Negotiation Supports in a Commodity Trading Market

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Abstract
Advanced electronic trading systems, such as the third phase of the TELCOT system, provide a negotiation mechanism for traders. The purpose of such a negotiation mechanism is to make the trading procedure more flexible. In principle, an electronic trading system establishes an environment in which traders select their partners based on posted trading terms such as product bid/offer prices, product attributes, and trading terms. Most trading systems, including the first and the second phases of the TELCOT system, assume that trading terms are fixed once they are posted by traders. The third phase of the TELCOT system, on the other hand, allows buyers to negotiate prices of sellers’ products. As a result, the third phase of the TELCOT system increases the total volume of products traded in the market. However, its negotiation capacity is restricted in that a buyer can extend only one counter-offer to a seller and it does not provide any support functions such as the negotiation price estimation. Assuming the improvement of the third phase of the TELCOT system, we propose negotiation support functions of the elicitation of a buyer’s preference on sellers and the estimation of negotiation prices. The preference elicitation is based on hierarchical constraint satisfaction, which is a technique of multi-constraint decision making. The negotiation price estimation function is proposed as a function of a buyer’s and seller’s price requirements, and the market quote.

Keywords: Commodity Trading, Electronic Marketplace, Hierarchical Constraint Satisfaction, Negotiation Support

1. Introduction
An automated system serving as a trading intermediary in an electronic marketplace reduces traders’ costs of searching for trading partners, and this reduction leads to increases in the efficiency of trading transactions (Bakos, 1991). Such cost reduction and increases in the trading transaction efficiency brought many forms of automated trading systems (Malone, Yates, & Benjamin, 1987), such as the TELCOT system for cotton trading (Lindsey, Cheney, Kasper, & Ives, 1990).

In commodity trading, a trader acquires potential trading partners’ information of the commodity and decides trading partners in a certain time limit. In traditional trading of the commodity with heterogeneous attributes, traders negotiate over variable trading terms such as prices, delivery dates, and payment terms. During a negotiation, a buyer and a seller consider attributes of commodity, and bid/offer trading terms to the other. An electronic commodity trading system, replicating the traditional commodity market, should facilitate certain negotiation supporting mechanisms. For instance, the third phase of the TELCOT system provides a primitive form of negotiation environment, through which a buyer can examine a seller’s posted information of the commodity price and other attributes, and offer a trading price of the commodity.

An improved form of negotiation environment should provide at least the market information and traders’ preference analyses functions (Robinson, 1997). That is, it should help a trader retrieve information on potential trading partners’ products and establish a preference order on them, so that the trader can start negotiation with the most preferable trading partner. In addition, a price determination function would be desirable in such a negotiation environment. Yen, Lee, and Bui (1996) propose such a negotiation support environment in a trading system called the intelligent clearinghouse. After considering traders’ product and trading constraints, it establishes a trader’s preference order on his potential trading partners and proposes a negotiation price in the middle point between the bid and the offer prices. This negotiation procedure is performed from the market-maker’s point of view. That is, the market-maker acts as an arbiter reducing the gap of sellers and buyers’ conflicting trading requirements.
We propose, in this paper, a negotiation support environment for buyers, which can improve the third phase of the TELCOT system. The negotiation price suggestion mechanism is more sophisticated, which is based on not only buyers’ and sellers’ price constraints but also the current market quote and the quote changes. A buyer’s preference ordering on sellers is considered as a hierarchical constraint satisfaction problem (Wilson & Borning, 1993). The goal of the proposed negotiation support environment is to facilitate buyers with a flexible trading market and to improve the effectiveness of the market.

Oliver (1996) proposes sixteen types of electronic commerce systems, which are classified by factors of negotiation vs. non-negotiation, system autonomy, the number of parties under consideration in trading partner selection, and the number of issues, i.e., attributes considered in trading partner selection. The negotiation support environment of this paper assumes that the trading market allows negotiation of trading terms of price, product delivery terms, etc. The system itself does not make binding offers; it supports traders to conduct negotiation during the process of trading partner selection. That is, the system does not have an automated negotiation capability. Each trader evaluates more than one potential trading partners. Thus, the trading partner selection is a multilateral matching process. Even though we focus on the negotiation of price, we do not exclude the possibility of negotiation of other trading terms. The proposed negotiation support environment, therefore, corresponds to Oliver’s category of multilateral and multi-issue negotiation systems without autonomous negotiation decision capabilities.

2. TELCOT and negotiation support systems

TELCOT is a computer-based real-time cotton trading system which is developed by Plains Cotton Cooperative Association (Lindsey et al., 1990). There are three phases of trading provided by the TELCOT system. The first phase with regular offers collects buyers’ bids for 15 minutes and selects a highest bidder whose price is not lower than the lowest price requested by sellers. This phase is a replica of floor trading of stocks. The second phase with firm offers improves the first phase by allowing a seller to offer a firm ask price, which is analogous to a sell offer in stock markets. The firm ask price remains until the seller’s products are sold or the seller withdraws it. A buyer who accepts the seller’s firm ask price first is selected as the trading partner.

The third phase of the TELCOT system supports a counter-offer function, through which a buyer can notify a seller an offer price based on the seller’s requested price. Thanks to its negotiation capacity, this counter-offer function has gained popularity among buyers. Its main advantage is the flexibility in trading agreement that increases the trading volume significantly; that is, a counter-offer may result in trading that otherwise would not occur in the second phase with firm offers (Lindsey et al., 1990). However, its negotiation capacity is limited in that upon a buyer’s counter-offer, the seller must either accept or reject, but he is not allowed to propose a further counter-offer to the buyer.

Even though the third phase of TELCOT significantly improves the previous phases by facilitating a real-time negotiation environment, its supporting capacity is very primitive. It provides an interactive system through which buyers can collect market information and propose counter-offer prices to sellers. However, it does not provide any function for buyers to establish preference orders on sellers. Further, it does not support buyers in the determination of counter-offer prices of sellers’ products. It is up to individual buyers to analyze market information, select sellers to negotiate with, and determine negotiation prices.

Yen et al.’s (1996) intelligent clearinghouse is a brokerage system that facilitates negotiation functions from the market-maker’s point of view. It assumes that both sellers and buyers post their buy and sell orders. With a certain protocol, it matches traders based on their posted trading requirements such as bid and offer prices. When there are traders who fail to find their trading partners, the clearinghouse determines pairs of traders if some minimal changes in their trading requirements would satisfy each other. Then, it suggests specific trading terms to both parties so that their trading requirements would agree. For instance, when the discrepancy between the sell and buy orders is due to their bid and ask price difference, it proposes a negotiation price at the middle point between the two prices.

The intelligent clearinghouse has a market structure that is different from the third phase of the TELCOT system. The TELCOT system acts as a marketplace-provider. It is mainly a buyer who finds his trading partners. If the buyer does not agree on a specific seller’s posted price, the system provides a channel for the buyer’s counter-offer and the seller’s response. However, the intelligent clearinghouse acts as a match-maker who determines trading partners of buyers and sellers if their trading terms are agreeable. Otherwise, it arbitrate between buyers and sellers in their discrepancy in trading terms.

The third phase of the TELCOT system and the intelligent clearinghouse provide negotiation support environments that establish on-line channels for negotiation or supply and analyze negotiation information. Their main goals are not the automation of negotiation, but the increase of trading effectiveness or productivity by supporting humans in contracting and trading situations.

There is another stream of research on negotiation support systems in electronic commerce, which aims at automated negotiation, corresponding to Oliver’s (1996) elec-
t = seller:offer

Figure 1. Trading negotiation procedure

Electronic commerce systems with intelligent autonomous negotiation agents. Beam and Segev (1997) further classify them into two types: one with learning capabilities and the other without learning capabilities. An automated negotiation support system without learning capabilities has intelligent artificial negotiation agents which have a knowledge-base with negotiation strategies programmed by human negotiation experts. In an automated negotiation support system with learning capabilities, intelligent artificial negotiation agents have machine learning capabilities, often without initial knowledge of negotiation strategies. They build negotiation strategy knowledge through training or actual negotiation sessions.

Chavez and Maes’s (1996) Kasbah is an agent-based negotiation environment for trading without learning capabilities, which autonomously performs negotiation and determines trading partners based on buyers’ and sellers’ negotiation strategies programmed to it. Dworman, Kimbrough, and Laing (1996) and Oliver (1997) present more advanced intelligent autonomous negotiation agents based on genetic algorithms with learning capabilities.

In the following section, we propose a negotiation support environment in a TELCOT-like trading market. We do not purport to develop an automated negotiation support system like Dworman et al.’s (1996) and Oliver’s (1997) systems; instead, we propose a few functions, e.g., negotiation price determination and evaluation of potential trading partners, crucial for negotiations in electronic marketplaces, which are similar to two of the three main features of the Kasbah negotiation agent system. The proposed negotiation support environment corresponds to a multilateral negotiation support system without an autonomous negotiation decision capability in Oliver’s (1996) framework for electronic commerce systems. Nevertheless, we expect that such additions to systems like TELCOT will contribute to the increase in trading effectiveness.

3. Negotiation support functions

In traditional trading, negotiation starts with a seller’s offer to sell his products under certain trading terms such as a price. Upon a seller’s offer, a buyer either accepts the offer, rejects the offer, or proposes a counter-offer, unless the seller revokes the offer; upon the buyer’s counter-offer, the seller either accepts the counter-offer, rejects the counter-offer, or proposes a further counter-offer, unless the buyer revokes the counter-offer; and so on. This typical trading negotiation is illustrated in the Petri net of Figure 1 (in which circle nodes labeled by $p_i$ denote states of affairs, or trading situations at specific moments, bar nodes labeled by $t_j$ denote traders’ actions and responses that change trading situations, and directed arcs denote pre- and post-conditions of actions.)

In a commodity trading market, sellers’ initial offers are made by posting their price requirements and commodity attributes. If we consider the trading negotiation procedure of Figure 1 in a commodity trading market, $p_0$ is the initial market situation to sellers who enter the market. From $p_0$, a new state $p_1$ is reached when a seller posts his product and trading attributes ($t_0$). The state $p_1$ is the initial market situation to a buyer who enters the market. At that situation, the public information on sellers’ products is available to the buyer. The negotiation support environment, then, estimates the buyer’s counter-offer prices (i.e., negotiation
offer prices) of outstanding sellers and establishes a preference order on sellers’ products. Note that the estimation of negotiation offer prices is performed before the preference ordering on sellers’ products. That is, in the preference elicitation, the negotiation support environment uses the estimated negotiation offer prices, instead of sellers’ posted prices of products.

As the result of the preference ordering, the buyer selects sellers for trading or negotiations. At \( p_1 \), the buyer can take one of three actions for each of the outstanding sellers, unless the seller has revoked his initial offer; e.g., to reject a specific seller’s terms \( (t_2) \) by not responding to the seller if the seller is not selected, to accept a specific seller’s terms \( (t_3) \) if the seller is selected and his offer price is acceptable without further negotiation, or to extend an offer to buy to the seller \( (t_4) \) with terms and an offer price that the buyer determines based on the suggested negotiation offer price, if the seller is selected and his offer price is to be negotiated. When the buyer extends an offer to the seller \( (p_4) \), now, it is up to the seller who can either reject the buyer’s counter-offer \( (t_6) \), accept it \( (t_7) \), or extend a further counter-offer to the buyer \( (t_8) \), unless the buyer has revoked his offer to the seller. Upon the seller’s counter-offer \( (p_7) \), the buyer has the same options to respond.

In the course of the trading negotiation procedure in a trading market, the proposed negotiation environment provides two functions: (1) the estimation or suggestion of negotiation offer prices and (2) the elicitation of preference on sellers’ products from sellers’ product and trading attributes and a buyer’s trading constraints. In the following sections, these two functions are described in detail.

### 3.1. Estimation of negotiation offer prices

Yen et al.’s (1996) intelligent clearinghouse system estimates a negotiation price in the middle point between a seller’s bid price and a buyer’s offer price, when the offer price is lower than the bid price. Chavez and Maes’s (1996) Kasbah negotiation agent system has a more sophisticated negotiation price estimation function, which is based on buyers’ and sellers’ range of trading prices, that is, those between a desired price and a highest (or lowest) acceptable price. Still, the negotiation price estimation is a function of buyers’ and sellers’ prices. In this paper, however, we view that a negotiation price \( (offer_{ij}) \) offered by buyer \( j \) to seller \( i \) at time \( t \) depends not only on the seller \( i \)'s bid price \( (bid_i) \) and the buyer \( j \)'s target price \( (target_j) \), but also the market quote at \( t \) \( (quote_t) \) and the quote change \( (q_{change}), \) \( q_{change} = \frac{quote_t - \alpha}{quote_t - \gamma}. \)

Buyer \( j \)'s target price is a price of commodity that \( j \) subjectively considers is reasonable. It corresponds to a buyer’s desired price (i.e., “what the user wants to pay for the good”) of the Kasbah negotiation agent system (Chavez & Maes, 1996). On the other hand, a buyer’s price constraint, which is used in the elicitation of preference on sellers, contains a price corresponding to the buyer’s highest acceptable price (i.e., “the highest price the user is willing to pay for the good”) of the Kasbah negotiation agent system. The major difference between the target price and the desired price of Kasbah is: the target price is one of factors for the estimation of the negotiation offer price, which is to be close to the target price, on the other hand, the desired price is the lower boundary (and the highest acceptable price the upper boundary) of the negotiation offer prices. That is, the target price is not necessarily the lower boundary of the negotiation offer prices.

The quote change is expressed by an index between 0 and 1, measuring the historical movement of quotes in the market. It is determined from each seller’s bid price, the buyer’s target price, and the estimated quote in the future \( (e_quote_{t+1}) \) obtained through a time series analysis on past quotes. The details of the estimation of negotiation offer prices are as follows.

1. If a seller’s bid price is lower than both the buyer’s target price and the current market quote, then the estimated negotiation price is the seller’s bid price. That is, in the case of

\[
\begin{align*}
\text{bid}_i &< \text{target}_j < \text{quote}_t,
\end{align*}
\]

or

\[
\begin{align*}
\text{bid}_i &< \text{quote}_t < \text{target}_j,
\end{align*}
\]

where the ‘x’ mark indicates an approximate position for the estimated price, the estimated offer price is:

\[
offer_{ij} = bid_i.
\]

Note that a negotiation offer price must not be suggested higher than the seller’s bid price, because we can hardly imagine any trading situation in which a buyer pays more than what a seller is asking for. If the suggested negotiation offer price equals to the seller’s bid price, there is no need for negotiation; the buyer can buy the seller’s product at the seller’s bid price.

2. If a seller’s bid price is lower than a buyer’s target price but higher than the current market quote, then the estimated offer price is between the current quote and the seller’s bid price. That is, in the case of

\[
\begin{align*}
\text{quote}_t &< \text{target}_j < \text{bid}_i,
\end{align*}
\]

the estimated offer price is:

\[
offer_{ij} = quote_t + q_{change} \cdot (\text{bid}_i - \text{quote}_t).
\]

The quote change index is

\[
q_{change} = \min \left\{ \max\left\{ e_{quote_{t+1}} - \text{quote}_t, 0 \right\}, \left\| \frac{\text{bid}_i - \text{quote}_t}{\text{bid}_i - \text{quote}_t} \right\| \right\}.
\]
That is, if the estimated quote at $t_1$ is higher than the seller’s bid price, then the index is 1; if the estimated quote at $t_1$ is lower than the quote at $t$ then it is 0; otherwise, it is a ratio of the quote difference to the quote-bid difference. The parameter $\alpha > 0$ measures the buyer’s urgency.

3. If the buyer’s target price is higher than the current quote but lower than a seller’s bid, then the estimated offer price is between the current quote and the buyer’s target price. That is, in the case of

$$ q_{\text{change}} = \min \left\{ \frac{\max \{ e_{\text{quote}_{t+1}} - \text{quote}_t, 0 \}}{\text{quote}_t - \text{target}_j}, 1 \right\}. $$

That is, if the estimated quote at $t + 1$ is higher than the buyer’s target price, then the index is 1; if the estimated quote at $t + 1$ is lower than the quote at $t$ then it is 0; otherwise, it is a ratio of the estimated quote-target difference to the quote-target difference.

4. If the buyer’s target price is lower than a seller’s bid price which is lower than the current market quote, the estimated offer price is between the buyer’s target price and the quote price. That is, in the case of

$$ q_{\text{change}} = \min \left\{ \frac{\max \{ e_{\text{quote}_{t+1}} - \text{quote}_t, 0 \}}{\text{quote}_t - \text{bid}_i}, 1 \right\}. $$

That is, if the estimated quote at $t + 1$ is higher than the quote at $t$, then the index is 1; if the estimated quote at $t + 1$ is lower than the buyer’s target price, then it is 0; otherwise, it is a ratio of the estimated quote-target difference to the quote-target difference.

5. If the buyer’s target price is lower than the current quote which is lower than a seller’s bid price, then the estimated offer price is between the buyer’s target price and the seller’s bid price. More specifically, if the current quote is rising, it is between the quote and the seller’s bid price; if the current quote is dropping, it is between the target price and the quote. That is, in the case of

$$ q_{\text{change}} < 0.5 $$

the estimated offer price is

$$ \text{offer}_{ij} = \text{target}_j + (2 \cdot q_{\text{change}}) \cdot (\text{quote}_t - \text{target}_j), $$

if $q_{\text{change}} < 0.5$; otherwise,

$$ \text{offer}_{ij} = \text{quote}_t + [2 \cdot (q_{\text{change}} - 0.5)] \cdot (\text{bid}_i - \text{quote}_t). $$

The quote change index is

$$ q_{\text{change}} = 0.5 \cdot \frac{\max \{ e_{\text{quote}_{t+1}} - \text{quote}_t, 0 \}}{\text{quote}_t - \text{target}_j}, $$

if $e_{\text{quote}_{t+1}} \leq \text{quote}_t$; otherwise,

$$ q_{\text{change}} = 0.5 \cdot \min \left\{ \frac{e_{\text{quote}_{t+1}} - \text{quote}_t}{\text{bid}_i - \text{quote}_t}, 1 \right\} + 0.5. $$

When the estimated quote at $t + 1$ is higher than the quote at $t$: if the estimated quote at $t + 1$ is lower than the buyer’s target price, then the index is 0; otherwise, it is a ratio of the estimated quote-target difference to the quote-target difference. When the estimated quote at $t + 1$ is higher than the quote at $t$: if the estimated quote at $t + 1$ is higher than the seller’s bid price, then the index is 1; otherwise, it is a ratio of the quote difference to the quote-target difference.

As noted previously, the future quote, a key factor in the determination of negotiation prices, is to be estimated through a time serious analysis. Since we are estimating the quote in the near future, it is desirable to apply techniques of exponential smoothing in order to place more weights on recent quote data. Among the components of the time series analysis, the irregular component may contain not only the well-behaved white noise but also the ill-behaved pink noise. In the time series analysis, the pink noise, which typically has big deviations, must be excluded. However, due to the effect of the pink noise, the current quote may be severely overstated or understated. Thus, for quote$_i$ in
the above methods to determine negotiation prices, instead of using the actual quote at \( t \), we may use the quote value at \( t \) determined by the curve obtained as the result of the time series analysis. When the deviation of the white noise is substantially big, it will also eliminate the effect of the white noise.

3.2. Elicitation of preference on sellers

Assume a set of sellers, in which seller \( i \) is characterized by \( n \) product attributes \( a_{i1}, a_{i2}, \ldots, a_{in} \) posted in the trading market or determined by the previous negotiation price estimation methods. Let \( x_k \) be a variable for a product attribute over the domain of \( D_k \). A buyer’s arithmetic constraint is an expression of ‘\( x_k = d'\), ‘\( x_k \leq d'\), or ‘\( x_k \geq d'\), where \( x_k \) is over a numeric domain \( D_k \). The function \( e(c, i) \) for a constraint \( c \) and a seller \( i \) measures the degree of the satisfaction of the constraint \( c \) by attributes of the seller \( i \)’s product. That is, \( e(x_k = d, i) = |d - a_{ik}|, e(x_k \leq d, i) = \max\{a_{ik} - d, 0\}, \) and \( e(x_k \geq d, i) = \max\{d - a_{ik}, 0\} \). A Boolean constraint is either \( x_k = d \) or \( x_k \neq d \), where \( x_k \) is over a non-numeric domain \( D_k \). A Boolean constraint is evaluated in such a way that \( e(d_k = d, i) = 0 \) if \( a_{ik} = d \); otherwise, \( e(d_k = d, i) = 1 \); and \( e(d_k \neq d, i) = 1 - e(d_k = d, i) \).

Suppose the buyer has a set \( C \) of constraints that are hierarchically organized by the importance of constraint satisfaction (Wilson & Borning, 1993). That is, the set \( C \) of constraint is partitioned to \( \Pi_c = \{\pi_1, \pi_2, \ldots, \pi_m\} \), such that the satisfaction of constraints in \( \pi_c \) is more important than the satisfaction of constraints in \( \pi_c' \) if and only if \( k < k' \).

It is required that the buyer specifies a price constraint. The product constraint has an upper-bound price, which the buyer is willing to pay for products. In general, it is not lower than the target price that was used to estimate the negotiation offer price in the previous section. The price constraint is on a negotiation offer price, not on a seller’s bid price, because the actual trading price is negotiable. Thus, a buyer’s preference ordering on sellers is in part based on the potential trading prices, not on sellers’ bids.

If the buyer’s constraints are linearly ordered, that is, every \( \pi_c \) is a singleton set, we can use a simple pairwise lexicographic comparison (Wright, 1975) to determine the preference on sellers. That is, a seller \( i \) is preferred to another seller \( i' \) if for some \( k \leq m \),

\[
e(c_k, i) < e(c_k, i') \quad \text{and} \quad e(c_l, i) = e(c_l, i') \quad \text{for every } l < k.
\]

In general, however, we must have an aggregation operator (Wilson & Borning, 1993) or utility function (French, 1988; Roberts, 1979) \( \sigma_l \) for each \( \pi_c \) in order to define:

\[
E(\pi_c, i) = \sigma_l(\{e(c_1, i), e(c_2, i), \ldots, e(c_p, i)\}),
\]

where \( \pi_c = \{c_1, c_2, \ldots, c_p\} \). Then, a seller \( i \) is preferred to another seller \( i' \) if for some \( k \leq m \),

\[
E(\pi_c, i) < E(\pi_c, i') \quad \text{and} \quad E(\pi_l, i) = E(\pi_l, i') \quad \text{for every } l < k.
\]

In the initial elicitation of the preference on sellers, the estimated negotiation offer price for each seller (or an offer price that the buyer determines based on the estimated negotiation offer price) is evaluated against the buyer’s price constraint. Upon a seller’s counter-offer, the buyer has two options. First, he can consider the seller’s counter-offer price as a firm price and re-elicit the preference on sellers based on the evaluation of the counter-offer price against the buyer’s price constraint. Second, he can increase the target price for the seller, re-estimate the negotiation offer price for the seller, and then re-elicit the preference on sellers. When the negotiation offer price was higher than the original target price, the new target price for the seller would be between the negotiation offer price and the original target price.

The above negotiation offer price estimation and preference elicitation methods restrict the use of a seller’s simple strategy of bidding as high as possible and a buyer’s corresponding strategy of setting the target price and the highest acceptable price as low as possible. With all other factors remaining the same, the estimated negotiation offer price for a seller will not be lower than those for sellers with lower bid prices. This does not support sellers’ strategy of inflating bid prices. However, if the negotiation offer price for a seller is estimated higher due to his high bid price, he will be evaluated lower in a buyer’s preference ordering on sellers. Thus, he has smaller change to receive offers from buyers.

With all other factors remaining the same, a buyer with a lower target price will estimated negotiation offer prices that are not higher than those with a higher target price. Since it is a multilateral trading situation and thus there is a competition among buyers, however, with low negotiation offer prices, his chance to succeed in transaction becomes low. This implies that the buyer’s strategy to lower the target prices and negotiation offer prices as an effect does not guarantee better deals.

3.3. An example

Assume that sellers are to post the product price, fiber length, and color in a cotton trading market. The the color attribute is measured by a real number between 0 and 1 denoting the gray scale based on the market’s color specification standards. Suppose there exist three sell orders: \( s_1 = (30.20, 12, 0.5) \), \( s_2 = (31.50, 13, 0.7) \), and \( s_3 = (31.30, 11, 0.6) \). Let the buyer’s target price be
$29.15, the current quote $31.10, and the quote change index 0.6. Further assume the buyer urgency index is 1. Then, the estimated negotiation offer prices are

\[ o_1 = \min\{29.15 + 0.6 \cdot (31.10 - 30.20), 30.20\} = \min\{29.42, 30.20\} = 29.69, \]

\[ o_2 = 31.10 + 2 \cdot (0.6 - 0.5) \cdot (31.50 - 31.10) = 31.18, \]

and

\[ o_3 = 31.10 + 2 \cdot (0.6 - 0.5) \cdot (31.30 - 31.10) = 31.14, \]

respectively.

Suppose the buyer has a price constraint of \( x_1 \leq 31.15 \), which is the most important, a color constraint of \( x_3 \geq 0.6 \), and a fiber length constraint of \( x_2 \geq 13 \), which is the least important. By the price constraint, \( s_1 \) and \( s_3 \) are preferred to \( s_2 \). By the color constraint, \( s_3 \) is preferred to \( s_1 \). Thus, \( s_3 \) is selected as the seller to be negotiated with. Upon the buyer’s offer to buy \( s_1 \)’s product at the price of $31.14, suppose \( s_3 \) extends a counter-offer with the price of $31.16. The buyer considers it as the seller’s firm price. Now, among the three sellers, \( s_1 \) is the most preferable. Thus, the buyer extends an offer to buy \( s_1 \)’s product at the price of $29.69. Upon the seller’s acceptance of the price, the buyer’s search for his trading partner succeeds.

### 3.4. Extensions

So far, we have presented a negotiation support environment for buyers with functions of negotiation offer price estimation and elicitation of preference on sellers. In this section, we sketch a few on-going research subjects, which extend the proposed negotiation support environment.

The buyer’s target price is one of factors governing the estimation of negotiation offer prices. We viewed that the target price is a price that the buyer subjectively considers as a fair price of sellers’ products, corresponding to a buyer’s desired price of the Kasbah negotiation agent system (Chavez & Maes, 1996). If the target price is unreasonably too low, the estimated negotiation offer price may be also very low and the buyer has a bigger chance to fail the negotiation. Thus, it would be desirable for the negotiation support function to assist the buyer in the determination of a reasonable target price. This is an issue that will be addressed in the future extension of the paper.

In the elicitation of preference on sellers, a buyer’s negotiation offer prices, instead of sellers’ posted or counter-offered prices, are considered. One drawback is that, in principle, negotiation prices for all sellers must be estimated, and it will cause a computational overhead. However, certain heuristics can reduce the number of sellers for whom the negotiation offer prices are to be estimated. For instance, if a seller has non-price requirements or constraints that must be satisfied, their satisfaction will reduce the number of sellers under negotiation considerations. We are currently investigating such heuristics.

In addition to the estimation of negotiation offer prices, there is another important issue, which buyers might expect the negotiation support environment to help determine. Intuitively, if the market quotes are expected to decrease continuously, a buyer may postpone negotiation. However, since the trading market under consideration is a multi-lateral, instead of bilateral, commodity market, buyers are competing. This implies that a buyer looking for some specific buyers’ products cannot wait for a long time. That is, if
a buyer waits more, he may have a better deal; but his chance to have the deal decreases. Another reason supporting our conjecture of the decreasing chance of the buyer’s successful trading is that sellers may want to sell their products as quickly as possible when the market quotes are expected to decrease continuously.

If the buyer knows the probabilites of successful trading negotiation with specific negotiation offer prices at specific negotiation time points, he may determine an optimal negotiation time. As such information is not easily available, we might build a model with the probabilities that sellers are available at specific time points. That is, an approximate model to determine the negotiation time point \( t^* \) for the most preferable seller would be

\[
p_t^* \cdot (\pi - \pi_t) = \max_{\pi \in T} \{ p_t \cdot (\pi - \pi_t) \},
\]

where \( p_t \) is the probability that the seller is available at \( t \), \( \pi \) is the upper-bound price that the buyer is willing to pay, \( \pi_t \) is the offer price for the negotiation at \( t \), and \( T \) is a time span under consideration.

\[4. \text{ Concluding remarks}\]

Negotiation support functions in a trading market can increase the total volume of the traded products by reducing the discrepancy in trading requirements of buyers and sellers who otherwise would not successfully find their trading partners. The third phase of the TELCOT system, aiming at this purpose, introduced a form of negotiation environment. However, its negotiation capacity is restricted in that a buyer can extend only one counter-offer to a seller and it does not provide any support functions such as the negotiation price estimation. Assuming the improvement of the third phase of the TELCOT system, we propose a negotiation support environment, which corresponds to a multilateral and multi-issue negotiation support system without an autonomous or automated negotiation decision capability in Oliver’s (1996) framework for electronic commerce systems, even though only the issue of price was explicitly addressed in the paper. Features the proposed negotiation support environment are summarized in Figure 2.

It provides process functions of the estimation of negotiation prices, the selection of a negotiation party through the elicitation of a buyer’s preference on sellers, and the on-line communication with the selected negotiation party, corresponding to the key negotiation activities of the Kasbah negotiation agent system (Chavez & Maes, 1996). Among these three functions, first two are addressed in the paper. The negotiation support functions utilize the publicly available information such as the price quotes in the market and sellers’ posted trading terms including product attributes and prices, and individual buyers’ private data. Individual buyers’ private data include their trading requirements or constraints and trading terms counter-offered by sellers, which override the posted terms. The second type of private data occurs in the course of a buyer’s negotiation with a seller. For instance, suppose that upon a seller’s posted price of $31.30, a buyer negotiates with the seller with a price of $31.14; next, the seller counter-offers with a price of $31.20. Then, the seller’s counter-offer price of $31.20 becomes the buyer’s private datum, which overrides the seller’s originally posed price of $31.30 in the further negotiation.

The negotiation price estimation function is proposed as a function of a buyer’s and a seller’s price requirements, and the market quote. In the estimation of negotiation offer prices, the market quote change plays an important role. For instance, when the buyer’s target price is lower than the quote but the seller’s bid price is higher than the quote, if the market quote is decreasing, the negotiation offer price is estimated to be between the buyer’s target price and the current quote; if the market quote is increasing, it is estimated to be between the current quote and the seller’s bid price. The preference elicitation is viewed as a problem of hierarchical constraint satisfaction, which is a technique of multi-constraint decision making.

In order to verify the usability of the proposed negotiation support environment, we plan to perform simulations on three different settings: the second phase of the TELCOT system with firm (i.e., non-negotiable) offers of sellers, the third phase of the TELCOT system with one round of buyers’ counter-offers, and the proposed negotiation support environment allowing interactive negotiation sessions between buyers and sellers. The goal of the simulations is to show that the proposed negotiation support environment increases the total volume of products traded in the market. That is, the use of the negotiation support environment would help traders find their trading partners; but without it they would fail to trade.

\[\text{References}\]

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