IMITATING THE KNOWLEDGE MANAGEMENT OF COMMUNITIES OF PRACTICE

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Abstract: Advances in technology have led to the development of knowledge management systems with the intention of improving organizational performance. Nevertheless, implementation of this kind of mechanisms is not an easy task due to the necessity of taking into account social aspects (such as reputation) that improve the exchange of information between groups of people. Considering, the advantages of working with groups with similar interests we have modelled communities of agents which represent communities of people interested in similar topics. In order to implement this model we propose a multi-agent architecture in charge of evaluating the relevance of the knowledge in a knowledge base and the degree of reputation that a person has as the contributor of information. We pay particular attention to showing how the use of the agents works by using a prototype system to search for knowledge related to a particular domain of a community of practice. Several communities of agents integrated into an organization have the capacity to follow the interaction process of employees when carrying out their daily activities.

1 INTRODUCTION

For several decades human behaviour has been studied with the objective of imitating certain aspects of it in computational systems (Schaeffer et al, 1996). Based on this idea we have studied how the people obtain and increase their knowledge in their daily work. From this study we realise that frequently, employees exchange knowledge with people who work on similar topics as them and consequently, either formally or informally, communities are created which can be called "communities of practice", by which we mean groups of people with a common interest where each member contributes knowledge about a common domain (Wenger, 1998).

Communities of practice enable their members to benefit from each other's knowledge. This knowledge resides not only in people's minds but also in the interaction between people and documents. An interesting fact is that individuals are frequently more likely to use knowledge built by their community team members than those created by members outside their group (Desouza et al, 2006). This factor occurs because people trust more in the information offered by a member of their community than in that supplied by a person who does not belongs to that community. Thus, a new concept takes place in the process of obtaining information. This concept is "trust" and can be defined as "confidence in the ability and intention of an information source to deliver correct information" (Barber & Kim, 2004). Therefore, 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. Of course, the fact of belonging to the same community of practice already implies that they have similar interests and perhaps the same level of knowledge about a topic. Consequently, the level of trust within a community is often higher that which exists out of the community. Because of this, as is claimed in (Desouza et al, 2006), knowledge reuse tends to be restricted within groups.

Bearing in mind that people exchange information with "trustworthy knowledge sources" we have designed a multi-agent architecture in which agents try to emulate humans evaluating

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knowledge sources with the goal of fostering the use of knowledge bases in companies where agents provide "trustworthy knowledge" to the employees. Thus, in section 2 the multi-agent architecture is described. Then, in section 3 we illustrate how the architecture has been used to implement a prototype which detects and suggests trustworthy documents for members in a community of practice. In section 4 related works are outlined. Finally in section 5 conclusions are described.

2 A MULTI-AGENT ARCHITECTURE TO DEVELOP TRUSTWORTHY KNOWLEDGE BASES

Many organizations worried about their competitive advantage use knowledge bases to store their knowledge. However, sometimes the knowledge which is put into a system is not very valuable. This decreases the trust that employees have in their organizational knowledge and reduces the probability that people will use it. In order to avoid this situation we have developed a multi-agent architecture in charge of monitoring and evaluating the knowledge that is stored in a knowledge base.

To design this architecture we have taken into account how people obtain information in their daily lives. Bearing in mind the advantages of working with groups of similar interests we have organized the agents into communities of people who are interested in similar topics. Thus, Figure 1 shows different communities where there are two types of agents: the *User Agent* and the *Manager Agent*. The former is used to represent each person that may consult or introduce knowledge in a knowledge base. The *User Agent* can assume three types of behaviour or roles similar to the tasks that a person can carry out in a knowledge base. Therefore, 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 (Pr)**.
- The person uses knowledge previously stored in the community. Then, the User Agent will be considered as a **Consumer (Co)**.
- The person helps other users to achieve their goals, for instance by giving an evaluation of certain knowledge. In this case the role is of a **Partner (Pa)**. So, Figure 1 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.

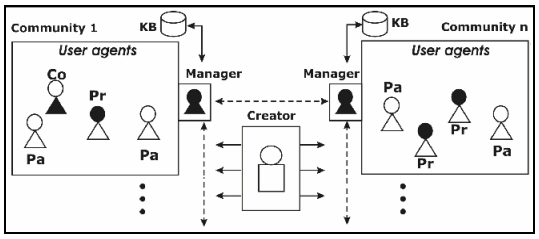

Figure 1: Multi-agent architecture.

The fact that this agent can act both as consumers and also as providers of knowledge may lead to better results because they aim to motivate the active participation of the individual in the learning process, which often results in the development of creativity and critical thinking (Kan, 1999).

The conceptual model of this agent, whose goals are to detect trustworthy agents and sources, is based on two closely related concepts: trust and reputation. The former can be defined as confidence in the ability and intention of an information source to deliver correct information (Barber & Kim, 2004) and the latter as the amount of trust an agent has in an information source, created through interactions with information sources. This definition is the most appropriate for our research since the level of confidence in a source is based on previous experience of this. It is for this reason that the remainder of the paper deals solely with reputation. However, if we attempt to imitate the behaviour of the employees in a company when they are exchanging and obtaining information we observe that apart from the concept of reputation other factors also influence. These are:

- Position: 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 (Wasserman & Glaskiewics, 1994). However, this is not a universal truth and depends on the situation. For instance in a collaborative learning setting collaboration is more likely to occur between people of a similar status than between a boss and his/her employee or between a teacher and pupils (Dillenbourg, 1999). Because of this, as will be explained

later, in our research this factor will be calculated by taking into account a weight that can strengthen this factor to a greater or to a lesser degree.

- Expertise: this term can be briefly defined as the skill or knowledge of a person who knows a great deal about a specific thing. This is an important factor since people often trust in experts more than in novice employees. Moreover, tools such as expertise location (Crowder et al, 2002) are being developed with the goal of promoting the sharing of expertise knowledge (Rodríguez-Elias et al, 2004).
- Previous experience: People have greater trust in those sources from which they have previously obtained more "valuable information". Therefore, a factor that influences the increasing or decreasing reputation of a source is "previous experience" and this factor can help us to detect invaluable sources or knowledge. One problem occurring in organizations is that some employees introduce information which is not particularly useful in a knowledge base with the only objective of trying to simulate that they are contributing information in order to generate points or benefits such as incentives or rewards (Huysman & Wit, 2000). When this happens, the information stored is generally not very valuable and it will probably never be used.

Taking all these factors into account we have defined an own "concept of reputation" (see Figure 2).

Figure 2: Reputation module.

That is, the reputation of $agent_s$ about $agent_i$ is a collective measure defined by the previously describe factors and computed as follows:

$$R_{si} = w_e * E_i + w_p * P_i + \left(\sum_{i=1}^{n} QC_i\right)/n$$

where R_{si} denotes the reputation value that $agent_s$ has in $agent_i$ (each agent in the community has an opinion about each one of the agent members of the community) .

w_e and w_p are weights with which the Reputation value can be adjusted to the needs of the organizations.

E_i is the value of expertise which is calculated according to the degree of experience that a person has in a domain.

P_i is the value assigned to the position of a person. This position is defined by the organizational diagram of the enterprise. Therefore, a value that determines the hierarchic level within the organization can be assigned to each level of the diagram.

In addition, previous experience should also be calculated. To accomplish this it is supposed 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_i (Quality of *i*'s Contribution). To attain the average value of an agent's contribution, we calculate the sum of all the values assigned to their contributions and we divide it between their total. In the formula n represents the total number of evaluated contributions.

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 information obtained from this agent.

The second type of agent within a community is called the *Manager Agent* (represented in black in Figure 1) which is in charge of managing and controlling its community. In order to approach this type of agent the following tasks are carried out:

- Registering an agent in its community. It thus controls how many agents there are and how long the stay of each agent in that community is.
- Registering the frequency of contribution of each agent. This value is updated every time an agent makes a contribution to the community.
- Registering the number of times that an agent gives feedback about other agents' knowledge. For instance, when an agent "A" uses information from another agent "B", the agent A should evaluate this information. Monitoring how often an agent gives feedback about other agents' information helps to detect whether agents contribute to the creation of knowledge flows in the community since it is as important that an agent contributes with new information as it is that another agent contributes by evaluating the relevance or importance of this information.
- Registering the interactions between agents. Every time an agent evaluates the contributions of another agent the Manager agent will register this interaction. But this

interaction is only in one direction, which means, if the agent A consults information from agent B and evaluates it, the Manager records that A knows B but that does not means that B knows A because B does not obtain any information about A.

Besides these agents there is another in charge of initiating new agents and creating new communities. This agent has two main roles: the "creator" role is assumed when there is a petition (made by a User Agent) to create a new Community and the "initiator" role is assumed when the system is initially launched. This agent, which is not included in any of the communities, is located in the centre of Figure 1, and is called the *Creator Agent*.

3 USING THE ARCHITECTURE

In order to evaluate the architecture and to gradually improve it we have developed a prototype system into which people can introduce documents and where these documents can also be consulted by other people. The goal of this prototype is that agents software 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 companies. In addition, we try to avoid the situation of employees storing valueless information in the knowledge base.

The main feature of this system is that when a person searches for knowledge in a community, and after having used the knowledge obtained, that person then has to evaluate the knowledge in order to indicate whether:

- The knowledge was useful
- How it was related to the topic of the search (for instance a lot, not too much, not at all).

User Agents will use this information to construct a "trust net". Thus, these agents can know how reliable the contributions of each person are and also what each contribution was. This information is very important to companies since by consulting it, it is possible to know which employees are the best contributors. From this information other information can be obtained. For instance, who should be consulted when there is a problem in a concrete domain, since we agree with (Ackoff, 1989) who claim that knowledge management systems should encourage dialogue between individuals rather than simply directing them to repositories.

In the next sub-sections, we describe different situations or scenarios to show how the agents work in this prototype. These situations will represent some general community rules and will show the main interactions between agents in a community.

3.1 A New User Arrives in a Community

This situation happens when, for instance, a user wants to join to a new community. To do this, the person will choose a community from all the available communities. In this case the Manager Agent will ask whether there is any agent that knows the new user in order to set a trust value on this person (this process is similar to the socialization stage of the SECI model (Nonaka & Takeuchi, 1995), where each one indicates its experience about a topic, in this case about another person).

When a user wants 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 others communities where the user is or was a member. In order to do this, the User Agent called, for instance, 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:

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

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 presents this reputation value (similar to when a person presents his/her curriculum vitae when s/he wishes to join in a company) to the community manager to which it is "applying". In the case of the user being new in the system (s/he has never been in a community) then this user is assigned a "new" label in order for the situation to be identified.

Once the Community Manager has obtained a Reputation value for j it is added to the community member list.

3.2 Using Community Documents and Updating Reputation Values

People can search for documents in every community in which they are registered. When a

person searches for a document relating to a topic his/her User Agent consults the Manager Agent about which documents are related to their search. Then, the Manager agent answers with a list of documents. The User Agent sorts this list according to the reputation value of the authors, which is to say that the contributions with the best reputations for this Agent are listed first. On the other hand, when the user doesn't know the contributor then the User Agent consults the Manager Agent about which members of the community know the contributors. Thus, the User Agent can consult the opinions that other agents have about these contributors, thus taking advantage of other agents' experience. To do this the Manager consults its interaction table and responds with a list of the members who know the User Agent Then, this User Agent contacts each of them. If nobody knows the contributors then the information is listed, taking their expertise and positions into account. In this way the User Agent can detect how worthy a document is, thus saving employees' time, since they do not need to review all documents related to a topic but only those considered most relevant by the members of the community or by the person him/herself according to previous experience with the document or its authors.

Once the person has chosen a document, his/her User Agent adds this document to its own document list (list of consulted documents), and if the author of the document is not known by the person because it is the first time that s/he has worked with him/her, then the Community Manager adds this relation to the interaction table explained in section 2. This step is very important since when the person evaluates the document consulted, his/her User Agent will be able to assign a QC for this document.

4 RELATED WORK

This research can be compared with other proposals that use agents and trust communities in knowledge exchange. In literature we found several trust and reputation mechanisms that have been proposed for large open environments, for instance: e-commerce (Zachaira et al, 1999), peer-to-peer computing (Wang & Vassileva, 2003), etc.

There are others works on trust and reputation (Griffiths, 2005; Yu & Singh, 2000). We shall only mention those works that are most related to our approach.

In (Schulz et al, 2003), 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 a virtual presence of a mobile user. Another interesting work is (Wang & Vassileva, 2003). In this work the authors describe a trust and reputation mechanism that allows peers to discover partners who meet their individual requirements through individual experience and 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 (Barber & Kim, 2004). 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 source or agents. This work has a goal similar to ours. However, the means of attaining it are different. In Barber and Kim's case they define reputation as a probability measure, since the information source is assigned a reputation value of between 0 and 1. Moreover, every time a source sends knowledge the source should indicate the certainty factor that the source has of that knowledge. 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 formula to define the reputation concept. This formula can be adapted, by modifying the value of the weights, to different settings. This is an important difference from other works which are focused on particular domains.

5 CONCLUSIONS

Communities of practice have the potential to improve organizational performance and facilitate community work. Because of this we consider it important to model people's behaviour within communities with the purpose of imitating the exchange of information in companies that are produced in those communities. Therefore, we attempt to encourage the sharing or information in organizations by using knowledge bases. To do this we have designed a multi-agent architecture where the artificial agents use similar parameters to those

of humans in order to evaluate knowledge and knowledge sources. These factors are: Reputation, expertise and of course, previous experience.

This approach implies several advantages for organizations as it permits them to identify the expertise of their employees and to measure the quality of their contributions. Therefore, it is expected that a greater flow of communication will exist between them which will consequently produce an increase in their knowledge.

In addition, this work has illustrated how the architecture can be used to implement a prototype. The main functionalities of the prototype are:

- Controlling whether employees try to introduce valueless knowledge with the goal of obtaining some profit such as points, incentives, rewards,, etc
- Providing the most suitable knowledge for the employee's queries, by using the reputation and relevance values that the agents have obtained from previous experiences.
- Detecting the expertise of the employees within an organization.

All these advantages provide organizations with a better control of their knowledge base which will have more trustworthy knowledge and it is consequently expected that employees will feel more willing to use it.

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