Negotiation Protocol Inter Agents in an Electronic Market

Samir Kechid and Habiba Drias
Department of Computer Science, Algeria University, Algeria

Abstract: *In this paper, we present a new environment of negotiation in a multi-agents system for the electronic market. Our environment presents two protocols of negotiation, namely; the protocol of negotiation by auction and the contract net protocol. The choice of the protocol to be used, is made according to the type of product negotiate, for certain products, we use the auction, and for others we use the technique of contract net protocol.*

Keywords: *Negotiation protocol, auction, contract net protocol, multi-agents systems, electronic business.*

Received January 5, 2004; accepted April 13, 2004

1. Introduction

The Artificial Intelligence (AI) is a data processing discipline, which aims at modeling intelligent human capacities (reasoning, understanding word, vision, etc.) in a way that the computer can reproduce these capacities [5, 6]. The so powerful, classic AI, does not succeed in handling some complex and diverse problems, such as the assistance to decision, the recognition and the understanding of forms, the behavior of industrial processes, etc.

The activity of the business on Internet is one of the fields of use of the Distributed Artificial Intelligent (DAI). At present it is limited to the publications of commercial occasions and the catalogues based on sales, but it should quickly include the mechanisms of negotiation, which will bring important progress of the commercial operation for both, the seller and the buyer [3, 4].

The negotiation is a process of interaction, which allows the conflicting parts to converge to a common decision. They start by expressing their conflicts, then they look for an agreement, that is by means of a process of concession or the search for new alternatives. In our context, the agents who are software constituents represent users, acting in a distant environment. The various communications are realized by the sending and the reception of messages. However potential conflicts can appear when it is about a task of decision-taking among these various users on a given subject or a problem to be resolved [8, 12].

There are several methods of negotiation:

- *Centralized Negotiation*: The process of centralized negotiation supposes that the superintendent agent has a global sight of the problem. He discovers the conflicts inter the agents thanks to his global sight of the problem, and he takes care of the resolution of these conflicts among the agents. The negotiation supposes the existence of an arbitrating agent, which receives the purposes in conflict of the various agents [3, 7, 14].
- *Distributed Negotiation*: In the distributed negotiation, the process of detection and resolution of conflicts is totally distributed inter agents. Every agent can discover the situations of conflicts from the information that he receives from the other agents [7, 9, 10, 15].
- *The Contractual Network*: The contractual network is an allowance of tasks technique dedicated to the resolution distributed by problems. It is a question of a set of agents who can create public contracts [1, 11, 13].

2. The Electronic Market Environment.

The model proposed takes advantage of two methods of negotiation for an electronic market, which are; the sale by auction and the sale in detail. The model of auction will be used for the commercialization of the products of big values, and the other one for any product. So, the market environment is distributed in three levels:

- *Level 1 (selection of method)*: This level allows to select the method to be applied for the sale or the purchase of a given products, according to the type of the product. The method of the auction is used for the products of big values; the other method is used for any type of product.
- *Level 2 (application of the method)*: This level allows making an agreement between the seller and the buyer for a given product by applying a negotiation method chosen in level 1.

- *Level 3 (conflict resolution)*: This level, presents the formalism which allows the agent to choose the best on the market. This method changes according to the criteria given by the user for the product. In the case of a product with a single criterion, which is the price, the best offer will be the one that has the biggest price for a sales offer, and the one that has the smallest price for a purchase offer. In the case of a product in several criteria, an evaluation function should be used, with giving the agent the ability to impose preferences on these criteria. These preferences are expressed as a percentage, which will be considered as a weight of the criterion.

The diagram of Figure 1 displays this environment.

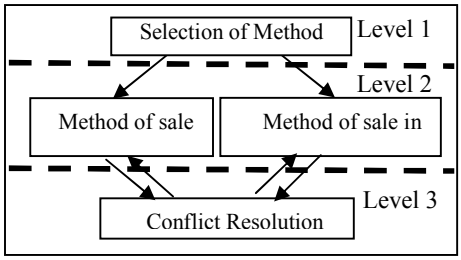

Figure1. The electronic market environment.

3. Evaluation Function of a Product

The fact that the preference of the criteria would change from an agent to other, requires a very specific method, which presents in a formal this preference. The method adapted to express this preference, is to affect a weight to every criterion, with the condition that their sum will be equal to 1 (the weight represents a preference rate), expressed by the following formula [7]:

$$\sum_{J:=1}^{n} P_{ij} = 1 \qquad (1)$$

where:

i: Expresses a given product.
j: Expresses a criterion associated to the product.
P: (Preference) expresses the weight concerning this criterion.

So, it is possible to define a formal function, which helps the agent to make the decision. This function is called the evaluation function (F) defined as follows:

$$F_i(x) = \sum_{J:=1}^{n} P_{ij}(x) * V_{ij}(x) \qquad (2)$$

where:

x: Represents an offer of a product i.
F: Expresses the function of evaluation of the product i of the offer x.
P_{ij}*:* Expresses the weight of a criterion j of the product i.
V_{ij}*:* Expresses the mean value of a criterion j, which is calculated by the following formula:

$$\begin{cases} V_{ij}(x) = \dfrac{Value_{ij}(x) - Min_{ij}(x)}{Max_{ij}(x) - Min_{ij}(x)} & \text{If the criterion j is to be maximized} \\ V_{ij}(x) = 1 - \dfrac{Value_{ij}(x) - Min_{ij}(x)}{Max_{ij}(x) - Min_{ij}(x)} & \text{If the criterion j is to be minimized} \end{cases} \qquad (3)$$

where:

- $Value_{ij}(x)$: Expresses the value of the criterion j of a product i, proposed by the offer x.
- $Min_{ij}(x)$: Expresses the minimal value of the criterion j, of a product i, proposed by the offer x.
- $Max_{ij}(x)$: Expresses the maximal value of the criterion j, of a product i, proposed by the offer x.

So, by basing itself on this formalism, the good offer will be the one that has the biggest evaluation function.

4. The Electronic Market by Auction

The offers presented in the market are classified in a list. These offers arise from announcements made by the participants of the market. Offers are the negotiable entity of the system, the one that refer to a product or a set of products. The offers are fundamentally of two different types: those that refer to products to be sold and those that refer to a call for tender of purchase.

Every offer presented in the lists of market is negotiable, through a stake. It means that it is done through the participants and treated by the server according to the auction mechanism. Every participant (a seller or a buyer) can as well hold an announcer's role as a tenderer. However, the seller or a buyer has no ability to bet a sales offer or a call for tender of purchase, respectively [9, 10].

4.1. The Negotiation Process

The negotiation process extends over several phases. It passes through the continuous phase and the timed phase. When, no stake is more accepted, the results are handled during the phase of conclusion, finally the negotiation is declared closed.

4.2. The Negotiation Phases

There are four phases of negotiation: Continuous, timed, conclusion, and closed.

4.2.1. Continuous Phase (Opened)

- The beginning and the end of this phase should be fixed by the announcer of the offer.
- Announcements can be sent and are published at once on the market.
- Every tenderer can send a stake to the system. The remaining time of the phase should be shown for every user.
- The stake is accepted if it belongs to the domain of stake. That is, if it is superior or equal to the initial minimal price in the case or no stake was registered or superior of a minimum increment fixes to the last stake leader registered. Until the stake is accepted or not, the screen of the concerned tenderer is motionless. This state comes to an end by a message of confirmation of reception if the stake is accepted, otherwise, the stake will be rejected.
- An accepted stake will be a leader if it is superior to all the stakes accepted before it. If several equivalent stakes are sent by various tenderers simultaneously, the first accepted stake will be a leader. Since a stake is a leader, it appears on the lists of market.
- If the stake leader is equal to the asked price (price of immediate sale), the stake is at once winning. No other stake can beat it, and the negotiation closes.
- If the stake leader is lower than the price asked on a sales offer, it can be beaten at any time by the stake of another tenderer. A stake leader, lower than the price asked at the end of continuous phase will pass by the timed phase.
- If the stake is lower than the reserved prices (secret), this one is accepted by the server, he can be a leader but will end in no deal in phase of conclusion.

4.2.2. Timed Phase (in Continuation)

- The beginning of this phase is some minutes after the end of the continuous phase.
- The end is at the end of a sold period of the auction but that no stake was accepted or in the lock of the market.
- No announcement can be sent.
- Every tenderer can send a stake to the system as long as the period of the auction is not sold. A countdown indicates the remaining time before the end of the period of the auction. The sending of a stake influences the countdown if it is accepted.
- The stake is accepted if it belongs to the domain of stake defined as in continuous phase.
- The stake is a leader if it is superior to all the stakes accepted before it.
- The wanted price is not effective any more. No stake can escape in the process of auction. About is the value with regard to the wanted price, any stake leader can be beaten by another stake.
- When all the offers of a column have a period of inactivity, the timed phase comes to an end for this column. Every stake leader will be definite winning or not of the deal in phase of conclusion.
- The reserved price is always active. At the end of the timed phase, the stake leader does not assure inevitably the signature of a deal.
- If no period of inactivity equal to the period of the auction was registered before date foreseen by lock of the negotiations, the stakes are not accepted any more from this date. The timed phase comes to an end and all the negotiations enter to the conclusion phase.

4.2.3. Conclusion Phase (in Treatment)

This phase begins in the actual lock of the negotiations (by period of the auction or in the lock of the market). It ends at the end of check of the reserved price, the duration of this phase can be some seconds.

- No announcement can be sent.
- No stake can be sent.
- If the actual lock arises further to a period of the auction without new stake, the stake leader is at once compared with the reserved price.
- If the date of the lock of the market was affected, the last possible accepted stakes are handled then the stake leader compared with the reserved prices.
- If the stake leader is superior or equal to the reserved price, the deal is acquired to the tenderer of this stake.
- If the stake leader is lower than the reserved price, the deal is refused, the negotiation is closed. The announcer can publish his offer during a new session by adjusting his reserved price if he wishes it.

4.2.4. Closed Phase (Initial or Final)

- An announcement can appear on lists between the opening of the market and the beginning of the continuous phase (if these two dates are not identical). One speaks then about initial phase. The negotiations are closed and no stake leader is registered on the offer.
- Announcements can be sent and are published at once on the market.
- No stake can be sent.
- The state of the announcement is available for all the participants.

5. The Market of Sale in Detail

Our protocol of negotiation in the market of detail, articulates around the principle of the vast protocol contract net, in which the acceptance of an offer passes by two stages, temporary acceptance stage and definitive acceptance stage [1, 13].

5.1. Description of the Protocol of Sale in Detail

This protocol of negotiation is made in two phases; temporary negotiation phase which allows the selection of a temporary seller and the definitive negotiation phase which allows the selection of a definitive seller. The temporary negotiation phase allows the agent seller or buyer to be susceptible to the other agents and to manage jointly several negotiation processes.

In this protocol, every agent negotiator will pass by several stages:

- *PreAccept*: Being accepted temporarily.
- *PreReject*: Being thrown back (rejected) temporarily.
- *DefinitiveAccept*: Being accepted definitively.
- *DefinitiveReject*: Being thrown back (rejected) definitively.

Before presenting the negotiation algorithms of the seller and the buyer, here is the definition of the primitive to be used:

- *PurchaseCall (Ai, Vj, P)*: An agent buyer Ai announces a call of purchase for a product P to an agent saller Vj.
- *PreProposition (Vj, Ai, P, C)*: An agent seller Vi offers a proposition of temporary sale of the product P to the agent buyer Ai, with the criteria C.
- *DefinitivePropostion (Vj, Ai, P, C*): An agent seller Vi offers a proposition of definitive sale of the product P to the agent buyer Ai, with the criteria C.
- *PreAccept (Ai, Vj, P, C)*: An agent buyer Ai, accepts temporarily the proposition of the seller Vj of a product P with the criteria C.
- *PreReject (Ai, Vj, P, C)*: An agent buyer Ai, throws back (rejects) temporarily the proposition of the seller Vj of a product P with the criteria C.
- *DefinitiveAccept (Vj, Ai, P, C)*: An agent buyer Ai, accepts definitively the proposition of the seller Vj of a product P with the criteria C.
- *DefinitiveReject (Vj, Ai, P, C)*: An agent buyer Ai, throws back (rejects) definitively the proposition of the seller Vj of a product P with the criteria C.

5.1.1. Negotiation Algorithm of an Agent Buyer

- Being an agent buyer Ai, announcing a call for purchase to the other agents sellers, to receive propositions of sale of a product *PurchaseCall (Ai, Vj, P),* the agent buyer is put in the state of wait of the propositions of sale.
- When the buyer Ai, receives a temporary sale proposition of from the seller Vj *PreProposition (Vj, Ai, P, C),* he estimates his proposition with the evaluation function of offer by using the criteria C. If he is satisfactory, he compares it with the previous temporary proposition, which was accepted. If it exists, he selects the best and sends a temporary acceptance *PreAccept* to the agent of whom his temporary *PreProposition* is better and who will be considered as temporary seller and sending a temporary refusal *Prereject* to the other agent.
- When the buyer Ai, receives a definitive sale proposition from the agent seller Vj, if the proposition is satisfactory and it is better than that of the temporary seller then he sends him a definitive acceptance *DefinitiveAccept* and rejects definitively *DefinitiveReject* the other agents and the negotiation ends, otherwise he sends him a refusal Definitive *DefinitiveReject*".

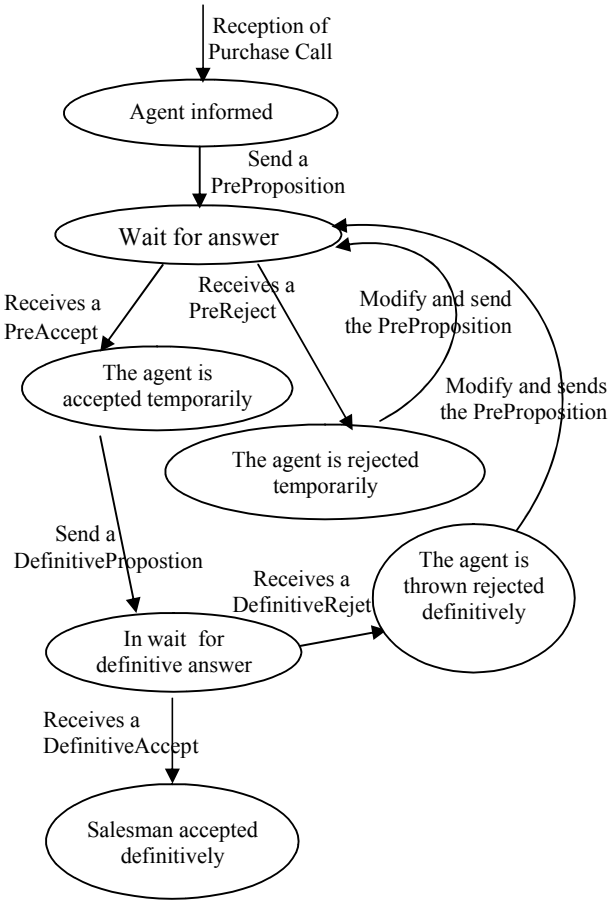

Figure 2. Behavior of an agent buyer in the negotiation protocol.

5.1.2. Negotiation Algorithm of an Agent Seller

- Being Vj an agent seller receiving a purchase call of a product P by a buyer Ai *PurchaseCall (Ai, Vj, P)*. The seller Vj sends his proposition temporary to the agent buyer Ai. *PreProposition (Vj, Ai, P, C)*.
- When the seller Vj receives a temporary refusal *PreReject (Ai, Vj, P, C)* of the agent buyer Ai, he can modify his temporary proposition and sends it again either stays in the state *PreReject* in wait.
- When the seller Vj, receives a temporary acceptance of the agent buyer Ai *PreAccept (Ai, Vj, P, C)*, he sends him a definitive proposition *DefinitiveProposition (Vj, Ai, P, C)*.

- When the seller Vj receives a definitive refusal *DefinitveReject*, he can modify his Temporary proposition either withdraws from the negotiation.
- When the seller Vj receives a definitive acceptance *DefinitveAccept*, the compromise is established and the negotiation ends.

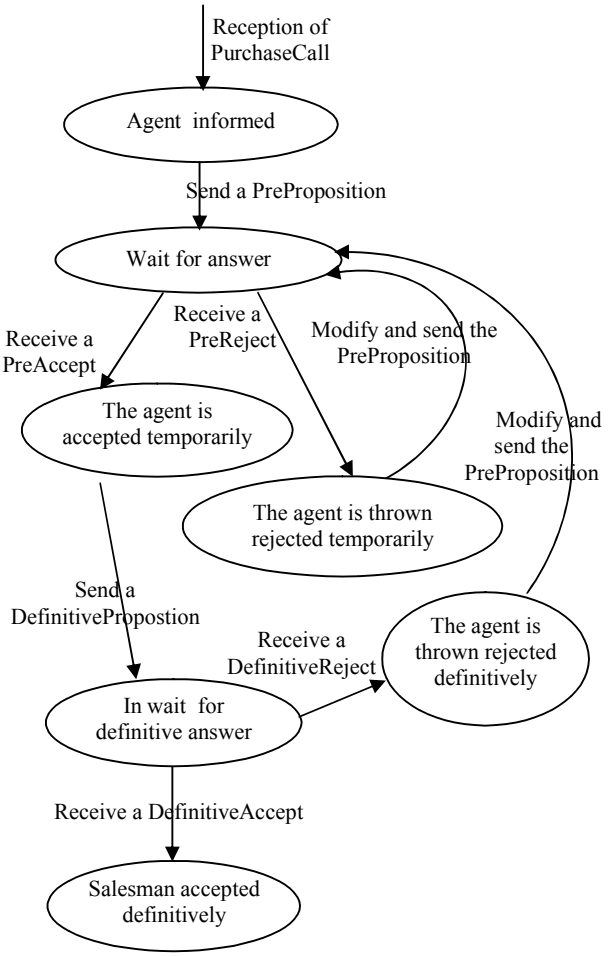

Figure 3. Behavior of an agent seller in the negotiation protocol.

6. Conclusion and Perspective

Computer systems working in real time face a sensitive increase of problems to be resolved. However, during these last years, efforts were made for a continuous progress of the intelligent systems with the aim of acting with more and more complex problems. The approach multi-agents leans on several basic concepts better to steer the reasoning. These concepts should be profoundly exploited to end up at better results.

The Electronic business systems could benefit from this approach. The user by his active role of interaction with the system would allow him to configure so that his request is satisfied in best. To have a compromise satisfying both seller and buyer, the system should be endowed with a method of negotiation among them. We presented two methods of negotiation, one for the auction market and the other one for the detail market, the used according to the type of product. The method of sale by auction allows selling important products. The method of sale of detail allows selling common products. In a negotiation protocol an agent needs to estimate the offers to establish a decision. Our methods are based on an evaluation function of the offers, which takes into account several criteria associated to the offer. We propose as perspective, enrich our system by another type of agent, which takes intermediary's role between the seller and the buyer to encourage the buyer to take the offer.

References

[1] Akine S., Pinson S., Melvin F., and Shakun, "Modèle de Négociations Multiples pour les Systèmes Multi-agents," Angers, 2001.

[2] Azondekon V. S., "Protocole du Commerce Electronique," *Département de Génie électrique et Génie Informatique Université de Sherbrooke*, 2000.

[3] Bond A. H. and Grasser, "Reading in DAI," *Morgan, Palo Alto,* CA, 1988.

[4] Darseyne D. and Moulin B., "Le Commerce Electronique," *Projet Short*, 2000.

[5] Ferber J., "Les Systèmes Multi-Agents, Vers une Intelligence Collective," *InterEditions*, 1995.

[6] Ferber J., "Les Systèmes Multi-Agents, un Aperçu Général," *Technique et Science Informatique,* vol. 9, no. 8, October 1997.

[7] Ito T. and Shintani T., "Persuasion Among Agent an Approach to Implementing Group Decision Support System Based on Multi-Agent Negotiation," *in Proceeding of the 15th International Joint Conference on Artificial Intelligence, Morgan Kaufman,* pp. 592-597, 1997.

[8] Labrou Y., "Semantics for an Agent Communication Language," *PhD Thesis,* The University of Maryland, Baltimore, Maryland, 1996.

[9] Lamouroux S. and Gérin-Lajoie R., "Le Serveur de Négociation GAMME*," Centre Inter Universitaire de Recherche en ANalyse des Organisations (CIRANO),* Montréal janvier, 1999.

[10] Manoja K. and Feldman I., "Business Negotiation on the Internet (Auction)," *IBM Research Division T. J. Watson Research Center Yorktown Height*, NY, 1999.

[11] Sandholm T. W. and Lesser V. R., "Issues in Automated Negotiation and Electronic Commerce: Extending the Contract Net Framework," *in Proceedings of the First International Conference on Multi-Agent Systems*, San Francisco, CA, pp. 328-335, 1995.

[12] Singh M. and Huhns M., "Declarative Representation of Multi-agent Systems," *IEEE*

Transactions on Knowledge and Data Engineering, vol. 5, no. 5, October 1993.

[13] Smith R. G., "The Contract Net Protocol: High Level Communication and Control in Distributed Problem Solver," *IEEE Transaction on Computers*, vol. C-29, no. 12, pp. 1104-1113, December 1980.

[14] Syacra K., "Resolving Goal Conflicts via Negotiation," *in Proceedings of the 14th National Conference on Artificial Intelligence*, pp. 592-597, Saint-Paul, Minnestoa, August 1988.

[15] Wirman P., Wellman M., and Walsh W., "The Michigan Internet Auction Boot: A Configurable Auction Server for Human and Software Agent," May 1998.

Samir Kechid is a teacher of computer science and software engineering at Algiers University of Science and Technology USTHB. He received his MSc degree in computer science and software engineering from USTHB, and currently working toward his PhD in computer science and software engineering. His research interests include multiagent systems, negotiation in e-commerce and retrieval information.

Habiba Drias is a professor of computer science and the general director of National Institute of Education in Computer Sciences, Algeria. She has received the MSc degree in computer science from Case Western Reserve University, Cleveland, Ohio, USA in 1984 and the PhD degree in computer science from Algiers University of Science and Technology USTHB in 1993, prepared at Paris 6 University from 1988 to 1992. She has taught compiling, architecture, operating systems, computational complexity, problem solving, multiagent systems at Algiers, Paris and Toulouse, France. Her research interests include the satisfiality problem, computational complexity, metaheuristics, multiagent systems and e-commerce. She has published over 40 papers in journals and conferences and supervised over a hundred BSc and MSc students projects and theses.