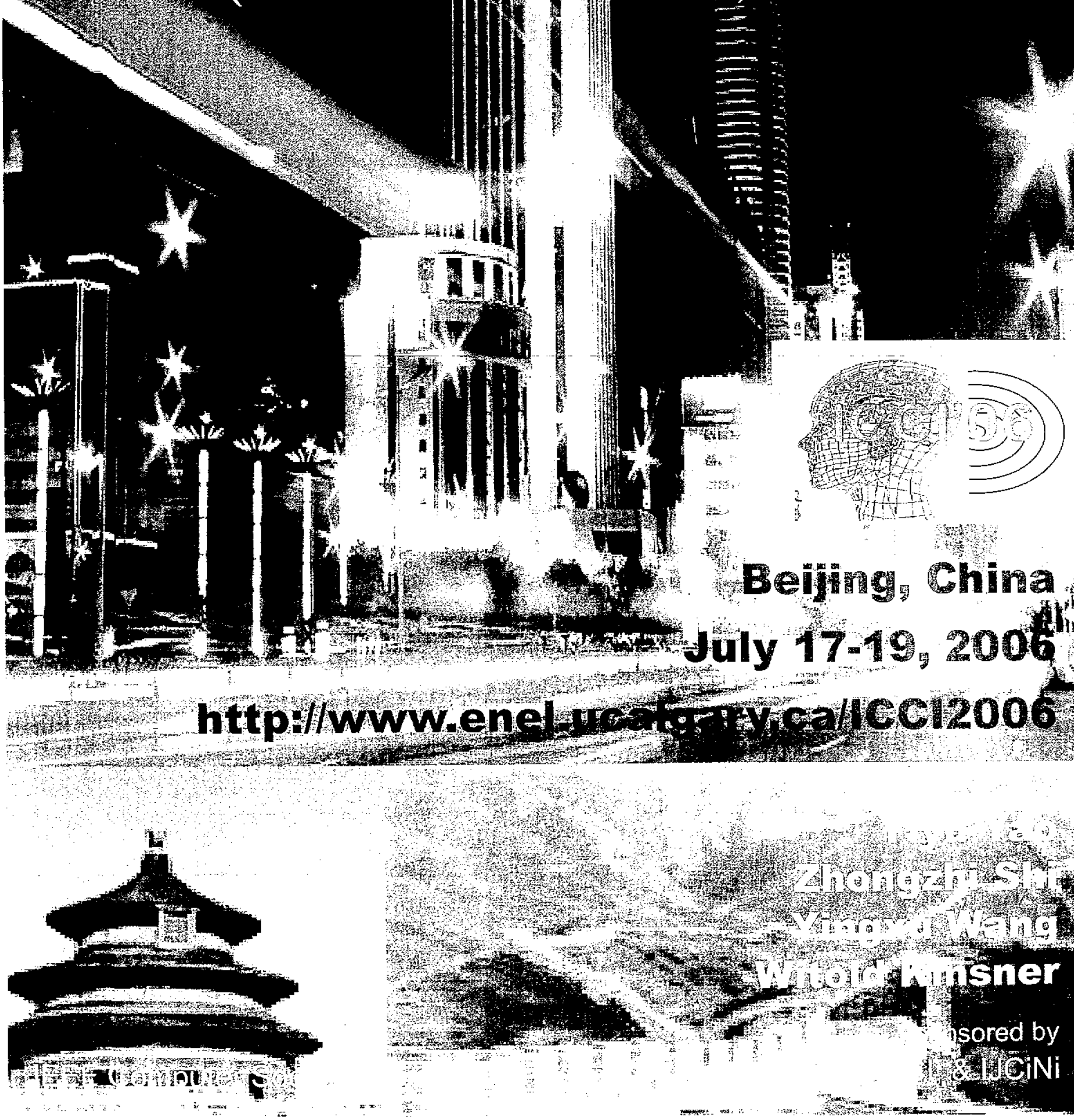
Fifth IEEE International Conference on

Cognitive Informatics

(ICCI 2006 Vol.I)



Beijing, China

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Zhongzhi Shi
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Yiyu Yao, Zhongzhi Shi, Yingxu Wang, and Witold Kinsner

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Preface

Welcome to the Fifth IEEE International Conference on Cognitive Informatics (ICCI 2006)!

Cognitive Informatics (CI) is a cutting-edge and multidisciplinary research area that tackles the fundamental problems shared by modern informatics, computation, software engineering, AI, cybernetics, cognitive science, neuro-psychology, medical science, philosophy, linguistics, life sciences, and many others. CI is the trans-disciplinary study of cognitive and information sciences, which investigates the internal information processing mechanisms and processes of the natural intelligence – human brains and minds – and their engineering applications.

The development and the cross fertilization among the aforementioned science and engineering disciplines have led to a whole range of extremely interesting new research areas. Following the first four successful conferences on Cognitive Informatics, ICCI'02 (Calgary, Canada), ICCI'03 (London, UK), ICCI'04 (Victoria, Canada), and ICCI'05 (Irvine, USA), ICCI'06 focuses on the theme of natural intelligence, autonomic computing, and neural informatics. The objectives of ICCI'06 are to draw attention of researchers, practitioners, and graduate students to the investigation of cognitive mechanisms and processes of human information processing, and to stimulate the international effort on cognitive informatics research and engineering applications. The ICCI'06 program encompasses 40 regular papers, 55 short papers, and 54 poster papers selected from 276 submissions from 18 countries based on rigorous reviews by program committee members and external reviewers. The program is enriched by 3 keynotes and 3 special lectures from prestigious scientists.

The growing field of CI covers many areas as follows in natural intelligence, autonomic computing, and neural informatics:

Natural Intelligence (NI)

- Informatics models of the brain
- Cognitive processes of the brain
- Internal information processing mechanisms
- Theories of natural intelligence
- Intelligent foundations of computing
- Descriptive mathematics for NI
- Abstraction and means
- Ergonomics
- Informatics laws of software
- Knowledge representation
- Models of knowledge and skills
- Language acquisition
- Cognitive complexity of software
- Distributed intelligence
- Computational intelligence
- Emotions/motivations/attitudes
- Perception and consciousness
- Hybrid (AI/NI) intelligence

Autonomic Computing (AC)

- Imperative vs. autonomic computing
- Reasoning and inferences
- Cognitive informatics foundations of AC
- Memory models
- Informatics foundations of software engineering
- Fuzzy logic
- Rough set theory
- Knowledge engineering
- Pattern recognition
- Artificial intelligence
- Software agent systems
- Decision theories
- Problem solving
- Machine learning
- Intelligent Internet
- Web contents cognition
- Nature of software
- Quantum computing

Neural Informatics (NeI)

- Neuroscience foundations of information processing
- Cognitive models of the brain
- Functional modes of the brain
- Neural models of memory
- Neural networks
- Neural computation
- Cognitive linguistics
- Neuropsychology
- Bioinformatics
- Biosignal processing
- Cognitive signal processing
- Gene analysis
- Gene expression
- Neural signal interpretation
- Visual information representation
- Visual information interpretation
- Sensational cognitive processes
- Human factors in systems

The ICCI'06 program as presented in the proceedings is the result of the great effort and contributions of many people. We would like to thank all authors who submitted interesting papers to ICCI'06. We acknowledge the professional work of the Program Committee and external reviewers for their effective review and improvement of the quality of submitted papers. Our acknowledgement also goes to the invaluable sponsorships of IEEE Computer Society, The IEEE ICCI Steering Committee, Chinese Academy of Sciences, IEEE Canada, IEEE CS Press, and The International Journal of Cognitive Informatics and Natural Intelligence (IJCiNi). We thank the keynote speakers and invited lecturers for presenting their visions and insights on fostering this emerging interdisciplinary area. We acknowledge the organizing committee members, particularly Dr. Y.Y. Yuan, Prof. G.Y. Wang, Prof. Z.G. Hou, and the ICCI'06 secretariats, Z.W. Shi, Y.H. Li, and all student volunteers who have helped to make the event a success.

Yingxu Wang
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COGNITIVE-BASED RULES AS A MEANS TO SELECT SUITABLE GROUPWARE TOOLS

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Abstract

Global software development projects have to deal with a variety of challenges with respect to communication and control. For this reason, processes that are crucially based on communication, such as requirement elicitation, have to be specially rethought to minimize critical situations. As requirement elicitation is a human-centred process, we propose using techniques from the field of cognitive psychology to define a new approach towards it. In short, we intend to reduce problems in communication by selecting a suite of elicitation techniques and groupware tools, according to stakeholders' preference in styles. In this article we introduce our approach and show the generation process of a set of preference rules of groupware tools.

1. Introduction

The development of software in scenarios where stakeholders are distributed throughout many geographically distanced sites is definitively installed in organizations but, on the contrary, research on methodologies to improve the development process is still a topic in expansion.

As a consequence of this dispersion, stakeholders must communicate with each others by means of specially designed technology, called groupware. By doing so, members of a distributed requirement elicitation process have to deal not only with the normal challenges of a requirement elicitation process [9, 15], but also with those derived from the lack of face to face interaction, the time difference between different sites and the cultural diversity of stakeholders, which are typical of distributed environments [8].

There are several research areas that have attempted to find solutions to communication problems in workgroups. One of them is Computer-Supported Cooperative Work (CSCW) which focuses on providing technology to enable communication, and also analyzes human behavior when working in a group. Another is Cognitive Informatics, an interdisciplinary area that applies concepts from psychology and other cognitive sciences to improving processes in engineering disciplines, such as informatics, computing, and software engineering [7, 20].

Since our main goal is to enhance interpersonal communication in geographically distributed teams, concepts from both areas will be used. On the one hand, people who are working at various different geographically sites communicate with each other using groupware, which is part of the studies in CSCW. Some examples of groupware used during multi-site developments are e-mails, newsgroups, mailing lists, forums, bulletin boards, shared whiteboards, document sharing, chat, instant messaging, and videoconferencing [8, 14]. On the other hand, communication between people involves aspects of human processing mechanisms that are analyzed by the cognitive sciences. In our proposal, we are particularly interested in using some techniques from the field of psychology, called Learning Style Models, which may be useful to select groupware tools and elicitation techniques according to the stakeholders' cognitive styles.

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Most of the related works which use learning styles in computer sciences concern educational purposes, such us their influence upon learning recursion [21], End-User Computing tools [5], or programming [19]; and they are also used to define frameworks for designing multimedia for computer science courses [4] or web-based courses in general [18]. On the contrary, few related works use psychological techniques to solve problems in Software Engineering. One work in this field is the use of cognitive styles as a mechanism for software inspection team construction [17], which describes an experiment to prove that heterogeneous software inspection teams give a better performance than homogeneous ones, where the heterogeneity concept is analyzed according to the participants' cognitive style. Although the concept of cognitive styles to classify people was used, our approach is not the same. As we have previously explained, we are not attempting to say which people seem to be more suitable to work together. On the contrary, we aim to give the best requirement elicitation techniques and groupware tools for an already chosen group of people.

Previously in [2] we have presented our model based on fuzzy logic and focused on the definition of strategies for the selection of requirement elicitation techniques. In this paper we focus on the selection of groupware tools, based on the stakeholders' cognitive aspects, and the definition of preference rules from a set of examples. To do so, in the following section we present common problems in GSD and introduce some concepts about technologies used to overcome distance, called groupware tools. Next, we introduce the learning style models, and present our general model based on fuzzy logic to select groupware tools. The last sections present the result of an application of our model to a set of real-life examples of stakeholders and address some conclusions.

2. GSD and groupware tools

As was mentioned before, the lack of face to face interaction makes the *loss of communication richness* one of the most cited problems in GSD, since stakeholders must interact by means of specially designed technology for collaboration, called groupware tools.

The most common groupware tools used during multi-site developments are: E-mails, Newsgroups and mailing lists, Electronic discussion or Forums, Electronic notice or Bulletin boards, Shared Whiteboards, Document sharing, Chat, Instant Messaging, Audio-conferencing, and Video-conferencing. [8, 14]

At first glance, groupware tools can be divided into *synchronous* and *asynchronous*, depending upon whether the users have to work at the same time or not [13]. Synchronous tools are, for instance, chat and instant messaging, while e-mails and forums are examples of asynchronous tools.

A second classification of groupware tools can be made according to the way in which they show the information. Some of them are based primarily on images, figures, and diagrams (shared whiteboards, videoconferencing); while others function by predominantly using words (chat, instant messaging, e-mails, newsgroups, mailing lists, forums).

According to previous works, the effectiveness of using synchronous and/or asynchronous collaboration is a topic often under discussion [8, 14]. As we were able to experiment by interviewing a group of stakeholders [1] we discovered that some people feel more comfortable using synchronous collaboration (such as instant messaging), while others feel that such technology is too intrusive and prefer using asynchronous tools (such as email). Similarly, some people tend to prefer working with tools based on graphics while others prefer verbal characteristics.

Currently, in distributed teams the selection of technology is usually made by managers that do not take the rest of the stakeholders into account. Our research focuses on analyzing the cognitive aspects of all the people participating in a virtual team and finding strategies for technology selection that can fit most of the stakeholders' preferences. In the next section we will introduce the notion of cognitive aspects and learning styles and how they can be used to improve communication in distributed teams.

3. Stakeholders' cognitive preferences

Since Cognitive Informatics relates cognitive and computer sciences in a bidirectional way [20], our research focuses on using cognitive theories (learning style models) to investigate a particular software engineering problem (the requirement elicitation process in distributed environments).

The learning style models (LSMs) are based on Jung's theory of psychological types, and are used to analyse and understand differences in human behaviour [17]. LSMs are instruments designed to measure human characteristics and explain differences between different people. They classify people according to a set of behavioural characteristics associated with the way they receive and process information, and their goal is to improve the manner in which people learn a given task.

Even when LSMs have been discussed in the context of analyzing relationships between instructors and students, we think that it is possible to take advantage of this kind of model and adapt it to virtual teams that deal with distributed elicitation processes. Since requirement elicitation is about learning the needs of the users [12] and users and clients also learn from analysts and developers (for instance, they learn how to use a software prototype, new vocabulary, etc.), so we can say that stakeholders play the role of student or instructor depending upon the moment at which the requirement elicitation process they are carrying out takes place [16].

The LSM we have chosen as a basis for our methodology is the one proposed by Felder-Silverman (F-S) [11], which classifies people into four categories, each of them further decomposed into two subcategories as follows: Sensing / Intuitive; Visual / Verbal; Active / Reflective; Sequential / Global. A graphical view of categories and subcategories is shown in Figure 1. Further detail about the characteristics of each subcategory can be found in [10, 11]

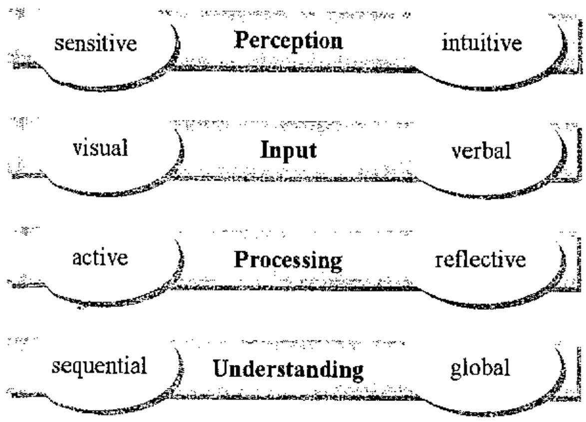

Figure 1: Felder and Silverman (F-S) categories and subcategories

3.1 A fuzzy model for supporting preferences

In order to support personal preferences towards groupware tools, in [1] a model based on fuzzy logic and fuzzy sets to obtain rules from a set of representative examples, in the manner of patterns of behaviour, has been proposed. Those patterns indicate the preferences of stakeholders in their daily use of groupware tools, according to their classification in the F-S model. In a similar way, we have proposed finding a suitable set of elicitation techniques according to the preferences for each category of the F-S model [2], but in this paper we will only present the first model, which concerns groupware tools preference rules.

The input variables of our fuzzy model are the four categories that correspond with the F-S model:

$$I = \{Active\text{-}Reflective,\ Sensing\text{-}Intuitive,\ Visual\text{-}Verbal,\ Sequential\text{-}Global\}$$

We have defined a domain (DDV) for each input variable by using the adverbs (and their corresponding abbreviations): Very (V), Moderately (M) and Slightly (S). which correspond respectively to strong, moderate and mild in the F-S model, but we have changed their names to avoid confusion with respect to the use of the first letter.

We have also expressed the results of the F-S test with a negative sign for the categories that appear first on the presentation of the characteristics (sensing, visual, active and sequential) and with a positive sign for the latter ones (intuitive, verbal, reflective, global). By doing so, the domain for each category has been defined as is shown in Table 1, while the definition domain function for the Active-Reflective category (similarly defined for the other three categories) is shown in Figure 2.

Table 1: Definition domain for F-S categories

	V	M	S	S	M	V	
Active	VAc	MAc	SAc	SRe	MRe	VRe	Reflective
Sensitive	VSe	MSe	SSe	SIn	MIn	VIn	Intuitive
Visual	VVi	MVi	SVi	SVe	MVe	VVe	Verbal
Sequential	VSq	MSq	SSq	SGl	MGl	VGl	Global

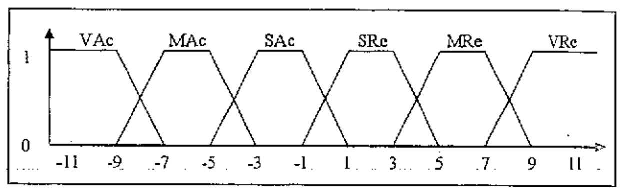

Figure 2: Definition domain for input variables of our fuzzy model

The output variable of our fuzzy model represents the groupware tool a person chooses as his or her prefered means of communication:

$$O_1 = \{Groupware\ Tool\}$$

and its domain would be all those groupware tools that can be used during a requirement elicitation process, for instance:

$$DDV_{Groupware\ Tool} = \{email,\ chat,\ videoconference\ ...\}$$

Once the model is defined, we need to obtain examples to which the machine learning algorithm can be applied. To do so, our first step is to ask people to fill in a test that will provide us with their learning style.

Later, we need strategies to discover stakeholders' preferences when using groupware tools. We can do that by asking people in a direct way which groupware tool they feel more comfortable using. This is simple because people use email, instant messaging, and chat quite normally in their lives and even if they have never used videoconferencing or shared whiteboards they can easily imagine how they would feel using them. For this reason, a simple question directed towards a group of stakeholders is enough for us to ascertain the output variable of our first model.

Once the mechanisms for obtaining examples are defined, we can obtain a set of examples $\theta = \{e_1, e_2, ..., e_m\}$, where each example would have the form $e_i = \{(x_{i1}, x_{i2}, x_{i3}, x_{i4}), y_i\}$. For instance {(MIn, MVi, VAc, SSq), videoconference} would be a possible instantiation.

Then, once we have an appropriate number of instances for our set of examples, we can apply a machine learning algorithm to generalize common features between examples. For instance, we have chosen the algorithm proposed in [6] that finds a finite set of fuzzy rules able to reproduce the input-output system's behaviour, as follows:

- Convert each example into one rule
- Remove those rules that are the same
- Analyze every rule to (where it is possible) extend it and generate a definitive rule.

Using this machine learning algorithm over a set of examples that represent the preferences of many stakeholders, we expect to obtain rules such as "*if X1 is VVi then Y1 is Instant Messaging*", which is interpreted as: "If a user has a strong preference for the Visual subcategory, the groupware tool that this person would prefer is Instant Messaging".

Once we have obtained the set of rules and we know the personal preferences of each person who works in a virtual team, it is possible to choose the best suite of groupware tools for that group of people by analyzing the results, with an appropriate tool that automates the process.

In the next section we will show the results of the application of a survey to professionals in computer sciences and users, and the preference rules we have obtained.

4. A case study

In order to gain useful information to obtain preference rules, we designed a survey to inquire into the stakeholders' personal preferences and to look for patterns of behavior. The subjects under study were software developers and users who were accustomed to groupware tools and had some proficiency using at least two of them (email and instant messaging). Some of the interviewees worked for private organizations that develop software for third parties; others were the academic staff of universities that cooperate with software development projects and users of software systems in different organizations; and a minimal number were students from the third year of a computer sciences degree.

The first task for everyone was to fill in the learning style test and send us the results. Then we asked them to fill in a survey about their preferences during their daily work with groupware tools. The questions we had prepared explored preferences by asking people to give a rank to a set of groupware tools. In order to be able to analyze the differences, we asked separate questions about preferences of working with only one partner or with a group, but in this article we only present the results obtained for answers that consider a single partner. Also, to make the example understandable we propose analyzing only the preferences for email and instant messaging. The selection of such groupware tools is due to the fact that all the people who answered the survey use both in their daily work and this does not occur with the rest of the tools.

76 people returned the survey, which were translated into 76 examples in our model. As a consequence of the application of the machine learning algorithm, 20 preference rules were obtained, as follows:

1. If X1 not in {MAc,SRe) and X4 in {VSq,MSq,VGl) then IM
2. If X1 not in {MAc,SRe) and X3 not in {MVi) and X4 not in {SGl,MGl) then IM
3. If X1 not in {SAc,SRe) and X2 not in {VSe) and X4 not in {MSq) then IM
4. If X1 in {VAc,SAc,VRe) and X2 not in {SSe) and X4 not in {MGl) then IM
5. If X1 not in {MAc) and X2 not in {SSe,VIn) and X4 not in {VSq,SGl) then IM
6. If X1 in {VAc,SAc,VRe) and X3 not in {VVi) and X4 not in {SSq,MGl) then IM
7. If X1 not in {MAc,SRe) and X2 not in {VIn) and X4 not in {SSq,SGl) then IM
8. If X1 not in {MAc,SAc) and X4 in {MSq,MGl,VGl) then IM
9. If X1 not in {MAc,SAc) and X2 not in {VSe) and X4 not in {SSq) then IM
10. If X1 not in {SAc,SRe) and X2 not in {VSe,SSe) then IM
11. If X1 in {VAc,MAc,VRe) and X4 not in {MSq,SSq) then IM
12. If X4 in {VSq,VGl) then Email
13. If X1 in {VAc,MAc,VRe) and X2 not in {MSe) and X4 in {VSq,MSq,VGl) then Email
14. If X1 in {SRe,VRe) and X2 not in {SSe) and X4 in {VSq,SGl,VGl) then Email
15. If X1 in {MRe,VRe) and X2 not in {MSe) and X4 not in {MSq) then Email
16. If X1 not in {MAc,SRe) and X2 not in {MSe,SSe) and X4 not in {SGl) then Email
17. If X1 not in {SAc,SRe) and X2 in {VSe,MIn,VIn) then Email
18. If X1 in {VAc,SAc,VRe) and X2 not in {VSe,SIn) and X3 not in {MVi) and X4 in {VSq,SGl,VGl) then Email
19. If X1 not in {MAc,SRe) and X2 not in {MSe) and X3 not in {VVi) and X4 in {VSq,SSq,VGl) then Email
20. If X1 in {VAc,SRe,VRe) and X2 in {SSe,MIn,VIn) and X4 not in {SGl,MGl) then Email

To interpret such rules let us explain the meaning of the last one:

If X1 in {VAc,SRe,VRe} and X2 in {SSe,MIn,VIn} and X4 not in {SGl,MGl} then Email

which can be interpreted as: If a user has a strong preference for the Active subcategory or a slight or strong preference for the Reflective subcategory, and a slight preference for the Sequential subcategory or moderated or strong preference for the Intuitive subcategory and his preference for the Global subcategory is not slight or moderate, he would prefer using Email (no matter which would be his preference for the Visual-Verbal catagory). The rest of the rules can be interpreted in a similar way.

The set of preference rules previously obtained is independent of any project, and can be applied in different circumstances that involve groupware tool selection. This is because information about preferences has been gathered independently of a given domain. We shall now illustrate how these rules can be used to select groupware tools for a given group of stakeholders in a particular project, as is shown in Figure 3.

Let us suppose that stakeholders S1 and S2 have to interact to define a new set of requirements for the new system, and they can collaborate by means of different groupware tools that are available in the project. Also, let us suppose that we know their learning style. Once the "virtual team" is determined, it is possible to suggest which groupware is better for them.

To do so we count on a database of preference rules about groupware tools and strategies to combine the known information about the stakeholders and their cognitive styles.

Let us suppose that stakeholder S1's learning style is **(MAc, MSe, SVi, SGl)** and stakeholder S2's learning style is **(MAc, VSe, VVi, VSq).**

When both styles are confronted with the preference rules, stakeholder S1 fits rule number 3: "If X1 not in {SAc, SRe} and X2 not in {VSe} and X4 not in {MSq} then IM", and number 10: "If X1 not in {SAc,SRe} and X2 not in {VSe,SSe} then IM" so the groupware tool that s/he would prefer is Instant Messaging.

Similarly, stakeholder S2 fits the rule number 17: "If X1 not in {SAc,SRe} and X2 in {VSe,MIn,VIn} then Email".

Taking into account the strategy suggested in [3] the preference of stakeholder S2 should weigh more than stakeholder S1's. This is because, as he has a strong preference for the Visual and Sequential subcategory, the improvement he could experiment is expected to be more significant than for stakeholder S2, who has only moderate and slight preferences and can adapt him/herself more easily.

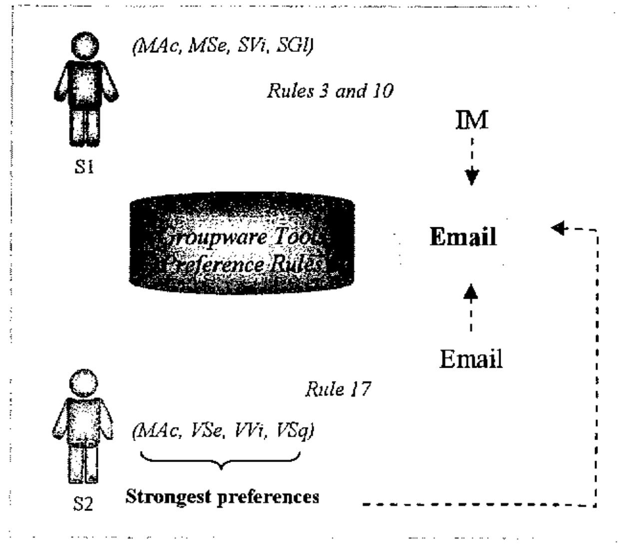

Figure 3: Groupware selection by means of cognitive-based preference rules

5. Conclusions and future work

Organizations that develop software currently have the possibility of saving costs by adopting a distributed structure where team members communicate through groupware tools.

The selection of appropriate technology and requirement elicitation techniques in such environments is a subject of research, because when stakeholders feel comfortable with the technology and methodologies they use, information gathered during elicitation is expected to be more accurate.

Taking this into account, we have developed a methodology to select requirement elicitation techniques and groupware tools according to the learning styles of the members of a given virtual team.

By developing our approach we realised that, although psychological techniques are not often applied to the improvement of software engineering processes, they could give people in charge of software development projects, the chance of counting on a widely proved theoretical basis, which also has the advantage of being easily understood by different types of stakeholders, whether they are professionals in informatics or otherwise.

Currently we are working on the validation of the preference rules we have obtained. To do so we are carrying out new experiments in academic and organizational environments. We are also working on empirical approaches to obtain preference rules for requirement elicitation techniques.

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