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최적 수송가격 결정을 위한 다자간 동시 자동협상 방법론 개발

박용성* · 조민제* · 최형림** · 김현수** · 홍순구**

Multi-lateral Concurrent Automated Negotiation for Optimal Freight Settlement

Yong Sung Park* · Min Je Cho* · Hyung Rim Choi**
Hyun Soo Kim** · Soon Goo Hong**

■ Abstract ■

The development of IT and explosively growing number of Internet users are rapidly spreading and developing e-commerce, while creating diverse on-line transaction methods such as a negotiation, a reverse auction, and a bid. Among these transaction methods, the transactions by means of a negotiation are being made for goods that have no posted price. In particular, the transactions by means of a negotiation are expected to be widely used in the B2B. In order to determine their transportation costs, shippers usually make negotiations with many transporters and logistics companies. And before long, these negotiations are expected to be made on an on-line automated negotiation system. Because of this, this study has tried to develop an automated negotiation methodology that is absolutely necessary for an on-line automated negotiation.

This study has estimated and selected the evaluation functions for multi-lateral negotiators' proposals, thus developing an automated negotiation methodology. As a result of this study, a new direction for an automated negotiation has been suggested. Also we expect that this study will be widely used in the automated negotiation of diverse fields.

Keyword : Automated Negotiation, Multi-lateral Negotiation, Negotiation Protocol, Optimal Freight

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* Department of Management Information Systems at Dong-A University
** Division of Management Information Science at Dong-A University

1. Introduction

A shipper tries to deliver their cargoes by means of an optimum transportation mode with a minimum cost. Meanwhile, a lot of transporters and schedule information providers provide diverse schedule information of many transportation modes on an on-line basis. Although shippers can make use of diverse information, but it is impossible to know an actual transportation cost. Of course, there is a way to estimate the standard transportation cost. However, most transportation costs are usually determined by a negotiation. In fact, in spite of the same transportation mode, their transportation costs are different according to the shippers.

Meanwhile, the development of information technology along with exponential increase of Internet users is rapidly spreading e-commerce, thus creating diverse transaction methods such as a negotiation, an auction, and bidding. In particular, negotiation-based transactions are expected to be steadily expanded as a pivotal transaction in the e-commerce [10, 13, 15]. Most B2B transactions in the e-commerce are being made by way of negotiations between participating bodies instead of the transactions by means of posted prices. Because of this, a negotiation carries significance in the B2B transactions.

Cargo transportation is also a B2B transaction between shippers and transporters or logistics companies, and its cost is determined by a negotiation, and before long an on-line negotiation will be a key factor for transportation cost determination. The studies on a negotiation system are divided into two : a negotiation support system and an automated negotiation system [2, 7]. The difference between these two systems comes from whether it needs a human assistance or not.

The negotiation support system provides a negotiator with necessary information for decision-making and also diverse dialogue channels electronically, but it needs a human touch for inputting of restraint conditions, initial problem setting and final decision-making. However, in case of an automated negotiation system, negotiations are being made through single or connected computers, and so the whole process of a negotiation including the generation of negotiation proposal, evaluation, and decision-making is automatically performed without human tough [4, 11].

By the way, we don't know when a negotiation will take place in the on-line system, and so cannot keep on waiting until a negotiation will take place. Therefore, we need software that can automatically perform a negotiation in place of man. To this end, many researches on agent-based automated negotiation system are recently being made actively[3, 5, 8-10]. In order to make a negotiation in place of man, the agent-based negotiation system is to be able to generate a negotiation proposal, and also make a counter offer for his partner negotiator's proposal.

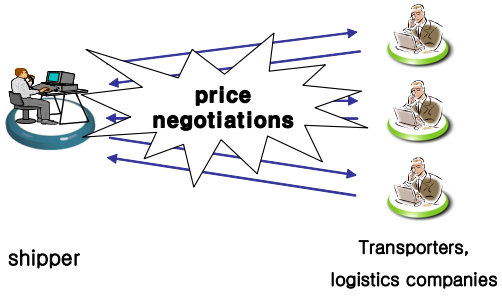
Accordingly, in an effort to find out an optimum transportation cost by means of a negotiation between a shipper and a transporter or a logistics company, this study has tried to develop an automated negotiation, which is absolutely necessary for an on-line negotiation system. The optimum transportation cost in here means a minimum transportation cost for a

shipper. Therefore, this study aims to help a shipper to determine an optimum transportation cost by means of automated negotiations with many transporters or logistics companies.

What matters most in making a negotiation proposal is to generate a proposal that can be accepted by a partner negotiator. For this purpose, it is necessary to estimate the evaluation function of a partner negotiator's proposal. This study has used a least square method to estimate an evaluation function, and based on this, has developed a method to produce a negotiation proposal, while suggesting diverse strategies to improve the shipper's negotiation results.

2. Negotiation Problems for Determining an Optimum Transportation Cost

For cargo transportation, a shipper usually makes price negotiations with many transporters or logistics companies. [Figure 1] shows how a shipper makes negotiations with diverse transporters or logistics companies.



[Figure 1] Negotiations to determine an optimum transportation cost

Although it is the same cargoes bound for the same area, transportation cost is quite different according to the transporters or logistics companies. It is so because there is the difference in transportation mode, the feature of each transporter and logistics companies, and their different transportation cost calculation method. Accordingly, a shipper ought to make negotiations simultaneously with many partner negotiators. As a whole, most studies have been made on a "1 to 1" negotiation basis, that is to say, a bilateral negotiation. However, in case of a negotiation for an optimum transportation cost, it is based on the negotiations with multiple partners instead of one single partner. In other words, it is a competitive price determination method of "1 to N", i.e. a multi-lateral negotiation [5, 7].

The negotiation defined by this study has focused on the lowest minimum transportation cost for a shipper, and the price only has been considered as a negotiation attribute. In actual case of selecting a transporter or a logistics company, such factors as price, delivery date, and services level are considered, but the most important factor is the price. In case of a delivery date, if it is difficult to keep the date, the transaction itself cannot be made. Also, in case of a service level, most services are similar more or less. Therefore, it is usually not included in consideration.

The number of negotiation participants is fixed. Therefore, if negotiations begin, it will be possible to be out of negotiation, but it is impossible to newly participate in the negotiation. And negotiations are to be made simultaneously with many participating companies, not sequentially.

Also the shipper makes an offer and a counter offer repeatedly and simultaneously. That is to say, a lot of transporters and logistics compa-

nies suggest their negotiation proposals, and the shipper compares and reviews these proposals, and then makes a response proposal or accepts an optimal proposal. However, the participating transporters or logistics companies don't know who are participating in the negotiation or What are the negotiation contents of other participants.

In this study, the major attributes of a negotiation are defined as shown in the <Table 1>, which include the purpose of a negotiation, a negotiation type, the beginning and closing of a negotiation, and the proceeding method of a negotiation.

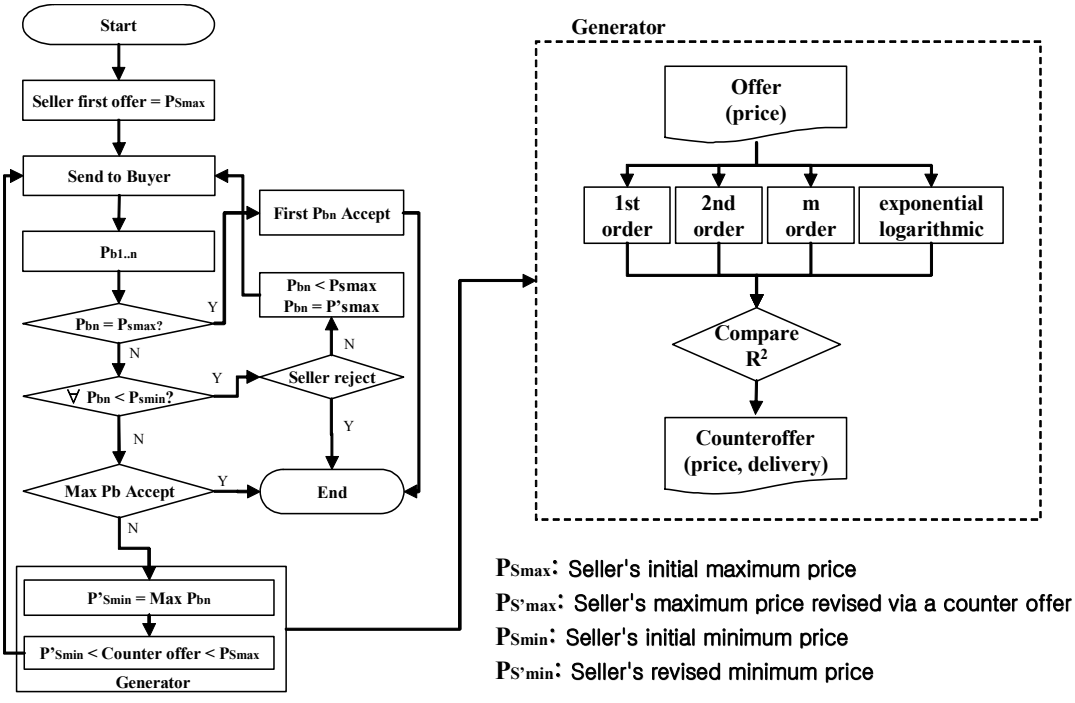
3. Multi-lateral Concurrent Automated Negotiation

3.1 Negotiation Scenario

[Figure 2] shows the whole process of a negotiation scenario. The picture on the right side in the [Figure 2] shows how a shipper makes a counter-offer in response to the negotiation partner's proposal. More details on this will be revealed in the "3.2 Counter-Offer Generation

〈Table 1〉 Negotiation problems for determining an optimum transportation cost

Purpose of negotiation		◦ To determine the transportation cost, a shipper makes negotiations with transporters or logistics companies, focusing on seeking a minimum transportation cost.
Transaction method		◦ Bargaining
Negotiation Type	Participant	◦ 1 (shipper) : N (transporters or logistics companies) (Multi-lateral negotiation)
	Attribute	◦ Price(Distributive negotiation)
	Relation	◦ Competition for cargo obtainment among transporters and logistics companies (Competitive negotiation)
Negotiation Message	Composition	◦ Price, Time bound
	Kind	◦ Offer : Initial negotiation proposal offered by a shipper and time bound ◦ Count-offer ・ Bid : a new negotiation alternative and time bound ・ Acceptance : accept the partner's negotiation proposal. ・ Rejection : reject the negotiation.
Beginning of negotiation		◦ A shipper makes an offer simultaneously to the transporters and logistics companies
Closing of negotiation		◦ A shipper accepts the proposal of his negotiation partner. ◦ A shipper rejects all the proposals suggested by transporters or logistics companies.
Exclusion from negotiation		◦ Rejection ◦ Go beyond the time bounds.
Negotiation proceeding		◦ Repeat a counter offer after an initial offer ◦ It is possible for a transporters or logistics companies to be out of negotiation, but impossible to newly participate in the negotiation. ◦ Transporters or logistics companies don't know who is participating in the negotiation and what are the contents of other negotiators. ◦ A single shipper makes negotiations simultaneously with many transporters or logistics companies. ・ A shipper sends an offer or a counter offer simultaneously to all the transporters or logistics companies. ◦ When generating a negotiation proposal, a shipper cannot make his price lower than the former one. ◦ Former negotiation history is to be out of consideration.



[Figure 2] Negotiation scenario

Method."

A negotiation begins with the offering of a shipper's minimum transportation cost and the maximum transportation cost that he is willing to pay. First of all, he sends his minimum price to each transporter or each logistics company. The purpose of sending his minimum price at first is a strategy to gain a better result from his negotiations. In order to maximize the shipper's results from his negotiations, this study has made use of an "Anchoring Effect." An anchoring effect means that man has an inclination to adhere to the offer price made by his counterpart, and that because of this inclination, he naturally begins with the price suggested by his partner in the negotiations. Accordingly, if a shipper takes an initiative in offering his minimum price, he can obtain a more favorable position thanks to the anchoring effect [1].

After all, owing to the initial offering price made by the shipper (or seller), it is inevitable for his partner's (or buyer) response price to be elevated.

In order to secure an anchoring effect, a negotiator ought to have information superiority over his negotiation partners. In this study, the shipper has information superiority over the transporters and logistics companies in terms of the number of negotiation participants and diverse kinds of negotiation proposals. Therefore, the shipper first makes an offering of his minimum price, having much information related to his negotiations, and consequently obtaining an anchoring effect.

The response proposals made by the trans-

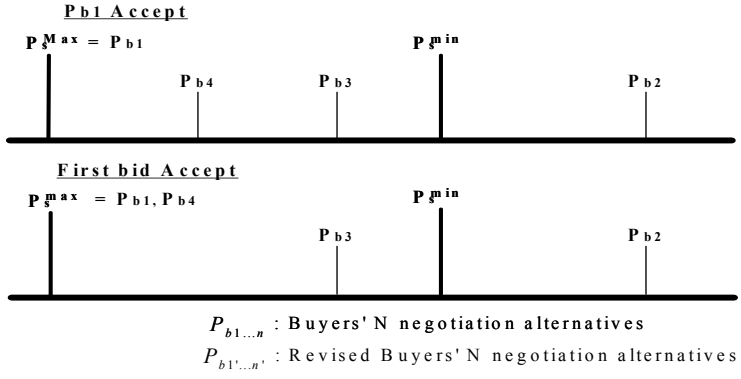
porters or logistics companies can be divided into three groups. The first case is that the prices of response proposals are the same with the price suggested by the shipper, the second case is that all the prices of response proposals are higher than the maximum price of the shipper, and finally the last one is that the prices of response proposals are between both the minimum price and maximum price of the shipper. Anyway, the shipper makes a different response against each proposal, also generating a new counter-offer and sending it to his negotiation partner.

The three kinds of proposals made by the transporters or logistics company are not fixed. They can be changed according to each negotiation round. In other word, in the first negotiation proposal, the shipper can make an offer of the price higher than his maximum transportation cost, but in the next negotiation proposal, he can make an offer between his minimum price and maximum price. The shipper's negotiation handling and his counter-offer don't respond to the initial proposals made by the transporters or logistics companies, but will be made in response to the proposal features of each negotiation round.

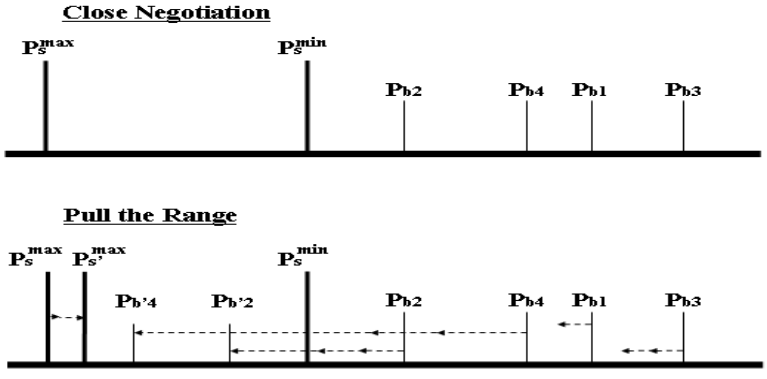
Among the proposal features of transporters or logistics companies, the first case is that among those proposals there can be a couple of the same prices as the initial minimum price of the shipper. In this case, as shown in the [Figure 3], there are two cases : one is that there is only one same price, and the other is that there are two or more. In case of one same price, as shown in the [Figure 1], i.e. $P_s^{\min} = P_{b1}$, the seller accepts the proposal and closes the negotiation. In case of two or more, i.e. $P_s^{\min} = P_{b1}, P_{b4}$ the seller accepts the first-come proposal from the buyers, and closes the negotiation.

The second case is that all the proposal prices made by transporters or logistics companies are higher than the maximum price ($P_x^{\min}$) of the shipper. As shown in the [Figure 4], there are also two cases in here.

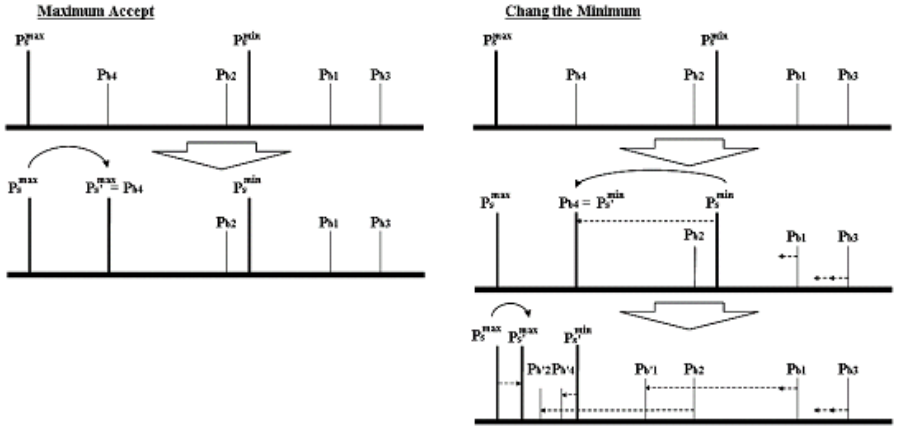
One is that the shipper closes his negotiation, and the other is that he widens the price range between the minimum price and maximum price, so that the proposal prices made by the



[Figure 3] In case that there is a buyer's proposal price that has the same price as the maximum price of a seller



[Figure 4] In case that all the buyers' proposal prices are lower than the seller's minimum price



[Figure 5] In case that the buyer's proposal prices are between the minimum price and maximum price of the shipper

transporters or logistics companies may come between his price range. Accordingly, the shipper sends a new offer price ($P_x^{\min}$) to all his negotiation partners instead of the initial offer price ($P'^{\min}_s$).

The third case is, as shown in the [Figure 5], that all the proposal prices suggested by the transporters or logistics companies are between the initial minimum price and maximum price of the shipper, or one or more proposal prices are in the range of the shipper. In this case, if the shipper is satisfactory with the lowest proposal price, he will accept the proposal. But if not, he will continue to generate a counter-offer to make his negotiation successful. In order to make a counter-offer, the shipper makes his initial maximum price equal to the lowest proposal price suggested by the transporters or logistics companies.

And then he continues to send his new counter-offer price ($P'^{\min}_s$) to his negotiation partners. In this case, even if his negotiation partner's prices are out of his price range, he can send his new counter-offer in an effort to in-

〈Table 2〉 Negotiation Scenario

1. Seller sets its desired maximum price ($P_s^{\min}$) and minimum price ($P_s^{\max}$).
2. The seller sends the set $P_s^{\min}$ to buyers concurrently. (offer).
3. The seller receives the message of counter offer from buyers.
A. When there are the same counter-offer prices from buyers as the seller's initial offer price :
A.1 In the case of one same price as the seller's offer price
A.1.1 The seller sends an acceptance message to the buyer and the negotiation ends.
A.2 In the case of more than one same price as the seller's offer price
A.2.1 The seller sends a acceptance message to the buyer who has arrived to the negotiation arena firs t and the negotiation ends.
B. When the counter-offer prices of buyers are all lower than seller's minimum price
B.1 When trying to pull up the Buyers' counter offer prices higher than seller's minimum price.
B.1.1 The seller generates a new counter offer price $P_s^{\min}$ lower than the offered maximum price ($P_s^{\min}$).
B.1.2 The seller sends the newly proposed counter-offer price to buyers and wait for messages from the buyers.
B.1.3 Continue the negotiation moving to the 3rd stage.
B.2 When buyers have no intention to raise their prices higher than the seller's minimum price, or when there is no room to negotiate (Criteria needed. Although several repetition took place, the buyers' prices do not go up than the minimum price).
B.2.1 The seller sends a rejection message to buyers and the negotiation ends.
C. When either all the buyers' prices are between the seller's initially offered maximum and minimum price range or at least one of the buyer's counter offer price is within the seller's maximum and minimum price range.
C.1 When the seller is satisfied with the highest price among the counter offer prices of buyers and accept the price
C.1.1 The seller sends an acceptance message to the buyer who counter-offered the highest price, sends rejection messages to the remaining buyers and ends the negotiation.
C.2 When the seller is not satisfied with the highest price of the buyers.
C.2.1 Instead of the seller's minimum price, set the highest price of the buyers and construct it as the seller's minimum price.
C.2.2 The seller sets a new counter offer price between the seller's maximum price and the newly set minium price (buyers' highest price).
C.2.3 The seller sends the newly constructed counter offer price to the buyers and waits for messages from the buyers.
C.2.4 Continue the negotiation by moving to the 4th stage.

duce them to a new negotiation.

The following <Table 2> shows the whole scenario of a negotiation.

3.2 How to Generate a Counter-Offer

In order to develop an automated negotiation, it is important to define a negotiation scenario in detail, but also more important one is to develop an algorithm, which automatically generates new negotiation proposals in response to the negotiator's proposals. On the basis of least square method, this study has selected the evaluation function according to the coefficient of determination of the regression formula. And then based on the selected evaluation function, this research has developed an algorithm.

As shown in the [Figure 2], a three-stage course is required to generate a counter-offer. First, the shipper estimates the evaluation func-

tion of his negotiation partner's proposal among many evaluation functions, and then selects the optimum evaluation function according to the coefficient of determination, and finally offers a suitable negotiation proposal based on this function. This proposal is the transportation cost suggested by the shipper.

Stage 1 : Least Square Method-based Evaluation Function Estimation

In order to make a successful negotiation, it is, of course, important for a shipper to offer the price that he wants, but another important one is how to make a counter offer in response to his negotiation partner's proposal. To do this, he has to be able to predict the negotiation proposals to be suggested by his negotiation partners. In order to predict negotiation proposals, he has to estimate the evaluation function of each individual negotiator.

To this end, this study has used a least square method-based evaluation function. Also, according to the negotiation round, the evaluation function can have the features of diverse functions, so that this study has used simultaneously a linear, quadratic, exponential, and logarithmic function. The model of evaluation function used in this study is the below Equation (1). $\beta_0, \beta_1, \cdots, \beta_n$ in the formula will be estimated according to the negotiation round. And x denotes a negotiation round, and y means a negotiation attribute.

$$\begin{aligned} v(x) &= \beta_0 + \beta_1 \cdot x \\ v(x_i) &= \beta_0 + \beta_1 \cdot x_i + \beta_2 \cdot x_i^2 + \cdots \beta_n \cdot x_i^n \quad (1) \\ v(x_i) &= \beta_0 + \beta_1 \cdot e^{x_i} \\ v(x_i) &= \beta_0 + \beta_1 \cdot \log_{10}(x_i) \end{aligned}$$

Accordingly, $\beta_0, \beta_1, \cdots, \beta_n$ can be derived from a least square method-based algorithm. The multinomial expression from 1st to nth has been changed into simultaneous equations. Because of this, as shown in the Equation (2), based on the reverse matrix $a \cdot x = b$, the simultaneous equations have been used. The exponential and logarithmic functions are based on the Equation (3).

$$\begin{bmatrix} \beta_m \\ \beta_{m-1} \\ \vdots \\ \beta_0 \end{bmatrix} = \begin{bmatrix} \sum_{i=0}^{n} x_i^{2m} & \sum_{i=0}^{n} x_i^{2m-1} \cdots & \sum_{i=0}^{n} x_i^{m} \\ \sum_{i=0}^{n} x_i^{2m-1} & \sum_{i=0}^{n} x_i^{2m-2} \cdots & \sum_{i=0}^{n} x_i^{m-1} \\ \vdots & \cdots \quad \cdots & \vdots \\ \sum_{i=0}^{n} x_i^{m} & \sum_{i=0}^{n} x_i^{m-1} \cdots & n+1 \end{bmatrix} \cdot \begin{bmatrix} \sum_{i=0}^{n} y_i x_i^{m} \\ \sum_{i=0}^{n} y_i x_i^{m-1} \\ \vdots \\ \sum_{i=0}^{n} y_i \end{bmatrix} \quad (2)$$

(exponential function)

$$\beta_1 = \frac{\sum_{i=1}^{n} y_i \cdot e^{x_i} - \bar{y} \cdot \sum_{i=1}^{n} e^{x_i}}{\sum_{i=1}^{n} (e^{x_i})^2 - \frac{\left(\sum_{i=1}^{n} e^{x_i}\right)^2}{n}}, \quad \beta_0 = \bar{y} - \frac{\beta_1}{n} \cdot \sum_{i=1}^{n} e^{x_i}$$

(logarithmic function)

$$\beta_1 = \frac{\sum_{i=1}^{n} y_i \cdot \log_{10}(x_i) - \bar{y} \cdot \sum_{i=1}^{n} \log_{10}(x_i)}{\sum_{i=1}^{n} (\log_{10}(x_i))^2 - \frac{\left(\sum_{i=1}^{n} \log_{10}(x_i)\right)^2}{n}}, \quad (3)$$

$$\beta_0 = \bar{y} - \frac{\beta_1}{n} \cdot \sum_{i=1}^{n} \log_{10}(x_i)$$

Accordingly, the evaluation functions derived from the above formulas can have many different evaluation functions according to the nego-

tiation attribute and negotiation round. Therefore, in the one or less round of negotiation, the evaluation function of linear, quadratic, exponential, and logarithmic functions is to be used, and in the two or more rounds of negotiation, the evaluation function of quadratic, exponential, and logarithmic functions is to be used.

Stage 2 : Coefficient of Determination-based Evaluation Function Selection

The selection of final evaluation function is to be made by R^2 in the Equation (4). By comparison of coefficient of determination, the evaluation function with the highest degree of explanation is to be selected.

$$R^2 = \frac{SSR}{SST} \quad (4)$$

In here, the SST that denotes the left term of Equation (5) means a total sum of squares, and the SSR that denotes the second term in the right of Equation (5) means a regression sum of squares.

$$\sum_{i=1}^{n}(y_i-\bar{y})^2=\sum_{i=1}^{n}(y_i-\hat{y})^2+\sum_{i=1}^{n}(\hat{y_i}-\bar{y})^2 \quad (5)$$

Stage 3 : Counter-Offer Generation

Based on the estimated evaluation functions, the shipper can predict his negotiation partners' proposals to be suggested in each negotiation round. By comparing his partners' proposals with his own, the shipper can generate a better counter-offer. In this case, the shipper usually takes his negotiation partners' position into consideration instead of adhering to his own, because it is important to make his negotiation a success as soon as possible. If the shipper continues to adhere to his own proposal, there is possibility that his negotiations are liable to fail, thus sometimes causing more expenses and losses.

4. Conclusion

In an effort to determine an optimum transportation cost, this study has developed a methodology for an automated negotiation between a shipper and transporters or logistics companies. Considering rapidly growing Internet and e-commerce, we can easily expect that an on-line negotiation will be absolutely necessary for the determination of an optimum transportation cost. At the same time, an automated negotiation system is required for an on-line negotiation.

In order to make negotiations simultaneously with many negotiation partners, this study has estimated the evaluation function of each negotiation partner's proposal, while based on this, generating a counter-offer. Instead of using a linear evaluation function like an ordinary evaluation method, this study has introduced a least square method-based evaluation function estimation.

This study has suggested a new methodology for the automatic evaluation of negotiation proposals, which can be used not only for determining an optimum transportation cost, but also for an automated negotiation of diverse fields. In this sense, this study has contributed to laying the foundation of an on-line automated

negotiation. Owing to the feature of its domain, this study has used only one attribute of "price", but from now on more attributes should be taken into consideration for an automated negotiation. Also, the method to test the validity and practicality of the newly developed automated negotiation has to be established.

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◈ 저 자 소 개 ◈

박 용 성 (ys1126@dau.ac.kr)

Y. S. Park is a post Doc. of BrainKorea(BK)21 at the Dong-A University in Korea. He received his BBA from Dong-A, and MS and a PhD in management information systems from Dong-A University in Korea. His major research interests include electronic commerce, decision support systems/expert systems, and management information systems. Now he is interested in the research area of port and logistics systems.

조 민 제 (mjcho@dau.ac.kr)

M. J. Cho is a Full time researcher of Center for Intelligent and Integrated Port Manegement Systems at the Dong-A University in Korea. He received his BBA from Dong-A University, and a MS in management information systems from Dong-A University in Korea. His major research interests include SOA, Agent System and intelligent manufacturing systems. Now he is interested in the research area of port and logistics systems.

최 형 림 (hrchoi@dau.ac.kr)

H. R. Choi is a professor in the Division of Management Information Science at Dong-A University in Korea. He received his BBA from Seoul National University, an MS and a PhD in management science from the Korea Advanced Institute of Science and Technology. His major research interests include AI for electronic commerce, automation of process planning and scheduling inmanufacturing domain, and intelligent manufacturing systems. Now he is interested in the research area of port and logistics systems.

김 현 수 (hskim@dau.ac.kr)

H. S. Kim is a professor in the Division of Management Information Science at Dong-A University in Korea. He received his BBA from Seoul National University, and MS and a PhD in management science from the Korea Advanced Institute of Science and Technology. His major research interests include data mining in digital product companies and virtual market.

홍 순 구 (shong@dau.ac.kr)

S. G. Hong is a professor in the Division of Management Information Science at Dong-A University in Korea. He received his BBA from Yeungnam University, and MS and a PhD in management information systems from University of Nebraska-Lincoln. His major research interests include data warehousing, knowledge management, e-commerce, IS evaluation, healthcare information systems.