NegocIAD : a multicriteria and multiagent system for negotiation support

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ABSTRACT. This research concerns the design and the realisation of a prototype of an interactive negotiation support system, NegocIAD. This system is based on a multicriterion approach of the negotiation and is developed with a multiagent architecture (Distributed Artificial Intelligence). First, we present the multicriterion approach adopted and the mathematical model developed and used in the prototype to support the negotiation process. Then, we present the multiagent architecture of the realised prototype developed in the Objlog language extended to the multiagent context. To illustrate the prototype, we present a simple example of negotiation supported by the NegocIAD system. Finally, we conclude on the limits and perspectives of our research.

RESUME. Cette recherche porte sur la conception et la réalisation d'un prototype de système interactif d'aide à la négociation, NegocIAD. Ce système s'appuie sur une approche multicritère de la négociation et a été développé selon une architecture multi-agents (Intelligence Artificielle Distribuée). Nous présentons tout d'abord succinctement l'approche multicritère adoptée ainsi que le modèle mathématique développé et utilisé dans le prototype pour supporter le processus de négociation. Ensuite nous présentons l'architecture multi-agents du prototype que nous avons développé dans le langage Objlog étendu au contexte multi-agents. Nous illustrons nos propos par la présentation d'un exemple simple de négociation supporté par NegocIAD. Enfin nous concluons sur les limites et les perspectives d'évolution de nos recherches.

KEY WORDS : Negotiation , Negotiation support system, multicriterion, multiagent systems, Distributed Artificial Intelligence.

MOTS-CLES : Négociation, système d'aide à la négociation, multicritère, systèmes multi-agents, Intelligence Artificielle Distribuée.

1. Introduction

The increase of exchanges of information and the multiplicity of actors implied in a decision process entails an entanglement growing actions and reactions. Such a complexity is not controllable by a single individual. In fact, it is quite rare that a decision, of a strategic or tactical nature, is taken by a unique decision maker; in most of the cases, such decisions are taken by a group of decision makers. Very often, teamwork improves the global problem processing, each member bringing a lighting according to its experience, its know-how, its level of information and its perception of the situation. One can define a group as the constitution of a network of persons having a common interest, and working on a same subject. This network can take different form: assembly in a hall or isolated work with exchange. Its finality is the problem solving and the decision-making. It can function by putting at stake either a mechanism of cooperation, or a mechanism of negotiation.

The design and the realization of systems supporting collective cognitive processes of negotiation or collaboration (processes associated to formulation or problem solving phases) would have to develop in a close future. The objective of these systems is to improve the quality of the work of a group, or even to increase its productivity. We also speaks of "groupware", "collaborative systems" or "Computed Supported Cooperative Work" (CSCW), or of "Computer-Augmented Teamwork" [Bostrom et al.92]. A.Karsenty [Karsenty 93] distinguishes five types of groupware: electronic mails, shared editors, conferences and meetings aided by computer, decision support systems and finally co-ordinators.

The concept of Negotiation Support System (NSS) is as recent as the Group Decision Support System concept (GDSS) [DeSantis & Gallupe 87]. It has taken such an importance in the scientific community that the title NSS has merged with the GDSS one to make only an single field of research: the GDNSS [Bui et al.90]. Several NSS have already been developed [Jarke et al.85]. First, a NSS serves as a mediator to bring together group members (points of view and respective positions), to conciliate differences and to suggest solutions of compromises. Thus, it allows to improve the quality and the negotiated agreement acceptability, to increase the quality of relationships during the negotiation and finally, to improve the capacity of negotiators to solve the conflict. As a tool of communication support between antagonistics, NSS have for object to reduce the emotional aspect that often characterizes exchanges, and to fall barriers associated to influences and/or to timidity. As a system of furtherance support of the process, it helps the members of the group to identify their true interests, and to place them in the context of the confrontation with the other interests and to help each member to evaluate the importance that it grants to its expectations. As neutral third party, these systems allow to develop scenarios that take into account the different positions.

Our research focuses on the development of a NSS based on a multicriteria approach of the negotiation. In a first time, we review the originality of this approach and we briefly present the multicriteria method, that we have adopted to support the process of negotiation. Then, we present in detail the prototype that we have developed with its multiagent architecture. An illustrative example of a negotiation realized with this prototype is presented. Finally, we conclude on limits and evolution perspectives of our researches.

2. A multicriteria approach of the negotiation

A NSS is often constituted of a set of models and a metamodel which federate the exchanges between these models. In general, a specific model is associated to each sub process of the global process of negotiation. These models mainly concern techniques and models from the theory of games.

In our research, we have adopted a multicriteria approach. The multicriteria approach of the decision support aims to widen the reflection on the choice of solutions in phase of selection [Roy 85] as well as in the construction of criteria [Bouyssou 89] and of solutions in the design phase. The multicriteria approach is extremely relevant for the design of DSS; the implementation of models and multicriteria techniques allows to conceive an assistance in the phases of design (possible solution elaboration) and selection (among these possible solutions) of the decision process concerned. Many multicriteria methods have allowed to develop many operational DSS [Pomerol 92-93].

However, to our knowledge, currently no multicriteria method exists which would allow, for a group of decision makers, to apprehend a process of negotiation. We had to develop such a multicriteria method allowing to support these processes, and to serve as foundation to a multicriteria NSS development. Note that concurrently to our research (on such a method), other researches are currently developed, notably at the Université Libre de Bruxelles (U.L.B.) [Marchant et al.94]

The method that we propose is based on the Promethee method (Preference Ranking Organization METhod for Enrichment Evaluations) proposed by Brans, Mareschal et Vincke [Brans et al.84] in a unique decision maker context. This method is one of the most recent multicriteria decision support methods of outclassing. Theses methods have emerged in the end of the 60s under the impetus of B.Roy, who proposed the method Electre[Roy 84-85]. The method Promethee uses abundantly of the notion of the "speudo-criterion" or "generalized criterion" (introduced by Roy et Bouyssou). We will now briefly review this Promethee method .

If one considers a criterion j to maximize and two actions a_i and a_k. To situate the two actions in relation to the criterion j, one can define $d_{ik}= a_{ij}-a_{kj}$ and consider the function of preference S of [0,1] in [0,1] :

$Sj\ (a_i, a_k) = Sj\ (d_{ik}) =$ • 0 si $d_{ik} = 0$: *indifference*;

• 1 si $d_{ik} > 0$: *strict preference;*

Sj (d_{ik}) is here a function of[0.1] in{ 0.1}. Consider a threshold q (q > 0), called the <u>indifference threshold</u> and pose:

$Sj\ (a_i, a_k) = Sj\ (d_{ik}) =$ • 0 si $d_{ik} <= q$: *indifference*;

• 1 si $d_{ik} > q$: *strict preference;*

To avoid the jump of 0 to 1 one introduces two thresholds q (indifference) and p (strict preference) and the speudo-criterion (with linear preferences) following [Pomerol & Romero 93] :

$Sj\ (a_i, a_k) = Sj\ (d_{ik}) =$ • 0 if $d_{ik} <= q$: *indifference*;

• $(d_{ik} - q)/ (p-q)$ if $q< d_{ik} <= p$;

• 1 si $d_{ik} > p$: *strict preference;*

The decision maker will be able to adopt, for each criterion j, a function of preference (or pseudo-specific criterion or "generalized criterion"). Brans and Mareschal propose six different typical functions, defining six typical generalized criteria : ordinary, in U, V, with stages, in V with stages and gaussian. When the decision maker has defined the type of pseudo-criterion that he wishes to use for each criterion j, one can then calculate the <u>preference rating</u> c_{ik} , by supposing fixed weights $w_j > 0$, normalized ($\Sigma_j w_j = 1$) :

$$c_{ik} = \Sigma_j w_j\ S_j\ (a_i, a_k) = \Sigma_j w_j\ S_j\ (d_{ik})$$

• the rating of preference $c_{ik} = 0$ if and only if a_i is indifferent to a_k for all criteria;

• the rating of preference $c_{ik} = 1$ if and only if a_i is strictly preferred to a_k for all criteria.

The obtained information can easily be represented as a graph by defining entering flow, exiting flow and net flow to each knot (action). We can calculate these flows according to the following formulas :

• flow exiting i : $\Phi_i^+ = \Sigma_k c_{ik}$

• flow entering i : $\Phi_i^- = \Sigma_k c_{ki}$

• net flow in i : $\Phi_i = \Phi_i^+ - \Phi_i^-$

The Promethee method exploits the information on these flows to conclude.

<u>In Promethee I (partial preorder)</u> : a_i outclasses a_k if and only if :

• $\Phi_i^+ > \Phi_k^+$ and $\Phi_i^- < \Phi_k^-$ or

• $\Phi_i^+ > \Phi_k^+$ and $\Phi_i^- = \Phi_k^-$ or

• $\Phi_i^+ = \Phi_k^+$ and $\Phi_i^- < \Phi_k^-$

In all other cases, a_i does not outclasses a_k. With Promethee I, we thus have a partial preorder. If we wish a total preorder, we will prefer Promethee II :

<u>In Promethee II (total preorder)</u> : a_i outclasses a_k if and only if $\Phi_i >= \Phi_k$. In all other cases a_i does not outclass a_k.

From the evaluation matrix established by the decision maker, and following a flow calculation, the Promethee method proposes a total or partial preorder on possible actions. To the knowledge of this preorder, the decision maker can then, return on his evaluation matrix and modify some evaluations, as well as weights that he has associated to each criteria. The newly obtained matrix will lead to a preorder that can be different from the precedent one. Through this "simulation", the decision maker can better measure implications of his evaluations and his weighting on the resulting preorder. The Promcalc software (PROMethee CALCulation) [Brans & Mareschal 91], allows to lead with an interactive manner, this process of simulation.

The Promethee method concerns only a single decision maker. Our method (based on Promethee) allows to support a decision process of negotiation of a group, consisting here in the emergence of a consensual preorder. To lead this process of negotiation, we will have recourse to an actor, real or potential, who will be appointed the "mediator" (or "facilitator"). For a complete presentation of this method see [Espinasse 94].

We consider a group of decision makers D_i ahead to choose among a set of actions a_i, actions evaluated according to a set of evaluation criteria c_j. To each decision maker of this group is associated an evaluation matrix analogous to the matrix proposed in Promethee. This method has several phases, and these phases have several stages :

Phase 1 : Individual evaluation

- stage 1: each decision maker of the group elaborates his own evaluation matrix;
- stage 2: for each decision maker, from a calculation of flow, we calculate an "individual preorder" on the actions;
- stage 3: decision makers and the mediator fix together, for example, a margin of general negotiation, indicating a maximum adjustment rate accepted on evaluations and weights of criteria (for example +-10%);

Phase 2 : Collective evaluation

- stage 1: from these individual evaluations, the mediator calculates a group matrix or evaluation matrix of collective evaluations (averages and dispersions);
- stage 2: from this collective evaluation matrix the mediator establishes a resulting preorder, called "collective preorder";

Phase 3: Conduct of the negotiation

- stage 1: test of consensus : for each of the decision makers, the mediator isolates all actions of the individual preorder whose total flow is superior or equal to this number : if one or several actions is/are common to all decision makers then there is consensus; if the consensus is not reached, the mediator defines from this preorder a threshold of consensus;
- stage 2: classification of decision makers : the mediator classifies decision makers according to their distance of the collective preorder;
- stage 3: proposal of adjustments : the mediator indicates to each decision maker in which directions (increase or reduction) some of his evaluations or weightings of criteria would have to be adjusted in order that a consensus is found;

During this stage, the mediator can adopt several strategies of negotiation. Two possible strategies are [Espinasse 94] :

- Strategy of reinforcement of the collective preorder : to bring the decision maker the most distant of the consensus to the collective preorder;
- Strategy of change of the collective preorder : to incite decision makers closest to the collective preorder, to move away of it and to approach more distant decision makers of the collective preorder.

Return to phase 1: each decision maker adjusts (or not) his evaluations and weightings in the directions suggested by the mediator.

3. A multiagent system for negotiation support

3.1. General problematic

The multicriteria assistance method with the negotiation that we have presented serves as a basis for our prototype. The mathematical model developed in this method is relatively simple and could have been extended, for example in order to detect possible criteria group, conflicting situations between decision makers and the emergence of coalitions between them, aspects on which the U.L.B. team [Marchant et al.94] already works. All these extensions should be extremely relevant to the management of the process of negotiation (definition of mediator and decision makers strategies used in the negotiation process).

We have preferred, on the basis of this simple mathematical model, to develop a first computer system prototype of assistance with the negotiation that would later be more complex. To develop this prototype, we have adopted a multiagent approach, associated to the Distributed Artificial Intelligence (DAI) [Ferber 88-89], [Bond & Gasser 88]. A first version of the prototype has been developed by using the Objlog language, extended to the multiagent context. Remind that Objlog is a self-referring language for development of knowledge based systems (Objlog is developed in Prolog). It is based on frames and allowing the vertical multiple and horizontal multiple inheritances, the management of exceptions, the classification and the analogy [Chouraqui & Faucher 90], [Dugerdil 88]. The main extensions to this language that we had to develop concern the communications between agents (decision makers and mediators agents) able to be implanted on a Ethernet network of Unix machines.

3.2. Multiagent architecture adopted

The prototype NegocIAD is a negotiation support system for a group of decision makers, managed by a mediator. It has been developed with a multiagent architecture. To each human decision maker can be dedicated a work station (or an unix process) as well as to the mediator. Decision makers and mediator communicate by Ethernet network, asynchronous communication (with or without continuation) supported by specific processes developed in language C according to a client-server philosophy .

General architecture

The developed system is composed of a population of artificial agents distributed on different machines dedicated to decision makers and to the mediator. These artificial agents are of a cognitive type notably when they are associated to human agents; other agents are more reactive when associated notably to criteria, actions, weights.

In the negotiation limits fixed by human decision makers, and delegated to their artificial agent associated, currently a simple margin of negotiation on evaluations of actions and the weighting of criteria, the negotiation process managed by the artificial mediator agent is semiautomatic by sending of messages between agents (demands and returns of evaluation adjustments so as to reach a consensus).

Of course, if the consensus cannot be reached within the limits of orders fixed by decision makers, the system suspends the negotiation so that he can be continued by a discussion between human decision makers, animated by the mediator. The following figure illustrates this multiagent architecture adopted :

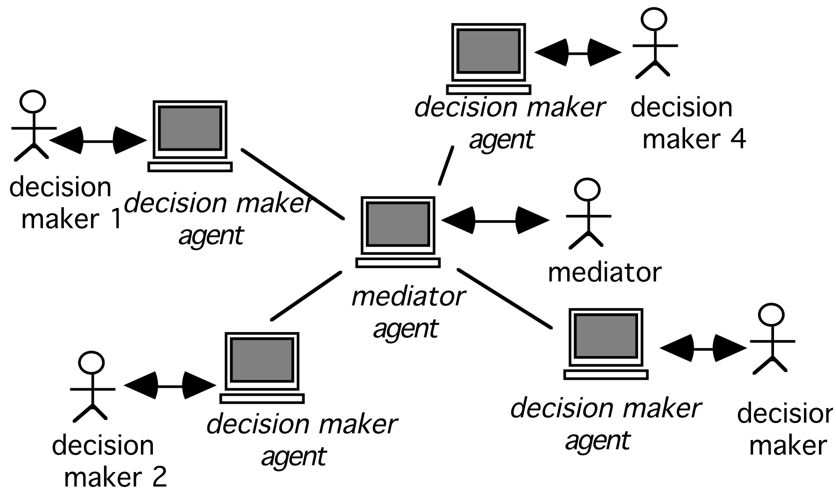

Figure 1 : General architecture of NegocIAD.

The general architecture specified, we will now focus on the knowledge representation associated to the decision maker and mediator agents.

The decision maker agent

The definition of the decision maker agent is based on a set of classes. First of all, we find similar classes to those already met for the description of the mediator agent. These classes are necessary for the representation of the problem : actions, criteria.

<u>The class Action</u>

Attributes:

Name of the action
Date of creation
Name of the specific decision maker
Value of the flow

Weight of classification inverts

List of pre-actions (actions that can precede the action concerned : these actions may be preceded by other actions)

List of the post-actions (actions may be temporarily followed by other actions.

Methods of input, modification, suppression.

The class Criterion (This class generate specific criterion classes belonging to decision makers)

Attributes:

Name of the criterion

Date of creation

Name of the specific agent

Name of the specific action

Weight: it is the specific weight that the decision maker grants to the specific action to the view of the criterion.

Margin of the weight: margin during the negotiation, it is given in percentage and allows the human decision maker to delegate to its agent associated a negotiation margin in which it will be able to adjust its evaluations.

Margin of the evaluation: the mediator gives to the decision maker for each of its evaluations a direction that indicates the position of the group on its evaluations. This direction is two types : to the high or downward. For example, if an evaluation of a decision maker is considered too in here of that of the group then the direction of this evaluation is to the rise and the decision maker will be able if it desires it, to reconsider it by increasing its value.

Direction: the consensus for the weight

List of correlations : indeed a criterion can be dependent an other without going until the aggregation.

Methods of input, modification, suppression.

They are others classes associated to the interface of dialogue decision maker-machine, notably Matrix and Field classes. Finally, the Manager class manage the communication between the decision maker and the mediator.

The class Manager:

Methods:

init_ pb: initialization method of the problem, whose characteristics are transmitted by the mediator through the support of network communication.

demand_ adjustment : demand of evaluation adjustment asked by the mediator.

adjustment_ network: return of evaluations calculated by the decision maker. These evaluations are returned to the some mediator is the place of residence.

Mechanism of communication

The mechanism adopted to support the communication between the decision maker agent and the mediator agent is of a "client-server" type. It consists to establish a communication between a machine supporting a decision maker agent and a machine supporting the mediator agent.

The class Manager is specific to the decision maker agent. Its aim is to scrutinize messages coming from the network, and to propagate the message to objects concerned. The main requests addressed to the decision maker, as to initialize the problem, to evaluate actions according to different criteria or to re-evaluate its point view during the negotiation process. The Manager transmits reevaluations of the decision maker agent to the mediator agent, by using the communication functions of the Unix system.

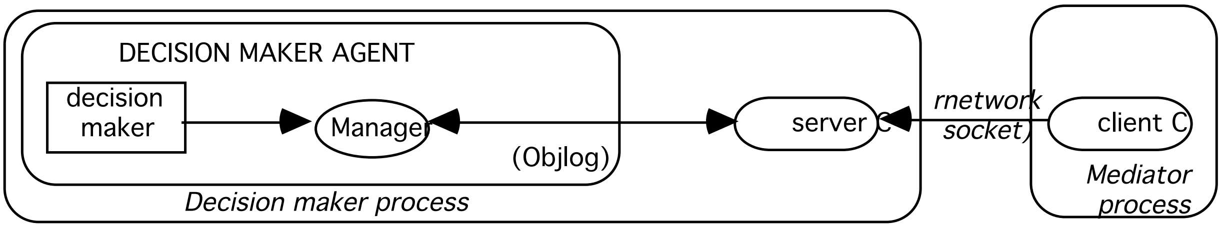

Figure 2 : Communication between decision maker and mediator agents .

Behavior of the decision maker agent

As we will see in the following illustrative example, the decision maker inputs his own evaluations and relative weightings to actions and criteria retained by the group. Then, he delegates to its artificial agent associated different orders or negotiation strategies. Actually, in our prototype, these orders concern only evaluation margins and weighting modulations. Finally, on the demand of the mediator agent, in following his suggestions (dispatched by messages), the decision maker agent adjusts its evaluations and weightings according to a strategy delegated by its human decision maker associated.

Mediator agent

This agent has to set the problem in term of object (instance of classes) and to communicate it to the various decision makers agents concerned. It represents the set of evaluations and each decision maker weightings. Finally, it manages the negotiation process through message sendings to decision maker agents. These messages suggest them to adjust their evaluations/weighting in a direction going to a consensus. This agent is based on classes : Agent-basis, Agent, Action and Criterion. Class Action and Criterion are similar to those already presented for the Decision maker agent.

The class Agent-basis : It generates instances of decision maker agents being able to participate in the negotiation. The attributes and methods of this agents are :

Attributes:

Name of the agent
List of name of the group: the decision maker can belong to an or several groups.
Date of creation : the date of creation allows the dynamic validation of each agent on the basis.
Area of competence (or specialty if the agent is typed): the decision maker can have an or several areas of competence.
Objectives: the decision maker agent is a cognitive agent, it has therefore a knowledge base..
Name machine : name under which is identified the machine of the decision maker.
Number of port: number attributed to a decision maker agent to receive communications.

Methods:

Method of choice of behavioral models : the decision maker could need behavioral models to manage conflicts that it have with the other decision makers.
Method of justification of adjustments: the decision maker can explain its evaluation and weighting adjustments.
Methods of input, modification, suppression.

Class Agents: It generates, in the representation of the Mediator agent, instances of decision maker agents that participate effectively to the negotiation. Attributes that characterize it are :

Attributes:

Name: name of the decision maker agent.
Group: list of group name to which belongs the decision maker (The decision maker can belong to one or several groups).
Date of creation.

There are other classes as the Weight class, classes concerning the communication interface man-machine (Matrix and Fields classes,...), and finally classes supporting the communication between the mediator agent and decision maker agents, as Network and Server classes .

Class Network:

Attributes:

Port: this attribute determines the communication port attributed to the agent,
Address: represents the name of the host machine,

Method:

Return_ network: function that allows to scrutinize the network, and to recuperate a possible message, in order to propagate it in the agent knowledge base.

Note that the Network class can be part of the environment of the decision maker, thus he could have also make demands of services to others agents. But for our system, it was not necessary to implant immediately such a complete architecture.

Class Server:

Attributes:

Port: defines the port or addresses the instance of the service,
Name_ decision_maker: determines to that addresses the message,
Machine: defines the name of the machine where is found the address.

Methods:

Instance_ server: method of creation of an instance of the server class,
Init_pb: method that initializes the facts base of the decision maker agent with specific data of the problem to solve, as the set of class Action, criteria and relative instances,
Demand_ adjustment: method that asks to a decision maker to adjust its evaluations according to a direction determined by the mediator,
Return_ adjustment: method that allows to put to day the basis on facts of the problem in function of readjustment values of the decision maker in question.

Behavior of the mediator agent

The human Mediator initializes the negotiation by defining, in consultation with the decision makers of the group, the criteria and actions associated to the problem. The formulation of the problem being defined, the mediator communicates it to its artificial agent. This agent communicates the problem formulation to the various decision maker agents associated to decision makers making part the group of negotiation. Note that, at any time, a decision maker can wish to leave the negotiation. Once the problem defined, for all human actors and artificial agents, the negotiation can start, managed by the mediator or its artificial agent associated, according to the mechanism presented in the in chapter 2. Briefly the behavior of the mediator agent can be described thus :

- creation of the skeleton on the knowledge base, notably instances of decision makers, of group, actions, criteria, as well as of instances that will insure the communication between mediator and decision makers agents;
- communication to the various decision maker agents implied in the negotiation, of the formulation of the problem adopted by the group;
- demand for each decision maker of its own evaluations and relative weightings to actions and criteria which define the problem;
- management of the negotiation: one installs in the event loop following :

```
so that not end of the program:
        so that negotiation not ended
                -to block the event loop of the "begin" menu of the mediator
                so that (all agents have not replied)
                        test if messages are present on the network
                        end so that
                        - to calculate the preorders (by calculation of Promethee flows)
                        - to evaluate if there is consensus:
                                if there are consensual actions
                                  then negotiation ended
                                otherwise: to do a round of the decision makers
                                        (according to the negotiation strategy adopted)
                                        if stop: re-adjustment (automatic or non)
                                        -test of end of negotiation demand of a decision maker
                -test of the mediator
        end so that
        -menu event loop
end so that
```

As evoked in chap.2, at the mediator level, different strategies of negotiation management can be defined. These strategies can be sophisticated and enrich the knowledge base of the mediator (extent in particular to the concept of belief). In our first prototype these strategies (2) are simple and already defined in the method.

Mechanisms of communications

The mechanism adopted to support the communication between the mediator agent and decision maker agents is also of "client-server" type. It consists to establish a communication machine-machine, machine supporting the mediator and machine supporting a decision maker. The mediator is going to make demands of services to the class Server, (to see next figure; direction 1) by sending a message. The class Server creates an instance of Server for each asked service, these instances are in charge to transmit the message corresponding to the service at the concerned address. Instances of Server call system function whose mode of connection is that of "Client" type. So that the message has not been transmitted, the hand is not rendered to the system.

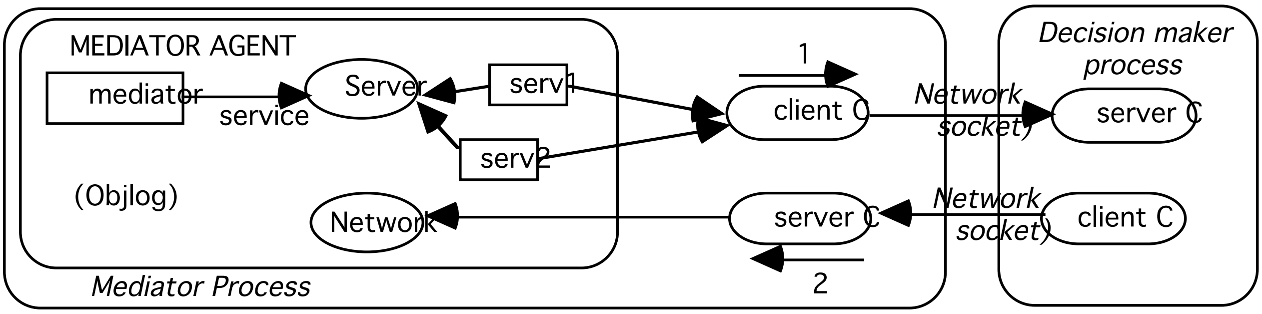

Figure 3 : Communication between mediator and decision maker agents.

Then, the mediator agent is waiting for replies, it tests if its Server class have instances. The Network class have to scrutinize the port of communication of the mediator so as to recuperate the set of messages that are addressed to it (to see previous figure; direction 2). After reception of the message, Server instances are destroyed, after having take into account the evaluations modifications of the decision maker.

4. An example of negotiation with NegocIAD

4.1. Presentation of the example

It is an extremely simple example allowing to illustrate the negotiation process supported by our prototype. Is three decision makers, Jean, Eric and Tom, all the three have to take a decision as for their destination of holidays for the next summer. To orient their choice, it has been retained as evaluation criterion: the distance of the country of stay, the cost of the stay and the language practiced. Finally, destinations retained are : America, Spain and Australia. So, we have :

- 3 actions: to go in America, in Australia, in Spain;

- 3 criteria: The Cost of the trip, the Distance to cover, and the Language practiced.

For each decision maker, criteria have not the same weighting.

4.2. Formulation of the problem by the mediator

The mediator communicate to the system what are decision makers that participate to the negotiation and elements of the problems (actions and criteria). The figure 4 illustrates the menu of the mediator and in particular the menu associated to the definition of the problem. Then, when the problem is completely defined, the mediator agent communicate elements of the problem to each decision makers machine and asks to their evaluations. The negotiation can begin, controlled by the negotiation module of the mediator agent.

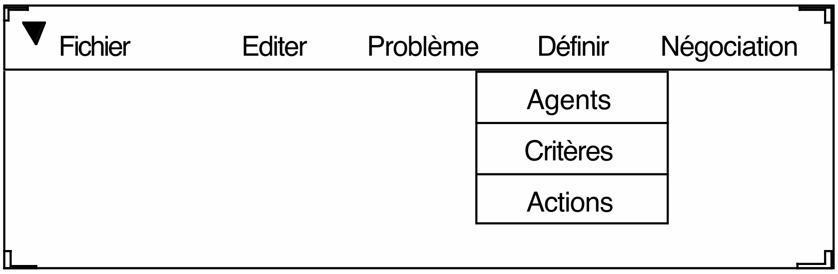

Figure 4 : Menu of the mediator.

4.3. Input of evaluations by each of decision makers

Each decision maker enters its evaluation actions/criteria, as well as its weightings of criteria in the matrix that is presented it in the next window:

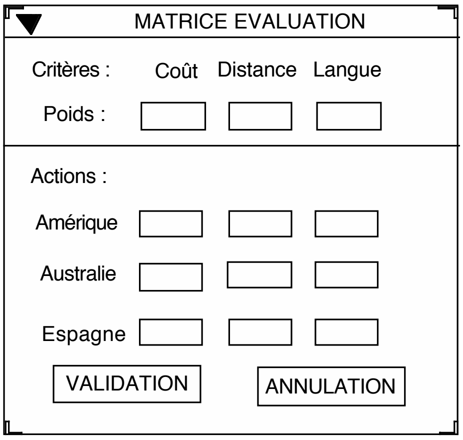

Figure 5 : Matrix of evaluations.

Note that the constitution of elements of the problem of the negotiation has a dynamic and non limiting : the number of actions and criteria retained by the group will depend of course on the problem of negotiation approached. This imposes on our matrix of evaluation to be dynamic. To represent the matrix through an agent representation has imposed us to represent each cell by an agent of the knowledge base. We have defined the Matrix class whose instances are agents. To represent the matrix in the knowledge base, we have established a structural relationship "has-part" with instances of a the Field class. So, an evaluation matrix is composed of a set of editing fields. For our illustrative example, we could have at the beginning of the negotiation, for each of the three decision makers, the following evaluation matrix :

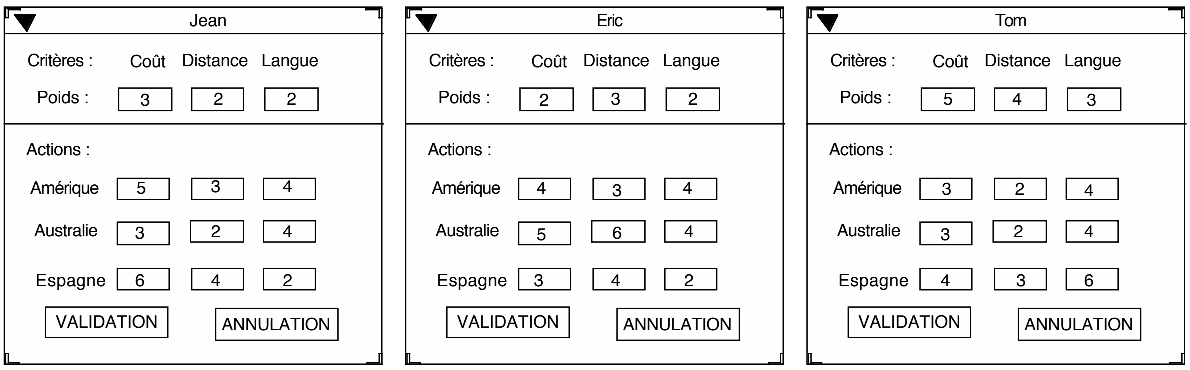

Figure 6 : Matrix evaluated by decision makers at the beginning of the negotiation

4.4. Management of the negotiation

In the research of a consensus, each decision maker is requested by the mediator to adjust its values of evaluation (and/or criteria weights), in margins that it have fixed before. In our prototype, this margin is simply given in percentage and represents the rate of modulation that a decision maker grants to its evaluations (or its weighting). This margin is given by the decision maker for all its evaluations.

The matrix of evaluation have to be richer in information. Indeed, for each of evaluations and similarly for the weighting, it appears necessary to describe the margin in which situates the evaluation and the senses of readjustment given by the direction of the consensus. Each evaluation or weighting becomes therefore a n-uplet container three aspects. The first describes the value, the second the current margin of modification (in percentage) already used by the decision maker, the third describes the direction of readjustment for a consensus. For example, at a step of the negotiation, the following matrix is presented to the decision maker Jean :

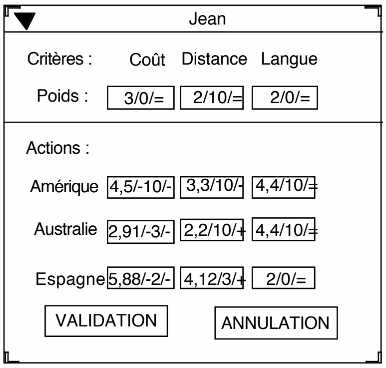

Figure 7 : Matrix of the decision maker Jean.

Note in the example that if the margin is (+/-) 10%, it is reached for most of evaluations. Concerning the evaluation to go in Australia for the Cost criterion, the evaluation has to be adjusted to the decline and one has a margin again of-7%. For the weight of the Cost criterion, the weight is found in the norm of the consensus (=) and one has again a maximal margin (+/-10%).

The system manages the negotiation of an automatic manner, through message sendings between decision makers and mediator artificial agents, until a consensus or until margins of negotiation are exhausted. In this last case, the negotiation fails. Then, the system asks to all human decision makers to enlarge evaluation and weighting margins or to adjust their evaluations beyond the limits of margins that they had fixed.

5. Conclusion

We are currently improving the conviviality of the interface between decision maker and system, in order to experiment with human decision maker groups. We try to obtain acceptable performances in the semiautomatic management of the negotiation process. This experimentation should allow us to discover sophisticated strategies of negotiation associated to the decision makers and the mediator behaviors in order to make our prototype more complex.

The mathematical model of the multicriteria method used in our prototype needs to be more complex to detect the possible criterion grouping, the conflicting situations between decision makers and the emergence of coalitions between these decision makers. The emergence of decision maker and mediator negotiation strategies also need to be taken into account in this model. All these extensions will be extremely relevant for a realistic semiautomatic management of a negotiation process between the artificial agents.

We plan to approach this complexification through new concepts which are actually emerging in the multiagent field. Thus, to make more complex the artificial agents of our system, we plan to define for them plans and beliefs, on which these agents will develop complex negotiation strategies. To extend our NegocIAD prototype, we are in the process of choosing a more advanced multiagent environment as the AOP-Agent 0 environment developed by Y.Shoham [Shoham 93] (in which the concepts of mental state, beliefs, obligations and capacities are already defined) or the Mering IV environment, developed by J.Ferber and P.Carles [Ferber & Carles 91-94], [Carles 93].

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