WEBMEETING - A GROUP DECISION SUPPORT SYSTEM FOR MULTI-CRITERIA DECISION PROBLEMS

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Abstract – *WebMeeting* is a Group Decision Support System designed to support distributed and asynchronous meetings. It aims at helping geographically distributed people and organisations in solving multi-criteria decision problems, by allowing their participation in the decision process through the Internet. This paper presents the *WebMeeting* architecture, as well as its main functionalities, namely the selection of alternatives, argumentation, voting techniques and meeting setup.

Keywords: Web-based Group Decision Support; Argumentation; Multiple Criteria Decision Making.

I. INTRODUCTION

Group decision-making plays an important role in today's organisations. The new economy, along with increased competition, requires decisions to be taken quickly but still keeping high levels of quality. In order to make better choices, decisions are often taken by groups of individuals coming from one or more organisations.

Companies are frequently faced with the evaluation and selection of alternatives. Usually these decisions are not trivial at all, considering that they may involve multiple and conflicting criteria. Some classic examples of this kind of problems are:

- buying cars for a fleet, considering criteria such as price, safety, maintenance costs, power, maximum speed, comfort, options;
- choice of the location to install a nuclear plant, taking into account criteria such as the capacity, population in the area, environmental impact, building and operational costs.

Up to now, most of the research in the area of multiple criteria decision making has concentrated on methods for supporting individual decision makers rather than groups [1]. When a multi-criteria problem is solved by a group of individuals, additional issues have to be considered: the participants may be disperse around the world; probably they will not be available for setting up a connection at the same time; and in some way or another, they have to agree on the "best" choice.

Some authors claim that the preferences of the different elements could be aggregated by using mathematical models and computations [2][3][4]. Others suggest that Group Decision Support Systems tools should include a multi-criteria module [5]. Somehow in this line, the *WebMeeting* approach proposes the integration of a multi-criteria module with an argumentation module, as a way to allow the participants to express their individual preferences and present arguments in favour / or against the alternatives (preferences being captured by the system through the individual multi-criteria module) [6].

The structure of this paper is the following: section II presents a short state-of-the-art on GDSS (Group Decision Support Systems); section III describes the *WebMeeting* prototype; and finally section IV presents some conclusions and proposes some lines for future research.

II. GROUP DECISION SUPPORT SYSTEMS

The concept of "group decision" exists since the beginning of the 70s, although the specific term (GDSS – Group Decision Support Systems) was not yet known by that time. In 1971 the EMISARI system was installed in the U. S. Office of Emergency, to help a group of people (between 100 and 200 persons), distributed along the country, to make decisions in situations of crisis. The configuration of that seminal experience was very close to the currently used definition of "decision room" [7].

The term Group Decision Support System [8][9][10] emerged effectively in the beginning of the 80s. According to Hubber [11] a GDSS consists of a set of software, hardware, language components and procedures that support a group of people engaged in a decision related meeting. A more recent definition is from Nunamaker [12], stating that GDSSs are interactive computer-based environments which support concerted and coordinated team effort towards completion of joint tasks.

The need of people to work in groups is well documented in literature: according to Simon [13] the escalating complexity of problems faced by organisations, due to lack of information and resources, is taking autonomy from individuals and substituting them with groups of human beings; Lauden & Lauden [14] say that 35 to 70 percent of managers time is spent in decision related meetings; Turban [15] states that the need of group work and meetings grow in the same proportion that grow the complexity of organisational decisions.

GDSSs aim at reducing the loss associated to group work and to maintain or improve the gain [7]. Nunamaker et al [16] identified some major sources of gain and loss associated to group work, namely:

a) Sources of gain:
- a group has greater knowledge than any individual participant;
- participants' different knowledge and processing skills allow results that could not be achieved individually;
- a group is better than an individual participant at detecting flaws in proposed ideas.

b) Sources of loss:
- participants can be reluctant to share their ideas for fear of getting a negative evaluation of their contribution;
- participants can fail to remember contributions of others;
- out of fear of politeness, participants can be hesitant about disagreeing with the positions or ideas of others;
- incomplete appreciation of the group work to be done can result in superficial or irrelevant discussions;
- without appropriate coordination for integrating the contributions of the participants, discussion cycling, incomplete discussion and premature decisions can result.

DeSanctis and Gallupe [17] presented a model for the study of GDSS that has been used for many authors since then. In this model GDSSs are classified in three levels, according to their goals:
- level 1: reduce communication barriers;
- level 2: reduce uncertainty / noise in group's decision process;
- level 3: drive / regulate the group decision process.

Another classification scheme that can be derived from the model by DeSanctis and Gallupe, considers the time and place dimensions (see figure 1). Today there is an increasing interest in the development of GDSS to support the "any time/any place" group decision making processes.

	Same time	Any Time
Same place	Decision Room	Local Decision Network
Any place	Teleconference	Remote Decision Making

Figure 1- Place / time dimensions for GDSS

III. THE *WEBMEETING* SYSTEM

WebMeeting is a GDSS that supports distributed and asynchronous meetings through the Internet. As it was referred above the *WebMeeting* system is focused on multi-criteria problems. Moreover the system is intended to provide support for the activities associated with the whole meeting life cycle, from the pre-meeting phase to the post-meeting phase.

The system aims at supporting the activities of two distinct types of users: ordinary group "members" and the "facilitator". The users of *WebMeeting* can access the system from anywhere through a PC and an Internet connection. The notion of "unavailability to participate in a meeting" becomes therefore almost meaningless. The facilitator prepares the meeting and invites a group of people to participate, and to exchange different points of view, expertise and information, in order to obtain the "best" solution. The members' participation does not need to be synchronous, so a participant can decide at what time he/she will contribute to the discussion. A hypothetical image of a group of *WebMeeting* users can be seen in figure 2.

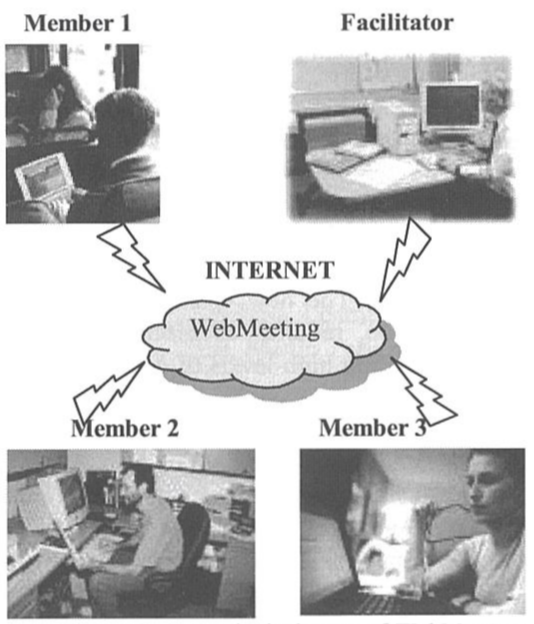

Figure 2- Hypothetical users of *WebMeeting*

A. *WebMeeting Modules*

The *WebMeeting* system is composed by the following modules: Setup, Management, Argumentation, Multi-criteria, Voting and Database.

The system architecture can be visualized in figure 3.

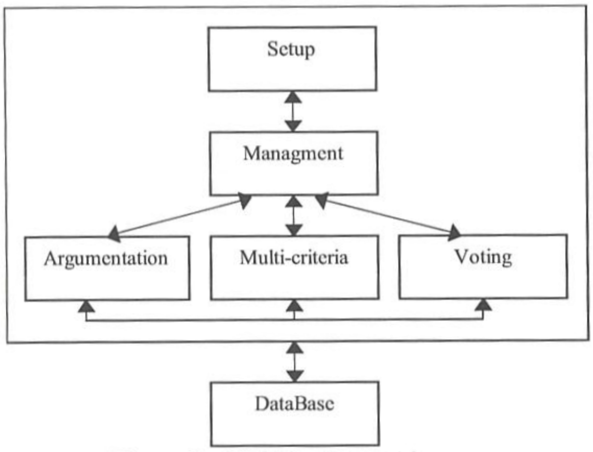

Figure 3- *WebMeeting* architecture

Setup Module

The Setup Module will be operated by a *facilitator* during the pre-meeting phase. This involves several configuration and parameterisation activities, such as the following:

- General meeting configuration – specifying dates for the start and the end, as well as the goal of the meeting.
- Selection of participants (from the database of expertise), invitation sending, confirmation of reception and participant replacement, if necessary. For each participant, the facilitator can also define his/her importance (number of votes).
- Definition of decision rules – voting rules (consensus, majority, qualified majority, maximum number of voting cycles, anonymity), rules for argumentation (minimum/maximum number of arguments for each participant; the arguments are or are not visible to all the participants), single or multiple alternative selection; visualisation (or not) of the values of alternatives values after normalisation.

Figure 4 presents the screen used for the configuration of decision rules.

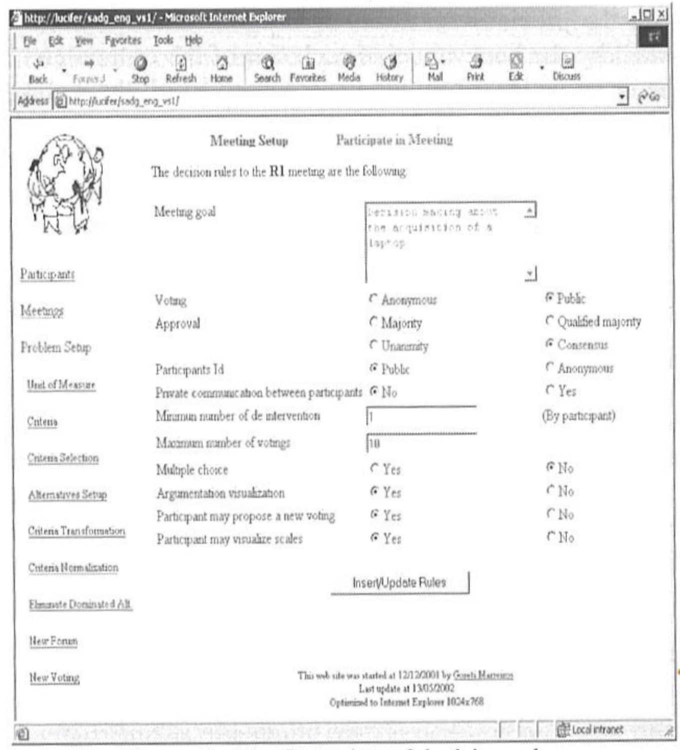

Figure 4- Configuration of decision rules

Multi-criteria Module

The *facilitator* uses this tool during the pre-meeting phase to configure the multi-criteria decision problem, by:

- inserting the evaluation criteria (eventually by re-using criteria previously defined for other meetings);
- configuring alternatives and defining the way scales are to be transformed (normalization, change of qualitative values into quantitative);
- deleting dominated alternatives.

The *members of the group* will also use this tool during the meeting phase, to:

- establish the relative importance of each criterion, by assigning weights to the criteria (this can be done directly or can result from a computation based on the judgements made by the participants);
- rank alternatives.

The process of establishing preferences is evolutive and, as time goes on, members can change the relative importance of each criterion and consequently express changes in their individual preferences.

This module implements the **eigenvector method** for assessing the weights of the criteria, and the algorithm for ranking the alternatives is "Technique for Order Preference by Similarity to Ideal Solution" (TOPSIS) [18]. This algorithm is based upon the concept in which the preferred alternative should have the shortest eucledian distance to the ideal solution and the farthest from the negative-ideal solution.

In TOPSIS it is assumed that each attribute takes monotonically increasing, or monotonically decreasing, utility. In other words, it intends that the value of each criterion is the possible greater (bigger profit or benefit), or the possible minor (lesser cost). In accordance with the previous sentence, the ideal solution is composed by the best values of each one of the criteria and the negative-ideal solution is composed by all the worst values of each one of the criteria.

For a correct application of the algorithm all the attributes must have quantitative values. In the case that some criterion has a qualitative value (fuzzy criterion), that value must be adequately transformed. In *WebMeeting* this transformation is a facilitator task.

For an efficient method application, all the alternatives must be not dominated. Therefore, in the *WebMeeting*, a method of verification was implemented with the consequent elimination of the dominated alternatives.

Figure 5 shows the screen used for assigning weights: the user can directly assign the weights, or their values can be computed based on a set of pairwise comparisons.

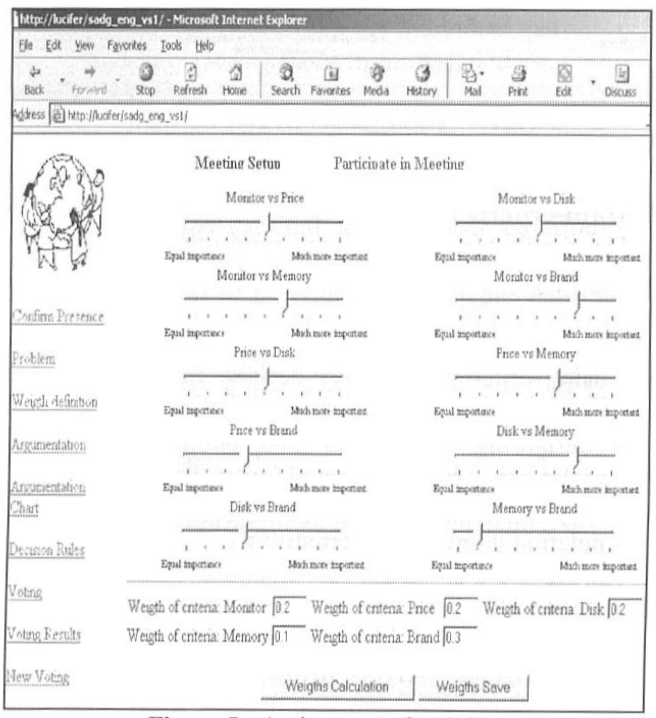

Figure 5- Assignment of weights

Argumentation Module

After establishing individual preferences (through the *WebMeeting* multi-criteria module, or with the help of any other tool, or simply by intuition) the participants are expected to "defend" those preferences. Each participant will therefore argue for the most interesting alternatives or against the worst alternatives, according to his/her preferences. By expressing their arguments, participants expect to influence the others' opinions and make them change their choices.

This module is based on the IBIS (Issue Based Information System) argumentation model [19] developed by Rittel and his colleagues in the early 70's. The core of this methodology is based on the matrix of **questions, ideas** and **arguments** that, all combined, represent a conversation. According to this model, an argument is a statement or an opinion which can support or object one or more ideas.

Between the three elements of IBIS model, exists nine possible links, as it is represented in figure 6.

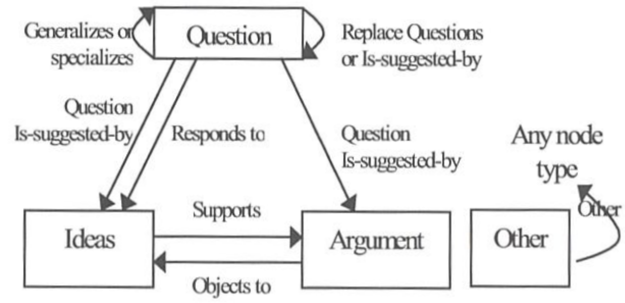

Figure 6- IBIS model adapted from Conklin and Begeman [20]

In implementing *WebMeeting,* some modifications to this model have been made.

- The **question** in the IBIS model is, in *WebMeeting*, the goal of the meeting.
- **Ideas** are the alternatives of the multi-criteria decision problem.
- **Arguments** in IBIS can be ***pros*** or ***cons*** *vis-à-vis* a given idea. In *WebMeeting* they can be: very cons, cons, neutral, pro or very pro. Additionally *WebMeeting* provides the possibility for one participant to argue using a argument from another member.

This module is very important in the in-meeting phase. It is used by the participants to defend their positions, but can also be used in the post-meeting phase by the facilitator. If for instance, the group does not reach a solution, the facilitator could use this module to check what was the alternative with more pro and less cons.

The IBIS model has been often used in the development of GDSSs, the first implementation being gIBIS [20]. By adopting this model, *WebMeeting* should enable a better organisation of the arguments exchanged by the participants. This should naturally facilitate opinion convergence, reducing the "noise" of meetings.

Figure 7 bellow presents an argumentation forum for a particular decision problem.

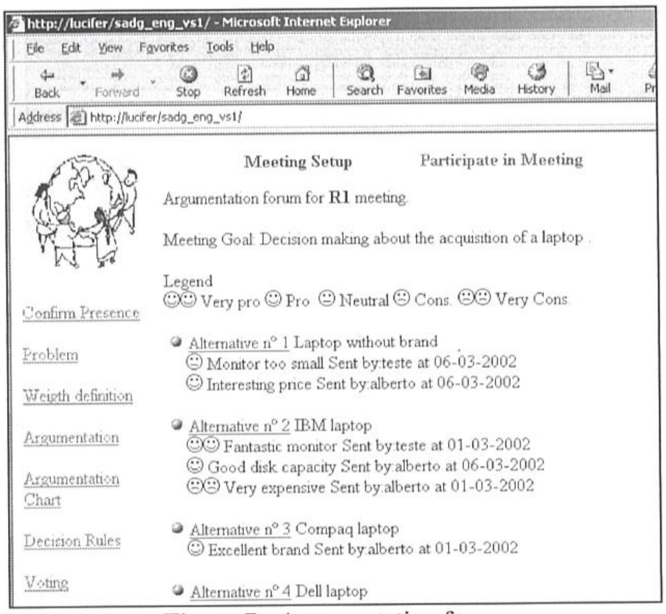

Figure 7- Argumentation forum

Voting Module

This module is responsible for the emission of "vote bulletins", and for the publication of results (intermediate and final). These activities are performed according to the decision rules that have previously been defined by the facilitator in the pre-meeting phase. Through these rules, WebMeeting can be easily configured, allowing e.g. the facilitator to define whether the vote is secret or not, or if the participants are equally important (in terms of number of votes), etc.

Even in the case that a decision is not achieved, the results of the voting may provide useful information for someone else to decide. Going through the information gathered in the argumentation forum could also be very helpful in understanding different opinions and ways of reasoning.

One example of a vote bulletin can be seen in figure 8.

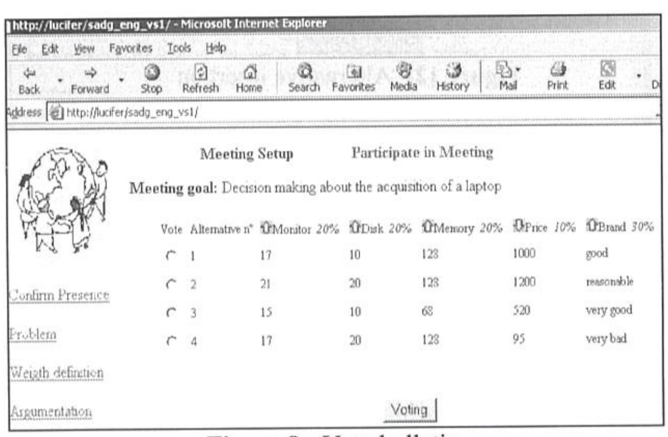

Figure 8- Vote bulletin

Management Module

This module supports the meeting in all its phases, sending "notifications" (by e-mail) to the facilitator or to the group members.

In the pre-meeting phase the facilitator will be notified if some of the invited participants does not confirm his/her "presence" in the meeting.

In the in-meeting phase this module will interact with both the facilitator and the group members, notifying them every time it is necessary (e.g. by announcing that a voting cycle was started not respecting a given decision rule).

If the participants reach a decision before the foreseen date, a notification will be sent to the facilitator and to the members.

In the post-meeting phase this module will send information to the participants about the results of the meeting. Some updating tasks will also be performed in this phase (e.g. updating the participation percentage of each element of the group members, and thus influencing the selection of participants in a future meeting).

Database Module

This is an "invisible" module that supports the whole application. All data related to the meeting (concerning the participants, the multi-criteria decision problem, the argumentation exchange flows, the results of the voting, ...) is stored in this database. This information can be used in future meetings.

B. WebMeeting Implementation Tools

The implementation of the *WebMeeting* system required a set of several, complementary technologies. The Web Server used was Microsoft Internet Information Server (IIS) and Active Server Pages (ASP) have been used as the technology to create dynamic and interactive web pages. Implementation was mainly done in the scripting languages associated with ASP - VbScript and JScript. The only exception was the implementation of the Eigenvector method, done using the R language (more convenient for mathematical computation). Microsoft Access was used as a database, and the link between the database and ASP was done through ActiveX Data Objects (ADO).

C. 3.3 Case Study

For a better understanding of the developed system, will be presented in next a brief illustration of what could be the resolution of a case study (adapted from a small example proposed by Janssen [21]), with the support of the *WebMeeting* system.

Let us assume an imaginary region in the south-west of the Netherlands. The road through the centre of the region has insufficient capacity which result in frequents traffic jams. To improve this situation three alternatives were suggested.

The effects of the three alternatives are listed in figure 9.

	Highway	Road/Bus	Train
Costs (mln of euros)	91	114	182
Travel Time (min/person/year)	30	15	10
Capacity (mln Km/year)	20	30	40
No_x Emissions (ton/year)	1000	750	400
Landscape (Hectare)	10	12	2
Users acceptation	Good	Very Good	Satisfactory

Figure 9- Information about different alternatives

The scores attached to landscape reflect the size of moorland lost within the first two alternatives and the loss of forest in the third alternative. The No_x emissions associated to the train alternative reflect the emission that result from the production of electricity required to run the trains.

A group of four persons and a facilitator, with the support of *WebMeeting* system, resolved the case study. To clarify the decision process, the experience is presented considering the three different phases of a meeting: pre-meeting, in-meeting and post-meeting.

Pre-meeting

In this phase the facilitator uses the setup module to configure all the meeting details: dates, group members, decision rules, etc. The screens of figures 10 and 11 illustrate some of those activities.

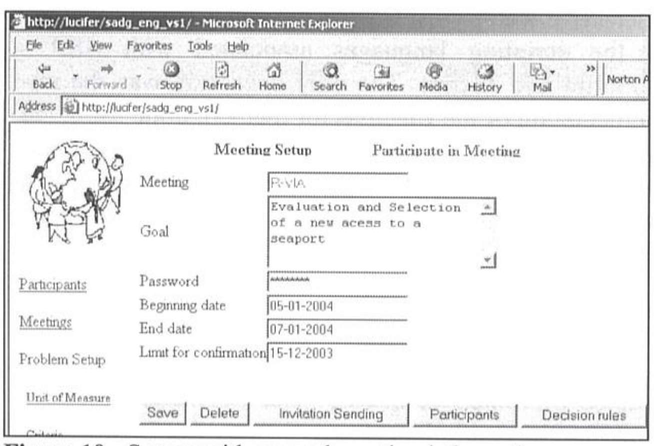

Figure 10- Screen with general meeting information

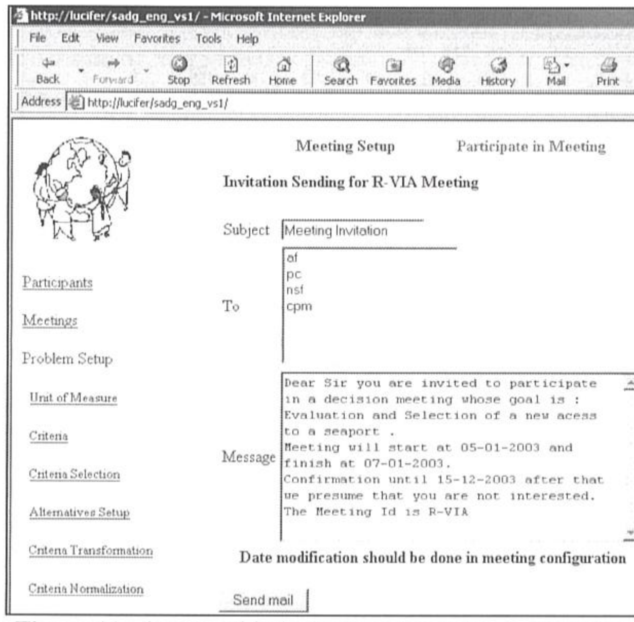

Figure 11- Screen with the invitation sending to the select participants

In the pre-meeting phase the facilitator should also configure the decision problem. The screen in figure 12 exemplifies the inclusion of the train alternative.

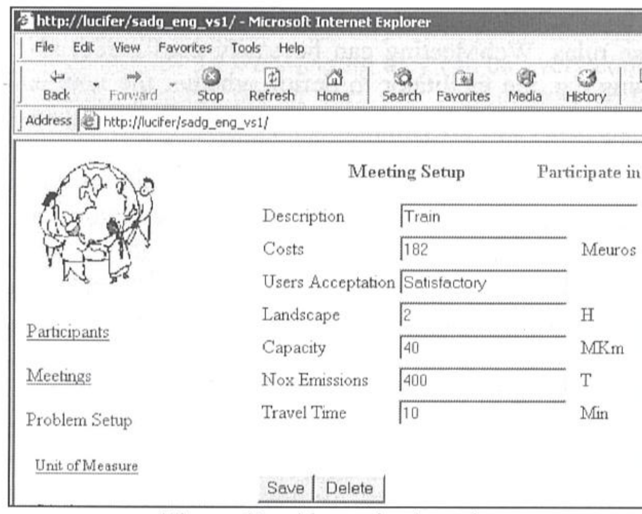

Figure 12- Alternative insertion

In-meeting

In this phase the participants will establish individual preferences and "defend" them. Figure 13 shows the results of the application of TOPSIS and in figure 14 it is possible to see the elaboration of an argument.

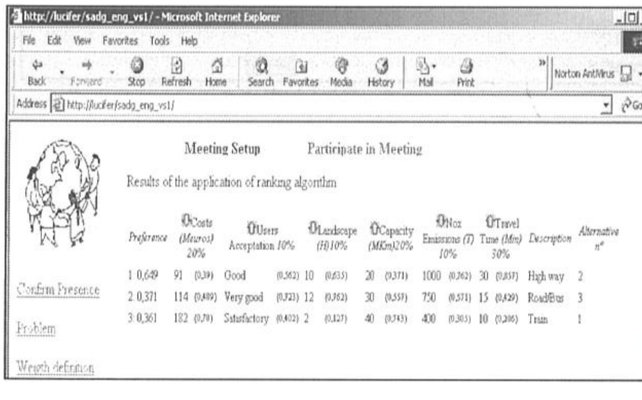

Figure 13- Results of the application of ranking algorithm by one of the group member

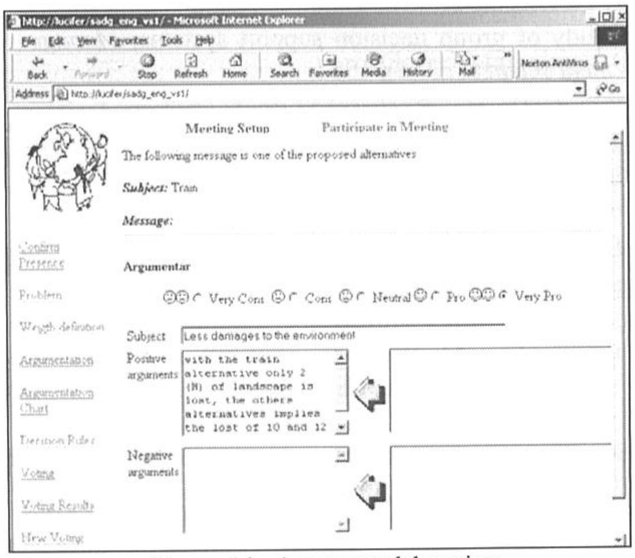

Figure 14- Argument elaboration

Post-meeting

After the meeting conclusion is necessary to perform some tasks, in figure 15 is possible to see an email sending by *WebMeeting* to the facilitator with suggestions to updating the participation percentage of each element of the group.

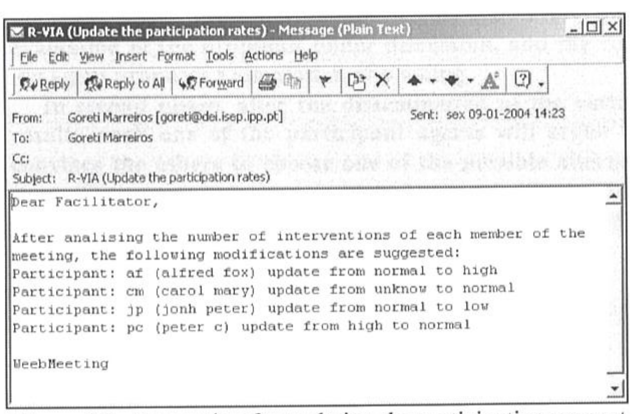

Figure 15- Suggestion for updating the participation percentage of each element

IV. Conclusions

This paper briefly describes the *WebMeeting* system, a GDSS that supports asynchronous and distributed meetings set up for solving multi-criteria decision problems. Preliminary experience with the system in some simple scenarios has demonstrated the potential of the system. However, to fully validate the approach, it is still desirable to run some experiments with more complex situations, and preferably in real time. Moreover for refining the system, feedback from real users of the system would be very important.

An interesting and somehow natural expansion of the *WebMeeting* system might involve the addition of functionalities to improve the intelligent behaviour of this group decision support system. In its present version, the system supports the meeting participants in constructing and sharing his/her own arguments, but does not actively supports the process of "argument elaboration". A more "intelligent system" should be able to suggest the use of arguments that might convince other members of the group. The use of Multi-Agent technology seems to be an adequate option to proceed in this line, and to provide *Webmeeting* with some degree of "intelligence".

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