

Using intelligent agents for knowledge management in e-commerce

Vlatka Hlupic¹, Athanasia Pouloudi², and George Rzevski¹

¹Brunel Centre for Knowledge and Business Process Management
Department of Information Systems and Computing
Brunel University, Uxbridge
Middlesex UB8 3PH, United Kingdom

²ELTRUN, The E-business Center
Department of Management Science and Technology
Athens University of Economics and Business
47A Evelpidon & Lefkados Str.
GR-113 62 Athens, Greece

E-mail: pouloudi@aueb.gr, Vlatka.Hlupic@brunel.ac.uk , rzevski@btclick.com

Abstract. *This paper investigates how knowledge management (KM) can create new business opportunities in the new business environment that is defined by electronic commerce. In particular, we argue that intelligent systems can offer additional capabilities and advantages for KM in comparison with more traditional information technologies. The potential of intelligent-agent based software for more effective KM in the context of e-commerce is investigated from the perspective of an SME involved in multi-agent software development, and propose a research agenda for KM research in e-commerce.*

Keywords. Knowledge management, E-commerce, intelligent agents, customer service

1. Introduction

Knowledge management (KM) is becoming a competitive differentiator for both 'traditional' and 'virtual' organisations. There is an expectation that the technical exploitation of knowledge data will improve substantially with the use of intelligent tools that have several additional capabilities in comparison to traditional KM tools, as discussed in this paper.

While some research also makes reference to the organisational context within which the technology will be used [3], [4], there is little evidence of whether or how the organisational and technical dimensions have been integrated. The challenges, both technical and contextual,

presented in this paper indicate that electronic commerce creates a new context for KM, not just in terms of the cultural and business environment created, but also in terms of the actual knowledge that is captured, exchanged and exploited. To deal successfully with the latter, it has been suggested that artificial intelligence, and intelligent agents in particular, have a key role to play [17].

This paper will consider how this new technology can be applied in practice and how the context of electronic commerce creates business opportunities for the provider of intelligent technology to support KM. The paper is structured as follows. The next section presents some of the key organisational and technical challenges for KM, with emphasis on the role of intelligent multi-agents and the challenges that electronic commerce presents for KM. The case of an SME involved in development of intelligent agents-based KM software is then introduced, a research agenda for KM research in e-commerce is proposed, and conclusions are drawn.

2. Key Challenges in Knowledge Management

The literature has been unable to agree on a definition for the term 'knowledge management' [2], [7], [10], [19]. One reason is that discussions of, and approaches to, the subject are rooted in different academic disciplines and areas of professional expertise (for example *information*

systems perspective [19], *innovation management perspective* [8], [9], [13], and *organisational learning* [15]. These perspectives do not adopt a *multi-disciplinary* approach, despite the multi-disciplinary interest in KM [11], [14]. We argue that KM must move towards a more *holistic* approach to nurturing and exploitation knowledge assets in both 'traditional' and 'virtual' business environments. In the paper we demonstrate this in two ways. First, in this section, we give as much attention to the capabilities of intelligent technology as to the context of electronic commerce applications. Second, in the following sections, we demonstrate how technology and context become intertwined in the empirical evidence that our case study provides. Starting with KM tools, this section presents a technological followed by an organisational perspective on KM.

2.1. Knowledge Management Tools

The majority of KM tools are designed to deal with *structured* data, where information is directly entered into fields or can be categorised in some manner. With KM systems, the key issue is probably the need to move beyond simple structured data mining towards the capture, mining and manipulation of tacit or unstructured data. A key challenge for the design of KM technology is the identification of patterns [1] in unstructured data that enables reuse of the technology and contributes to system flexibility [16]. There is an expectation that the new generation of KM tools will address this challenge using artificial intelligence (AI) techniques such as case based reasoning, neural networks and intelligent agents. This paper focuses on the role of the latter.

2.2. Intelligent agents

Intelligent agents are software objects (special types of computer programs) capable of communicating with each other and reasoning about information contained in messages that pass among them. To be classified as *intelligent*, agents must be able to make decisions under conditions of uncertainty, to act upon incomplete information, albeit in a narrow knowledge domain. Multi-agent systems use multiple intelligent agents and are characterised by distributed problem solving. They contain software objects (agents) capable of exchanging messages among themselves and their users,

interpreting the meaning of messages and negotiating decisions. An interesting development in multi-agent systems is an attempt to provide agents with a mechanism for modifying protocols that regulate negotiations, which they conduct among themselves [12], which enables them to incrementally improve their decision-making performance. These capabilities are particularly useful in electronic commerce (as discussed further on in this paper) where intelligent agents have been taken up. The concept of multi-agent design and control is well developed, although not necessarily articulated in the context of KM [17].

3. Challenges for knowledge management in the context of e-commerce

KM, while supported by technology, remains a complex management practice for all organisations – tools will not work unless they can be integrated in the organisational and cultural context. The following paragraphs consider the reasons why this may be the case at four separate but interconnected levels, where KM benefits are realised: the individual, organisational, interorganisational and international levels. Particular emphasis is given to the additional challenges that are present in an electronic commerce context.

At an *individual level*, KM provides organisational members with opportunities to operate in an environment of continuous change. Attention to the individual level signifies acceptance of idiosyncratic knowledge, recognising that personality plays a critical role in the way that people acquire, perceive, value and use knowledge [5]. This is particularly relevant for the e-commerce context. Specifically, in business-to-consumer e-commerce relations, in contrast to traditional commerce, the customer is not visible and typically not known. The technological awareness of individuals also varies. The potential customer population is large (possibly global) and the 'customer' could have any background (cultural, financial or educational). In KM terms, this presents a business opportunity: customer behaviour can be electronically recorded, therefore can be manipulated and exploited for competitive advantage. Intelligent agents can play a key role here by providing personal attention to the customer, learning and remembering individual

preferences, which can be communicated or negotiated as needed. The business implication for the company using the technology is dual: customer service can improve as individual traits are catered for and the company gains knowledge about trends and patterns that can be unveiled from customer choice.

At an *organisational level*, KM supports the streamlining of activities and facilitates improved organisational response to internal and external changes. In organisations that use electronic commerce, the notion of business processes maybe entirely different, as these companies are based on different business models [18]. On the one hand, as business processes are predominantly electronic, they should be more transparent and traceable than in traditional business – thus, information about business transactions is structured and explicit and this should facilitate KM. On the other hand, several business processes transcend the boundaries of the organisation, as electronic links to customers, suppliers and other stakeholders make the organisation an extended, networked enterprise. This makes it harder to convert information into knowledge: different organisational settings and therefore different cultural environments, with different sets of tacit knowledge, interact. A related difficulty at this level, which also applies to traditional companies, is that the available data about processes, procedures, and resources may be incomplete. This makes it harder to uncover patterns that can lead to knowledge codification and possibly the generation of new knowledge. The use of intelligent agents can be helpful in this respect. Specifically, intelligent agents that are characterised by autonomous learning can use previous history, and learn from it even if the way in which it is interpreted changes at a very fast rate.

Interorganisational and international levels (in many cases, these can be used interchangeably in e-commerce) are therefore more relevant in considering the challenges of the KM context in electronic commerce. At the moment, little is known about the transfer of knowledge at an interorganisational level. The potential role of multi-agents, at this interorganisational level, is in their ability to represent business partners in the networked enterprise and conduct negotiations on their behalf. They can be also utilised for business-to-business types of

transactions, operating, for example, in the context of supply chain dealings. Both roles entail technical and organisational issues. Agents will negotiate what to do next in every particular situation, based on local information and a set of general rules, without any need for optimisation algorithms to be programmed into the system in advance.

Electronic commerce combines a business with a technological environment, as transactions occur electronically. It is obvious from the discussion in this section that it offers a good opportunity to illustrate the interdependence of technical and organisational (often *inter-organisational*) factors in KM. In the next section we consider the technical and business environment of a recently established company that develops, supplies and supports multi-agent software, and serves as a case study for considering the potential of intelligent agents for KM in e-commerce.

4. Use of Multi-Agents for KM in E-Commerce: Empirical Insights

Following from the previous discussion on the interrelations of technical and organisational factors related to KM in electronic commerce, this section presents how these are witnessed in practice. For our description we adopt the perspective of a small enterprise, providing an 'insider view' to the opportunities and challenges it faces in providing multi-agent support for KM in electronic commerce. Starting with a description of the company and its multi-agent software, the section leads on to a discussion of the role of intelligent agents in KM, which serves as a guide for proposing a broader agenda for research in this area.

4.1. The company

The company has been established in October 1999 to exploit multi-agent research but it has a long history of informal existence marked by previous international collaboration among its founders. Although its physical premises are in the UK, it is largely a virtual corporation with researchers, system designers and programmers collaborating over intranets and the Internet. For example, the main activities related to software development are carried out in Russia. The company aims to become "virtual" and to sell its products and services mainly though the Internet. In doing so, it would become an e-commerce-

based organisation selling products and services that support e-commerce.

The corporation has a flat structure, where 'teamwork dominates every aspect of corporate life'. Also, the corporation considers intellectual capital to be its key asset. Consequently, KM is important for the company not just as a product but as a competitive differentiator: the company is its own customer. For example, organisational memory is facilitated by the company's own KM software. Similarly, the company culture is maintained through an extensive electronic network. The company is currently in the process of extending the functionality of its web site for procurement and selling its product and services. Plans for e-commerce include using the company's web site for selling, in large volumes, scaled down multi-agent tools and shells to small-to-medium software developers around the world.

4.2. Capabilities of Multi-Agent Software

Multi-agent software provided by the Company, contains agents that are trained (have access to knowledge) rather than programmed to do a particular job. Advanced versions of agents can learn from experience and have distinguishing personality traits. The principal element of multi-agent systems, which enables them to achieve a limited-scale perception, cognition and execution, is an Ontology, which contains knowledge about the domain in which the system operates. To keep the Ontology simple, the domain of agent activity has to be reasonably narrow. The second component of the system is the Engine. A key advantage of this architecture is that modifications are easy because the agent code is reusable, multi-agent engines are expandable and the Ontology can be updated by operators without any knowledge of computer programming using a visual tool called Ontology Constructor. The Agency is the space where agents are created and where they work (negotiate), the Core is a set of run-time algorithms enabling parallel work of a very large number of agents and the Genetic Engineering Lab is a place where the performance of agents is monitored and modifications are made to their "genetic code" to improve their performance (e.g., to negotiate more aggressively, or more carefully).

4.3. Supporting Knowledge Management for E-commerce

In the context of electronic commerce, agents improve the performance of portals and web sites by providing visitors with an intelligent, personalised, one-to-one service. In particular, they communicate with each visitor as an individual, recognising specific needs and expectations. They also recognise visitors when they return to the site. In addition to this customer relationship management role, multi-agents match portal offerings to visitor's demands rapidly and effectively and negotiate discounts and special deals on behalf of their clients. From a KM perspective, they continuously analyse available data in the background, with a view to discovering, preserving, maintaining and updating knowledge about each visitor. Discovering and managing knowledge through the use of agents can be directed both to the business environment (customers, competitors, investors, administrative and legal factors, new technologies, etc.) but also to the client's own business processes (cost-effectiveness of human and technological resources, organisational structures, business culture, geographical locations, etc.).

The competitive differentiator of a Multi-Agent Knowledge Management System is based on effective clustering algorithms that enable rapid discovery of knowledge, which as discussed in previous sections can be 'buried' in unstructured data. The key to the effectiveness is the use of multi-agent technology, which provides distributed intelligence to help the process of clustering. Principles and rules of clustering, which are obeyed by agents, are in the first instance entered into the system ontology by KM experts. The system is designed to enable operators without knowledge of computer programming to modify and update clustering principles and rules and thus influence the system performance. The company's selling point is that this system is much less expensive than a typical data mining system and far more effective (e.g., as it enables knowledge exploitation of unstructured data) and user friendly. A unique aspect of the system's user friendliness is the capability to provide the user with a graphical representation of clustering results so that stronger links between data elements appear clearly.

It is worth noting that clustering becomes a self-organising process. As new data become available to the system the clusters of knowledge are re-evaluated and reconfigured, allowing for a dynamic interpretation of business results. Furthermore, the system can provide patterns without 'knowing' much about the data. This means, on the one hand, that the system may highlight relationships between data that is not obvious, even to the knowledgeable human agent, thus unveiling real competitive edge issues for their clients. On the other hand, the clustering process becomes faster if human agents define restrictions for the clustering processes, based on their capability to interpret meaningful associations amongst data elements. This dilemma between speed and scope of data analysis illustrates the interplay of technical capabilities and organisational priorities. The human agent can improve the efficiency of the technology by a good understanding of the context, which can lead to a better definition of ontology as well as a more insightful interpretation of the data analysis results. Obviously, the responsibility for the translation of results in appropriate business policies lies also with the human agent.

5. Implications for Research in Knowledge Management for E-Commerce

The interactive character of electronic commerce enables information (and, hence, knowledge) sharing across organisational entities or individuals, often across national boundaries. Through their electronic commerce interactions and transactions companies acquire much information that can easily be stored and exploited (as the data is usually in electronic form). However, few users of electronic commerce have considered using this information as a basis for understanding and managing their organisational knowledge better. The potential benefits of more effective KM in the context of e-commerce are apparent for both organisational processes and interorganisational relations, and we argue that multi-agent technology has an important role to play in this area. In the previous section we saw how a software house exploited their multi-agent software for KM in electronic commerce for the company and the company's clients.

Electronic commerce is a unique environment for KM, not only because it uses the Internet as a

platform but also because the data available to users of e-commerce become dated very quickly as the electronic market changes at a rapid pace. Therefore 'traditional' information technologies cannot deduce knowledge for the future exclusively from past data because of dynamic changes in the turbulent global economy. Intelligent multi-agent technologies can provide a technological solution for dealing with the uncertain conditions of this context, manipulating incomplete or ill-structured historical data.

At the moment, both research and practice of KM in e-commerce are in their infancy. For example, there are a number of problems that we have identified in current practice as well as in the theoretical understanding of KM, namely:

- the variety of theoretical approaches to KM and the lack of consensus in the literature about what constitutes KM and how effective KM can be achieved,
- the limited availability of empirical reports to support these approaches and provide guidance for further improvements in KM practice,
- the lack of KM tools and the differences in the support that existing tools provide to user organisations,
- the lack of awareness about KM opportunities for both traditional and virtual organisations, either because of technical limitations of the available tools or because user organisations are unable to identify or communicate their needs for more effective KM and the organisational structures that will support them, and
- the lack of substantial research effort to investigate technical and social aspects of KM in e-commerce environments.

As a consequence of these problems, it is not surprising that the appreciation of the challenges and necessity to integrate technical and organisational aspects of KM, which we believe is critical for more effective KM, is at best incomplete. Both organisational and technical issues of KM raise significant challenges. However, it is also evident that, even though they are often separated in the literature, in a practical context they are inseparable as they inform and influence each other. We argue that research in KM should reflect this synergy of organisational and technical issues. Research needs to be directed towards understanding how these areas limit or enhance the competitive benefits of KM

theories and models; what this new way of working entails with regard to skills, organisational structures and operations.

Furthermore, there is a lack of published empirical work in this area and there is a lack of tools that organisations can utilise and adapt for KM activities in both traditional and virtual business environments. Similarly, evaluation measures for any available tools are lacking. The investigation of the product and approach followed by the case company considered in this paper provides some insight in the potential of intelligent agents for KM in electronic commerce but clearly presents a specific, sole experience of a recently established company. More research is needed to provide a more in-depth understanding of the way in which companies respond to KM, and in particular to the use of KM technologies to exploit and enhance their electronic commerce activities. We argue that important areas for further research in this area include the following aspects.

First, in order to inform technological improvements, it is necessary to investigate and evaluate KM tools (including multi-agent-based tools) in real e-commerce environments. This should result in a better understanding of the potential and current limitations of such tools, leading, in turn, to specification of requirements for further development of such tools. Second, in order to improve KM at the strategic level in the use of electronic commerce, it is necessary to identify main barriers and driving forces for KM in e-commerce. This involves defining what knowledge is relevant in the context of e-commerce and how it can be captured, stored, refined and applied. A related aspect is the identification of critical success factors for effective KM in e-commerce based environments, including research on organisational structures that support KM in e-commerce. Third, KM provides an opportunity to improve organisational practices and processes. Therefore, future research should investigate issues related to teamwork, leadership, culture, incentives and motivation for KM, identifying ways for integrating KM into the daily workflow and particularly the types of reward structures to support knowledge sharing and collaboration. An important dimension of this research is exploring how KM can lead to individual and organisational learning as this will lead to sustainable competitive advantage.

6. Conclusions

This paper has discussed the potential of intelligent agents for KM in e-commerce, using insights from an SME providing such KM tools. The paper emphasised that technical, organisational and interorganisational aspects need to be considered in parallel for providing useful solutions for organisations doing business electronically. The research setting described in this paper could stimulate interest for identifying opportunities for competitive advantage for e-commerce user organisations from better KM and threats from KM practices in a business context. A number of future directions of research in this area have been identified on that basis. The main recommendation is for considering the future of technology within the context in which it will be applied.

References

- [1] Brash, D. (2000). Developing and validating generic knowledge: an initial experience report. In Edwards J and Kidd J (eds). Proceedings of the Knowledge Management Conference (KMAC 2000), 17-18 July, Birmingham.
- [2] Brooking, A. (1999). Corporate Memory – Strategies for Knowledge Management. International Thomson Business Press. UK.
- [3] Delesie, L. and Croes, L. (2000). Managing the variability of medical care: fostering consensus, benchmarking and feedback. The case of drug prescription patterns among Belgian home practitioners. In Edwards J and Kidd J (eds). Proceedings of the Knowledge Management Conference (KMAC 2000), 17-18 July, Birmingham.
- [4] Edwards, J. & Gibson, P.R. (2000). Knowledge management using CSCW in global strategic alliances and joint ventures via the Internet. In Edwards J and Kidd J (eds). Proceedings of the Knowledge Management Conference (KMAC 2000), 17-18 July, Birmingham.
- [5] Guns, W.D. & Välikangas, L. (1998). Rethinking knowledge work: creating value through idiosyncratic knowledge. *Journal of Knowledge Management* 1 (4), 287-293.
- [6] Hart, P. & Saunders, C. (1997). Power and trust critical factors in the adoption and use of electronic data interchange. *Organization Science* 8 (1), 23-41.

- [7] Hlupic, V., Pouloudi, A. & Rzevski, G. (2001). Towards an integrated approach to knowledge management: 'hard', 'soft' and 'abstract' issues. Forthcoming, Knowledge and Process Management.
- [8] Kuhn, O. & Abecker, A. (1997). Corporate Memories for Knowledge Management in Industrial Practice: Prospects and Challenges. *J of Universal Computer Science* 3 (8), 929-954.
- [9] Leonard-Barton, D. (1995). *Wellsprings of Knowledge - Building and Sustaining the Sources of Innovation*. Boston: Harvard Business School Press.
- [10] Malhotra, Y. (1997). Current Business Concerns and Knowledge Management [WWW Document] URL <http://www.brint.com/interview/times.htm>
- [11] McAdam, R. & McCreedy, S. (2000). A critical review of KM models in the learning organisational 6 (3), 91-100.
- [12] Muller, J.P., Wooldridge, M. & Jennings, N.R. (1996). (eds). *Intelligent Agents III, Agent Theories, Architectures and Languages*, Springer-Verlag.
- [13] Nonaka, I. & Takeuchi, H. (1995). *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*, OUP, Oxford.
- [14] Phillips, N. and Patrick, K. (2000). Knowledge management perspectives, organisational character and cognitive style. In Edwards J and Kidd J (eds). *Proceedings of the Knowledge Management Conference (KMAC 2000)*, 17-18 July, Birmingham.
- [15] Ruggles, R. (1997). *Knowledge Tools: Using Technology to manage Knowledge Better*, Ernst & Young Center for Business Innovation Working Paper (April 1997).
- [16] Selvin, A.M. & Buckingham Shum, S. (2000). Rapid Knowledge Construction and Dissemination: A Case Study in Corporate Contingency Planning Using Collaborative Hypermedia. In Edwards J. & Kidd J (eds). *Proceedings of the Knowledge Management Conference (KMAC 2000)*, 17-18 July, Birmingham.
- [17] Smith, R.G. & Farquhar, A. (2000). The road ahead for knowledge management: an AI perspective. *AI Magazine*, Winter, 17-40.
- [18] Tapscott, D., Ticoll, D. & Lowy, A. (2000). *Digital capital: harnessing the power of business webs*. Boston, MA: Harvard Business School Press.
- [19] Trauth, E.M. (1999). Who Owns my Soul? The Paradox of Pursuing Organizational Knowledge in a Work Culture of Individualism. *Proceedings of the 1999 ACM SIGCPR Conference on Computer Personnel Research*, pp. 159-163.