

# KNOWLEDGE MANAGEMENT SYSTEMS WITH REPUTATION AND INTUITION

## *What for?*

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**Abstract:** Nowadays knowledge management is considering to be one of the more important processes by those companies worried about their competitiveness. These companies focus their efforts on developing systems that can be used to capture, store and reuse the knowledge generated by their employees. Nevertheless, all this effort may be in vain if the system is not greatly used by the employees because the knowledge that these systems have is often not valuable or on other occasions the knowledge sources do not provide the necessary confidence to reuse the information. In an attempt to avoid this situation, we propose a multi-agent architecture based on communities of practice and on the reputation concept with the purpose of controlling the utility of information stored in a knowledge base.

## 1 INTRODUCTION

In recent years knowledge management is a topic of special interest to organizations who are worried about their employees' learning and competitiveness since a suitable management of this process can help organizations to increment the collaboration of their members and encourage the sharing of information between them. The exchange of information among employees in an organization represents an important success factor in improving the knowledge flow necessary for a suitable knowledge management. An essential ingredient of knowledge sharing information in organizations is that of "community of practice", by which we mean groups of people with a common interest where each member contributes knowledge about a common domain (Wenger, 1998). This concept has become more and more popular within the field of the knowledge management where it is mainly used as a knowledge management tool to support the externalization of knowledge, both for reuse as well as for purposes of innovation (Huysman & Wit, 2000). The importance of the concept of communities of practice at an organizational level is parallel to the growth in the interest of management

approaches such as organizational learning and knowledge management. Communities of practice enable their members to benefit from each other's knowledge. Most of the learning that takes place in organizations occurs informally in communities of practice (Lesser, 2000). 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, 2006). For these reasons, we consider the modelling of communities of practices into knowledge management systems an adequate method by which to provide these systems with a certain degree of control to measure the confidence and quality of the information provided for each member of the community.

In order to carry this out, we have designed a multi-agent architecture in which agents try to emulate humans' rating knowledge sources with the goal of fostering the use of knowledge bases where intelligent agents provide "trustworthy knowledge" to the employees and foster knowledge flow among them.

The remainder of this work is organized as follows. The next section presents two important concepts that take place in the process of obtaining

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information (trust and reputation). In section three the multi-agent architecture proposed to manage trustworthy knowledge bases is described. In section four the reputation management used in the agents' community is presented. In section five we illustrate how the architecture and reputation management have been used to implement a prototype which detects and suggests trustworthy documents for members in a community of practice. Finally in section six conclusions are presented.

## 2 TRUST AND REPUTATION

The main goal of our work is to rate the credibility of information sources and of knowledge. To do this, we first need to define two important 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. There are other definitions for these concepts (Gambetta, 1988; Marsh, 1994). However, we have presented the most appropriate for our research since the level of confidence in a source is based on previous experience of this.



Figure 1: Reputation factors.

The reputation of an information source not only serves as a means of belief revision in a situation of uncertainty, but also serves as a social law that obliges us to remain trustworthy to other people. 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. 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 interaction with them. It is for this reason that the remainder of this 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. For this reason, in this paper

we argue that reputation is not a single notion but one of multiple parts (see Figure 1). 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-Elías 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 trustworthy sources or knowledge.
- **Intuition:** When people do not have a previous experience they often use their "intuition" to decide whether or not they are going to trust something. Other authors have called this issue "indirect reputation or prior-derived reputation" (Mui et al, 2002). In human societies, each of us probably has different prior beliefs about the trustworthiness of strangers we meet. Sexual or racial discrimination might be a consequence of such prior belief (Mui et al, 2002). We have tried to model intuition according to the similarity between the user profiles, the greater the similarity between one agent and another, the greater the intuition level.

Taking all these factors into account we have defined an own "concept of reputation". In section four we shall describe how we use this definition to rate knowledge and information sources.

### 3 A MULTIAGENT ARCHITECTURE TO DEVELOP TRUSTWORTHY KNOWLEDGE BASES

When implementing a knowledge management system we must consider the importance a knowledge base has within that system. In this work we have focused our attention on the difficulties of controlling the quality of the contributions and the “reputation” of contributors of a knowledge management system. A knowledge management system must store only useful knowledge for employees. However, sometimes the knowledge which is put into a knowledge base is not very valuable. This decreases the trust that employees have in their knowledge bases and reduces the probability of people using 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 and concretely how this exchange of information takes place in communities of practice. 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 2 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 may 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**.
- The person uses knowledge previously stored in the community. Then, the User Agent will be considered as a **Consumer**.
- 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**. 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.

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).

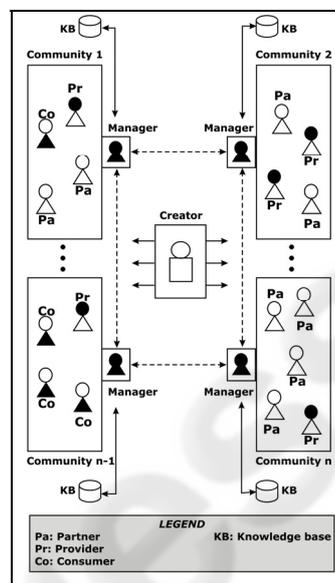


Figure 2: Multi-agent architecture.

The second type of agent within a community is called the *Manager Agent* (represented in black in Figure 2) which is in charge of managing and controlling its community. In order to accomplish this, the Manager Agent can perform the following tasks:

- 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 rate 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 agent A consults information from agent B and evaluates it, the Manager records that A knows B but that does not mean 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 2, and is called the *Creator Agent*.

The following section describes how the agent works in order to obtain reputation values.

#### 4 REPUTATION MANAGEMENT IN AGENTS' COMMUNITIES

The idea of using reputation values has two objectives. The first of them is that agents help employees to discover the information that is most relevant for them, thus, decreasing the overload of information that employees often have and strengthening the usage of knowledge bases in companies. Another objective is to avoid the situation of employees storing valueless information in a knowledge base. In order to accomplish this successfully, we need to manage reputation in such a way that the agents can obtain reputation values that can be used to maintain the quality of the information in knowledge bases.

Bearing in mind that the reputation notion described in section 2 is composed of position, expertise, previous experiences and intuition, we will describe the formulas used to measure the level of reputation in agents' communities.

For instance, the reputation of agent<sub>j</sub> in the eyes of agent<sub>s</sub> is a collective measure defined by the previously describe reputation factors in section two and is computed as follows:

$$R_{sj} = w_e * E_j + w_p * P_j + w_i * I_j + \left( \sum_{j=1}^n QC_j \right) / n$$

where  $R_{sj}$  denotes the reputation value that agent<sub>s</sub> has in agent<sub>j</sub> (each agent in the community has an opinion about each of the other agent members of the community).

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

$P_j$  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.

$I_j$  is the value assigned to the intuition which is calculated by comparing the users' profiles of each one.

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  $QC_j$  (Quality of  $j$ '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 expression  $n$  represents the total number of evaluated contributions.

Finally,  $w_e$ ,  $w_p$  and  $w_i$  are weights with which the Reputation value can be adjusted to the needs of the organizations. For instance, if an enterprise considers that all their employees have the same category, then  $w_p=0$ . The same could occur when the organization does not take its account employees' 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 information obtained from this agent.

Moreover, 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. For instance, an 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 ( $R_{Aj}$ ). This is calculated as:

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

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  $R_{Aj}$  will be calculated. Then, the User Agent  $j$  presents this reputation value (similar to when 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 (Abdul-Rahman & Hailes, 2000).

In the case of the user being new in the 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.

In the following section, we will describe a prototype developed to validate each of our proposals.

## 5 PROTOTYPE

In order to evaluate the architecture and formulas to manage reputation 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 for agents software 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 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.

When a user wants to join to a new community the person will use a “*Register Menu*” and choose a community from all the available communities. In this case the Manager Agent will ask whether there are any agents that know new user in order to set a reputation value on this person.

In addition, the prototype provides the options of proposing new documents, using community documents and updating reputation values, proposing new topics in the community, etc. We shall now describe only two situations, due to limitations of space:

1) Proposing new documents. It is assumed that any person is able to propose documents in those communities where he/she is a member. To propose a document a person must use the “Propose Menu” and will have to configure the followings options:

- **Community:** The person must select the community to which s/he proposes to add a document.
- **Topic:** In each community there may be different topics or areas and the user will choose the one in which s/he intends to propose the document.
- **Document:** The proposed document.

- **Author:** Indicates who the author of the document is since a person may propose other authors’ documents. In this case, the proposal is considered as a contribution but not as the proposer’s own contribution.

- **Knowledge Source:** Where the knowledge came from. It could have come from a partner, from the person him/herself, from a web page, etc.

Once the user has chosen the options, the User Agent takes the values and sends them to the Manager Agent that is in charge of adding the new document to the community document list and modifying the frequency of contribution of this agent in this community.

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 the 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. 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.

## 6 CONCLUSIONS

The main contribution of this paper is to add a reputation concept to knowledge bases with the idea of emulating people's behaviour within communities since according to literature the exchange of knowledge is likely to take place in these communities thanks to the trust that members have in each other. Moreover, we have proposed a new definition of "reputation" which considers aspects that affect the degree of trust that a person has in something (a knowledge source, a person, a piece of knowledge). In this definition intuition, a concept that according to (Mui et al, 2002) has not yet been modelled by agent systems has been included.

Another important advantage of our approach is that we use easy and generic formulas to measure the reputation in knowledge management systems. This is very important because our focus may be useful in several situations.

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

- Detecting information which is not particularly useful in a knowledge base.
- Displaying useful information to employees according to the user's profiles.
- Detecting the most important knowledge sources of a company. Since our approach rates information as well as the contributor this could also help companies to detect those employees with more knowledge about a topic (expert detection).

This architecture may also be useful in the implementation of a recommender system as the better evaluated information can be sent to interested parties. For instance, our research group will use our architecture to evaluate research papers and the best evaluated papers will be sent to the members of the group who work on related topics. In addition the architecture can be used to support virtual communities, or to detect the most trustworthy employees or with the best reputation.

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

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