DEFINING A MODEL FOR AGENT-BASED PARTICIPANT SUPPORT IN GROUP DECISION MEETING

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Abstract – This paper aim to present a multi-agent model for a simulation system, whose goal is to help one specific participant of multi-criteria group decision making process.

This model has five main intervenients types: the human participant, who is using the simulation and argumentation support system; the participant agents, one associated to the human participant and the others simulating the others members of the decision meeting group; the directory agent; the proposal agents, representing the different alternatives for a decision (the alternatives are evaluated based on criteria); and the voting agent responsible for all the voting mechanisms.

At this stage it is proposed a two phase algorithm. In the first phase each participant agent makes his own evaluation of the proposals under discussion, and the voting agent proposes a simulation of a voting.

In second phase, after the dissemination of the voting results, each one of the participant agents will argue to convince the others to choose one of the possible alternatives. The arguments used to convince a specific participant are dependent on agent knowledge about that participant. The two-phase algorithm is applied iteratively.

Keywords: Group decision making; Argumentation; Intelligent agents

I. INTRODUCTION

The impact of decision making in today's organization is so high and complex, that rarely the decision making process is made just by one individual. Groups of individuals have access to more information and more resources [1], what will (probably) allow to reach "better" and quicker decisions.

Complete business decisions often involve a number of alternatives evaluated by multiple conflicting criteria [2], for instance the decision about the location for the new Lisbon airport, can involve criteria like: distance to a city (this criteria can influence the number of days that tourists stay in the country), building and operational costs, existence of public transports, environmental impact, etc. When a multicriteria decision problem is analysed (decided) by a group of individuals additional aspects have to be considered: the members of the decision meeting can be dispersed across countries, time and costs constrains to realize face-to-face decision meeting, and each participant has his/her preferred or less preferred alternatives and because of that will try to convince the others, through argumentation, that one alternative is better or worst than another.

In the argumentation process it is very important the knowledge that the participant has about the other members of the group, because this knowledge is valuable and will certainly influence his/her argumentation strategy.

In previous paragraphs we have focused two points: the need to support a group having as task a multi-criteria decision making, and the need to support a participant in his/her argumentation elaboration process.

Regarding the first point it has already been developed the *WebMeeting* system, designed to support distributed and asynchronous meetings [3]. It aims at helping geographically distributed people and organizations in solving multi-criteria decision problems. Figure 1 presents the *WebMeeting* screen used for the configuration of all the meeting details: dates, group members, decision rules, etc.

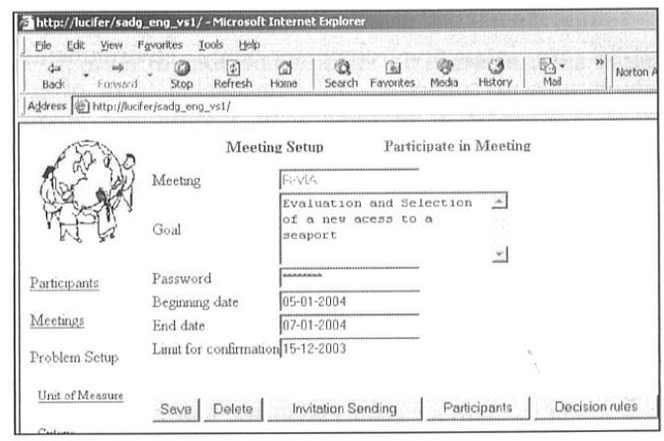

Figure 1- Screen with general meeting information

Figure 2 bellow presents an argumentation forum for a particular decision problem.

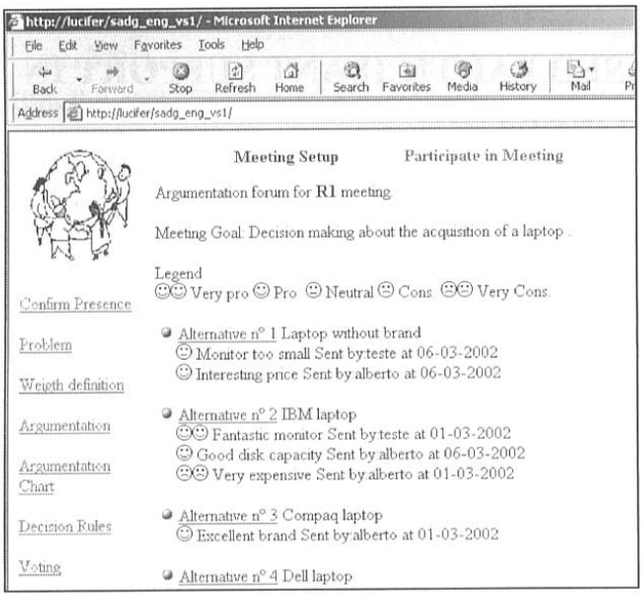

Figure 2- Argumentation forum

This papers aims to present a multi-agent model for a training system, whose goal is to support one specific participant of a multi-criteria group decision making helping him/her especially in the argumentation process. This paper has five main sections. The next section presents a short look on Group Decision Support Systems (GDSS). Section 3 presents a brief overview of argumentation, multi-agent systems and their relations with GDSS. Section 4 presents a multi-agent model to support the argumentation process in a multi-criteria group decision problem. The final section presents some conclusions about the proposed model.

II. Group Decision Support System

Group Decision Support Systems (GDSS) can be presented as a set of software, hardware, language components and procedures that support a group of people engaged in a decision related meeting [4]. Another definition for GDSS is from Nunamaker [5], says that GDSS are interactive computer-based environments which support concerted and coordinated team effort towards completion of joint tasks. Tung and Heminger[6] says that GDSS are designed to minimize or overcome process losses of manual meetings, while seeking to enhance process gains.

DeSanctis and Gallupe [7] proposed a taxonomy to classify GDSS based on group members' proximity (face-to-face, dispersed), group size (small, large), and task type (planning, creativity, intellective, preference, cognitive conflict, mixed motive). Another classification could be derived from DeSanctis and Gallupe taxonomy and considers only the time/place dimensions: (i) same-time and same-place; (ii) same-time different places; (iii) different-time and same place; (iv) different-time and different-place.

In the 80's most of the research in the GDSS area was focused in the same-time/same-place, for instance in the University of Arizona (place were was developed one of the first GDSS, the GroupSystems[8]) researchers had setup several decision rooms and were performed several experiences and studies[9][10][11].

In the last years GDSS research have had its focus in different-time (asynchronous)/different-place, several web-based GDSS have been developed [12][13].

Group decision making involves discussion between group members, several GDSS includes mechanism to support the exchange of arguments to support points of views [14][15][3].

Issue-Based Information System (IBIS) [16] is an argumentation model that is used with that purpose. This model allows to structure a discussion, but the actual implementations of this model does not help group members in the elaboration of arguments.

Another recent line of research in GDSS is the link to argumentation and multi-agent systems that will be presented in next section.

III. Argumentation and Multi-Agent Systems

A. *Terms Definitions*

Wooldridge and Jennings defined the term agent like a hardware and/or software-based computer system that enjoys the following properties [17]:

- Autonomy - Agents operate without the direct intervention of humans and have some kind of control over their internal state.
- Social ability - Agents interact with other agents (and possibly humans) via some kind of agent communication language.
- Reactivity - Agents perceive their environment and respond in a timely fashion to changes that occur in it.
- Pro-activeness - Agents do not simply respond to their environment, they are able to exhibit goal-directed behavior by taking the initiative.

Multi-agent Systems (MAS) are software systems composed of several autonomous agents running in a distributed environment.

A classical definition of argumentation is from Toulmin [18] and defines argumentation as a process of making assertions or claims and providing support and justification for these claims using accumulated data, facts and evidence.

In MAS literature argumentation is referred as a key form of interaction among autonomous agents [19][20].

In the MAS, context argumentation is defined as an interactive process emerging from exchanges among agents to persuade each other and bring about a change in intentions [19].

Within MAS literature, the BDI model (Belief, Desire and Intentions) is widely used to express the mental state of agents [19][21]. The *Beliefs* of one agent, repre-

sent what an agent believes in each moment and describe the agent world (environment); *Desires* is referred to what an agent aims to obtain and *Intentions* represent a set of actions that the agent select to fulfil its goals.

Kraus et al [19] referred that, in order to negotiate effectively, an agent should be able to:

- represent and maintain a model of its own beliefs, desires, goals and intentions;
- reason with other agents beliefs, desires, goals and intentions;
- influence other agents' beliefs, intentions and behaviour.

In the context described above argumentation is the mean by which one agent tries to modify other agent(s) intention structures. Argumentation is a dynamic process, for instance agent *A* could be trying to convince other agents to make some action and in that same moment agent *B* is trying to convince agent *A* to do *X*. An agent may update its beliefs based in world observation and in messages that he receive from other agents.

B. How does argumentation, MAS and GDSS interact?

As it was mentioned before, the goal of GDSS is to help a group that is responsible for a decision making. In this process many times 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.

If a user of a GDSS could be helped by an agent that inform him/her what are the best arguments to convince another member of the group, this will be very useful.

There are already in literature descriptions of agent based GDSS, some of them will be described afterwards.

Zamfirescu[22] propose an agent-based GDSS architecture. In this model two kinds of agents are proposed: interface agents and resource agents. The first, the interface agents, assists each one of the members of the decision meeting, and there is also an agent to support the group facilitator. The resource agents provide services to the rest of the system (communication services, Decision Support System services and information retrieval services).

Ito and Shintani [23] propose an architecture for an agent based GDSS, where to each member (human) of the decision meeting is associated an agent. The key idea of this system is the persuasion mechanism between agents. The persuasion in this system is already done in pairs, for instance, agent *A* tries to convince the agent *B* about the choice of alternative *X*, if agent *A* succeed then they will form a group and together will start a new persuasion cycle and try to convince another agent about the choice of *X* alternative.

Espinasse et al [24] propose a multi-agent architecture to a Negotiation Support System (NSS) to multi-criteria decision problems. NSS started to be a part of GDSS, but nowadays there are systems that exist out of GDSS, although they could be found like a GDSS component. In this architecture it is proposed a community of agents, where each agent is associated to a human decision maker, and a mediator agent is associated to the human mediator. There are other agents (reactive type) that are associated to criteria, actions and weights.

IV. Proposed Model

A. Model

The model presented here envisages to represent the main components of a group decision making process. The model is to be used in a multi-agent system designed to simulate groups in a decision making process involving argumentation. The goal is to support one specific participant of a group decision making helping him/her especially in the argumentation process.

In the simulation system each member of the decision meeting is represented by a participant agent, but only one of them have an human decision maker behind (figure 3).

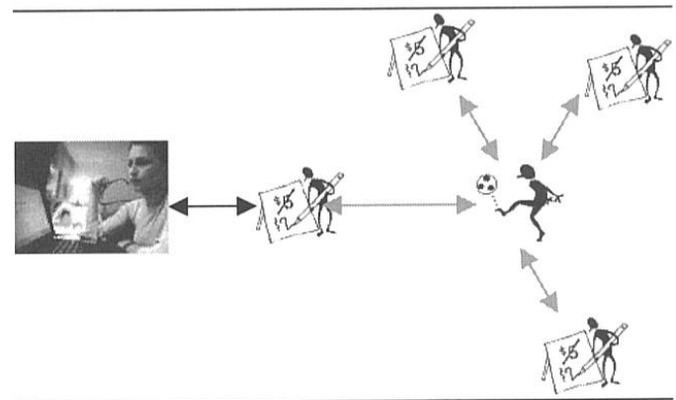

Figure 3- Simulation system (participant agents)

In order to understand better the characteristics of the agents referred above, it is important to identify the different kind of decision support structures meetings. Holsapple and Whinston [25] propose the following classification (figure 4):

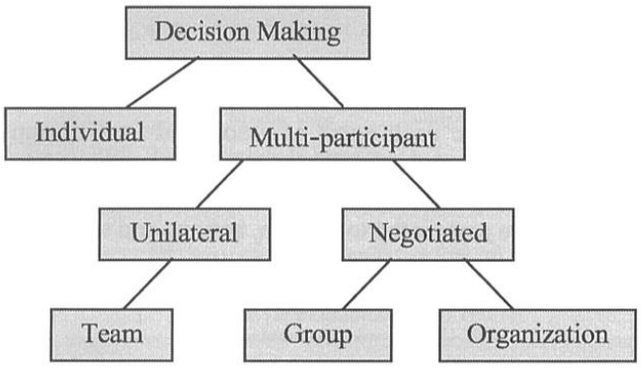

Figure 4- Decision making structure

Under this classification the decision-making can be individual or multi-participant. In the case that the decision is **multi-participant** (involves more than one person), there are yet two possible scenarios: the decision making could be **unilateral** or **negotiated**.

If the decision is Unilateral, that means that just one of the participants have the decision power, the remaining participants act like consulters. This structure is denominated of **team.**

If decision-making is negotiated, then two decisions making structures are possible: a group and an organization. The main difference between them relies in the authority distribution among the members of the decision meeting.

In **group** structure all the members have the same authority in the decision making process.

In an **organization** structure the members have different levels of authority, what could mean that for instance the number of votes of each member could be different.

1) Participant Agent

Under the decision making structure presented we start to describe some of the characteristics of participant agent:

- ***Agent identification***: name.
- ***Function***: decision maker or adviser, not all the agents could have decision power, some of them could act just like advisers, decision-making structure in this case is a team.
- ***Number of votes***: human decision maker could be in a simulation of a decision-making of organization type, and in that case not all the agents have necessarily the same number of votes.
- ***Possibility of veto***: although this characteristic is not considered in the decision structure presented, in some decisions one or more agents could have the right to perform a veto on a decision.

Bellow it is described more emotional and social characteristics of this agent:

- ***Unacceptable situations***: for instance, products from one specific country or enterprise; the inexistence of warranties; decisions very risky.
- ***Preferred situations***: is the opposite of the previous characteristic, for instance if the decision context is the acquisition of a car the agent could have a strong preference for Germany manufactures, or diesel motors.
- ***Authority:*** in the decision making process can be involved agents that have hierarchical dependencies, which will influence their behavior, for instance one agent can be easily persuaded by other agent if he has hierarchical dependencies to him.
- ***Trust:*** the agent have a list of one or more agents in which he trust, he could choose one alternative that is suggested by one of the agent trust list without further constraints, just because he has trust on that agent. The inverse situation is also valid, the agent may have a list of agents that he think they have trust on him.
- ***Gratitude:*** as in previous point the agent has also a list of agents that he think they have a "debt of gratitude" to him, so he could appeal to past situations to say "in situation X I make you a favor, so perhaps now you can help me....". The agent has also a list of agents to whom he has a gratitude debt. Brito et al [26] referred the concepts of negotiable gratitude and non-negotiable gratitude.
- ***Dislike:*** the agent may have a list of agents that he assumes they don't like him, and the reasons for that dislike can be several. The agent can also have a list of agents that he does not like.

Figure 3 represents a macro view of the proposed model, shown now in figure 5 where it is possible to see with more detail the model. At this step there are introduced in the model three distinct agent types: directory agent, proposal agents and voting agent.

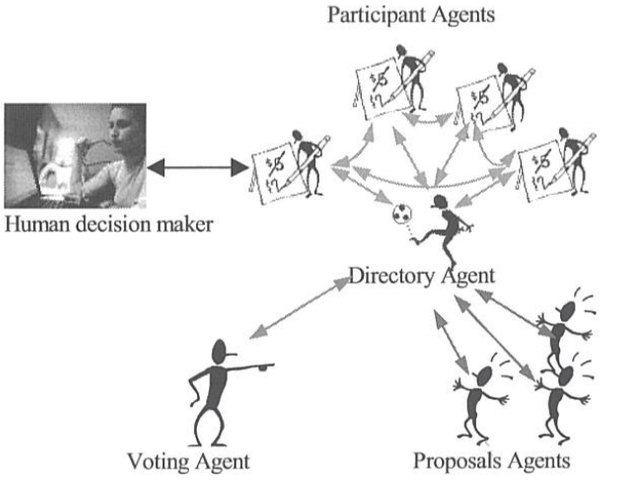

Figure 5- Proposed model

2) Directory agent

In figure 3 is possible to see one agent in the center of the others, this will be the director agent. As the name implies, a directory agent points (supplies the address of) to an appropriate agent, service, or resource when questioned.

Is not clear yet if the directory agent could accumulate some of the facilitation functions or if will be necessary a facilitator agent.

3) Proposal Agents

These agents represent the different alternatives that are under discussion/selection in the decision meeting. One proposal/alternative is characterized by several criteria, for instance if the decision problem is the acquisition of a house, the next criteria can be considered as relevant:

- price;
- localization;
- constructed area;
- garden area;
- facilities: swimming pool, tennis;
- year of construction;
- warranty.

Some of the previous criteria could yet have some sub criteria, for instance the criterion localization could be sub-dived in: facilities in neighborhood (supermarket, gymnasium, etc.), traffic in that zone, public transports (metro, bus,…), quality of the air, and others.

Probably in the future a criterion agent will represent each criterion, but at this phase all the information about the alternative will be in the proposal agent.

4) Voting Agent

This will be the agent responsible by the voting simulation. This agent retain information like for instance:

- Decision name.
- Participants that are in the decision meeting.
- Number of votes of each participant.
- Several proposals that are in discussion.
- Voting methods: these methods in general presume that each participant has the same number of votes, but under the proposed model participants can detain different number of votes. Bellow are presented some voting methods:
  - Plurality method: each participant vote in the most preferred alternative (proposal). The most voted alternative wins.
  - Majority rule: similar to the plurality method, but the winning alternative must have more than 50% of the total votes.
  - Unanimity: the winning alternative should have all the votes.
  - Instant Run-off: this is a multi-round voting method. Each participant votes in the most preferred alternative. After that the alternative with the least vote in each round is eliminated. Process is repeated until there is only one winning alternative.
  - Average rating: participants have a fixed amount of scores that can be assigned to the alternatives. To each alternative is given a total score by adding the scores assigned to each voter. The alternative(s) with the highest total score win.
  - Approval voting: every voter can vote in the alternative(s) he/she approves. The alternative with most votes wins.
- Voting procedures: time to initiate a voting, stopping conditions, rules to interpret results.

B. Model application to a decision meeting

At this stage it is proposed a two phase algorithm. In the first phase each participant agent makes his own evaluation of the proposals under discussion, and the voting agent proposes a simulation of a voting.

In second phase, after the dissemination of the voting results the human user of the simulation system would like to receive argumentation suggestions from his own participant agent, in order to convince the other participants about his preferred proposal.

After one voting the participant agents analyze the results, one possible approach is the following:

- The proposal that is in first is the one the participant agent most appreciated (note that the fact of a proposal is in first place, does not mean that is the winner, it depends on the voting methods).
- The proposal that is in first is unacceptable for the participant agent. In this case the participant agent probably will choose the most acceptable proposal that is better classified and will take several actions:
  - Change his own vote to another proposal that may have more possibilities to win the proposal that is now in first.
  - Argue to the remaining participants agents, about the qualities of that proposal and the disadvantages of the proposal that is in first.
  - Argue to one specific participant agent and try to change this vote based in some of the emotional and social characteristics that were referred (gratitude, authority, trust, etc).
- The most preferred alternative of the participant agent is almost winning, so it will try to argue in order to change the vote of some other participants, following some of the procedures pointed in previous paragraph.

The persuasion process between participant agents is an interactive and evolutive process. One agent may try to persuade one of the others agents, and in the exactly same moment other agents could be trying to persuade him. The arguments used by one participant to persuade

take in consideration the arguments received from other participants.

The two-phase algorithm is applied iteratively since according the changes in the alternatives selected by the different participants (changes that resulted from the argumentation) a new voting is obtained and the results can change. The algorithm stops when a stable situation is achieved.

Note that the objective of our model and algorithm is to obtain a list of valid arguments to use in order to convince other participants. The voting process is not a real voting but just a voting simulation.

V. Conclusions

Argumentation, Multi-Agent Systems and multi-criteria group decision making are three keywords of high importance. This paper presented a model that links the three referred areas, with special attention to the participant agents ability to elaborate arguments.

In the proposed model there are still some open questions, like for instance: the existence, or not, of one facilitator agent; the existence of criteria agents and perhaps sub-criteria agents.

Regarding the three agent based GDSS presented in section III some of the differences of the proposed model are:

- The fact that this is a model to a simulation system, making possible to the human participant to apply different argumentation strategies (proposed by its participant agent) and analyze the results of each strategy.
- The social and emotional characteristics of the participant agents.

As future work it is considered the refinement of the proposed model.

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