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PROCEEDINGS
Volume II

Edited by:
Pedro Isaías
Miguel Baptista Nunes
Inmaculada J. Martínez

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IADIS INTERNATIONAL CONFERENCE
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These proceedings contain the papers and posters of the IADIS International Conference WWW/Internet 2006, which was organised by the International Association for Development of the Information Society and co-organised by Universidad de Múrcia – Facultad de Comunicación y Documentación in Murcia, Spain, October 5 – 8, 2006.

The purpose of this conference is to serve as a forum to gather researchers, practitioners, students and anyone who works or studies the field of WWW/Internet. The following fifty-seven areas have been object of paper and poster submissions:

Accessibility; Adaptive Web Systems; Collaboration; Computer-Mediated Communication; Data Mining; Database Planning and Development; Digital Economy; Digital Libraries and E-Publishing; Distributed and Parallel Applications; E-Business and E-Commerce; E-Government; E-Learning; Electronic Data Interchange; Quality, Evaluation and Assessment; Extensible Languages; Global Tendencies in WWW/Internet; Groupware; Human Computer Interaction; Hypermedia; Information Architectures; Information Visualization; Intelligent Agents; Interfaces; Internet & Customer Relationship Management; Internet Payment Systems; Internet Services; Languages; Metadata; Performance Issues; Personalized Web Sites and Services; Portal strategies; Protocols and Standards; Searching and Browsing; Security Issues; Semantic Web; Social & Legal Issues; Storage Issues; System Integration; Teaching and Learning Strategies; Technology Innovation and Competitiveness; Technology Management; Technology Strategies; Tele-Work; WWW/Internet Applications; WWW/Internet Case studies; WWW/Internet Impacts; Web Engineering; Web Personalization; Web Software; Wireless Applications; Ubiquitous Computing; Usability; User Modelling; Virtual Communities; Virtual Reality; XML.

The IADIS WWW/Internet 2006 Conference had 286 submissions from more than 29 countries. Each submission has been anonymously reviewed by at least two independent reviewers, to ensure the final high standard of the accepted submissions. The final result was the approval of 71 full papers, which means that the acceptance rate was below 25%. A few more papers have been accepted as short papers and posters. Best papers will be selected for publishing as extended versions in the *IADIS International Journal on WWW/Internet* (IJWI*)*.

The conference, besides the presentation of full papers, short papers, posters, and doctoral consortium presentations also included keynote presentations and a tutorial from internationally distinguished researchers.

As we all know, organising a conference requires the effort of many individuals. We would like to thank all members of the Program Committee for their hard work in reviewing and selecting the papers that appear in the proceedings.

These volumes have taken shape as a result of the contributions from a number of individuals. We are grateful to all authors who have submitted their papers to enrich the conference proceedings. We would like also to express our gratitude to Professor Katia Sycara, Director of the Intelligent Software Agents Lab, Carnegie Mellon University, USA, and to Professor Fausto Giunchiglia, Head of the Department of Information and

Communication Technology, University of Trento, Italy, for accepting our invitation as keynote speakers. We wish to thank all members of the local organizing committee in Murcia, sponsors, delegates, invitees and guests whose contribution and involvement are crucial for the success of the conference.

Each of the Proceedings contains a rich experience of the academic & research institutions and the industry on diverse themes related to the Internet and Web. We do hope that researchers, knowledge workers and innovators both in academia and the industry will find it a valuable reference material.

Last but not the least, we hope that everybody will have a good time in Murcia, and we invite all participants for the next year edition of the *IADIS International Conference WWW/Internet 2007*.

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TOWARDS A MULTIAGENT ARCHITECTURE TO PROCESS KNOWLEDGE

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ABSTRACT

Currently, Knowledge Management (KM) is a key factor in the competitive advantage of organisations. Because of this different technology has been developed to support KM strategies. However, KM systems are often unsuccessful because they were designed from a technological point of view which did not take into account the knowledge tasks that they should support. In this paper we describe a multi-agent architecture to assist in the implementation of KM systems. This architecture was developed by taking into account the main knowledge process models and life cycles that literature proposes.

KEYWORDS

Knowledge Management, Software Agents.

1. INTRODUCTION

Nowadays, knowledge management (KM) is an important topic for companies worried about employees' learning and about their competitiveness. In the last decades, KM has captured enterprises' attention as one of the most promising ways to attain success in this era of information (Malone, 2002). KM can be defined as a discipline that enables an organization to take advantage of its intellectual capital in order to reuse it and learn from previous experience (Rus and Lindvall, 2002).

On the other hand, Knowledge Management Systems (KMS) are tools whose main goal is to support knowledge creation (Jennex, 2005). Developing KMS is a difficult task since it is often necessary to know a priori what information will be requested, who will demand the information, who will supply the information, and when and how it will be used. Moreover, before developing this kind of systems it is advisable to study and understand how the transfer of knowledge is carried out among people in real life and then to provide tools that foster that interchange of information. This is a lack of many traditional KMS, which as is indicated in (Hahn, 2000), mainly focus on the technology without taking into account the fundamental knowledge problems that KMS are likely to support.

In order to avoid the previous problem, before designing our architecture we designed a KM life cycle which is the base of the architecture as will be explained in the remainder of this paper. Therefore, in section 2 we sumarize different knowledge models proposed in literature and we present our knowledge model. In section 3 our architecture is described by explaining how each agent supports the stages of the KM cycle. Finally, conclusions are presented in section 4.

2. KNOWLEDGE PROCESSES

There are different proposals concerning the knowledge life cycle, Nonaka and Takeuchi (1995) propose one of the most widely discussed approaches, namely the SECI process where the interaction between tacit and explicit knowledge emerges as a spiral (knowledge spiral) that includes four layers of knowledge conversion: s*ocialization* involves the sharing and exchanging of tacit knowledge between individuals to create common mental models and abilities, most frequently through the medium of shared experience; *externalization* is the process of articulating tacit knowledge into comprehensive forms that can be understood by others; c*ombination* involves the conversion of explicit knowledge into a more complex set of explicit knowledge, and i*nternalization* is the process of adding explicit knowledge to tacit new knowledge through experimenting in various ways, through real life experience or simulations (Nonaka and Takeuchi, 1995).

There is no consensus to define the stages that form a KM life cycle. In addition to SECI, Davenport and Prusak identify three tasks of knowledge management: (generation, codification/coordination and transfer) (Davenport, 1997). Wiig (1997) distinguishes five KM processes: (knowledge creation, knowledge storing, knowledge use, knowledge leverage, knowledge sharing). The similarities found in the stages of the models described in literature helped us to define a process that integrates the different proposals (see Figure 1). Most proposals consider stages to acquire, use, transfer and disseminate knowledge. However, an important feature for us is to formalize and store the information in order to reuse it. Because of this a stage in charge of this issue was added to the model. On the other hand, knowledge is useful when it is updated. Therefore, it is necessary to control how the information and knowledge evolve in order to eliminate obsolete information. This is the goal of the last stage.

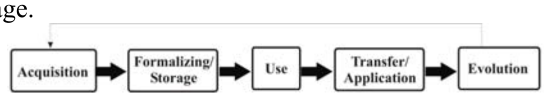

Figure 1. Proposed Knowledge Management Life Cycle Model

3. SUPPORTING THE KNOWLEDGE MODEL WITH AGENTS

Different techniques are used to implement KMS. One of them, which is proving to be quite useful, is that of intelligent agents (van-Elst, 2003). Software agent technology can monitor and coordinate events, meetings and disseminate information (Balasubramanian, 2001). Furthermore, agents are proactive; this means they act automatically when it is necessary without human help. Because of this, agents can automatically explore information avoiding overloading employees with extra work (users of KMS often complain about the overload of work imposed upon them by searching for or introducing information).

All these features led us to use intelligent agents how technology to support the implementation of a KMS that takes the previous model into account. In this section we will present how the different agents act in order to support the knowledge life cycle explained above.

Knowledge acquisition is the stage responsible for making the organization knowledge visible. This stage considers the activities necessary to create organizational knowledge. Furthermore, the acquisition stage determines the organization skills necessary to import knowledge from external sources. The definition of the knowledge to be acquired can be assisted by classifying types of knowledge and knowledge sources (Dickinson, 2002). To support this stage we propose including in our architecture an agent called the *Captor agent*. This agent is responsible for collecting the information (data, models, experience, etc) from the different knowledge sources. It executes a proactive monitoring process to identify the information and experiences generated during the interaction between the user and groupware tools (email, consulted web pages, chats, etc.). In order to accomplish this, the Captor agent uses a knowledge ontology which defines the knowledge to be taken into account in a domain. Another useful ontology is the source ontology which defines where each type of knowledge might be found. These ontologies have not been explained here due to space limitations. The Captor agent communicates with another agent (the *Constructor agent*) which is in charge of creating knowledge. For example, when the Captor agent acquires information this can be converted into knowledge and the Captor agent sends this information to the Constructor agent.

Knowledge formalizing/storing is the stage that groups all activities focused on organizing, structuring, representing and codifying the knowledge with the purpose of facilitating its use (Davenport, 1997). To help carry out these tasks we propose a *Constructor agent*. This agent is in charge of giving an appropriate electronic format to the experiences obtained so that they can be stored in a knowledge base to aid retrieval. Storing knowledge helps to reduce dependency on key employees because at least some of their expert knowledge has been retained or made explicit. In addition, when knowledge is stored, it is made available to all employees, providing them with a reference to how processes must be performed, and how they have been performed in the past. Moreover, the Constructor agent compares the new information with old knowledge previously stored and decides whether to delete it and add new knowledge or to combine both of them. In this way, the combination process of the SECI model is carried out, producing new knowledge resultating in the merging of explicit knowledge plus previous explicit knowledge.

Knowledge use is one of the main stages, since knowledge is useful when it is used and/or reused. KMS should offer the possibility of searching for information; they can even give recommendations or suggestions with the goal of helping users to perform their tasks by reusing lessons learned and previous experiences. In our architecture the agent in charge of this activity is the *Searcher agent*, which searches in the knowledge base for information that is needed. The result of the search will be sent to the *Interface agent.* This will be explained in the next section. This agent could be implemented with different retrieval techniques. However, since this architecture is proposed at a high level these aspects will not be dealt with in this paper. Nevertheless, we would like to emphasize that the *Searcher agent* fosters the internalization process of the SECI model, since the employees have the opportunity of acquiring new knowledge by using the information that this agent suggests.

Knowledge transfer/application is the stage in charge of transfering tacit and explicit knowledge. Tacit knowledge can be transfered if it has been previously stored in shared means, for example: repositories, organizational memories, databases, etc. In addition, the transfer stage can be used with mechanisms to inform people about the new knowledge that has been added. For this stage we propose a *Disseminator agent*, which must detect the group of people, or communities who generate and use similar information: for example, in the software domain, the people who maintain the same product or those who use the same programming language. Therefore, this agent fosters the idea of a community of practice in which each person shares knowledge and learns thanks to the knowledge of the other community members (Wenger, 1998). Finally, the disseminator agent needs to know exactly what kind of work each member of the organization is in charge of and the knowledge flows associated with their job. In order to accomplish this, the disseminator agent contacts to a type of agent called the *Personal agent* which gives him information about the profiles of the user. Comparing this stage with the SECI model we can say that the *Disseminator agent* fosters the socialization process since it puts people who demand similar knowledge in touch and once in contact they can share their experience, thus increasing their tacit knowledge.

Knowledge Evolution. This stage is responsible for monitoring the knowledge that evolves daily. This process constantly reviews the changes that occur in the organization process and activities that have associated knowledge in the form of knowledge packages. To carry out this activity we propose a *Maintenance agent*. The main goal of this agent is to keep the knowledge stored in the knowledge base updated. Therefore, information which is not often used is considered by the maintenance agent as information to be possibly eliminated.

3.1 Architecture of the system

Once the knowledge model which the architecture is based on and the agents which support the different stages are defined we can then define how the agents are organized into different agencies. Figure 2 shows that the architecture is formed of two agencies made up of several agents.

The **Knowledge Agency** consists of the Constructor agent, the Captor agent, the Searcher agent, the Disseminator agent and the Maintenance agent previously described. Therefore, the agency is in charge of giving support to the KM process.

The **User Agency** consists of the *Interface agent* and the *Personal agent*. The *Interface Agent* acts as an effective bridge between the user and the rest of the agents. Such agents actively assist a user in operating an

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interactive interface. In our knowledge management system, the interface agent is proposed to help users to search for useful information related to their activities and give recommendations about employees' expertise or knowledge sources that can be consulted. Furthermore, it interacts with the user receiving user specifications and delivering results. The interface agent communicates with the *Personal agent* which obtains user profiles and information relevant to users' knowledge that helps to determine the expertise level and knowledge that each person has or that a person may need.
Two further components used in this architecture are:

The **Shared Ontology**, this ontology is shared by all team members and provides a conceptualization of the knowledge domain. The Shared Ontology is used for the consistent communication of the agencies. Finally, the **Groupware Tools**. This architecture can be connected to groupware tools that might be used as a means of obtaining, communicating and interchanging information.

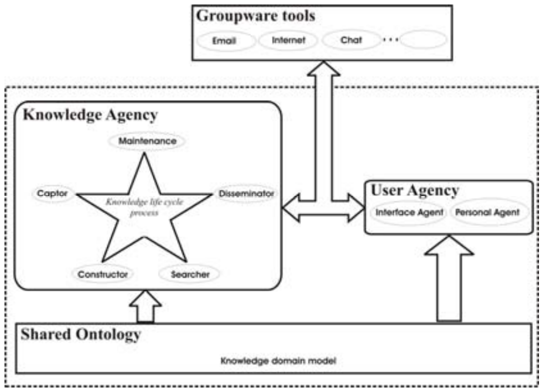

Figure 2. Multi-Agent Architecture for Knowledge Management

This architecture has being designed by using INGENIAS (Pavón and Gómez-Sanz, 2003) methodology due to it being based on the definition of a set of meta-models that describe the elements that form a MAS from several viewpoints. In addition, INGENIAS provides a set of tools that supports analysis, design and code generation activities. The platform that we are using to develop the architecture is JADE since it is FIPA compliant and is currently one of the most used. We are also studying JADEx in order to see how easy it would be to migrate to this new platform.

3.2 Collaboration between Agents

In order to exemplify how the architecture works we are going to describe a possible scenario that can take place in an organization.

Let us imagine that a person is writing a email and the agents start to work in order to check whether the mail contains information that should be stored in the data base (we suppose that the employees know that the mail are reviewed and they agree with this).

As Figure 3 shows, the Interface Agent captures each event that is trigged by the Employee. In this case the employee sends an email. Then, the Interface Agent advices the Captor Agent that an even has been triggered. Afterwards, the Captor Agent determines the type of groupware tool used (email) to identify and obtain information topics about related task. In order to obtaining information from the mail, a new agent can be added to the system (it would not form part of our architecture) but would be an agent that has been already developed to assist in this task. There exist several agents implemented to deal with email (Maes, 1994). Most of the current implementations are text classifiers or keyword extractors. The Captor Agent would study whether the information sent by the "email agent" should be transformed into knowledge. Finally, the Constructor Agent receives the information which is structured in form of, for instance, cases for its later storage.

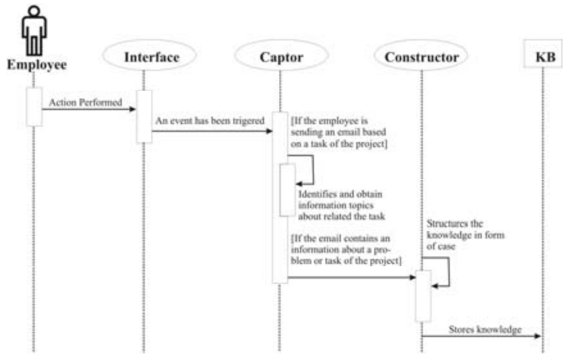

Figure 3. Scenario of Agent Collaboration

4. CONCLUSION

This paper describes a multi-agent architecture to develop KM systems. The architecture has been described at a high level of abstraction and because of this we have indicated the tasks that each agent should carry out but without explaining how these will be performed. The main feature of this architecture is that it is based on a KM model to ensure that the architecture supports the main processes that should be promoted by a KM system. Moreover, the multi-agent architecture follows a knowledge management approach, providing agents that foster the process of the SECI model with the goal of guaranteeing a continuous flow of knowledge.

ACKNOWLEDGEMENT

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