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Jörg M. Haake
Sergio F. Ochoa
Alejandra Cechich (Eds.)

Groupware: Design, Implementation, and Use

13th International Workshop, CRIWG 2007
Bariloche, Argentina, September 2007
Proceedings

Springer

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Preface

This volume constitutes the proceedings of the 13th International Workshop on Groupware (CRIWG 2007). The conference was held in Spain (Medina del Campo) in 2006, Brazil (Porto de Galinhas) in 2005, Costa Rica (San Carlos) in 2004, France (Autrans) in 2003, Chile (La Serena) in 2002, Germany (Darmstadt) in 2001, Portugal (Madeira Island) in 2000, Mexico (Cancun) in 1999, Brazil (Buzios) in 1998, Spain (El Escorial) in 1997, Chile (Puerto Varas) in 1996, and Portugal (Lisbon) in 1995.

The CRIWG workshops have been motivated by advances in computer-supported cooperative work (CSCW), and by the need for CSCW to meet the challenges of new application areas. This workshop aims at providing a forum for academic researchers and professionals to exchange their experiences and their ideas about problems and solutions related to the design, development and use of groupware applications. Researchers report their ideas, models, designs and experiences to CRIWG submitting full-paper contributions to present achieved or mature works, and shorter papers to report work in progress.

CRIWG 2007 received 65 submissions from 15 different countries, 49 full papers and 16 work-in-progress papers. Each article was reviewed by at least three members of the Program Committee, using a double-blind reviewing process. Based on the reviewers' recommendations 27 papers were finally accepted: 17 full papers and 10 work-in-progress papers. These papers were grouped into six tracks: group awareness and social aspects, groupware design and development, computer-supported collaborative learning, groupware applications and studies, group negotiation and knowledge management, and groupware activities and evaluation. In addition, we are pleasured to have had Jonathan Grudin from Microsoft Research, USA, as keynote speaker.

CRIWG 2007 would not have been possible without the work and support of a great number of people. First of all we want to thank the members of the Program Committee for their valuable reviews of the papers. We are grateful for the advice and support provided by the CRIWG Steering Committee. We extend a special acknowledgement to our sponsor organizations: Universidad Nacional del Comahue (Argentina), Universidad de Chile (Chile), FernUniversität in Hagen (Germany), Microsoft Research (USA) and Microsoft Chile (Chile), SADIO (Argentina).

Last, but certainly not least, we thank the attendees for their interest in CRIWG 2007. We hope they had an enriching experience at the conference.

Please get involved!

September 2007

Joerg M. Haake
Sergio F. Ochoa
Alejandra Cechich

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Fostering Knowledge Exchange in Virtual Communities by Using Agents

Javier Portillo-Rodríguez, Aurora Vizcaíno, Juan Pablo Soto, Mario Piattini, and Gabriela N. Aranda

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Abstract. Nowadays, the increase in information and in sources from which to obtain knowledge have generated a large-scale development of knowledge sharing systems. However, these systems do not always live up to the expectations of the organisations that use them, as they do not take the fundamental social aspects necessary for the flow and sharing of knowledge between the members of a community into consideration. The objective of our work is' to emulate the behaviour of communities of practice, where the confidence that exists between the members of these communities leads to an exchange of knowledge. We have, therefore, designed a three-level multi-agent architecture which takes into account both the way in which a community member behaves and the community to which that member belongs.

Keywords: Knowledge Management, Multi-agent Systems, Reputation, Trust.

1 Introduction: From Communities to Communities of Practice

Intellectual capital and knowledge management are currently growing since knowledge is a critical factor for an organization's competitive advantage [1]. This growth determines organizations' performance by studying how well they manage their most critical knowledge. One important instrument in knowledge management is communities [2], [3]. Although there is no generally accepted definition, a community can be defined as a group of socially interacting people who are mutually tied to one another and regularly meet at a common place [4]. The development of Internet and groupware technologies has led to a new kind of community - "virtual communities", where members may or may not meet one another face to face and may exchange words and ideas through the use of computers networks [5].

Our research is focused upon professionally-oriented comunities, which consists of company employees who communicate and share information in order to support their professional tasks. A special case of professionally-oriented communities are the

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"Communities of Practice" (CoPs), defined by Wenger et al. [6] as groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis.

The following section shows our proposal to support CoPs concepts by defining a Multi-Agent Architecture. In Section 3 we describe both a prototype with which to rate the architecture, and the manner in which the formulas to calculate reputation in virtual communities are defined. Finally, in Section 4 we compare our proposal with other related works.

2 Our Proposal: A Multi-agent Architecture to Support CoPs

In order to support concepts related to CoPs and Knowledge Management, we have designed a three level multi-agent architecture.

We have chosen the agent paradigm because it constitutes a natural metaphor for systems with purposeful interacting agents, and this abstraction is close to the human way of thinking about their own activities [7]. This foundation has led to an increasing interest in social aspects such as motivation, leadership, culture or trust [8]. Our research is related to the latter concept of "trust" since artificial agents can be made more robust, resilient and effective by providing them with trust reasoning capabilities.

The architecture is composed of Reactive, Deliberative and Social Levels and is mainly based on the concepts of trust and reputation. Trust can be defined as confidence in the ability and intention of a source of information to deliver correct information [9] and reputation as the amount of trust an agent has in a source of information, which is created through interactions with those information sources. It is important to take these concepts into account because if we wish to foster knowledge exchange in communities of practice we have to know that people in real life in general and in companies in particular, prefer to exchange knowledge with "trustworthy people" by which we mean people they trust. People with a consistently low reputation will eventually be isolated from the community since others will rarely accept their justifications or arguments and will limit their interactions with them. It is for this reason that we considered the Social Level to be an important contribution to the multi-agent architecture that we propose. The reactive and deliberative levels are considered by other authors as typical levels that a multi-agent system must have [10]. In the following paragraphs we shall describe each level of architecture in detail.

2.1 Reactive Architecture

This architecture was designed to the reactive level of the agent. The architecture must respond at the precise moment at which an event has been perceived. This architecture is formed of the following modules:

Agent's internal model: Because an agent represents a person in a community this model stores the user's features. Therefore, this module stores the following parts:

- The *interests*. This part is included in the internal model in order to make the process of distributing knowledge as fast as possible. That is, the agents are able to search for knowledge automatically, checking whether there is stored knowledge which matches its own interests. This behaviour fosters knowledge sharing and reduces the amount of work that employees have to do because they receive knowledge without having to make searches.
- The *user's profile*. This part describes the profile of the person on whose behalf the agent is acting. This module is composed of the users' preferences, expertise and position. The *Preferences* can be used to discover how the user prefers the agent to present the information to him/her. *Expertise* is the skill or knowledge of a person who knows a great deal about a specific thing. Since we are emulating virtual communities it is important to know the degree of expertise that each member of the community has in order to decide how trustworthy a piece of knowledge is, as people often trust in experts more than in novice employees. Another important piece of information considered in the user's profiles is that of *Position,* since employees often consider information that comes from a boss as being more reliable than that which comes from another employee in the same (or a lower) position as him/her [11]. Such different positions inevitably influence the way in which knowledge is acquired, diffused and eventually transformed within the local area. Because of this, in our research these factors will be calculated by taking into account a weight that can strengthen this factor to a greater or to a lesser degree.

Behaviour generator: This component is necessary for the development of this architecture since it has to select the agent's behaviour. This behaviour is defined on the basis of the agent's beliefs. Moreover, this component responds immediately to the perceptions received of the environment.

History: This component stores the agents' interactions with the environment.

Belief generation: This component is one of the most important in the cognitive model because it is in charge of creating and storing the agent's knowledge. Moreover, it defines the agent's beliefs.

Beliefs: The beliefs module is composed of three kinds of beliefs: inherited beliefs, lessons learned and interactions. Inherited beliefs are the organization's beliefs that the agent receives. For instance: an organizational diagram of the enterprise or the philosophy of the company or community. Lessons learned are the lessons that the agent obtains while it interacts with the environment. The information about interactions can be used to establish parameters in order to know what the agent can trust (agents or knowledge sources). This module is based on the agent's interests and goals, because each time a goal is realized, the lessons and experiences generated to attain that goal are introduced into the agent's beliefs as lessons learned.

2.2 Deliberative Architecture

This architecture was designed to the deliberative level of the agent (see Figure 1).

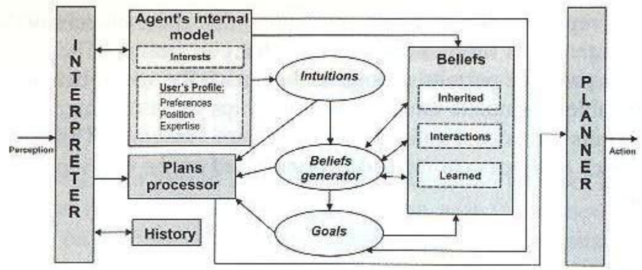

Fig. 1. Deliberative architecture

Its components are:

Agent's internal model: this module is the same as that which is described in the reactive architecture. It is composed of interests and of the user's profile.

Plans processor: This module is the most important in this architecture as it is in charge of evaluating beliefs and goals in order to determine which plans have to be included in the Planner to be executed.

Belief generator: As in the previous architecture, this component is in charge of creating, storing and retaining the agent's knowledge. In addition, it is also in charge of establishing the agent's beliefs. The belief creation process is a continuous process that is initiated at the moment at which the agent is created and which continues during its entire effective life.

Intuitions: Intuitions are hypothesis that have not been verified but which the agent believes to be true. According to [12] intuition has not yet been modeled by agent systems. In this work we have attempted to adapt this concept as we consider that people in real communities are influenced by their intuitions when they have to make a decision or believe in something. This concept is emulated by comparing the agents' profiles in order to obtain an initial value of intuition that can be used to form a belief about an agent.

History: This component stores the agents' interactions with the environment.

Goals: The goals are formed by using the agent's objectives. For instance, one of the goals of each member of a community of practice is knowledge exchange. The goals are defined in accordance with the community or group in which the agent interacts.

2.3 Social Architecture

This architecture is quite similar to the deliberative architecture.

The main differences are the ***Social Model*** and ***Social Behaviour Processor***. The first one represents the actual state of the community, the community's interests, the members' identifiers and the goals that will be proposed by the agents in order to satisfy needs or interests related to its interactions with other agents. These goals should be coherent both with the agent's beliefs and with other agents' beliefs.

The ***Social Behaviour Processor*** processes the opinions and beliefs of the community's members. To do this, this module needs to manage the goals, intuitions and beliefs of the community in order to make a decision.

Both models represent the opinions and beliefs that the members of a community have about an agent, and their interaction with the community. The social focus that this architecture provides permits us to give the agents the social behaviour necessary for them to be able to emulate the work relationships in an organization. In addition, this layer permits the decentralization of decision making. That is, it provides methods by which to process or make decisions based on the opinions of the members of a community.

3 Prototype

In order to test our architecture we have developed a prototype system in which a community shares knowledge. The goal of this prototype is to allow software agents to help employees to discover the information that may be useful to them, thus decreasing the overload of information that employees often have and strengthening the use of knowledge bases in enterprises. In addition, we attempt to detect and thus avoid the situation of employees storing valueless information in the knowledge base.

To design this prototype we have designed a *User Agent* and a *Manager Agent*. The former is used to represent each person that may consult or introduce knowledge in a knowledge base or in a knowledge management system. Therefore, the *User Agent* can assume three types of behavior or roles similar to the tasks that a person may carry out in a knowledge base. The User Agent plays one role or another depending upon whether the person that it represents carries out one of the following actions:

- The person contributes new knowledge to the communities in which s/he is registered. In this case the User Agent plays the role of **Provider**.
- The person uses knowledge previously stored in the community. Then, the User Agent will be considered as a **Customer**.
- The person helps other users to achieve their goals, for instance by giving an evaluation of certain knowledge. In this case the role is that of a **Partner**. So, Figure 2 shows that in community 1 there are two User Agents playing the role of Partner, one User Agent playing the role of Consumer and another being a Provider.

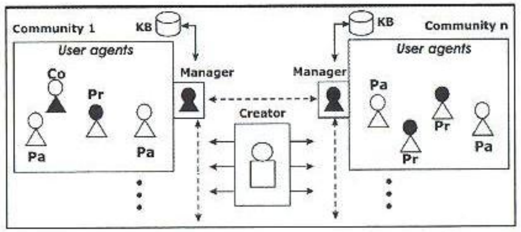

Fig. 2. Communities of agents

The second type of agent within a community is called the *Manager Agent* (represented in black in Figure 2) which must manage and control its community. In order to approach this, the agent carries out the following tasks:

- Registering an agent in its community.
- Registering the frequency of contribution of each agent.
- Registering the number of times that an agent gives feedback about other agents' knowledge.
- Registering the interactions between agents.

When a user wishes to join to a community in which no member knows anything about him/her, the reputation value assigned to the user in the new community is calculated on the basis of the reputation assigned from other communities where the user is or was a member. For instance, a User Agent called j, will ask each community manager where he/she was previously a member to consult each agent which knows him/her with the goal of calculating the average value of his/her reputation (R_j). This is calculated as:

$$R_j = \left(\sum_{i=1}^{n} R_{ij}\right)/n \qquad (1)$$

where n is the number agents who know j and R_{ij} is the value of j's reputation in the eyes of i. In the case of being known in several communities, the average of the values R_j will be calculated. Then, the User Agent j presents this reputation value (in a way similar to that in which a person presents his/her curriculum vitae when s/he wishes to join a company) to the Manager Agent of the community to which it is "applying". This mechanism is similar to the "word-of-mouth" propagation of information for a human [13]. We do realize that reputation is clearly a context-dependent quantity. For instance, one's reputation as a computer scientist should have no influence upon one's reputation as cook [14]. However, if we are trying to emulate the behavior of people working in communities of practice then we should emulate how some people's opinions influence others.

If any of the User Agents in the new community knows the person who wishes to join the community then his/her initial reputation value will be the average of the R_{ij} of agents who knows him/her.

R_{ij} is the value of reputation of j in the eyes of i. This value is computed as follows:

$$R_{ij} = w_e{*}E_j + w_p{*}P_j + w_i{*}I_j + \left(\sum_{i=1}^{n} QC_{ij}\right)/n \qquad (2)$$

where E_j is the value of expertise which is calculated according to the degree of experience that the person upon whose behalf the agent acts has in a domain.

P_j is the value assigned to a person's position. This position is defined in the agent's internal model of the reactive architecture described in Section 2.1.

I_j is the value assigned to intuition which is calculated by comparing each user's profile. For instance, users with similar profiles (preferences) could interact more times. Intuition is an important component both in the deliberative and in the social architecture because it helps agents to create their beliefs and behavior according to their own features.

In addition, previous experience should also be calculated. We suppose that when an agent A consults information from another agent B, the agent A should evaluate how useful this information was. This value is called QC_{ij} (Quality of *j*'s Contribution according to the Agent i). To attain the average value of an agent's contribution, we calculate the sum of all the values assigned to these contributions by the Agent i, for instance n and we divide it by the number of evaluations (n).

Finally, w_e, w_p and w_i are weights with which the Reputation value can be adjusted to the needs of the organizations or communities. These weights represent different values depending on the category of each employee. For instance, if an enterprise considers that all its employees have the same category, then $w_p=0$. The same could occur when the organization does not take its employee's intuitions or expertise into account.

In this way, an agent can obtain a value related to the reputation of another agent and decide to what degree it is going to consider the importance of the information obtained from this agent. Formulas (1) and (2) are processed in the social and deliberative architecture respectively.

4 Related Work

This research can be compared with other proposals that use agents and trust in knowledge exchange. For instance, in [13], the authors propose a model that allows agents to decide which agents' opinions they trust more and propose a protocol based on recommendations. This model is based on a reputation or word-of-mouth mechanism. The main problem with this approach is that every agent must keep rather complex data structures which represent a kind of global knowledge about the whole network. In [15], the authors propose a framework for exchanging knowledge in a mobile environment. They use delegate agents to be spread out into the network of a mobile community and use trust information to serve as the virtual presence of a mobile user. Another interesting work is [14] where the authors describe a trust and reputation mechanism which allows peers to discover partners who meet their individual requirements through individual experience and by sharing experiences with other peers with similar preferences. This work is focused on peer-to-peer environments.

Barber and Kim present a multi-agent belief revision algorithm based on belief networks [9]. In their model the agent is able to evaluate incoming information, to generate a consistent knowledge base, and to avoid fraudulent information from unreliable or deceptive information sources or agents. In our case, the focus is very different since it is the receiver who evaluates the relevance of a piece of knowledge rather than the provider as in Barber and Kim's proposal.

Therefore, the main difference between our work and previous works is that we take into account factors that might influence the level of trust that a person has in a piece of knowledge and in a knowledge source. Moreover, we present a general and fairly simple formula to define the reputation concept. This formula can be adapted to different settings by modifying the value of the weights. This is an important difference from other works which are focused on particular domains.

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