Argument-based Decision Making in Ambient Intelligence Environments

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Abstract: Decision-making is a cognitive process of the foremost importance to set a line of action under change; it is said to be a psychological construct, being therefore latent and not directly observable. Indeed, issues of construct validity are paramount, where the information gathered would provide insight regarding the construct of emotional intelligence and how one would attempt to clarify its meaning and measure it. In this paper this problem will be addressed in terms of an argumentation-based system, where intelligent agents simulate the behaviour of individuals as group members that take part in a decision making process.

Keywords: Quality-of-Information, Argumentation, Group Decision Support Systems, Agent Based Simulation.

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1 INTRODUCTION

Decision making is said to be a psychological construct, depending on the individual or individuals. For instance, in an organizational setting, with an over-abundance of corporate data, an undo to be fed to decision making processes, it may be linked to organizational trauma, like downsizing, budget constraints or workload, or may come to notice with no apparent foundation. On the other hand, decision-making is a process of choice that has hidden in it a potential that literally dwarfs the problem in itself; indeed a deliberate effort to broaden our experiences is the single most helpful effort in making good decisions. Choice based on an exchange of arguments may be an excellent way to justify possible preferences and to convince others that one's alternative is to be followed (Bench-Capon and Dunne, 2005; Marreiros et al., 2007a).

Another point that should be stressed is the importance of social and emotional behaviour in-group dynamics (Forgas, 1995; Loewenstein and Lerner, 2003; Barsade, 2002).

Group decision is a complex process, once decision makers do not have in general all the information they need, so they must do it based on incomplete and imprecise one.

On the other hand, agent based methodologies for problem solving has been making their point in simulating group behaviour, catering for individual modelling, operational flexibility and data distribution. In this work we propose the simulation of group decision making through an agent based approach (Hagras et al., 2004; Masthoff et al., 2007). Once the simulation may be viewed as an automated conciliation process (Jennings et al., 2001), an argumentation-based approach will be thought-out.

Indeed, there are a great variety of dialogues ranging from exchanges of pre-formatted messages to argumentation-based dialogues (Amgoud et al., 2006). In this latter category, Douglas Walton and Erik Krabbe (1995) identify six major classes:

- **Inquiry dialogues** – a lack of knowledge is in the origin of this type of dialogue, where two or more partakers will collaborate to establish the truthfulness or falseness of a given sentence (e.g. this is the case that may arise with the dialogues that may involve scientific researchers).
- **Persuasion** – this dialogue occurs when there is a conflict between two partakers, where each one aims to plead his/her case; i.e. to endorse some proposition or course of action).
  - **Negotiation** – the aim of this dialogue is to reach a distribution of scare resources that may be acceptable to all. Each partaker in the negotiation aims to maximize his/her part in the sharing out (e.g. a seller/buyer dialogue).
- **Deliberation** – a dialogue where two or more partakers share the responsibility to present a plan of action. The goal in this kind of dialogue is to achieve an agreement on a plan of action, and each participant aims to agree on the plan that is more favourable for his or her intentions. Contrary to persuasion, this class of dialogue does not emerge from a conflict, but from the need to perform an action.
- **Information seeking dialogue** – a particular partaker inquires an equal on the truthfulness or falseness of a given sentence. This dialogue is similar to that of an inquiry one, but diverge on the primary knowledge, with one of the agents thinking that the counterpart has more knowledge on a specific topic (e.g. this may be the case of an expert consultation).
- **Eristic dialogue** – partakers use this type of dialogue as an alternative for physical fighting; it is a very intense dialogue, with each one aiming to win.

It is unquestionably difficult to sort a dialogue attending to the types mentioned above. In this work we will focus on the process of exploring the persuasion dialogues that seem to be the most adequate to phase out group decision making; i.e. the choice phase (where there is no space for negotiation, as alternatives are already settled).

2 AMBIENT INTELLIGENCE

Ambient Intelligence (AmI) deals with a world where computing devices are spread all over the place (ubiquitously), allowing people to live in digital environments in which the electronics are sensitive to the people's needs. AmI environments may be diverse (e.g. decision room, health care units, stores), but the idea behind this work is to provide a better support to the human beings engaged in-group decision-making, in order to provide them with the indispensable information and knowledge.

In this work it is proposed a multi-agent (simulator) argumentation based system whose aim is to simulate group decision-making processes. The simulator considers and supports the emotional factors of partakers (agents) and their argumentation processes.

This system is integrated in an ubiquitous agent based group decision support system (Marreiros et. al, 2007a) and intended to be used for intelligent decision making, a part of an ambient intelligence environment where networks of computers, electronics and services are shared (Marreiros et. al, 2007b).

Figure 1 *An Ambient Intelligent-based Decision Laboratory*

As an example of such a scenario, it will be considered a meeting, involving people in different locations (some at the meeting room, others in their offices) with access to different devices (e.g. computers, PDAs, mobile phones or even embedded systems as part of the meeting room or of their twins) (Figure 1).

3 THE MULTI-AGENT SIMULATOR

In a previous work it were identified the main agents involved in a simulation of a group decision meeting (Marreiros et al., 2005), i.e. Partaker Agents, Facilitator Agent, Register Agent, Voting Agent and Information Agent (Figure 2).

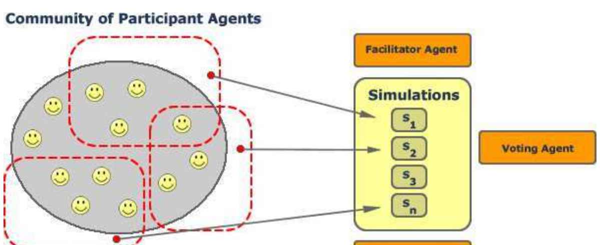

Figure 2 *A Multi-Agent based Architecture to Group Decision Simulation*

The Facilitator Agent caters for the simulation tasks (e.g. looking at the make-up of the decision rules). It also controls the group formation process and manages the inclusion of new partaker agents into the agent community.

The Voting Agent executes tasks related with the voting simulation process, according to the decision rules settled by the Facilitator one.

The Information Agent caters for the on-going information throughout the simulation process.

We will carry on with the architecture of the partaker agent (Figure 3).

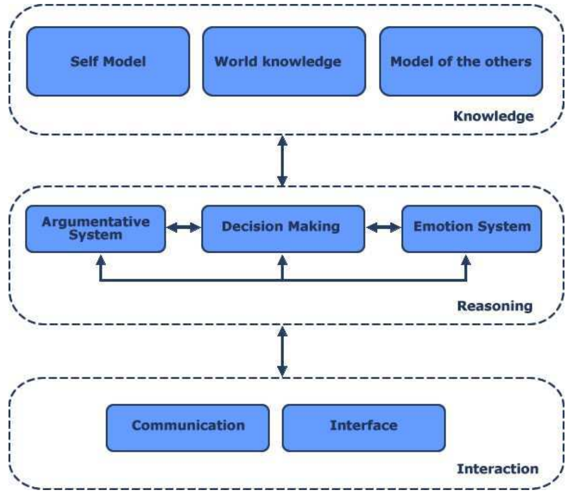

Figure 3 *Partaker Agent Architecture*

In the knowledge layer the partaker agent keeps information about the environment, the profiles of the other agents, as well as about its own preferences and goals (i.e.its own profile).

The interaction layer is in charge of all the communications, either with the other agents or the group decision simulator.

The reasoning layer includes three major sub-systems:

- The argumentative system – that is in charge of the arguments generation process. This component will generate explanatory arguments and persuasive ones, according to the agent emotional state, based on its perception of the expectable behaviour of the others agents;
- The decision making system – will support agents in the choice of the preferred alternative and will classify all the set of alternatives in three classes: preferred, indifferent and inadmissible;
- The emotional system (Marreiros et al., 2008) – will generate emotions and moods, affecting the choice of the arguments to send to the others participants, the evaluation of the received arguments and the final decision.

4 THE PARTAKER AGENT KNOWLEDGE BASE

With respect to the computational paradigm it were considered extended logic programs with two kinds of negation, classical negation, ¬, and default negation, *not*. Intuitively, *not p* is true whenever there is no reason to believe *p* (close world assumption), whereas ¬ *p* requires a proof of the negated literal. An extended logic program (program, for short) is a finite collection of rules and integrity constraints, standing for all their ground instances, and is given in the form:

$p \leftarrow p_1 \square \ldots \square p_n \square \mathit{not}\ q_1 \square \ldots \square \mathit{not}\ q_m$; *and*

? p₁ □ . . . □ pₙ □ not q₁ □ . . . □ not qₘ , (n, m ≥ 0)

where *?* is a domain atom denoting falsity, the p_i , q_j , and p are classical ground literals, i.e. either positive atoms or atoms preceded by the classical negation sign ¬. Every program is associated with a set of abducibles. Abducibles may be seen as hypotheses that provide possible solutions or explanations of given queries, being given here in the form of exceptions to the extensions of the predicates that make the program. These extended logic programs or theories stand for the partaker agents Knowledge Bases (KBs) (Neves, 1984).

The KB of a Partaker Agent KB_{AgP} is now given as $KB_{AgP} = AgP_iOPub\ U\ AgP_iOPri\ U\ AgP_iOOPub\ U\ AgP_iOOPri\ U\ AgP_iP\ U\ AgP_iPO\ U\ AgP_iW$, where AgP_iOPub stands for the public goals of agent AgP_i, AgP_iOPri denotes the own goals of agent AgP_i, AgP_iOOPub caters for the set of public goals that agent A_gP_i trusts that are being hold by their counterparts, AgP_iOOPri stands for the set of private goals that AgP_i believes the other agents hold, AgP_iP denotes its own profile, AgP_iPO stands for what AgP_i knows about the counterparts profiles and, AgP_iW stands for the world knowledge. The AgP_iPO is defined according to a set of predicate extensions, which are described below:

- Emotional state – characterizes the mood of the agent, which may be understood as positive, negative or neutral, according to the quality-of-information it holds;
- Benevolence – an agent may be, or may not be benevolent. If an agent is benevolent, and receive a request from an equal, to change its preferred choice(s), it will accept the request without the need of supporting arguments, since the alternative will fit in to its internal set of favourite ones. If a benevolent agent receives more than one request to change its preference, and every one of the requests is acceptable, it will acknowledge the appeal of the most trustworthy one;
- More or less preferred argument(s) – agents may have a specific preference about the argument(s)s to send;
- Gratitude debts of the agent – results from previous contacts (simulations) in the community of partaker agents;
- Foe(s) – the agents that, for some particular reason, the partaker agent is not akin to intermingle;
- Credibility – each agent evaluates the credibility of other agents based on two key components: trustworthiness and expertise;
- Reputation – each agent uses the reputation system to measure the character of the others agents in the community of partaker agents.

As it was stated before, the knowledge layer may incorporate some vagueness, particularly in what concerns the information about the others agents profile. Consequently it is imperative to figure out the quality-of-information that the agent possesses, and in particular that of the profile of its equals.

To put a figure on or measure the quality-of-information, the following quality operators were defined, namely $Q_{EmotionalState}$, $Q_{Gratitude}$, $Q_{Credibility}$, $Q_{Enemies}$, $Q_{Benevolent}$, $Q_{TimeDependent}$ and $Q_{PreferredArguments}$, where the quality-of-information about the property K is given by: $Q_K = 1/Card$, where *Card* denotes the cardinality of the exception set for K. If the exception set is disjoint the quality-of-information is set as:

$Q_K = \frac{1}{C_1^{Card} + \ldots + C_{card}^{card}}$, where C_{card}^{card} is a card-combination subset, with *Card* elements. A measure of the quality-of-information that agent AgP_i holds up about agent AgP_j is given as follows:

$$Q^{AgP_i}(\mathrm{Profile}_{AgP_j}) = \frac{\sum_{k=1}^{N} Q_k^{AgP_j} * W_k^{AgP_i}}{\sum_{k=1}^{N} W_k^{AgP_i}}$$

where N denotes the number of attributes in the extension of a predicate on the agent profile, $Q_k^{AgP_j}$ is a measure of the quality-of-information of K and $W_k^{AgP_i}$ (taken in the interval [0,1]) stands for the contribution of K (weight) to the agent profile creation. As an example, let us consider the extensions of the predicates *credibility*, *emotional state*, *foe*(s), *benevolence*, and *gratitude* as the information that agent AgP_i has about the profile of agent AgP_j, which is given in the form:

$$\neg credibility(Ag,V) \leftarrow not\ credibility(Ag,V) \wedge not\ exception_{credibility}(Ag,V).$$
$$exception_{credibility}(Ag,V) \leftarrow credibility(Ag,\wedge).$$
$$exception_{credibility}(agP_k,V) \leftarrow V \geq 3 \wedge V \leq 5.$$

$$\neg emotionalState(Ag,V) \leftarrow not\ emotionalState(Ag,V) \wedge not\ exception_{EmotionalState}(Ag,V).$$
$$exception_{EmotionalState}(Ag,V) \leftarrow emotionalState(Ag,\wedge).$$
$$exception_{EmotionalState}(agP_k, positive).$$
$$exception_{EmotionalState}(agP_k, negative).$$

$$\neg benevolence(Ag,V) \leftarrow not\ benevolence(Ag,V) \wedge not\ exception_{benevolence}(Ag,V).$$
$$exception_{benevolence}(Ag,V) \leftarrow benevolence(Ag,\wedge).$$
$$exception_{benevolence}(agP_k,\wedge).$$

$$\neg gratitude(Ag,V) \leftarrow not\ gratitude(Ag,V) \wedge not\ exception_{gratitude}(Ag,V).$$
$$exception_{gratidao}(Ag,V) \leftarrow gratitude(Ag,\wedge).$$
$$gratitude(agP_k, agP_i).$$

$$\neg enemies(Ag,V) \leftarrow not\ enemies(Ag,V) \wedge not\ exception_{enemies}(Ag,V).$$
$$exception_{enemies}(Ag,V) \leftarrow enemies(Ag,\wedge).$$
$$enemies(agP_k, agP_m).$$

According to the modus operandi referred to above, the quality-of-information that agent AgP_i has on itself, is given as:

$$Q^{AgP_i}(profile_{AgP_j}) = \frac{2,27}{5} = 0,55$$

In view of that each predicate on the agent profile stands for an axle on a multi-dimensional space, one may have (Figure 4), were the dashed area gives a measure of the quality-of-information that a specific agent has about the other agents in the agents community or regarding a particular set of agents.

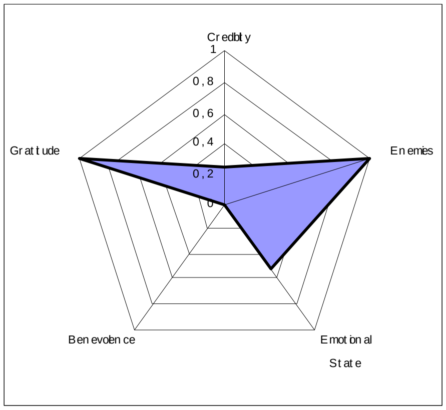

Figure 4 *The Quality-of-Information represented in a Hyper-dimensional Space*

5 THE ARGUMENTATION SYSTEM

This component will produce persuasive arguments based on the information that subsist on the Partaker Agent KB (Kraus et al., 1998). In this section we will get going by presenting the argumentation protocol for two agents and the description of the persuasion process (i.e. the choice of the opponent, the argument generation process, its selection and evaluation).

5.1 The Partaker Agent Strategies

. The goals of each partaker agent (AgP_iO) are defined according to the agent strategies. In the model that we are puting forward partaker agents follow two different approaches: behaviour dependent and goal dependent.

In the goal correlated approach two tactics are considered, i.e. shielding the most preferred alternative or avoiding that an unacceptable one will turn into the group option. This approach it is also influenced by another construct, its time dependent behaviour, i.e. if an agent is arguing, but concludes that it is impossible to achieve an agreement on time, on a particular argument, it will change its tactic to avoid unacceptable choices.

On the other hand, the behaviour-correlated approach settles on the method for the selection of the partaker agent in order to persuade its opponent, which may take the form:

- Determined – the agent will get through all the available arguments along with a particular counterpart, ahead of its peers;
- Anxious – the agent will try to persuade an equal, but if the move is unsuccessful, it will shift to another agent.

5.2 The Argumentation Protocol

During a group decision-making simulation, partaker agents may exchange phrases like: *request*, *refuse*, *accept* and *apply for with argument*.

request $(AgP_i, AgP_j, \alpha, arg)$ - in this case agent AgP_i is asking agent AgP_j to perform action α, where the parameter *arg* may be void.

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

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

In Figure 5 it is advanced the argumentation protocol for two agents. However, it must be noted that this is the simplest scenario. In general, not only group decision-making involves more than two agents, but, at the same time AgP_i is trying to persuade AgP_j, this same agent may be involved in diverse persuasion dialogues with other elements of the group.

Begin
request$(AgP_i, AgP_j, Action)$
If *refuse* $(Proponent, AgP_i, Action)$
  do
    $Arg \leftarrow select\_arg(AgP_i, AgP_j, Action, Args\_List)$
    request$(AgP_i, AgP_j, Action, Arg)$
  While *(refuse* $(Proponent, AgP_i, Action)$ *and not timeout)*
End

Figure 5 The *Argumentation Protocol for two Agents*

We must be aware that in this work it was adopted, in terms of argumentation, the same ontology as the one that is found in Kraus (Kraus et al., 1998). So, we proceed the following arguments: *appeal to prevailing practice*; *a counter example*; *an appeal to past promise*; *an appeal to self-interest*; *a promise of future reward*; and a *threat* (i.e. these are the arguments that agents will use to persuade one another).

5.2 The Opponent Selection

The earliest measure in an argumentation dialogue is the opponent selection. In this process the partaker agent considers three different features, namely its own strategies (behaviour and goal related), the other agents voting preferences and the quality-of-information of the KBs of the other group members.

5.3 The Arguments Selection

In (Kraus et al., 1998) it is used a pre-order for the selection of the arguments to send, being the strongest argument a threat and the weakest argument an appeal to prevailing practice. Another approach that may be found in the literature to govern the argument selection process, is based on a mixture of the alternatives *utility* and *trust* on the interlocutor.

In our model it is proposed that the selection of arguments should be based on the agent emotional state. We propose the following heuristic (Marreiros et al., 2008): if the agent is in a good mood it will start with a weak argument; if the agent is in a bad mood it will start with a strong argument.

There are several studies that point out that an agent in a good mood is risk averse and an agent in good mood is more open to risk taking. On the other hand, agent in a bad mood wants to make agreements quickly in order to achieve a good mood. We adopt the scale proposed by Kraus (Kraus et al., 1998) for the definition of strong and weak 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 driven by the existence in the opponent profile of a (un)preference for a particular argument. If the agent does not detain information about the preference of the opponent, the selection inside each class follow the order defined by Kraus (Kraus et al., 1998).

5.4 The Arguments Generation

Argument nature and type may change, however six types of arguments are assumed to have persuasive force with the human beings (Karlins and Abelson, 1970; Pruitt, 1981): *threats*; *promise of a future reward and appeals*; *appeal to past reward*; *appeal to counter-example*; *appeal to prevailing practice*; and *appeal to self interest*. These are the arguments that agents will use to persuade one another. This selection of arguments is compatible with the power relations identified in the political model put forward by Frech and Raven (French, and Raven, 1959): *reward*, *coercive*, *referent*, and l*egitimate*. This component will generate persuasive arguments based on the information that exists on the partaker agent KB.

In this section we describe and specify the persuasive arguments that our agents may change. For each argument it is given a little example.

Threats

As it was referred to above, threats are very common in human negotiation, assuming, in general, two distinct forms: you should perform *action A* otherwise I will perform *action B*; and you should **not** perform *action A* otherwise I will perform *action B.*

In our model this type of arguments may be formalized as follows:

Threat(Justification, Conclusion, Threatened_goal)

Example 1: AgP_1 ask AgP_2 to vote on alternative A_i with the argument that if he/she refuses he/she will vote on alternative A_j that he/she believes that it is unacceptable for AgP_2.

Promises

Like threats, we may have two distinct forms of rewards, namely: If you perform action *A* I can perform *B*; and If you do not perform action *A* I perform *B*.

In our model this type of arguments may be formalized as it is given below:

Promise(Justification, Conclusion, Promised_goal)

Example 2: AgP_1 ask AgP_2 to vote on alternative A_i with the argument that if he/she accept he/she will stay in debt of gratitude.

Appeal to counter-example

In this case, the partaker agent that makes a request supported by this argument, expect to convey the opponent that there is a contradiction between what he/she says and his/her past actions.

The argument appeal to a counter-example is an explanatory argument and in our model it is given as follows:

Appeal_counter_example (Justification, Conclusion)

Example 3: AgP1 asks AgP2 to vote on alternative Ai, if AgP2 refuses then AgP1 may counter argument with an appeal to a counter-example saying, for instance, that in the past he/she preferred alternative Am and change to An, so why not to do the same now?

Appeal to self-interest

In this case the partaker agent that makes a request supported by this argument expects to convince his/her interlocutor that making action *A* is of his/her best interest.

The argument appeal to self-interest is an explanatory argument and in our model it is depicted as follows:

Appeal_self_interest (Justification, Conclusion)

Example 4: Suppose that AgP1 ask AgP2 to avoid voting on alternative Ai, supported by the argument that AgP3 voted in the Ai alternative and AgP2 do not like AgP3.

Appeal to past reward

In this case the partaker agent that sends such kind of argument expects that his/her interlocutor will perform an action based on a past promise.

In our model the appeals to past rewards are put forward as follows:

Appeal_past_reward (Justification, Conclusion)

Example 5: If in some point in the past agent AgP1 sent a request to AgP2 to vote on a specific alternative with the promise that he/she will stay with a debt of gratitude, if AgP2 accept it, in a future decision AgP2 may send a request supported by this argument.

Appeal to prevailing practice

In this case, a partaker agent believes that the opponent will refuse to perform a request, since it contradicts one of its own goals. For that reason the partaker agent sends a request with a counter-example from a third partner or from past actions of the opponent.

In our model the appeal to prevailing practice is given as follows:

Appeal_prevailing_practice (Justification, Conclusion)

Example 6: Suppose that AgP_1 knows that AgP_2 had a strong preference for the alternative A_i and changed for alternative A_j. If he/she intends to ask AgP_3 to change his/her preference to alternative A_j he/she could support his/her request with the argument that another agent, who also prefers alternative A_i, to change his/her preference to alternative A_j.

The last four types of arguments are explanatory arguments, and are given in terms of the production:

Argument_type(Justification, Conclusion).

5.5 The Arguments Evaluation

In each argumentation round the partaker agents may receive requests from several partners, which in general, may turn out to be exclusive (e.g. in the same round the agent AgP_i may receive a request to vote on alternative A_i and other to vote on alternative A_j). The agent should analyse all the requests based on different indicators, namely the utility of the proposal, 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 demand for the self, the credibility of the proponent and one or more of its profile descriptors (e.g. benevolence). Next is presented the algorithm for the evaluation of this type of requests (without arguments):

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

where AgP denotes the identity of the agent that perform the request, n the total number of requests received in instant t and Action the demanded action (e.g. voting on alternative number 1).

Begin
If $\neg$ *profile*$_{AgPi}$*(benevolent)* ***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

Figure 6 The *Request Evaluation*

The algorithm for the evaluation of requests with arguments is presented next:

Begin
If *goal(preferrred)* ***then***
    Foreach $request(Sender, AgP_i, Action, Arg) \in \mathrm{Re}\,q^t_{AgP_i}$
        If $AgPO_{AgP_i} \square Action$ ***then***
$EvaluateRequest \leftarrow EvaluateRequest \cup request(Sender, AgP_i, Action, Arg)$
        Else
        $RefuseRequest \leftarrow RefuseRequest \cup request(Sender, AgP_i, Action, Arg)$
Else
    Foreach $request(Sender, AgP_i, Action, Arg) \in \mathrm{Re}\,q^t_{AgP_i}$
        If $AgPO_{AgP_i} \square \neg Action$ ***then***
    $RefuseRequest \leftarrow RefuseRequest \cup request(Sender, AgP_i, Action, Arg)$
        Else
$EvaluateRequest \leftarrow EvaluateRequest \cup request(Sender, AgP_i, Action, Arg)$
$(AgP, RequestAction) \leftarrow EvaluateRequestsArgs(EvaluateRequest)$
Foreach $request(Sender, AgP_i, Action, Arg) \in EvaluateRequest$
    If *(Sender=AgP or RequestAction=Action)* ***then***
        accept (Sender, AgP_i, Action)
    Else
        refuse (Sender, AgP_i, Action)
Foreach $request(Sender, AgP_i, Action, Arg) \in RefuseRequest$
    refuse (Sender, AgP_i, Action)
End

Figure 7 The Algorithm for *Argument Evaluation*

From the analysis of the algorithm, a particular attention must be given to the predicate $EvaluateRequestsArgs(EvaluateRequest)$ that answers for the evaluation of all the requests. This evaluation is performed using the following criteria: *strength of the argument*, *opponent credibility*, *existence of preference for the argument*, *quality-of-information* about the opponent KB, *convincing factor* (that caters for the validity of the argument).

6 EVALUATION

In this section we will present a simple case study and act upon 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 at an University. The selection is made by a group of persons that evaluate 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, i.e. the evaluation of 4 candidates based on 5 criteria.

Table 1 *A Multi-criteria Problem*

	Candidate 1	***Candidate 2***	***Candidate 3***	***Candidate 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 data several scenarios were established in order to try to understand the role of emotional agents on the simulation. Table 2 shows the agents initial preferences. Based on both tables, 5 variations of each scenario were created, resulting in 25 test scenarios.

Table 2 *The 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

The results are visualized in Table 3.

Table 3 *The Simulation Results*

Number of simulations	25
Number of simulations where the number of exchanged arguments using emotional agents was higher than when using non-emotional ones	2
Number of simulations where the number of exchanged arguments using non-emotional agents was higher than when using emotional ones	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 8 illustrates the number of arguments that were necessary to exchange before achieving an agreement in each simulation by agent type (emotional or non-emotional). 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 ones.

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

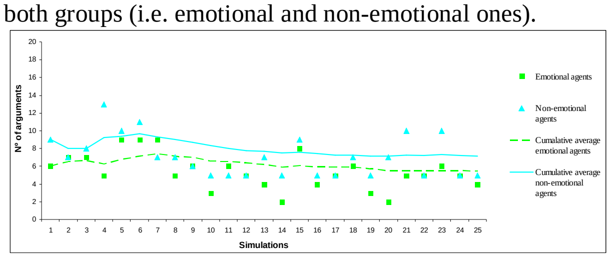

Figure 8 ***The*** *Average Number of Arguments by Agent Type (emotional vs non-emotional ones)*

Based on the experiments realized so far it is possible to conclude that clusters of agents bearing emotional intelligence achieve agreements in a faster rate than those without such features. This seems to point out that those meeting partakers that bring emotional factors into their judgements will add more success to the argumentation process.

7 CONCLUSIONS

In this work it was proposed an architecture for partaker agents, following the requisites of *argumentative capabilities*, *anthropomorphic characteristics*, *quality-of-information*, *ability to represent incomplete information and emotional factors*. On the other hand, it were made a set of experiences using the developed system in some real-world situations. The results pointed out the advantage of meeting partakers that use the decision support system that considers emotional factors in the phase of argumentation.

It is also essential to notice the importance to have a formal representation of the partakers KBs profiles. On the other hand the prototype that we are presenting should be considered only as a simulator, playing the role of a decision support system, and not as a system that intends to substitute the meeting or even to substitute some meeting partaker.

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