LAID - a Smart Decision Room with Ambient Intelligence for Group Decision Making and Argumentation Support considering Emotional Aspects

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Abstract

Decision Making is one of the most important activities of the human being. Nowadays decisions imply to consider many different points of view, so decisions are commonly taken by formal or informal groups of persons. Groups exchange ideas or engage in a process of argumentation and counter-argumentation, negotiate, cooperate, collaborate or even discuss techniques and/or methodologies for problem solving. Group Decision Making is a social activity in which the discussion and results consider a combination of rational and emotional aspects. In this paper we will present a Smart Decision Room, LAID (Laboratory of Ambient Intelligence for Decision Making). In LAID environment it is provided the support to meeting room participants in the argumentation and decision making processes, combining rational and emotional aspects.

1. Introduction

Nowadays, groups of persons are involved in decision making processes related with subjects 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. Group decision making processes represent very complex human activities. A better understanding of those processes implies the relation of several disciplines like for instance, psychology, sociology, political science, etc.

Although the importance of group decision making, few attention has been given to the environments where these decisions are taken, the Decision Rooms. Fortunately, Smart Decision Rooms are emerging as the environments with the ability to support meeting participants in an intelligent and unobtrusive way. These environments should be aware of people needs, customizing requirements and forecasting behaviours. These trends have been emphasized in Ambient Intelligence. Besides, in a global world, meeting rooms cannot be limited by the room walls. Meeting participants may be anywhere, and Ubiquitous Computing is necessary to guarantee their involvement in the decision process, even if they are not inside the Smart Decision Room.

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

In classical decision theory, proposals are chosen by individual decision makers in order to maximize the expected coefficient of utility. However, when these choices are transposed to quotidian life, it is almost impossible to say that decisions are not influenced by emotions and moods.

Since a few years ago specialists in decision making area started to consider emotion as a factor of influence in the decision making process [1, 2]. In psychological literature several examples could be found on how emotions and moods affect the individual decision making process. 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 rest of this paper is structured as follows. Section 2 provides a general approach to ubiquitous group decision making. Section 3 presents some existent Smart Decision Rooms. Section 4 describes briefly the hardware and software of LAID (Laboratory of Ambient Intelligence for Decision Making), a Smart Decision Room. In section 5 it is proposed a Multi-agent System whose aim is to model Group Decision Making processes with particular emphasis to the participant agent architecture, its main components and interactions. Sections 6 and 7 detail the emotional and argumentation modules of participant agent architecture. Section 8 presents some implementation details and an illustrative example, and finally section 9 presents some conclusions and future work.

2. Ubiquitous group decision making

Jonathan Grudin [3] classifies the digital technology to support the group interaction into three phases: the pre-ubiquitous, the proto-ubiquitous and the ubiquitous ones. In the pre-ubiquitous phase, that begun in the 70's, it was supported face-to-face meetings. In the proto-ubiquitous phase, distributed meetings were supported. This phase come to life in the 90's. The ubiquitous phase is now getting under way, supports meetings, and it is distributed in time and space. Systems need to be built to support distributed and asynchronous decision meetings or social events.

Ubiquitous computing was introduced in the 90's and anticipates a digital world which consists in many distributed devices that interact with users in a natural way. This vision was too far ahead for its time, however the hardware to implement Mark Weiser's vision [4] is now commercially available and at a low cost. In an ambient intelligent environment, people are surrounded with networks of embedded intelligent devices providing ubiquitous information, communication and services. Intelligent devices are available whenever needed, enabled by simple or effortless interactions, attuned to senses, adaptive to users and contexts, and acting autonomously. High quality information and content may therefore be available to any user, anywhere, at any time, and on any device.

Today, there is an increasing interest in the development of Group Decision Support Systems (GDSS) to formalize and develop "any time and any place" group decision making processes, instead of "same place and same time" ones. With the economy globalization, possible participants to form the group, like specialist or experts in specific areas, are located in different points of the world and there is no way to put them in the same decision room. Thus, Ubiquitous Computing appears like the natural answer to solve this problem.

There are many areas where ubiquitous group decision making apparently makes sense. One of the most cited areas in literature is healthcare, since patient treatment involves several specialists, like physicians, nurses, laboratory assistants, radiologists. These specialists could be distributed along departments, hospitals or even living in different countries. The HERMES system, a web-based GDSS, was tested according to this scenario [5]. There are other GDSS that support ubiquitous decision making (GroupSystems software; WebMeeting software; and VisionQuest software).

3. Smart Decision Rooms

Decision Making is one of the noblest activities of the human being. Most of times, decisions are taken involving several persons (group decision making) in specific spaces (e.g. meeting rooms). It is expected that meeting room environments follow the trends of Ambient Intelligence. These spaces receive the name of Intelligent or Smart Decision Rooms, and they should support efficient and effective interactions among their occupants. The generic goal of such environments is to support group interactions at real time and in an intelligent way.

The infrastructure which can be used for such rooms includes a suite of multimodal sensory devices, appropriate computing and communications systems. In [6] the components of a smart environment are identified.

In the field we can find interesting projects like SMaRT [7], AVIARY [8], M4 (Multi Modal Meeting Manager) and AMI (Augmented Multi-party Interaction) [9], IDIAP [10], and LAID (Laboratory of Ambient Intelligence for Decision Making) [11]. This last system will be presented more in detail in this paper.

SMaRT [7] intends to provide meeting support services that do not require explicit human-computer interaction, enabling the room to react appropriately to users needs, maintaining the focus on their own goals. It supports human-machine, human-human, and human-computer-human interactions providing multimodal and flexi-modal interfaces for multilingual and multicultural meetings.

M4 aim is to design a meeting manager that is able to translate the information that is captured from microphones and cameras into annotated meeting minutes allowing high-level retrieval questions, as well as summarization and browsing [9]. It is concerned with the construction of a demonstration system to enable structuring, browsing and querying of an archive of automatically analyzed meetings.

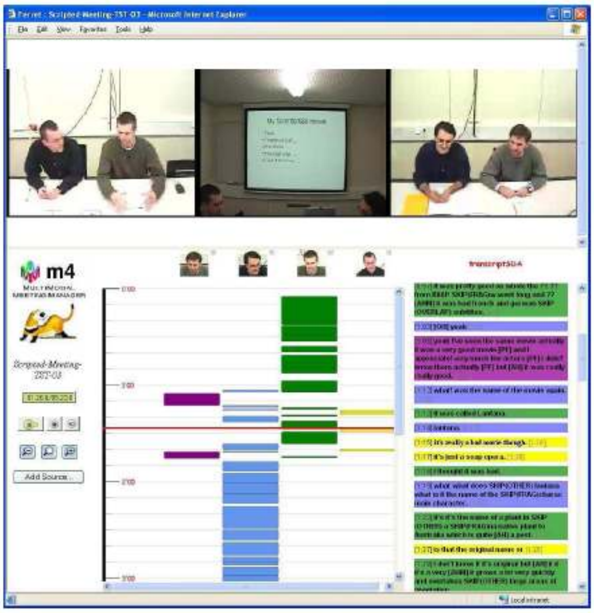

Figure 1. M4 meeting browser [9]

There is also AMI concerned with new multimodal technologies to support human interaction, in the context of smart meeting rooms and remote meeting assistants. It aims to enhance the value of multimodal meeting recordings and to make human interaction more effective in real time. In M4 project the software goal includes the analysis and processing of the audio and video streams, robust conversational speech recognition, to produce a word-level description, recognition of gestures and actions, multimodal identification of intention and emotion, multimodal person identification and source localization and tracking (Figure 1).

The IDIAP smart meeting room [10] can receive meetings containing up to six participants. The hardware is composed by a table, whiteboard, computer projection screen, 24 microphones configured as lapel microphones, in the ears of a binaural manikin, and in a pair of 8 channel tabletop microphone arrays, three video cameras, and equipment for capturing time-stamped whiteboard strokes (Figure 2). The recorded data is precisely synchronized so that every microphone, pen-stroke, and video sample can be associated with simultaneously captured samples from other media streams. The software component uses XML to catalogue all the data and it is mentioned an off-line media interactive browsing system.

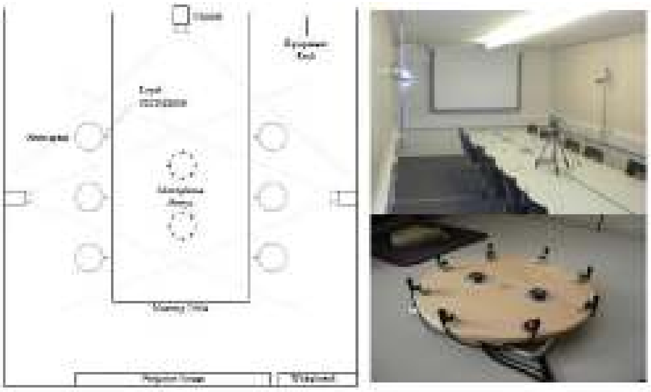

Figure 2. IDIAP Smart Meeting Room perspective and microphone arrays [10]

The AVIARY system [8] takes as input four static cameras with highly overlapping fields of view, four active cameras (pan/tilt/zoom), two microphones and two computers.

Some other Smart Meeting Rooms are described in [7].

4. LAID Intelligent Decision Environment Room

LAID [11] is an Intelligent Environment to support decision meetings (Figure 3).

Figure 3 - Laboratory of Ambient Intelligence for Decision Making

LAID is composed by the following hardware (Figure 4):

- Interactive 61'' plasma screen
- Interactive holographic screen
- Mimio® Note grabber
- Six interactive 26'' LCD screens, each one for 1 to 3 persons
- 3 cameras, Microphones and activating terminals controlled by a CAN network.

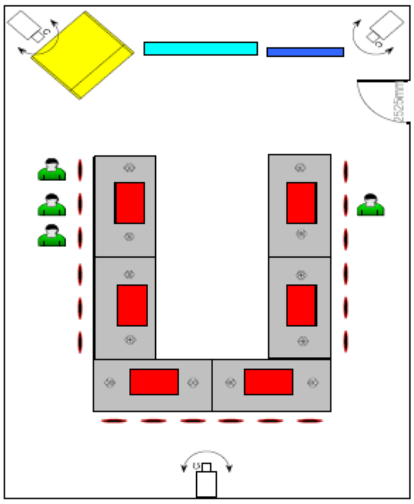

Figure 4. LAID diagram

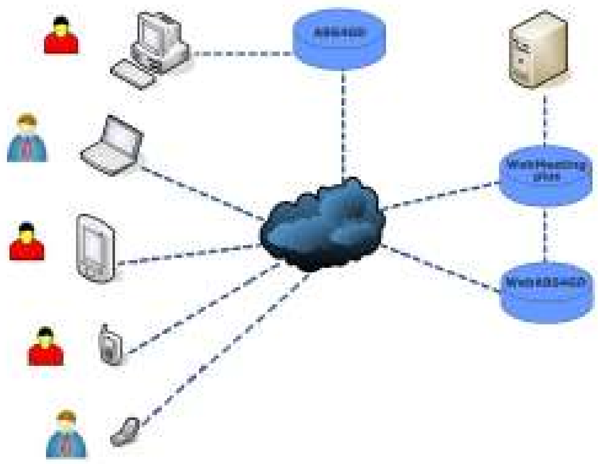

Figure 5. LAID Software architecture

At the software level (Figure 5) LAID is equipped with a system that supports the decision making process. Particularly this system supports persons in group decision making processes considering the emotional factors of the intervenient participants, as well as the argumentation process. The systems described in the previous sections do not have mechanisms to support argumentation processes, as well as, the emotional and social aspects involved in the group decision process. For this reason this paper will give a special focus on these characteristics (emotional aspects and argumentation support).

LAID is composed by the following modules: WebMeeting Plus, ABS4GD, WebABS4GD, and the pervasive hardware already referred.

WebMeeting Plus is a tool to help geographically distributed people and organisations in solving multi-criteria decision problems, namely supporting the selection of alternatives, argumentation, voting techniques and meeting setup. WebMeeting Plus is an evolution of the WebMeeting project with extended features for audio and video streaming. In its initial version, based on WebMeeting, it was designed as a Group Decision Support System supporting distributed and asynchronous meetings through the Internet.

ABS4GD (Agent Based Simulation for Group Decision) is a multi-agent simulator system whose aim is to simulate group decision making processes, considering the emotional and argumentative factors of the participants.

WebABS4GD is a ubiquitous version of the ABS4GD tool to be used by users with limited computational power (e.g. PDA) or users accessing the system through the Internet.

5. Modelling Group Decision Making by Multi-Agent Systems

Agent Based simulation is considered an important tool in a broad range of areas. For instance, some examples of our previous research group work are found in e-commerce [12], and electricity markets [13].

Multi-agent systems seem to be quite suitable to simulate the behaviour of groups of people working together [14], 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. It is important to notice that in our approach Agents are not intended to substitute meeting participants. We want to simulate participants in the meeting in order to have an idea of the meeting trends. One specific meeting participant may use this information to define an argumentation policy, taking into account emotional factors associated to the other meeting participants.

5.1. Multi-agent Model

Each participant of the group decision making process is associated with a set of agents to represent himself and 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 has access to an Agent Based Simulation Tool for Group Decision (AGS4GD) developed under the ArgEmotionAgents project [11]. This tool improves the knowledge of the community of agents, then making possible to predict the behavior of other participants and to advice on the best practices.

5.2. Participant Agent Architecture

In this section we will first present the architecture of participants' agents, because they represent the main role in group decision making and then we will detail the components of this architecture.

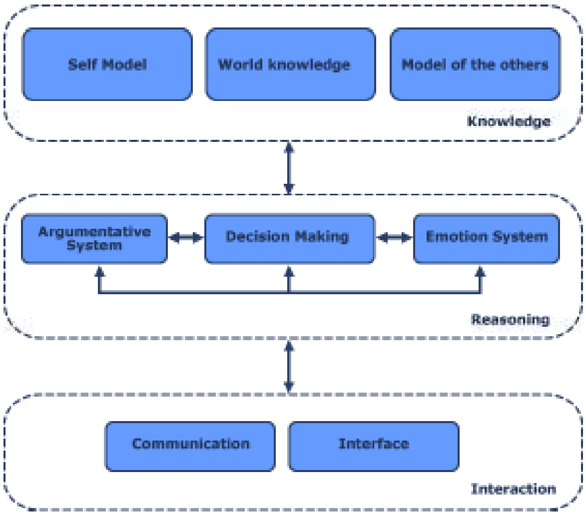

Figure 7. Participant agent architecture

In the knowledge layer the agent has information about the environment in which it is situated, about the profile of the other participants' agents that compose the simulation group, and regarding its own preferences and goals (its own profile). The information in the knowledge layer takes into account uncertainty and will receive more accuracy along the time through the interactions done by the agent.

The interaction layer is responsible for the communication with other agents and for 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 considering what he thinks about the others agents profiles (including the emotional state);
- The decision making module – will support agents in the choice of the preferred alternatives and will classify all the set of alternatives in three classes: preferred, indifferent and inadmissible;
- The emotional system – will handle 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.

6. Emotional System

The Emotional System module is common to WebMeeting Plus and ABS4GD.
The emotions that will be simulated in our system are those identified in the reviewed version of the OCC model [15]: joy, hope, relief, pride and gratitude, like distress, fear, disappointment, remorse, anger and dislike. The agent emotional state (i.e. mood) is obtained in this module based on the emotions felt in past and in the other agents' mood [14].

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

6.1. Appraisal

The appraisal mechanism is based on the OCC model [15]; the simulator user defines the conditions for the emotion activation. An example may be:

$$\textit{If } Goal(AgP, X) \textit{ AND } Request(AgP, AgP_y, X)$$

$$\textit{Then } Emotion(hope, '+', t, X, I)$$

In the previous example the emotion *hope* is appraised if Agent AgP_i has the *goal X* and asks agent AgP_j to perform *X*, in this case the emotion *hope* is generated.

Another example is the gratitude rule:

$$\textit{If } Request(AgP, AgP_y, \emptyset X) \textit{ AND } Accept(AgP_y, AgP, \emptyset X)$$

$$\textit{Then } Emotion(gratitude, '+', t, AgP_y, I)$$

A weight, in the interval [0,1], is settled for each condition in the emotion generation. The intensity of the emotion is calculated according the conditions weights. A particular emotion could be expressed or not by the agent, depending on the intensity of the others emotions.

6.2. 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 at instant *t*, for $AgPi_{ActEmo,t}$, will be the one that maximize the differential between the intensity and the activation. Let Δ be the set of all the differentials:

$$\Delta = \{(Int_1 - Act_1),\ldots(Int_n - Act_n)\}$$

$$Emo^t_{AgP_i} = \left\{(Emo_j, Int_j, Act_j) : (Emo_j, Int_j, Act_j) \in AgP^t_{iEmo}, (Int_j - Act_j) = \max \Delta\right\}$$

6.3. 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 maintains 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.

6.4. Mood

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

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

K^+ and K^- are the sum of the intensity (I) of the positive/negative emotions felt in the last n periods, and n can be parameterized by the user. Only emotions that are above the threshold activation are considered. The mood is obtained considering the following conditions:

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

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

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

Each participant agent has a model of the other agents, in particular the information about the other agents' 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.

7. Argumentation System

Argument nature and type can vary, however six types of arguments are assumed to have persuasive force in human based negotiations [16]: threats; promise for 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: reward, coercive, referent, and legitimate.

The argumentation system will generate persuasive arguments based on the information that exists in the participant's agent knowledge base [11].

The Argumentation System module is also common to WebMeeting Plus and ABS4GD.

In Figure 8, can be seen 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, this agent may be involved in other persuasion dialogues with other group members.

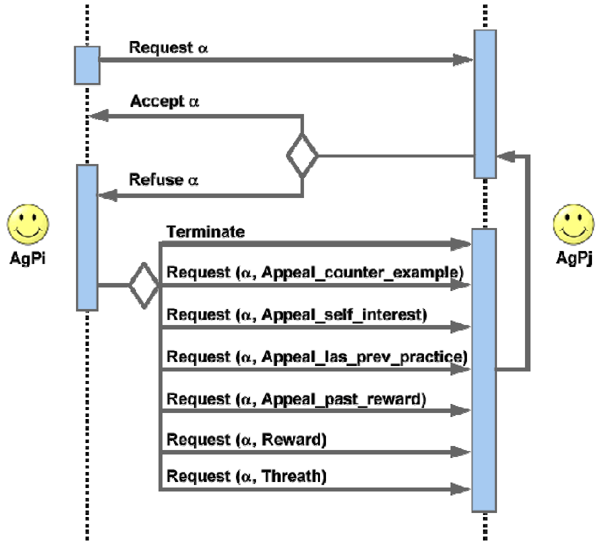

Figure 8. Argumentation protocol for two agents

As we see agents have a set of possible arguments to exchange, so it is important to define rules to the argumentation selection. Another important aspect is the evaluation of the received arguments.

7.1. 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.

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 [17].

7.2. 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:

$Req^{t}_{AgP_i} = \{request^{t}_{1}(AgP, AgP_i, Action), ..., request^{t}_{n}(AgP, AgP_i, Action)\}$, 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 $AgPO_{AgP_i} \square Action$ ***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

8. Implementation and Experiments

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

8.1. 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/.

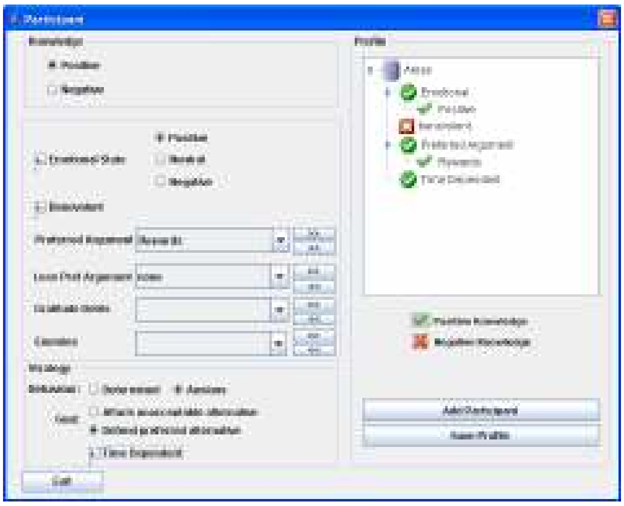

Figure 9. Participant agent profile

In figure 9 it is possible to visualize the setup of a new participant agent in the community.

8.2. Experiments

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

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 the results can be visualized in table 3.

Table 3. Simulation results

Number of simulations	25
Number of simulations where the number of exchanged arguments using emotional agent s was higher than when using non-emotional agents	2
Number of simulations where the number of exchanged arguments using non-emotional a gents was higher than when using emotional agents	23
Maximum number of exchanged arguments for emotional agents	9
Minimum number of exchanged arguments for emotional agents	2
Maximum number of exchanged arguments for non-emotional agents	13
Minimum number of exchanged arguments for non-emotional agents	5
Average of the exchanged arguments for emotional agents	5.4
Average of the exchanged arguments for non-emotional agents	7.1

Figure 10 illustrates the number of arguments that were necessary to exchange before achieving an agreement in each simulation by agent type (emotional or non-emotional).

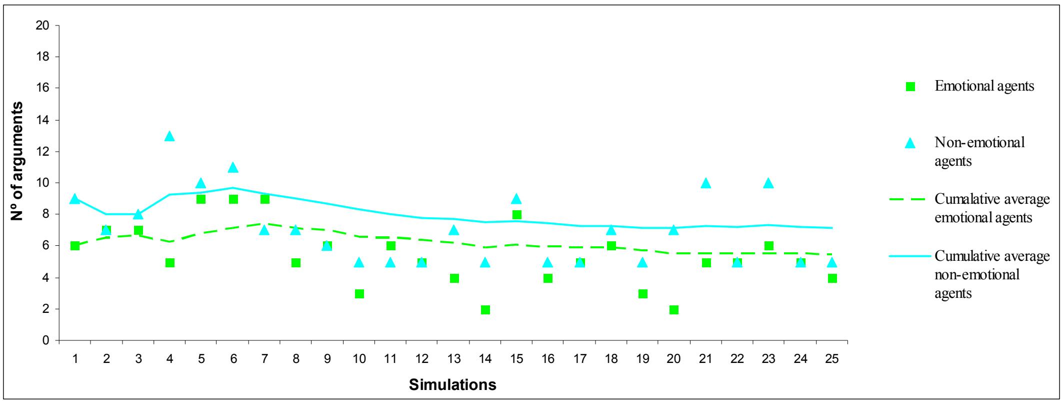

Figure 10 – Average number of arguments by agent type (emotional vs non-emotional agents)

The average of arguments when emotional agents are used is 5.4 and for non-emotional agents is 7.1. The line represents the cumulative average of exchanged arguments for non emotional agents and the single dashed 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.

9. Conclusions and Further Work

Most of the works related with Ambient Intelligence in meeting rooms are centering the attention in the sensing and recognition phases. In LAID environment we put more effort in the decision support phase, since we think that these environments will just be considered as intelligent if they are able to give a real support to the most complex aspects in the decision making process. In the case of LAID the attention was given to the emotional factors and to the argumentation support.

In spite of being considered a Smart Decision Room, LAID is not closed in the real meeting room walls. Ubiquity is a real need today and we have developed a system allowing the virtual presence of meeting participants in the decision making process, even if they are not inside the meeting room. The developed system was designed to allow the participation at any moment (asynchronous meetings), in any place (distributed meetings), and on any device (ubiquity).

Agent-based simulation was used to model groups in the analysis of alternative decisions. Thus it is possible to know in advance the trends of the meeting alternatives and to know if the preferred or undesired alternatives have possibility to win or not. In the first case, the argumentation process may be conduced to try to guarantee the victory of the preferred alternative. In the second case the argumentation process will try to avoid the victory of the undesired alternatives. In any case, emotional factors will be taken into attention to give more impact to arguments.

We made a set of experiences using the developed system in some real-world decision problems. The results pointed out the advantage of meeting participants that use the decision support system considering emotional aspects in the phase of argumentation.

Some directions are being followed in the further work. We are now studying some additional support to meeting participants. A recent work is focused in the Idea Generation support. IGTAI (Idea Generation Tool with Ambient Intelligence) is a prototype of an idea generation support system (e.g. for Brainstorming), the main idea is to use domain ontologies in the process of idea generation. Some work is also being done in the use of sensorial information, namely by cameras and microphones, to identify who is speaking in order to center the camera image in that person, allowing an automatic and more attractive production of the meeting video. The idea is to allow a more realistic view of the meeting for participants that are not present in the meeting room, but that may be using notebooks or PDA to follow the meeting.

10. References

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