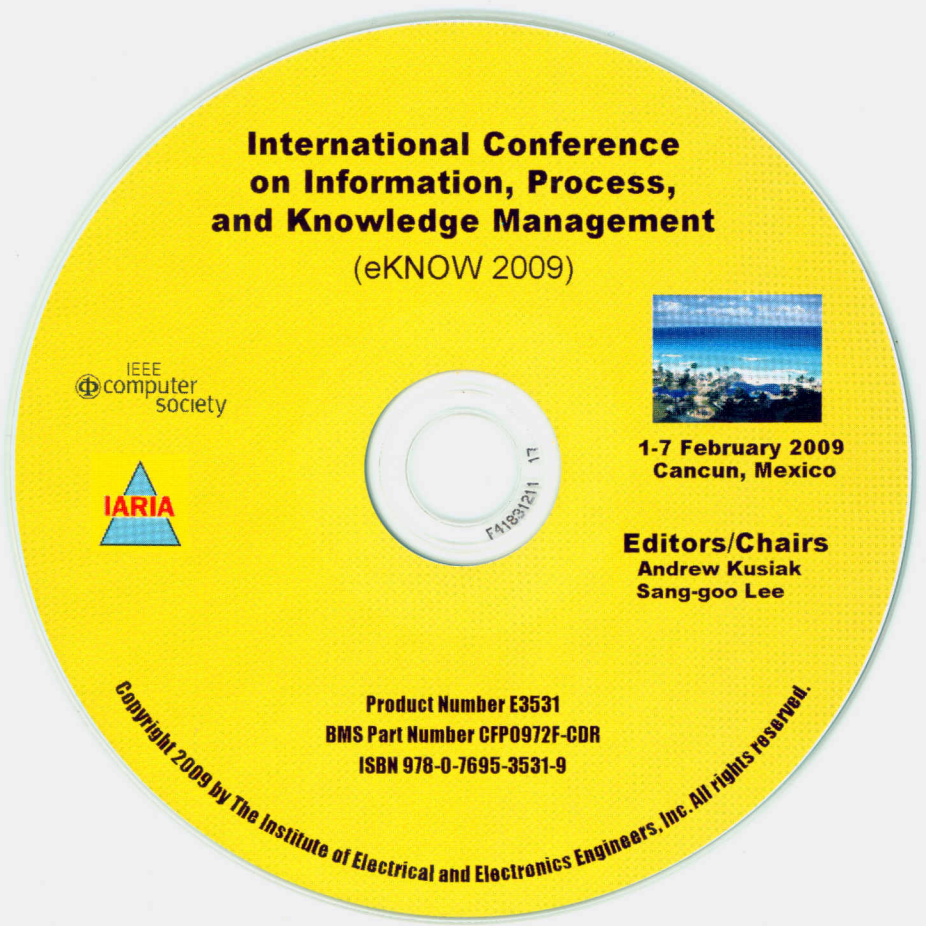
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Preface
eKNOW 2009

The first edition of the International Conference on Information, Process, and Knowledge Management (eKNOW 2009), was held in Cancun, Mexico, February 1st- 6th, 2009. The event was driven by the complexity of the current systems, the diversity of the data, and the challenges for mental representation and understanding of environmental structure and behavior.

Capturing, representing, and manipulating knowledge was and still is a fascinating and extremely useful challenge from both theoretical and practical perspective. Using validated knowledge for information and process management and for decision support mechanisms raised a series of questions the eKNOW 2009 conference was aimed at.

eKNOW 2009 provided a forum where researchers were able to present recent research results and new research problems and directions related to them. The topics covered aspects from knowledge fundamentals to more specialized topics such as process analysis and modeling, management systems, information management, decision support, and semantics processing and ontology.

We take this opportunity to thank all the members of the eKNOW 2009 Technical Program Committee as well as the numerous reviewers. The creation of such a high-quality conference program would not have been possible without their contribution. We also kindly thank all the authors who dedicated much of their time and efforts to contribute to the eKNOW 2009. We truly believe that, thanks to all these efforts, the final conference program consisted of top quality contributions.

This event could also not have been a reality without the support of many individuals, organizations, and sponsors. We are grateful to the members of the eKNOW 2009 organizing committee for their help in handling the logistics and for their work to make this professional meeting a success.

We hope that eKNOW 2009 was a successful international forum for the exchange of ideas and results between academia and industry and for the promotion of progress in knowledge, information and process management research.

Cancun's exotic and historical places surely provided a pleasant environment during the conference and we hope you had a chance to visit the surroundings.

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Poster

Encouraging the Reuse of Knowledge in Communities of Practice by Using a Trust Model

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***Abstract*— One technique with which to foster knowledge reuse in organizations is that of Communities of Practice where the feeling of trust between members is highly important in the sharing and reuse of knowledge. However, CoPs members are currently often geographically distributed, which decreases this feeling of trust. It is consequently more difficult for them to know how trustworthy a fellow-member is. This work attempts to assist CoPs members in deciding what or who to trust. One contribution of this work is a trust model which takes into account certain factors that human beings consciously or unconsciously use when they have to decide whether or not to trust in something or somebody. Moreover, in order to illustrate how the model can be used, a tool with which to recommend documents is described.**

Communities of Practice, Trust model, Multi-agent Systems, Knowledge Management.

I. INTRODUCTION

Communities of Practice (CoPs) are becoming increasingly more common in organizations due to the fact they are a means of sharing knowledge [15] [8]. They are frequently defined as groups of people who share a concern, a set of problems, or a passion about a topic and who extend their knowledge and expertise in this area by interacting on an ongoing basis [22]. However, CoPs members are ever-increasingly distributed throughout different geographic locations. This implies a lack of face-to-face communication which affects certain aspects of interpersonal relationships. For instance, if people never experience face-to-face communication and only use groupware tools to communicate, then trust often decreases [11]. This lack of trust makes it more difficult for CoPs members to know which of their fellow-members are more trustworthy. This presents a problem, as in CoPs the main knowledge sources are the members themselves. We thus consider that it is highly important to be able to discover how trustworthy a knowledge source (i.e. another member) is. This knowledge will help members to decide whether or not a piece of knowledge is valuable depending on the knowledge source from which it originates. Therefore, in order to support CoPs members in this task, this paper describes a trust model designed solely for CoPs in which various psychological aspects that a person uses, either consciously or unconsciously, to value whether another person is trustworthy have been considered. This model has been used in the implementation of a prototype in which software agents make recommendations to users about what documents are most relevant to them according to their preferences and trust in knowledge sources. The remainder of this paper is therefore organized as follows: Section Two outlines related work. Section Three describes the trust model that we propose. Section Four explains the details of how this model was implemented in a prototype. Finally, in Section Five, our conclusions are summarized.

II. RELATED WORK

This research can be compared with other proposals that use agents and trust models in knowledge exchange. In [4] the authors present a trust and reputation model that considers trust and reputation as emergent properties of direct interactions between agents, based on multiple interactions between two parties. In this model, trust is a belief an agent has about the performance of the other party to solve a given task, according to own knowledge. In [1] the authors propose a model which allows agents to decide which agents' opinions they trust more and to 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 maintain rather complex data structures which represent a kind of global knowledge about the whole network.

Barber and Kim present a multi-agent belief revision algorithm based on belief networks [3]. 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. This work has a similar goal to ours. However, the means of attaining it are different. In Barber and Kim's case reputation is defined 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, that 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.

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In [10] the authors present a trust and reputation model which integrates a number of information sources in order to produce a comprehensive assessment of an agent's likely performance. In this case the model uses four parameters to calculate trust values: interaction trust, role-based trust, witness reputation and certified reputation. We use certified reputation when an agent wishes to join a new community and uses a trust value obtained in other communities, but in our case this certified reputation is made up of four factors and is not only a single factor.

Also, works such as [7] use the term 'Community' to support knowledge management but a specific trust model for communities is not used.

The main differences between these reputation models and our approach are that these models need an initial number of interactions to obtain a good reputation value and it is not possible to use them to discover whether or not a new user can be trusted. A further difference is that our approach is orientated towards collaboration between users in CoPs. Other approaches are more orientated towards competition, and most of them are tested in auctions.

III. THE TRUST MODEL

It is first important to clarify that this trust model was designed to be used in companies in which CoPs are created as a knowledge management strategy with the goal of sharing knowledge and reusing lessons learnt. The word 'employees' therefore appears in this paper on several occasions, as it is assumed that the final aim of this research is to support companies, enterprises and organizations in general in the creation and use of CoPs as a means of improving their knowledge management.

Figure 1. Trust factors

Many authors consider that trust facilitates problem solving by encouraging information exchange [1]. However, the development of trust in a virtual setting is often more difficult than in co-located meetings [16]. Moreover, the idea of trusting or not trusting in something or somebody is context dependent. For instance, at an auction people may attempt to cheat in order to obtain greater benefits. Furthermore, in a CoP other factors may arise which might be objective and sub-objective. Both types have been considered in this model (see Figure 1), since both are frequently relevant in the personal decision-making processes.

The first is that of the **Position** that a person holds in the organization in which the CoPs exist. Position often influences the level of trust because employees frequently 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. 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 employees or between a teacher and pupils. pupils [5]. In an enterprise this position can be established in different ways, for instance by using an organizational diagram or classifying the employees according to the knowledge that a person has. Such different positions inevitably influence the way in which knowledge is acquired, diffused and eventually transformed within the local area. Because of this, as will later be explained, this factor will be calculated in our research by considering a weight that can strengthen this factor to a greater or to a lesser degree. This is an objective factor since it is provided or indicated by an exterior entity (for instance, it may be provided by the organization, by the community itself, etc).

Level of 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. In addition, an "individual" level of knowledge is embedded in the skills and competencies of the researchers, experts, and professionals working in the organization [16].

This factor can be seen as objective or subjective according to where this concept originates. For instance if it is specified by the organization it will be considered as objective. However, if its value is provided by the opinion of another agent then it will be seen as a subjective value.

Previous experience: A trusting decision is based on the truster's relevant prior experiences and knowledge [8, 11]. Experiences and knowledge form the basis of trust in future familiar situations [12]. Consequently, members of CoPs have greater trust in those knowledge sources from which they have previously obtained more "valuable information". Therefore, previous experience increases or decreases trust, and this factor can be very useful in detecting trustworthy knowledge sources in CoPs. In this case this factor is subjective since it depends on a person's opinion.

Intuition: When people do not have any 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" [15]. 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 [15]. In this research, intuition has been modelled according to the similarity between agents' profiles: the greater the similarity between one agent and another, the greater the level of trust. This is, of course, a highly subjective value because it is almost at the same level as a hunch and depends directly on the point of view of each person.

As will later be explained, it is possible to decide to place more importance upon one factor or another according to the setting in which the trust model is used. For this reason, we have pondered each factor with a weight which emphasizes a factor or decreases its importance. An explanation of how to use this model will be shown in the following section.

IV. A PROTOTYPE TO RECOMMEND DOCUMENTS

In order to test the trust model, a prototype with which to recommend documents to CoPs members was developed. This prototype allows CoPs members to introduce documents relating to different topics. Each time a person uses a document recommended by this tool, that person should evaluate it to enable the prototype to obtain user-feedback.

The prototype was developed by using software agents, as they are able to monitor and coordinate events, meetings and disseminate information [2].

Furthermore, agents are proactive in the sense that they can take the initiative and achieve their own goals. The autonomous behaviour of these agents is critical to the goal of this research since agents can act on behalf of their users by carrying out difficult and often time-consuming tasks that employees have to perform when using a knowledge management system such as searching for or introducing new information. In this tool each user is represented by one software agent which is in charge of assisting him/her to search for information. The architecture of the agents is formed of two layers, one reactive and one deliberative-social [17], in which there is a Trust Generator.

As this paper is focused on the trust model, this section will centre on explaining how the Trust Generator works and calculates each factor of the trust model explained in the previous section, and which is considered in the following formula:

$$\mathbf{T}_{ij} = wp*P_j + we*LE_j + wi*I_{ij} + PE_{ij} \quad (1)$$

Let us then imagine that an agent i must evaluate how trustworthy another agent j is. It will therefore use Formula (1) in which $\mathbf{T}_{ij}$ is the value of j's trust in the eyes of i. We shall now describe how each factor of the formula is calculated.

Position (P): When a new member joins a community that person must indicate his/her position within the organization and his/her software agent will calculate the Position (P) value of that person by using the following formula:

$$\mathbf{P} = UPL/NL \quad (2)$$

where:
UPL = User's Position level
NL = number of levels in the community

Therefore, if a community, for instance, has 5 possible position levels then NL=5, and if the new member has a level of UPL=2 then the value of P will be 2/5=0.4. Therefore, the different values of P for a community with five levels will be those shown in Table 1:

TABLE I. EXAMPLE OF POSITION LEVELS

Levels	Values P
1	0.2
2	0.4
3	0.6
4	0.8
5	1

The P values will always be between 0 and 1. Moreover, situations may exist in which P will not been taken into account, for instance in those CoPs in which all the members have the same level or whose members do not wish to consider this criterion. In these cases wp (weight of position) will be zero and position will not be considered in the formula. A further situation exists in which wp is equal to zero. This occurs when the value of the Previous Experience PE > U (U being a threshold which is chosen when creating the community). In this case, the agent will use the following formula to calculate the wp value:

$$\mathbf{wp} = \text{int}\,(U/PE_{ij}) \text{ being } PE_{ij} > 0$$

where:
U = Threshold of Previous Experience
PE_{ij} = Value of Previous Experience of an agent *i* with another agent *j*.

Thus, when PE_{ij} is greater than a particular threshold U, wp will be 0, thus ignoring the position factor. However, when one agent does not have enough Previous Experience (PE) of another it may use other factors to obtain a trust value. On the other hand, when the agent has had a considerable amount of previous experience with this agent or with the knowledge that it has provided then it is more appropriate to give more weight to this factor, since previous experience is the key factor in all trust models, as will be described in Section 4. Therefore, if an agent *j* has a high value of position but most of agent *i*'s previous experience of *j* has not been successful then the position will be ignored. This thus avoids the situation of, for instance, a boss who does not contribute with valuable documents but is considered trustworthy solely because s/he is a boss.

Level of Expertise (LE): As was previously mentioned, this factor is used to represent the level of knowledge and know-how that a person has in a particular domain. In this

prototype this factor may change since a person may become more expert in a topic as time goes by.

In this tool, when creating a community the levels of expertise considered is also indicated, for instance: novice, beginner, competent, expert and master. Each time a new member joins a community s/he will indicate the level of expertise that s/he considers him/herself to have. If the members of the community and their level of expertise are known to the creator of the community then that person can introduce them in the tool. Once the level of expertise has been introduced, the user agent will calculate the value for this level by using the following formula:

$$\mathbf{LE} = L/NT+AV_j \quad (3)$$

where L is the level of expertise that was introduced, and NT is the number of levels in the community. The term AV_j is the Adjustment Value for agent j. This term is extremely important since it will be used to adjust the experience of each user. This term was introduced with the goal of avoiding two situations:

- That a person either deliberately or mistakenly introduces a level of experience that is not the level that s/he has.
- That, whilst in the community, a person becomes more expert leading to the situation that his/her level of expertise should be adjusted.

Initially AV_j will be 0, and each time a member interacts with a document or information provided by j the member will rate this document or information and send this evaluation to the manager agent in charge of managing the community. The manager agent will verify whether the evaluation is negative or positive. If it is positive, then agent j's level of experience can be modified by calculating AVj as:

$$\mathbf{AV_j} = (VL_n - VL_{n-1})/PT \quad (n \neq 1)$$

If it is negative, then:

$$\mathbf{AV_j} = -(VL_n - VL_{n-1})/PT \quad (n \neq 1)$$

where VL_n is the value that a particular level of experience has. PT is the Promotion Threshold which is used to determine the number of positive rates necessary to promote a superior level of experience. Let us illustrate this with an example. In a community there are four levels with the following values.

TABLE II. POSITION VALUES

Labels	Level(n)	Value(VL)
Beginner	1	0.25
Competent	2	0.5
Expert	3	0.75
Master	4	1

In this case, the difference between the levels is 0.25 as:

$VL_n - VL_{n-1} = 0.25$.

In this version of the tool it is assumed that at least 5 rates are necessary to change the level so PT will be 5, and AV_j will be 0.25/5=0.05. This is therefore the value that will be added when a positive rate is received or that will be subtracted when this rate is negative. With five positive rates (5*0.05=0.25) there is thus a level promotion.

Intuition: This term is used when the Previous Experience is low and it is necessary to use other factors to calculate a trust value. This is one contribution of our work, since most of the earlier trust models are based solely on previous experience. The agents attempt to emulate human behaviour, as people often trust more in people who are similar to themselves. For instance a person who has to choose between information from two different people will normally choose that which comes from the person who has the same background, same customs etc., as him/her. By following this pattern, the agents compare their own profiles with the other agents' profiles in order to decide whether a person appears to be trustworthy or not. Therefore, the more similar the profiles of two agents are, for instance i and j, the greater the I_{ij} value in formula (1) will be. We could say that an agent 'thinks' "I do not know whether I can trust this agent but it has similar features to me so it seems trustworthy". The agents' profiles may alter according to the community in which they are working. In our case, as the data stored in the agents' profiles are 'position' and 'expertise', both these features will be taken into account. Therefore, the factors that the tool compares are:

- Experience Difference (ED)
- Position Difference (PD)

Thus, the Intuition value of an agent *i* about *j* (I_{ij}) is:

$$\mathbf{I_{ij}} = ED_{ij} + PD_{ij} \quad (4)$$

where $ED_{ij} = LE_i - LE_j$ and $PD_{ij} = P_i - P_j$

This formula (4) is based on the idea that a person normally has a greater level of trust in people who have a higher level of experience or who are in a higher position than that person him/herself. Hence, when an agent compares its profile with another agent with higher values, the value of intuition will be positive. Let us consider the case of agent *i* which has values of LE_i=0.2 and P_i=0.6. This agent wishes to know how trustworthy another agent *j* is. In this case the agent will use Formula (1) and, depending on

the information that it has about *j*, it will or will not be necessary for it to calculate the intuition factor. In this situation we shall suppose that there is little previous experience and that this must be calculated. The values for the agent *j* are LE_j=0.5 and P_j=0.5. As Figure 2 shows:

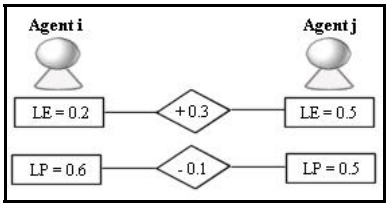

Figure 2. Comparing profiles

I_{ij}=0.2 as ED_{ij}=0.3 and $PD_{ij=}$-0.1

As with position, intuition will or will not be calculated depending on the level of PE (previous experience). Thus, the weight of intuition, (see Formula 1) wi will be calculated as follows:

$wi = int (U/PE_{ij})$ with $PE_{ij} \neq 0$.

Previous Experience: This factor is the most decisive of all the factors in Formula (1). In fact, all the previous factors depend on it as an agent will decide whether or not to use the remaining factors according to the value of Previous Experience (PE). Previous Experience is obtained through the interactions that the agent itself has, so this is direct experience. Each time one agent interacts with another (by interacting we mean that one agent uses a document provided by another), the first agent asks its user to rate that document in order to discover whether the document was: useful for him/her, related to the topic at hand, recommendable for other people interested in the same topic, up-to-date.

The agent then labels this interaction with a label from Table 3. A value for Current Experience (CE) is thus obtained which will modify the previous value of PE in accordance with the following formula:

$$PE_{ij}(x) = PE_{ij}(x\text{-}1) + CE_{ij}(x) \quad (5)$$

TABLE III. PE LABELS

Label	PE Level
Very Bad	- 0.3
Bad	- 0.2
Medium	+ 0.1
good	+ 0.2
Very good	+ 0.3

where $PE_{ij}(x)$ is the value of Previous Experience that the agent i has about another agent j in an interaction x.

$EP_{ij}(x\text{-}1)$ is the value of Previous Experience that the agent i had about another agent j before the interaction x.

$CE_{ij}(x)$ is the value of the experience that i has had with j in the interaction x.

For instance, if an agent i has just taken part in an interaction with the agent j, and this is labelled as "bad", but the value of $PE_{ij}(x\text{-}1)$ was 0.8, then the value of $PE_{ij}(x)$ will be 0.6 obtained from (0.8+(-0.2)). Moreover the agent i will send the manager agent the value of $CE_{ij}(x)$ in order to calculate $\mathbf{AV_j}$ (see Level of Expertise).

As has previously been explained, the Position and Intuition factors depend on the PE value. When an agent has sufficient PE then Position and Intuition can be ignored, and only the PE and the Level of Expertise will be considered. The latter is also included to ensure that an agent takes advantage not only of its own previous experience but also of that of the other agents since Level of Expertise (**LE)** is adjusted by the $\mathbf{AV_j}$ which comes from other previous experience.

In order to illustrate how the prototype works, let us look at an example. If a user selects a topic and wishes to search for documents related to that subject, his/her user agent will contact other user agents which have documents related to the theme at hand. The user agent will then calculate the trust value for each agent, meaning that these agents are considered to be knowledge sources and the user agent needs to calculate which "knowledge source" is more trustworthy. Once these values have been calculated, the user agent shows its user only the documents which have come from the most trustworthy agents.

V. CONCLUSIONS

In this paper a trust model to encourage the reuse of knowledge in CoPs has been described. The main features of the model are:

The model helps to detect an increasing problem in companies or communities in which employees are rewarded if they contribute with knowledge in the community. Thus, if a person introduces, for instance, non-valuable documents with the sole aim of obtaining rewards, the situation can be detected since these documents will have low trust values and the person will also be considered to be less trustworthy. The agent will, therefore, not recommend those documents. Moreover, the formulas proposed are very simple and easy to understand. This is an advantage over the previous models which are often not greatly used since they are difficult to implement.

Furthermore, a tool based on the trust model has been explained. The tool uses trust values to recommend documents, which may imply a reduction in users' overload since they do not need to search for the most appropriate documents as their software agents do it for them.

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