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Preface

Delegates and friends, I am very pleased to extend to you the warmest of welcomes to this, the seventh International Conference on Knowledge-Based Intelligent Information and Engineering Systems at the University of Oxford in the UK. It was a great pleasure to be involved in the organization of this popular conference, and it gives us a great deal of satisfaction to be so involved.

The KES conference series is now well established, and it continues each year to attract participants from all geographical areas of the world, including Europe, the Americas, Australasia, and the Pacific Rim. The conference continues to attract large numbers of papers. We are impressed this year by the quality of the papers we have received and the wide range of topics. I am sure that the presentations will be of great interest to you as delegates, and will act as useful catalysts for discussion.

The papers for KES 2003 were either submitted to Invited Sessions, chaired and organized by respected experts in their fields, or to General Sessions, managed by an extensive International Program Committee. Whichever route they came through, all papers for KES 2003 were thoroughly reviewed. This has resulted in a satisfying level of quality in the accepted papers appearing in the proceedings.

Thanks are due to very many people who have given their time and goodwill freely to make the conference a success. Thanking individuals is always fraught with difficulty, as someone is always unintentionally omitted. The conference Administrator, Maria Booth, the KES Secretariat at the University of Brighton, together with the local Oxford Committee have all worked hard to bring the conference to a high level of organization, and we thank them. The International Program Committee gave their expertise in the review of the papers and we are grateful for that. We particularly thank the Invited Session Chairs Committee for bringing many interesting sessions to the conference. We thank the keynote speakers for their high-profile keynote talks. Finally, we thank the authors, presenters, and delegates without whom the conference would not take place.

Knowledge-based intelligent engineering systems continue to be a subject that attracts the interest of researchers, and makes a significant contribution to the world economy. We are fortunate to be involved in such a fascinating research area. Enjoy your conference, and we look forward to meeting you and talking with you.

July 2003 Vasile Palade, Bob Howlett, and Lakhmi Jain

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Table 2. The appropriate spline wavelet descriptors for discrimination and discriminative measures at $\alpha = 5$

	SAMSAI	CHA WA	NOKE	DUANG	OU
SUENG	$\lvert M_{1,0,5}\rvert$ 0.0039	$\lvert M_{1,0,5}\rvert$ 0.0035	$\lvert M_{1,2,5}\rvert$ 0.0013	$\lvert M_{0,1,5}\rvert$ 0.0031	$\lvert M_{1,0,5}\rvert$ 0.0043
SAM SAI		$\lvert M_{0,1,5}\rvert$ 0.0149	$\lvert M_{1,2,5}\rvert$ 0.0039	$\lvert M_{1,3,5}\rvert$ 0.0054	$\lvert M_{1,3,5}\rvert$ 0.0121
CHA WA			$\lvert M_{1,2,5}\rvert$ 0.0043	$\lvert M_{1,3,5}\rvert$ 0.0039	$\lvert M_{0,3,5}\rvert$ 0.0064
NOKE				$\lvert M_{1,0,5}\rvert$ 0.0054	$\lvert M_{1,2,5}\rvert$ 0.0023
DAUNG					$\lvert M_{1,2,5}\rvert$ 0.0030

of basis functions to perform recognition under the impact of rotations. The proposed algorithm based on standard deviation and energy combined with the variance-based procedure makes it possible to efficiently construct a set of descriptors suitable for discrimination under the impact of the rotation. The best discrimination properties for the set of the Thai musical instruments are displayed by $\{|M_{0,1,1}|, |M_{1,2,3}|, |M_{1,2,5}|, |M_{0,1,6}|, |M_{1,1,7}|\}$, appropriate $\alpha = \{1, 3, 5, 6, 7\}$.

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A Multi-agent System for Knowledge Management in Software Maintenance

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Abstract. Knowledge management has become an important topic as organisations wish to take advantage of the information that they produce and that can be brought to bear on present decisions. This work describes a system to manage the information and knowledge generated during the software maintenance process, which consumes a large part of the software lifecycle costs. The architecture of the system is formed from a set of agent communities, each community is in charge of managing a specific type of knowledge. The agents can learn from previous experience and share their knowledge with other agents, or communities.

Keywords: Muti-agent systems, Knowledge Management, Software Maintenance

1 Introduction

Knowledge is a crucial resource for organizations, it allows organizations to fulfil their mission and become more competitive. For this reason, companies are currently researching techniques and methods to manage their knowledge systematically. In fact, nearly 80% of companies worldwide have some knowledge management efforts under way [5].

Organizations have different types of knowledge that are often related to each other and which must be managed in a consistent way. For instance, software engineering involves the integration of various knowledge sources that are constantly changing. The management of this knowledge and how it can be applied to software development and maintenance efforts has received little attention from the software engineering research community so far [3]. Tools and techniques are necessary to capture and process knowledge in order to facilitate subsequent development and maintenance efforts. This is particularly true for software maintenance, a knowledge intensive activity that depends on information generated during long periods of time and by large numbers of people, many of whom may no longer be in the organisation.

This paper presents a multi-agent system (KM-MANTIS) in charge of managing the knowledge that is produced during software maintenance. The contents of this paper are organized as follows: Section 2 presents the motivation for using a Knowledge Management (KM) system to support software maintenance. Section 3 describes the implementations of KM-MANTIS. Finally, conclusions are presented in Section 4.

2 Advantages of Using a KM System in Software Maintenance

Software maintenance consumes a large part of overall lifecycle costs [2, 8]. The incapacity to change software quickly and reliably causes organizations to lose business opportunities. Thus, in recent years we have seen an important increase in research directed towards addressing these issues.

On the other hand, software maintenance is a knowledge intensive activity. This knowledge comes not only from the expertise of the professionals involved in the process, but it is also intrinsic to the product being maintained, and to the reasons that motivate maintenance (new requirements, user complaints, etc.) processes, methodologies and tools used in the organization. Moreover, the diverse types of knowledge are produced at different stages of the MP.

Software maintenance activities are generally undertaken by groups of people. Each person has partial information that is necessary to other members of the group. If the knowledge only exists in the software engineers and there is no system in charge of transferring the tacit knowledge (contained in the employees) to explicit knowledge (stored on paper, files, etc) when an employee abandons the organization a significant part of the intellectual capital goes with him/her.

Another well-known issue that complicates the MP is the scarce documentation that exists related to a specific software system, or even if detailed documentation was produced when the original system was developed, it is seldom updated as the system evolves. For example, legacy software written by other units often has little or no documentation describing the features of the software. By using a KM system the diverse kinds of knowledge generated may be stored and shared. Moreover, new knowledge can be produced, obtaining maximum benefit from the current information. By reusing information and producing relevant knowledge the high costs associated with software maintenance could also be decreased [4].

Another advantage of KM systems is that they help employees build a shared vision, since the same codification is used and misunderstanding in staff communications may be avoided. Several studies have shown that a shared vision may hold together a loosely coupled system and promote the integration of an entire organisation [7].

3 A Multi-agent System to Manage Knowledge in Software Maintenance

The issues explained above motivated us to design a KM system to capture, manage, and disseminate knowledge in a software maintenance organisation, thus increasing the workers' expertise, the organisation's knowledge and its competitiveness while decreasing the costs associated with the software MP.

KM-MANTIS is a multi-agent system where different types of agent manage the diverse types of information generated during SMP. Agents interchange data and take advantage of the information and experience acquired by other agents.

In order to foster the interchange of information the system uses an open format to store data and metadata XMI (XML metadata interchange) [6]. This is an important advantage of this system, since data and metadata defined along with other tools that support XMI can also be managed by KM-MANTIS. And it also facilitates the interchange of information between agents since they all use the same information representation.

3.1 The KM-MANTIS Architecture

The system is formed of a set of agent communities which manage different types of knowledge.

There are several reasons why agents are recommendable for managing knowledge. First of all, agents are proactive, this means they decide to act when they find it necessary to do so. Moreover, agents can manage both distributed and local information. This is an important feature since software maintenance information is generated by different sources and often from different places.

One aspect related to the previous one is that agents may cooperate and interchange information. Thus, each agent can share its knowledge with others or ask them for advice, benefiting from the other agents' experience. Therefore, there is reuse and knowledge management in the architecture of the system itself.

Another important issue is that agents can learn from their own experience. Consequently the system is expected to become more efficient with time since the agents have learnt from their previous mistakes and successes.

On the other hand, each agent may utilize different reasoning techniques depending on the situation. For instance, an agent can use an ID3 algorithms to learn from previous experiences and use case-based reasoning to advise a client on how to solve a problem.

The rationale for designing KM-MANTIS with several communities is that during the software MP different types of information are produced, each with its own specific features. The types of information identified were: information related to the products to be maintained; information related to the activities to be performed in order to maintain the products; and, peopleware involved during software maintenance [10].

Therefore, KM-MANTIS has three communities: a community termed the "products community", another called the "activities community", and the last community denoted as the "peopleware community". In what follows we describe each community in more detail.

Products Community: This community manages the information related to the products to be maintained. Since each product has its own features and follows a specific evolution this community has one agent per product. The agents have information about the initial requirements, changes made to the product, and about metrics that evaluate features related to the maintainability of the product, (this information is obtained from different documents such as modification requests, see Figure 1, perfective, corrective or preventive actions performed or product measurements). Therefore, the agents monitor the product's evolution in order to have up to date information about it at each moment.

Each time an agent detects that information about its product is being introduced or modified in KM-MANTIS (the agent detects this when the application identification number that it represents is introduced or displayed in the interface of KM-MANTIS), the agent analyses the new information, or comparing it to that previously held in order to detect inconsistencies, or checking the differences and storing the relevant information in order to have up-to-date information.

Information relevant to each product (data) is stored in an XMI repository. The XMI repository also stores rules (knowledge) produced by the agents through induction and decision trees-based algorithms. The decision to use XMI documents based on the MOF (Meta Object Facility) standard makes it possible for agents to have access to the different levels of information and knowledge that they need to process and classify their information and the queries that they receive.

Activities community: Each new change demanded implies performing one or more activities. This community, which has one agent per activity, is in charge of managing the knowledge related to the different activities including methods, techniques and resources used to perform an activity.

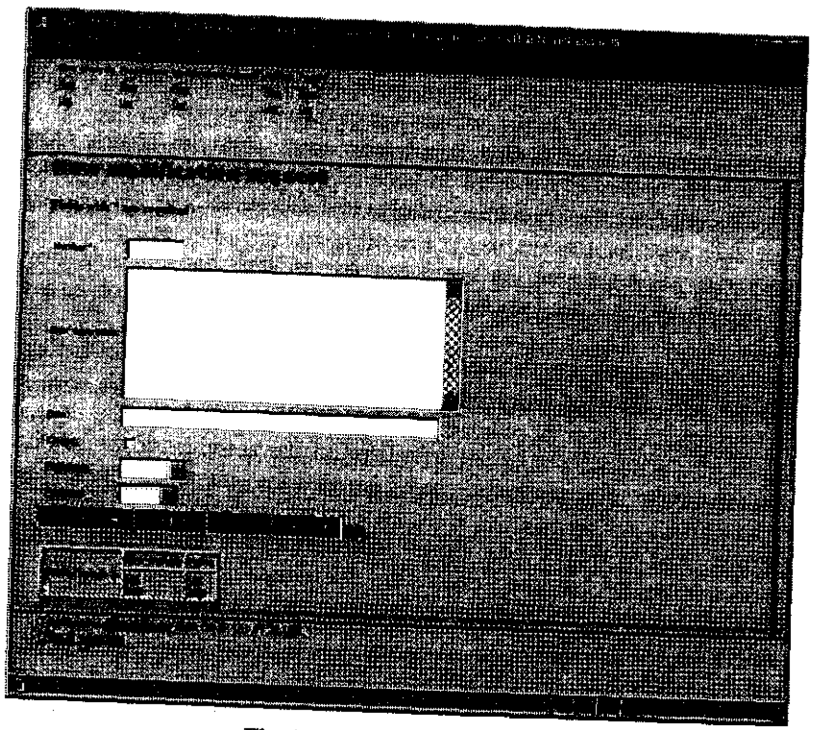

Fig. 1. KM-MANTIS Interface

Activities agents can also obtain new knowledge from their experience or taught learning. For instance, an activity agent learns which person usually carries out a specific activity or what techniques are most often used to perform an activity.

Furthermore, activities agents use case-based reasoning techniques in order to detect whether a similar change under analogous circumstances was previously requested. When this is the case the agent informs the users on how that problem was previously solved, taking advantage of the organization's experience.

Peopleware Community: Three profiles of people can be clearly differentiated in MP [9]: the maintenance engineer, the customer and the user. The Peopleware community has three types of agent, one per profile detected. One agent is in charge of the information related to staff (maintainers). This is the staff agent. Another manages information related to the clients (customers) and is called the client agent. The last one is in charge of the users and is termed the user agent.

The staff agent monitors the personal data of the employees, in which activities they have worked, and what product they have maintained. Of course, the agent also has current information about each member of the staff. Therefore it knows where each person is working at each moment.

The agent can utilise the information that it has to generate new knowledge. For instance, the staff agent calculates statistics to estimate the performance of an employee.

The client agent stores the information of each client, their requirements (including the initial requirements, if they are available) and requests. The client agent also tries to gather new knowledge. For instance, it tries to guess future requirements depending on previous requirements or it estimates the costs of changes that the client wants to make, warning him, for instance, of the high costs associated with a specific change request.

The user agent is in charge of knowing the requirements of the users of each product, their background and also their complaints and comments about the products. New knowledge could also be generated from this information, for example by testing to what degree the users' characteristics influence the maintenance of the product.

Each type of agent has a database containing the information that they need. In this case there is no community repository because there is no data common to the three types of agents.

3.2 Implementation Considerations

In order to manage the XML documents different middleware alternatives were studied, some being object-relational databases such as ORACLE 9, Microsoft SQL Server 2002 and Tamino which have been designed specifically for XML documents. Finally Tamino, a Software AG's product, was chosen, because KM-MANTIS needs to store a huge amount of XML documents and manage them efficiently. The fact that an object-relational database needs to translate XML to tables and vice versa considerably reduces its efficiency.

On the other hand, the platform chosen for creating the multiagent system is JADE [1] which is FIPA compliant. The agent communication language is FIPA ACL. Agents interchange information in order to take advantage of the knowledge that

4 Conclusions

Software maintenance is one of the most important stages of the software life cycle. This process takes a lot of time, effort, and costs. It also generates a huge amount of different kinds of knowledge that must be suitably managed.

This paper describes a multiagent system in charge of managing this knowledge in order to improve the MP. The system has different types of agents in order to deal with the different types of information produced during SMP. Agents generate new knowledge and take advantage of the organization's experience.

In order to facilitate the management of data and metadata or knowledge a XMI repositories have been used. XMI uses the MOF standard which enables the description of information at different levels of abstraction.

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