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Singapore, May 2005
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1 Part I

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Computational Science and Its Applications – ICCSA 2005

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Preface

The four-volume set assembled following *the 2005 International Conference on Computational Science and Its Applications*, ICCSA 2005, held in Suntec International Convention and Exhibition Centre, Singapore from 9 May 2005 till 12 May 2005, represents the fine collection of 540 refereed papers selected from nearly 2700 submissions.

Computational science has firmly established itself as a vital part of many scientific investigations, affecting researchers and practitioners in areas ranging from applications such as aerospace and automotive, to emerging technologies such as bioinformatics and nanotechnologies, to core disciplines such as mathematics, physics, and chemistry. Due to the sheer size of many challenges in computational science, the use of supercomputing, parallel processing, and sophisticated algorithms is inevitable and becomes a part of fundamental theoretical research as well as endeavors in emerging fields. Together, these far-reaching scientific areas contribute to shape this conference in the realms of state-of-the-art computational science research and applications, encompassing the facilitating theoretical foundations and the innovative applications of such results in other areas.

The topics of the refereed papers span all the traditional as well as emerging computational science realms, and are structured according to six main conference themes:

– Computational Methods and Applications
– High-Performance Computing, Networks and Optimization
– Information Systems and Information Technologies
– Scientific Visualization, Graphics and Image Processing
– Computational Science Education
– Advanced and Emerging Applications

In addition, papers from 27 workshops and technical sessions on specific topics of interest, including information security, mobile communication, grid computing, modeling, optimization, computational geometry, virtual reality, symbolic computations, molecular structures, Web systems and intelligence, spatial analysis, bioinformatics and geocomputation, to name a few, complete this comprehensive collection.

The warm response of the great number of researchers to the offer to present high-quality papers in ICCSA 2005 took the conference to record heights. The continuous support of computational science researchers has helped build ICCSA into a firmly established forum in this area. We look forward to building on this symbiotic relationship together to grow ICCSA further.

We recognize the contribution of the International Steering Committee and we deeply thank the International Program Committee for their tremendous support in putting this conference together, nearly 900 referees for their diligent work, and the Institute of High Performance Computing, Singapore for its generous assistance in hosting the event.

We also thank our sponsors for their continuous support without which this conference would not have been possible.

Finally, we thank all authors for their submissions and all invited speakers and conference attendees for making the ICCSA conference truly one of the premium events in the scientific community, facilitating the exchange of ideas, fostering new collaborations, and shaping the future of computational science.

May 2005

Marina L. Gavrilova
Osvaldo Gervasi

on behalf of the co-editors

Vipin Kumar
Antonio Laganà
Heow Pueh Lee
Youngsong Mun
David Taniar
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Organization

ICCSA 2005 was organized by the Institute of High Performance Computing (Singapore), the University of Minnesota (Minneapolis, MN, USA), the University of Calgary (Canada) and the University of Perugia (Italy).

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Table of Contents – Part I

Information Systems and Information Technologies (ISIT) Workshop

Mobile Communications (Mobicomm) Workshop

Authentication Authorization Accounting (AAA) Workshop

Computational Geometry and Applications (CGA'05) Workshop

Virtual Reality in Scientific Applications and Learning (VRSAL 2005) Workshop

Molecular Structures and Processes Workshop

Pattern Recognition and Ubiquitous Computing Workshop

Table of Contents – Part II

Approaches or Methods of Security Engineering Workshop

A Cognitive Perspective for Choosing Groupware Tools and Elicitation Techniques in Virtual Teams

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Abstract. Nowadays groupware tools, as well as requirement elicitation techniques, are chosen without a clear strategy that takes into account stakeholders' characteristics. When the chosen technology is not appropriate for all the group members it might affect their participation and the quality of the requirement elicitation process itself.

In order to improve communication, and therefore stakeholders' participation, we propose choosing an appropriate set of groupware tools and elicitation techniques according to stakeholders' preferences. This paper presents a prototype tool that makes a selection based on cognitive techniques.

1 Introduction

Multi-site development is a current matter of study and discussion, since global development is becoming a usual style of software production. On the other hand, it is a fact that during a traditional requirement elicitation process, stakeholders must face many problems that have been detected and analyzed for decades [3, 7, 16]. Moreover, when participants are distributed geographically new problems often arise. For example, communication and coordination are more difficult because of differences in culture, timetable, language, etc. [2, 6].

CSCW and Cognitive Informatics are two areas of research that try to minimize the impact of these problems. On the one hand, CSCW (Computer-Supported Cooperative Work), addresses research into experimental systems and the nature of organizations [12], taking into account human behaviour and the technical support people need to work as a group in a more productive way. On the other hand, Cognitive Informatics [5, 21] is an interdisciplinary research area that tackles the common root problems of modern informatics, computation, software engineering, artificial intelligence (AI), neural psychology, and cognitive science. This research area, initiated few years ago, focuses on the nature of human processing mechanisms, especially respect to information acquisition, memory, categorization, retrieve, generation, representation, and communication [21].

O. Gervasi et al. (Eds.): ICCSA 2005, LNCS 3480, pp. 1064 – 1074, 2005.

Cognitive science is related to computer science in many research areas (artificial intelligence, expert systems, knowledge engineering, etc). Cognitive informatics principles of software engineering encompass some basic characteristics of the software development process that include the difficulty of establishing and stabilizing requirements, changeability or malleability of software, etc. [22].

Since our main goal is to enhance interpersonal communication in geographically distributed teams, we are particularly interested in some techniques from the field of psychology called Learning Style Models (LSM). LSM classify people according to the way they perceive and process information, and analyse relationships between students and instructors. Considering that during requirement elicitation a person acts like student and instructor alternatively; we propose using LSM as a base for improving the requirements elicitation process. In doing so, we propose choosing a set of groupware tools and requirement elicitación techniques that support not only the communication itself but also the stakeholders' preferences.

In the following two sections we present some basic concepts about groupware tools and learning style models. In section four, we describe a model that supports stakeholders' personal preferences in geographically distributed processes, and a prototype tool that uses the previous model to automate the selection process. Finally, we present some related works and conclusions.

2 What Is Groupware?

Generally speaking, groupware is software to enable communication between cooperating people who work on a common task. It may include different communication technologies, from simple plain-text chat to advanced videoconferencing [11]. To avoid ambiguities we will refer to every simple piece of communication technology as a groupware tool, and to the systems that combine them as groupware packages.

The most common groupware tools used during multi-site developments are e-mails, newsgroups, mailing lists, forums, electronic notice boards, shared whiteboards, document sharing, chat, instant messaging, and videoconferencing. [6, 11, 13].

At first glance, groupware tools can be divided into *synchronous* and *asynchronous*; whether the users have to work at the same time or not [14]. Examples of synchronous tools are chat and videoconferencing, while e-mails and document sharing are examples of asynchronous. A second classification can be made according to the way in which they show the information: based primarily on images, figures, diagrams, etc. (shared whiteboards, videoconferencing) or based on words (chat, instant messaging, e-mails, forums, etc.).

Virtual teams choose a combination of groupware tools according to their possibilities or the kind of activities they are carrying out. They can choose between using a groupware package (that offers a combination of tools) and using individual tools in an ad-hoc way. Respect to using synchronous or asynchronous tools in group work, some authors note that both types of communication are important. In the one hand, asynchronous collaboration allows team members to construct requirements individually and contribute to the collective activity of the group for a later discussion. On the other hand, real time collaboration and discussions give the stakeholders the chance of getting instant feedback [13]. However, according to the classification of styles presented previously, people would have preferences for one or the other, in the same way that some people would prefer working with tools based on visual or verbal characteristics.

3 Learning Style Models

A learning process involves two steps: *reception* and *processing* of information. During the first step, people receive external information –which is observable through senses– and internal information –which emerges from introspection–, then they select a part to process and ignore the rest. Processing involves memorization or reasoning (inductive or deductive), reflection or action, and introspection or interaction with others [8, 9].

Learning Style Models (LMS) classify people according to a set of behavioural characteristics pertaining to the ways they receive and process information and this classification is used to improve the way people learn a given task.

These models have been discussed in the context of analyzing relationships between instructors and students. We take advantage of this model and discussions by adapting their application to a virtual team that deals with a distributed requirement elicitation process. To do so, we consider an analogy between stakeholders and roles in LSM since during the elicitation process everybody "learns" from others [17], so that stakeholders play the role of student or instructor alternatively, depending on the moment or the task they are carrying out.

After analyzing five LSM in [17] we found out that every item in the other models was included in the model proposed by Felder-Silverman [9], so that we may build a complete reference framework choosing this as a foundation.

The Felder-Silverman (F-S) Model classifies people into four categories, each of them further decomposed into two subcategories. Characteristics of each subcategory are:

- *Sensing* (concrete, practical, oriented toward facts and procedures) or *Intuitive* (conceptual, innovative, oriented toward theories and meanings);
- *Visual* (visual representations of presented material – pictures, diagrams, flow charts) or *Verbal* (written and spoken explanations);
- *Active* (working by trying things out, working with others) or *Reflective* (thinking things through, working alone);
- *Sequential* (linear, orderly, learn in small incremental steps) or *Global* (holistic, systems thinkers, learn in large leaps).

People are classified by a multiple-choice test that gives them a rank for each category. Depending on the circumstances people may fit into one category or the other, being, for instance, "sometimes" active and "sometimes" reflective, so preference for one category is measured as *strong*, *moderate*, or *mild*. Only when there is a strong preference, people can be catalogued as a member of a certain group.

The test, proposed by Barbara Soloman and Richard Felder, is available at http://www.engr.ncsu.edu/learningstyles/ilsweb.html.

4 A Personal Preference-Based Model to Enhance Distributed Elicitation

A first step, before proposing a methodology for supporting distributed elicitation, is determining the aspects that have to be considered and the way in which they relate to each other. With the aim of recommending a set of suitable groupware tools and elicitation techniques during a particular elicitation process, we have defined a model, which is depicted in Figure 1, whose primary concepts are described in Table 1.

Table 1. Main concepts of our personal preference-based model

Concept	Description
Virtual Team	Virtual team [19] virtual community [10], distributed group [15] are terms used to refer to a group of people who work together on a project. Their main characteristic is that people are distributed over many sites, and they use information technology to communicate and coordinate efforts. In our model the common project or task carried out is the requirement elicitation process, which is the process of "extract and inventory the requirements from a combination of human stakeholders" [20].
Stakeholder	Typical stakeholders are users (those who will operate the system), customers (those who have commissioned the system), system developers, etc. [20] Each person in a virtual team is supposed to play (at least) one *Role* during the elicitation process, and, as it is a person, he or she has some *Personal Characteristics* that tell us about his or her preferences when he/she perceives and process information.
Groupware Tools	As we have mentioned before, groupware is software to enable communication. According to the way in which they show the information, groupware tools have different *Representation Modes* and different *Interaction Modes*.
Elicitation Techniques	Elicitation is fundamentally a human activity where communication plays a transcendental role [20]. The election of elicitation techniques plays a very important role in distributed teams. Since face-to-face interaction is not possible, techniques have to be adapted to be used in combination with groupware. Some techniques that seem to be adaptable to the distributed elicitation process are question and answer methods, customer interviews, brainstorming, idea reduction, storyboards, prototyping, questionnaires, and use cases [15]. Like groupware tools, elicitation techniques have different *Representation Modes*.
Representation Mode	The way groupware tools and elicitation techniques present the information. For instance, it can be based on images or based on words.
Interaction Mode	The way people interact with others depends on the characteristics of the groupware tools. For instance, interaction can be synchronous or asynchronous.
Personal Characteristics	It is information about personal characteristics and preferences of stakeholders. For instance the result of the classification of Felder-Soloman test is information about his or her preferences when perceiving and processing information.
Role	It represents information about the role that stakeholders play during the requirement elicitation process. Examples of *roles* are end-user, client, analyst, project manager, etc.

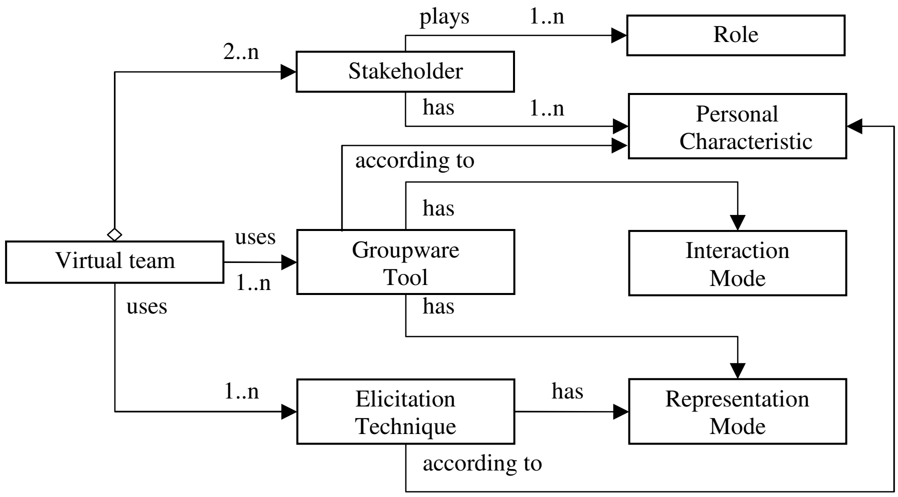

Fig. 1. A model to support personal preferences in a virtual community

Relationships between previous concepts can be expressed generally as:

- A *Virtual Team* represents a group of *Stakeholders* that work cooperatively on a common task (which in our case is the Requirement Elicitation Process).
- *Stakeholders* play *Roles* that imply rights and responsibilities associated to their job. In our case the roles involved in the elicitation process are: users, clients, managers, analysts, project managers, etc.
- *Stakeholders* communicate with each other using some *Groupware Tools* and build different models of a problem using a set of *Elicitation Techniques*.
- *Groupware Tools*, as well as *Elicitation Techniques*, are supposed to be chosen according to the stakeholders' *Personal Characteristics*, in order to make them feel comfortable and improve their performance.
- Each *Groupware Tool* has a *Representation Mode* (verbal or visual) and an *Interaction Mode* (synchronous or asynchronous) which are important in deciding the suitability for a stakeholder's personal preferences.
- In a similar way, each *Elicitation Technique* has a predominant *Representation Mode* (verbal, visual, or a possible good combination of both) that we will take into account to suggest their use or non-use.

4.1 A Cognitive Approach to Choose Groupware Tools

In order to support personal preferences, in [17], we have proposed a classification of the most commonly used groupware tools focusing on Visual/Verbal and Active/Reflective categories of the F-S model. The classification is based on the description and the strategies suggested by Felder and Silverman for each subcategory.

Figure 2 shows the results of such classifications. The sign "++" is used to indicate those groupware tools which are more suitable for people with a strong preference for a given subcategory. The sign "+" indicates that a groupware tool would be mildly preferred by a stakeholder with those characteristics. Finally, the sign "-" suggests that a particular groupware tool would be "not suitable" for that subcategory.

		Visual	Verbal	Active	Reflective
Asynchronous Tools	E-mails	+	++	-	++
	Mailing lists, Newsgroups	-	++	-	++
	Asynch. shared whiteboards	++	-	-	++
	Forums	-	++	-	++
Synchronous Tools	Instant messaging	+	++	++	-
	Synch. shared whiteboards	++	-	++	-
	Chat	-	++	++	-
	Videoconferencing	++	++	++	-

Fig. 2. Characterization of groupware tools based on F-S model

To choose a set of groupware tools for a given group of stakeholders we have suggested representing the information we know about each participant in a two-way matrix [17]. By doing so, we can have a view of stakeholders' preferences in general and, according to the quadrant that contains more instances, choose those groupware tools that adapt to most people in the group. Figure 3 shows an example of such a matrix.

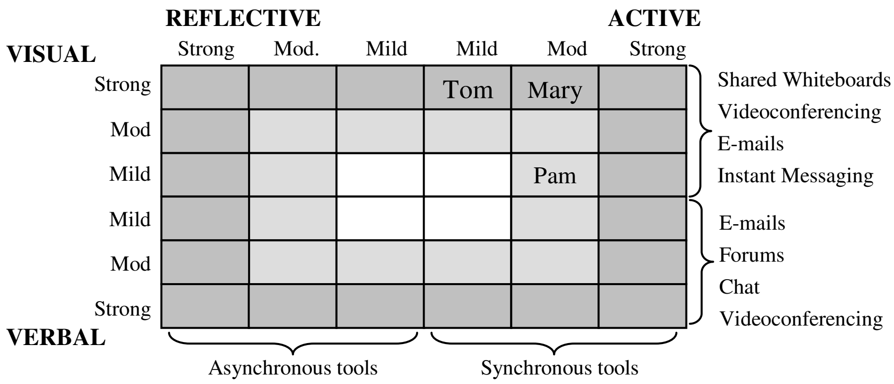

Fig. 3. Choosing a set of groupware tools according to F-S Model categories

In order to obtain a set of rules that tell us which groupware tool is more suitable according to the stakeholder's cognitive style, we have presented a model based on fuzzy logic and fuzzy sets [1]. The model takes four inputs (X_1, X_2, X_3, X_4), which are the preferences for each category of the F-S Model, and an output variable (Y) that is the preference of a stakeholder for one of a given set of groupware tools.

For each input variable we have defined a domain using the adverbs (and their correspondent abbreviations): Very (*V*), Moderate (*M*) and Slight (*S*), which correspond to *strong*, *moderate* and *mild*, respectively, in the F-S model. We have changed their names to avoid confusion with respect to the use of the first letter, so that the definition domain for the category Reflective-Active, for example, would be: Very reflective (VRe), Moderately reflective (MRe), Slightly reflective (SRe), Slightly active (SAc), Moderately active (MAc), Very active (VAc).

Using a machine learning algorithm it is possible to obtain rules such as: *if X_1 is VAc and X_3 is VVi then y is IM;* which is interpreted as: *"If a user has a strong preference for the Active subcategory and a strong preference for the Visual subcategory, the tool that this person would prefer is Instant Messaging"*

In a similar way it is possible to find a suitable set of elicitation techniques according to the preferences for each category of the F-S model.

4.2 Automation of the Selection Process

With the aim of finding a set of groupware tools and elicitation techniques that are suitable for a given group of stakeholders, we have designed a prototype tool – based on the model previously explained – that do it in an automatic way. Its mechanism can be simply explained as follows:

1 Stakeholders are asked to fill in a multiple-choice test so as to know their preferences. This information is maintained throughout the cooperative process.
2 Once a group of stakeholders is defined, our tool analyses their personal preferences using the sets of rules previously generated.
3 As a result, the tool returns the most suitable groupware tools and elicitation techniques for that group of people.

The tool's architecture has been designed basically on three layers: (1) a lower layer –*Persistent Data*– keeps the information concerning personal preferences of stakeholders, rules of suitability preferences-groupware tools and rules of suitability preferences-elicitation techniques; (2) the middle layer –*Application Logic*– contains those components that interact with the database and interface layers in order to find information and, by applying the appropriate algorithms, analyses it and produces a suitable answer; and (3) the upper layer –*User Interface*– contains all those components with which users of the tool interact.

Figure 4 shows a screen of our prototype tool where three stakeholders (Mary, Tom and Pam) are interacting. Some information about their predominant personal characteristics is shown on the upper right hand side of the screen. On the bottom there are two lists of suggested groupware tools and elicitation techniques that would be most suitable for them.

Our tool is currently under test and validation by categorizing people with different profiles and from different organizations. First experiences would indicate that results might be considered to guide elicitation; however further validation is needed to reach more conclusive results.

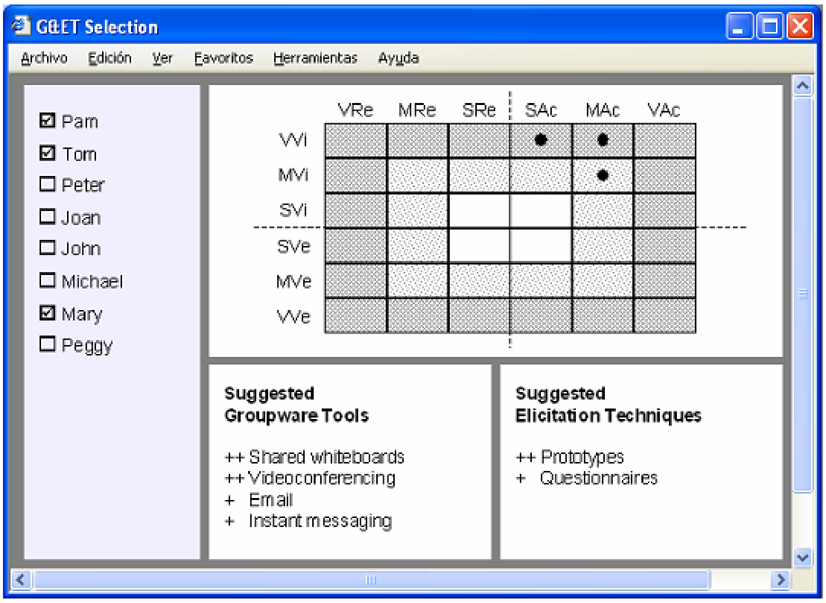

Fig. 4. An interface that shows the suggestions for a particular group of stakeholders

5 Related Work

There are some previous works about analysis of groupware tools and effectiveness in distributed teams. For instance in [6] it is described a case study of a real multi-site organization, where stakeholders use a mix of synchronous and asynchronous tools (teleconferencing, document sharing, email.) to interact. The authors collected data from inspecting documents, observed requirements meetings, and performed semi-structured interviews with stakeholders. Some problems detected for stakeholders are: (1) lack of informal or face-to-face communication; (2) difficulty in sharing drawings on a whiteboard during spontaneous discussions.

A second example is an exploratory empirical study about effectiveness of requirement engineering in a distributed setting, presented in [15]. Students from different graduate Software Engineering courses played the role of customers or engineers in separate groups, using a previously selected set of groupware tools (audio-conferencing, chat, email). They were restricted to do just four planned audio-conferencing meetings but the use of other technologies was unrestricted. Participants playing the role of software engineers wrote a Software Requirements Specification (SRS) that was analyzed with a set of metrics to assess document quality. Results concluded: (1) students who played the role of software engineers chose the elicitation techniques according to their previous experience; (2) groups producing high quality SRS were those that had only used the synchronous tools and did not need to use asynchronous elicitation methods.

Results in both cases have interesting points to be analyzed from a cognitive perspective. Why did students who wrote the highest quality SRS documents not need to use email to communicate with their customers? May be their personal characteristics were suitable for synchronous tools, while those who needed email interaction needed more time to think and prepare questions or answers so that synchronous communication was not the best way of communication for them; or may be they needed "to see" the words written, and audio-conferencing was not appropriate. In addition, stakeholders that mentioned the need to use a whiteboard to draw during discussions in [6], indicates a strong preference for visual subcategory.

Related work concerning selection of elicitation techniques is found, for instance, in [4], where the author focuses on the fact that elicitation techniques are chosen without having a valid guide to select the best one. The author comes to this conclusion after presenting a survey of works about theories, empirical analysis and comparisons between different elicitation techniques. Finally, he does not propose a definitive solution to the problem, but he remarks some important aspects for us, like how to measure the adequacy of elicitation techniques, how metrics are defined, etc.

Relative to the use of cognitive styles in software engineering there is a work about a mechanism for software inspection teams construction [18]. The paper describes an experiment that aims to prove that heterogeneous software inspection teams have better performance than homogeneous ones. Heterogeneity concept is analyzed according to the cognitive style of participants. To classify the possible participants they use the MBTI (Myers-Briggs Type Indicator) which is a tool similar to the F-S model we have presented so far. A difference between both approaches is that they focus on choosing people, according to their personal characteristics, to form the best group of inspectors, while our approach looks for the best technologies and methodologies according to personal preferences of a given group of stakeholders.

6 Conclusions

Global or multi-site software development seems to be more common every day. Organisations have adopted a decentralised, team-based, distributed structure where members communicate through groupware tools.

As the quality of requirements depends on the selection of appropriate technology, we think that by improving the communication during the elicitation process, the elicitation process itself will be also improved. Having this in mind, we have proposed a model and its supporting tool to recommend the more suitable elicitation techniques and groupware tools according to the stakeholders' learning preferences.

An aspect that needs further discussion is the possibility of solving conflicts when stakeholders' preferences seem to be opposite. We are working on that restriction. Additionally, we are using this tool in academic and industrial environments, to evaluate its effectiveness in real situations.

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