Theoretical and Empirical Researches in Urban Management
Number 1(10)/2009

INTERDEPENDENCY BETWEEN SIMULATION MODEL DEVELOPMENT AND KNOWLEDGE MANAGEMENT

Florica LUBAN
Academy of Economic Studies, Bucharest, Romania
florica.luban@man.ase.ro

Daniela HÎNCU
Academy of Economic Studies, Bucharest, Romania
daniela.hincu@man.ase.ro

Abstract
The paper discusses the relationship between simulation and knowledge management. Simulation models are increasingly being used to simulate processes in many different domains, including urban management, for solving decision problems. Usually, during the model development, the simulation team developing the model must rely on the knowledge provided by domain experts. In order to facilitate this simulation modelling process, appropriate collaborative knowledge management tools may be utilised. On the other hand, simulation models can facilitate knowledge management activities and processes as models could be used to evaluate decision alternatives before they are implemented or models could be used to simulate missing business data needed for discovering knowledge patterns. The paper concludes with a brief literature review of the some interdisciplinary applications that involve the combined use of both approaches. These applications include the use of system dynamics simulation for analysis of knowledge management strategies in organisational populations, learning curves, capital human modelling, and investigation of the influence of knowledge transfer and proximity (geographical, cognitive, and organizational) on the firm agglomeration process inside an industrial district.
Keywords: simulation modelling, knowledge management, system dynamics

1. Introduction

Knowledge management, while conceptually ancient, is a relatively new form of collaborative computing. The goal of knowledge management is to capture, store, maintain and deliver useful knowledge in a meaningful form to anyone who needs it anyplace and anytime within an organization. Basically, knowledge management is collaboration at the organization level. Although knowledge management is primarily process-oriented with strategies determined by the organizational culture, motivation and policies, knowledge management needs the right methods, technologies and tools for a successful implementation (Luban 2006).

For many decades, simulation modelling has been one of the most well known decision support techniques (Luban 2005b; Sargent 2008). A common definition of a simulation is a reproduction of an item or event. Simulations can be produced in all fields through computer games, role-plays, or building models. But the specific goal of simulation is to mimic, or simulate, a real system so that we can explore it, perform experiments on it, and understand it before implementing decision alternative in the real world (Albright and Winston 2007; Pidd 1998).

This paper discusses the links and interdependencies between knowledge management and simulation. The potential benefits from of the integration of simulation modelling and knowledge management tools are investigated and some applications of system dynamics simulation are presented.

2. Knowledge management and simulation

Knowledge and knowledge management are becoming increasingly important for the life and there is an ongoing change towards knowledge-based societies and economies in which research, innovation, and knowledge are the major components (Beijerse 1999; Sveiby 2001; Luban 2006). In (Nonaka and Takeuchi 1995) it is shown that the concept of knowledge management has emerged due to a change in business trends, which have evolved from an environment that was predictable and incremental, to one that is radical and discontinuous. In such turbulent business environments, knowledge is one of the main sources of lasting competitive advantage.

Recent strategic management literature stresses that the competitive strategy cannot be based only on cost and differentiation but it should be devoted to create and manage new knowledge, so fostering innovation. This new knowledge results as the collection of pieces of information and knowledge that are owned by a variety of parties, and then requires, to be developed, the combination of the external learning processes (e.g. learning by imitation and learning by interaction) with the internal ones (Research and Development activities, learning by doing and by using). The innovation process of firms can be conceived as an open system where heterogeneous inputs (internal and external knowledge) are transformed into outputs (results of innovation).

Knowledge management aims to satisfy, and where possible, exceed customer expectations. By providing the right information, to the right people at the right time, knowledge management techniques and software applications enable companies to design their operational processes to be truly dynamic and human resources to be truly effective.

As information systems have proliferated in organizations, it has been a natural outcome to assume the increased potential of using modern information technologies such as Internet, intranets, browsers, data warehouses, data filters and software agents to systematise, facilitate and expedite firm-wide knowledge management. A knowledge management system could be defined as a technology system

Theoretical and Empirical Researches in Urban Management
Number 1(10)/2009

that uses information technology to create, organize and disseminate knowledge throughout an organization. At face value, it appears that such a task could be effectively managed by a purpose built system containing organizational information and processes (Luban 2005a).

In reality however, few organizations have tackled knowledge management as effectively as they should. There are many reasons why computer driven knowledge management has failed: the nature of knowledge (the value of knowledge is realized only when it brings a meaning into context), the culture of the organization (an organization is an artifact of personal experience and social relations and managing information at social level is not easy because people-centered information is unstructured, emergent and creative), how to effectively use technology to facilitate synergy within an organization's structure (one of the critical tasks of the management is to coordinate different packets of knowledge through information exchange and sharing). Malhotra (2004) shows that the failure of knowledge management systems is not so much a failure of technology, but a failure of strategy and process. Technology is simply a resource to enable the process to operate; if the process is well thought out then the supporting technology is more likely to be appropriate. In other words, if a better understanding exists of both knowledge and knowledge management strategies, goals and processes, then technology can be developed to meet those needs.

There are numerous definitions of knowledge management available in the literature. Unfortunately, there's no universal definition of knowledge management, just as there's no agreement as to what constitutes knowledge in the first place. A general consent, (Luban 2000), is that knowledge management is related to generation, codification and transfer of knowledge in organisations in order to improve business performance and decision making. A possible reason, (Hlupic, Verbraeck and Vreede 2002), for the vagueness and ambiguity is that the word knowledge means different things to different people. In addition, there are different types of knowledge namely, explicit knowledge where the information is easy to understand and financially tangible and tacit knowledge which is difficult to document or categorise and is nonfinancially tangible (Davenport and Prusak 1998).

In (UDC 2003) it is shown that knowledge management draws from a wide range of disciplines and technologies: cognitive science; expert systems, artificial intelligence and knowledge base management systems; computer-supported collaborative work (groupware); library and information science; technical writing; document management; decision support systems; semantic networks; relational and object databases; simulation; organizational science; object-oriented information modeling; electronic publishing technology, hypertext, and the World Wide Web; help-desk technology; full-text search and retrieval; performance support systems. Although around 20 kinds of disciplines and study areas were listed above, Hlupic, Verbraeck and Vreede (2002), consider that the literature does not address the role of modelling in the context of knowledge management.

A simulation model could be a useful and versatile tool to gain insight into the operation of systems. Next to, e.g., natural systems, human systems also urban systems can be subject to simulation. Generally, a model that represents certain key characteristics or behaviours of the system is analyzed to show the eventual real effects of alternative conditions and courses of action. This type of model is like other mathematical model, but it explicitly incorporates uncertainty in one or more input variables. Simulation allows these random input variables to take on various values, and it keeps track of any resulting output variables of interest. The strength of simulation is that it enables precisely this "what if" analysis, i.e., it allows to "look into the future" under certain assumptions.

Simulation has many different definitions (Luban 2005b). One oldest and much cited is given in (Naylor et al. 1966): simulation is a numerical technique for conducting experiments on a digital computer, which involves certain types of mathematical and logical relationships necessary to describe the behavior and structure of a complex real-world system over extended periods of time. It is important to mention that all definitions have some common assumptions: usually, a mathematical and logical model of the analysed system is developed; the system may be actual or theoretical; the system can be described in terms acceptable to a computing system; usually, a computer is used; simulation involves the generation of artificial history of a system, and the observation of that artificial history to draw inferences concerning the operating characteristics of the real system; simulation is experimentation; the goal of the simulation: to find "something" about the operation of the real-world system.

In (Hlupic, Verbraeck and Vreede 2002; Luban and Hîncu 2008), it is shown that although the literature separates simulation and knowledge management, a more detailed analysis of these areas reveals that there are many links between them. More knowledge about the system can be discovered during simulation modeling process, and model development can be facilitated by collaborative knowledge management tools.

3. The relationship between knowledge management and simulation

In this section the relationship between knowledge management and simulation are discussed following the phases of the simulation modelling process presented in Figure 1.

Simulation models are often designed to address a set of modeling objectives or to answer a set of questions. Once a problem (system) to be modelled is identified, data about the system is collected and analysed. System data and results are obtained by conducting experiments on the real system. During

Theoretical and Empirical Researches in Urban Management
Number 1(10)/2009

this process, new knowledge about the system can be discovered, which can be used for problem solving and decision making. System theories are developed by abstracting what has been observed from the system and by hypothesizing from the system data and results. If a simulation model exists of this system, then hypothesizing of system theories can also be done from simulation data and results. System theories are validated by performing theory validation. Theory validation involves the comparison of system theories against system data and results over the domain the theory is applicable for to determine if there is agreement. This process requires numerous experiments to be conducted on the real system.

In (Benjamin, Patki and Mayer 2006) it is shown that ontology based tools for knowledge management can be used to facilitate the first phase of the simulation modeling process. Domain ontology can help with the unambiguous interpretation of the problem statements and in precisely conveying information about the problem to the simulation modeler. Also, ontology enable shared and clear understanding the problem of real system by harmonizing statements of objects that are described from multiple perspectives.

The next phases of simulation model development process relate to development of conceptual model, specification for computerised model, simulation model and simulation results. In (Sargent 2008) it is shown that the conceptual model is the mathematical/logical/verbal representation of the system developed for the objectives of a particular study. The specification for computerised model is a description of the software design and specification for programming and implementing the conceptual model on a particular computer system. The simulation model is the conceptual model running on a computer system such that experiments can be conducted on the simulation model. The simulation model data and results are the data and results from experiments conducted on the simulation model. The conceptual model is developed by modelling the system for the objectives of the simulation study using the understanding of the system contained in the system theories. The simulation model is obtained by implementing the model on the specified computer system, which includes programming the conceptual model whose specifications are contained in the simulation model specification. Inferences about the system are made from data obtained by conducting computer experiments on the simulation model.

More knowledge about the system can be discovered during these phases, and model development can be facilitated by knowledge management tools. An operational simulation model is obtained through validation and verification of models, and this phase can also be supported by collaborative knowledge management tools whereby knowledge needed for model testing can be elicited and generated with the help of these tools. These tools can also support the process of designing simulation experiments, and as possible alternatives to be simulated are considered new knowledge about the system and alternative configurations can also be discovered. Analysis of output results can also be facilitated by collaborative knowledge management tools, and output results obtained as a result of "what if" analysis can provide further knowledge about existing and alternative systems.

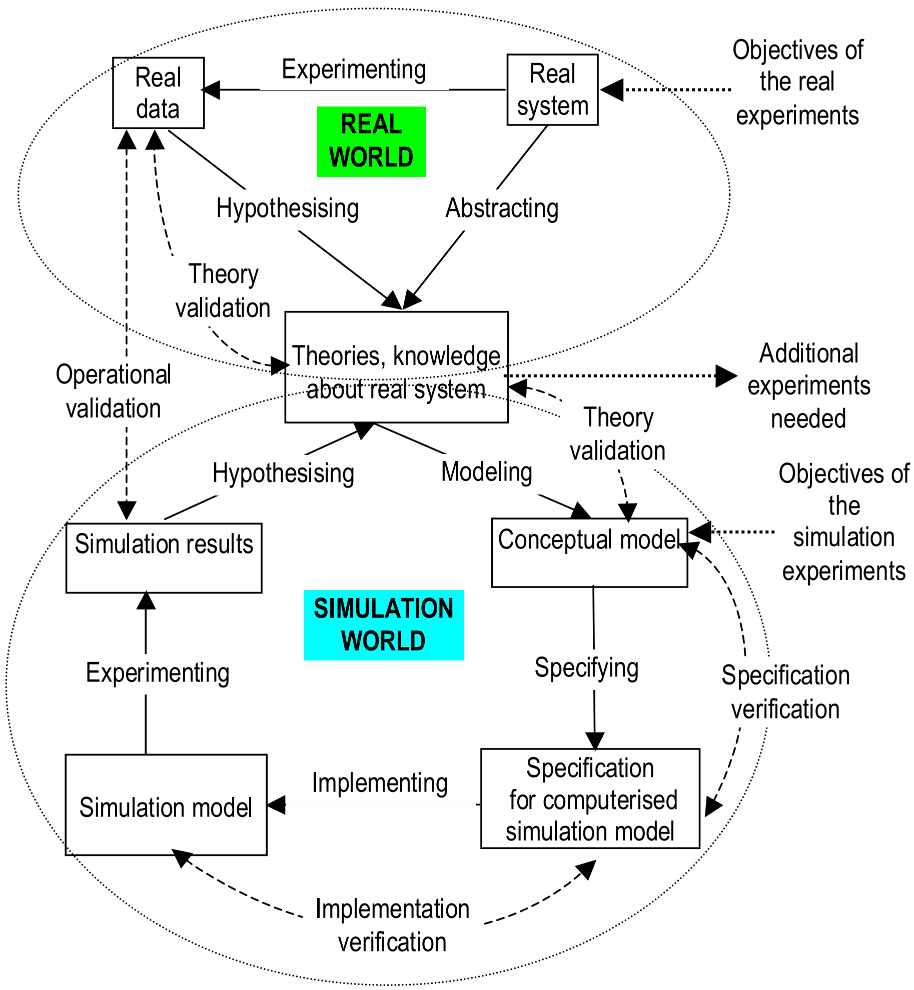

FIGURE 1 – SIMULATION MODEL DEVELOPMENT PROCESS
Source: Sargent (2008)

On the other side, (Hlupic, Verbraeck and Vreede 2002), simulation can be used in the knowledge management processes for:

- simulating missing business data;
- investigating knowledge management processes, knowledge flow and knowledge processing activities;

- evaluating alternative models of knowledge management strategies;
- evaluating the effect of new knowledge management practices on business processes;
- gaining managerial abilities by business simulation games focused on knowledge management.

Many benefits could be obtained from interdisciplinary approach that would involve the combined use of both approaches. In (Edwards et. al. 2004) it is presented a simulation model as part of the knowledge elicitation process in a project simulating maintenance operations in an automotive engine production facility.

Canals, Boisot and MacMillan (2004) develop an evolutionary agent-based simulation model derived from a knowledge-based theoretical framework, and use it to explore the effect of knowledge management strategies on the evolution of a group of knowledge-intensive organizations located in a given geographical area. From the analysis of the results, a set of hypotheses on the influence of knowledge management strategies and the degree of development of information and communication technologies on the evolution of organizational populations are derived.

Srinivasan and Horowitz (2004) propose the use of simulation as a tool for assessing the quality of an analytical knowledge management model constructed using a technique called Root Causes Analysis (RCA) Modelling, generically known as Structural Equation Modelling. The RCA modelling technique refers specifically to the methodology applied to a broader set of business challenges, where root causes were hypothesized for creating potential management responses to key business challenges and the relationships between the root causes and the challenge being addressed were modelled using a structural equation model. Different types of sensitivity analyses were conducted to demonstrate the robustness of the model.

4. The use of system dynamic simulation in the knowledge management processes

Accelerating economic, technological, social, and environmental changes enhance the dynamic complexity of the economic systems, making difficult for managers to fully understand the behavior of such systems, and so the knowledge management. System dynamics simulation allows modeling, describing, and understanding the behavior of complex systems, so improving the capacity of individuals and organizations to learn and manage the knowledge related to these systems.

Several authors used this system dynamics simulation to analyse some specific problems. Many applications of system dynamics simulation are in the knowledge management processes. These applications include the following:

Naim and Towill (1994) describe a family of system dynamics learning curves models that have been found particularly appropriate in modelling and forecasting the performance of business organisations. These models may be utilised as a management decision support tool for monitoring and controlling the start-up phases of new product and the associated manufacturing processes. The proposed system dynamics learning curve models are required for two quite different situations. The first is based on historical information where the model is to be added to a company or consultancy date base. The second is for on-line forecasting and control of a business activity.

System dynamics simulation has been used by Repening and Sterman (2001) to study the improvement paradox: why despite of the increasing number of tools and techniques available to improve performance, there is a little improvement in the ability of organizations to embed these innovations in their everyday activities.

Black, Carlile and Repenning (2004) utilise a system dynamics model to explain why the implementation of new technologies often disrupts occupational roles in ways that delay the expected benefits.

Sveiby, Linard and Dvorsky (2002) report on a project which integrates work on intangible assets with system dynamics based human capital modelling undertaken for the Australian Federal Public Service by the UNSW Centre for Business Dynamics. The paper presents a dynamic management flight simulator which can help managers to understand better the dynamic interrelationships in organisation design and, in particular, the interrelationships between an organisation's profitability and investment in people competence, internal structure and relationship building measures with customers. The expected use of such a simulator is assisting managing partners of professional services organisations to improve the allocation of both their own and their staffs' value adding capacity.

A paradox that characterises the actual competitive scenario is that, although the market and economy are more and more and more globalised, the localisation of firms is still a relevant factor to achieve and maintain competitive advantage in the long-term. Dangelico, Garavelli and Messeni Petruzzelli (2007) develop a system dynamics model for describing, formalizing, and investigating the influence of knowledge and proximity dimensions (geographical, cognitive, and organizational) on the firm agglomeration process inside a technology district. Porter (1998) defines such agglomeration of firms as geographic concentrations of interconnected companies, suppliers, service providers, and associated institutions in a particular industry where firms compete but also cooperate with one another. Different types of industrial districts have been distinguished. An important distinction can be made to identify their technological nature. Technology districts are considered as an evolution of industrial districts, based on a set of more knowledge-based firms, localized in distinctive regions where technological

Theoretical and Empirical Researches in Urban Management
Number 1(10)/2009

externalities and low communication costs are especially conducive to raise innovation. A common feature of industrial and technology districts is that both of them exploit benefits arising from agglomeration economies, related to the common sharing of resources. However, the strategic relevance of agglomeration seems to be menaced by the current economic scenario, which is more and more globalised and allows firms to reach new markets and sources of competitive advantage, once unreachable. Actually, thanks to globalization, firms can select production factors world-wide localized without the need of being close to them, thus achieving advantages in terms of costs and differentiation also without specific localization investments.

The model proposed in (Dangelico, Garavelli and Messeni Petruzzelli, 2007) analyses the district evolution according to a knowledge-based perspective. For each model variable, suitable proxies, mainly based on the notion of patents, are identified. The simulation allows investigating how different values of organizational and cognitive proximity can affect the knowledge sharing and the agglomeration process of a high technology district. Results show that only when district firms are organizational and cognitive proximate, they can fully exploit the benefits of agglomeration, in terms of knowledge sharing and creation. Then, only in this case the district evolves, being able to attract new firms.

5. Conclusion

Issues discussed in this paper reveal there are many interdependencies between simulation modelling and knowledge management. Many benefits could be obtained from interdisciplinary approach that would involve the combined use of both approaches. For example, simulation allows modelling, describing, and understanding the behaviour of complex systems, so improving the capacity of individuals and organizations to learn and manage the knowledge related to these systems.

Further work in this area relates to conducting further case studies using knowledge management tools applications during conducting simulation modelling studies, and recording the costs and benefits obtained from this approach.

Bibliography

Albright, S.C. and Winston, W.L. (2007). *Management science modeling*. Thomson South-Western

Beijerse, R. P. (1999). Questions in knowledge management: Defining and conceptualising a phenomenon. *Journal of Knowledge Management,* 3(2), 94.

Benjamin, P., Patki, M. and Mayer, R. (2006). Using ontologies for simulation modeling. In L. F. Perrone, F. P. Wieland, L. J. Liu, B.G.. Lawson, D.M. Nicol, and R.M. Fujimoto (eds.) *Proceedings of the 2005 Winter Simulation Conference* (pp. 1151-1159). Piscataway, New Jersey: IEEE.

Black, L.J., Carlile, R.P. and Repenning, N.P. (2004). A dynamic theory of expertise and occupational boundaries in new technology implementation: building on Barley's study of ICT scanning, *Administrative Science Quarterly*, 49(4), 572-607.

Canals, A., Boisot, M. and MacMillan, I. (2004). Evolution of knowledge management strategies in organizational populations: a simulation model. *Working paper series: WP04-007*. Retrieved December 15, 2008 from Internet Interdisciplinary Institut Web site: http://www.uoc.edu/in3/dt/eng/wp04007.html

Dangelico, R.M., Garavelli, A.C. and Messeni Petruzzelli, A. (2007). A system dynamics model to analyze technology districts' evolution in a knowledge-based perspective. *Regional Studies Association International Conference, Regions in Focus?* 2-5th April, Lisbon, Portugal. Retrieved December 15, 2008 from http://www.regional-studies-assoc.ac.uk/events/lisbon07/papers/Dangelico.pdf

Davenport, T.H. and Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Boston, Harvard Business School Press.

Edwards, J.S., Alifantis, T., Hurrion, R.D., Ladbrook, J., Robinson, S. and Waller, A. (2004). Using simulation model for knowledge elicitation and knowledge management. *Simulation Modelling Practice and Theory* 12, 527 - 540

Hlupic, V., Verbraeck, A. and Vreede, G.J. de (2002). Simulation and knowledge management: separated but inseparable? In Verbraeck, A. and Krug, W. (eds.), *Proceedings 14th European Simulation Symposium*. SCA Europe BVBA, Retrieved December 15, 2008 from http://sk-3.tbm.tudelft.nl/files/papers/2002/ESS2002-bus-9.pdf

Luban, F. and Hîncu D. (2008). Knowledge management and simulation modeling. In Simion M. Gh., Talpasanu, I., (scientific editors), Proceedings. *The 32nd Annual Congress of the American Romanian Academy of Arts and Sciences*, Boston, USA, July 22-26, 2008, (pp. 481 – 484). Polytechnic International Press, Montreal, Quebec.

Luban, F. (2006). *Sisteme bazate pe cunoştinţe în management*. Bucureşti, Editura ASE.

Luban, F. (2005a). Methods for evaluating economics of knowledge management systems. In Information & Knowledge Age: *The Proceedings of the Seventh International Conference on Informatics in Economy*, Bucharest, Romania, May 2005, (pp. 1268 – 1273). Bucureşti, Editura Economică and INFOREC Printing House.

Luban, F. (2005b). *Simulări în afaceri*. Bucureşti, Editura ASE

Luban, F. and Breazu, G. (2000), Managementul cunoştinţelor. *Economia – seria Management*, 3(1-2), 53 – 57.

Malhotra, Y. (2004). Why Knowledge Management Systems Fail? Enablers and Constraints of Knowledge Management in Human Enterprises . In Michael E.D. Koenig and T. Kanti Srikantaiah (Eds.), *Knowledge Management Lessons Learned: What Works and What Doesn't*, Information Today Inc. (American Society for Information Science and Technology Monograph Series), 87-112. Retrieved December 15, 2008 from http://www.brint.org/WhyKMSFail.htm

Naim, M.M. and Towill, D.R. (1994). System dynamics and learning curves. In Conference Proceedings. *The 12th International Conference of the System Dynamics Society*, Stirling, Scotland (pp. 164-173). Retrieved December 15, 2008 from http://www.systemdynamics.org/conferences/1994/proceed/papers_vol_2/naimm164.pdf

Naylor, T.H., Balintfy, J.L., Burdick, D.S. and Chu, K. (1966). *Computer simulation techniques*. New York, John Wiley

Nonaka, I. and Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*, Oxford, OUP.

Pidd, M. (1998). *Computer simulation in management science*, Fourth edition, Chichester, John Wiley.

Porter, M. (1998). *Clusters and the new economics of competition*, Harvard Business Review 76 (6), 77-90.

Repenning, N.P. and Sterman, J.D. (2001). Nobody ever gets credit for fixing problems that never happened: creating and sustaining process improvement, *California Management Review*, 43(4), 64-88.

Sargent, G. R. (2008). Verification and validation of simulation models. In S. J. Mason, R. R. Hill, L. Mönch, O. Rose, T. Jefferson, and J. W. Fowler (eds.) *Proceedings of the 2008 Winter Simulation Conference* (pp. 157-169). Piscataway, New Jersey: IEEE.

Srinivasan, A. and Horowitz, B. M. (2004, October). Use of simulation experiments to evaluate knowledge management modeling quality. *Journal of Knowledge Management Practice*, Volume 5 (online open access journal). Retrieved December15, 2008 from http://www.tlainc.com/articl76.htm

Sveiby, K.E., Linard K. and Dvorsky, L. (2002). *Building a knowledge-based strategy. A system dynamics model for allocating value adding capacity*. Retrieved December 15, 2008 from Sveiby Knowledge Associates Web site: http://www.sveiby.com/Portals/0/articles/sdmodelkstrategy.pdf

Sveiby, K.E. (2001). *What is Knowledge Management?* Retrieved December 15, 2008 from Sveiby Knowledge Associates Web site: http://www.sveiby.com/Portals/0/articles/Knowledge Management.html

UDC, (2003). *Introduction to knowledge management*. Retrieved December 15, 2008 from The University of North Carolina at Chapel Hill Web site: http://www.unc.edu/~sunnyliu/inls258/ Introduction_to_Knowledge_Management.html