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An ontology-based knowledge network to reuse inter-organizational knowledge

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Researchers have developed various types of Knowledge Management approaches that only focus on managing organizational knowledge. However, these designs are inadequate because employees are often needed to access knowledge from other knowledge sources in order to complete their works. Therefore, a new interorganizational Knowledge Management practice is required to enhance the sharing of knowledge across organizational boundaries in their business networks. In this paper, we investigate the application of ontology mediation that provides mechanisms of reconciling inter-organizational knowledge. An ontology-based Interorganizational knowledge Network that incorporates ontology mediation is developed so that heterogeneity of knowledge semantic in the ontologies could be reconciled. The reconciled inter-organizational knowledge could be reused to support organizational Knowledge Management process semi- or automatically.

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An Ontology-Based Knowledge Network to Reuse Inter-Organizational Knowledge

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Abstract

Researchers have developed various types of Knowledge Management approaches that only focus on managing organizational knowledge. However, these designs are inadequate because employees are often needed to access knowledge from other knowledge sources in order to complete their works. Therefore, a new inter-organizational Knowledge Management practice is required to enhance the sharing of knowledge across organizational boundaries in their business networks. In this paper, we investigate the application of ontology mediation that provides mechanisms of reconciling inter-organizational knowledge. An ontology-based Inter-organizational knowledge Network that incorporates ontology mediation is developed so that heterogeneity of knowledge semantic in the ontologies could be reconciled. The reconciled inter-organizational knowledge could be reused to support organizational Knowledge Management process semi- or automatically.

Keywords

Mediation, Ontology Mapping, Ontology Merging, Knowledge Management, Inter-organizational Knowledge

Introduction

Knowledge is currently recognized as one of the most important management assets in organizations because knowledge enables them to utilize and develop resources, enhance their fundamental competitive ability and develop substantial competitive advantage. The uniqueness of knowledge also enables organizations to differentiate themselves from rival competitors. Failure to manage knowledge effectively would result in the loss of organizations' priceless inspiration and creativity (Coulson-Thomas 1997). Under this circumstance, the concept of Knowledge Management (KM) is emerged with the purpose of preserving and capitalizing on organizational knowledge for the future benefit of organizations. KM encourages organizations to create and use knowledge continuously for the innovation and enhancement of service, product and operation. Simultaneously, it also aims to improve the quality, content, value and transferability of individual and group knowledge within an organization (Mentzas et al. 2001). This is achieved by organizing formal, direct and systematic process to create, store, disseminate, use and evaluate organizational knowledge using the appropriate means and technologies (Leung 2006) as illustrated in Figure 1.

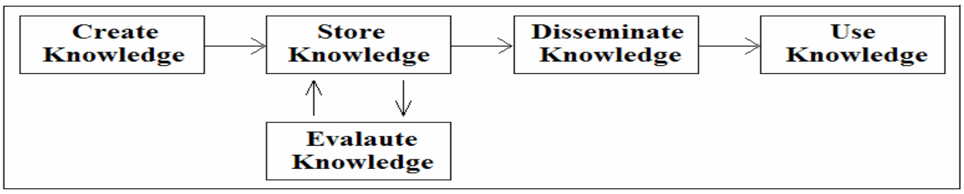

Figure 1: Knowledge Management Process

Nonaka, Toyama & Konno (2001) suggest that there are four methods to create organizational knowledge by means of interaction between explicit and tacit knowledge. While tacit knowledge is personal, complex and hard to communicate and formalize because it is gained through individual insights overtime and is resided in human, mind and body, explicit knowledge is structured, relatively simple and can be captured, recorded, documented, codified and shared using formal and systematic language (Goh 2002; Nonaka & Takeuchi 1995). The first method to create knowledge is socialization. It is the process of developing new tacit knowledge from tacit knowledge embedded in human or organization through experience sharing, observation and traditional apprenticeship. The second method is called externalization. This is the process of turning tacit knowledge into new explicit knowledge simply by transforming tacit knowledge in the form of document such as manual and report. The third method is combination. This is the process of merging and editing "explicit knowledge from multiple sources" into a new set of more comprehensive and systematic explicit knowledge. The last one is called internalization. This is the process of embodying explicit knowledge as tacit knowledge by learning, absorbing and integrating explicit knowledge into individual's tacit knowledge base.

The second and third stages of KM, store and disseminate are often linked with technologies. Explicit knowledge created is collected and stored in some sort of database or knowledge base in which the users can access using "search and retrieve" tools, intranets, web access and applications, groupware and so on (Alavi & Leidner 1999; Smith 2001). The retrieved knowledge can then be used by knowledge workers to add value to current business process, implement and coordinate organizational strategy, predict trends in the uncertain future, deliver new market values, create new knowledge, solve existing problems and so on (Bailey & Clarke 2001; Newman 1997). The fifth stage of KM is knowledge evaluation. This phrase eliminates incorrect or outdated knowledge (Alavi & Leidner 1999). In other words, organization must keep creating new knowledge to replace any knowledge that has become invalid.

Researchers have developed various types of KM approaches ranging from industrial specific to procedure-wise, for example, the re-distributed KM framework is developed to manage organizational help desk knowledge (Leung 2006). Unfortunately, these designs are only focused on managing organizational knowledge which is inadequate in the current business environment. It is inadequate because employees are often required to access knowledge from other knowledge sources in order to complete their works in the knowledge explosion era, for instance, an investment manager has to retrieve company's financial report, share performance report and regional economy reports from external sources if s/he wants to adjust the proportion of a particular share in the investment portfolio. Wagner (2005) argues that knowledge-sharing in an inter-organizational network allows a richer and more diverse body of knowledge to be created as compared with sharing in one organization. As external source of knowledge is essential for organizational performance, a new inter-organizational KM practice is required to enhance the sharing of knowledge across organizational boundaries in their business networks (Oinas-Kukkonen 2005).

This paper discusses the role of ontology in supporting KM. We investigate the application of ontology mediation approach that provides mechanisms of reconciling inter-organizational knowledge to develop a new inter-organizational KM practice. The paper also discusses the reusability of the reconciled inter-organizational knowledge to support the organizational KM process in terms of knowledge creating, storing, dissemination, using and evaluation. The rest of the paper is organized as follows. Section 2 discusses the role of ontology in KM. A proposed reusable inter-organizational knowledge network us outlined in Section 3. Finally, conclusion is given in Section 4.

Role of Ontology in Knowledge Management

The success of KM largely depends on human and social factors such as human relationships, interpretations, processes, resources, culture, mentality and so forth (Holsapple 2005). The cooperation and collaboration among groups, individuals and leaders in knowledge transfer and sharing can add value to knowledge (Goh 2002). Although technology itself adds no value to knowledge, it still plays an important role in streamlining the KM process, for instance, electronic repository and search engine can be used to facilitate knowledge storing and dissemination. A minority view KM as another repackaging project of Information Technology (IT) and even confuse Knowledge Management System (KMS) with Information System (IS) because their concepts are alike (Lueg 2001). On one hand, IS utilizes data to yield useful information in order to support and improve business operation as well as problem-solving and decision-making within an organization, on the other hand, KMS is an IT-based system designed to fit in the KM process (Alavi & Leidner 1999; Whitten, Bentley & Dittman 2001). In general, special algorithm or technique is required in an IS to pull together small chunks of data for the transformation of information whereas knowledge, relatively larger in size, is required to convert into a particular type of representation that can be stored in a KMS. To retrieve the stored knowledge, users can use the dissemination function embedded in the KMS. Although the technologies used to perform information transformation as well as knowledge storing and retrieval are significantly different, it is in fact the well-developed IT and IS that provide many of the foundations for the development of specific KM tools (Jurisica, Mylopoulos & Yu 2004), for example, modern database technology enables enormous amount of explicit knowledge, originally in the form of text, audio or video, to be accommodated within electronic repository in various digital formats or representations.

The adoption of advanced data communication technology makes it possible for one organization to access useful knowledge that stores in other KMS from all over the world. However, it is shown that some of the KMSs are incompetent to cooperate with the current distributed knowledge environment, especially those that are designed to manage merely organizational knowledge. Those systems are tailor-made according to different specific KM approaches, organizational KM strategies and business requirements without the concern of system interoperation. The lack of interoperability means that heterogeneous KMSs from different organizations are not able to communicate, cooperate, exchange as well as reuse knowledge with one another. Even though knowledge is available from other organization's KMS, the absence of a common language, for achieving interoperation on system, syntax, structure and semantic levels, has put up a barrier to prevent employees from accessing relevant knowledge as needed to complete their work. Here, system heterogeneity includes hardware, operating systems and communication incompatibilities whereas syntactic and structural heterogeneity refer to different representation languages, data representation and data modeling formats (Aparicio, Farias, & dos Santos 2005; O'Sullivan & Lewis 2003). Although the emergence of middleware technology and standardization have provided ways to support system, syntactic and structural heterogeneity, it is essential to shift our focus from system, syntactic and structural to semantic heterogeneity due to the rapid increase of the amount and diversity of knowledge caused by the popularity of the World Wide Web (WWW). To solve semantic interoperability problem, a KMS must be able to understand semantic of the incoming knowledge request before it can satisfy the knowledge request. At the same time, the requested KMS must also possess the capability to understand the semantic of the response in return. Hence, this research proposes the use of ontology and its related mediation methods which possess knowledge reusability and mismatches reconcilability to fill this gap.

Ontology, a branch of philosophy, was borrowed by artificial intelligence community and defined as an explicit specification of a conceptualization while a conceptualization is an abstract, simplified view of the world that we wish to represent for some purpose (Gruber 1993). Based on this definition, Studer, Benjamins & Fensel (1998) make the following conclusion: 1) an ontology is a machine-readable specification of a conceptualization in which the type of concepts used and the constraints on their use are explicitly defined, and 2) an ontology should only capture consensual knowledge accepted by large group of people rather than some individual. By representing domain specific knowledge with vocabularies in terms of objects and their interrelated describable relationships in ontologies, inference engine and other application program from one intelligence system would be able to understand and reuse another system's knowledge.

The popularity of the WWW further magnifies the importance of ontology. The HTML-based web content is solely designed for formatting and displaying information on the web and computers have no way to understand and process the semantics (Antoniou & Harmelen 2004). The disadvantage of HTML-based web content is reflected completely when users attempt to retrieve information from the web using a search engine. It is very common for a search to return more than ten thousand results. The application of search operators may be able to narrow down the results to a few hundreds, but users still require extensive effort to locate the right information within a pool of results. It is due to the fact that application program resided in the search engine can only perform keyword search in the HTML-based document without understanding the actual semantic of the document, for example, searching the web with the keyword "bank" using Google search engine will return any webpages that contain "bank" or with "bank" as one of the indexes, regardless whether "bank" means a financial institute, river bank or cant on those webpages. This leads to the emergence of the Semantic Web. The Semantic Web is the extension of the current one, in which web content is represented in a structural form within ontologies by a finite list of vocabularies and their relationships (Berners-Lee, Hendler & Lassila 2001). In this way, ontologies enable computer program, software agent and search engine to understand the semantics, thus making it possible for them to process the web content. Ontologies also provide a shared understanding of a domain which is necessary to overcome differences in terminology from various sources (Antoniou & Harmelen 2004).

Hence, the concept of ontology can also be applied to solve the semantic interoperation problem in the distributed KMS environment. In this approach, explicit knowledge of KMSs is annotated in form of machine-processable metadata according to a domain or topic specific ontology (Davies et al. 2005; Mentzas et al. 2001). Using the ontology, one KMS can communicate with others in spite of the underlying system, syntax and structure heterogeneities, thus allowing the involved systems to understand the incoming request and the return knowledge because they are using the same set of vocabularies in the ontology. Besides, the exploitation of above ontological metadata enables ontology-based searching to take place for the retrieval of a more precise collection of knowledge, for example, to look for banking knowledge, user is required to search for "bank" as a concept of "financial institute", then the search engine will be able to find the relevant pieces of knowledge by examining the ontological metadata which has previously been added to the content of each piece of knowledge (Hasse, Volker & Sure 2005). Another way of adopting the ontological metadata in knowledge retrieval is by ontology browsing, for example, the help desk self-help KMS developed by Leung (2006). In this KMS, ontologies that contain the classification of technical problems and their related symptoms are constructed. Each instance in the ontology is linked together with related resolutions stored in the knowledge base. To retrieve resolutions for a specific problem, user is required to browse the ontologies and select the most appropriate instance via the user interface. Other form of searching technique includes contextual searching (Hasse, Volker

& Sure 2005). This technique queries the domain (or topic) specific ontology for the retrieval of knowledge that is relevant to user's current searching pattern.

Ontology Mediation

Unfortunately, it is unrealistic to expect all individuals and organizations will agree on using one or even a small set of ontologies (de Bruijn et al. 2006). The adoption of such an approach is problematic. On one hand, it is lengthy and non-trivial to define and maintain a large globally shared ontology, on the other hand, the globally shared ontology approach may hinder a system from reflecting its actual business requirements due to the fact that design of the system is restricted by terminologies defined in the ontology (Visser & Cui 1998). Researchers such as Berners-Lee, Hendler & Lassila (2001) state that there would be a large number of small domain specific ontologies developed by communities, organizations, departments or even individuals. While multiple ontologies allow system to be designed according to its actual requirements without committing to a particular set of terminologies, data heterogeneity caused by multiple ontologies has become an obstacle for the interoperation of systems (Visser et al. 1998). Since vocabularies and their relationships defined in the ontologies are inconsistent, therefore it is impossible for one system to understand and reuse other ontologies unless the ontologies are reconciled in some form. The above inconsistent problem caused by multiple ontologies is commonly termed as ontology mismatches.

Klein (2001) points out that ontology mismatches can appear at language level when two or more ontologies written in different languages are combined. There are altogether four types of language level mismatches which include syntax, logical representation, semantics of primitives and language expressivity mismatch. Alternatively, ontology level mismatches can also occur when two or more ontologies programmed in the same or different languages with overlapping domain are combined. At this level, Klein (2001) inherits Visser et al.'s concept (1997) to divide the mismatches into conceptualization and explication. On one hand, a conceptualization mismatch happens when there is a semantic difference in the interpretation of a domain and this mismatch can be further divided into scope as well as model and granularity mismatch. On the other hand, an explication mismatch refers to a difference in a way the conceptualization is specified and the mismatch includes paradigm, concept description, synonym terms, homonym terms and encoding mismatch. Syntax, logical representation and semantics of primitives mismatch are relatively easy to resolve and researches have provided several mechanisms to solve ontology mismatches at language level, for instance, Superimposed Metamodel (Bowers & Delcambre 2000) and Layered approach (Melnik & Decker 2000). Although the establishment of an ontology language standard is currently not possible to eliminate the effect caused by language level mismatches, such an action would help to define and standardize solution on the mismatches, for example, to setup a standard mapping mechanism between Extensive Markup Language (XML) and Resource Description Framework (RDF), RDF and Web Ontology Language (OWL), and so on. The World Wide Web Consortium (W3C), an international consortium for developing web standards, is responsible to develop, standardize and recommend new generation of ontology language.

Based on the actual requirements, organizations and individuals are expected to develop their own ontologies of different languages, scopes, coverage and granularities, modelling styles, terminologies, concepts and encodings. To reuse other ontologies of different types, ontology mediation is required to reconcile mismatches between heterogeneous ontologies so that knowledge sharing and reuse among multiple data sources can be achieved (Predoiu et al. 2006). There are two major kinds of ontology mediations which include mapping and merging. Ontology mapping is a process of relating similar concepts and relations from different ontologies to each other in which the correspondences between different entities of the two ontologies are formulated as axioms in specific mapping language (de Bruijn et al. 2006; Klein 2001). Since the involved ontologies do not require any adaptation, ontology mapping often specifies just a part of the overlap between ontologies which is relevant for the mapping application (Scharffe, de Bruijn & Foxvog 2006). Two common approaches used to establish mapping between ontologies are listed as follows.

- The first approach is to relate all ontologies to a common top-level ontology so that different ontologies are mapped together indirectly by the top-level ontology as illustrated in Figure 2a (Wache et al. 2001). Consequently, conflicts and ambiguities can be resolved since concepts used in different ontologies are inherited from the common ontology. Based on this approach, the Process Specification Language (PSL) is developed as a mediating ontology to formalize and structure manufacturing terms and concepts along with their definitions (Gruninger & Kopena 2005). The PSL can then be used to facilitate correct and complete exchange of process information among application ontologies of heterogeneous manufacturing systems. There are other possible ways of developing top-level ontologies which include using background knowledge and lexical databases such as WordNet. However, this approach has three major drawbacks. First, constructing a large-scale common top-level ontology from scratch is never a simple task. Even if we take a simpler path by merging various local ontologies together, the experiences of building the air campaign planning ontology and the Suggested Upper Merged Ontology (SUMO) tell us that the actual merging processes are trickier than expected, not only because there is inconsistency between chunks of theoretical content but also because there were structural differences between the local ontologies (Valente et al. 1999; Niles & Pease 2001). Second, this approach can only be adopted in a relatively stable environment where maintenance is minimal because a substantial amount of resources and overheads are required to maintain a common top-level ontology. Third, established mappings between local ontologies and top-level ontology can easily be affected by the elimination and addition of local ontologies as well as changes in either local or common ontologies because local ontologies are related indirectly with each other through the common ontology.

- Rather than mapping all ontologies to a common top-level ontology, one-to-one mapping approach requires mappings to be created between each pair of ontologies as shown in Figure 2b (Predoiu et al. 2006). Mena et al. (2000) adopts the one-to-one mapping approach to develop OBSERVER that is capable of browsing and querying information scattered across multiple heterogeneous repositories. The lack of a common top-level ontology in this approach makes it possible to be adopted in a highly dynamic environment. This advantage may be offset by the lack of common terminologies, thus increasing the complexity of defining mapping between local ontologies. Another major drawback of this approach occurs when a large number of heterogeneous ontologies are involved in the interoperation. Such an interoperation will greatly increase the amount of mappings and extra effort is required to control and maintain the mappings.

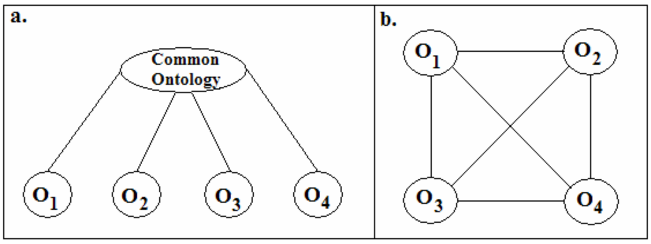

Figure 2: Two Mapping Approaches

Generally, ontology mapping can be divided into three phrases as shown in Figure 3 (Predoiu et al. 2006). First of all, ontologies are required to convert to a common format if they are specified in different languages, for example, iPROMPT and AnchorPROMPT require ontologies of different formats to be converted to RDFS (Noy & Musen 2003). This format translation can be performed using either a self-developed translator or a public one. In the second phrase, ontology matching is performed in order to discover and specify similarities between two source ontologies. Finding similarities play a very important role in any ontology mapping process and some researchers even consider it as a separate ontology mediation method. However, we only view ontology matching as a single part of the mapping process in this paper. Finally, semantic bridges or alignments that define mapping axioms are created to establish correspondences between the similarities of the ontologies. There is also a feedback loop iterated from this phrase to the previous one which can provide more accurate similarity measures if part of the mapping is specified.

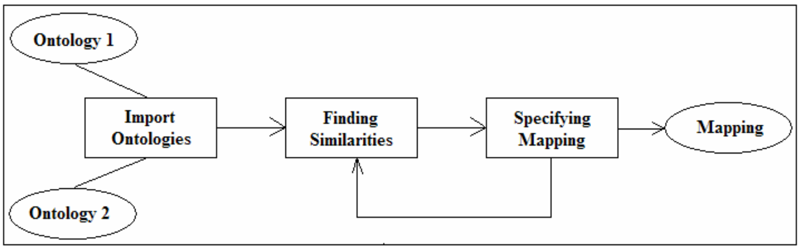

Figure 3: Generic Mapping Process (Predoiu et al. 2006)

There are various types of ontology matching techniques, ranging from simple heuristic, probabilistic reasoning, to multiple strategies. Ontology matching using simple heuristic technique often depends on lexical, structural or syntactic information of the source ontologies. Heuristic-based matching exploits rules for comparing properties and semantic relations in a pair of concepts from two different ontologies (Castano et al. 2007). An example of using simple heuristic to perform ontology matching is iPROMPT, a key component of a multiple-ontology management tool called PROMPT Framework (Noy & Musen 2003). iPROMPT is an interactive merging tool, which helps users in the ontology merging process by suggesting matching candidates, identifying inconsistencies and potential problems as well as suggesting possible solution to resolve them. iPROMPT uses lexical based similarity measure to check for identical concept names of two different ontologies. Simple heuristic technique is relatively easy to design and implement but this simplicity only allows ontology matching to be performed in a very narrow scope, for instance, iPROMPT is only capable of checking identical concept names with no spelling deviation.

Another type of ontology matching technique is based on probabilistic reasoning which calculates the probability of similarity of two concepts from two different ontologies. Prasad, Peng & Finin (2002) combine Rainbow classifier, simple heuristic and Bayesian reasoning to develop a semi-automatic ontology matching mechanism for ITTalks which is a web-based system for automatic and intelligent notification of information technology talks. The first step in the matching process requires each ontology to build a model that contains statistical information of the associated exemplar documents. Rainbow classifier is then used to compare exemplar of one ontology with statistical information of other ontology and the returned similarity scores will be used to produce a set of possible matchings between the two ontologies. Here, the authors propose two algorithms to perform subsumption checking and to synthesis the similarity scores toward the final matchings. The first one is based on simple heuristic, which states that a concept from one ontology should match with the parent concept if it matches with the majority of the children of the parent concept in another ontology. The second one is based on Bayesian reasoning which is a probabilistic algorithm used to solve uncertainty in similarity comparisons. In this case, Bayesian reasoning is adopted to look for the best mapping concept that is lower in the hierarchy and with the posterior probability greater than 0.5. According to the evaluations conducted by the authors, Bayesian approach outperforms the heuristic one in terms of accuracy because the former approach has a stricter constraint.

Many mapping methodologies exploit only one single similarity measure during their matching processes, for instance, iPROMPT could only detect lexical similarity in its matching process. In order to achieve high accuracy and effectiveness in ontology matching, multiple strategies that combine various types of similarity measures is developed, for instance, A Mapping Framework for Distributed Ontologies (MAFRA) adopts a multiple strategies that combine semantic, property, bottom-up and top-down similarity measures (Maedche et al. 2002). In another instance, Ehrig & Sure (2004) combines fifteen different similarity measures to find matching candidates between two or more ontologies. The overall results in the evaluations show that the multiple strategies outperform those that use only one similarity measure in terms of precision.

The second type of ontology mediation is merging. Unlike mapping that links two separate ontologies together in a consistent and coherent form, ontology merging creates a new ontology (in one subject) by unifying two or more different ontologies on that subject and it is usually hard to identify regions of the source ontologies from the merged ontologies (Pinto & Martins 2001). As compared with mapping that keeps the original ontologies unchanged, merging requires at least one of the original ontologies to be adapted so that the conceptualization and the vocabulary match in overlapping parts of the ontologies (Ding et al. 2002). While a majority of semantic web researchers foresee the main stream would switch to the approach of developing enormous amount of small domain specific ontologies, McGuinness et al. (2000) argues that some of the industries or organizations still require to develop very large and standardized ontology, for instance, SNOMED CT is a comprehensive clinical ontology developed by the College of American Pathologists that contains about 344,549 distinct concepts and 913,697 descriptions (Lussier & Li 2004). Universal Standard Products and Services Classification (UNSPSC) is another instance of large ontology that provides a common coding scheme for the classification of products and services between buyers and sellers in order to automate "buy and sell" processes (Granada Research 1998). Theoretically, it is more efficient and effective to merge existing ontologies than to build a large ontology from scratch. In practice, the process of ontology merging is more than just simple revisions, improvements or variations of the source ontologies since the involved ontologies are developed by different people for different purposes with different assumptions and using different vocabularies (Lambrix, Habbouche & Perez 2003; Pinto & Martins 2001). McGuinness et al. (2000) specify the three major tasks that are required to merge two ontologies: 1) coalesce two semantically identical terms from different ontologies so that they can be referred to by the same name in the resulting ontology, 2) identify terms that should be related by subsumption, disjointness or instance relationships, 3) verify and validate correctness and consistency of the merged ontology. Chimaera, developed by the Stanford University Knowledge Systems Laboratory, is an example of a semi-automatic merging tool that supports the above three tasks.

Reusable Inter-organizational Knowledge Network

Despite the underlying semantic, system, syntax and structure heterogeneities, organizational KMSs are able to communicate with each other using the concept of ontology and mediation. We argue that ontology and ontology mediation could be further contributed towards the reformation of the existing KM frameworks that only focus on managing organizational knowledge. As knowledge from external source plays a more important role in supporting organizational activities, it is essential to develop a new KM approach that has capability to manage this type of knowledge. Here, we term external source of knowledge as inter-organizational knowledge. Inter-organizational knowledge can be defined as a set of explicit knowledge that is formalized and created by other organizations. This research proposes to develop a reusable inter-organizational knowledge network that provides a platform for organizations to access and reuse their inter-organizational knowledge of a domain, for example, IT help desks of different companies, Microsoft, Adobe and Google can establish a network for managing their inter-organizational knowledge of help desk. In the network, the formalized inter-organizational knowledge is reusable in a way that it can be retrieved by any organizations to support their own KM processes in terms of knowledge creating, storing, dissemination, using and evaluation. To establish a domain specific network, the participant organization must commit itself to a mutual agreement that allows other participants to access an agreeable portion of knowledge stored in its own knowledge repository. Besides, a single organization can commit to more than one network of different domains. The proposed network incorporates ontologies to allow organizations to represent their knowledge in a machine-readable format. In addition, the proposed network also adopts ontology mediations so that heterogeneity of knowledge semantic in the ontologies could be reconciled.

To setup the network, the involved organizations first need to think about three important considerations related to ontology mediation. Figure 4 illustrates an ontology mediation decision matrix. The first consideration is whether to adopt a common top-level ontology or an one-to-one mapping approach in the network. Even though top-level ontology approach can provide a better mechanism to resolve conflicts and ambiguities, such an approach can only be applied to an environment where maintenance effort is minimal. Organization must also make sure that they have sufficient resources to build the common ontology. Conversely, if frequent maintenance is required or resources are insufficient, it is much more appropriate to exploit the one-to-one approach. Another thing that needs to be considered is whether to perform mediation automatically or semi-automatically. Mediation can be performed semi-automatically which requires the support of automatic tools as well as human intervention, for instance, iPROMPT compares concepts between two ontologies using simple heuristic to identify lexical similarities. Based on the computational result derived from the similarities and differences of the ontologies, iPROMPT will then be able to suggest a list of possible actions for ontology merging (Noy & Musen 2003). Hence, the final decision on choosing the most suitable mediation method will be left to users. Other forms of support provided by automatic tools include post-mediation verification, validation, critiquation as well as conflicts recognition and resolution (McGuinness et al. 2000; Noy & Musen 2000). Although semi-automatic mediation could achieve better result in terms of accuracy, it still substantially relies on human efforts and is rather time consuming. Without human intervention, process of semi-automatic mediation cannot be completed, thus compromising the accuracy of the mediation result. As semi-automatic tool is not capable of supporting mediation on-the-fly, it would be ideal to perform mediation automatically. Unfortunately automatic tools are unable to detect and interpret concepts that do not have a close correlation. Moreover, it may also fail to handle any unforeseeable situations since the tool is designed to perform mediation under certain pre-defined circumstances, for example, the automatic mapping tool developed by Ehrig & Sure (2004) may fail to find matching candidates if the matching condition is not described in the fifteen pre-defined similarity measures. Of course, there is not any tool that can guarantee full accuracy. However, if automatic mediation is done and inference builds on top of it, inaccurate results can bring down the value of the mediation process. The last thing that we need to consider is the choice of ontology matching technique. To choose the right technique, organization must consider the level of matching accuracy that it can accept and the level of resources that it can afford for implementation. Obviously, simple heuristic is relatively easy to implement but the accuracy of matching result is low. Alternatively, multiple strategies matching could produce the most accurate result but it is relatively difficult to design and implement. Probabilistic reasoning is the technique that can balance between matching accuracy and implementation effort.

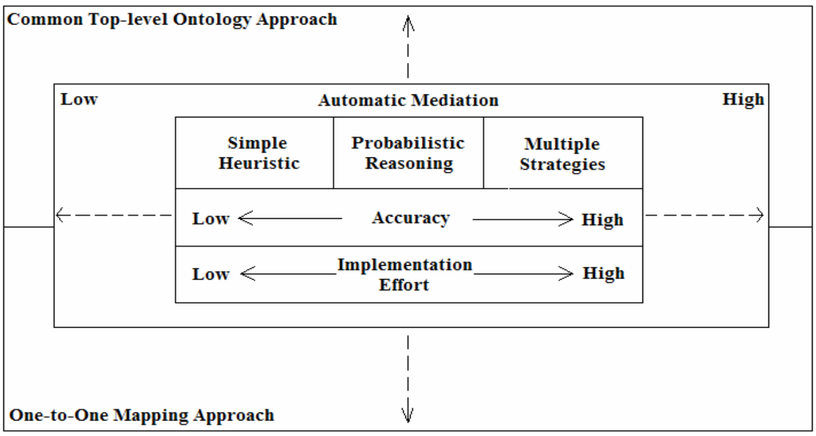

Figure 4: Ontology Mediation Decision Matrix

Reusability of Inter-organizational Knowledge

The reconcilability of ontology mediation allows the participant organizations to reuse inter-organizational knowledge within the network even though there are fundamental differences among organizations in terms of KMS structures and knowledge formats. Under a mutual agreement, organizations are permitted to retrieve inter-organization knowledge and the retrieved knowledge can be reused to support the five stages of KM process. Conventionally, technology has very limited contribution in knowledge creating process especially in socialization, externalization and internalization where tacit knowledge is involved, for example, word processing tools can be used to record and visualise explicit knowledge in externalization and internalization whereas communication tools such as email and telephone provide a platform for the exchange of explicit knowledge in socialization. However, ontology merging tools are capable of combining two or more ontologies together semi- or automatically in the network, thus providing a practical way to create knowledge through combination, for instance, Company A can create its own help desk knowledge by merging "help desk ontologies" of Company B, Company C, Microsoft and Oracle. As a result, associated inter-organizational knowledge of the merged ontology can be reused and stored in Company A's knowledge base. While ontology merging and knowledge combination are never a trivial task even with the assistance of automatic tools, they are still less demanding than building from scratch.

Knowledge dissemination tool allows user to retrieve and use knowledge from organizational knowledge repository. If user cannot find any suitable organization knowledge, s/he has to seek the knowledge from other external sources, for example, if user cannot find Windows XP Reinstallation Instruction in Company A's knowledge base, user may have to search from Microsoft's knowledge base or through other search engines using separate user interfaces, However, with the support of automatic mapping tool, it is practical for mapping to be performed on-the-fly so as to allow user to access inter-organizational knowledge that stores in other repositories within the network. In this case, mapping tools of Company A will map its ontology with other ontologies that contain the relevant concepts. Therefore, the inter-organizational knowledge will be retrieved and delivered in a "black box" to user via the same user interface. In addition, inter-organizational knowledge can be reused to support knowledge evaluation process in KM. This is achieved by setting up dedicated mappings between two or more ontologies. Once a piece of knowledge is updated, the updated inter-organizational knowledge will be translated into a suitable format and delivered to the source knowledge base through the mapping, for instance, Microsoft has updated Window XP Reinstallation Instruction, the dedicated mapping is responsible to converted the revised knowledge to a acceptable format and delivery to the target ontology of Company A.

Conclusions

KM allows organization to formalize its process to create, store, disseminate, use and evaluate organizational knowledge. However, this design is inadequately to meet the current business environment. Thus, the reusable inter-organizational knowledge network is developed to enable the participant organizations to reuse inter-organizational knowledge that stores in knowledge repositories of the organizations. The retrieved inter-organizational knowledge could be reused to support knowledge creating, storing, disseminating, using and evaluation in the KM process. The application of ontology and ontology mediation not only provides a mechanism to represent knowledge and resolve ontology mismatches, it also helps to automate the KM process.

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