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Trends in Practical Applications of Agents and Multiagent Systems

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ADVANCES IN INTELLIGENT AND *SOFT COMPUTING* 71

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8th International Conference on Practical Applications of Agents and Multiagent Systems

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Systems Research Institute
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Editors

Yves Demazeau
Laboratoire d'Informatique de Grenoble
Centre National de la Recherche
Scientifique, Maison Jean Kuntzmann
110 av. de la Chimie
F-38041 Grenoble, France
E-mail: yves.demazeau@imag.fr

Frank Dignum
Department of Information and
Computing Sciences
Universiteit Utrecht Centrumgebouw Noord,
office A117, Padualaan 14, De Uitho
3584CH Utrecht, The Netherlands
E-mail: dignum@cs.uu.nl

Juan M. Corchado
Departamento de Informática y Automática
Facultad de Ciencias Universidad
de Salamanca Plaza de la Merced
S/N 37008 Salamanca, Spain
E-mail: corchado@usal.es

Javier Bajo
Escuela Universitaria de Informática
Universidad Pontificia de Salamanca,
Compañía 5, 37002 Salamanca, Spain
E-mail: jbajope@upsa.es

Rafael Corchuelo
ETSI Informática Universidad
de Sevilla Avda. Reina Mercedes
s/n 41012 Sevilla, Spain
E-mail: corchu@us.es

Emilio Corchado
Departamento de Informática
y Automática Facultad de Ciencias
Universidad de Salamanca Plaza de la
Merced S/N 37008 Salamanca, Spain
E-mail: escorchado@ubu.es

Florentino Fernández-Riverola
Escuela Superior de Ingeniería
Informática, Edificio Politécnico,
Despacho 408, Campus Universitario
As Lagoas s/n, 32004 Ourense, Spain
E-mail: riverola@ei.uvigo.es

Vicente Julián
Departamento de Sistemas Informáticos
y Computación Universidad Politécnica
de Valencia, Camino de Vera s/n
46022 Valencia, Spain
E-mail: vinglada@dsic.upv.es

Pawel Pawlewski
Department of Computing and Management
Poznan University of Technology
Strzelecka Str. 11, 60965 Poznan, Poland
E-mail: pawel.pawlewski@put.poznan.pl

Andrew Campbell
Department of Computer Science
Dartmouth College 6211 Sudikoff Laboratory
Hanover, NH 03755-3510, USA
E-mail: campbell@cs.dartmouth.edu

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Preface

New trends and strategies on Agents and Multi-Agent Systems have recently appeared and many effective applications of this technology are now deployed. An international forum to present and discuss the latest scientific trends and strategies on practical applications of Agents and Multi-Agent Systems, to assess the impact of the approach, and to facilitate technology transfer, has become a necessity.

PAAMS, the International Conference on Practical Applications of Agents and Multi-Agent Systems is an international yearly forum to present, to discuss, and to disseminate the latest developments and the most important outcomes related to real-world applications. It provides a unique opportunity to bring multi-disciplinary experts, academics and practitioners together to exchange their experience in the development of Agents and Multi-Agent Systems.

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PAAMS 2010 included a total of 7 special sessions and 2 workshops: Special sessions on Adaptive Multi-agent Systems, Multi-agent systems for Health Care and Bioinformatics, Multi-agent systems for Ambient Intelligence, Multi-Agent Systems for Manufacturing and Supply Chains, Enterprise Application and Information Integration, Software Agents in Knowledge Management and Bio-inspired and Multi-Agent Systems: Applications to Languages. The workshop on Artificial Intelligence and Distributed Computing included sessions on Sensing Systems and Intelligence and Ageing Well in the Knowledge Society. Finally, the workshop on on Systems, Man, & Cybernetics: SMC-Workshop.- IEEE-SPANISH CHAPTER provided an interesting opportunity to present and discuss the latest theoretical advances related to agents in the IEEE Spanish Chapter.

We would like to thank all the contributing authors, as well as Workshop and special session organizers and the members of the Program Committees and the

Organizing Committees for their hard and highly valuable work. Their work has helped to contribute to the success of the PAAMS 2010 event. Thanks for your help, PAAMS 2010 wouldn't exist without your contribution.

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A Multi-agent Recommender System to Suggest Documents in Communities of Practice

Aurora Vizcaíno, Juan Pablo Soto, Javier Portillo-Rodríguez, and Mario Piattini

Abstract. The importance of knowledge management has, in recent years, led to the incorporation of Knowledge Management Systems (KMS) into companies. Some of these KMS could be considered as Recommender Systems that are able to recommend knowledge, which is part of the company's intellectual capital. However, these KMS are not always welcome in the company, since the knowledge is not stored by using a quality control, or because employees feel that these kinds of systems, rather then helping them, cause them extra work. In this paper we present an agent architecture combined with a trust model trying to avoid some of the problems that appear when a KMS is introduced into companies.

Keywords: Knowledge Management Systems, Recommender Systems, Agent Architecture.

1 Introduction

In recent years, knowledge has become an extremely important factor, to the point that intellectual capital is now one of the most important assets for many organizations [1]. At present organizations must operate in a climate of rapid market change and high information volume which increases the necessity to create Knowledge Management Systems (KMS) that support the knowledge process. It is possible to consider certain Recommender Systems, such as KMS, which recommend knowledge, information or documents to employees with the goal of reusing a company's intellectual capital [2].

Aurora Vizcaíno · Javier Portillo-Rodríguez · Mario Piattini
Alarcos Research Group,
Universidad de Castilla – La Mancha
Paseo de la Universidad, 4, 13071, Ciudad Real, Spain
e-mail: {aurora.vizcaino,javier.portillo,mario.piattini}@uclm.es

Juan Pablo Soto
Departamento de Matemáticas,
Universidad de Sonora
Rosales s/n, Centro, 83000, Hermosillo, México
e-mail: jpsoto@gauss.mat.uson.mx

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However, these kinds of systems are not always welcomed by a company's employees because [3]:

1. Employees often feel that they are overloaded with new work as they have to introduce Knowledge Objects (KOs) into the system.
2. On other occasions employees waste a considerable amount of time searching for information since they do not know the best way in which to do so or they do not know what information may be useful.
3. With regard to the previous point, sometimes there is not quality control with regard to the KOs introduced into the system, and when employees finally discover information or review the information recommended they realise that it is not useful.
4. Employees may introduce information into the systems which is not very valuable, with the sole goal of appearing to be contributing since some companies give incentives to employees that contribute with knowledge.

Our work is focused on attempting to reduce the impact of these last three problems. We therefore use software agents to search for information on behalf of users, and these software agents are in charge of recommending the most suitable knowledge to them. In order to tackle problems three and four we have developed an internal agent architecture and a trust algorithm with which to rate KOs and Knowledge Sources (KSs). The software agents will therefore use this algorithm in order to decide whether a KO or KS should be recommended to a particular user.

The agent architecture and the trust model are focused on Communities of Practice (CoPs) which are a natural means of sharing knowledge. CoPs 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. CoPs share values, beliefs, and ways of doing things. Therefore, many companies report that such communities help to reduce the problems caused by a lack of communication, and save time by 'working smarter' [4].

Therefore in Section 2 the architecture is described and later, in Section 3 the recommender system developed in order to check the efficiency of our proposals is explained. After that in Section 4, a brief description of the algorithm used in the architecture to check whether a KO or KS is trustworthy is outlined. Finally, our conclusions are outlined in Section 5.

2 Internal Agent Architecture

The internal agent architecture proposed is composed of two levels: reactive and social-deliberative.

The reactive level is considered by other authors to be a typical level that a Multi-agent System (MAS) must have [5]. A deliberative level is often also considered as a typical level, but a social level is not often considered in an explicit manner, despite the fact that these systems (MAS) are composed of several individuals, the interactions between them and the plans constructed by them. The social level is only considered in those systems that attempt to simulate social

behavior. Since we wish to emulate human feelings such as trust and intuition, we have added a social level that considers the social aspects of a community and which takes into account the opinions and behavior of each of the members of that community. Other previous works have also added a social level. For example, in [6] the authors attempts to emulate human emotions such as fear, thirst or bravery, but the architecture used is made up of three levels: reactive, deliberative and social. In our case the deliberative and social levels are not separate levels since we are aware that plans created in the deliberative level involve social interactions. We therefore consider that, in our case, it might be more efficient to define a level which is composed of two parts (social-deliberative level) rather than considering two separate levels. Each of these levels is explained in the following subsections.

2.1 Social-Deliberative Level

At this level, the agent has a type of behavior which is oriented towards objectives, that is, it takes the initiative in order to plan its performance with the purpose of attaining its goals. The components of the social-deliberative level are (see Figure 1):

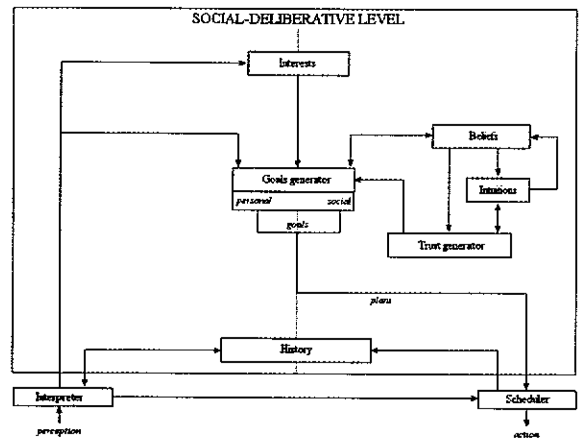

Fig. 1 Deliberative-Social level

Goals generator. Depending on the state of the agent, this module must decide what the most important goal to be achieved is.

Social beliefs. This component represents a view that the agent has of the communities and their members, for instance, beliefs about other agents.

Social interests. This is a special type of belief. In this case it represents interest in other agents.

Intuitions. As we are modelling community members we have attempted to introduce factors into this architecture that influence people when they need to make decisions about whether or not to trust in a knowledge source. One of these factors is intuition, which is a subjective factor since it depends on each individual. This concept is extremely important when people do not have any previous experience. Other authors have called this issue "indirect reputation or prior-derived reputation" [7]. 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 [7]. We often trust more in people who have similar features to our own. For example, when a person consults a community in a search for rating products or services such as *Tripadvisor* [8], s/he often checks comments from people who are of the same age as or have similar interests to him/her. In this research, intuition has therefore been modelled according to the similarity between agents' profiles: the greater the similarity between one agent and another, the greater the level of trust. The agents' profiles may change according to the community in which they are working.

Trust generator. This module is in charge of generating a trust value for the knowledge sources with which an agent interacts in the community. To do this, the trust generator module considers the trust model explained in detail in [9] which considers the information obtained from the internal model and the agent's intuitions.

2.2 *Reactive Level*

This is the level in charge of perceiving changes in its environment and responding to these changes at the precise moment at which they occur, i.e., when an agent executes another agent's request without any type of reasoning. The components that form part of the reactive level have been omitted due to space constraints.

3 A Recommender System

A recommender system has been developed in order to test the internal agent architecture. In this system each CoP member is represented by a software agent called a User Agent. A new community member must first join a community, which is done by using the "Register" menu and choosing a community from those which are available. Once registered, a member can provide new KOs or use those which are already available in the community and/or propose new subjects. The two first situations are described.

1. **Proposing a new KO.** In order to provide a KO (for instance a document) a person must use the "Propose" menu and must configure the following options:

- *Topic*: There may be different topics or areas in each community. The users can choose that in which they intend to propose the document.
- *Select Document*: The proposed KO (in this case a document).

Once the user has chosen the options, the User Agent sends the values to another software agent called the Manager Agent which is in charge of adding the new KO to the community and modifying the frequency of contribution of the User Agent in that community.

2. **Using community KO.** Members can request the recommendation of a particular KO and their User Agent will help them to find that which is most suitable. Therefore, when a person searches for a KO relating to a particular subject their User Agent consults the Manager Agent about which KOs are related to that subject. The Manager Agent then replies with a list of KOs. The User Agent sorts this list (list on left of Figure 2) by using an algorithm which will be explained in the following section of this paper. The User Agent can therefore detect how worthy a KO is, thus saving employees time, since they do not need to review all the KOs related to a particular subject but only those considered to be most relevant by the members of the community or by the user him/herself.

Once one or several KOs have been chosen, the user must then evaluate the KOs consulted in order to provide feedback to the community about them (list on right of Figure 2).

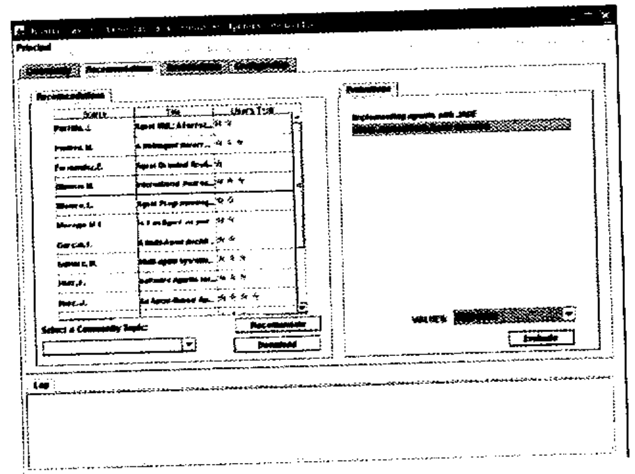

Fig. 2 Using community KOs

4 Description of the Algorithm

This section describes the algorithm used to permit the agents to recommend a KO. The input of this algorithm is a set of KOs. Each KO may or may not have been evaluated previously, signifying that a KO may already have a list of evaluations (along with the identity of each person who evaluated it), or it may not have any evaluations. This aspect will be taken into account by the algorithm, which therefore distinguishes two groups:

Group 1 (G1): This group is formed of the KOs that have already been evaluated. This is the most important group since if the agents have previous evaluations of a KO they have more information about it, which facilitates the task of discovering whether or not its recommendation is advisable.

Group 2 (G2): these KOs have not been used previously so the agents do not have any previous evaluations of them. Let us now observe how each group is processed by the algorithm.

In G1 the KOs will be ordered by a Recommendation Rate which is calculated by the User Agent for each KO. Hence RR_k signifies the Recommendation Rate for a particular KO called k, and is obtained from:

$$RR_k = w_1 \times TE_i + w_2 \times TS_{ik} \tag{1}$$

where TE_i is the pondered mean of the evaluations determined by the trust that an agent "*i*" has in each evaluator (the person who has previously evaluated that KO). TE_i is calculated as:

$$TE_i = \frac{\sum_{j=1}^{n} (E_{jk} \times TS_{ij})}{\sum_{j=}^{n} TS_{ij}} \tag{2}$$

Therefore, TS_{ij} is the trust value that the User Agent "*i*" has in the knowledge source "*j*", since in a CoP the source which provides a KO will usually be a CoP member. TS_{ij} therefore represents the trust that an agent "*i*" has in another agent "*j*" (explained in detail in [11]) and E_{jk} is the evaluation that an agent "*j*" has made with regard to a particular KO "*k*".

The parameter TS_{ik} used in Formula (1) similarly indicates the trust that an agent "*i*" has in a knowledge source "*k*". In other words, the agent must take two things into consideration when calculating the RR_K:

- The other agents' opinions of a KO "*k*" pondered by the trust that agent "*i*" has in the person who provided that evaluation.
- The opinion that the agent "*i*" has in the agent that has provided the KO "*k*".

Both w1 and w2 are weights which are used to adjust the formula. The sum of w1 and w2 should be 1.

G2 will use another formula to calculate the RR_k for each KO since, in this case, there are no results of previous evaluations of the KOs. The formula used is, therefore:

$$RR_k = w_1 \times TS_{ix} + w_2 \times \mathrm{Re}_x \tag{3}$$

where TS_{ix} is the Trust that the User Agent "i" has in the KS "x" which provides the KO "k", and Re_x is the reputation that the KS has (according to another member's agent's opinion). This Re_x value is calculated by asking those agents with a higher trust value about the KS with a weighted mean, which is subsequently calculated. Re_x is therefore obtained as:

$$\mathrm{Re}_x = \frac{\sum_{j=1}^{n} (TS_{jx} \times TS_{ij})}{\sum_{j=1}^{n} TS_{ij}} \tag{4}$$

where TS_{jx} is the trust that an agent "*j*" has in the KS "*x*" and TS_{ij} is the trust value that the agent "*i*" has in agent "*j*". Therefore, the agent's opinion of KS "*x*" is adjusted by the opinion that the agent "*i*" has with regard to the agent that is giving its "opinion" (trust value in the KS "*x*"). It is possible to stress the values of TS_{ix} and Re_x by using the weights w_1 and w_2.

5 Conclusions

CoPs are a means of knowledge sharing. However, the knowledge that is reused should be valuable for its members, who might otherwise prefer to ignore the documents that a community has at its disposal. In order to encourage the reuse of documents in CoPs, in this work we propose a multi-agent recommender system with which to suggest trustworthy documents. Some of the advantages of our system are:

- The use of agents to represent members of the community helps members to avoid the problem of information overload since the system gives the User Agents the ability to reason about the trustworthiness of the other agents or about the recommendation of the most suitable documents to the members of the community. Users are not, therefore, flooded with all the documents that exist with regard to a particular subject, but their User Agents filter them and recommend only those which are most trustworthy (when they have rates) or those which are provided by more trustworthy sources or sources which have preferences and features that are similar to those of the user in question.
- Detecting whether members store documents that are not useful, since the system provides users with the opportunity to evaluate the documents consulted, and when a document is frequently evaluated with low marks then the Manager Agent will check who the provider is and whether most of that person's documents have a low evaluation, two options can be considered. First, that the person does not have sufficient knowledge of the subject, in which case the Manager Agent can consult that person's Level of Expertise (which is indicated when a person joins a community), and modify it if necessary. The second option is that this person may be consciously introducing invaluable documents. In this case the trust in this source will be low and the documents will rarely be recommended. The system can also detect those users with the greatest level of participation and those whose documents have obtained higher rates. This information can be used for two purposes: expert detection and/or recognition of fraudulent members who contribute with worthless documents. Both functionalities imply various advantages for any kind of organization, i.e., the former permits the identification of employee expertise and measures the quality of their contributions, and the latter permits the detection of fraud when users contribute with non-valuable information.
- The system facilitates the exchange and reuse of information, since the most suitable documents are recommended. Furthermore, the proposed algorithm can calculate a trust value even when the community has only recently been created since, in order to calculate trust, various known factors are used such as

Position, Level of Expertise and even Intuition [9]. This is a key difference with regard to other algorithms which use only previous experience and which cannot then calculate trust values if the system is just starting to work. When a new member arrives it is also impossible for other algorithms to calculate a previous trust value related to this new member. A further contribution of this algorithm is that it is quite flexible since in many situations weights are used to modify the formulas. This algorithm could, therefore, be used by the designers of other recommender systems who could decide what values they should give to these weights in order to adapt the formula to their needs.

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