Enterprise Knowledge Modeling: Challenges and Research Issues

Sung-kwan Kim, Richard Woolridge, University of Arkansas at Little Rock, USA

ABSTRACT:

With the increased importance in knowledge management, the role of knowledge modeling has also increased. An enterprise knowledge model is a representation of organizational knowledge. By defining organization knowledge, an enterprise knowledge model helps businesses plan and control this precious organizational resource. This paper surveys the current status and practices of enterprise knowledge modeling and identifies the key issues and challenges involved in enterprise knowledge modeling. The five primary issues identified are integration of multiple knowledge models, development of standard methodology, evaluation of knowledge model, management of the evolving knowledge model, and development of knowledge ontology. Each issue is discussed and further research directions are suggested.

Keywords: *Knowledge model, Enterprise knowledge modeling, Modeling methodology, Knowledge ontology*

Introduction

An organization's competitive advantage and financial performance is closely tied to its ability to create and use knowledge (Tanriverdi 2005). In fact, organizational success may be due more to knowledge management than manufacturing prowess, cheap capital, cooperative relationships, or many other previously identified factors of success (Nonaka and Takeuchi, 1995). Knowledge enables organizations to deal with complex problems, helps them make better decisions, and helps them respond to the market appropriately (Grangel et al., 2007). With knowledge management, organizations continuously innovate and successfully compete in the marketplace. In a society where the only real organizational resource is knowledge (Drucker, 2002), the management of knowledge resource is a critical factor for business success.

Organizational decisions are becoming more global, interconnected and complex than those of the past and this additional complexity is increasing demand for knowledge management (Courtney, 2001). Knowledge management (KM) is defined as (AS 2005, p. 2): "A trans-disciplinary approach to improving organisational outcomes and learning, through maximizing the use of knowledge. Knowledge management is concerned with innovation and sharing behaviors, managing complexity and ambiguity through knowledge networks and connections, exploring smart processes, and deploying people-centric technologies." Information technologies have responded to this demand by providing knowledge management improvements both within and among enterprises (Chalmeta and Grangel, 2008). These methods, techniques, and

tools are intended to permit knowledge to be delivered at the right time, to the right people, in the right format satisfying all the quality and budget requirements (Wiig et al., 1997).

Knowledge management (KM) is a multi-disciplined approach to accomplish organizational goals by systematically managing knowledge. KM activities focus on processes such as capturing, creating, organizing, disseminating and sharing knowledge. Effective KM fosters innovation by encouraging the exchange of ideas, improves decision making quality, enhances the relationship with stakeholders (e.g., customers, suppliers, and employees, etc.), increases revenues by better responding to the market, and reduces costs by streamlining business processes.

Information technology (IT) has been identified as one of the critical success factors for supporting KM (Kim and Trimi, 2007; Edwards et al., 2005; Metaxiotis et al., 2005). IT has been perceived to improve KM processes with reduced cost and increased speed. For example, technologies such as intranet, groupware, web conferencing, and document management system improve the speed and quality when acquiring and sharing knowledge. Data management technologies, such as data warehouses, create an organizational memory by organizing and storing knowledge using structured repositories. Knowledge is disseminated efficiently through education/training software or knowledge based systems. Business intelligence technologies such as data mining, OLAP (online analytical processing), and data analytics help discover new knowledge through exploring the pools of data stored in organizational memory. Intranets and corporate portals, data warehouses or knowledge repositories, data analytics, decision support tools, groupware, and document management systems are some of the very popular technologies for KM (Chalmeta and Grangel, 2008; Kim and Trimi, 2007).

While technology facilitates the *process* of knowledge creation, organization, utilization, and communication, the actual knowledge *product* managed by these tools is also important. Indeed, without knowledge content there is little value in knowledge management technology. The success of KM is dependent on its contents, not the technology. Businesses need a tool with which they can manage the knowledge contents so that they are identified, defined, organized, and communicated in an effective and efficient manner. A knowledge model can provide such a tool with which an organization can organize and manage knowledge contents. This paper surveys the field of enterprise knowledge modeling (EKM). The current status and practices of EKM are presented. The issues and challenges involved in EKM are identified and discussed. Then further research suggestions are made.

Knowledge Model

A model is a simplified representation of reality and is used to gain insights into complex problems (Sen and Vinze, 1997). A model simplifies the complex reality by capturing the essence and ignoring noises of reality. Modeling provides developers and users with the ability to visualize the target systems and communicate it effectively. Developers and users, therefore, can better understand the domain reality by building a model. Modeling is typically used to analyze the problem domain before

implementation, to reduce complexity of reality and to communicate a common understanding of the system to users and among developers (Whitman et al., 2001). If users can better communicate and understand the system, they will be more involved in the implementation process. There will be a higher chance of acceptance of the system after installation.

A knowledge model is a specification of a domain, or problem-solving behavior, focused on the domain or behavior's concepts, relations, and reasoning steps, which are abstracted from implementation specific characteristics (Shum et al., 2000). It depicts the structure of knowledge components, their relationships, characteristics, usages, and constraints. By creating a knowledge model, a business firm can visualize and better understand its knowledge structure. This knowledge model will provide the basis for planning and control over knowledge contents used in the business operations. Given the complexity of managing knowledge (i.e., dynamic, changing, and unstructured), the time and efforts used in building the model are justified (Cemosek and Naiburg, 2004). Since the knowledge model is a high level model and built at the conceptual level, it is very stable and doesn't change frequently. A knowledge model, like other conceptual level models, focuses on the nature of the problem under consideration. A knowledge model can be used for the development of a new KM system. It can be an excellent way of communicating organizational knowledge among its members (Whitman and Huff, 1997). Knowledge model provides a conceptual framework for structuring and managing enterprise knowledge so that it is clearly defined, shared and used when needed

Often a knowledge model is built around key business processes (Shankar and Gupta, 2005). A typical business process involves several activities which attempt to achieve stated business goals. A business process is cross-functional and spans multiple organizational areas. Since there are multiple processes in business organizations, multiple knowledge models may be developed. For example, each department may have its own knowledge model. Different processes in the organizations may require their own knowledge models. Often this uncoordinated approach may bring in inconsistent and fragmented picture of the entire organizational knowledge. There is clearly a need for enterprise wide model that can provide a holistic view of the organizational knowledge (Kavakli and Loucopolous, 1999).

Enterprise Knowledge Modeling

One of the goals of KM is the communication and sharing of enterprise knowledge between different people across the organization (Kavakli and Loucopoulos, 2006). A problem is how to describe knowledge so that it can be communicated clearly. A natural language can be used. The natural language is easier to understand and transfer. But it lacks formality. This lack of formality may make the communication difficult and confusing (Loucopoulos, 1993). Enterprise knowledge modeling (EKM) solves the problem by providing a global view of knowledge that it can be communicated among different functional areas and different management levels across the organization (Fox et al., 1993). With EKM, knowledge can be explicitly defined at the organizational level.

EKM refers to a collection of modeling techniques for describing the structures, relationships, meanings, and other properties of enterprise knowledge and provides a common language to describe the enterprise knowledge that can be easily understood across the organization (Whitman et al., 2001). EKM includes three components: product, process, and modeling language. A product is an outcome of EKM which is a set of models used for describing knowledge. A process is a way-of-working. It describes a set of rules and semantics supporting the usage of concepts. A modeling language provides a set of tools supporting the way-of-working. These together allow developers to manage the EKM process in a structured way rather than by intuition. It provides guidelines on what should be analyzed, why it should be considered and how it should be conducted in which sequence. It also includes means to maintain the outcome of the process (Rolland et al., 1999). EKM provides businesses with a holistic view of the enterprise knowledge. EKM is a systematic approach to developing and documenting enterprise knowledge. EKM is very useful in providing integrated views within an enterprise. EKM improves the communication of knowledge between different processes, manages KM complexity by visualizing enterprise knowledge, promotes capitalization of enterprise knowledge and knowhow, and helps maintain and control enterprise knowledge (Vernadat, 2002).

There are a number of EKM approaches used. Rolland et al. (1999) classified EKM into three categories: activity-oriented models, product-oriented model, and decision-oriented models. Activity oriented models are most popular. These models attempt to describe the development process as a set of activities and constraints controlling the order of the activities. Product oriented models put forward the result of these activities. The most recent class of process models follows a decision-oriented paradigm. These models are known to be semantically more powerful than other models because they explain why transformations happen. Decision-oriented models are not only able to explain how but also why the process proceeds. Thus, a decision–oriented modeling paradigm is considered to be the most appropriate for EKD process (Rolland et al., 1999).

Discussions On Challenges And Research Issues

While it offers a number of benefits, EKM presents its own challenges. A number of issues exist about how to develop enterprise knowledge models. For example, the following questions should be addressed - Is there a single, generic model that stores whole enterprise knowledge in one view? Can the knowledge entities be precisely defined? How can we determine which one is a better model? How can an enterprise knowledge model be created and kept current? (Fox, 1993) In the following sections, challenges and issues involving EKM are discussed. Five primary issues have been identified: integration of multiple knowledge models, development of standard methodology, evaluation of EKM, management of the evolving EKM and development of knowledge ontology.

Integration Of Multiple Knowledge Models

One of the primary issues in EKM is how to integrate multiple knowledge models. Any enterprise level modeling should allow multi-views of a target system. The multiple

views complement each other with each view focusing on a different aspect of system. So the multiple view approach offers a better understanding of complete systems (Frank, 2002). However, including all the knowledge required for all of the views into a single model significantly increases model complexity, which in turn decreases understanding and decreases the ability to communicate the model. Therefore, models typically are restricted to representing a single view or perspective of the target system. Multiple knowledge models are created to provide different views for different actors in the organizations (Kavakli and Loucopolous, 1999).

While this single view approach promotes understanding of invididual models by reducing complexity, the multiple views can lead to a fragmented and inconsistent understanding of the entire enterprise knowledge which negates the reason for EKM (Whitman et al., 2001). This fragmentation is due to the independently developed models not adequately accounting for shared model concepts. Fox and Gruninger (1998) call this the correspondence problem.

This correspondence problem introduces the issue of consistency and integrity into the enterprise-wide model (Maedche et al. 2003). For example, the same concept may be in multiple models, but under different names in each model. In addition, different concepts may be in multiple models, but may share the same name. As a consequence, communication of knowledge concepts among different levels, processes, and departments can be ineffective. These correspondence problems can lead to integrity issues during the update process and increase the costs of those updates. One way maintain the ability to communicate and to maintain model integrity is to integrate the knowledge models. The integration of different views is vital to achieving a complete representation of the enterprise (Whitman et al., 2001). Integration provides a unified and global view of knowledge from multiple knowledge models. Therefore, there is a need for a method that can allow for multiple models that enables a single integrated view (Frank, 2002.)

Integrating multiple models has been a challenging issue. Two popular approaches to integration are mapping and merging (Connolly and Begg, 2006; Kolaitis, 2005; Maedche et al., 2003). Merging is the approach in which several knowledge models are combined into global EKM. For example, first two of the local knowledge models are merged and a new model is produced. Modelers then successively merge the remaining local knowledge models until all the local models are represented in the final EKM. Validating the final enterprise knowledge model is one of the key challenges. Validation is achieved reviewing the final EKM with domain users to ensure that the model is a true representation of organizational knowledge. Mapping relates a portion of the source (i.e., local knowledge model/view) to the target (i.e., EKM or integrated view). In mapping approach, similarity extraction identifies commonality among different knowledge elements and semantic mapping establishes correspondence between common elements where appropriate. The differences between models can be syntactical, structural or semantic ones. Especially, semantic mapping requires most laborious efforts and resources (Karagiannis, 2006). This extraction of similarity and establishing correspondence are two challenging issues (Maedche et al. 2003). One of the most difficult tasks is how to bring together models that have been realized using different meta-models. A meta-model defines a model used in implementation. The

concepts, syntax, and notations used are different in each model. A direct mapping between models with different definitions is a tough task. For the models built on different meta-models, mapping should be realized on the meta-layer (e.g., ontology) that acts translator between meta-models (Karagiannis, 2006).

In summary, the research knowledge models integration issues include, but are not limited to:

- Developing both the theory and the practice for model merging and mapping
- Developing methods, tools, and techniques to validate merged/mapped models
- Developing methods, tools, and techniques to extract multi-model element similarities
- Developing methods, tools, and techniques to establish common element correspondence
- Developing methods, tools and techniques to integrate models built on different meta-models

Development Of Standard EKM Methodology

Another issue in creating an EKM is a lack of methodology that is specifically oriented towards the development of an EKM. A methodology is "an organized collection of concepts methods (or techniques), beliefs, values, and normative principles supported by material resources" and a technique "consists of a well-defined sequence of elementary operations that more or less guarantee the achievement of certain outcomes if executed correctly" (Iivari et al., 2000, p. 186). It has long been recognized that there is a need to align the methodology with the type of problem being solved (Vessey and Glass, 1998). With a methodology, modelers can perform the activities in a coherent, consistent, accountable, and repeatable manner.

Modeling methodologies require at least four components: product, procedures, modeling language, and context (Wand and Weber, 2002). A product is the desired output of the modeling process. Actually it is a set of models used for describing the system to be constructed. A product of the modeling process defines the set of concepts and constraints with their properties and relationships. A methodology also includes a collection of procedures. These procedures define a way-of- working (a set of rules) supporting the usage of concepts. A procedure describes the order and decision made in the constructing the product. A third component of a methodology is a modeling language. The fourth component is the context, which is the setting within which the process is used to create a product using a modeling language, which include factors such as individual difference and social agenda. A good model needs a tool supporting the way-of-working. (Rolland et al., 1999.)

In other conceptual modeling areas such as process modeling or data modeling, there are a few well established and standardized methodologies - e.g., entity relationship

(ER) model in data modeling, data flow diagram (DFD) in process modeling, and unified modeling language (UML) in object-oriented (OO) modeling. Well-established methodologies often integrate best practices and provide an easy-to-use, yet expressive tool. Those methodologies provide a formal basis for designing and developing models and facilitate the development process.

Currently, EKM methodologies utilize proprietary, general purpose, or designed for other purpose methodologies. Individual businesses and consulting firms depend on their own proprietary methods or use the conceptual modeling techniques designed for other purposes – e.g., ER (Entity Relationship) model, UML (Unified Modeling Language) class model. General purpose modeling languages such as UML allow for modeling a wide range of domains (Frank, 2002). For example, UML is becoming industry's most recognized and widely applicable OO modeling standard. However, it is increasingly used in business modeling beyond OO realm and is often used as modeling language for EKM. As with all languages, UML defines syntax (both graphical and textual, in this case) and semantics (the underlying meanings of the symbols and text). An example of a knowledge model using UML is the knowledge model for vessel scheduling process built by Kim et al. (2006).

Proprietary methodologies are an insufficient solution to the lack of EKM methodology problem. Small companies often cannot afford their own proprietary methodologies. They don't have expertise and people. If there is a standard methodology available, it will encourage small companies to use it to create EKM (Rolland et al., 1999).

The utilization of these non-task specific methodologies create issues in the resulting knowledge models (Chalmeta, and Grangel, 2008). These non-task specific methodologies do not provide exact concepts and graphical representation appropriate for modeling knowledge, which create semantic problems. A standard method expressly oriented to modeling knowledge will bring improvement on building accurate knowledge models in the syntactical, structural and sematic senses; as well as, promote the development of commercial tools. A standard methodology will provide a unified view on EKM and promote industry consensus on benefits it brings (Frank, 2002).

Development of a standard methodology is dependent on the availability of a precise and expressive modeling language. An effective modeling language is critical to the visualization, task development, and documentation required for standard methodology tasks. "Language description should be sufficiently formalized. In other words, the language description should fulfill formal requirements such as completeness, simplicity, and correctness." (Frank p.3, 2002).

In summary, the research issues in this area include (but are not limited to):

- Developing a modeling language whose syntax and semantics are specifically designed for knowledge modeling.

- Developing the methodology procedures specifically designed for knowledge modeling

- Defining the knowledge modeling context that specifies the constraints for the knowledge modeling methodology

- Developing example knowledge modeling products to demonstrate methodology utility and value

- Developing a meta-model that defines the standard methodology expressively oriented toward enterprise knowledge modeling. The meta-model will determine the structure, components, and relationships among components in the methodology.

Validation And Evaluation Of EKM

Validation is a critical function that is achieved by reviewing the final EKM with domain users to ensure that the model is a true representation of organizational knowledge. An enterprise model must accurate, complete, relevant and valid (Fox and Gruninger, 1998). The evaluation and feedback based on the evaluation are the two key factors to a successful EKM (Gómez-Pérez, 2001). Evaluation requires the identification of the evaluation criteria, identification of who will evaluate the model, specification of when and how the evaluation process will be performed, and specification of how the evaluation results will be taken into account (Dieng et al., 1999).

A rigorously validated model will represent the domain with accuracy and completeness. Without rigorous validation, model defects can propagate to subsequent system development activities causing delays and potentially costly rework (Shanks et al., 2003). According to Brank et al (2005), most companies evaluate the model using one of three approaches: to compare the model to a golden standard (e.g., established benchmark), to apply the model to the target domain using domain data, or to review the model using human experts. Another way of validating any model is to test its conformance to a meta-model. A meta-model is a "model of a model" that provides a set of standards and modeling constructs (Atkinson and Kuhn, 2003). It is a definition and specification of a model; it is independent of the domain. According to Henderson-Seller (2003), one of the popular meta-models at the conceptual level is the OPF (Open Process Framework) Meta Model. The meta-model specifies five elements of a conceptual model: work product, producers, work unit, language, and stages. Each approach to EKM validation has strengths and weaknesses, so combining more than one approach may yield better outcomes.

A set of criteria must be identified in order to evaluate a model and it is very difficult to define a set of criteria that satisfy all requirements. Tolvanen (1998) offers two relevant criteria: richness and problem domain correspondence. Richness assesses the semantic richness of the model. A model should provide sufficient semantic concepts so that it can describe all relevant aspects of the problem domain. The second criterion evaluates the problem correspondence. It will check whether the constructs of the

model correspond to the aspects of the problem domain. Fox and Gruninger (1998) suggested six characteristics that should be used to evaluate an enterprise model: functional completeness, generality, efficiency, perspicuity, precision granularity, and minimality. If the model represents the target domain well and accurately, it is functionally complete. Generality will evaluate how well it is applicable across the different domains. The more general the model, the more compatible and sharable it is with other domains. Efficiency will check if the model is developed and maintained with the least costs. Perspicuity evaluates if the model is easily and correctly understood and interpreted by the users. Precision granularity tests whether the model definitions are divisible and independent of each other. To be minimal, the model must contain the minimal, yet sufficient number of concepts. Gómez-Pérez (2001) suggested five criteria for evaluation: consistency, completeness, conciseness, expandability and sensitiveness. As Whitman and Huff (1997) pointed out, a model should also support step-wise refinement. A good model supports hierarchical decomposition of the problem. As mentioned, there is no single best approach to model evaluation. The choice will depend on the purpose, the application in which the model is to be used, and on what aspect of the model evaluators are trying to evaluate. (Brank et al., 2005)

Other issues to be addressed are the identification of who will evaluate the model, specification of when and how the evaluation process will be performed, and specification of how the evaluation results will be taken into account (Dieng et al., 1999). The evaluation can be done informally or more formally. A more formal evaluation can be performed by using a standard methodology. The informal evaluation can be conducted by development team and users. A focus group of experts or walkthrough by users, developers, and quality assurance team is an excellent way of validating ontology. Although there are many studies on knowledge-based system evaluation, this field is just emerging. It is difficult to define a set of criteria that satisfy all requirements (Grüninger et al., 2000). In addition to validation and verification, determining the frequency of evaluation and establishment of a mechanism of linking the feedback to the model are also critical issues in the ontology assessment. The interval for evaluation will depend on the nature of knowledge and business for which the model is being built.

In summary, the research issues in this area include (but are not limited to):

- Developing methods, tools, and techniques to establish evaluation criteria
- Developing methods, tools, and techniques to choose and establish the evaluation process, including participants, steps, dependencies, completion criteria, and feedback loops

Management Of Evolving EKM

An enterprise model must not only be accurate, current and complete, but also relevant (Whitman and Huff, 1998). As the business environment changes, the required quality and quantity of knowledge will change, which will drive changes in the model. The process of evaluation will highlight the addition of new knowledge and update/deletion

of outdated knowledge. Regular audit and evaluation is necessary to maintain an effective knowledge model (Whitman et al., 2001).

When it is developed, a model is based on the typical scenario of business processes and operations. Developers are mostly concerned with the normal flow through the business. But there are abnormal scenarios. They are exceptional flows of a business process or events. They are the ones that do happen but are not considered to be the norm. Since most developers and users cannot tell the every possible circumstance at the beginning, unexpected situations and business scenarios may be developed later after the model has been created. For the enterprise model to be effective, it must have the ability to be quickly and easily modified to support new events (Whitman et al., 2001).

An effective knowledge model is extensible, dynamic, and maintainable (Whitman and Huff, 1997). These characteristics enable the model to incorporate changes. The change in the environment in which the knowledge model has been built is unpredictable. When the environment changes, then the assumptions made when the model was built may change. If the model is difficult to maintain, the validity of the model will be easily lost (Maedche et al., 2003). The model is not useful if it is not synchronized with reality (Whitman and Huff, 1997). A model must change as the system changes. It must also provide important information on both the rate of change and the reason for change (Whitman et al., 2001).

A temporary, expedient action that is easy to formulate and implement may lead to problems in long term. Managerial efforts should be directed to developing a way of systematically managing the evolution of EKM. Systematically managing the evolution of knowledge models will avoid long-term problems (Whitman and Huff, 1997).

In summary, the research issues in this area include (but are not limited to):

- Developing a set of metrics to measure relevance and currency
- Developing methods, tools, and techniques to manage EKM evolution

Development Of Knowledge Ontology

Recently, ontology-based enterprise modeling approach has emerged. This ontological approach to modeling is gaining popularity with its representational capability and its power of expression (Kim et al., 2011; Wand and Weber, 2004; Pinto et al., 2009). Ontology is the study of entities that exist in the world: a formal, explicit specification of a shared conceptualization (Gruber, 1992). In the context of knowledge management, ontology means a specification of knowledge that can be designed for knowledge sharing and reuse (Pinto et al., 2009; Vernadat, 2002).

The knowledge concept represents knowing about an entity which can be a person, thing, concept, event, or organization and ontological description specifies conceptualizations of such entities formally (Gómez-Pérez, 2001). Ontological

specification typically includes the descriptions of properties, relationships, constraints, and behaviors of entities. The properties describe the characteristics of an entity. The relationships explain the association among the entities (e.g., generalization and specialization, container and contents, assembly and components, participant, use, etc.) The constraints specify the rules governing the entities and the behaviors describe the actions the entities can take. Ontological study categorizes things that exist in the domain world. The product of such analysis is a catalog of the entities that are assumed to exist in a domain of interest (Sowa, 2003). Ontology can be used as a means with which developers capture knowledge about a domain of interest by specifying relevant concepts of knowledge items and relationships between them.

An Ontology Based Enterprise Knowledge Modeling (OBEKM) provides many benefits. The ontological description of knowledge can be a formal enterprise knowledge model. This identifies and defines the enterprise entities, their attributes and relationships between them. (Kavakli and Loucopolous, 1999). Since ontology represents entities that exist conceptually or physically in reality, any model built on ontology remains constant and doesn't change frequently. An ontology-based knowledge modeling provides stability and reliability in representing and maintaining enterprise knowledge. Ontology based models are highest level description of target reality. They have a higher power of expression, are more user oriented, goal oriented, and are more extendable (Spyns et al., 2002). Ontology-based modeling supports a shared and common understanding of a domain and improves communication between the stakeholders by removing semantic heterogeneity. Ontology is not task specific and implementation specific. Ontologies by definition are generic and task independent. The generic and implementation-independent ontology is easily shareable and reusable. The question is how to provide a way of build ontologies. Guidelines, rules, and frameworks with which developers can build the ontologies accurately and reliably are required.

For an ontology based modeling methodology to develop into a more mature and reliable methodology, there are many issues remaining to be addressed. One such task is the development of the theoretical foundations of ontology that support the development of EKM methodology (Grüninger et al., 2000). A well founded and coherent theory of ontological design can provide a rigorous basis for specifying, designing, constructing, and maintaining domain ontology. This will result in a more scientific methodology with which developers can build more generic models sharable and reusable across many domains.

Finally, the ontology model should be consistent with key enterprise metrics. Businesses should direct their efforts to developing a set of metrics which can be used to measure the effectiveness and efficiency of the ontologies.

In summary, the research issues in this area include (but are not limited to):

- Development of a theory for ontology use in EKM
- Developing methods, tools, and techniques to create and maintain an OBEKM

- Developing methods, tools, and techniques to measure and evaluate OBEKM

Conclusion

This paper surveyed the area of EKM. EKM is a very effective and powerful way of managing enterprise knowledge as an organization resource because EKM provides a tool for identifying, analyzing, structuring, and visualizing the knowledge contents at the enterprise scale. KM is a collection of activities of managing knowledge. The most important step to KM is to identify what to manage – i.e., knowledge. Successful KM should begin with EKM. The success of KM is dependent on its contents, not the technology. Businesses need a tool with which they can manage the knowledge contents so that they are identified, defined, organized, and communicated in an effective and efficient manner. A knowledge model can provide such a tool with which a business firm can organize and manage this precious organizational resource. While EKM provides a number of benefits to businesses, it also presents a number of challenges, too. This paper identified and discussed the issues and challenges to be resolved for the successful EKM practices: integration of multiple knowledge models, development of standard methodology, evaluation of EKM, management of the evolving EKM and development of knowledge ontology. The use of ontology is very promising and provides a powerful tool for solving many of the problems discussed in this paper. But the theory and practice of ontology based knowledge model are emerging and still in its infancy. We expect a great deal of research in this area. As businesses are getting more and dependent on knowledge, the importance of KM will keep increasing. The role of EKM will continue to grow.

References

AS (2005). Australian standard knowledge management (Report Number 5037). Standards Australia.

Atkinson, C. and Kuhne, T. (2003), Model-driven development: a metamodeling foundation. Software, 20(5), 36-41.

Brank, J., Grobelnik, M., and Mladenić, D. (2005), A survey of ontology evaluation techniques. Paper presented at the Conference on Data Mining and Data Warehouses (SiKDD), Ljubjana, Slovenia.

Cemosek, G. and Naiburg, E. (2004), The value of modeling: a technical discussion on software modeling, Accessed March 2010 at: http://www.ibm.com/developerworks/rational/library/6007.html

Chalmeta, R and Grangel, R (2008), Methodology for the implementation of knowledge management system. Journal of the American Society for Information Science and technology, 59 (5), 742-755.

Connolly, T. and Begg, C. (2006), Database systems: a practical approach to design, implementation, and management, Pearson Education, Essex, England.

Courtney, J. F. (2001), Decision making and knowledge management in inquiring organizations: toward a new decision-making paradigm for DSS. Decision Support Systems 31(1), 17-38.

Dieng, R., Corby, O., Gibson, A., and Ribière, M. (1999), Methods and tools for corporate knowledge management. International Journal of Human-Computer Studies, 51, Article No. ijhc.1999.0281. Accessed November 2010 at: http://ideallibrary.com

Drucker, P. (2002), Managing in the next society, HarperCollins, New York, NY.

Edward, J., Shaw, D., and Collier, P. (2005), Knowledge management systems: finding a way with technology, Journal of Knowledge Management, 9(1), 113-125.

Fox, M. S. (1993), Issues in enterprise modeling. Proceedings of the IEEE Conference on Systems, Man, and Cybernetics, Le Toquet France.

Fox, M., Chionglo, J.F., and Fadel, F.G. (1993). A common sense model of the enterprise, Proceedings of the 2nd Industrial Engineering Research Conference, 425-429, Norcross GA: Institute for Industrial Engineering.

Fox, M. and Gruninger, M. (1998), Enterprise modeling, The American Association for AI, Accessed March 2010 at: http://www.eil.utoronto.ca/enterprise-modelling/papers/fox-aimag98.pdf

Frank, U. (2002), Multi-perspective enterprise modeling (MEMO)-conceptual framework and modeling languages. Proceedings of the 35th Hawaiian International Conference on System Sciences, Grand Wailea, Maui, Hawaii.

Gómez-Pérez, A. (2001), Evaluation of ontologies. International Journal of Intelligence Systems. 16 (3), 391-409.

Grangel, R, Chalmeta, R, and Campos, C (2007), A modeling framework for sharing knowledge. In Apolloni, B., Howlett, R. J. and Jain, L. (Eds.): KES 2007/WIRN 2007, Part II, LNAI 4693, 1230-1237. Srpinger-Verlag Berlin Heidelberg.

Gruber, T. R. (1992), Toward principles for the design of ontologies used for knowledge sharing. In Proceedings of the International Workshop on Formal Ontology, Padova, Italy.

Grüninger, M., Atefi, K., and Fox, M. (2000), Ontologies to Support Process Integration in Enterprise Engineering, Computational & Mathematical Organization Theory, 6, 381-394.

Henderson-Seller, B. (2003), Method Engineering for OO Systems Development. Communications of the ACM, 46(10), 73-78.

Iivari, J., Hirschheim, R, and Klein, H. (2000), A Dynamic Framework for Classifying Information Systems Development Methodologies and Approaches. Journal of

Management Information Systems, 17(3), 179-218.

Karagiannis, D. (2006), metamodels in action: an overview. Filipe, J., Shishkov, B. and Helfert M. (eds.): ICSOFT 2006, First International Conference on Software and Data Technologies, Setubal, Portugal, September 11-14.

Kavakli, E. and Loucopoulos, P. (2006), Experiences with goal-oriented modeling of organisational change, IEEE Transactions on Systems, Man and Cybernetics, 36(2), 221-235.

Kavakli, V. and Loucopoulos, P. (1999), Focus issue on legacy information systems and business process change: modeling of organizational change using the EKD framework, Communications of AIS, 2(6), 2-29.

Kim, S, Felan, J, and Kang, M. (2011), A ontological approach to enterprise knowledge modeling in a shipping company, International Journal of Knowledge Management, 7(4), 70-84.

Kim, S. and Trimi, S. (2007), IT for KM in the management consulting industry, Journal of Knowledge Management, 11(3), 145-155.

Kim, S, Lim, S., and Mitchell, R. (2006), A method for knowledge modeling: Application of Unified Modeling Language (UML) to knowledge modeling, International Journal of Knowledge Management, 2(4), 17-31.

Kolaitis, P. G. (2005), Schema mapping, data exchange, and metadata management. Proceedings of PODS, Baltimore, Maryland, June.

Loucopoulos, P. (1993), Information systems and enterprise integration, Fourth International Workshop on the Database Approach to Information Systems and Database, Lloret De Mar, Catalonia, September.

Maedche, A., Motik, B.., Stojanovic, L, Studer, R., and Volz, R. (2003), Ontologies for enterprise knowledge management. IEEE Intelligent Systems, March/April, 26-33.

Metaxiotis, K., Ergazakis, K. and Psarras, J. (2005), Exploring the world of knowledge management: agreements and disagreements in the academic/practitioner community, Journal of Knowledge Management, 9(2), 6-18.

Nonaka, I. and Takeuchi, H. (1995), The knowledge-creating company: how Japanese companies create the dynamics of innovation. Oxford University Press: New York, NY.

Pinto F. M, Marquez, A., & Santos, M. F. (2009), Ontology-supported database marketing. Database Marketing & Customer Strategy Management, 16 (2), 76-91.

Rolland, C., Nurcan, S., and Grosz, G. (1999). Enterprise knowledge development: the process view, Information and Management, 36, 165-184.

Sen, A. and Vinze, A.S. (1997), Understanding the complexity of the model formulation process: A protocol analysis approach. Decision Sciences, 28(2), 443.

Shankar, R. and Gupta, A. (2005), Towards framework for knowledge management implementation. Knowledge and Process Management, 12(4), 259-277.

Shanks, G., Tansley, E., and Weber, R. (2003), Usingy ontology to validate conceptiual models. Communications of the ACM, 46(10), 85-89.

Shum, S. B., Motta, E. and Domingue, J. (2000), ScholOnto: an ontology-based digital library server for research documents and discourse. International Journal on Digital Libraries, 3(3), 237-248.

Sowa, J. F. (2003), Ontology, Accessed May 2008 at: http://www.jfsowa.com/ontology/index.htm.

Spyns, P., Meersman, R., and Jarrar, M. (2002), Data modeling versus ontology engineering. SIGMOD Record, 31(4), 12-17.

Tanriverdi, H. (2005) Information technology relatedness, knowledge management capability, and performance of multibusiness firms. MIS Quarterly 29(2), 311-334.

Tolvanen, J. P. (1998), Incremental method engineering with modeling tools: theoretical principles and empirical evidence. Dissertation (Ph. D), University of Jyväskylä.

Vernadat, F. B. (2002), Enterprise modeling and integration (EMI): current status and research perspectives. Annual Reviews in Control 26 (2002), 15-25.

Vessey, I. and Glass, R. (1998), Strong vs. weak. Communications of the ACM, 41(4), 99.

Wand, Y. & Weber, R. (2004), Reflection: ontology in information systems. Journal of Database Management, 15(2), 3-6.

Wand, Y. and Weber, R. (2002), Research commentary: Information systems and conceptual modeling--a research agenda. Information Systems Research, 13(4), 363.

Wiig, K., Hoog, R., and Spek, R. (1997), Supporting knowledge management: a selection of methods and techniques. expert systems with applications, 13(1), 15-27.

Whitman, L. and Huff, B. (1997), A living enterprise model, Proceedings of the Sixth Industrial Engineering Research Conference, Miami Beach, FL, May.

Whitman, L., Ramachandran, K., and Ketkar, V. (2001), A taxonomy of a living model of the enterprise. Proceedings of the 2001 Winter Simulation Conference. . Peters, B.A., Smith, J.S., Medeiros, D.J., and Rohrer, M.W. (eds).

About the Authors:

Sung-kwan Kim is an Associate Professor at the University of Arkansas at Little Rock. He teaches database management system and system development methodology at the undergraduate and graduate programs. His research interests include enterprise knowledge modeling and data modeling. He has published in the *International Journal of Knowledge Management*, *Journal of Knowledge Management*, *Journal of Knowledge Management Practice,* and *Journal of the Society of E-business Studies*. He has received his Ph. D. from the University of Nebraska at Lincoln.

Sung-Kwan Kim, Ph. D., Associate Professor, University of Arkansas at Little Rock, Management Department, 2801 S. University Avenue, Little Rock, AR 72204; Tel: 501-569-8859; E-Mail: sxkim@ualr.edu

Richard Woolridge is an Assistant Professor at the University of Arkansas at Little Rock. Prior to earning his Ph.D. from The University of Alabama, he had a twenty-year career in industry as an entrepreneur, consultant, process developer, project leader, architect, practice manager, software developer, and commercial software product manager.

Richard Woolridge, Assistant Professor, University of Arkansas at Little Rock, Management Department, 2801 S. University Avenue, Little Rock, AR 72204; Tel: 501-569-8889; E-Mail: rwwoolridge@ualr.edu