An Efficient Negotiation Model for the Next Generation Electronic Marketplace

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***Abstract*-E-commerce is expected to dominate the market if coupled with the appropriate technologies and mechanisms. Mobile agents are one of the means that may enhance the intelligence, and improve the computational efficiency of systems in the e-marketplace. In this paper, we propose a dynamic multilateral negotiation model that can be used to extend the functionality of autonomous agents, so that they reach to an agreement aiming to maximise their owner's utility. The model considers both contract and decision issues, is based on real market conditions and has been empirically evaluated.**

I. Introduction

Electronic commerce constitutes a field dominating transactions in the present and is foreseen to further expand in the future. In order to harness its full potential and achieve the degree of automation required by e-commerce applications, a new technology is necessitated. Agent technology, which is already affecting almost every aspect of computing, seems to play a leading role to these issues. This paper is based upon the notion of interacting agents, which exhibit properties such as autonomy, reactivation, and pro-activation, in order to achieve particular objectives and accomplish their goals on behalf of their owners in a negotiation environment.

One of the major changes that will be brought about by e-commerce is that dynamic pricing and personalisation of offers will become the norm for many transactions requiring thus extended negotiation capabilities. In this paper, the role of agents in the context of the negotiation phase will be explored. Negotiation may be defined as "*the process by which a joint decision is made by two or more parties. The parties first verbalise contradictory demands and then move towards agreement by a process of concession or search for new alternatives*" [1]. In human negotiations, the parties bargain to determine the price or other transaction terms. In an automated negotiation, software agents engage in broadly similar processes to achieve the same end. When building an autonomous agent which is capable of flexible and sophisticated negotiation, three broad areas need to be considered [2]: (i) what negotiation protocol and model will be adopted, (ii) what are the issues over which negotiation takes place, and (iii) what reasoning model will the agents employ (*negotiation strategies*). The negotiation protocol defines the "rules of encounter" between the agents [3]. Then, depending on the goals set for the agents and the negotiation protocol, the negotiation strategies are determined [4]. Given the wide variety of possibilities, there is no universally best approach or technique for automated negotiations [5], rather protocols and strategies need to be set according to the prevailing situation.

This paper concentrates predominantly on the first point, by proposing a negotiation protocol to be employed in an automatic multi-lateral multi-step negotiation model for the electronic *Business-to-Consumer* (B2C) marketplace (a highly competitive environment). Negotiators are assumed to be self-interested, aiming to maximise their personal profit. Given the inherent computational and communication costs present in the framework considered, a multi-step negotiation mechanism is needed to economise on these costs. In contrast, single-step mechanisms do not perform as well in such complex frameworks [6]. In essence, the negotiating parties hold private information, which may be revealed incrementally, only on an as-needed basis. The negotiation environment considered covers multi-issue contracts and multiparty situations, while being a highly dynamic one, in the sense that its variables, attributes and leading objectives may change over time.

The rest of the paper is structured as follows. In *Section II* the role of mobile intelligent agents in the B2C e-commerce is examined. In *Section III*, the negotiation protocol adopted is presented. The protocol does not follow the usual alternating sequential offers pattern, but instead employs a contract ranking mechanism. *Section IV* elaborates on the proposed negotiation model, which enhances the existent models introducing the *decision issues* concept. Finally, in *Section V* conclusions are drawn and directions for future plans are presented.

II. Agents' Roles in B2C e-commerce

In this section, the roles of agents in an e-commerce context are explored. Mobile intelligent agents can act as mediators in five of the six e-commerce phases [7]: need identification, product brokering, buyer coalition formation, merchant brokering and negotiation.

In the *need identification stage*, the customer recognises a need for some product or service. This need can be stimulated in many different ways (e.g., by advertisement, through friends, etc.). However, in e-commerce, it can also be stimulated by the user's agent. Such an agent is typically called a notification agent. It acts autonomously to inform the user of relevant data, it responds to changes in the environment and, occasionally, it is proactive in that it may provide the user with data that are not exactly what had been asked for,but are judged to be quite interesting to worth informing the user. In order to accomplish its tasks, the notification agent needs to have a profile of the user.

Having recognised a need, the user passes to the *product brokering stage*, in which an agent is involved in determining what product to buy to satisfy this need. The main techniques used here are: feature-based, collaborative and constraint-based filtering. Thereafter, customers may move directly to the *merchant brokering phase,* or they may interact with other similar buyers to try and form a coalition (*buyer coalition formation phase*). Coalition may be viewed as a group of agents cooperating with each other in order to achieve a common task. In these *buyer coalitions,* each buyer is represented by her own agent, and together these agents try and form a group in order to approach the merchant with a larger order.

Merchant brokering involves the agent finding an appropriate merchant to purchase the item from. Initial work in this area focused on finding the merchant that offered the good at the cheapest price. However, in many cases, price is not the only determinant for the user, as other issues may be important (e.g., delivery time, gift services, warranty), while many merchants prefer their offerings not to be judged on price alone. Thus, there is a move to extend these agents to consider multiple issues.

Having selected a merchant, the next step is to negotiate the terms and conditions under which the desired product will be delivered (*negotiation phase*). In more detail, the agents prepare bids for and evaluate offers on behalf of the parties they represent aiming to obtain the maximum benefit for their users, following specific negotiation strategies. The rest of the paper elaborates on a negotiation protocol and model for multilateral negotiations.

III. A Negotiation Protocol

In order to create a successful negotiation framework, the design of an appropriate protocol that will govern the interactions between the negotiators is needed. Depending on the specific negotiation problem that needs to be solved, a protocol comprises a set of rules that constrain the proposals the negotiation parties are able to make. In [5], a generic framework for automated negotiation is presented. The simplest protocol, which minimises the complexity of the rationale behind the decision models of the agents, specifies that the agents can only accept or reject others' proposals. Nevertheless, in complex cases where multiple issues are considered, this convention may lead to a very time-consuming and inefficient process, since the agents have no means to verify why the specific proposal is unacceptable, or towards which direction of the negotiation space they should move. In order to improve on the efficiency of the negotiation process, the responding agent should be able to transmit to the offer generating party some feedback on the proposal it receives. One possible form this feedback may take is *critique*, which is a list of comments on elements of the proposal the agent likes or dislikes. The feedback sent by the recipient of a proposal to the offer generating party may take the form of a *counter proposal*. It is an alternative proposal more favorable to its sender, generated in response to an offer, thus increasing the probability of an agreement.

In relative research literature, the interactions among the parties follow mostly the rules of an alternating sequential protocol in which the agents in turn make offers and counter offers (e.g., [8]). This model however requires an advanced reasoning component on behalf of the Buyer as well as the Seller. In the context of this paper we tackle the case where the Buyer does not give a counter offer (which involves incorporating to the model all Buyer's trade-offs between the various attributes) to the Seller, but ranks the Seller's offers instead. This ranking is then provided to the Seller, in order to generate a better proposal. This process continues until a mutually acceptable contract is reached. This is more efficient in cases, in which the Buyer is not able to express all his/her requirements and preferences in a completely quantified way, while being capable of selecting, classifying or rating the contract(s) proposed.

Considering the case of bilateral negotiation, once the agents have determined the set of issues over which they will negotiate, the negotiation process consists of an alternate succession of contract menus, composed of N contract proposals (i.e., N packets consisting on n-plets of values of the n contract issues) on behalf of the Seller's agent, and of subsequent rankings of them by the Buyer's agent, according to his/her preferences and current conditions. Thus, at each round, the Seller sends to the Buyer N contracts, which are subsequently evaluated by the Buyer and a rank vector is returned to the Seller. This process continues until a contract proposed by the Seller is accepted by the Buyer, or one of the negotiating parties terminates the negotiation (e.g., if the time deadline is reached without an agreement being in place). Even though negotiation can be initiated by Sellers or Buyers, only the Sellers propose concrete contracts, as there is no counter offer generation mechanism for the Buyers. We hereafter consider the case where the negotiation process is initiated by the Buyer who sends to the Seller an initial *Request for Proposal* specifying the types and nature of the contract issues and the values of all non negotiable parameters.

IV. An Efficient Negotiation Model

In this section, an efficient dynamic negotiation model is presented, based on the *multi-issue* value scoring system introduced by Raiffa [9], in the context of bilateral negotiations involving a set of quantitative variables. Our aim is to extend this framework into a *multi-party, multi-issue*, *dynamic* model. This is important since multilateral negotiations are common in the environment of the electronic marketplace. Based on the designed negotiation protocol, the proposed model is exploited by the Seller to create subsequent contracts, while used by the Buyer to evaluate and rate the contracts offered. In *subsection A*, our dynamic negotiation model is presented and its innovations are highlighted, while in *subsection B*, the proposed model is being applied to a specific test-case.

A. The Proposed Negotiation Model

It has been argued in the literature (e.g., [2]), that Raiffa's framework [9] is based on several implicit assumptions that, even though they may lead to good optimisation results, they are inappropriate for the needs of the e-marketplace, such as: (i) privacy of information for the negotiators is not supported, (ii) the utility function models must be disclosed, (iii) the value regions for the contract issues for both parties must be identified in advance, (iv) the only parameters that determine the utility of the contracts for the negotiators, are the values of the issues under negotiation.

Nevertheless, there are usually several issues, that even though their values are not under negotiation and they are not included in the contract parameters, they affect the evaluation of the values of the contract issues. Without being exhaustive, such issues may consist of: the number of competitor companies, the number of substitute or complementary products/services, the quantity of product in stock, the number of current potential buyers, the reputation/reliability of each Seller/Buyer, the time until the negotiation deadline expires, the resources availability and restrictions, etc. We will refer to these issues as *decision issues* (*DIs*). The values of the DIs may change overtime, depending on the e-marketplace conditions and on the Seller's and Buyer's state. The DIs do not only affect the evaluation of the contracts, but they also have an impact on the generation of subsequent offers. It is noted here that DIs' values do not necessarily depend on the actions of the negotiating party they affect, while they may affect one or both negotiators. The values of the DIs should have a strong and direct influence on the behaviour of the negotiating agents, while they should be able to evaluate the utility of the contracts under the current circumstances in the e-marketplace and act accordingly.

From the above analysis, it is clear that optimal solutions cannot be found in the e-commerce domains, as computational and communication resources usually impose non-zero negotiation duration, and time-varying issues may change the negotiation conditions for both parties. Thus, we shall propose a dynamic model for individual agent negotiation that can be exploited by strategies in order to determine contracts acceptable to the opponent parties but which, nevertheless, maximise the agent's own utility function.

In an e-marketplace environment, the roles of the negotiation agents may be classified into two main categories that, in principle, are in conflict. Thus, we divide the negotiating agents into two subsets: $\{Agents\} = \{SellerAgents\} \cup \{BuyerAgents\}$. The agents that represent *Sellers* will be denoted by $S = \{S_1, S_2, ...\}$, and the ones that represent potential *Buyers* will be denoted by $B = \{B_1, B_2, ...\}$. For the values of the DIs we will use the following notation: d_j, $j = 1,...,m$.

We may now introduce the utility function of the proposed framework as follows [4]. Let $U_i^a : [m_i^a, M_i^a] \rightarrow [0,1]$ express the utility that agent $a \in S \cup B$ assigns to a value of contract issue i in the range of its acceptable values. Let w_i^a be the importance of issue i for agent a. We assume the weights of all agents are normalised to add up to 1, i.e., $\sum_{i=1}^{n} w_i^a = 1$. Using the above notation, the agent's $a \in S \cup B$ utility function for a contract $C_k = \{c_{k1}, ..., c_{kn}\}$ can be defined as follows: $U^a(C_k) = \sum_{i=1}^{n} w_i^a U_i^a(c_{ki}, d_j^{t_k})$, where $d_j^{t_k}$, $j = 1,...,m$, is the value of the decision issue d_j at the time t_k, when contract C_k is proposed. It is mentioned here, that not all DIs are involved in the utility estimation of the values of any contract issue i. Furthermore, it should be noted that the utility function $U_i^a(c_{ki}, d_j^{t_k})$ may be any functional form (e.g., linear, polynomial, exponential, quasilinear, etc.) of the value of the contract issue c_{ki} and of the value of the decision issue d_j at the time contract C_k is proposed, while nonlinear approaches could be used to model the overall utility, without affecting the basic ideas of the model. Examples of utility functions formulations are studied in *subsection B*.

In order for the utility function of any contract issue i for any negotiator to lie within the range: $[0,1]$, the value of issue i must lie within the range of its acceptable values. To ensure this, we introduce the notion of *value constraints*, that is expressed as follows: $m_i^a \le c_i \le M_i^a$. In case the *value constraints* hold for all contract issues, the utility function can be used to measure the satisfaction of a negotiator as far as the proposed contract is concerned. Nevertheless, often, the value constraints are not met for some contract issues, for the party to whom a contract is being proposed. In this case, there is not much value in using the above specified utility function to measure the satisfaction degree of this negotiator, as the contract is completely unacceptable. In that sense, agents exhibit lexicographic preferences. In order to express that, we may introduce a *value constraint validity vector*: $VCV^a = [VCV_i^a]$, $i = 1,...,n$, where $VCV_i^a \in \{0,1\}$, depending on whether the value constraint for negotiating party a is met for contract issue i (i.e., $VCV_i^a = 1$) or not (i.e., $VCV_i^a = 0$).[1]

In principle, Sellers and Buyers present conflicting interests in the values of the contract issues. In consequence, the utility functions must verify that given a Seller S and a Buyer B negotiating values for contract issue i, then: $[\partial(U_i^S)/\partial c_i] \cdot [\partial(U_i^B)/\partial c_i] < 0$, i.e., under the same conditions, in case higher values of contract issue i result in higher (lower) utility for the Seller at the same time they result in lower (higher) utility for the Buyer. Nevertheless, it must be mentioned that there are cases in which the Sellers and Buyers may have a mutual interest for the value of a contract issue [9].

As already mentioned in *section III*, the Buyer ranks the contracts proposed by the Seller. For the simplest ranking function, the ranks that may be assigned to any contract proposed are boolean variables - i.e., one instance of the set $\{accept, reject\}$. In a more sophisticated approach, the ranks lie within a range $[m_r, M_r]$, where any contract rated with less than M_r is not acceptable by the Buyer. In this approach, when a contract is rated with M_r, then the negotiation terminates as the proposed by the Seller contract is accepted by the Buyer. As proved in [4], the second formulation of the ranking function range is more flexible than the simple $\{accept, reject\}$ rating system, as it highly contributes to reducing the duration of the negotiation procedure. In order to signal the case where at least one value constraint is not met for the Buyer for a certain contract, we introduce another parameter called *contract value constraints validity* that will be denoted by $CVCV_k^a$ for contract C_k and is given by the following equation: $CVCV_k^a = \prod_{i=1}^{n} VCV_{ki}^a$. Based on the previous analysis, in case all *value constraints* are met for contract C_k, it stands that $CVCV_k^a = 1$. On the other hand, in case at least one *value constraint* is not valid for contract C_k, it stands that $CVCV_k^a = 0$, and then the particular contract is definitely rejected.

B. Applying the Negotiation Model in a Test Case

In order to make the proposed negotiation model more comprehensive, we will present an illustrative test case. Let us consider a Seller agent S and a Buyer agent B that negotiate over the purchase of a specific product (e.g., photo camera films). Let us assume the existence of two negotiation issues: price and quantity. We may use the following notation: $c_1 = price\_value$ and $c_2 = quantity\_value$, where $i = 1,2 \Rightarrow n = 2$. As decision issues we will consider the quantity of film packs available in stock (d_1), which only affects the utility function of the Seller, and the time until the expiration date of the films to be purchased (d_2), which has an impact on the utility function of both parties. We assume that the acceptable value ranges for the contract issues for the two parties are: $[m_1^S, M_1^S] = [10,20]$, $[m_1^B, M_1^B] = [5,15]$, $[m_2^S, M_2^S] = [100,500]$ and $[m_2^B, M_2^B] = [200,300]$, while the possible value ranges for the decision issues are:

[1] In order to refer to the case where the mere presence or absence of a particular feature is required by a negotiator, we could add boolean constraints to our model. However, as they can be reduced to value constrains [4], they will not be further analysed.

$[m_{d_1}, M_{d_1}] = [0,1000]$ and $[m_{d_2}, M_{d_2}] = [0,24]$. Let now the weights for the contract issues utility functions $U_{\{1,2\}}^{\{S,B\}}$ in the overall utility function $U^{\{S,B\}}$ for the two parties be: $[w_1^S, w_1^B, w_2^S, w_2^B] = [0.8,0.6,0.2,0.4]$. This weight assignement indicates that the price is more important than the quantity for both negotiators, while for the Buyer the quantity issue is twice as important as it is for the Seller.

A reasonable assumption is that the upper limit for the quantity the Seller is willing to sell is equal to the product stock size, i.e,. $d_1 = M_2^S$. It is highly possible that the utility of a successful contract for a certain quantity of product units, is worth more for the Seller in case the product stock size is large and especially if the product is old. That is because normally, as the product value declines as the expiration date approaches, the Seller seeks to reduce the product quantity in stock, in fear of being forced to sell it at very low prices or even not selling it at all. It is also assumed that the expiration date of the films to be purchased also affects the utility for the potential Buyer, as he/she might not intend to use them shortly or due to uncertainties on the usage temporal scheme of the product. Thus, if d_2 is low (i.e., the expiration date of the product approaches) the value of the quantity purchased is low for the Buyer and high for the Seller. Based on the analysis above, we may model the utility of contract C_k for issue i as follows:

(i) $U_1^S = \frac{c_1 - m_1^S}{M_1^S - m_1^S}$, for $c_1 \in [m_1^S, M_1^S]$, (ii) $U_1^B = \frac{M_1^B - c_1}{M_1^B - m_1^B}$, for $c_1 \in [m_1^B, M_1^B]$, (iii) $U_2^S = \left(\frac{d_1}{M_{d_1}}\right) \cdot \left(\frac{M_{d_2} - d_2}{M_{d_2}}\right) \cdot \frac{c_2 - m_2^S}{M_2^S - m_2^S}$, for $c_2 \in [m_2^S, M_2^S]$ and (iv) $U_2^B = \left(\frac{d_2}{M_{d_2}}\right) \cdot \frac{c_2 - m_2^B}{M_2^B - m_2^B}$, for $c_2 \in [m_2^B, M_2^B]$.

Let us now consider two contracts proposed by the Seller to the Buyer: $C_1 = [12,210]$ and $C_2 = [15,290]$, while $d_1 = 500$ and $d_2 = 10$. Given the above parameters and using the above types, we may calculate the utility of the two contracts for the negotiating parties:

TABLE I.
UTILITIES OF THE TWO CONTRACTS UNDER CONDITIONS $\{500,10\}$.

	U_1^S	U_1^B	U_2^S	U_2^B	U^S	U^B
C_1	0.2	0.3	0.080	0.042	0.176	0.197
C_2	0.5	0	0.139	0.375	0.428	0.150

From the table above, it is obvious that the Seller's utility of contract C_2 is higher than the one of contract C_1. Exactly the opposite stands for the Buyer.

Let us now consider the same two contracts but change the stock size and the expiration date as follows: $d_1 = 1000$ and $d_2 = 20$. We calculate again the utility of the two contracts for the negotiators that has as follows:

TABLE II.
UTILITIES OF THE TWO CONTRACTS UNDER CONDITIONS $\{1000,20\}$.

	U_1^S	U_1^B	U_2^S	U_2^B	U^S	U^B
C_1	0.2	0.3	0.020	0.083	0.164	0.213
C_2	0.5	0	0.035	0.750	0.407	0.300

From the table above, we can see that still, for the Seller, the utility of C_2 is higher than the utility of C_1, as it was with the previous decision issues values. Nevertheless, for the Buyer the status has been reversed, as now the utility of the second contract is higher than the utility of the first one, while exactly the opposite stood for the previous decision issues values. But the fact that the stock size is twice as high as it was before, slightly increases the second contract issue utility of both contracts for the Seller compared to the previous situation, while it does not affect this contract issue utilities of the Buyer. Additionally, the fact that the time until the expiration date is twice as high as before, decreases drastically the second contract issue utility of both contracts for the Seller compared to the previous situation, while it increases the utilities of both contracts for the Buyer.

Via the above test case we have illustrated the fact that the utility of different contracts and the resulting contract preference hierarchy for the two negotiators, may highly depend not only on the values of the contract issues, but also on the values of the decision issues that are not under negotiation, while their values do not depend –at least directly– on the actions of the two parties. The same conclusion is reached for multilateral negotiation situations, based on some more complicated test cases [4].

V. CONCLUSION

This paper presented a *multi-party*, *multi-issue*, *dynamic negotiation model*, to be exploited by mobile intelligent agents in an e-commerce environment. The proposed framework is adequate in cases where the disclosure of information is not acceptable, possible, or desired by the parties. Its efficiency is due to the fact that it requires a flexible and light reasoning component on behalf of the Buyer agent that utilises a *ranking mechanism* to replace the counter-offer complicated scheme, while considering potential decision issues. Thus, it supports an evaluation of the contracts proposed, based not only on the values of the issues under negotiation, but also on the e-marketplace conditions and the negotiator's state. This model has been adopted by self-interested autonomous agents using several negotiation strategies and has performed well on the generation of subsequent offers and the ranking of the contracts proposed. Future plans involve its extensive empirical evaluation against existent models and against the optimal solution of the negotiation problem.

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