ABS4GD: A Multi-agent System that Simulates Group Decision Processes Considering Emotional and Argumentative Aspects

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Abstract

Emotion although being an important factor in our every day life it is many times forgotten in the development of systems to be used by persons. In this work we present an architecture for a ubiquitous group decision support system able to support persons in group decision processes. The system considers the emotional factors of the intervenient participants, as well as the argumentation between them. Particular attention will be taken to one of components of this system: the multi-agent simulator, modeling the human participants, considering emotional characteristics, and allowing the exchanges of hypothetic arguments among the participants.

1 Introduction

Despite the great variety of Decision Support Systems (DSS) tools and techniques, most are simple artefacts developed to help a particular user involved in a specific decision process. However, groups are used to make decisions about some subject of interest for the organization or community in which they are involved. The scope of such decisions can be diverse. It can be related to economic or political affairs like, for instance, the acquisition of new military equipment. But it can also be a trivial decision making as the choice about a holiday destination by a group of friends. It may be claimed, therefore, that Group Decision Support Systems (GDSS) have emerged as the factor that makes the difference when one assess the behavior and performance of different computational systems in different applications domains, with a special focus on socialization.

Groups of individuals have access to more information and more resources what will (probably) allow to reach "better" and quicker decisions. However working in group has also some difficulties associated, e.g. time consuming; high costs; improper use of group dynamics and incomplete tasks analysis.

If the group members are dispersed in time and space, the need of coordination, informal and formal forms of communication and information sharing will increase significantly. GDSS aim at reducing the loss associated to group work and to maintain or improve the gain.

During group decision making process different types of conflicts and disagreements arise, and it is necessary to overcome them. Argumentation can be an excellent choice to justify possible choices and to convince other elements of the group that one alternative is better or worst than another.

In this work it is proposed an architecture for a ubiquitous group decision support system that is able to help people in group decision making processes and considers the emotional factors of participants and their associated processes of argumentation.

This system is intended to be used for intelligent decision making, a part of an ambient intelligence environment where networks of computers, information and services are shared [Marreiros et al, 2007]. As an example of a potential scenario, it is considered a distributed meeting involving people in different locations (some in a meeting room, others in their offices, possibly in different countries) with access to different devices (e.g. computers, PDAs, mobile phones, or even embedded systems as part of the meeting room or of their clothes). Figure 1 shows an Intelligent Decision room with several interactive Smartboards. The meeting is distributed but it is also asynchronous, so participants do not need to be involved at any time (like the meeting participant using a PDA and/or a notebook in Figure 1). However, when interacting with the system, a meeting participant may wish to receive information as it appears. Meetings are important events where ideas are exposed, alternatives are considered, argumentation and negotiation take place, and where the emotional aspects of the participants are so important as the rational ones. This system will help participants, showing available information and knowledge, analyzing the meeting trends and suggesting arguments to be exchanged with others.

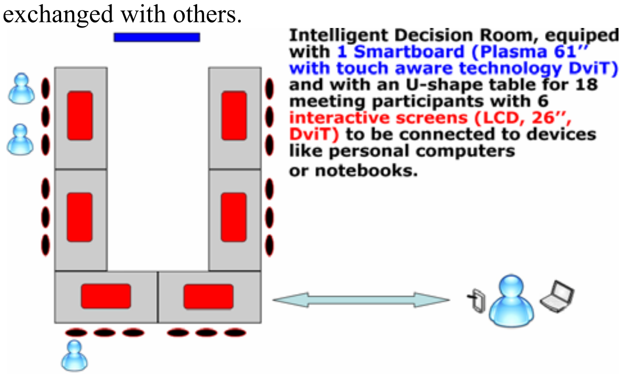

Figure 1- Distributed decision meeting

The use of multi-agent systems is very suitable to simulate the behavior of groups of people working together and, in particular, to group decision making modeling, once it caters for individual modeling, flexibility and data distribution. In classical decision theory, proposals are chosen by individual decision makers in order to maximize the expected coefficient of utility. However, when those choices are transposed to quotidian life, it is almost impossible to say that decisions are not influenced by emotions and moods.

2 Emotion and Decision

In the last years, researchers' from several distinct areas (psychology, neuroscience, philosophy, etc) have begun to explore the role of the emotion as a positive influence on human decision making process. The seminal work of the neuroscientist Antonio Damásio [Damásio, 1994] contributed significantly for the interest increase of emotion relevance in individual, and consequently group, decision making processes. Others researchers reinforce this idea identifying emotion as the key element in intelligence and adaptive nature of human being [Goleman, 1995; Ledoux, 1996; Bechara et al., 1997]

In psychological literature several examples could be found on how emotions and moods affects the individual decision making process [Forgas, 1995][Lowenstein and Lerner, 2003][Schwarz, 2000][Barsade, 2002]. For instance, individuals are more predisposed to recall memories that are congruent with their present emotional state. There are also experiences that relate the influence of emotional state in information seeking strategies and decision procedures.

The emotional state of an individual impacts their behavior, as well as their interactions with the other group members. The individual emotional state varies along the time and is influenced by the emotional state of the remain members of the group decision.

The process of emotional contagion is the tendency to express and feel emotions that are similar to and influenced by those of others. This process could be analyzed based on the emotions that a group member is feeling or based on the group members mood [Neumann and Strack, 2000].

A more detailed review of the influence of emotion in group decision making can be found in [Marreiros et al, 2005].

One of the reasons pointed by Rosalind Picard [Picard, 2003] to give machines emotional characteristics is the necessity of obtaining a better understanding of the human emotions. As we seen before, individuals emotional state affects its performance and its relationships inside the group. We defend that a simulator of group decision making scenarios should handle emotions in order to have a better representation of the reality.

3 Ubiquitous System Architecture

One's aim is to present a ubiquitous system able to exhibit an intelligent and emotional behavior in the interaction with individual persons and groups. This system supports persons in group decision making processes considering the emotional factors of the intervenient participants, as well as the argumentation process.

Groups and social systems are modeled by intelligent agents that will be simulated considering emotional aspects, to have an idea of possible trends in social/group interactions.

The main goals of the system are:

1. The use of a simplified model of Groups and Social Systems for Decision Making processes, balancing Emotional and Rational aspects in a correct way;
2. The use of a decision making simulation system to support meeting participants. This will involve the emotional component in the decision making process;
3. The use of an argumentation support system, suggesting arguments to be used by a meeting participant in the interaction with other participants;
4. The mixed initiative interface for the developed system;
5. The availability of the system in order to be used in any place (e.g. meeting room, using a web based

tool), in different devices (e.g. computers, notebooks, PDAs) and at different times (e.g. on-line meeting, asynchronous meetings).

The system consists of a suite of applications as depicted in Figure 2.

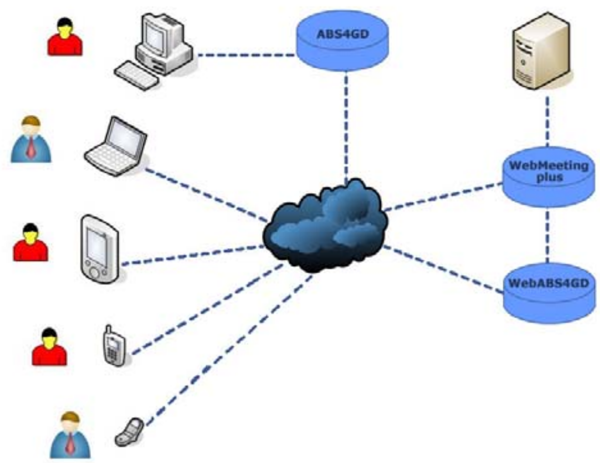

Figure 2- System architecture

The main blocks of the system are:

1. WebMeeting Plus – this is an evolution of the Web-Meeting project with extended features for audio and video streaming. In its initial version, based on Web-Meeting, it was designed as a GDSS that supports distributed and asynchronous meetings through the Internet. The WebMeeting system is focused on multi-criteria problems, where there are several alternatives that are evaluated by various decision criteria. More-over, the system is intended to provide support for the activities associated with the whole meeting life cycle, i.e. from the pre-meeting phase to the post-meeting phase. The system aims to support the activities of two distinct types of users: ordinary group "members" and the "facilitator". The system works by allowing participants to post arguments in pro/neutral/against the different alternatives being discussed to address a particular problem. It is also a window to the information repository for the current problem. This is a web based application accessible by desktop and mobile browsers and eventually WML for WAP browsers;
2. ABS4GD – this is the simulation tool resulting from the ArgEmotionAgents project. ABS4GD (Agent Based Simulation for Group Decision) is a multi-agent simulator system whose aim is to simulate group decision making processes, considering emotional and argumentative factors of the participants. ABS4GD is composed by several agents, but the more relevant are the participant agents that simulate the human beings of a decision meeting (this decision making process is influenced by the emotional state of the agents and by the exchanged arguments). The user maintains a database of participant's profiles and the model´s history of the group; this model is built incrementally during the different interactions of the user in the system.
3. WebABS4GD – this is a web version of the ABS4GD tool to be used by users with limited computational power (e.g. mobile phones) or users accessing the sys-tem through the Internet. The database of profiles and history will not be shared by all users, allowing for a user to securely store its data on the server database, which guarantees that his/her model will be available for him or her at any time.

4 ABS4GD Description

There are two different ways to give support to decision makers. The first one is supporting them in a specific decision situation. The second one intends to give them training facilities in order to acquire competencies and knowledge to be used in a real decision group meeting.

In our approach the decision making simulation process considers emotional aspects and several rounds of possible argumentation between meeting participants. The simulator is composed of several agents, but the more relevant are the participant agents that simulate the human participants of a meeting. This decision making process is influenced by the emotional state of the agents and by the exchanged arguments [Marreiros et al, 2006]. A database of profiles and history with the group's model is maintained and this model is built incrementally during the different interactions with the system. It is important to notice that this simulator was not developed in order to substitute a meeting or even to substitute some meeting participants. The simulator is a tool that can be used by one or more participants to simulate possible scenarios, to identify possible trends and to assist these participants (in this way it can be seen as a what-if tool of a decision support system). However, the criteria used by this decision support system are not just rational, since they will consider emotions [Santos et al, 2006].

In this section it is characterized the decision problem and the group decision making protocol, also detailing the main components of this simulator, with particular focus on argumentation and emotion.

4.1 Decision problem configuration

The alternatives are completely identified by the participant agents. Let $A=\{A_1,A_2,\dots,A_n\}$ be an enumerated set of n alternatives, where $n >= 2$. The criteria are also known. Let $C=\{C_1,C_2,\dots,C_m\}$ be an enumerated set where $m >= 2$. The decision matrix will be composed of n alternatives and m criteria. Let $D = [D_{ij}]_{nxm}$ where D_{ij} represents the value of the alternative Ai respectively to criterion Cj, and $i = 1,\dots n$ and $j = 1,\dots m$.

The participants of a specific simulation constitute the set AgP = {AgP1,…,AgPk}, where k is the number of participants and k >= 2. Each AgPi has defined a set of weights for the criteria. $W_{AgPi} = \{ W_{C1}, \ldots W_{Cm}\}$ be the set of weights for $AgPi$, where $\sum_{j=1}^{m} W_{C_j} = 1$, $W_{C_j} \geq 0$, standing for the definition of a multi-criteria problem.

4.2 Group Decision Making Simulation Protocol

It is possible to find several classifications of decision models and problem solving. One of the most cited is Simon's classification that identifies the following phases: intelligence, design, choice and implementation [Simon, 1960]. Another classification is based on the political model, in which the decision is seen as a consequence of strategies and tactics used by individuals, aiming that the final result is the most advantageous [Salancik and Pfeffer, 1977]. In this model, it is assumed that group members have different and possibly conflicting goals, leading to problems of conflict resolution and of power relations among them.

The proposed protocol combine the ideas mentioned before, with the particularity that here one is only considering the choice phase (Figure 3). It is not handled the pre-decision one, where the decision problem is taken in consideration as well as the simulation parameters (e.g. approving rule, duration).

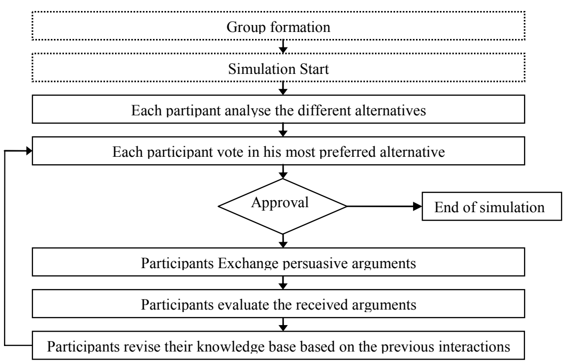

Figure 3- Group decision protocol

4.3 Multi-Agent Model and Participant Agent Architecture

Multi-agent systems seem to be quite suitable to simulate the behavior of groups of people working together [Marreiros et al, 2005], as well as to assist the participants presenting new arguments and feeding the simulation model of the group by observing the interaction and history of the meeting.

Each participant of the group decision making process is associated with a set of agents to interact with other participants. The community should be persistent because it is necessary to have information about previous group decision making processes, focusing credibility, reputation and past behaviors of other participants.

The participant should have access to an Agent Based Simulation Tool for Group Decision (AGS4GD) developed under the *ArgEmotionAgents* project. This tool will improve the knowledge of the community of agents, then making possible to predict the behavior of other participants and to advice on the best practice.

This support to the participants will be implemented using mixed initiative interaction. According to this concept, Intelligent Agent Based Systems can offer solutions where the user is allowed to change the proposed ones (e.g. to a particular problem), permitting the user to learn at the same time with his/her interactions, changing algorithms and models, therefore closing the gap on its view of the world in future interactions.

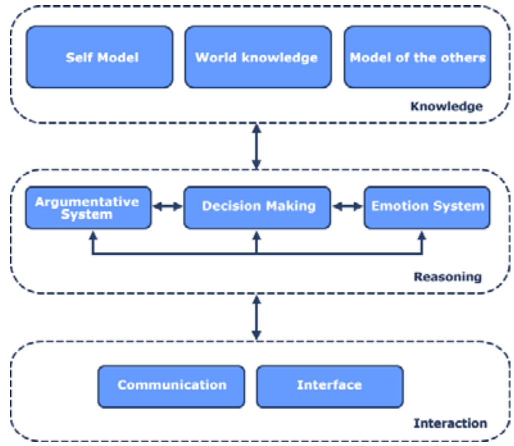

Figure 4 – Participant agent architecture

In the knowledge layer the agent has information about the environment where he is situated, about the profile of the other participant's agents that compose the simulation group, and regarding its own preferences and goals (its own profile). The information in the knowledge layer is dotted of uncertainty and will be accurate along the time through interactions done by the agent.

The interaction layer is responsible for the communication with other agents and by the interface with the user of the group decision making simulator.

The reasoning layer contains three major modules:

- The argumentative system – that is responsible for the arguments generation. This component will generate explanatory arguments and persuasive arguments, which are more related with the internal agent emotional state and about what he, think of the others agents profile (including the emotional state);
- The decision making module – will support agents in the choice of the preferred alternative and will classify all the set of alternatives in three classes: preferred, indifferent and inadmissible;
- The emotional system – will generate emotions and moods, affecting the choice of the arguments to send to the others participants, the evaluation of the received arguments and the final decision.

4.4 Argumentation System

During a group decision making simulation, participants' agents may exchange the following locutions: request, refuse, accept, request with argument.

Request (AgP_i, AgP_j, α, *arg*) - in this case agent AgP_i is asking agent AgP_j to perform action α, the parameter *arg* may be void and in that case it is a request without argument or may have one of the arguments specified in the end of this section.

Accept (AgP_j, AgP_i, α) - in this case agent AgP_j is telling agent AgP_i that it accepts its request to perform α.

Refuse (AgP_j, AgP_i, α) - in this case agent AgP_j is telling agent AgP_i that it cannot accept its request to perform α.

In Figure 5, it is possible to see the argumentation protocol for two agents. However, note that this is the simplest scenario, because in reality, group decision making involves more than two agents and, at the same time AgP_i is trying to persuade AgP_j that, this agent may be involved in other persuasion dialogues with other group members.

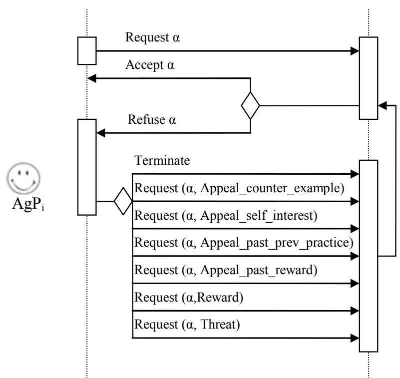

Figure 5 - Argumentation protocol for two agents

Argument nature and type can vary, however six types of arguments are assumed to have persuasive force in human based negotiations [Karlins and Abelson, 1970][O'Keefe, 1990][Pruitt, 1981]: threats; promise of a future reward and appeals; appeal to past reward; appeal to counter-example; appeal to prevailing practice; and appeal to self interest. These are the arguments that agents will use to persuade each other. This selection of arguments is compatible with the power relations identified in the political model [French and Raven, 1959]: reward, coercive, referent, and legitimate.

This component will generate persuasive arguments based on the information that exists in the participant's agent knowledge base [Marreiros et al, 2006].

4.4.1 Arguments Selection

In our model it is proposed that the selection of arguments should be based on agent emotional state. We propose the following heuristic:

- If the agent is in a good mood he will start with a weak argument;
- If the agent is in bad mood he will start with a strong argument.

There are several studies that point that an agent in a good mood is risk averse and agent is on a good moo he is more available to risk taking. On the other side, a bad mood agent wants to make agreements quickly in order to achieve a good mood.

We adopt the scale proposed by Kraus for the definition of strong and weak arguments, where the appeals to a prevailing practice are the weakest and threats are the strongest arguments. We defined two distinct classes of arguments, namely a class for the weaker ones (i.e., appeals) and a class for the remainders (i.e., promises and threats). Inside each class the choice is conditionally defined by the existence in the opponent profile of a (un)preference by a specific argument. In case the agent does not detain information about that characteristic of the opponent, the selection inside each class follow the order defined by Kraus [Kraus et al, 1998].

4.4.2 Arguments evaluation

In each argumentation round the participant agents may receive requests from several partners, and probably the majority is incompatible. The agent should analyse all the requests based on several factors, namely the proposal utility, the credibility of proponent and the strength of the argument.

If the request does not contain an argument, the acceptance is conditioned by the utility of the request for the self, the credibility of the proponent and one of its profile characteristics, i.e., benevolence. We consider:

$$Req^t_{AgP_i} = \left\{ request^t_1(AgP, AgP_i, Action), ..., request^t_n(AgP, AgP_i, Action) \right\}$$

, where AgP represents the identity of the agent that perform the request, n is the total number of requests received at instant t and Action the request action (e.g., voting on alternative number 1). The algorithm for the evaluation of this type of requests (without arguments) is presented next:

Begin
If $\neg$ *profile*$_{AgPi}$*(benovolent)* ***then***
  Foreach *request(Proponent,*AgP_i*,Action)* $\in Req^t_{AgP_i}$
    refuse (Proponent, AgP_i*, Action)*
Else
  Foreach *request(Proponent,*AgP_i*,Action)* $\in Req^t_{AgP_i}$
   If $AgPO_{AgP_i} \vdash Action$ ***then***
    Requests $\leftarrow$ *Requests* $\cup$ *request(Proponent,*AgP_i*,Action)*
   Else
    refuse (Proponent, AgP_i*, Action)*

$(AgP, Requested\_Action) \leftarrow$ *Select_more_credible(Requests)*
Foreach *request(Proponent,*AgP_i*,Action)* $\in$ *Requests*
  If *(Proponent=AgP or Request_Action=Action)* ***then***
   accept (Proponent, AgP_i*, Action)*
  Else
   refuse (Proponent, AgP_i*, Action)*
End

4.5 Emotional System

Partially due to some of the facts presented in section 2, in recent years there has been an increased interest in developing architectures for emotional agents. Some example of developed architectures are: *Cathexis* [Velasquez, 1998], *Flame* [El-Nasr, 2001], *TABASCO* [Staller and Petta, 2001], *MAMID* [Hudlicka, 2006], *Salt&Peper* [Botelho and Coelho, 2001], *EMA* [Gratch and Marsella, 2006].

Our participant agent is composed by an emotional system, which, beside other tasks, will generate emotions. Those emotions are the identified in the reviewed version of the OCC model [Ortony, 2003]: joy, hope, relief, pride and gratitude, like distress, fear, disappointment, remorse, anger and dislike. The agent emotional state (i.e. mood) is calculated in this module based on the emotions felt in past and in the other agents' mood [Santos et al, 2006].

In figure 6 it is possible to visualize the main components of the emotional system.

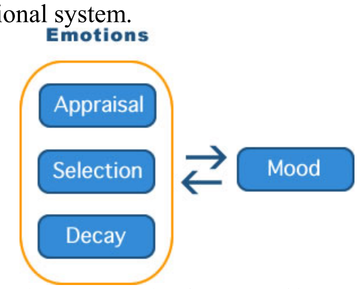

Figure 6 – Emotional system architecture

The emotional system is composed by three main components: appraisal, selection and decay.

A. Appraisal

The appraisal mechanism is based on OCC model, the simulator user defines the conditions for the emotion activation. An example may be:

Hope(AgPi,X):-Goal(AgP_i,X),
Request (AgP_j,X).

In the previous example the emotion Hope is appraised if Agent AgP_i has the goal(X) and asks to agent AgP_j to perform the X then the emotion hope is generated.

To each condition for the emotion generation is settled a weight, in the interval [0, 1]. The intensity of the emotion is calculated according the conditions weight.

A particular emotion could be or not expressed by the agent depending on the intensity of the others emotions.

B. Selection

All the emotions defined in the simulator have a threshold activation, which can be influenced by the agent mood. The activation threshold is a value between 0 and 1.This component selects the dominant emotion.

$AgP_{i,Emo,t}$ is the set of all the emotions generated by the agent AgP_i and respective intensities and activations thresholds.

$AgP_{i,Emo,t}=\{(Emo_1,Int_1,Act_1),\ldots(Emo_n,Int_n,Act_n)\}$

The selected emotion in instant t, $AgPi_{ActEmo,t;}$ will be the one that have a higher difference between the intensity and the activation.

C. Decay

Emotions have a short duration, but they do not go away instantaneously, they have a period of decay. There are several proposals for this calculation. In our model we consider three possibilities: linear, exponential and constant. In linear and exponential function the emotion decays until disappear, in constant function the emotion maintain the initial value and in a specific moment take the value zero. The constant decay function can be for instance applied to the hope emotion.

The characterization of the decay function for each type of emotion, allows modeling the decay celerity of the different emotions.

D. Mood

The agent mood is calculated based on the emotions agents felt in the past and in what agent think about the moods of the remaining participants. In our approach only the process of mood contagion is being considered, we do handle the process of emotions contagion. We consider only three stages for mood: positive, negative and neutral. The mood of a specific participant is determined according the following:

$$K^+ = \sum_{i=t-n}^{t-1} I_i^+ , K^- = \sum_{i=t-n}^{t-1} I_i^-$$

K^+ and K^- are the sum of the positive/negative emotions felt in the last n periods, and n can be parameterized by the simulator user. Only emotions that are above the threshold activation are considered.

$$\begin{cases} \text{If } K^+ \geq K^- + l \text{, then positive mood} \\ \text{If } K^- \geq K^+ + l \text{, then negative mood} \\ \text{If } \left| K^+ - K^- \right| < l \text{, then neutral mood} \end{cases}$$

The value of *l* varies according what a specific participant thinks about the mood of the group and his potential mood.

$$\begin{cases} l = 0.10 \text{, if group mood is positive and } K^- \geq K^+ \\ l = 0.10 \text{, if group mood is negative and } K^+ \geq K^- \\ l = 0.05 \text{, if group mood is neutral} \\ l = 0.01 \text{, if group mood is negative and } K^- \geq K^+ \\ l = 0.01 \text{, if group mood is positive and } K^+ \geq K^- \end{cases}$$

Each participant agent has a model of the other agents, in particular the information about the other agent's mood. This model deals with incomplete information and the existence of explicit negation. Some of the properties that characterize the agent model are: gratitude debts, benevolence, and credibility.

Although the emotional component is based on the OCC model, with the inclusion of mood, it overcomes one of the major critics that usually is pointed out to this model: OCC model does not handle the treatment of past interactions and past emotions.

5 ABS4GD Implementation And Experiments

Some implementation details of the simulator (ABS4GD) and WebMeeting Plus are described here.

5.1 Implementation

ABS4GD and WebMeeting Plus were developed in Open Agent Architecture (OAA), Java and Prolog. More information about OAA can be found in www.ai.sri.com/~oaa/.

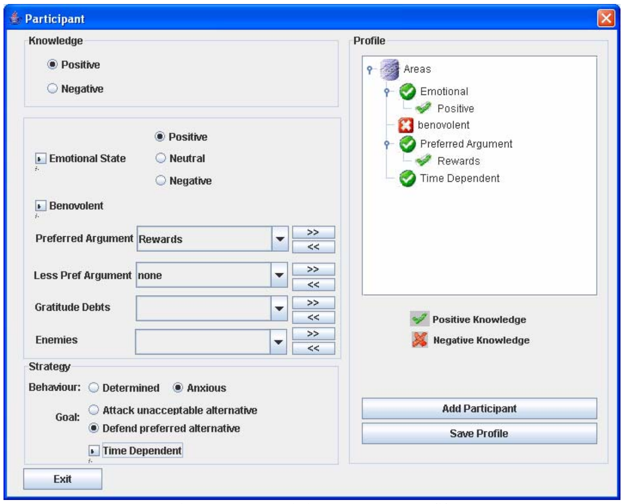

Figure 7 – Participant agent profile

In figure 7 it is possible to visualize the setup of a new participant agent in the community.

5.2 Experiments

In this section we will present a simple case study and perform some studies on possible scenarios

As we already referred our system deals with multi-criteria problems. These problems can be more or less complex and involve polemic or trivial decisions. The example that we will use is based on the selection of candidates to hire in a University. The selection is made by a group of persons that evaluates the candidates based on several criteria (e.g. teaching abilities, academic degree, scientific research activity, management abilities). Table 1 shows the problem that we intend to simulate, that is the evaluation of 4 candidates based on 5 criteria.

Table 1 – Multi-criteria problem

	Candidate n.1	Candidate n.2	Candidate n.3	Candidate n.4
Teaching	70	60	30	50
Scientific	20	30	80	70
Academic	80	40	80	60
Management	30	60	10	30
Professional	20	30	10	30

Based on this problem several scenarios were established in order to try to understand if emotional agents have more success in the simulations than non-emotional agents. Table 2 shows agents initial preferences. Based on both tables 5 variations of each were created, resulting in 25 test scenarios.

TABLE 2 - AGENTS INITIAL PREFERENCES

	Teaching	**Scientific**	**Academic**	**Management**	**Professional**
AgP_{α}	0.1	0.4	0.4	0.05	0.05
AgP_{β}	0.15	0.4	0.15	0.15	0.15
AgP_{φ}	0.4	0.1	0.1	0.3	0.1
AgP_{θ}	0.4	0.1	0.3	0.1	0.1

Experiments were conducted by the user of the system and figure 8 illustrates the number of arguments that were necessary to exchange before achieving an agreement in each simulation by agent type (emotional or non-emotional).

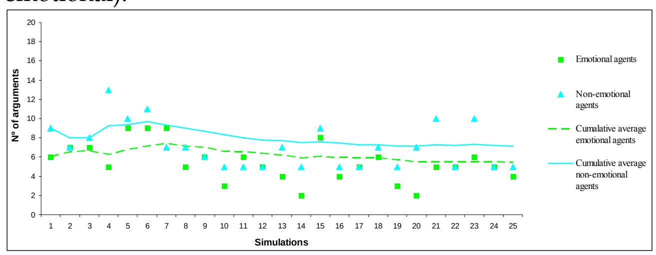

Figure 8 – Average number of arguments by agent type (emotional vs non-emotional agents)

The average of arguments when emotional agents are used is 5.4 and for non-emotional agents is 7.1. The line in blue represents the cumulative average of exchanged arguments for non emotional agents and the green line represents the same for emotional agents.

The number of agreements achieved was the same for both groups (i.e., emotional and non-emotional agents).

Based on the experiments realized it is possible to conclude that groups of agents with emotional intelligence achieve agreements faster than groups of agents without those characteristics. This seems to point out those meeting participants considering emotional factors will have more success during the argumentation process.

6 Conclusions

This work proposes a simple architecture for a ubiquitous group decision making system able to support distributed and asynchronous computation. This system supports a group of people involved in group decision making, being available in any place (e.g. at a meeting room, when using a web based tool), in different devices (e.g. computers, notebooks, PDAs) and at different time (e.g. on-line meeting, asynchronous meetings). One of the key components of this architecture is a multi-agent simulator of group decision making processes, where the agents present themselves with different emotional states, being able to deal with incomplete information, either at the representation level, or at the reasoning one. The discussion process between group members is made through the exchange of persuasive arguments, built around the same premises stated to above. Future work includes the refinement of the architecture, as well as the improvement of the interaction between the simulator and the group members.

Most of these ideas covered by this work are not exclusive to Decision Making processes. There are other social interaction domains in which emotion, argumentation, ubiquitous computing and ambient intelligence are important. We expect that the experience with Group Decision Making support presented here will give some useful insights for this new way to interact in the future. Ubiquity will be the natural form of work, environments with ambient intelligence will be spread everywhere and if on one hand people show a trend to meet asynchronously and in a distributed way, the systems, on the other hand, will need to compensate this by involving emotional aspects and high level assistance, like argumentation and negotiation support.

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