schmitz
Mario Barcelo-Valenzuela
Jose Tomas Palma-Mendez
Fernando Martin-Rubio

VOLUME 2, NUMBER 5

COMMON GROUND

www.Technology-Journal.com

INTERNATIONAL JOURNAL OF TECHNOLOGY, KNOWLEDGE AND SOCIETY
http://www.Technology-Journal.com

First published in 2006 in Melbourne, Australia by Common Ground Publishing Pty Ltd
www.CommonGroundPublishing.com.

ISSN: 1832-3669
Publisher Site: http://www.Technology-Journal.com

The INTERNATIONAL JOURNAL OF TECHNOLOGY, KNOWLEDGE AND SOCIETY is a peer refereed journal. Full papers submitted for publication are refereed by Associate Editors through anonymous referee processes.

Typeset in Common Ground Markup Language using CGCreator multichannel typesetting system
http://www.CommonGroundSoftware.com.

Ontologies as Strategy to Represent Knowledge Audit Outcomes

Alonso Perez-Soltero, University of Sonora, Mexico
Gerardo Sanchez-Schmitz, University of Sonora, Mexico
Mario Barcelo-Valenzuela, University of Sonora, Mexico
Jose Tomas Palma-Mendez, University of Murcia, Spain
Fernando Martin-Rubio, University of Murcia, Spain

Abstract: Normally, after applying a knowledge audit methodology, the results are presented in a final report including knowledge inventory, knowledge maps, and knowledge flows. After analyzed the inventory, maps and flows, it is possible to identify inefficiencies reflected in duplication of efforts, knowledge gaps, knowledge barriers and knowledge-bottlenecks. All this information is integrated at the final report and is presented to managers, including diverse knowledge management initiatives. The main problems of representing the knowledge audit results only in this way, are the inefficiency of searching specific information about a knowledge asset; and difficulty of reuse them if a technological solution is needed as a part of a knowledge management initiative. The aim of this paper is to demonstrate the importance of using ontologies as a strategy to represent formally knowledge audit results to solve the previous problems and additionally obtain the next benefits: A support tool to detect problems/opportunities found in the organization to improve knowledge management; the results of the audit can be reused if a technological solution is needed; as a source of reference to know what, where, characteristics, classification and value of any assets of knowledge; as a form to represent the flow and its relation with the rest of assets; an efficient way to retrieve information from the inventory and/or flows of knowledge and automatically to know the impact and relation with the rest of the knowledge assets.

Keywords: Knowledge Audit, Ontologies, Knowledge Management, Knowledge Map, Knowledge Flow, Knowledge Inventory

Introduction

MANY ORGANIZATIONS ARE familiar with managing their operations, marketing, finance, sales or even supply chain. However, it is far from adequate for them to win in the very dynamic and highly competitive markets nowadays (Cheung et al., 2005). Increasingly the knowledge and skills of employees are seen as valuable assets that may be utilized in order to gain competitive advantage at an organizational level (Burnett, 2004). It is known that if knowledge is managed well, organizations can leverage on their knowledge, internal and external, for creation of new knowledge and innovation. It thus helps them to create values to the organizations (Cheung et al., 2005).

There are challenges related to knowledge management (KM) into organizations. One challenge is associated to knowledge auditing. In this case, knowledge audit methodologies do not establish a clear strategy explaining a suitable place where the knowledge audit in a enterprise or area should be initiated to give an order to complete the audit, in other words, they attempt to audit everything, significant or not to the organization. Other deficiencies found in the great majority of the knowledge audit methodologies, is that they do not establish measurement criteria to verify the impact related to KM processes. The methodologies analyzed need to be completed applied to detect problems/opportunities and then propose some improvements to the organization in relation to KM (Perez-Soltero et al., 2006). Other aspect refers to knowledge audit outcomes. After applying a knowledge audit, the results are presented in a final report including knowledge inventory, knowledge maps, and knowledge flows. All this information is integrated at the final report and is presented to managers, including diverse KM initiatives. The knowledge audit results represented only of this form has some disadvantages as: inefficiency of searching specific information about a knowledge asset; and difficulty of reuse them if a technological solution is needed as a part of a knowledge management initiative. Other of the main challenge is related to appropriate knowledge representation to manage knowledge efficiently within an organization.

The aim of this paper is to demonstrate the importance of using ontologies as a strategy to represent formally knowledge audit results to improve the efficiency of searching specific information about knowledge assets; and facilitate knowledge reuse if

a technological solution is needed as a part of a KM initiative.

The structure of this paper first describes some concepts related to knowledge in organizations, knowledge audit, knowledge audit methodologies and ontologies. Secondly, the importance of using ontologies to support knowledge audit outcomes and main aspects to consider in an ontology-based framework are analized. Finally, a discussion, conclusion and future work are explained.

Conceptual Framework

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

Knowledge in Organizations

It is very common the distinction between 'tacit knowledge' and 'explicit knowledge.' As (Polanyi, 1967) put it, 'We can know more than we can tell'. This phrase was used to describe tacit knowledge. Tacit knowledge is the knowledge that a person posses and that 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). The 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), "semistructured" (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 with the physical aspects of the knowledge and responds to the questions: What? Who? Where? and When?. It is a knowledge that 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?

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 the knowledge audit 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 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 Tanniru, 2001). Liebowitz defines a knowledge audit as a tool that assets potential stores of knowledge. It is the first part of any KM strategy. By discovering that 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 where change needs to be introduced to enterprise. Part of the knowledge audit is capturing "tacit" knowledge (Liebowitz et al., 2000).

The knowledge audit is used to provide a sound investigation into the organization's knowledge "health". 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-centred (Hylton, 2002b).

S. Capshaw 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 in knowledge within the enterprise (Capshaw, 1999).

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 the 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).

Knowledge Audit Methodologies

According to (Robertson, 2002) there are many benefits in applying a KM framework or methodology: offers legitimacy, provides consistent language, outlines a process, provides a checklist, offers a source of ideas and addresses non-technical aspects.

Gartner Group contends, for example, that a "knowledge audit" needs to be undertaken during the initial stages of the KM program. They state: The audit should identify the knowledge requirements of all processes that are heavily dependent on intellectual assets and that underlie the targeted business objectives. The audit ought to identify knowledge sources that can fulfil these knowledge requirements and the high-level business process steps where that knowledge must be applied (Gartner Group, 2000).

Company executives would do well to give serious consideration to undertaking a knowledge audit – even a small one. It is perfectly acceptable, and highly recommended that an organization begins a corporate knowledge audit by auditing one small team, unit, department, or a business process (Hylton, 2002a).

A knowledge audit will consist of two major tasks, each of which can be done without the other. The first, often called knowledge mapping, involves locating repositories of knowledge throughout the organization. This effort is primarily technological and usually prepares the way for creating a knowledge database. The knowledge mapping process is relatively straightforward. It takes an inventory of what people in the organization have written down or entered into information systems, as well as identifying sources of information employees use that come from the outside (such as public or university libraries, Web sites or subscription services). Finding and organizing all that data may be time-consuming, but it is not conceptually difficult. The second, a more intensive category of audit task attempts to capture the patterns of knowledge flow in the organization. This knowledge flow audit examines how people process information that ultimately determines how well an organization uses and shares its knowledge (Stevens, 2000).

While there seem to be several ways of conducting a knowledge audit (Liebowitz et al., 2000), (Henczel, 2000), (Lauer & Tannuri, 2001), (Housel and Kanevsky, 2001), (Hylton, 2002c), (Skyrme, 2002), (Schwikkard & du Toit, 2004), (Burnet et al., 2004), (Choy et al., 2004), (Iazzolino & Pietrantonio, 2005), (Cheung et al, 2005), in general knowledge audits consist of: the identification of knowledge needs through the use of questionnaires, interviews and focus groups; the development of a knowledge inventory mainly focusing on the types of knowledge available; where this knowledge is located; how it is maintained and stored, what it is used for and how relevant it is; analysis of knowledge flows in terms of people, processes and systems, the creation of a knowledge map; finally an audit detailed report.

Ontologies

An ontology, is a shared, formal conceptualization of a domain (Gruber, 1993; Borst et al., 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 semantic web which facilitates sharing and re-use of knowledge not only between software agents and computers but also between individuals (Fensel, 2001).

Ontologies to Support Knowledge Audit Outcomes

Typical Outcomes from Knowledge Audit Methodologies

Normally, after applying a knowledge audit methodology, the results are presented in a final report including knowledge inventory, knowledge maps, and knowledge flows. After the inventory, maps and flows are analyzed; it is possible to identify inefficiencies reflected in duplication of efforts, knowledge gaps, knowledge barriers and knowledge-bottlenecks. All this information is integrated in the final report and it is presented to managers, including diverse knowledge management initiatives. The knowledge audit results represented only of this form has some disadvantages as: inefficiency of searching specific information about knowledge assets; and difficulty of reusing them if a technological solution is needed as a part of a knowledge management initiative.

Ontologies into Knowledge Audit Methodologies

There are few proposes to apply ontologies in knowledge audits methodologies, some of them are only ideas and includes some aspects of auditing phases.

(Kingston, 2001) suggests an ontology that represents all the aspects of multi-perspective modeling. The multi-perspective modeling idea is that for any "knowledge asset" to be represented adequately, it's necessary to represent a number of different perspectives on its knowledge – and, possibly, to represent the asset at multiple different levels of decomposition. That is, for any knowledge resource, it can represent *what* it is, *who* possesses it, *how* it is used, *where* it can be found, *when* it is needed and *why* it exists (or why it is useful) (Zachman, 2002). In relation to levels of decomposition, Zachman illustrates the different levels of abstraction using examples from design and construction of a building, starting from the "scope" level (which takes a "ballpark" view on the building which is primarily the concern of the architect, and may represent the gross sizing, shape, and spatial relationships as well as the mutual understanding between the architect and owner), going through the "enterprise" level (primarily the concern of the owner, representing the final building as seen by the owner, and floor plans, based on architect's drawings) and on through three other levels (the "system" level, the "technology constrained" level and the "detailed representation" level, respectively the concerns of the designer, the builder and the subcontractor) before arriving at the "functioning enterprise" level (in this example, the actual building). Zachman describes this framework as "a simple, logical structure of descriptive representations for identifying 'models' that are the basis for designing the enterprise and for building the enterprise's systems" (Zachman, 2002).

If knowledge is collected and indexed considering the multi-perspective modeling and applying ontologies to represent it, should be possible to browse all the people who possess a particular knowledge resource (or part of it); or all the knowledge resources held by a particular person; or all the activities that can be supported by a particular knowledge resource. This approach is not included in any knowledge audit methodology.

(Kingston, 2001) designed an approach to knowledge auditing which uses an ontology of knowledge-related terms. The aim is to carry out a knowledge audit of Artificial Intelligence research and researchers, and so the terms focus on research topics, publication details, and so on.

(Iazzolino and Pietrantonio, 2005) suggests in their knowledge audit methodology where the first phase is aiming at (a) analyzing the whole organizational knowledge in all different forms and kinds and then (b) at classifying these forms and kinds by the three components of the enterprise intellectual capital: the human capital, the structural capital and the relational capital. The specific outcome to obtain behind this phase is then a map of the entire organization's knowledge that must be used for building-up a related descriptive frame of enterprise intangible assets – the ontology-based schemes can be specifically used to do this (Van Elst and Abecker, 2001).

The ontology-based scheme is not detailed nor explained; additionally, the knowledge audit methology proposed doesn´t explain how to apply the ontology and the way to analyze and classify the total organizational knowledge.

Necessity of a Framework to Structure Knowledge Audit Outcomes

The main thing that makes knowledge difficult to manage directly is a lack of some frame of reference or an adequate representation scheme (Gordon, 2000). As a way of representing, sharing and reusing organizational knowledge, the ontological discipline acts as both a knowledge modeling language and knowledge engineering technique (Vasconselos et al., 2003).

There are important aspects to consider in an ontology-based framework to represent the knowledge audit outcomes. These aspects are shown in figure 1.

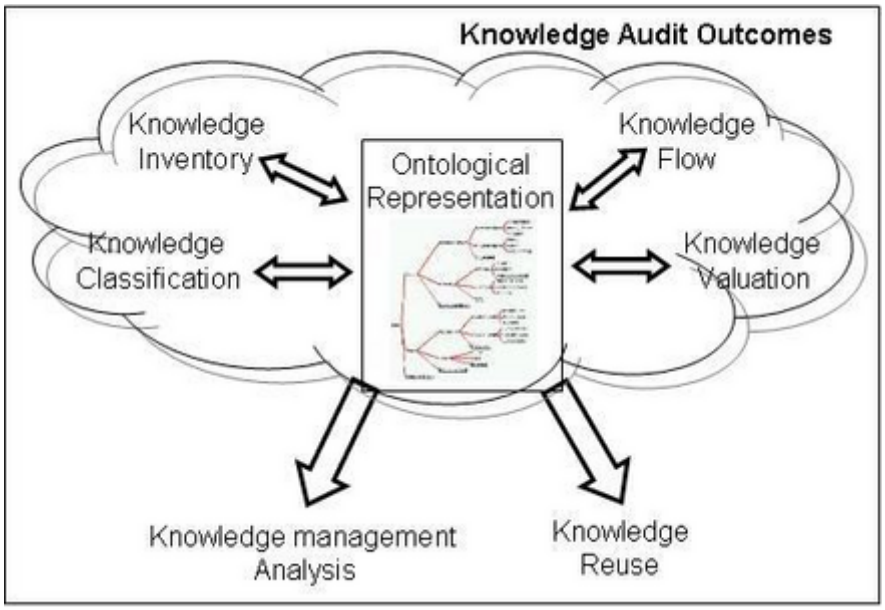

Fig. 1: Aspects to consider in an ontology-based framework to support knowledge audit outcomes

Applying an approach to represent knowledge audit outcomes supported by ontologies it is possible to solve the problem previously explained and exhibits various aspects of knowledge audits outcomes at the same time. Some of these aspects are knowledge inventory, knowledge flow, knowledge classification, and knowledge valuation; as well a knowledge management analysis; and the additional benefit of knowledge reuse.

Some strategies could be applied to carry out these objectives and are detailed in next section.

Important Aspects to Consider in an Ontology-Based Framework

After analyzing diverse literature, we have found feasible to apply a preliminary ontology-based framework taking into account the important aspects previously proposed. Next, the important aspects proposed, different approaches that can be implemented and some practical examples are explained.

- *Knowledge Inventory*: As a source of reference to know what, who and where any asset of knowledge is located. The double arrow between knowledge inventory and ontological representation shown in figure 1, means, knowledge assets could be represented in an ontology and searching on it, the knowledge inventory can be retrieved partially or totally.

The ontological approach uses ontologies to represent and manage both organisational knowledge containers and contents (Vasconselos et al., 2003). If knowledge is collected and is indexed according to aspects of an ontology, that is, for any knowledge resource, it can represent *what* it is, *who* possesses it, *how* it is used, *where* it can be found, *when* it is needed and *why* it exists (or why it is useful); then it should be possible to browse all the people who possess a particular knowledge resource (or part of it); or all the knowledge resources held by a particular person; or all the activities that can be supported by a particular knowledge resource (Kingston, 2001). (Van and Abecker, 2001) state a related descriptive frame of enterprise intangible assets – the ontology-based schemes can be specifically used to do this.

(Gualtieri and Ruffolo, 2005) propose an ontology-based framework called COKE (Core Organizational Knowledge Entities). The COKE ontologies formally represent *human resources* (represents individuals working in the organization and social groups they are involved in. Each individual profile is represented in term of implicit, explicit, individual and social knowledge, organizational role, social group membership, required technical resources), *business processes* (contains procedural knowledge related to the managerial, operational and decisional processes. Each of them is described in terms of activities, subprocesses, transition states and conditions, involved actors, treated topics, etc.), *knowledge objects* (maps the structure of logical objects, e. g. database schema, database tables, textual documents, web pages, etc.; containing explicit knowledge under structured, semi-structured or unstructured form (AAAI, 2000)), *technical resources* (identifies the tools by which knowledge objects are created, acquired, stored and retrieved) constituting the main elements characterizing the organizational structure and playing a fundamental role in business activities execution.

(Jackson, 2004) in his research has used a real life consulting case study to show how the needs of organizations can be addressed by providing rigorous

classifications of their knowledge as a basis for knowledge storage and access on Intranets. The discussion space of ontologies was used in its philosophical and technological sense to provide a platform of methods to try and provide a practical response based upon theory.

- *Knowledge Flow*: As a form to represent and retrieve information from the flow and its relation with the rest of assets. The double arrow between knowledge flow and ontological representation shown in figure 1, means, flows could be represented in an ontology and searching on it information about knowledge flows can be retrieved partially or totally.

Another use for an ontology is one that highlights particular communities of practice. Such communities consist of groups of like-minded workers, possibly across companies and even technical sectors, who share a number of assumptions (tacit knowledge) about their work, maybe focusing on particular approaches or sub-disciplines. Traversing relationships in a valuation ontology, weighted to reflect their importance (for valuation), can show links between people. There are, of course, issues here about how to draw boundaries around such communities, which relationships to track and how to weight them, and how to calculate the strength of a connection. Nevertheless ontologies, by providing the conceptual apparatus to express the relationships, hierarchies and axioms that will be of importance to defining a community, can be of help in understanding such communities, which often are difficult for management to track because of their informal nature (O'Hara and Shadbolt, 2001).

- *Knowledge Classification*: As a source of reference to know characteristics and classification of knowledge assets. The double arrow between knowledge classification and ontological representation shown in figure 1, means, knowledge classification could be represented in an ontology and searching on it the classification can be retrieved partially or totally.

A Cost/benefit analysis for KM decisions such as whether to codify or recodify a body of knowledge could be highly valuable. An ontology for classifying such bodies of knowledge in their organizational context along value-relevant dimensions would be applied, to provide an understanding of the value of the knowledge within the business plan/processes of the host organization, and provide useful pointers towards a cost/benefit analysis of a proposed codification (O'Hara and Shadbolt, 2001).

Knowledge resources can be classified in different ways in an ontology. (Weinberger, 2003) proposes two subclasses: 1. Documents – structured repositories that include best practices, lessons learned, FAQ, stories, guides, proposals and engagements, as well as other documents forms, and 2. Pocket Items - accommodates soft knowledge "passing" in various pipelines, such as bulletin boards, knowledge pockets (expert heads), discussion groups, knowledge centers and knowledge markets. Documents can be classified as explicit, articulated, codified, concrete and source. Pocket Items classified as tacit, subjective and intuitive.

- *Knowledge Valuation*: As a form to value any assets of knowledge. The double arrow between knowledge valuation and ontological representation shown in figure 1, means, knowledge valuation could be represented in an ontology and searching on it, the knowledge valuation can be retrieved partially or totally.

The aim of a knowledge valuation ontology should be to allow users to express factors relevant to valuing a particular piece of knowledge. Much of this, of course, is an open question given that knowledge's non-marketability makes it very difficult to suggest an objective value (O'Hara and Shadbolt, 2001).

Considering this difficult, however some researchers as O'Hara and Shadbolt state the more a piece of knowledge is used, the more valuable it is, the more likely it is to be embodied in and essential for production processes. Hence we will want a knowledge valuation ontology to enable the expression of the connectedness of a piece of knowledge or a knowledge source with a network of users or community of practice. Using inference-supporting ontologies to understand the value of knowledge has the potential to be an important tool for the management of knowledge assets. We have seen what a large part of a company's value is down to the intangible assets, and knowledge is one of the most important of those. Knowing more about what it is worth is a key factor in using it properly (O'Hara and Shadbolt, 2001).

Several parameters and combinations of parameters to knowledge valuation have been tested and the following four have been found to be the most useful in all audits. *Importance* (How important is the knowledge to the company?), *difficulty* (How difficult would it be to replace this knowledge?), *study–experience* (Is the knowledge acquired mainly from study or practice?), *known by* (What proportion of the staff in the knowledge area know this?). Parameter values are estimates and can be subjective. However some validation does occur during the interview process and it is important to inform managers that the parameters reflect what their staff is thinking and if this is a problem then this may also be something that requires attention (Gordon 2000). These are some examples of parameters that could

be used as attributes of an ontology to knowledge valuation.

Many, if not all, knowledge asset instances will have base indicators of value, which would be expressed as attributes of the instances. For example: Publications might include an attribute quantifying its citations, or the citation rates of the authors, and the impact factor of the journal in which it was published. Individuals may have as attributes the ranking of their institution, the number of publications or patents for which they are responsible, the amount of research funding for which they are responsible, or simple indicators of rank (e.g. Professor, CEO) (O'Hara and Shadbolt, 2001).

- *Knowledge Management Analysis*: As a support tool to analyze organizational knowledge management processes, detect problems/opportunities and knowledge gaps found in the organization to improve knowledge management in the organization. The arrow from ontological representation to knowledge management analysis shown in figure 1, means the ontology could be examined to obtain the knowledge management analysis considering the inventory, flows, classification and valuation.

The current state of knowledge within an organization is mapped, e.g. by creating a matrix of domain problems crossed with known solutions/best practice. Hence, such a matrix can be used to identify knowledge gaps, such as problems for which the organization possesses either no solution, or only unreliable or expensive ones. For an organization with a large library of knowledge sources, some automatic processing may help to link some problems with solutions. An ontology that relates knowledge sources to particular people and processes within the organization could help cut down search spaces dramatically (O'Hara and Shadbolt, 2001).

- *Knowledge Reuse*: As knowledge representation strategy to reuse the results of the audit if a technological solution is needed. The arrow from ontological representation to knowledge reuse shown in figure 1, means the ontology provides a collective understanding of a domain in a way to facilitate knowledge sharing and reuse between software agents and computers but also between individuals.

Ontologies to reuse knowledge in a technological issue are very important. At present, the greatest needs are in the areas of integration, standardization, development of tools, and adoption by users (Antoniou and Harmelen, 2004). A strategy to satisfy this necessity has been developing software applications using Web technologies. Some of the audit outcomes could be available in a web-based system. From this point of view, the next development step should be centered on Semantic Web vision. (Antoniou and Harmelen, 2004) state the goal of the Semantic Web is to assist human users in their day-to-day online activities. In the context of the Web, ontologies provide a shared understanding of a domain. Such a shared understanding is necessary to overcome differences in terminology. It is easy to see that ontologies support semantic interoperability.

The ontological approach uses ontologies to represent and manage both organizational knowledge containers and contents. This technique allows the representation of organizational knowledge in a way that facilitates knowledge sharing and reuse between organizational agents (Vasconselos et al., 2003).

(Gualtieri and Ruffolo, 2005) sample that a Knowledge Management System must be able to support the generation, discovery, capture, store, distribution and application of a wide variety of knowledge (i.e. explicit knowledge under structured, semi-structured and unstructured forms and individual and social aspects of implicit knowledge) through related knowledge-based services. Moreover, a Knowledge Management System needs capability to interoperate with already existing organizational information systems. To satisfy these requirements a Knowledge Management System needs knowledge representation capabilities that can be provided by ontology languages, able to allow the specification of the different organizational knowledge forms and kinds and to carry out an abstract representation of organizational entity supporting interoperability among different systems and organizational areas.

For example (Sridharan et al., 2004) propose a framework for a knowledge management system which uses ontology to enable efficient reuse and sharing of knowledge in a web based learning environment.

Discussion

After analysing the literature related to utilize ontologies in knowledge audit methodologies, we have found few cases of its application. There are cases where ontologies are applied in some phases. Explicitly, not any ontology is applied as an integral knowledge representation strategy to represent their outcomes, however it exists evidence of benefits in activities related to knowledge inventory, knowledge flow, knowledge classification, knowledge valuation, knowledge management analysis and knowledge reuse. Considering the aspects of the ontology-based framework to support knowledge audit outcomes proposed and illustrated in figure 1, it is possible to represent the knowledge inventory, knowledge flow, knowledge classification and knowledge valuation;

additionally, if the ontology is developed considering these aspects, it will be possible to obtain the inventory, flow, classification and knowledge valuation of the organizational knowledge assets partially or totally. The execution of a query to the ontology can be executed using a specific tool to retrieve all the elements related with a specific concept. For example a query result can contain people knowing a given concept or systems containing knowledge objects related to some concepts.

Further, if the ontology is examined a KM analysis to detect problems/opportunities and knowledge gaps found in the organization might be obtained to improve KM into organization. Finally, the ontology would be a good scheme to reuse the results of the knowledge audit if a technological solution is needed. This would allow a management of the tacit and explicit knowledge stored in structured, semistructured or unstructured machine-readable form.

Conclusions and Future Work

This paper demonstrates and analyzes the importance of using ontologies as a strategy to represent formally knowledge audit results. The evidence in literature was found and shows benefits in issues related to knowledge inventory, knowledge flow, knowledge classification, knowledge valuation, knowledge management analysis and knowledge reuse. Considering these aspects, a preliminary integral ontology-based framework to support knowledge audit outcomes is proposed.

Additionally, applying this approach the following benefits could be obtained: a support tool to detect problems/opportunities found in the organization to improve KM; the results of the audit can be reused if a technological solution is needed; as a source of reference to know what, where, characteristics, classification and value of any assets of knowledge; as a form to represent the flow and its relation with the rest of assets; an efficient way to retrieve information from knowledge inventory and/or knowledge flows and automatically to know the impact and relation with the rest of the knowledge assets.

There are different activities to be carried out in future work. Some of them are related detailing the ontology structure in terms of classes, attributes and relations in each of the aspects of the ontology-based framework proposed to support knowledge audit outcomes. Later, it will be validated in a test case. Perhaps applying a software tool to model the ontology could be a good strategy to facilitate the validation process.

Acknowledgments

To the Universidad de Sonora and to ‘Programa de Mejoramiento al Profesorado PROMEP’ for the support of this research and the development of the Information Technologies Academic Group.

References

AAAI Spring Symposium (2000). S. Staab, D. O'Leary (eds.) Bringing Knowledge to Business Processes, *Proceedings of 2000 AAAI Spring Symposium*, AAAI Press, 2000

Antoniou G. and Harmelet F.V. (2004). A Semantic Web Primer. *MIT press*. USA.

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

Borst W.N.,. Akkermans J. M., and. Top J. L. (1997). “Engineering ontologies”. *International Journal of Human-Computer Studies*, 46:365–406.

Burnet S., Illingworth L., Webster L. (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).

Cheung C.F., Ko K.C., Chu K.F., Lee W.B. (2005). “Systematic Knowledge Auditing With Applications”. *Journal of Knowledge Management Practice*, August 2005.

Choy S.Y., Lee W.B., Cheung C.F. (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., Connolly D., Van-Harmelen F., Hendler J., Horrocks I., McGuinness D.L., Patel-Schneider P.F., and Stein L.A. (2004). “OWL Web Ontology Language Semantics and Abstract Syntax”. *Technical report, World Wide Web Consortium (W3C)*, February 2004.

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

Gartner Group (2000). “Mapping knowledge to the process: directions to success”. Advisory Research Note.

Gordon J.L. (2000). “Creating Knowledge Structure Maps to support Explicit Knowledge Management”, *Proceeding of the Twentieth Annual International Conference on Knowledge Based Systems and Applied Artificial Intelligence (ES2000)* pp. 34-48, Cambridge, England, December 2000.

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

Gualtieri A. and Ruffolo M. (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.

Housel T.J. and Kanevsky V. (2001). "Knowledge Value-Added (KVA) Methodology". The international Engineering Consortium. http://www.iec.org (accessed April 15 2006).

Hylton, A. (2002)a. "A Knowledge Audit Must be People-Centred & People Focused". http://www.annhylton.com/siteContents/writings/writings-home.htm, 2002. (accessed December 2 2005).

Hylton A. (2002)b. "Measuring & Valuing Knowledge: Role of the Knowledge Audit". http://www.annhylton.com/siteContents/writings/writings-home.htm. (accessed January 12 2006)

Hylton A. (2002)c. "A KM initiative is Unlikely to Succeed without a Knowledge Audit". http://www.annhylton.com/siteContents/writings/writings-home.htm. (accessed January 12 2006)

Iazzolino G. and Pietrantonio R. (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". *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". *Proceeding of the II German/Austrian Conference on Artificial Intelligence*. September 2001.

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

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

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

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

O'Hara K. and Shadbolt N. (2001). "Issues for an Ontology for Knowledge Valuation". *Proceedings IJCAI Workshop on E-Business and the Intelligent Web*. Seatle.

Perez-Soltero A., Barcelo-Valenzuela M., Sanchez-Schmitz G., Martin-Rubio F., Palma-Mendez J.T. (2006), "Knowledge Audit Methodology with Emphasis on Core Processes", *Proceedings of the European and Mediterranean Conference on Information Systems (EMCIS 2006)*. Editors: Professor Zahir Irani, Mr Omiros D. Sarikas, Professor Juan Llopis, Dr Reyes Gonzalez, Dr Jose Gasco ISBN: 1-902316-46-0, Costa Blanca, Alicante, Spain.

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

Robertson, J. (2002. "Benefits of a KM framework". http://www.intranetjournal.com/articles/200207/se_07_31_02a.html (accessed 12 January 2002).

Skyrme D. (2002). "Knowledge Audit". http://www.skyrme.com/services/kmaudit.htm (Accessed January 18 2006).

Sridharan B., Tretiakov A. & Kinshuk (2004). "Application of Ontology to Knowledge Management in Web based Learning". In Kinshuk, Looi C.-K., Sutinen E., Sampson D., Aedo I., Uden L. & Kähkönen E. (Eds.), *Proceedings of the 4th IEEE International Conference on Advanced learning Technologies 2004* (August 30 - Sept 1, 2004, Joensuu, Finland), Los Alamitos, CA: IEEE Computer Society (ISBN 0-7695-2181-9), 663- 665.

Stevens, L. (2000). "Knowing what your company knows: a knowledge audit is a necessary precursor to a new KM initiative", http://www.destinationcrm.com/km/dcrm_km_article.asp?id=475 (accessed 12 January 2006)

Schwikkard D.B. and Du Toit A.S.A. (2004). Analising knowledge requirements: a case study. *Aslib Proceedings*, 56(2): 104-111.

Van Elst L. & Abecker A. (2001). "Domain Ontology Agents in Distributed Organizational Memories", *Working Notes of the Workshop on Knowledge Management and Organizational Memories (IJCAI-2001)*, Seattle.

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

Vasconcelos J., Kimble C., Rocha A. (2003). "Ontologies and the Dynamics of Organisational Environments: An Example of a Group Memory System for the Management of Group Competencies", *Proceedings of I-KNOW 2003*, Austria, July 2003.

Weinberger H, Te'eni D, Frank AJ (2003). "Ontologies of organizational memory as basis for evaluation". *Proceedings of the Eleventh European Conference on Information Systems* (Ciborra CU, Mercurio R, de Marco M, Martinez M, Carignani A eds.), Naples, Italy.

Zachman J. (2002). "The Framework for Enterprise Architecture". *Zachman Institute for Framework Advancement (ZIFA)*. http://www.zifa.com (09 Mayo 2006)

About the Authors

Prof. Alonso Perez-Soltero
Alonso Perez-Soltero Professor at the Department of Industrial Engineering in University of Sonora, Mexico.

Prof. Gerardo Sanchez-Schmitz
Gerardo Sanchez-Schmitz Professor at the Department of Industrial Engineering in University of Sonora, Mexico.

Prof. Mario Barcelo-Valenzuela
Mario Barcelo-Valenzuela Professor at the Department of Industrial Engineering in University of Sonora, Mexico.

Dr. Jose Tomas Palma-Mendez
Jose Tomas Palma-Mendez Doctor at the Department of Information & Communication Engineering in University of Murcia

Dr. Fernando Martin-Rubio
Fernando Martin-Rubio Doctor at the Department of Information & Communication Engineering in University of Murcia

THE INTERNATIONAL JOURNAL OF TECHNOLOGY, KNOWLEDGE AND SOCIETY

Please visit the Journal website at http://www.Technology-Journal.com for further information:

- ABOUT the Journal including Scope and Concerns, Editors, Advisory Board, Associate Editors and Journal Profile
- FOR AUTHORS including Publishing Policy, Submission Guidelines, Peer Review Process and Publishing Agreement

SUBSCRIPTIONS
The Journal offers individual and institutional subscriptions. For further information please visit http://ijt.cgpublisher.com/subscriptions.html. Inquiries can be directed to subscriptions@commongroundpublishing.com

INQUIRIES
Email: cg-support@commongroundpublishing.com