MULTI-AGENT NEGOTIATION MODEL BASED-ON ARGUMENTATION IN THE CONTEXT OF E-COMMERCE

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Keywords: Argumentation, Auto-negotiation system, Multi-agent, Negotiation model.

Abstract: In the e-commerce transactions, there are lots of commodities with the same name, but anyone of these commodities have certain attributes which differ itself from others. During the traditional process of multi-agent negotiation, only one commodity can be selected as the negotiation object from these commodities with same name, if buyer agent want to find an appropriate commodity, the flexibility and efficiency of multi-agent negotiation would be low. This paper studies the multi-agent negotiation model by argumentation for a group of commodities. It firstly defines all kinds of negotiation elements, then establishes a negotiation model based-on argumentation and describes the negotiation agreements and strategies, and finally an example would be presented for testifying the effects of this model.

1 INTRODUCTION

Since the 90s of last century, along with the development of e-commerce, multi-agent negotiation is becoming a hot research topic. Multi-agent negotiation based-on argumentation is an important kind of automatic negotiation, through it agents can take part in the process of negotiation more flexibility and affect other agent's beliefs, desires or objectives (Rahwan et al, 2003.

In the field of multi-agent negotiation based-on argumentation, Jennings and others presented a model based-on argumentation for multi-issue negotiation (Jennings et al, 1998); Jing-hua Wu studied the encouragement model in the multi-agent negotiation(Wu et al, 2006). However, these papers are almost concentrated in abstract models. In this models, the negotiation object is always just one commodity, and argumentation content is usually not commodity's attributes, such as threat and reward. In the researches of multi-issue negotiation, all the issues are defined in advance (Wu et al, 2008; Gu et al, 2010). In the e-commerce transactions, there are lots of commodities with the same name, but anyone of these commodities have certain attributes which differ itself from others. During the traditional process of multi-agent negotiation, only one commodity can be selected as the negociation object from these commodities with same name, if buyer agent want to find an appropriate commodity, the flexibility and efficiency of multi-agent negotiation would be low.

This paper divides the pricing factors of these commodities into two classes: main attributes and secondary attributes. The main attributes is the common attributes of these commodities and determine the general price, and the secondary attributes affect the range of price fluctuation of these commodities. Secondary attributes would be considered as argumentation objects, and agents select certain commodity by argumentation. This paper firstly defines all kinds of negotiation elements, then establishes a negotiation model based-on argumentation and describes the negotiation agreements and strategies, and finally an example would be presented for testifying the effects of this model.

Supported by Chinese National Science Fund (71071005, 70940005).

2 MULTI-AGENT NEGOTIATION MODEL BASED-ON ARGUMENTATION

2.1 Assumptions

This paper supposes that there are three participants: seller, buyer and third-party. The third-party plays a coordinating role and is responsible for the

Jiang G., Xu Y. and Liu Y..
MULTI-AGENT NEGOTIATION MODEL BASED-ON ARGUMENTATION IN THE CONTEXT OF E-COMMERCE.
DOI: 10.5220/0003176604220425
In *Proceedings of the 3rd International Conference on Agents and Artificial Intelligence* (ICAART-2011), pages 422-425
ISBN: 978-989-8425-41-6

establishment of trading relations, the proposal forwarding and the arbitration.

2.2 The Relevant Definitions

2.2.1 Definition 1

Set of Negotiation Participants: $\{S, B, A\}$, S indicates the Seller Agent, B indicates the Buyers Agent and A denotes the Third-party Agent.

2.2.2 Definition 2

Negotiation Issue: $I = \{I_0, I_k\}$, negotiation issue consists of two sub-issues: the main issue and argumentation issue. The main issue is price. The argumentation issue I_k refers the secondary attribute, and $I_k \in \Omega, \Omega = \{I_1, I_2, \cdots; I_k, \cdots; I_n\}$.

2.2.3 Definition 3

Price Range and Bid Range: The Price Range is $\left[P^S_{\min}, P^S_{\max}\right]$, it is given by the seller. $P^S_{\min}$ is the seller's reservation value and not known to the outside world; Bid Range is $\left[P^B_{\min}, P^B_{\max}\right]$, it is given by the buyer. $P^B_{\max}$ is the buyer's reservation value and not known to the outside world.

2.2.4 Definition 4

Value of Argumentation Object: Argumentation object is corresponding to the secondary attribute of goods. Argumentation object is inherently valuable. Value of argumentation object is $(P_{\max} - P_{\min})\varepsilon_k$. ε_k is the weight of secondary attribute of number k, in addition $\sum_{k=1}^{n} \varepsilon_k = 1$.

2.2.5 Definition 5

Utility: Utility is negotiating expectation or assessment of opponent's offer. The utility can be divided into two classes: expectation utility and negotiation utility. The expectation utility is depended on three factors: Price Range, Bid Range and argumentation. Negotiation utility is related to times of negotiation. In round t, the negotiation utility of seller is $U^s_t = \frac{P_t - P^B_{\min}}{P^S_{\max} - P^B_{\min}}$, and the buyer's is $U^B_t = \frac{P^S_{\max} - P_t}{P^S_{\max} - P^B_{\min}}$.

For a certain commodity with m argumentation objects, the seller's expectation utility is:

$$\hat{U}^S_m = \frac{(P^S_{\max} - P^S_{\min})(\frac{\omega^S_1}{2} + \sum_{i=1}^{m} \lambda^S_{ij} \varepsilon^S_{ij}) + (P^S_{\max} - P^B_{\min})\frac{\omega^S_2}{2}}{P^S_{\max} - P^S_{\min}} \quad (1)$$

Among them, ω^S_1 and ω^S_2 are the weights, in addition $\omega^S_1 + \omega^S_2 = 1$. ε^S_{ij} is the number i secondary attribute, $\sum_{i=1}^{M} \varepsilon^S_{ij} = 1, 1 \le m \le M$, M is the amount of argumentation objects. λ^S_{ij} is the number j impact factor of the number i secondary attribute, $\lambda^S_{ij} \in [-1, 1], \sum_{j=1}^{N} \lambda^S_{ki} = 0$, N is the amount of values of the number i secondary attributes.

For a certain commodity with m argumentation objects, the buyer's expectation utility is:

$$\hat{U}^B_m = \frac{(P^B_{\max} - P^B_{\min})(\frac{\omega^B_1}{2} + \sum_{i=1}^{m} \lambda^B_{ij} \varepsilon^B_{ij}) + (P^S_{\max} - P^B_{\min})\frac{\omega^B_2}{2}}{P^B_{\max} - P^B_{\min}} \quad (2)$$

2.3 Model Description

Multi-Agent negotiation model based-on argumentation is defined as a seven-tuple $\{A, O, I, R, \Omega, T, S, P, B\}$. In the seven-tuple, A means negotiation agent, O means the negotiation object, I is the negotiation issue, R is the range of Agent's price offer, Ω is the space of negotiation issue, T indicates the times, S is the negotiation strategy, P is the negotiation agreement, and finally B is agent's behavior.

3 NEGOTIATION AGREEMENT

Negotiation agreement is the standard of behavior which agents must comply with when they communicate with each other. This paper uses this agreement as the following steps:

(1) The Buyer Agent and the Seller Agent send the initial prices to the Third-party Agent at the same time. The Third-part Agent forwards their prices and determines a certain commodity at random, and then informs the result to Buyer Agent and Seller Agent.

(2) Buyer Agent and Seller Agent evaluate the opponent price and confirm that whether accept opponent proposal or not, and send the their results to the Third-party Agent; Third-party Agent judges :if anyone of them accepts opponent proposal, then process turns to the Sept 3, if there is no acceptance, then process turns to the Sept 4.

(3) If there is only one acceptance, the Third-part Agent informs that deal can be done; if there are two acceptances, the Third-party Agent informs that deal can be done according to the price offered by last biding agent.

(4) If there is no acceptance, the Buyer Agent and Seller Agent evaluate the commodities which have different secondary attributes according to the existing prices.

a. If no one has achieved the expectation utility, both sides continue to offer new prices. Process turns to the Step 1.

b. If one party achieved its expectation utility, that is $\exists U_t^S \geq \hat{U}_m^S$ or $\exists U_t^B \geq \hat{U}_m^B$, then the agent will send initiative argumentation for the commodity which has m secondary attributes. The argumentation would be evaluated by the opponent agent, if it be accepted, deal can be done, if not, process turns to the Step 4. If both sides send argumentations at the same time, the last argumentation would be selected by Third-party Agent.

(5) If deal is done, the negotiation is over, if any agent refuses negotiation or the negotiation exceeds maximum time, then the negotiation would be stopped.

4 NEGOTIATION STRATEGY

Negotiation strategy is what behaviors should be taken in the process of negotiation. By these behaviors agent can achieve its max utility. In other words, negotiation strategy is how to provide price (Wang et al, 2009).

In this paper, concession strategies are adopted. $P_{\min}$ is minimum price offered by agents, and $P_{\max}$ is the maximum price. T is the maximum time negotiation allows, t is a time variable, τ is an index. Specific concession strategies are defined as follows:

$P(t) = P_{\min} + (P_{\max} - P_{\min})\left[\frac{t}{T}\right]^{\tau}$ （$\tau > 0$ ）,The smaller of attribute value, the better;

$P(t) = P_{\max} - (P_{\max} - P_{\min})\left[\frac{t}{T}\right]^{\tau}$ （$\tau > 0$）,The bigger of attribute value, the better.

When $0 < \tau \leq 0.5$ negotiation strategy belongs to impatient type; when $0.5 < \tau < 2$, negotiation strategy belongs to moderate type; when $2 \leq \tau$ negotiation strategy belongs to economical type (Li et al, 2008).

5 EXAMPLES

There is a category of flash disk. Its brand is M, the type belongs to N, and Type N has three kind of color: red, blue and gray. M and N are the main attributes, color is secondary attributes.

It is assumed that the Pricing Range of S is [220,312], the impact factor of color λ^S has three values: 1, 0, -1, corresponding to red, blue and gray, the weight of color is 0.1. The Bid Range of B is [226,305], the impact factor of color λ^B also has three values: 1, 0, -1, corresponding to red, blue and gray, the weight of color is 0.08. Negotiation strategy of both sides is to take a moderate type, and both the indexes τ are 0.8. When B start to bid, it select commodity in random. Now expectation utility of both sides can be computed, results are shown in the Table 1.

Table 1: Agent's expectation utility.

Color \ Participant	S	B
Red	0.59	0.40
Blue	0.49	0.48
Gray	0.39	0.56

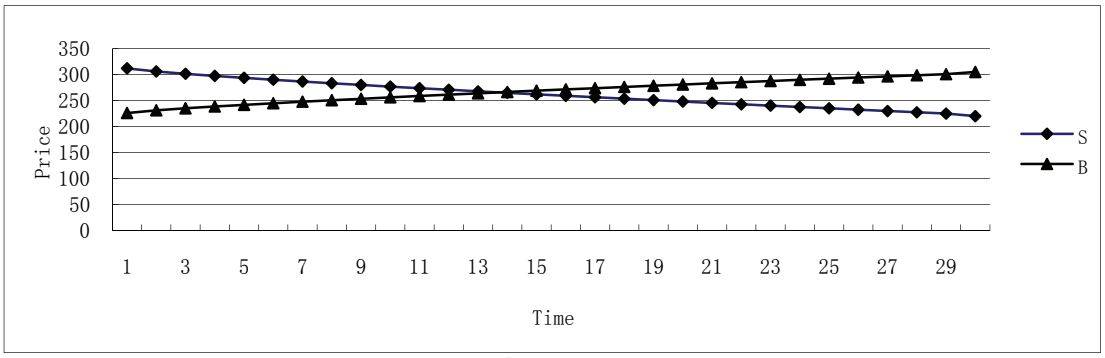

Figure 1: The bargaining process of negotiation.

The bargaining process is shown in Figure 1. According to negotiate agreement, in the Round 9, the pricings of B and S are 256.15, 276.89, deal can't be made. However, $U_9^B = 0.41$, $U_9^B > \hat{U}_{red}^B$, Pursuant to the agreement, B would send argumentation initiatively. $B(\text{red}, 276.89) \Rightarrow S$, in this condition, the negotiation utility of S is 0.59 which is equal to expectation utility, so S would accept the argumentation of B, deal can be done.Conclusions can be got from analysis: if argumentation is abandoned, deal can be done in round 13. From here we can see that agents send argumentation initiatively in appropriate time according to their expectation utility, not only satisfactory solution would be got as soon as possible, but also a group of commodities can be negotiated in one process.

6 CONCLUSIONS

In the field of multi-agent negotiation, very few researches on negotiation based-on argumentation are for groups of commodities. This paper researches the multiple commodities negotiation by argumentation mechanism, established negotiation model and testifies it by an example. It proves that blinding negotiation processes of many commodities into a uniform multi-agent negotiation process by argumentation is good selection. As the complexity of commodity transactions, researches on multi-agent negotiation based-on argumentation need to be further excavated.

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