AN AUTOMATED NEGOTIATION SYSTEM FOR PRICE COMPARISON BASED ON AGENT TECHNOLOGY

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Abstract: In order to promote the efficiency of online negotiation, Distribute Artificial Intelligence is adopted in designing an automated negotiation system to improve negotiation process. This system can be used to deal with multilateral price comparison and automated negotiation. The results from simulation are meaningful and useful, which also verified the efficiency and effectiveness from both price comparison and automated negotiation.

1 INTRODUCTION

The negotiation and price comparison can be critical issues in business world. In e-business field, negotiation based on Internet technology has been getting popular after buyers found the proper goods and prices of these goods. If a buyer would pay less to buy the prefered goods, it is neccerssory to compare the price with other sellers via internet first, and then to bargain with one of sellers. There are two kinds of nigotiations either online or offline between buyers and sellers directively. Obviously, both negotiations can be time-consuming and very low effectiveness. To save time and cost of negotiations for both buyers and sellers, it is useful and meaningful to design a price comparison system with automated negotiation fuctionality.

Based on literature study, related research effors in e-commerce and e-business have been concentred on application of agent technology, such as intelligent recommendation systems, auction systems and so on. Current research contributions are limitted on price comparing among sellers. In this paper, agent technology will be employed in negotiation process to deal with multilateral price comparison as well as automated negotiation. The aim of our efforts is to design a price comparison system with automated negotiation based on agreement and strategy.

2 RELATED WORKS

Negotiation Support System (NSS) is one of group decision support systems, which has been adopted to promote trading and coordinate conflicts of trading in both e-commerce and e-business. NSS can be traced back in 1980s; it has been a special field to deal confliction and negotiation with advanced information technology and decision theory. Many scholars engaged in NSS research from different perspectives, and developed some corresponding NSS software, such as CAP, DECISIONMAKER, NEGO, DECISION CONFERENCING, MEDIAT - -OR, RUNE, PERSUADER, INSPIRE, and etc (Wang, 2008).

With the application of agent technology in negotiation system, negotiation efficiency has been greatly improved because agent-based negotiation support technology can promote negotiation process effectively. The agent technology could reduce human-computer interaction time, decrease the complexity of system operation (Bartolini, et al. 2004), expand the application of negotiation, and avoid being emotional human disturbance. According to literature study, the agent technology has been continuing as the hot topic in negotiation study, such as obtaining the rival's preferences like attribute weight and constrain, being the negotiation expert with domain knowledge including market condition and inventory information, gaming with each other's preferences etc, which can be much better than artificial negotiation to complete complex negotiation process (Chari and Manish, 2009). For

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example, some systems were developed for e-commerce training or experiment, such as the Kasbah (Raymond, 2007) and the Tete-a-Tete (Maes, et al. 1999) in MIT. The former system took advantage of price to present different bargaining attitude. In fact it could only carry on single-attribute negotiation because it wasn't involved in artificial intelligence and machine learning technique. The latter one applied to retail model of electronic trading system. Its purpose is to solve the multi-attribute negotiation problem based on multi-attribute utility theory. However, the system could not deal with the monotonic issues during the period of negotiation. AuctionBot (Wurman, et al. 1998) is an auction agent system that was developed by Michigan University, which was a single attribute online auction server. It didn't process multi-attribute between the agents of buyers and sellers.

The systems above designed have been only concentrated on negotiation agreement or strategy modelling in previous study. Fewer research contributions reported auto-negotiation systems in simulation on trading behaviours that related to multi-attribute with monotonic issues. Inspired by previous research contribution, we would come up with a comprehensive, practical, and flexible B2C e-commerce auto-negotiation model in this paper, which is expected to deal with the multilateral multi-issue negotiation.

3 NSS SYSTEM THEORITY

In order to design a universal quantitative Agent negotiation model, we assumed that the issues are mutually independent. These issues could be merged as one if interdependence existing. Meanwhile, we assumed that each issue value is continuous. Accordingly, the formalized description of bilateral multi-issue negotiation model can be presented as following:

$$N = < A, I, V, W, U, P, S, T_{\max} > .$$

- $A = \{a_i \mid i = 1, 2, \cdots, I\}$ indicates the agent sets of participators in the negotiation, and n represents the agent number of participators in the negotiation. Then, B (Buyer) is denoted as Seller Agent, and S (Seller) is indicated as Buyer Agent.
- $I = \{i_j \mid j = 1, 2, \cdots J\}$ presents the issue set of negotiation. J represents the number of issues.
- V is defined as the value range of the issues. $V = \{V_1, V_2, \cdots, V_n\}$. i_j values range corresponds to V_j , and $V_j = [\min_j, \max_j]$.
- W is weight set of the negotiation issues, which can be denoted as $W = \{w_i^a \mid j = 1, 2, \cdots, m\}$. w_i^a represents the preference degree of Agents on issue j, $\sum_{i=1}^{n} w_i^a = 1$.
- U is defined as the effectiveness evaluation function of negotiation issues.
- P is named as the set of negotiation protocol.
- S represents the negotiation strategy.
- $T_{\max}$ specifies the maximum times of negotiation. Within the limited times of negotiation, the negotiation must be ended before approaching $T_{\max}$, whether the negotiation is success or not.

3.1 Negotiation Protocol

The Negotiation Protocol is a set of rules that Agents must observe mutually. Bilateral agents should have consistent rules, such as constraints, specified negotiation status (start, end, etc) and variables, which should be confirmed respectively during negotiation. The negotiation protocol is presented in Figure 1.

The *w* can be changed at the end of the stage, and then submit a new negotiation session to go further. When the seller B sends a request to the buyer B (state 1 to state 2), S in three ways:

(1) Agrees with the proposal, the negotiation will succeed (state 2 to state 4);

(2) Rejects the proposal, the negotiation will get failed (state 2 to state failure);

(3) Sent proposal, the negotiation stage is Counter Offer (state 2 to state 3).

3.2 Negotiation Strategy

3.2.1 Utility evaluation

The negotiation decision function that was proposed by Faratin (Faratin, et al. 2000) is adopted in this paper to deal with the multi-attribute decision making and the single-conflict negotiation. During the negotiation, participants expected to have maximum utility with the lowest price. Utility is closely related with issues, which can be criterions to evaluate the differences among different issues. Different agents would have different criterions to evaluate different issues. For example, for sellers, the higher commodity price, the better utility is, and then the price is ascending and goes up. However, this is just the opposite to the buyer, the lower commodity price, the better utility is, which is descending and goes down. In this case, the evaluation function can be divided into monotone increasing and monotone decreasing function.

Take price issue as an example, B hopes X_i the smaller the better. It's monotone decreasing function, being standardized as follows:

$$v_i^a(x_i)=\begin{cases}\dfrac{(\max_i - x_i)}{(\max_i - \min_i)} & 若\ \max_i - \min_i \neq 0 \\ 1 & others\end{cases} \quad (1)$$

$v_i^a(x_i): V_i \to [0,1]$ 。

S hopes X_i the bigger the better. Its monotone increasing function can be standardized as follows:

$$v_i^a(x_i)=\begin{cases}\dfrac{(x_i - \min_i)}{(\max_i - \min_i)} & 若\ \max_i - \min_i \neq 0 \\ 1 & others\end{cases} \quad (2)$$

$v_i^a(x_i): V_i \to [0,1]$ 。

So, a_i for the overall evaluation function, the Offer is shown as following:

$$V^i(x) = \sum_{1\le j\le n} \omega_j^i v_j^i(x_j) \quad (3)$$

$V^i(x)$ is getting bigger when the degree of satisfaction is higher, which can be seen whether it is a standard negotiation. The discriminate function is presented as following:

$$I^s(t', x^t_{b\to s}) = \begin{cases} reject & if\ \ t' > t^s_{\max} \\ accept & if\ \ V^s(x^t_{b\to s}) \ge V^s(x^{t'}_{s\to b}), t' > t \\ x^{t'}_{s\to b} & otherwise \end{cases} \quad (4)$$

$x^t_{b\to s}$ will be judged by Agent S that proposed by Agent B. If t+1 exceed the $T_{\max}$, the proposal will be rejected, and the negotiation will be fail. Otherwise, Agent S will evaluate the proposal and counter it. If the counter is less, the Pareto optimal value can be reached. In this case, Agent S will accept the proposal and return a message of accepted B, and then the negotiation will succeed. if it is more, Agent S will send the counter to B, and the process will continue.

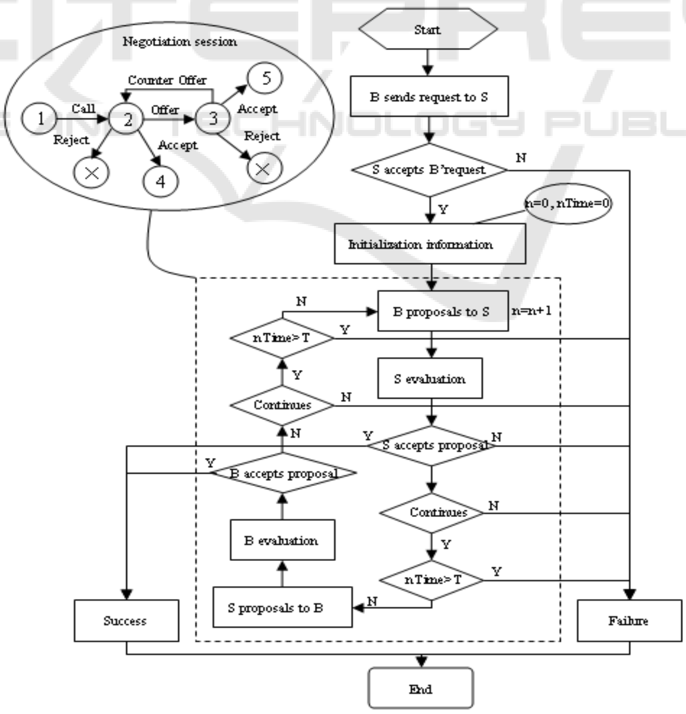

Figure 1: Negotiation protocol.

3.2.2 Counter-proposal Strategy

In this paper, we adopted the time-dependent strategy proposed by Jennings (Sierra, et al. 1999). We use the discount parameter β as the scope value of the sides to insistence and compromise in adjusting strategy based on time, resource and opponent's behaviours.

Generally speaking, if the negotiation time is longer, the Agent will make the concession more visible in proposal, which can be indicated as the discount parameter β （ $0 \le \beta$ ） and used in convergence control. We define the discount parameter β as follows: the negotiation conducts one time for a given issue *i*, and then Agent will be considered bearing larger risk, so the effectiveness of the evaluated value *i* must have some discounts.

In the negotiation process, both agents have to go through several rounds between proposals and counter proposals before they obtained a satisfied and consistent outcome. If there is no consensus, both agents need to update the value of their proposals, and send counter-proposals. Therefore, we need to adjust the reservation value according to different weights.

For issue *i*, the proposal value of a function can be expressed as:

$$x^t_{S\to B}(t)=\begin{cases}\min_i^S+\Phi_i^S(t)(\max_i^S-\min_i^S) & x_i \text{ is increasing}\\ \min_i^S+(1-\Phi_i^S(t))(\max_i^S-\min_i^S) & x_i \text{ is decreasing}\end{cases} \quad (5)$$

Let $x^t_{S\to B}$ is the proposal value of S to B in time t. Let $\Phi^s_j(t)$ is the effectiveness of the reservation value which Agent S plans to reach it in this round. Here, time is a valuable resource for both sides. Meanwhile, both sides have their own deadline. As time goes by, the utility will continue to reduce. We employed the interaction frequency dependence (Faratin, et al. 1998) to determine the reservation effectiveness of each round.

$$\Phi_i^S(t)=k_i^S+(1-k_i^S)\left(\frac{t}{T_{\max}}\right)^{\frac{1}{\beta}} \quad (6)$$

Let k^s_j is a constant, which represents the initial value effectiveness of Agent S for j. we assumed that x^0_j is the initial value for j, then:

$$k_i^S=\begin{cases}(x_i^0-\min_i^S)/(\max_i^S-\min_i^S) & x_i \text{ is increasing}\\ (\max_i^S-x_i^0)/(\max_i^S-\min_i^S) & x_i \text{ is decreasing}\end{cases} \quad (7)$$

The value of β decides the attitude of insistence and compromise. When $\beta>1$, the initial value will get close to its reservation value very quickly, which means that the convergence rate is very fast. The β is bigger, the faster the convergence rate is. When $\beta<1$, the agent will try to maintain the initial value at the beginning of negotiation, which would not convergence until it is close to the deadline. When $\beta=1$, $\Phi^s_j(t)$ is linear variation, and each round of concession rate is the same. Suppose that k = 0.1, for different β, when T assigns, *Φ(x)*with β relations as shown in Figure 2.

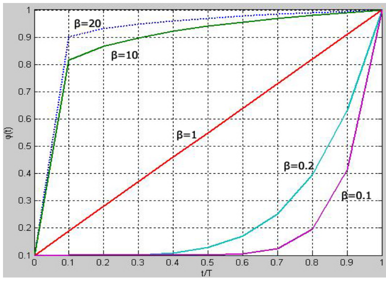

Figure 2: *Φ(x)* with β relations.

As the explanation above, the bilateral negotiation strategies associated with β can be shown in table 1.

Table 1: Negotiation Strategy.

β	Agent S	Agent B
$\beta<1$	Strong-arm strategy	Conservative
$\beta=1$	Linear strategy	Uniform linear
$\beta>1$	Concessive strategy	Compromissary

Participants will yield to the proposal value step by step and gradually close to the agreement during negotiation. The time functions in different forms will have different concession scope. During strategy determination and choice, β can be selected with multiple factors, such as resource, opponent behaviours, time, and etc.

4 ANALYSES AND DESIGN ON AUTOMATED NEGOTIATION SYSTEM FOR PRICE COMPARISON

The automated negotiation system for price comparison is designed to deal with the e-commerce trading process, which combined with B2C features and addressed the multilateral multi-issue negotiations. If the system can conduct the fundamental process of e-commerce trading, the designed features should be included as following:

customer login management, commodity query and search function, price comparison decision-making and so on. The system structure of automated negotiation system for price comparison can be depicted in Figure 3.

The components of the system can divided into three parts, such as market service centre agent system, the customer master agent system and the shop master agent system. The classes and methods can be shown in figure 4.

In the system development process, XML format is used for transmission or database storage of negotiation strategy orders, shop negotiation strategy orders, shopping information and etc. System configuration files, as well as the files of state agency using XML files will be stored on the server. Therefore, Java XML coding is involved in system development.

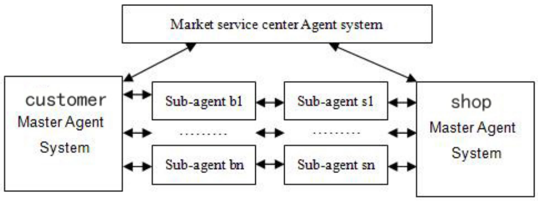

Figure 3: System Structure.

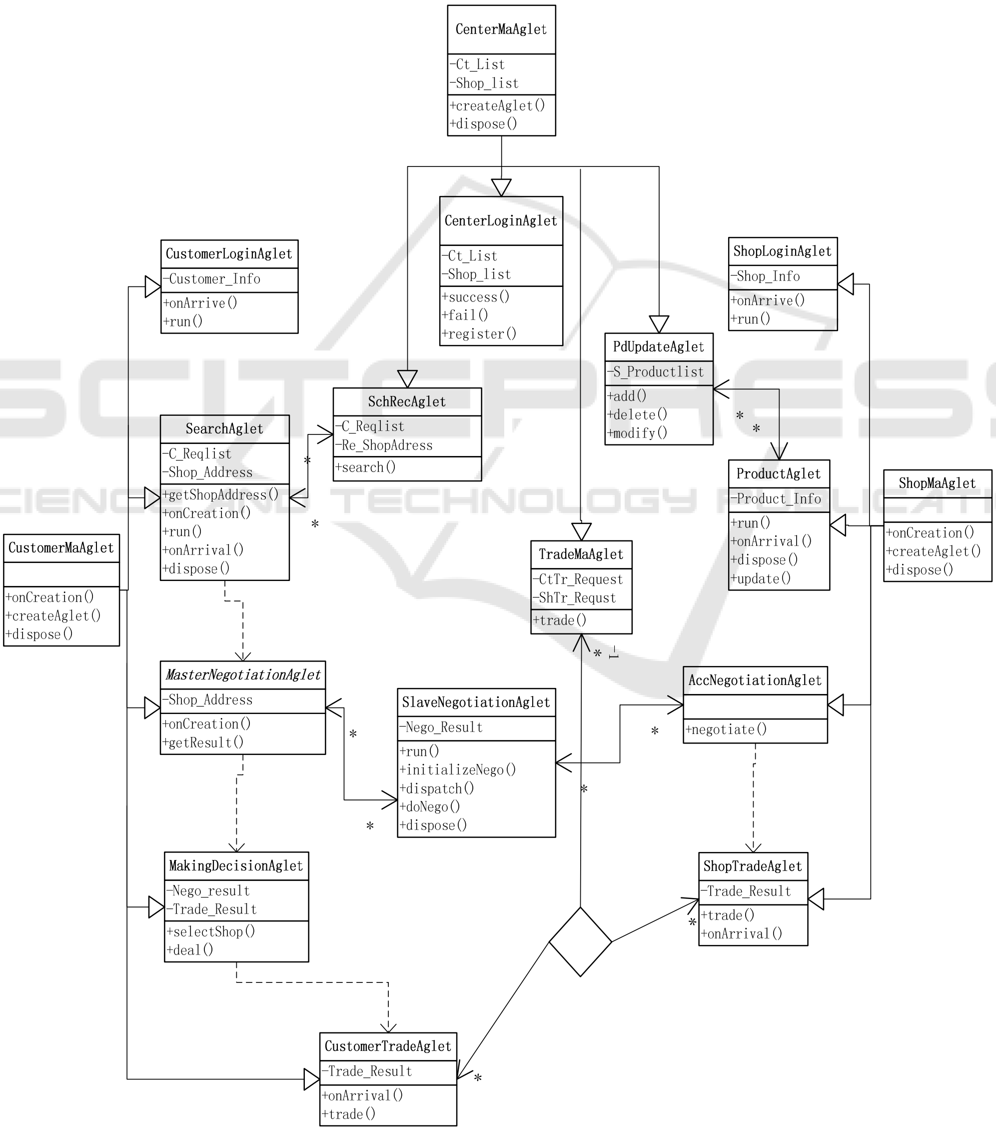

Figure 4: Agent class implements chart.

5 IMPLEMENTATION OF THE NEGOTIATION SYSTEM FOR PRICES COMPARAISON

The Aglet development tool, which IBM Japan Corporation developed, is used in this system implementation because Aglet provided software development toolbox (ASDK) and Aglet Workbench platform are simple, scalable and reusable. This system focuses on a certain brand of camera in carrying on the automated negotiation. The issues include commodity price (P), delivery time (DT) and service Guarantee (SG, 1 expresses National joint guarantee; 3 indicates 7 days unconditioned goods returned; 4 means No after-sales service.). Table 2, tables 3 and Table 4 present the negotiation data of participators, including the proposal value (P.V), reservation values (R.V) and the weight (W) of each issue in the process.

It should be noted that, in the real online negotiation participators do not know the weight of each issue on each other.

Table 2: Customer negotiation information.

Issue	P.V	R.V	W
P（￥）	3500	3950	0.7
DT（day）	2	12	0.1
SG（style）	1	3	0.2

Table 3: Negotiation information of seller 1.

Issue	P.V	R.V	W
P（￥）	4200	3600	0.8
DT（day）	15	2	0.1
SG（style）	4	1	0.1

Table 4: Negotiation information of seller 2.

Issue	P.V	R.V	W
P（￥）	4000	3500	0.7
DT（day）	12	2	0.1
SG（style）	4	1	0.2

The purpose of the multi-Agent system on camera price comparison is to fulfil negotiation between the buyer and multiple sellers within the limited time to approach the most superior choice based on results comparison. In order to evaluate the system, we took the camera model of Canon's G10 carrying on the simulation experiment. Figure 5 demonstrates variation on utility value between Agent B and Agent S.

As shown in the initial round, Agent S utility is higher, but it has a lower benefit compare to Agent B. In the subsequent round, both sides carry on the negotiation based on the action rules and discount parameter β. As time goes on, the utility value has been changed from time to time. The value of Agent S has been enhancing in the view of Agent B, but its own value is decreasing. In the 11th round, utility value curve is crossed in the figure. The meaning of intersected point is that the counter proposals utility value of Agent B in the next round will be lower than Agent S in the current round. Therefore, the negotiation succeeds at this point.

When the curves appear intersection point, it means that the negotiations is succeeded and should be stopped there. In this case, each sub-agent feedbacks the results to the host Agent, and the market service canter Agent compares the price that the score highlighted wins. From the experiment results, we know that the utility value of seller 1 is 0.54, and the seller 2 is 0.63. Accordingly we chose seller 2 as the trader. The price highlighted in final round is 3680 Yuan; and delivery time is within 3 days complying with the national joint guaranteeing program.

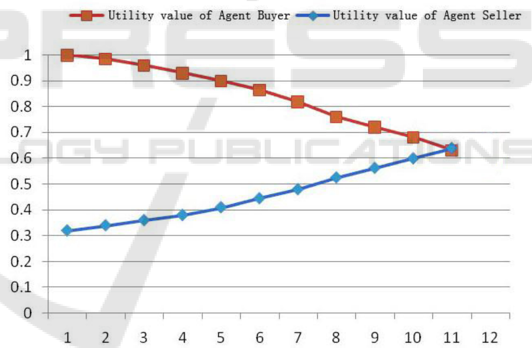

Figure 5: Utility values Curve of Offer and Counter.

From the results of system operation as well as the analysis on experiment, it is very clear that the system completely fulfilled the automated multi-agent negotiation and achieved the purpose on comparison price.

6 CONCLUSIONS

To deal with the inefficiency online negotiation and time-consuming, in this paper, we provided an automated negotiation system model that resolves the multilateral multi-issue with comparison price. The model includes many aspects, such as the process, the evaluation function, and counter proposal strategy. The system model included the Agent technology of Distributed Artificial Intelligence, which is used to define decision-making agent system, buyer agent system and seller agent system and to form a multi-agent system. We also use the Aglet to develop an automated negotiation system for price comparison, which can be implemented to replace the human participating for trading price selecting among numerous buyers. The system model in this paper is a good experience for further studying on automated negotiation in general, and on dealing with multi-issues with preference in particular. Of course, many research efforts are still needed on studying the automated negotiation on recourses comparison and selection in e-business field.

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