AGENT BASED SIMULATION FOR GROUP FORMATION

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ABSTRACT

Group decision making plays an important role in today's organisations. The impact of decision making is so high and complex, that rarely the decision making process is made just by one individual. The simulation of group decision making through a Multi-Agent System is a very interesting research topic. The purpose of this paper it to specify the actors involved in the simulation of a group decision, to present a model to the process of group formation and to describe the approach made to implement that model. In the group formation model it is considered the existence of incomplete and negative information, which was identified as crucial to make the simulation closer to the reality.

INTRODUCTION

The problem of group decision-making has gained great relevance in the scope of Decision Support Systems, which were initially designed as individual tools. Quickly those tools have demonstrated to be limited, in the sense that in today's organizations several persons, entities or agents are involved in most of the decision processes. In that way, the decision problems are considered from different points of view, with different opinions about the importance of the decision criteria (for example, in the purchase of a car we will be able to consider criteria like price, technical characteristics, design or manufacture). Groups of individuals have access to more information and more resources (Nunamaker et al., 1991), and that will (probably) allow reaching "better" and quicker decisions.

In the last years Group Decision Support Systems (GDSS) research focused in asynchronous (different-time) and ubiquitous (different-place) tools, and several web-based GDSS have been developed (Marreiros et al, 2004a; Karacapilidis and Papadias, 2001; Marreiros et al, 2005).

Despite of the quality of developed GDSS, they present some limitations like, for instance, the modelling of the group decision making problem through a Multi-Agent System.

The use of Multi-Agent Systems seems very suitable to simulate the behaviour of groups of people working together and, in particular, to group decision making modelling, because it allows:

- Individual modelling – each participant of the group decision making can be represented by an agent that will interact with other agents. Agents can be modelled with social and emotional characteristics in order to become more realistic.
- Flexibility – with this approach it is easy to incorporate or remove entities. It is also possible to change the characteristics of the individuals, for instance, in order to analyze its impact in the group behaviour.
- Data distribution – frequently, in group decision making, participants are geographically distributed. Agents that represent participants, with this approach, may be running in different machines.

If the group decision making problem is to be resolved by a group of intelligent agents then it is, first of all, necessary to constitute the group.

In Multi-Agent literature the references to tasks related to team formation are in the area of cooperative problem solving. Wooldridge and Jennings identified four stages in the resolution of the cooperative problem solving process (Wooldridge and Jennings, 1999):

- Recognition of the problem - an agent identifies the potential for cooperation.
- Team formation - the agent solicits assistance for the identified problem.
- Plan formation - the newly formed collective attempts to construct an agreed joint plan.

- Execution - members of the collective play out the negotiated roles.

Several authors consider that the focus of team formation is the agent's mental state and its motivation to form teams and collaborate (Cohen et al, 1997; Wooldridge and Jennings, 1999). Dignum and his colleagues present a theory for agent team formation that is based on structured dialogues, with an emphasis on persuasion (Dignum, 2000).

This paper aims to specify the different tasks involved in the formation of a group of agents that will be the main actors in the simulation of a group decision making meeting. This work is included in ArgEmotionAgents project (POSI / EIA / 56259 / 2004 - Argumentative Agents with Emotional Behaviour Modelling for Participants' Support in Group Decision-Making Meetings), which is a project supported by FCT (Science & Technology Foundation – Portugal) envisaging the use of Multi-Agent Systems approach for simulating Group Decision-Making processes, where Argumentation and Emotion components are specially important.

The paper is organised as follows. The following section presents the main participants in the process of a group decision making simulation. After that, it is presented a model for multi-agent group formation, where it is considered the incomplete information handling and the existence of explicit negation. Implementation details are discussed before the final section that presents some conclusions about the proposed model and point out some directions for future work.

INTERVINING AGENTS IN SIMULATION OF GROUP DECISION MAKING AND THEIR ROLE

In our opinion, the simulation of group decision making through a multi-agent system implies the need for different kind of agents (Marreiros et al, 2004b):

- Participant Agents (AgP) – these agents will simulate the role of persons in the group decision making process. The agents are dotted of social and emotional characteristics that will personalize its behaviour. Each agent will have a model of himself and a model of the others, that will be refined with the information received during simulations.
- Facilitator Agent (AgF) – this agent will help the responsible for the simulation in its organization. According to coordinator instructions, will require the formation of a group of agents with skills to understand and resolve a specific problem. This agent will also interview during the simulation, sending for instance stimulus messages to the less participative agents, and will summarize the results of the simulation.
- Register Agent (AgR) – for an agent to became part of the community of participant agents (AgP), it should first make a registry, making available some public information about its profile.
- Voting Agent (AgV) – experience tells that almost all the group decision making meetings have one or more voting phases. This agent will be responsible for the tasks related with the voting simulation process.
- Information Agent (AgI) – the agent that detains information about the different proposals (alternatives) that will be evaluated by the group of agents during the group decision making simulation.

This paper focus in the first three kinds of agents (AgP's, AgF and AgR), because these agents will be directly involved in the group formation process. In the following section we will present a model to support the tasks associated with the group formation process.

MODEL FOR GROUP FORMATION

After the identification of the main actors in the simulation of a group decision making process and the characterization of its role, it is necessary to establish the steps for the creation of a community of participant agents. The importance of maintaining a community of agents during several simulations is directly related to the need of obtaining information about the credibility, the reputation of the agents, as well as past behaviours, promises that have been made, etc. This information will be very useful when agents are participating in the simulation of the group decision meeting.

Inclusion in the Community of Participant Agents

The selection of agents to participate in the simulation of a group decision making is made from a community of participant agents (AgP). First of all; the agent must be registered to be selected. Some information about potential participant should be available in order to allow the acceptance of this participant agent by the Register Agent (AgR):

Agent (Id):: area_of_expertise,
interest_topics,
availability.

Where *Id*, *area_of_expertise*, *interest_topics* and *availability* represent respectively the identification of the agent, the set of areas where the agent is expert, the interest topics for the agent and its availability at that moment.

The community of participant's agents is a set of N agents, AgP_1, AgP_2, …, AgP_N, denoted by AgP. The availability of each agent, in the community, can be classified according three states: uncommitted, committed, or in action. An **uncommitted** agent is available to participate in a simulation of a group decision making. An agent **in action** is already involved in a simulation that is running. At last, a **committed** agent has agreed to be part of a group, but the simulation has not yet started.

Incomplete Information

The Knowledge Base (KB) of the Register Agent was defined in the previous section. But agents do not have a way to represent explicit negative information in the KB, as for instance, topics that do not have any interest to the agent. In other words, instead of being based on the Closed-World Assumption (which tell us that any missing information in the KB is false), the knowledge that something is false must be explicitly represented in the KB. In this sense, the KB has two different types of knowledge: the positive knowledge (what is known to be *true*), and the negative knowledge (what is known to be *false*). All the rest is *unknown*. Suppose that in the KB of the AgR the information related to the areas of expertise of the AgP_i identified as Michel is represented in program 1:

area_of_expertise ('Michel', tourism).
¬area_of_expertise('Michel',cousine).

Program 1- representation of the information related to the expertise areas of a specific agent

If the KB is questioned about if the area of expertise of Michel is Pharmacy the answer should be unknown, because there is no information related to that.

Following the approach described in Analide and Neves (2002) situations of incomplete information may involve two kinds of nulls. The Extended Logic Programming (ELP) will be the approach followed for the knowledge representation.

The first type of Null value is an undetermined unknown value, which means that, there is a missing value but the possible instantiations for that value are completely unknown. Suppose that one of the agents belong to the community AgP, and in the moment of register he does not specify his interest topics, just inform that he has interest topics. This means that the interest topics of this agent are unknown. Program 2 represents the use of this kind of Null.

```
¬topic_of_interest (A,B):-
        not topic_of_interest(A,B),
        not exception_topic_interest(A,B).
exception_topic_interest(A,B):-
        topic_interest(A, something).
topic_of_interest('Jonh', something).
```

Program 2 : representation of information related to the agent interest topics

The other type of Null value represents information of an enumerated set. Following the previous example suppose that an agent does not give information related to his availability, then in this case there are three exceptions allowed: uncommitted, committed or in action. This could be represented as in program 3:

```
¬availability(A,B):-
        not availability(A,B),
        not exception_availability(A,B).
exception_availability(A,B):-
        availability(A, availability).
exception_availability ('John',committed).
exception_availability ('John',uncommitted).
exception_availability ('John',in_action).
```

Program 3 : representation of information related to the agent availability

Multi-Agent Model for Group Formation

The simulations of group decision making processes will be coordinated by the decision maker agent. This agent will be responsible by the phase identified as problem recognition (Wooldridge and Jennings, 1999). The coordinator of the simulation has to identify the quantity of participants that will be needed to form the group and the lifetime of the simulation.

After identifying the above referred aspects, the coordinator, asks the Facilitator Agent (AgF) to form a team. The Facilitator Agent will send a request to the Register Agent (AgR) to contact potential interested agents:

Request_form_group (AgF, AgR, K, S_i*, expertise_areas, lifetime)*

In the previous message K is the necessary quantity of agents, S_i is the identification of the future simulation, *expertise_areas* are the areas of expertise that agents must have and lifetime is the number of periods of the simulation. After receiving this request, the Register Agent will send a request to the community of participant agents with the information of the required expertise and the lifetime of the simulation.

Request_form_group (AgR, AgP, S_i*, expertise_areas, lifetime)*

The agents of the community may answer to the facilitator with three possible types of answers: interest_in_participate, not_interested or they could simply ignore the request.

interest_in_participate(AgP_j*, AgF,* S_i*)*
not_interested(AgP_j*, AgF,* S_i*)*

To realize the selection of the interested agents, the AgR will analyse the received answers and verify if they are in accordance with his KB. If the AgR identified agents that did not answer or say that are not interested and, as being an agent with special interest to the group, he could establish a direct contact.

Request_form_group (AgR, AgP_j*,* S_i*, expertise_areas, lifetime)*

The formation of the final group is based in the received answers and in the inference process realized through the KB of the register agent, with the objective of maximizing the knowledge of the group.

The AgR will send a message to the AgF with a possible group, which should be approved by the simulation coordinator.

Proposed_group(AgR, AgF, $\{AgP_x,\ldots,AgP_y\}$*)*

If the simulation coordinator approves the group, the AgF will inform the agents and the simulation start. Otherwise, the facilitator will request other potential group to the AgR.

IMPLEMENTATION ISSUES

A prototype of the multi-agent model for group formation is being developed in order to validate the model and also to generate simulation results that can be analyzed. In this section we review the multi-agent platform that is being used to implement the proposed model, and present some details of our implementation.

Multi-Agent platform

The prototype is being developed in Open Agent Architecture (OAA) and Java. OAA (Cohn at al., 1994; Martin et al, 1999) developed at the Artificial Intelligence Center of Stanford Research Institute, is a framework for integrating a community of heterogeneous software agents in a distributed environment. The main features of OAA platform are:

- Openness – agents may be written in various languages (Prolog, Java, ANSI C/C++, LISP) and operating systems. The language and operating systems barrier are in this way minimized.
- Distributive – agents may be distributed by multiple networked machines. This is a very important advantage to increase simulation runs, specially in scenarios where are involved a great number of agents.
- Extensible – it is possible to add or remove agents at run-time, allowing the creation of flexible and robust scenarios.
- Mobile – simple OAA based user interfaces can run on personal digital assistants (PDA).

The OAA framework is composed by two distinct types of agents: the OAA facilitator agent and client agents. Usually there is only one facilitator by application, but it is also possible to have multiple facilitators. The OAA facilitator agent is responsible for tasks related to coordination and communication. The OAA Facilitator has, in somehow, behaviour similar to a router in the sense that it is responsible for distributing data and messages among its set of client agents. The first communication between two clients agents is necessarily made through the facilitator, after what they can communicate directly if necessary. The other type of agent is the client agent that, when invoked, creates a connection with a facilitator and informs him of what services he provides.

OAA has an Inter-agent Communication Language (ICL) that is shared by all agents independently of the language in which they are programmed or the operating system of the machine where the agents reside. The ICL language is close to KQML (Mayfield et al., 1996).

OAA is widely accepted. There are more than 30 applications developed based on this platform (Cheyer and Martin, 2001).

Prototype

At this moment the various agents are created in java as a java thread, but we are considering the implementation of the AgR in PROLOG because, as being responsible for the selection of the group elements, this agent has to reason based in incomplete information.

In figure 1 it is possible to see the public profile of one of the agents that belong to the community of participant agents (AgP).

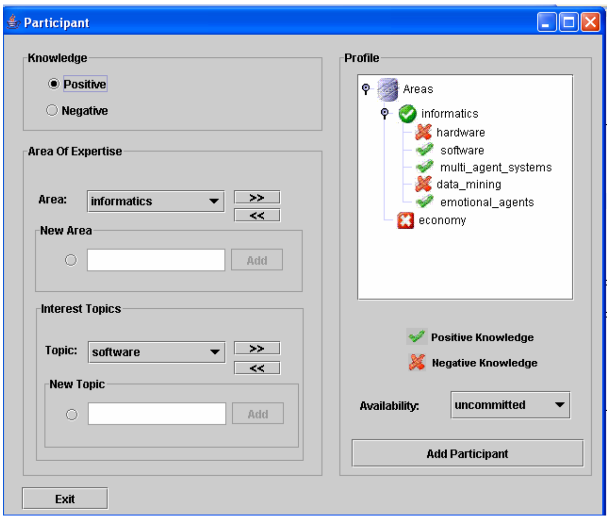

Figure 1: Creation of participant agents (Profile definition)

In this case the agent is expert in informatics, particularly in topics related to software, multi-agent systems and emotional agents, and he has no knowledge in topics related to data mining and hardware (negative information). The agent has no knowledge also in economic area.

In figure 2 it is possible to see all the community of participant agents. The agent created above belongs to this community.

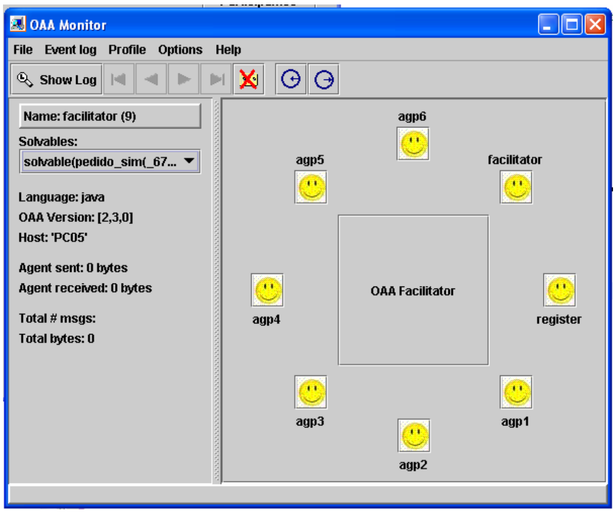

Figure 2: AgP Community

The AgR works closely to the OAA facilitator agent. The OAA facilitator is responsible for all the communication and coordination tasks, and the AgR is responsible for the participants profile maintenance and for the group formation process.

CONCLUSION

The simulation of group decision making through a multi-agent system allows, in particular, studying the behaviour of agents along the time. The process of group formation could be done by the person responsible for the simulation, or through automatic selection of the group members, where the agents manifest interest or not in the participation in a specific group decision simulation.

This paper proposes a multi-agent model to support the process of group formation, where it is considered the existence of incomplete and negative information about the skills of the potential group members. For the selection of the effective group it is considered, the total knowledge of the group, besides the abilities of each one of the elements.

Future work will include the continuation of the implementation of this model as a first step to the simulation of a multi-agent group decision making. It is also our propose to incorporate some of the group decision simulation results in the selection phase of a future simulation. An example could be for instance the group willingness characteristic. As result of several simulations it could be estimated the willingness of a specific agent to group work. The agent reputation is another characteristic that will be considered in the group formation process.

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