

## A Study on Automated Negotiation Methodology for Multi-lateral Concurrent Negotiation \*

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### Abstract

Though studies on negotiations have actively been conducted in the field of e-Commerce so far, some problems have yet to be solved and many application fields of negotiation systems exist. Currently, many businesses shift from various fields to e-Commerce market, due to recent social changes and expansion of e-Commerce market; however, we need to develop the study of automated agents to resolve the issue of negotiation, which is an essential element in the e-Commerce, by minimizing human interference under the e-Commerce environment.

In this study, we intend to propose a new negotiation protocol considering the negotiation alternatives through continuous negotiation rounds in relation to an automated negotiation issue whose participants are one to N (seller to buyers). We also present an agent-facilitated negotiation methodology by which negotiation alternative generation process is automated, in consideration of buyer's negotiation attributes and strategies in the negotiation system.

**Keywords:** Automated negotiation, Multi-lateral negotiation, Negotiation protocol, Agent

### 1. Introduction

The development of information and communications and increase in the Internet users accelerate the diffusion speed of e-Commerce, which has short history. The diffusion and evolution of e-Commerce changes economic stakeholders' activities fundamentally beyond simple relocation of trading places. e-Commerce, in particular, has penetrated into our lives deeply, while it progresses with various forms including m-Commerce and T-Commerce. e-Commerce has evolved to the extent that humans trade in the e-Commerce using all the relevant circumstances and tools in our daily lives, thanks to an advent of the Ubiquitous Age.

Most studies concerned with e-Commerce by far have mainly focused on automated negotiations and offer generation issues in the form of bilateral (one to one) negotiation. In this private treaty pricing method, either a buyer and a seller decides concrete price through negotiations, or initial price is presented at the level following the negotiators' negotiation power without actualization of price. Negotiations will repeat until the parties reach mutually agreed price through negotiations and coordination to make a favorable price to either party. The study on competitive bid pricing mode, one to N or the study on M:N multi-lateral negotiation is insufficient by far. Bilateral negotiation is private negotiation between a seller and a buyer, but the price in competitive negotiation is decided in front of other buyers through competition among multiple buyers. In the market with stringent competition, the price tends to go up, because of competition among buyers. In a loose competition market, sellers make constant efforts to find buyers, competing each other among the sellers. In a one to one negotiation, only private negotiation takes place between a buyer and a seller, but the situation becomes complex in a multi-lateral negotiation, due to competitive price presentation among the concerned parties.

With regard to competitive bid pricing, we can find auction, bidding or altered forms of these mostly through recent online trading. The existing methods take a mode to adopt maximum or minimum offer price via one round of negotiation, rather than reaching the convergence of offers through repetition of negotiation process. Therefore, there is a shortcoming not to induce continuous buyers' competition. This, in other words, means that seller's pricing ability and other buyers' negotiation attributes and strategies are excluded unlike negotiation.

The problem of multi-lateral negotiations in automated negotiation lies in the establishment of automated negotiation in negotiations through agents. In doing so, the essentials to be considered are generally for what negotiation protocol can be used, what attributes exist in the negotiation process and what an inferred model can an agent adopt [1]. The problem of existing automated negotiation system is that complete automation has not been done in the processes of identifying negotiation attributes, construction of negotiation alternatives, assessment of negotiation alternatives considering other parties' negotiation strategies and presentation of offers, but large part of these processes depends on humans.

Hence, this study proposes the protocol for new automated negotiation considering negotiation attributes of multiple negotiators (buyers) through continuous negotiation rounds in regard to multi-lateral concurrent

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negotiations between a single seller and multiple buyers (1: N negotiation mode). In this negotiation system, we intend to automate counter offer generation process which considers buyers' negotiation attributes and strategies.

**2. The characteristics of multi-lateral negotiation**

As described in Introduction, the online modes of multi-lateral automated negotiations that we can find most are auction, bidding and altered forms of these. Auction means a market structure in which sellers or buyers present their bidding prices to acquire goods and then the final successful bidder and contract price are decided. This is also considered as a type of market to decide goods prices of which objective pricing is difficult. McAfee and McMillan (1987) define auction as a market structure where price and allocation of resources are decided according to the bid-based rules [2]. The auction system has been developed, mainly used for wholesale prices decision of the following commodities: natural resources, antiques, flowers, works of art and used articles, as well as agricultural and marine products, of which standard pricing is difficult or standard quality decision is difficult. Recently, auction, however, is used in retail markets including department stores and large scale retail outlets, in addition to wholesale markets. Furthermore, courts, customs house and government agencies that procure government supplies use this auction system, and thus it is familiar with us in our economic activities [3]. Auction using cable TV and telephone has emerged, thanks to the development of information technology (IT) and it is actively carried out on the Internet.

Various types of auction, for example, ascending, descending and concurrent bidding methods, have been used. The auction actually has been developed, based on the ascending and descending methods. There are many kinds of auction methods, if we enumerate various types of auction that have been altered by each commodity, nation, region and age. Having said so, identification of what kinds of auction can be suitable for what business types and items will be one method to deal with commodity trading. The types of auction are summarized in <Table 1>.

<Table 1> Types of Auction

Classification		Mode	
Auction Name	Composition of auction participants	Single Auction (one to N, n:1)	Double Auction (n:m)
			SDA, CDA**
	Status of competitive price	Outcry bid = Recognition	Sealed-bid = Haphazard
		Ascending/Descending, simultaneous bidding	FPSB***, Vickrey, Tender
	Pricing direction	Ascending-Bid	Descending-Price
		The English Auction, Consecutive Auction	The Dutch Auction
	Price bidding timing	In consecutive order	Simultaneous
		Consecutive Auction	Simultaneous-Bidding Auction

Execution region	Production Area Auction	Consumption Area Auction	
Status of mobility	Mobile Auction	Fixed Auction	
Commodity listing	Total Volume Listing Auction	Sample Listing Auction	
Unit commodity	Unit Price (weight, quantity) Auction	Gross Volume Auction	
Kinds of Commodity	Antiques	Marine Products	Used Cars

\* : Sealed-bid double auction  
 \*\* : Continuous double auction  
 \*\*\* : First price sealed bid auction

Source: www.auction.co.kr, Yeon-Sil Gang, Yeon-Soo Kim (1998)

The types of general auction is classified into single auction and double auction, depending on the composition of auction participants as seen in <Table 1>. Depending on the status of bidding prices, namely, depending on the recognition on the status of competitive price, auction is divided into an outcry bid and a sealed bid. According to price bidding timing, auction can be categorized into consecutive and simultaneous methods. The consecutive method is generally means time consecutive auction. Like the general English Auction, bidders present prices by turns and this process repeats, and when there is no more price presentation, a successful bidder is decided. A representative example of simultaneous-bidding auction is the Korea-Japan Auction (simultaneous bidding auction). This auction method is mainly used in the wholesale markets for agricultural and marine products in Korea and Japan, which is rarely used in other countries. The characteristic of this system is that all the buyers can present bidding prices, revealing their prices in hand signal simultaneously or almost simultaneously. In this manner, auction is proceeded very fast. Buyers here should present the highest price within limited time. Although buyers can present their own prices simultaneously, they can pull up their own prices within permitted time, monitoring others' prices. Time is critical to pricing, regardless of ascending or simultaneous bidding method, because the rule does not exclude raising the bidding price by revising it. The price is decided instantly in the simultaneous-bidding auction, unlike general auction where price gradually changes. The reason is that the auction price is decided by bidding openly among the bidding participants. This method provides an advantage that bidding participants can save time.

In negotiation, we may also consider such a simultaneous mode. Excluding the case in which interests are involved with multiple parties, most multiple negotiations are conducted with different targets every time to solve a single problem. In doing so, the effort to search for negotiation targets and carry out multiple negotiations means more time and expenses. In negotiation, however, simultaneous negotiation is carried out with multiple negotiation targets like the mode of auction, and thus efficiency of it will increase. Generally, the types and forms of negotiations can be categorized as shown in <Table 2>. The criteria for categorization include composition of participants, the number of attributes of negotiation targets, market characteristics, the number of negotiation methods and so on [4].

&lt;Table 2&gt; Types of Negotiations

The Number of Parties	The Number of Attributes	The Relationship of Market	The Number of Protocol and Goods
Bilateral	Distributive	Competitive	Combinatory
Multi - Lateral	Integrative	Cooperative	Combined

Source: Young-Jae Park (2002)

Depending on the negotiation types, the negotiation methods and characteristics become different. Having said this, the one to N negotiation usually has quite complex problems, which performs negotiations with multiple parties, not with a single party, unlike the one to one negotiation and auction. In the first place, the price is not only decided by buyers' competition, but also sellers participate in pricing actively through presentation of negotiation alternatives in the one to N negotiation, unlike one to N auction, in terms of pricing method. Here, a negotiation alternative, as well as pricing method, can be another attribute of commodity. In regards with presenting a negotiation alternative, the concerned parties just conduct an assessment of the other party's negotiation alternative, set its own alternative responding to it, and present it as a negotiation alternative in the one to one negotiation. However, in the one to N negotiation, a seller receives multiple buyers' counter offers, which means assessing multiple counter offers together.

The studies on the negotiation system to solve the aforementioned negotiation problems have been continuously carried out, and an example can be Sardine. The Sardine (J. Morris and P.Maes, 2000) developed by MIT is an airplane negotiation agent. When a buyer grants weights to desired items, the seller presents available selling price of a ticket meeting the conditions of each item most [5] and [6]. This system holds an advantage that can present a strategy to satisfy a seller, beyond limitations of a negotiation system, which considered only buyers. However, this system has a drawback that a consumer's demand is so simple that there is no competition among sellers.

Chavez and Maes conducted a study on a negotiation market, "Kasbah," in which multi-lateral negotiation is made in the central market (Chavez et al, 1996). Kasbah carries out negotiation in a method to repeatedly propose revised prices until the other party's agent is satisfied by using a simple numerical function, not using artificial intelligence or a mechanic learning method [7]. Kasbah system decides the status of negotiation with only price information and the agent finishes the negotiation with regard to the first offer that meets buyer's needs; thus, we can find a shortcoming that Kasbah system cannot reflect buyer's needs sufficiently. analyzed.

### 3. Seller Oriented Multi - lateral Concurrent Negotiation (SOMCoN)

The negotiation agent for automated negotiation uses the protocols or strategies used in game theory and economics.

In carrying out negotiation, negotiation participants' environmental elements, that is, following problems in negotiation, have great impacts on the protocol and strategy of negotiation: goods with which goals, how many attributes and what characteristics. In the end, a negotiation can be possible or impossible, depending on negotiation environment, and the negotiation environment will have impact upon the size of benefits gained through the method of negotiation and negotiation. Nick Jennings (2005) explains the components of automated negotiation in the category of mechanism design and agent strategies in Negotiation Technologies [8].

Mechanism design is the law for game and it means a protocol as the rules for composition of negotiation participants, closing of negotiation, offer and acceptance, time bound and participation in and walking out of the negotiation. Namely, mechanism design means protocol. Agent strategies is a method to succeed in negotiation. Agent strategies means the decision making and offer construction strategies that an agent has in order to succeed in negotiation. Of course, the success in negotiation means maximum utility (or benefit), and this utility (or benefit) includes the maximum utility (or benefit) of the entire participants, in addition to one's own utility (or benefit). Negotiation methodology for multi-lateral concurrent negotiation can be classified into two: First, seller oriented multi-lateral concurrent negotiation (SOMCoN) protocol inducing competition through presentation of seller's continuous negotiation alternatives, so as to attract continuous participation of multiple buyers in negotiations, unlike existing auction method. Second, method to set seller's strategies and negotiation alternatives considering the attributes of multiple buyers.

#### 3.1 Negotiation Protocol of SOMCoN

Mechanism Design, namely, protocol means game rules (negotiation method) described above. The game rules include bargaining mechanism, negotiation types, definition of negotiation terms and messages and preconditions for negotiation progress as shown in Table 3. Bargaining mechanism follows buying and selling process between sellers and buyers, which is called Bargaining, an altered form of auction, as well as auction that can be found most on the Internet [9]. This Bargaining mode is divided into a bilateral negotiation and multi-lateral negotiation, depending on negotiation participants' composition [10]. The negotiation protocol of SOMCoN supports multi-lateral negotiation mode in which a seller and multiple buyers concurrently conducts the bargaining. The negotiation type classification can be made according to the number of negotiation targets (attributes) and market features, in addition to the number of participants. The protocol in this study can be viewed as distributive negotiation targeting a single attribute in regard to price and also competitive negotiation where buyers negotiate competitively with regard to a single commodity [11].

In negotiating an offer and a counter-offer, there are messages exchanged between a seller and buyers. In the negotiation message, a negotiator's intention expression to deliver to the other party and time bound for the other party's counter-offer, that is time bound (T) are included. This negotiation message composition is also defined by negotiation protocol. A seller and a buyer make a counter offer within the time bound desired by the other party. Any seller and buyer who are over the time bound are deemed that they have no negotiation intention anymore.

In automated negotiation's protocol negotiation, negotiation environment and preconditions, which are the factors having impact upon negotiation results, are included. These preconditions include the conditions of initiation of, participation in, walking out of negotiation and closing of negotiation, as well as negotiation conditions. In addition, negotiation alternatives acceptance and handling, time bound for counter offer presentation and whether to make offer and participants public, consideration of prior bargaining relation and prior negotiation and order to conduct negotiation with negotiators can be included. Although concrete offer creation methods and strategies are not included in relation to offer generation in negotiation, the method and rules for constructing offers are specified in the negotiation protocol. <Table 3> summarizes the protocol for multi-lateral concurrent negotiation in one to N relation presented in this dissertation.

<Table 3> Negotiation Protocol of SOMCoN.

Target Markets	- Markets where precise price of commodity is not decided and upper limit in price is silently set (i.e.: used articles and real estate)
Trading Mode	- Bargaining
Negotiation Types	Participants - 1 Seller : N Buyer (Multi - lateral Negotiation)
	Attribute - Price (Distributive Negotiation)
Negotiation Message	Relation - Competition among buyers for a single commodity (Competitive Negotiation)
	Composition - Price - Time Bound for counter offer
Negotiation start	Types - Offer: Seller's initial offer and time bound - Counter offer * Bid: New offer and time bound * Accept: Accept other party's counter offer * Reject: Reject negotiation
	- Seller sends its offer to expected buyers concurrently.
Negotiation end	- Accept - Reject from all the participating buyers
Rejected as a negotiation party	- Reject - Over time bound
Negotiation progress	- Repetition of counter offer in regard to the initial offer - Although buyers can get out of the negotiation, they cannot participate again. - Buyers cannot know other buyers' participation or responses. - A single seller conducts negotiation with multiple sellers. * The seller makes an offer and later a counter offer to buyers concurrently. - Buyers cannot lower the price than previous price, when generating a negotiation alternative. - Ignore previous negotiation history.

The protocol in this study aims at a seller's selling a single commodity at maximum price. The target market is the market where precise prices of goods are not set like in auction. Targeting the goods with upper limit on the price, the market can be limited to used car and real estate markets. For overcoming the complexity in one to N negotiation and for gradual approach, the negotiation price is preferentially considered, despite the attribute of pertinent goods. The number of negotiation participants is fixed, once the negotiation starts; therefore, walking out of the negotiation is possible, but new participation is impossible. One seller negotiates with multiple buyers concurrently. Concurrent negotiation is that a seller sends its offer and counter offer to multiple buyers, not negotiating consecutively with multiple buyers with regard to a single commodity. In other words, buyers present their own counter offers, respectively, and the seller compares and reviews these buyers' counter offers and generates his own optimal counter offer and negotiate with buyers. In doing so, buyers do not know who participated in the negotiation and other buyers' negotiation alternatives, except for seller's negotiation alternative (counter offer).

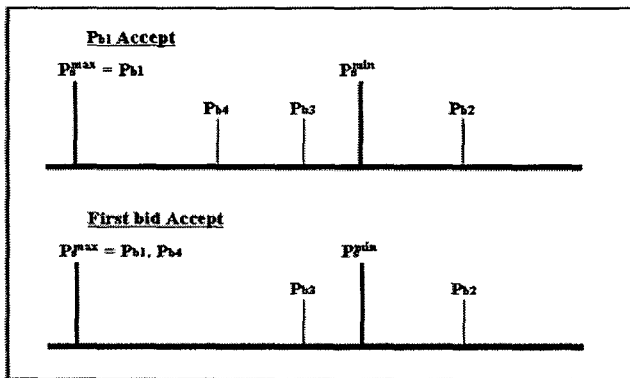
**3.2 Strategy to Improve Seller's Negotiation Performance in SOMCoN**

SOMCoN intends to present a strategy satisfying a seller as well beyond the existing negotiation system's limitations that considered only buyers. To this end, an initial offer is presented by the seller in negotiation for anchoring effect. Anchoring effect means that a human tends to negotiate from the offered price level unconsciously, because humans are liable to be restricted to initially offered price by the other party. So, if you offer price first, a price favorable to you can be decided, due to the anchoring effect [12]. In the end, the buyer's resistance price has no other choice but to go up, because of the seller's resistance price. To obtain the anchoring effect, you need to have advantage in information compared to the other parties in negotiation. This can be suitable for the protocol of SOMCoN in which buyers are not able to know who and how many participated in the negotiation and what counter offers have been presented. The seller's pricing method according to the protocol presented in this dissertation and the strategy to lead the negotiation in a direction to one's own way are explained as follows. Here, the negotiation terms and signs are first explained:

- $T$  : Time Bound
- $P_s^{max}$  : Seller's initial maximum price
- $P'_s^{max}$  : Seller's maximum price revised via a counter offer
- $P_s^{min}$  : Seller's initial minimum price
- $P'_s^{min}$  : Seller's revised minimum price
- $P_{b1...n}$  : Buyers' N negotiation alternatives
- $P'_{b1...n}$  : Revised Buyers' N negotiation alternatives

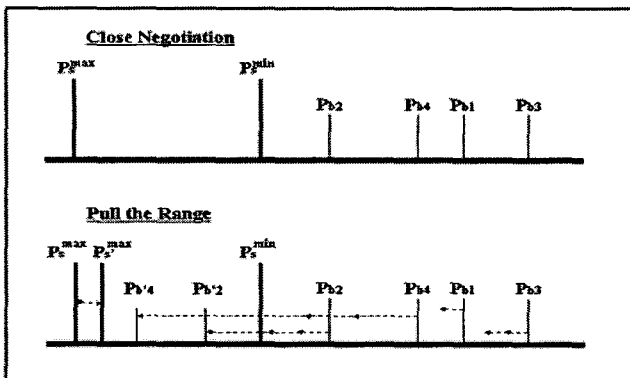
First, seller sets its maximum price  $P_s^{\max}$  and minimum price  $P_s^{\min}$ , and presents the maximum price to the potential buyers as an initial offer. Buyers sets counter-offers (negotiation alternatives)  $P_{b1...n}$  for the seller's initial offer and present them to the seller. The counter-offer prices of the buyers can be indicated into three categories:

First is the case in which the same price exists as the seller's offer price. Here, two cases can occur, depending on if one same price as the initial seller's offer price exists or more than one same price exist as shown in <Figure 1>. If the buyers' counter offer prices have one price, which matches the seller's initial offer price,  $P_s^{\max} = P_{b1}$ , as shown in <Figure 1>, then the counter offer is accepted and the negotiation ends. When there are more than one same price, namely,  $P_s^{\max} = P_{b1}, P_{b4}$ , the buyer who came to the negotiation arena first will be accepted and the negotiation ends.



<Figure 1> When the same proposed prices (Buyer's counter offer price) of Buyer as the Seller's maximum price exist.

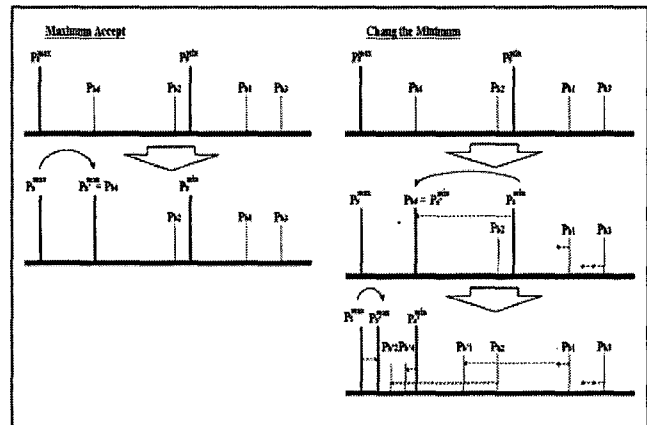
Second is the case in which buyers' counter offer prices are all lower than the seller's minimum offer price  $P_s^{\min}$  as shown in <Figure 2>. Here, two cases make take place as well.



<Figure 2> When Buyers' counter offer prices are lower than Seller's minimum price.

Depending on the seller's negotiation intention, the negotiation can end or continue by adjusting the buyers' counter offer prices to be included between the seller's maximum and minimum prices. The seller presents a new counter offer price from  $P_s^{\max}$  to  $P_s^{\min}$  to all the buyers and requests buyers to take a new action with regard to the offered price.

Third is the case in which all the buyers' counter offer prices are between the seller's initial maximum price and minimum price or one or more of the buyers' counter offer prices are between the seller's maximum and minimum price range as shown in <Figure 3>. If the seller is satisfied with the highest price of the buyers' prices, he/she will accept the buyers' price, but if not, new negotiation should continue through new pricing. To set revised counter-offer, the seller changes buyers' highest price to seller's minimum price and set a new counter-offer price  $P_s^{\min}$  and presents it to the buyers and this process repeats. In doing so, negotiation can end, depending on the seller's negotiation intention, because buyers' counter offer prices do not reach the seller's minimum price, or when seller's new counter-offer is presented to them, the buyers are induced to present their counter-offer prices stand between the seller's maximum and minimum prices to continue the negotiation.



<Figure 3> When Buyers' counter offer prices are within the range of Seller's maximum and minimum prices.

### 3.3 Negotiation Scenario of SOMCoN

The following <Table 4> shows a negotiation scenario in a chart format. The next flow chart following <Table 4> shows overall flow chart of the process by each situation processing explained in the seller's pricing method in the previous Chapter. In this scenario, negotiation starts with a seller's initial maximum price notification. Buyers assess the offer and the maximum and minimum price range changes. And then optimal offer is presented by repeating the process. The situations are classified into three cases, depending on received counter-offers from buyers, after seller's proposing the initial offer. Depending on the

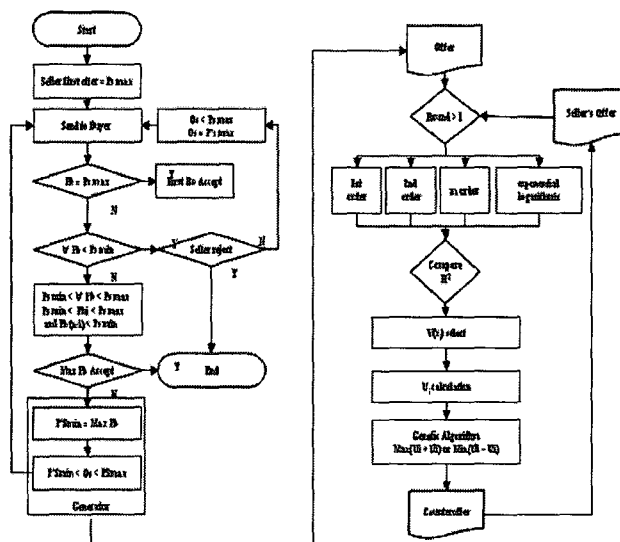
situations and results, the process repeats, respectively. In <Table 4>, the repetition of negotiation has been shown.

<Table 4> Negotiation Scenario

<p>1. Seller sets its desired maximum price (<math>P_s^{max}</math>) and minimum price (<math>P_s^{min}</math>).</p> <p>2. The seller sends the set <math>P_s^{max}</math> to buyers concurrently. (offer)</p> <p>3. The seller receives the message of counter offer from buyers.</p>
<p>1. When there are the same counter-offer prices from buyers as the seller's initial offer price:</p> <p>1.1 In the case of one same price as the seller's offer price</p> <p>1.1.1 The seller sends an acceptance message to the buyer and the negotiation ends.</p> <p>1.2 In the case of more than one same price as the seller's offer price</p> <p>1.2.1 The seller sends a acceptance message to the buyer who has arrived to the negotiation arena first and the negotiation ends.</p>
<p>2. When the counter-offer prices of buyers are all lower than seller's minimum price</p> <p>2.1 When trying to pull up the Buyers' counter offer prices higher than seller's minimum price.</p> <p>2.1.1 The seller generates a new counter offer price <math>P_s^{max}</math> lower than the offered maximum price (<math>P_s^{max}</math>).</p> <p>2.1.2 The seller sends the newly proposed counter-offer price to buyers and wait for messages from the buyers.</p> <p>2.1.3 Continue the negotiation moving to the 3rd stage.</p> <p>2.2 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).</p> <p>2.2.1 The seller sends a rejection message to buyers and the negotiation ends.</p>
<p>3. 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.</p> <p>3.1 When the seller is satisfied with the highest price among the counter offer prices of buyers and accept the price</p> <p>3.1.1 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.</p> <p>3.2 When the seller is not satisfied with the highest price of the buyers.</p> <p>3.2.1 Instead of the seller's minimum price, set the highest price of the buyers and construct it as the seller's minimum price.</p> <p>3.2.2 The seller sets a new counter offer price between the seller's maximum price and the newly set minimum price (buyers' highest price)</p> <p>3.2.3 The seller sends the newly constructed counter offer price to the buyers and waits for messages from the buyers.</p> <p>3.2.4 Continue the negotiation by moving to the 4th stage.</p>

3.4 Counter Offer Price Constructing Process

Quantification of how much the pertinent negotiator is satisfied with negotiation proposals on each negotiation attributes is difficult. This is affected by an evaluation function that is adopted by a negotiation agent, according to its strategy. Each agent can use different evaluation functions, which can have an impact upon the satisfaction of negotiators. Therefore, negotiation agents should have various evaluation functions depending on each negotiation attribute, and it is required to possess the evaluation functions that can reflect satisfaction on the offers of negotiators. As a general offer evaluation method, linear evaluation function expressing the offer as linear and relative expected value of each offer within the limited range of negotiation attribute (maximum price and minimum price of negotiation attribute) is used, and the study on non-linear expected value has not been greatly performed[4], [5] and [6].



<Figure 4> One to N Negotiation Process and Counter Offer Generator

The change transition of offers with regard to each attribute of negotiators is predicted through the least-square approximation method and it was used as evaluation function of each offer. In constructing evaluation function through the least-square approximation method, the evaluation function can have the characteristics of various functions, such as linear function or quadratic function, according to negotiation rounds; thus, the nth order evaluation function, that is, polynomial function, as well as the evaluation functions like linear, quadratic, exponential and logarithmic, were simultaneously applied. The evaluation function model predicted through negotiation process is shown in formula (1). In each formula, are estimated at every negotiation round. Here, indicates negotiation round and indicates negotiation attribute.

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

Hence, the values of are drawn by the least squares approximation method algorithm. At every negotiation round, the selection of estimated multiple functions is to select the evaluation function with the highest explanation capability by comparing the coefficients of determination as shown in formula (2).

$$R^2 = \frac{SSR}{SST} \tag{2}$$

Here, the total sum of squares (SST) is the value expressing the left term of formula (3), which means total changes or total sum of squares. The regression sum of squares (SSR) is the value expressing the second term the right of formula (3), which means regression change or sum of regression squares.

$$\sum_{i=1}^n (y_i - \bar{y})^2 = \sum_{i=1}^n (y_i - \hat{y})^2 + \sum_{i=1}^n (\hat{y}_i - \bar{y})^2 \tag{3}$$

The seller submits its counter offer for the next round through counter offer generation section in the figure, according to the selection of an evaluation function through estimation by the least squares approximation method and comparison of.

#### 4. Conclusion & Discussion

The methodology of SOMCoN proposed in this study is to increase the utility of each negotiator's negotiation in consideration of negotiation attributes and strategies, as well as continuous negotiation rounds targeting multiple negotiators.

The results obtained in this study can judgmentally be applied to used articles market and real estate market online. Generally, prices are not clearly set and single type of articles is sold in the used articles and real estate markets; therefore, continuous negotiations are needed. In the used articles market, the prices of most articles do not exceed their costs and there are upper limits on the prices of the articles, except for articles with high scarcity or antiques that can have value above their costs. In the real estate market, the optimum price range of real estate trading prices exists, due to revision of laws and introduction of systems to prevent speculation and tax evasion in Korea, in view of large fluctuation of real estate prices, according to demand and a big gap between declared values and actual market values. Looking at the application of the protocol proposed in this dissertation, its application is forecast to be adequate to the markets mentioned above, because their maximum

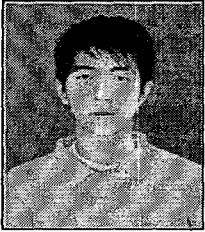
values are restricted and the negotiation prices are set within the given range.

For the follow up study process, feasibility verification seems to be needed through comparison of the system proposed in this study with various negotiation systems currently operated in the online system. In addition, assessment of satisfaction of the real trading experiment participants through application of the system to actual used articles market or real estate market is considered to be required.

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