전자상거래에서 멀티 이슈 기반의 에이전트 협상 방법

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An Agent-based Negotiation with Multi-issue in E-Commerce

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Abstract

Our paper proposes an agent based automated negotiation model. The agents can perform an integrative negotiation with multi-issue in a one-to-many way. The negotiation protocol follows the offer-counteroffer principal, and an adapted offer generation strategy. With the utility theory, agent could evaluate the offers and determine the following actions. In order to yield a top-quality deal and shorten the negotiation period, agents propose multiple offers, which consist of a particular combination of issue values and have the identical utility with the given utility. The experiment shows that the model ensures the participants could reach a better agreement in a short time.

1. Introduction

Negotiation means two or more parties bargain with one another in order to reach mutually beneficial agreements on price or other transaction terms. In the research realm of agent-mediated electronic commerce, agent based negotiation system has shown its attractiveness in recent years because of the flexible characteristics of agent - autonomous, reactive, and proactive [1] radically change the style of the traditional electronic commerce. Ideally, the agent based negotiation system should not only bargain over the price of a product, but also take into account other issues on product aspects and seller aspects. In such multiple-issue negotiation problems, while the agents consider multiple issues, they automatically prepare offers for and evaluate offers on behalf of the parties they represent with the aim of obtaining the maximum benefit for their users.

From the agent based negotiation perspective, many approaches have been proposed to solve the problem. Kasbah [2] is the first negotiation agent supporting competitive negotiation. The autonomous negotiation determines trading partners based on buyers' and sellers' negotiation strategies programmed to it. Tête-à-Tête [3] allows the buyer to indicate his preferences on the multiple attributes including both product aspects and seller aspects which are used to influence the purchase decision. Luo [4] developed a fuzzy constraint-based framework for multiple-issue negotiations in competitive trading environments. Ferranti [6] developed a suite of algorithms for multi-issue negotiation that covers both concessionary behavior and trade offs that aim to find a win-win solution for both parties.

This study proposes an agent based one-to-many parallel negotiation system, which uses software agents to facilitate autonomous and automatic multiple-issue negotiation process. In order to shorten the negotiation period and improve the negotiation efficiency, agents generate multiple offers each round, which have the same utility and a particular combination of issue values. With this mechanism, agents could try to meet opponents' desire at the best possible.

The rest of the paper is structured as follows. In section 2, we analyze the negotiation issues. In section 3, we present the proposal. Section 4 presents the negotiation strategy. Section 5 presents the negotiation protocol, Section 6 shows the implementation and experiments results. Section 7 concludes our work.

2. Issue analysis

Obviously, the negotiation issues not only include product aspects (e.g. price, product technical specifications, etc) but also seller aspects (e.g. delivery day, warranty period, etc). While taking into account these issues as negotiation issues, some problem should be considered. The first one is the continuity of the issue, for example, issue price is continuous since it can be represented by real numbers in a restricted given range, while the issue warrant period may be discrete since it can be represented by a finite integer domain (e.g. {6, 12, 18, 24} unit: month). The second one is the negotiability of the issue, for example, the product's technical specifications are inherent so that it is un-negotiable while the warranty period is indicated by the seller so it may be negotiable. The third problem is the range of issue's value, since in the negotiation process some issues' (both discrete and continuous) value may have a restricted range. It is necessary to ensure that the value of each issue in the proposed offer or received offer not exceeds the range.

We can define some of the necessary parameters: let set $A = \{a, b\}$ be a pair of negotiating agents. To a specified agent a ($a \in A$), let J ($J = \{1, ..., n\}$) be the issue set under negotiation in a given encounter. For each issue j ($j \in J$), each agent a has a lower and an upper reservation value, min_j^a and max_j^a respectively, resulting a domain for each particular issue: $D_j^a = [min_j^a, max_j^a]$.

3. Representing Offers

An offer from agent b to agent a in the rth negotiation round is defined as $p_{b\to a}^r = < pName, J >$, where $pName$ denotes product name; J denotes the issue set, each element in the set is a name-value pair:

$IS = < (issue_1, value_1), (issue_2, value_2), (issue_3, value_3), ..., (issue_s, value_s) >$.

Let j designate an issue and p_j be the value of the jth issue in the set of IS.

4. Negotiation strategy

The negotiation strategy is the way in which a given party acts within those rules in an effort to get the best outcome of the negotiation, for example, when and what to concede. The strategy of each participant is necessarily private. In this model, the negotiation strategy includes proposal evaluation, proposal acceptability criteria, and offer generation.

4.1 Proposal Evaluation

Multi-Attribute Utility Theory (MAUT) is an evaluation scheme which is very popular by consumer organizations for evaluating products.

According to MAUT, Evaluation of a proposal $p_{b->a}$ involves summing the valuation of each issue in the negotiation subject. The evaluation function of agent a over an issue j is given by V_j^a where $V_j^a : D_j \to [0,1]$. A weight w_j^a is associated by agent a to issue j where the sum of weights of all issues is 1. An Agent can change its preferences for an issue by changing the weights associated to the corresponding issue. Thus, the utility of agent a over a proposal p, consisting of a set of values for all issues, can be defined as:

$$U^a(p) = \sum_{1 \le j \le n} w_j^a V_j^a(p_j). \qquad (1)$$

The evaluation function over the issues as required by equation 2, is given by the distance to the worst bid acceptable to this agent, relative to its range of acceptable values. Depending on the issue, the evaluation function looks different. If the issue is continuous, the evaluation function also will be a continuous one, if it is a discrete variable, the function will be discrete. Hence this scales the acceptable bids for the agent to the domain [0, 1]:

$$V_j^a(p_j) = \begin{cases} \text{Continuous Issue:} \\ \dfrac{p_{b\to a}[j] - \min_j^a}{\max_j^a - \min_j^a}, & \text{if increasing} \\ \dfrac{\max_j^a - p_{b\to a}[j]}{\max_j^a - \min_j^a}, & \text{if decreasing} \\ \text{Discrete Issue:} \\ \dfrac{distance(p_{b\to a}[j], \min_j^a)}{distance(\max_j^a, \min_j^a)}, & \text{if increasing} \\ \dfrac{distance(\max_j^a, p_{b\to a}[j])}{distance(\max_j^a, \min_j^a)}, & \text{if decreasing} \end{cases} \qquad (2)$$

where increasing and decreasing refer to the direction of change in score with increasing value of the issue.

If the issue's value is not in D_j^a, , the issue's utility is 0. If the negotiation offer contains an un-negotiable issue, the utility of this issue is $-\infty$, therefore the offer's utility is $-\infty$, and agent will send a REFUSE message to its opponent.

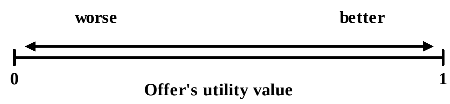


Fig. 1. Estimation of issue's utility.

As shown in Figure 1, the utility of a valid offer is in the range [0, 1], if the utility value is close to 1, it means the offer is good. Oppositely, if the utility value is close to 0, the offer is bad.

It should be made clear that an agent will not publicize the information about the acceptable value ranges of its issues, the weights over the issues and its utility function because doing so would enable it to be exploited. Furthermore, each agent will have distinctive reservation value range to each issue.

4.2 Proposal Acceptability Criteria

During the negotiation process, a number of Seller Agents (SAs) on behalf of sellers, and a Buyer Agent (BA) on behalf of a buyer, compare received offers with its expectation and tend towards coming to a mutually acceptable agreement over the price and other issues. The initial offer for sellers and buyer is formed by selecting the local optimal value of each issue. In the negotiation process, BA firstly starts with the initial offer and sends it to opponents. In each round, both sides propose offers in alternate.

Every agent records a utility threshold T that represents its expectant utility to received offers. If the received offers are more attractive than its expectation, it means both sides can reach an agreement by simply agreeing to the received offer. Otherwise, negotiation proceeds to the next round, agent will concede to decrease its threshold T according to an adjustment parameter Δ ($T = T - \Delta$) and generate multiple offers with the utility, the process continues until one of the SAs or the BA gets an offer with greater utility than its expectation or equal to its expectation. The basic principal is depicted in Figure 2.

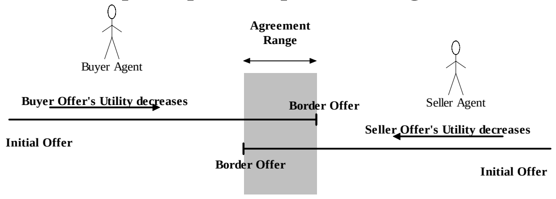


Fig. 2. Principal of making concessions.

An agent can accept a proposal if the offer's utility value intersects its threshold T. In any negotiation round, each agent may multiple proposals from its opponent(s). Let S be the received proposals set and p ($p \in S$) be one proposal and p' be any other proposal from the relative complement of $\{p\}$ in S. Accordingly, the acceptability criteria of agent a are defined as:

$U^a(p) \geq T$

$U^a(p) \geq U^a(p')$

where: $p \in S$ and $p' \in S - \{p\}$

4.3 Offer generation

The basic negotiation protocol of exchanging a single offer in every round is time-consuming and laborious, especially if both sides are unwilling to concede. The unwillingness to make compromises might result from the fact that the negotiation just does not tend towards the desired direction. For example, suppose both the seller and the buyer take issue warranty as the most important issue. Offers from the buyer may reflect that the warranty should be long-term. However, these proposals are not attractive enough to the seller since this issue is associated with cost criteria to seller so as to the seller expects a short warranty period. It is probably unwilling to concede, even if other issues in the proposals have a good value. This could cause the both sides block the progress of the negotiation, although a compromise would be possible, the utility of the final deal may be much lower.

To reduce the number of negotiation round and possibly avoid such a deadlock situation, we adopt "multiple offers per round" instead of "one offer per round". The idea is that the generated offers have the same utility while they consist of a particular combination of issue values. Submitting several offers per round could speed up the negotiation process, because the offers with various combinations of issue values provide a wider selection to choose from and thus increase the possibility of the opponent gets a desired offer.

Since each agent has a local preference to each issue. Therefore, the offer generation involves search for prospective solutions from the individual area of interest that move the parties towards an agreement from the common area of interest. The constraints are:

$min_j^a \leq p[j] \leq max_j^a$

$U^a(p) = T$

5. Negotiation Protocol

Negotiation protocol determines the flow of messages between the negotiating parties, dictating who can say what, when and acts as the rules by which the negotiating parties must abide by if they are to interact. The protocol is public and open to all parties. The negotiation protocol for this m odel is given as the state sequence of agents.

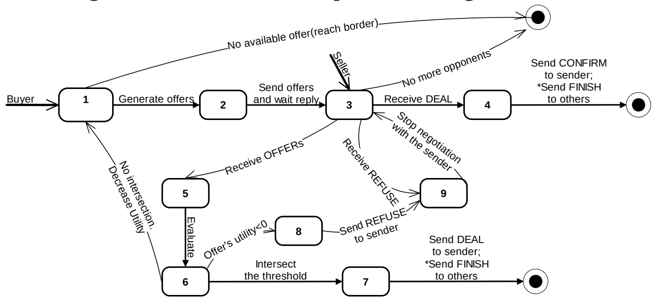


Fig. 3. Negotiation protocol shown as the state sequence of agents. (*: the individual activity of BA)

6. Implementation and Evaluation

We have implemented a prototype system using IBM Aglet Software [5] with JDK1.4.2. We have developed three kinds of agents for the solution of negotiation problems: BA to interact with sellers and initiate the negotiation, SA to act on behalf of seller, Offer Evaluation and Generation Agent (EBA) to calculate offers' utility and generate offers based on invoker's preferences.

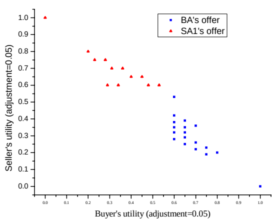
We have analyzed the negotiation data of purchasing a server, the negotiable issues are price (dollar), delivery day (day), and warranty period (month). Issue price is continuous, which has a minimum value 10000 and maximum value 15000, issue delivery day is discrete, the value domain is {1, 2, 3, …, 12}, issue warranty period is discrete, the value domain is {6, 12, 18, 24}.

Table 1. The issues' weight and criteria of each participant.

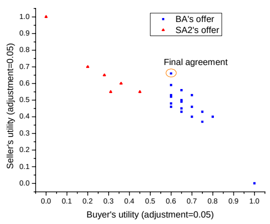
Participant	Price	Delivery	Warranty
Buyer	0.5	0.2	0.3
Seller 1	0.3	0.2	0.5
Seller 2	0.3	0.4	0.4
Seller 3	0.4	0.3	0.3
Seller 4	0.4	0.2	0.4

To test the effectiveness of the parallel negotiation, we deployed a BA on behalf of a buyer and four SAs on behalf on sellers. Each agent has a different attitude to each negotiable issue, which is shown in Table 1. Each participant's adjustment value is 0.05, for example, in the first negotiation round, the BA's threshold is 1, if it cannot get an agreement with SAs, and then it will decrease its threshold to 0.95.

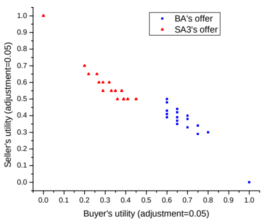
The experiment is finished in 6 rounds, BA makes a deal with SA2 ultimately, the deal offer is [price: 10000.00, delivery: 12, warranty: 12]. This offer has a utility value with 0.60 from buyer's perspective and a utility value with 0.66 from seller 2's perspective. In Figure 4, (a), (b), (c), and (d) illustrates the detailed negotiation process between BA and SA1, SA2, SA3, and SA4 respectively. In the first round, the buyer sends an initial offer to four SAs, since each SA's utility threshold is 1 and the received offer's utility is 0, the SAs send their initial offers to BA. Similarly, the received offers' utility is 0, BA decreases its threshold to 0.95, a set of offers are generated based on it if possible. Unfortunately, in the generated offers, the values of issue price exceed the acceptable value range. Therefore, BA keeps decreasing the threshold until it generates valid offer(s) successfully. From the first round to the fifth round, the two sides conceded but still cannot reach an agreement. At beginning of the sixth round, BA's threshold is 0.65, it receives offers and then calculates their utility values, however, there is no offer meeting BA's desire, BA changes the threshold to 0.6, a set of offers are generated and sent to four SAs. Meanwhile, SA2's threshold is 0.55, there are two BA's offers having a higher utility value than 0.55, SA2 takes the offer with greatest utility value as the deal offer, and then informs to BA, BA waits for the other three agents' response, but they simply propose a set of counter offers, the counter offers' utilities are all lower than the deal offer, so BA makes a deal with SA2 finally, the negotiation process ends with an agreement.



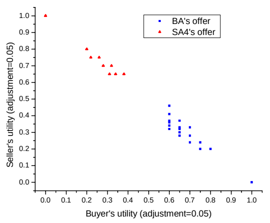
(a) BA Vs SA1



(b) BA Vs SA2



(c) BA Vs SA3



(d) BA Vs SA4

Fig. 4. The negotiation process - split into four individual conversations

Since the adjustment parameter determines the step of threshold changed in the negotiation process, if the step is too small, the generated offers have not much different from the offers generated in previous round. Therefore these offers are unlikely to be accepted by opponent(s). However since it changes the offers gently, it could assist buyer's to get better negotiation results to the greatest extent. It would also extend the negotiation round. Figure 5 illustrates the relation between the buyer's changed adjustment value and the final deal's utility value from buyer perspective while four SAs' adjustment value is kept constant (0.05). The deal offer's utility is 0.72 when the adjustment value is 0.01. When the adjustment value is 0.07, the deal offer's utility is 0.58. Figure 6 shows the relation between the buyer's changed adjustment value and the negotiation round while four SAs' adjustment values are kept constant (0.05). The negotiation round is 9 when adjustment value is 0.05 while it is 4 when adjustment value is 0.08. The results have proved the aforementioned viewpoint.

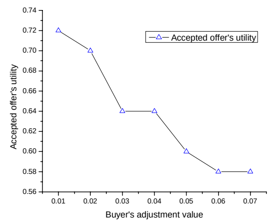


Fig. 5. Comparison of adjustment and deal's utility

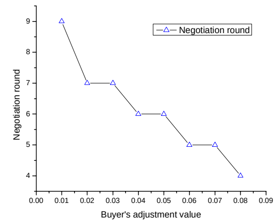


Fig. 6. Comparison of adjustment and negotiation round

7. Conclusion

We have proposed an agent based parallel negotiation system. In the environment, automated software agents deal with a negotiation in a one-to-many way. The agent can perform complex negotiations about multiple independent issues. The high degree of automation is incarnated in that agents process the negotiation under considering of multiple factors, including multi-issue, evaluating offers, making concessions, and generating multiple offers with the same utility. With these mechanisms, the system ensures the various agents on behalf on different users could reach a mutually beneficial agreement. The system effectiveness has been evaluated with a prototype system for a real world simulation.

8. References

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