

Ambient Intelligence in Emotion Based Ubiquitous Decision Making *

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Abstract

As the time goes on, it is a question of common sense to involve in the process of decision making people scattered around the globe. Groups are created in a formal or informal way, 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. In this work it is proposed an agent-based architecture to support a ubiquitous group decision support system, i.e. based on the concept of agent, which is able to exhibit intelligent, and emotional-aware behaviour, and support argumentation, through interaction with individual persons or groups. It is enforced the paradigm of Mixed Initiative Systems, so the initiative is to be pushed by human users and/or intelligent agents.

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 take 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 behaviour and performance of different computational systems in different applications domains, with a special focus on socialization.

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. 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 environments where networks of computers, information and services are shared. 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). This meeting is distributed but it is also asynchronous, so participants do not need to be involved at any time. 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.

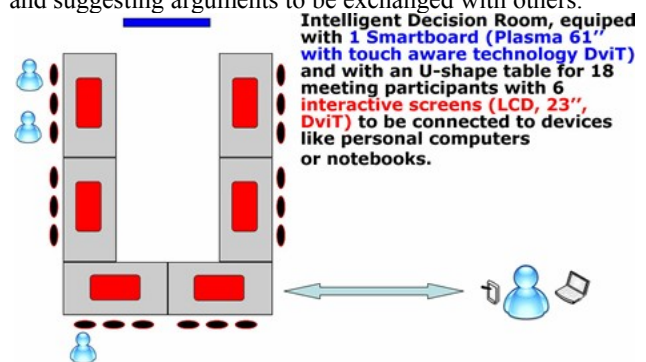


Figure 1 - Distributed Decision Meeting

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The use of multi-agent systems is very suitable to simulate the behaviour of groups of people working together and, in particular, to group decision making modelling, once it caters for individual modelling, flexibility and data distribution [Marreiros et al., 2005a]. 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 Ubiquitous group decision making

Jonathan Grudin [Grudin 2002] 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 came to life in the 90's. The ubiquitous phase is now getting under way, supports meetings, and it is distributed in time and space. The proposed system will be built to develop distributed and asynchronous decision meetings or social events.

Ubiquitous computing was introduced by Mark Weiser [Mark Weiser 1991], 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 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. This interest came with the need of joining the best potential group of participants. 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 was no way to put them in the same decision room. Until some years ago, a way out of this scenario was to wait until all the participants meet together. Actually, there is a growing interest in developing systems to hold up such scenarios.

There are many areas where ubiquitous group decision making apparently makes sense. One of the most cited areas in literature is healthcare, since patient's 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 [Karacapilidis, et al., 2001]. There are other GDSS that support ubiquitous decision making (GroupSystems software; WebMeeting [Marreiros et al., 2004]; VisionQuest software).

3 Mixed initiative systems

In the last years researchers had pondered on the merits of a total automation of user necessities (via intelligent agents) versus a total user control of operations and decisions (via Graphical User Interfaces) [Shneiderman and Maes, 1997]. Indeed, there is an interesting dualism between Artificial Intelligence (AI) and Human Computer Interaction (HCI). In AI, one tries to model the human thinking by creating computer systems able to do intelligent actions. In HCI, one designs computer interfaces to attract the user, supporting him/her to execute intelligent actions. The link between these two fields is the so-called Mixed Initiative Interaction. This refers to a flexible interaction strategy, where each agent (human or computer) can contribute to problem resolution with their best at their right moment [Hearst, 1999]. The concept of Mixed Initiative Systems is quite adequate to the group decision field. It is certainly very useful for a participant in a meeting to be assisted by a system able to show the available information and knowledge, analyzing the meeting trends and suggesting arguments to be exchanged with other specific participants.

In this work, a mixed initiative systems is seen as a collection of joint processes linking users and a community of computer agents that work as a whole, like a personal assistant to satisfy user needs. Agent-based systems are ideal to accomplish this purpose due to their autonomy and independence to execute repetitive, boring and time consuming tasks. Cesta and D'Aloisi [Cesta and D'Aloisi 1999] identified three characteristics needed in order to make the agents to participate in a mixed initiative interaction with users:

- Agents should adapt their behaviour to the user they are supporting, according to the philosophy of adaptive interfaces;
- Agents should act according to some principles of initiative shift taking among them, their users and other agents in the environment (when they exist);
- Agents should give to the user a level of 'super-control' in order to enhance the sense of trust between them. The user must have the possibility of inspecting the agent and then it will be able to prevent any undesirable operation and/or failure.

The proposed model is a duo between participants and agents with a various level of trust in order to work more effectively. This solution based on the levels of trust should solve the problem of the reliance on the agents. Any participant of the meeting would question if the agent representing him/her was doing the right thing. In this way, participants can inspect the agent to see what arguments are being used in the interaction process with other agents or participants in order to increase or decrease its reliance. A key aspect of the agent is its profile that should be specified in an uninterrupted process, continuously changing in order to have the

larger possible amount of information in order to be able to predict the participant actions and needs.

4 Ubiquitous system architecture

One's aim is to present a ubiquitous system able to exhibit an intelligent and emotional behaviour 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 modelled 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:

- The use of a simplified model of Groups and Social Systems for Decision Making processes, balancing Emotional and Rational aspects in a correct way;
- The use of a decision making simulation system to support meeting participants. This will involve the emotional component in the decision making process;
- The use of an argumentation support system, suggesting arguments to be used by a meeting participant in the interaction with other participants;
- The mixed initiative interface for the developed system;
- 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.

The main blocks of the system are:

- **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* (Marreiros et al., 2004), 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. Moreover, 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 favour/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;

- **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.
- **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 system 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.

5 Multi-agent model

Multi-agent systems seem to be quite suitable to simulate the behaviour of groups of people working together [Marreiros et al., 2005a], 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 behaviours of other participants.

The participant should have access to an Agent Based Simulation Tool for Group Decision (AGS4GD) developed under

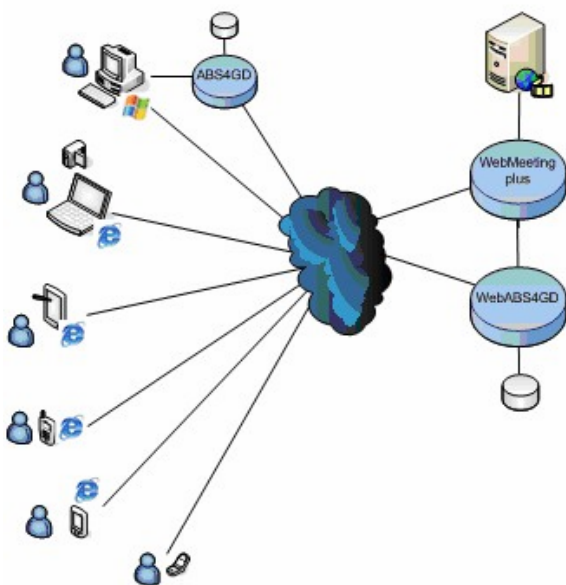


Figure 2 - System Architecture

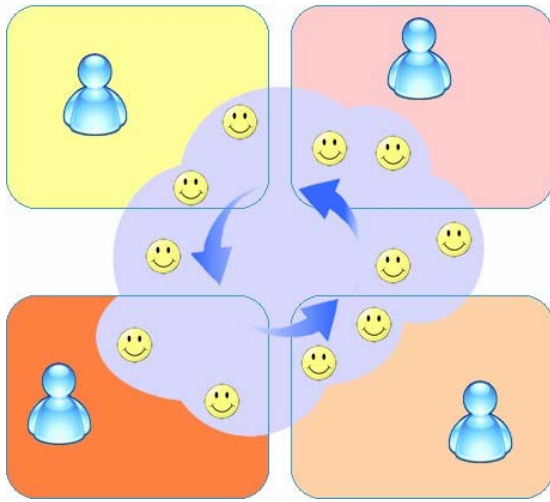


Figure 3 - Multi-Agent Model

the *ArgEmotionAgents* project. This tool will improve the knowledge of the community of agents, then making possible to predict the behaviour 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 its interactions, changing algorithms and models, therefore closing the gap on its view of the world in future interactions.

6 ABS4GD description

A first prototype of the Agent Based Simulator for Group Decision Making is proposed. According to Zachary and Ryder [Zachary and Ryder 1997] 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.

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, 2006a]. 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.

6.1 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 $n \geq 2$. The criteria are also known. Let $C = \{C_1, C_2, \dots, C_m\}$ be an enumerated set where $m \geq 2$. The decision matrix will be composed of n alternatives and m criteria. Let $D = [D_{ij}]_{n \times m}$ where D_{ij} represents the value of the alternative A_i respectively to criterion C_j , and $i = 1, \dots, n$ and $j = 1, \dots, m$.

The participants of a specific simulation constitute the set $AgP = \{AgP_1, \dots, AgP_k\}$, where k is the number of participants and $k \geq 2$. Each AgP_i has defined a set of weights for the criteria. Let $W_{AgP_i} = \{W_{C_1}, \dots, W_{C_m}\}$ be the set of weights for AgP_i , where $\sum_{j=1}^m W_{C_j} = 1$, $W_{C_j} \geq 0$, standing for the definition of multi-criteria problem.

6.2 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, 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 is an amalgam of the one mentioned before, with the particularity that here one is only considering the choice phase (Figure 4). 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).

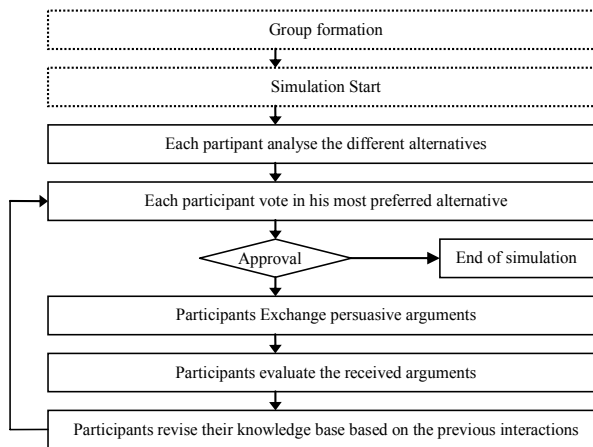


Figure 5 - Group decision protocol

6.3 Argumentation system

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

Request ($AgP_i, AgP_j, \alpha, arg$) - 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 that are specified in the following 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 can not 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.

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, 1990]: 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 e 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, 2006b].

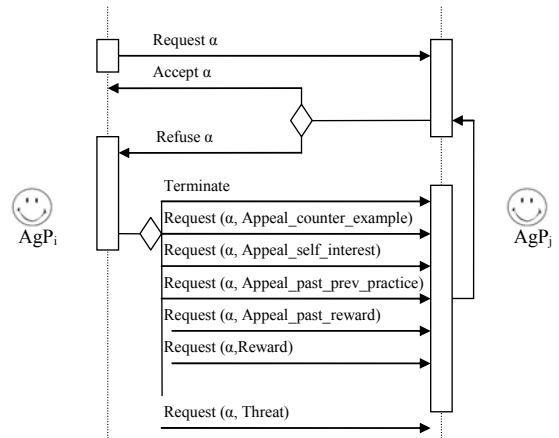


Figure 4 - Argumentation protocol for two agents

6.4 Emotional system

The emotions that will be simulated in our system are those identified in the reviewed version of the OCC model: joy, hope, relief, pride and gratitude, like distress, fear, disappointment, remorse, anger and dislike [Marreiros et al 2005b]. 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].

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, following the approach described in [Neves 1984]. Some of the properties that characterize the agent model are: gratitude debts, benevolent, credibility [Andrade et al. 2005], (un)preferred arguments.

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.

6.5 Implementation

Some details of the implementation of the simulator previously are described.

The system was developed in Open Agent Architecture (OAA), Java and Prolog. OAA is structured in order to: minimize the effort involved in the creation of new agents, that can be written in different languages and operating on diverse platforms; encourage the reuse of existing agents; and allow for dynamism and flexibility in the makeup of agent communities [OAA, URL].

Some screens of the prototype may be found in Figures 6 and 7.

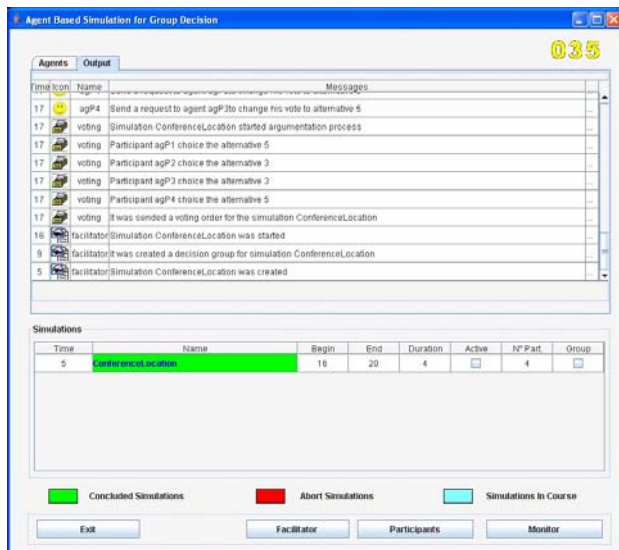


Figure 6 – Argumentation Dialogues

Figure 6 shows an extract of the arguments exchanged by the participant agents. Once a simulation is accomplished, agents update the knowledge about the other agent's profile (e.g. agent credibility).

Figure 7 shows the collection of agents that work at a particular moment in the simulator: 10 (ten) participant agents, the facilitator agent (responsible for the follow-up of all simulations), the voting agent, the clock agent (OAA is not specially designed for simulation, for that reason it was necessary to introduce a clock agent to control the simulation), the oaa_monitor (i.e. an agent that belongs to the OAA platform, and is used to trace, debug and profile communication events for an OAA agent community) and the application agent (responsible for the communication between the community of agents and the simulator interface).

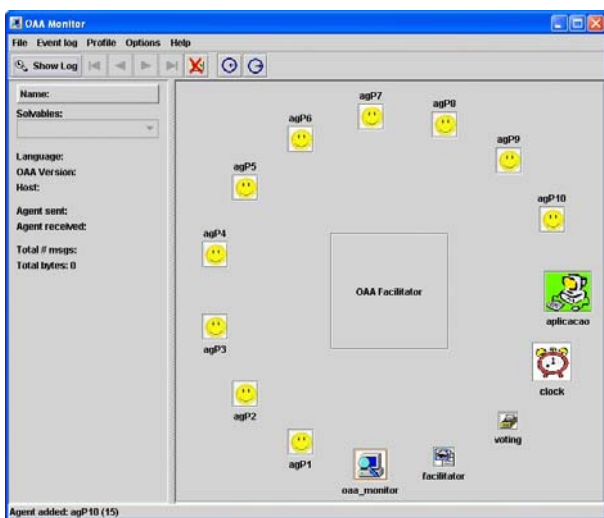


Figure 7 - Community of Agents

7 Conclusions

This work proposes a simple architecture for a ubiquitous group decision making system able to support distributed and asynchronous computation. This system will support 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 [Neves 1984]. 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, here declared under the umbrella of the mixed initiative systems paradigm.

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