*2009 International Conference on Computer Engineering and Applications*
*IPCSIT vol.2 (2011) © (2011) IACSIT Press, Singapore*

# A Procurement Negotiation System with Fuzzy-based Intelligent Agents

Shui-Shun Lin [1 +], Ying-Shen Juang [2], Jen-Teng Tsai [3], Jia-Nan Yen [3]

[1] Department of Business Administration, National Chin-Yi University of Technology, Taichung, Taiwan, ROC
[2] Department of Business Administration, Chung-Hua University, Hsin-Chu, Taiwan, ROC
[3] Department of Industrial Engineering and Enterprise Information, Tunghai University, Taichung, Taiwan, ROC

**Abstract.** Procurement operation generally takes place between a manufacturer and its suppliers in a supply chain. To ensure productivity and reduce cost, negotiation is inevitable while performing procurement operations. However, the procurement negotiation activities for manufacturers with their suppliers are still not performed systematically, greatly due to limited manpower or utilities, which result in time-consuming and cost-raising procurement processes. In this paper, we investigate the procurement processes, the current conditions of negotiation strategy and the negotiable subject in electronic component manufactures. A fuzzy-based dynamic adjustment strategy is constructed and a negotiation system is implemented to increase the possibility of successful negotiations. The average overall success rate of negotiation accounts for 79%, and agreement is normally reached within 29 negotiations.

**Keywords:** intelligent agent, negotiation, information system, fuzzy theory

## 1. Introduction

Enterprise procurement is an activity of interchanging products or services between the trading partners. However, most buyers are still assessing, selecting, and negotiating with suppliers on manual basis due to the lack of manpower and process time, which leads to low efficiency. In the course of negotiation, concessions might be made to reach an agreement. However, most tactics for making concessions are objectively determined, without taking the other party's attitude and behavior into consideration.

Based on human thinking and practical negotiation, we proposed in this study a more flexible negotiation model for enhancing successful trading possibility. We carry out interviews with experienced experts in electronics industry. Current negotiation tactics and subject that can be negotiated are investigated, and a dynamic utilization adjustment strategy with fuzzy theory for negotiation is established. Through this negotiation strategy, the buyer and the seller can assign several agents at the same time for cooperative negotiation.

The objective of this study is threefold: (1) To collect information on the procurement process, current negotiation tactics and negotiable subjects in the electronics industry in Taiwan. (2) To develop a negotiation mechanism on the basis of intelligent agent and fuzzy theory enabling multi-subject purchase negotiation between several buyers and suppliers. (3) To construct a prototype system with intelligent agents to fully visualize the negotiation operation.

## 2. Literature Review

[+] Corresponding author. Tel.: +886-4-23924505 ext. 7774; fax: +886-4-23929584. *E-mail address*: sslin@ncut.edu.tw

With the vigorous development of electronic transactions in a supply chain over the recent years, the negotiation methods and on-line systems are increasingly proposed [1,2,3,4,5]. An efficient frontier model was proposed in [6] to check whether negotiation results are beneficial. According to this model, one will consider risks and returns when making investments, and each risk point has a corresponding portfolio which can realize the maximum return of investment. Highest returns of investment of different risk points will form a curve, which is called as efficient frontier.

A multi-attribute utility theory for negotiation was developed in [7]. The seller and the buyer set in advance the high, middle and low utility values of each attribute. The theory then generates different proposals based on these utility values. It calculates the overall utility of each proposal, and starts negotiation from the proposal with the highest utility value. The process is terminated when an agreement is reached.

Reference [8] depicted a similarity negotiation model. The agent checks the similarities between products of the supplier and the demands of the user to find appropriate products for each party.

A concept of e-union, the formation of an alliance of several electronic markets, was advocated in [9]. In e-union, if a buyer cannot execute a transaction in the original electronic market, it can dispatch an agent to partner's electronic markets for alternative searching. The communication between the agent and the electronic market was realized by XML.

A time-oriented multi-attribute negotiation tactic was proposed in [10]. However, it doesn't utilize the information that the other party may obtain in the course of negotiation to make further decisions.

In this study, negotiation results are similar to the risk points of efficient frontier model in [6]. Each negotiation result has a negotiation combination which realizes maximum benefits of the buyer and the seller. The efficient frontier model is therefore adopted in this study to assess negotiation results.

# 3. Proposed Negotiation Method

## 3.1. Utility Functions for Subjects and Their Similarity

Subjects of negotiation such as price and delivery date are quantitative, while delivery location and payment terms are qualitative. We deal with quantitative subjects only in this study. The overall negotiation utility can be obtained by Equation 1, where $U$ is the overall utility ranging from 0 to 1, $V_i$ is the utility value of subject $i$ ranging from 0 to 1, and $w_i$ is the weight of subject $i$ ranging from 1 to 9.

The quantitative subjects can be divided into benefit-oriented and cost-oriented subject. Equation 2 shows the calculation of the overall similarity ($Sim^{s,b}$) between the buyer and seller, ranging from 0 to 1. Equation 3 shows the calculation of the normalized weight of the buyer and seller concerning subject $i$ ($g_i$). The similarity between the buyer and seller in subject $i$ ($S_i^{S,B}$) is mainly obtained by analyzing the differences between the buyer and seller. In (4) $x_i^S$ represents the proposal of the seller concerning subject $i$, and $x_i^B$ represents that of the buyer concerning subject $i$.

$$U = \frac{\sum w_i \times V_i}{\sum w_i} \quad (1) \qquad Sim^{S,B} = \frac{\sum g_i s_i^{S,B}}{\sum g_i} \quad (2) \qquad g_i = \sqrt{w_i^S \times w_i^B} \quad (3) \qquad S_i^{S,B} = 1 - \frac{|x_i^S - x_i^B|}{Max\{x_i^S, x_i^B\}} \quad (4)$$

## 3.2. Proposed Negotiation Procedure

The proposed negotiation procedure with one-to-one paring between buyer and seller is proposed as illustrated in Figure 1. Some key principles and methods are depicted as in the following sections.

## 3.3. Pairing Principles

The one-to-one negotiations between buyers and sellers are completed and proposals are accepted if $U^S(x^B) \geq T$ or $U^B(x^S) \geq T$. If a buyer receives many proposals from several sellers, or vice versa, the optimum pairing is needed.

Optimum pairing is to locate the maximum similarity between buyers and sellers ($Sim_{ij}$); however, buyers or sellers ($a_{ij}$) in one group can not appear in another group, where $i$ represents the buyer, and $j$ the seller. In this study, we use an integer programming model to solve the paring problem. The optimization model is shown in (5).

$$\text{Max. } z=\sum_{i=1}^{n}\sum_{j=1}^{m} Sim_{ij}a_{ij}$$

$$\text{s.t. } a_{i1}+a_{i2}+...+a_{im}=1, \quad (5)$$

$$a_{1j}+a_{2j}+...+a_{nj}=1,$$

$$a_{ij}=0 \text{ or } 1$$

## 3.4. Searching for New Proposals

In the course of negotiation, if the utility value, $U^S(x^B)$ or $U^B(x^S)$, of the proposal of the other party to our party does not match the threshold value ($T$), our party will concede and make a new proposal so as to carry out another negotiation. In this study, we regard the negotiation as a multiple objective decision process, and use fuzzy theory with the mutual benefit and cooperation tactic to generate new proposals.

In searching for new proposals, we hope that the new proposal can reach maximum utility of the other party $U^S(x^B)$, or $U^B(x^S)$, and maximum similarity of both parties, $Sim\ (x^S,x^B)$, as well. While tallying with the new proposal of multiple objective decision, the utility of a subject to the other party, $U_i^S(x_i^B)$ or $U_i^B(x_i^S)$, is to be found. The multi-objective optimization model is shown as in (6).

$$\text{Max. } U^S(x^B)$$

$$\text{Max. } Sim\ (x^S,x^B) \quad (6)$$

$$\text{s.t. } U_i^S(x_i^B)>0,\ i=1,2,\ \ldots,\ m$$

We use Max-Min Method to solve problems concerning multiple objectives. The decision model is then formulated as in (7). The objective is to maximize $\lambda$, where $\lambda = Min\{U^S(x^B), Sim(x^S,x^B)\}$, and is the minimum value of the other party's utility and both parties' similarity.

$$\text{Max. } \lambda$$

$$\text{s.t. } U^S(x^B)>\lambda \quad (7)$$

$$Sim(x^S,x^B)>\lambda,$$

$$0\le\lambda\le 1$$

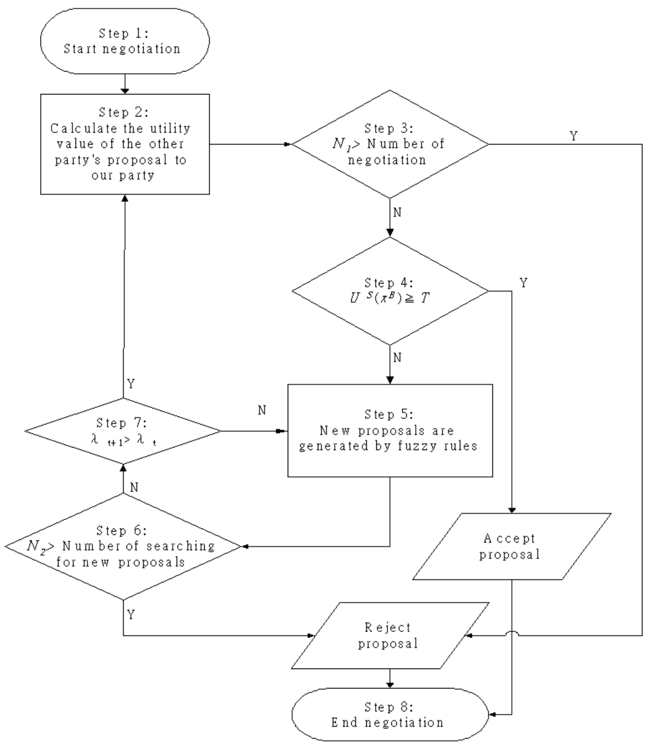


Fig. 1: Proposed negotiation procedure.

If the $\lambda$ value of the new proposal is larger than that of the last proposal ($\lambda_{t+1}>\lambda_t$), then the new proposal is sent to the other party. If not, search for new proposal is needed.

## 3.5. Space and Extent of Concession

In the course of negotiation, a new proposal shall satisfy the spirit of mutual benefit, so as to improve both parties' satisfaction and enhance the probability of concluding the transaction. It needs to exert different controls on the extent ($C_r$) and space ($C_r x_{i,t}^d$) of concession. The extent of concession, $w_i^S$ or $w_i^B$, should be determined. Take the seller's extent of concession as in (8) as an example. If our party attaches great importance to a subject but the other party does not, our party's extent of concession will be lower than that of the other party. If our party attaches the same importance to such subject as the other party, both parties' extent of concession will be the same.

$$C_r=\frac{10-w_i^S}{(10-w_i^S)+(10-w_i^B)} \quad (8)$$

## 3.6. Fuzzy Inference Scheme

We use semantic variables in the fuzzy theory to define membership functions concerning semantic values. The weight of a subject, ranging from 1 to 9, is evaluated by the buyer and seller mainly based on its semantic level. The higher the level is, the higher the weight.

In the fuzzy inference scheme, the semantic variable is defined as Important, Neutral or Careless based on the level of subject being valued. There are nine fuzzy rules generated from three semantic variables concerning both buyer and seller simultaneously.

# 4. System Implementation

## 4.1. Implementation Tools and Interface

The prototype system is implemented with MS Internet Information Server and ASP.NET. The MS Access is used to construct database. The interface of system parameter setting includes the setting of weight for membership functions, parameters of fuzzy tactics, maximum number of negotiation and proposals, and the utility threshold. The setting of parameters of fuzzy tactics is for adjusting the space of concession in the fuzzy rule.

## 4.2. Verification of the Negotiation Process

To facilitate the observation of negotiation results, the verification process is limited to three subjects: price, payment days and delivery days. Table 1 shows a sample of the initial settings for both parties.

The administrator is responsible for establishing negotiation and setting subjects. After obtaining account numbers, the buyer and the seller can setup parameters of a proposal, such as upper and lower limits, as well as weight of each subject. After the negotiation mechanism is triggered and a successful negotiation reached, the system will generate a negotiation report and automatically notify buyers and sellers with e-mails.

The system makes 28 concessions for the sample proposal mentioned in Table 1, and then an agreement is reached. The negotiation result is shown in Table 2.

Table 1: Setting of parameters of buyer and seller

| Subject | Buyer | | | Seller | | |
|---|---|---|---|---|---|---|
| | Upper Limit | Lower Limit | Weight (Orientation) | Upper Limit | Lower Limit | Weight (Orientation) |
| Price ($) | 3100 | 2600 | 5 (C)* | 3500 | 2700 | 5 (B) |
| Payment Days (Day) | 21 | 10 | 4 (B) | 17 | 7 | 5 (C) |
| Delivery Days (Day) | 16 | 8 | 8 (C) | 18 | 10 | 7 (B) |

*The letter B or C in parentheses indicates that the subject is Benefit-oriented or Cost-oriented, respectively.

Table 2: Negotiation results

| Subject | Price | Payment Days | Delivery Days |
|---|---|---|---|
| Value | 3097 | 12 | 10 |
| Indicator | Buyer Utility | Seller Utility | Similarity |
| Value | 0.50144 | 0.50367 | 0.99721 |

## 4.3. Analysis of Multiple Buyers and Sellers Negotiation

There are several groups designed and each group consists of several buyers and sellers. We carried out the sensibility analysis of the negotiation success rate for two, three and four pairs of buyers and sellers, with the aim of verifying whether the negotiation mechanism is disturbed by member numbers in a group. The purpose is to observe the success rate of negotiation and the number of negotiations. A smaller negotiation number implies a more efficient negotiation. Besides, a successful negotiation is defined as follows: when utility values ($U$) of both the buyer and the seller reach the system threshold value ($T$), and thus an agreement is reached.

In this study, we examine the success rate of negotiation on the basis of three indicators: overall success rate (OSR), buyer success rate (BSR), and seller success rate (SSR). Table 3 shows the success rate of negotiation and the average number of negotiations.

The sensibility analysis shows that for the overall success rate, success rates of all groups reach at least 67%, and as high as 94%. For the buyer success rate, the average success rate reaches 100%. For the seller success rate, the average success rate reaches 89%. By observing results of the three groups, we found that the average overall success rate accounts for 79%. In addition, we found that the success rate will not be reduced by the number of negotiation participants, and an agreement is usually reached by 20 to 29 interactions.

Table 3: Success rate of negotiation and average number of negotiation

| Group | OSR | BSR | SSR | Average # of Negotiation |
|---|---|---|---|---|
| I (2-2) | 75% | 100% | 100% | 27 |
| II( 3-3) | 67% | 100% | 67% | 20 |
| III (4-4) | 94% | 100% | 100% | 29 |
| Average | 79% | 100% | 89% | 25 |

## 5. Conclusion

In this study, we collected information about procurement process, negotiation tactics and negotiable subjects in electronics industry in Taiwan. With the aid of expert interview, we consequently proposed an automated negotiation mechanism based on intelligent agent and fuzzy theory. The negotiation mechanism connecting several buyers and sellers provides an efficient means for reducing procurement costs and improving enterprise competitiveness. If the intelligent agent is used as the substitute for manual negotiation, several subjects can be negotiated at the same time, facilitating the negotiation operation between business partners.

Some future exploration to this study is possible: (1). Enhancing the complexity of negotiation subject. In practical negotiations, other subjects such as the type of payment will be considered. If the payment is made in cash, other subjects such as discounts will arise. This will enhance the negotiation complexity. (2). Considering the partnership between the buyer and the seller. Consuming habit and trust affect the procurement behavior. The trust relationship between partners can be further introduced in the negotiation process.

## 6. References


[1] J.L. Mumpower, The Judgment Policies of Negotiators and the Structure of Negotiation Problems, *Management Science*, 1991, 37(10): 1304-1324.

[2] J.R. Oliver, A Machine-Learning Approach to Automated Negotiation and Prospects for Electronic Commerce, *Journal of Management Information Systems*, 1996, 13(3): 83-112.

[3] L. Zhao, W.K. Ng, and E.P. Lim, "Cooperative Multi-attribute Bilateral Online Negotiation for E-commerce," *Proceedings of the 12th International Workshop on Database and Expert Systems Applications*, 2001, pp. 703-707.

[4] K.M. Chao, R. Anane, J.H. Chen, and R. Gatward, Degree of Satisfaction in Agent Negotiation, *Proceedings of the IEEE International Conference on I-Commerce (CEC'03)*, June, 2003, pp. 68-75.

[5] K.Y. Lee, J.S. Yun, and G.S. Jo, MoCAAS: Auction Agent System Using a Collaborative Mobile Agent in Electronic Commerce, *Expert Systems with Applications*, 24, 2003, pp.183-187.

[6] H. Markowitz, Portfolio Selection, *The Journal of Finance*, 1952, 7(1): 77-91.

[7] M. Barbuceanu and W.K. Lo, A Multi-attribute Utility Theoretic Negotiation Architecture for Electronic Commerce, *Proceedings of the 4th International Conference on Autonomous Agents*, 2000, pp. 239-246.

[8] J. Ueyama and E.R.M. Madeira, An Automated Negotiation Model for Electronic Commerce, *Proceedings of the 5th International Symposium on Autonomous Decentralized Systems*, 2001, pp. 29-36.

[9] H. Li, J. Cao, D.C. Lacouture, and M. Skibniewski, A Framework for Developing a Unified B2B E-trading Construction Marketplace, *Automation in Construction*, 2002, 12: 201-211.

[10] S.S. Fatima, M. Wooldridge, and N.R. Jennings, An Agenda Based Framework for Multi-Issues Negotiation, *Artificial Intelligence*, 2004, 152(1): 1-45.