Intelligent Clearinghouse: Electronic Marketplace with Computer-Mediated Negotiation Supports

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Abstract

In this paper, we propose an intelligent clearinghouse system, an electronic marketplace with computer-mediated negotiation supports. Most existing electronic market systems support relatively stable markets: traders are not allowed to revise their bids and offers during the market transaction. The intelligent clearinghouse addresses dynamic markets where buyers and sellers are willing to change their utilities as market conditions evolve. Traders in dynamic markets may suffer a significant loss if they fail to execute transactions promptly. The clearinghouse enables traders to compromise their original utilities to avoid transaction failures. This paper describes the foundation of the clearinghouse system and discusses its trading mechanism, including its order matching method and negotiation support capabilities.

1 Introduction

Nobody ever saw a dog make a fair and deliberate exchange of one bone for another with other dogs [18]. This observation by Adam Smith reflects human's unique ability for exchanges or market transactions that have eventually evolved our society into a market economy. It is thus very natural for us to have adopted advanced computer and communication technologies to assist market activities, the heart of our market society. Over the last two decades, a variety of electronic commerce systems have been introduced around the world. Thanks to recent development of information superhighway, electronic marketplaces are expected to grow dramatically in their numbers and types within coming years.

Electronic markets in general serve as a middleman between buyers and sellers [1]. Acting as a broker or a dealer, electronic marketplaces allow consumers to purchase products or services electronically without contacting a large number of vendors individually. Most electronic market systems currently under operations support relatively stable markets where traders have fixed utilities and assets. In these stable markets, transactions occur only when traders' buying and selling intentions, that are fixed and explicitly expressed, cross each other. CompuServe's Electronic Mall, for instance, adopt posted-off pricing [19]: sellers post asking prices and buyers decide how many items to purchase at the posted price. If there is no buyer who is willing to pay for the posted price, sellers are likely to face transaction failures because of the price rigidity.

In dynamic markets, market participants are to change their transaction goals or utilities as market conditions evolve. The key difference between dynamic markets and stable markets is the importance of immediate transaction. Buyers and sellers in dynamic markets may suffer a significant loss if they cannot execute transactions promptly. For example, failure of immediate transaction will be disastrous to sellers of perishable goods such as cut flowers. In certain markets, the prices of the goods may change while a trader is waiting for a compatible trading partner. A prolonged transaction may cause a loss to the trader. Thus, traders in dynamic markets are willing to revise their prices or preferences to avoid failure of immediate transactions.

This paper proposes an electronic market system, called intelligent clearinghouse system, that addresses the dynamic markets. In general, existing electronic market systems support relatively stable markets and do not allow traders to revise their utilities during the market transaction. There is no room for negotiations between market participants in those systems. By contrast, the intelligent clearinghouse system includes computer-mediated negotiation supports as well as conventional order matching capabilities. Since the electronic market contains a pool of information about bids and offers, it can provide traders with important guidelines of how to avoid transaction failures by adjusting their utilities to changing market situations. By offering negotiation supports, the intelligent clearinghouse system intends to maximize immediate transactions of traders who otherwise would fail to execute transactions promptly.

In the next section, we briefly review existing ele-
traditional markets, together with their advantages over traditional marketplaces. This is followed in section 3 by the limits of negotiation capacities in current electronic marketplaces. Section 4 describes the intelligent clearing system and section 5 then discusses its trading mechanism, including both order matching and negotiation supports. An example of dynamic markets is discussed in section 6 to illustrate the functionality of the intelligent clearinghouse system.

2 Background: electronic markets

The electronic market effect occurs in the case of computer-based markets where information technologies serve as intermediaries between multiple buyers and suppliers [1]. Electronic marketplaces are of increasing interest around the world since they provide several advantages over conventional markets. The use of IT significantly reduces costs incurred during transactions, from search for a trading partner to trade settlement such as payment [2]. Computer-based market systems also provide an access to virtually anyone at any time, thus easily becoming around the clock global markets [8]. In addition, electronic marketplaces provide regulatory advantages such as electronic audit and surveillance [5].

Over the past few years a large number of electronic market systems have emerged as electronic alternatives for traditional markets. Computer reservation systems, such as SABRE or Apollo, have already evolved from a single source marketing channel to an electronic market system [7]. FAST, a computer network broker for electronic parts and components, helps a buyer transact with a vendor who offers the best price [17]. In Japan, AUCNET is introduced for transacting used cars through TV terminals [22]. Computer on-line shopping systems, such as CompuServe's Electronic Mall, have greatly expanded a prospective consumer base by connecting their networks with Internet, which has become a de facto information superhighway [9]. After merge of Home Shopping Network and QVC, TV home shopping systems are enjoying an unprecedented growth in their retail sales, and are threatening conventional mail order companies [10].

Computer based trading systems are also making inroad into financial and commodity markets. NASDAQ displays dealers' quoted prices on a widely distributed electronic billboard system so that customers can execute transactions at the best dealer bid-offer quote for OTC (over-the-counter) securities trading [23]. The London Stock Exchange also introduced a similar system called SEAQ. The electronic market system, such as CATS, Instinet, INTEX, SOFFEX and Globex, is a market based on fully automatic order matching [6]. Once investors enter their buy or sell orders, a computer based market system matches these orders based on certain trading rules. TELCOT, implemented by the Plains Cotton Cooperative Association (PCCA), is an electronic market system for cotton spot trading [14]. Similarly, EASE is introduced in United Kingdom to replace conventional regional auction markets for agricultural products, such as cattle and grain [3].

3 Need for negotiation supports

3.1 Role of middleman in markets

Every market transaction consists of search, coordination and negotiation [13]. Search reflects efforts by a trader to obtain information on trading counterparts that best fit his or her preferences. Once a few trading candidates are chosen, the next step is coordination, an effort by trading parties to increase their resource utilization and value. If buyers and sellers fail to reach an agreement on transaction terms, negotiations may have to be repeated many times before the contract is finally formulated. The coordination refers to a process to reach an agreement with a prospective trading partner, and thus includes negotiation and contract formation. The trade settlement clears the transactions through physical exchanges of goods and accompanied payment.

The markets of the original economic concept are those where buyers and sellers must bargain with each other directly. Since an individual trader pays for the full cost of locating and bargaining with a compatible trading partner, there is no strong incentive to conduct a complete search for the best trading partner in this direct search market. Failure to conduct a thorough search may cause transactions to occur some distance from the best possible deal. Without any intermediary, all the tasks associated with bargaining and negotiation is undertaken by individual traders.

When trades become sufficiently heavy, middlemen begin to offer specialized search services to market participants [15]. For a fee, brokers try to find compatible trading partners for their clients. Since brokers are frequently in contact with many market participants on a continuing basis, they are likely to know how sellers' product offerings or buyers' bids can be bettered off. Brokers provide these services at a cheaper price than is possible in a direct search market. Their extensive contacts provide them with a pool of information on products and prices which individual traders could not economically duplicate. By charging a commission less than the cost of direct search, they give traders an incentive to make use of their services.

In reality, middlemen provide market participants with services more than just search, and often extends their services to coordination such as negotiations and contract formations. Since brokers charge a commission on the basis of sales, they provide advises to their clients or initiate negotiations in an attempt to secure the transaction. For instance, when a home buyer cannot find a
property that satisfies his preferences in terms of price and location, a real estate broker may advise how he can realize his buying intention by relaxing his budget constraints or preferences on locations. Similarly, financial brokers, who have an access to information of trading activities and price movements in trading floors, often help their clients execute transactions by suggesting the change of reservation prices.

### 3.2 Lack of negotiation support capability

Most electronic market systems discussed above serve as an intermediary between buyers and sellers. Acting as a middleman between suppliers and customers who otherwise would have to search out each other by themselves, those electronic market systems significantly reduce the search cost that traders have to bear to locate trading partners. However, their functionality is mainly focused on providing information on trading partners so that traders are better informed about the counter parts. For example, NASDAQ and SEAQ enables investors to find the best dealer quotes, but do not support any negotiations [8]. Coordination between dealers and investors is done by a traditional method (telephone negotiations) when they do not agree with transaction prices. No negotiation supports are provided by the system. There exist a few systems, such as TELCOT, that support primitive negotiations. TELCOT allows buyers to place a counter order to a seller [14]. The role of TELCOT for this coordination, however, is just to forward the counter order message to the associated seller, thus being far from active intermediary services that can be obtained from human brokers (such as advises for compromise).

From an economic viewpoint, equilibrium in a market takes place when all market participants (both sellers and buyers) can carry out their plans: the market clears and all goods are sold. But the real world does not always satisfy this assumption of market equilibrium. Disequilibrium occurs when some market participants cannot realize their original selling and buying intentions. If this is the case, electronic markets can help clear markets by extending their roles into the active intermediary role such as negotiation support. Sellers usually set the reservation (ask) price because they do not have perfect information about consequences of their actions in markets. The reservation price serves as sequentially rational rules under this incomplete market information [20]. If the market condition turns out to be worse than expected, sellers are likely to reduce their reservation prices since otherwise they might fail to sell out their products. Similarly, a buyer may soften his preferences, if he finds it difficult to purchase an item at his terms. This phenomenon is more salient in dynamic markets. The active intermediary service such as negotiation support is crucial to traders who need prompt and secured transactions. The intelligent clearinghouse system aims to provide centralized and computer-mediated negotiation support capabilities to those traders.

### 4 Intelligent clearinghouse system

We delineate the intelligent clearinghouse system that provides centralized computer-mediated negotiations to traders. The intelligent clearinghouse system is an electronic marketplace that addresses dynamic markets, in which market conditions are changing fast over time and traders are likely to revise their original intentions to avoid transaction failures. There are ample examples of markets that exhibit this dynamics: markets for perishable goods, stock markets with fast price movements, and markets for urgent buyers. Since intelligent clearinghouse system contains a centralized database of bids and offers, it can provide market participants with crucial information on how they can increase the possibility of successful transactions by revising their goals and constraints.

The intelligent clearinghouse system consists of communications networks and a central processor. The communications networks link traders' computer terminals with the central processor. Since the clearinghouse requires frequent interactions between traders and the market during the negotiation support process, having a high quality and economical networks is crucial to its successful implementation. Recently, wireless mobile communications have become increasingly popular [11]. The dynamic markets often involves traders on the move. For instance, a buyer of parking lots in downtown area may be driving his or her car in search for a parking space near from the destination. Mobile communications is removing obstacles of space in electronic commerce. The costs of mobile communications are decreasing by twenty five percent every year. Such reduction has made mobile communications affordable to most economic agents that need to do business on the move. With mobile communications and computing, the clearinghouse can accommodate dynamic markets in which the adoption of electronic marketplace was not feasible in the past.

The central processor is a computer-based market system that performs an automatic order matching and provides negotiation supports. The central processor consists of database and a trading mechanism. The database maintains all standing buy and sell orders. When a sell or buy order is received, the trading mechanism first attempts to create transaction by matching the new order with standing counter orders. When the order matching fails, the trading mechanism initiates the negotiation process, which aims to achieve compromises from prospective trading partners for immediate transactions. The rest of the paper will focus on methods that can be employed by the central processor for transactions and negotiations.
5 Trading mechanism of clearinghouse

5.1 Order matching for transactions

The clearinghouse employs a continuous market trading for creating transactions [12]. Transactions can occur whenever a bid and an offer cross on the basis of certain trading rules. The database keeps tracks of all standing buy and sell orders that have been received but have failed to be traded. When a bid arrives, the clearinghouse attempts to match the buy order with one of standing sell orders. Similarly a sell order is attempted to be matched, upon its arrival, with one of standing buy orders. If there is no standing counter orders, bids and offers will be registered as standing orders until eligible counter orders are received or traders cancel their orders.

The transaction for a bid or for an offer is 1-to-N matching: matching of one bid (or offer) against multiple standing sell (or buy) orders. Different trading mechanisms can be employed depending on markets and products sold. In this paper, we speculate a trading mechanism similar to the continuous trading for financial issues. Electronic trading systems for stocks and bonds (such as Instinet and Globex) apply trade matching rules that consider price, quantity and time. The difference of our approach from that of financial continuous market is that the bid and offer received by the clearinghouse include not only price and quantity but also other attributes.

A noncompensatory strategy is incorporated with a lexicographic strategy to determine the transaction (matching). A noncompensatory strategy combines data such that the presence of one attribute does not compensate for the absence of other attributes [21]. This means that a low value on one attribute cannot be offset by a high value on another attribute. A lexicographic strategy ranks attributes in their order of importance and then selects the trading partner rated best on the most important attribute [24]. If there is a tie, the alternative counterparts are compared on the next most important attribute.

The lexicographic strategy requires to list the attributes of products in their order of importance. In our system, the price is the most important attribute, since bid and offer price generally represents the utility of traders over other attributes. Thus, the clearinghouse awards the standing counter order with the best price to an incoming buy and sell order (if those standing orders satisfy conditions for other attributes). The standing buy order with the highest bid price will be assigned to an incoming offer, and the standing sell order with the lowest ask price will be matched to an arriving bid. The transaction price (market price) will be set at the bid (or offer) price of incoming orders. If there are more than two standing counter orders with the best price, the next important attribute will be considered to break the tie. This process will continue until one eligible counter order is remained for the transaction. The last attribute considered is an order arrival time. Thus, if two counter orders have the same values over all attributes, the FIFO (First In First Out) principle will be employed to break the tie. The use of time dimension ensures that only one counter order will be solicited. All incoming orders that are not matched in the transaction process will be forwarded to the negotiation process.

One important consideration is a partial transaction: an incoming buy or sell order may fulfill only part of its demand or supply. If the quantity of a buy (or sell) order is larger than the supply (or demand) of the matched standing sell (or buy) order, the unfulfilled quantity will be attempted to be matched with remaining standing sell (buy) orders. If there is no standing counter order qualified for the matching, the clearinghouse will ask the trader whether he or she is willing to accept the partial transaction. If the partial transaction is confirmed, the unfulfilled quantity will be registered as a standing order for the further transactions. Otherwise (that is, if the trader does not want a partial transaction), the clearinghouse will keep the whole quantity in the standing order list with an additional constraint for the non-partial transaction.

Finally, the information distribution of standing counter orders is crucial for traders to prepare their bids and offers. In financial markets, electronic trading systems (such as Globex and Instinet) display the best two bid prices and ask prices to give traders an idea of the market price movement. The clearinghouse will allow traders to browse standing counter orders before they enter bids and offers. Unlike financial issues, the products sold by the clearinghouse contain multiple attributes beyond price and quantity. Thus, the system will provide an automatic search method by which traders can browse the information on the prospective counter orders.

The operation of transactions can be divided into: (1) collection of bids and offers and (2) order matching. In the beginning of each time period, the clearinghouse receives bids from the buyers and offers from the sellers. We assume n(t) sellers and m(t) buyers enter the market at time t, that is, i = 1, 2, . . . , m(t), and j = 1, 2, . . . , n(t).

The information of the j-th bid is represented by an array that contains l possible requirements bj = \{b_{j1}, b_{j2}, . . . , b_{j1}\}, which include the price and other possible requirements from the buyers, and an array of 0−2 integers bcj = \{bcj1, bcj2, . . . , bcj1\} indicates the conditions of the requirements: 0 for “does not care”, 1 for “negotiable”, and 2 for “not negotiable”. The information of the j-th offer are represented by arrays qj and cqj, which contain similar information to bj and bcj. The ranges of the requirements or conditions, such as price,
can be either ordinal or cardinal. Within the range of each requirement, the utility is assumed to be monotone increasing or decreasing. For example, the utility of 8 dollars is more than the utility of 6 dollars, and the utility of grade “A” product is higher than grade “B” product, and so on.

There are two possibilities that a requirement $b_{ik}$ of buyer $i$ and a condition $o_{jk}$ of seller $j$ is satisfied:

- Either buyer $i$ or seller $j$ indicates he or she does not care about the requirement. That is, $o_{ik} = 0$ or $d_{jk} = 0$.
- For both seller and buyer, the requirement asked or condition specified is accepted by the other side.

The information will not display $b_{ci}$ and $o_{cj}$, though. Thus, if traders seek transactions urgently, they will bid (or ask) price high (or low) enough to secure the transaction. Otherwise, they will attempt to exploit the facility of negotiations by entering their reservation prices that are negotiable.

5.2 Computer-mediated negotiation

The negotiation is initiated when a bid or an offer fails to be transacted, although there exist standing counter orders. The transaction failure results from the discrepancy between buy and sell orders in terms of price and product attributes. The negotiation process is designed to provide traders with advice on how their buying and selling intentions can be realized by adjusting their utilities to new market conditions. It is up to traders whether to accept the advice or not. The advice is most valuable to traders who need prompt transactions and thus are willing to negotiate on the terms of transactions.

Heuristics Principle:

1. The smaller the number of negotiable attributes, the better the deal.
2. Total ordering of importance of attributes.
3. Negotiation is first attempted over negotiable attributes. Non-negotiable attributes are considered only when this first attempt fails.
4. Tie break rule: if the number of attributes negotiated is the same, the counter order with minimum discrepancy will be selected.

5.2.1 Single-attribute negotiation

Heuristics for single attribute negotiation (for buying order $i$):

Case 1: When $k$-th attribute is in the negotiable attributes of buying order $i$, that is, $k \in NAB_i$.

Step 1: Find the set of negotiable selling orders $NS_i$ for buyer order $i$ where all the attributes are satisfied ($b_{im} \in AS$ $o_{jm}$ for all $m$) except $k$-th attribute ($b_{ik} \in ANS$ $o_{jk}$).

1. If no counter order exists ($NS_i = \emptyset$), go to step 4.
2. Otherwise, go to Step 2.

Step 2: Find the subset of negotiable selling orders for $i$-th buying order ($NS^k_i \in NS_i$) where $k$-th attribute is negotiable ($k \in NAS_j$). Then find the one that with smallest discrepancy over $k$-th attribute (if there is a tie, select both $j$).

1. If no such counter order exists ($NS^k_i = \emptyset$), go to step 4.
2. Otherwise, go to Step 2.

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Step 3: Find the subset of negotiable selling orders for i-th buying order \( NS_i^k \in NS_i \) where k-th attribute is non-negotiable \( k \in FAS_j \). Then find the one that with smallest discrepancy over k-th attribute (if there is tie, then rule FIFO is applied).

1. If no such counter order exists \( NS_i^k = {} \), store the buying order \( i \) as a standing order and stop.

2. Otherwise, initiate the negotiation for buyer \( i \). In this case, we cannot use mid-point negotiation, since k-th attribute is not negotiable to j-th seller. Instead, we have to ask the buyer in whether he would like to accept the offer from seller \( j \) that with the smallest discrepancy.

Case 2: when k-th attribute is in the set of non-negotiable attributes of buying order \( i \), that is, \( k \in FAB_i \).

Step 4: The subset of negotiable selling orders for i-th buying order \( NS_i \) where all the attributes are satisfied \( (b_{im} AS o_{jm} \) for all \( m \)) except k-th attribute \( (b_{ik} ANS o_{jk}) \) and \( k \in NAS_j \).

1. If no such counter order exists \( NS_i = {} \), store the buying order \( i \) as a standing order and stop.

2. Otherwise, go to Step 5.

Step 5: Find the subset of negotiable selling orders for i-th buying order \( NS_i^k \in NS_i \). Then find the one that with smallest discrepancy over k-th attribute (if there is a tie, select both \( j \)). Then, initiate the negotiation for buyer \( i \). Send the offer of buyer \( i \) to the seller \( j \) and ask whether it can be accepted or not. If yes, the negotiation is done, otherwise, move on to the next standing seller in \( NS_i^k \).

The negotiation process continues until the beginning of the next time period.

5.2.2 Multiple-attribute negotiation

In most cases, the traders are willing to settle the less important attributes first so they can start negotiating the most important attribute, for example, price. However, it is often that there are more than one attributes do not match. The negotiation process for multiple attributes is more complicated. For this paper, we provide two approaches. The first uses the same heuristics as the single-attribute negotiation. The second is a two-stage process, which settle the less important attributes first and then the most important attribute. It combines the utility theory, multi-criteria decision making, and the concept of convergence.

First Approach

Two guidelines recommended for the first approach are:

1. The set of negotiable attributes \( k \) should be treated as a package.

2. The system should automatically create the negotiation partners \( NS_i^k \).

As mentioned earlier, the attributes have ordering of importance. It may be possible to determine the order of counter orders in \( NS_i \) for negotiation based on the order of attributes. In other words, identify which seller should negotiate first from \( NS_i \).

Case 1: When the set of attributes \( k \) is a subset in the negotiable attributes of buying order \( i \), that is, \( k \in NAB_i \). For example, assume \( k_1 \), \( k_2 \) and \( k_3 \in NAB_i \).

If there are three counter selling orders in \( NS_i \), we can decide which one to negotiate first with buyer \( i \). For instance, seller 2 is chosen as the first candidate for negotiation. If his \( k_1 \) and \( k_2 \in NAB_i \), \( k_3 \in FAB_i \), and \( k_1 \in FAS_j \), \( k_2 \) and \( k_3 \in NAS_j \), then the following guides can be produced.

(1) to buyer \( i \), initiate negotiation over \( k_1 \)

(2) to seller 2, initiate negotiation over \( k_3 \)

(3) to both buyer \( i \) and seller 2, initiate a middle-point negotiation over \( k_2 \).

Thus, the system sends advice to buyer \( i \) to relax requirements over \( k_1 \) and \( k_2 \) (\( k_1 \) is value of seller 2 and \( k_2 \) is a middle point between buyer \( i \) and seller 2), and send advice to seller 2 to relax requirements over \( k_2 \) and \( k_3 \) (\( k_3 \) is the value of buyer \( i \) and \( k_2 \) is the middle point between seller 2 and buyer \( i \)).

Case 2: When the set of attributes \( k \) is a subset in the non-negotiable attributes of buying order \( i \), that is, \( k \in FAB_i \).

As in the case of the single attribute negotiation, further analysis can be done to find out counter orders that are willing to negotiate on the attributes that are non-negotiable for buyer \( i \).

Second Approach

The second approach uses the combination of utility theory and multi-criteria decision making to develop the negotiation rules. The first objective is the most important attribute, for example, price, and the second objective is the total utility of the other attributes. For example, when buyer \( i \) places an order for a product or a service, his order \( b_i \) is timestamped and entered to the system. Then the clearinghouse sets the price \( b_{i1}(t) \) aside and selects the feasible set \( NS_i \) based on total utility \( \phi_i \), where

\[
\phi_i = \sum_{m=2}^{t} f_{im}(o_{jm}),
\]
the utility functions \( f_i = (f_{i2}, f_{i3}, \ldots, f_{in}) \), and the attributes \((a_{ij2}, a_{ij3}, \ldots, a_{ij})\).

All the selling orders in \( NS_i \) are ranked according to \( \phi_j \). Note here, we add \((t)\) to both buying price and selling price, because the negotiation is a dynamic process. The price \( o_{j1}(t) \) of the first selling order in \( NS_i \) now is compared with \( b_{i1}(t) \). If \( b_{i1}(t) \geq o_{j1}(t) \), the transaction pair is identified and \( b_{i1}(t) \) is the transaction price. Otherwise, the clearinghouse on behalf of the seller \( j \) makes a counter offer \( o_{j1}(t) \) to buyer \( i \).

For the buyer, the objective is to minimize the buying price \( b_{i1}(t) \), such that

\[ \tau_{b,i} \leq b_{i1}(t) \leq \mu_{b,i}. \]

For the seller, the objective is to maximize the selling price \( o_{j1}(t) \), such that

\[ \mu_{s,j} \leq o_{j1}(t) \leq \tau_{s,j}, \]

where

\[ \tau_{b,i} = \text{aspiration level of the buyer}, \]
\[ \tau_{s,j} = \text{aspiration level of the seller}, \]
\[ \mu_{b,i} = \text{reservation level of the buyer}, \]
\[ \mu_{s,j} = \text{reservation level of the seller}. \]

Offers from the buyers and sellers are between their respective reservation and aspiration levels. For buyer,

\[ b_{i1}(t) = b_{i1}(t - 2) - \theta_i (o_{j1}(t - 1) - o_{j1}(t - 3)), \]

for seller,

\[ o_{j1}(t + 1) = o_{j1}(t - 1) - \alpha_j (b_{i1}(t) - b_{i1}(t - 2)), \]

where \((o_{j1}(t - 1) - o_{j1}(t - 3))\) and \((b_{i1}(t) - b_{i1}(t - 2))\) are the most recent concessions made by the buyer and seller. \( \theta_i \) and \( \alpha_j \) are the coefficients of the parties' tendency to reciprocate and they can be time dependent. If \( \theta_i \) and \( \alpha_j \) are both negative, the negotiation is moving toward a compromise.

6 Example: Parking Lot Clearinghouse

In this section, we use an example, the parking space reservations, to illustrate the negotiation process.

6.1 Nature of the Problem

In any large city, parking is a serious problem not only to the traffic authorities but also to those automobile owners. Drivers are moving and the conditions of the parking lots are also changing, such as, have parking space or not. Due to lack of timely and accurate information about the available parking lots and an clearinghouse to facilitate the parking lot reservations, decision can be suboptimal.

The automatic parking reservation system, the clearinghouse, is an electronic mobile market who receives orders from drivers (buyers) and offers from car parking lots managers (sellers) continuously. Based on the information from the buyers and the sellers, the system searches for transaction pairs. Once a transaction pair is identified, the information about the buyer and seller will be sent to their counter parts. Otherwise, the system starts the negotiation process.

We assume that there are five attributes important to the parking lot seekers: price, distance to the destination, with cover or not, security patrol, and pick-up service. These attributes can be represented by an array \( r = (r_1, r_2, r_3, r_4, r_5) \). The requirements of the \( i \)-th buyer are represented by an array \( b_i = (b_{i1}, b_{i2}, \ldots, b_{i5}) \) and an array of 0-2 integers \( bc_i = \{bc_{i1}, bc_{i2}, \ldots, bc_{i5}\} \). The conditions of the \( j \)-th parking lot are represented by arrays \( o_j \) and \( oc_j \) which contain the same information as arrays \( b_i \) and \( bc_i \):

for \( r_1 \) \[ b_{i1}, o_{j1} \in R, \]
for \( r_2 \) \[ b_{i2}, o_{j2} \in R, \]
for \( r_3 \) \[ b_{i3}, o_{j3} \in \{Y, N\}, \]
for \( r_4 \) \[ b_{i4}, o_{j4} \in \{Y, N\}, \] and
for \( r_5 \) \[ b_{i5}, o_{j5} \in \{Y, N\}. \]

The objective of the clearinghouse is to maximize the number of transactions. The parking lot owners also forgo the rights of responding directly to the drivers, thereby ensuring that all transactions are routed through the clearinghouse. As a result, if there is no transaction (match of all the attributes), the driver has to negotiate with the owner of the parking lot through the clearinghouse.

For example, when driver \( i \) calls the clearinghouse that he needs a parking lot, he needs to provide his name, the current location, and the following information:

\[
\begin{align*}
b_{i1} &\leq 5 \text{ dollars/hour} & bc_{i1} &= 1 \\
b_{i2} &\leq 500 \text{ meters} & bc_{i2} &= 2 \\
b_{i3} &= Y & bc_{i3} &= 2 \\
b_{i4} &= Y & bc_{i4} &= 0 \\
b_{i5} &= Y & bc_{i5} &= 2
\end{align*}
\]

Similarly, when the car parking lot owner \( j \) informed the clearinghouse that a parking space is available, he should also provide the same information:

\[
\begin{align*}
o_{j1} &= 8.00 \text{ dollars/hour} & oc_{j1} &= 1 \\
o_{j2} &= 500 \text{ meters} & oc_{j2} &= 2 \\
o_{j3} &= Y & oc_{j3} &= 2 \\
o_{j4} &= Y & oc_{j4} &= 2 \\
o_{j5} &= Y & oc_{j5} &= 1
\end{align*}
\]

Note that for the parking lots, most of the information are facts and they cannot be negotiated, for example,
Total utility $\phi_i$ can be calculated as follows:

$$\phi_i^1 = 5 + 4 + 3 + 6 = 18,$$
$$\phi_i^2 = 5 + 8 + 5 + 4 = 22,$$
$$\phi_i^3 = 2.5 + 8 + 3 + 4 = 17.5,$$ and
$$\phi_i^4 = 7.5 + 8 + 5 + 6 = 26.5.$$

If the buyer acts up the threshold for $\phi_i^j$ to be 20, then only parking lots $B$ and $D$ are qualified. The $NS_i$ is arranged according to $\phi_i^j$, then $NS_i = \{4, 2\}$.

The clearinghouse compares the prices of the buyer $i$ and the owner of parking lot $D$ or $j = 4$. Since the buyer willing to pay five dollars and the seller asks for ten dollars, the price does not match. The clearinghouse on behalf of the owner of parking lot $D$, makes a new offer $o_{41}(t)$ to the buyer.

If the respective reservation and aspiration levels are selected to be:

$$n_{i,4} = 4 \quad n_{i,j} = 8$$
$$\mu_{i,1} = 6 \quad \mu_{i,4} = 5.5.$$

The negotiation can be formulated as follows:

For the buyer, the objective is to minimize the buying price $b_{i1}(t)$, such that

$$b_{i1}(t) = b_{i1}(t - 2) - \theta_i(o_{j1}(t - 1) - o_{j1}(t - 3)),$$
and

$$4 \leq b_{41}(t) \leq 6.$$

For the seller, the objective is to maximize the selling price $o_{j1}(t)$, such that

$$o_{j1}(t + 1) = o_{j1}(t - 1) - \gamma_j(h_{j1}(t) - h_{j1}(t - 2)),$$
and

$$5.5 \leq o_{j1}(t) \leq 8.$$

If $\theta_i$ and $\theta_j$ are both negative, then after certain rounds of exchange offers, a compromise can be reached. If within a predetermined number of rounds a compromise still cannot be reached, the negotiation moves to the next standing seller, which is parking lot $B$.

### Summary

The purpose of this paper is to propose an intelligent clearinghouse system that includes computer-mediated negotiations for dynamic markets. Under extremely fast changing market conditions, we advocate that the provision of a computer-mediated negotiation supports help clear markets by minimizing transaction failures. The role of such a systems is twofold: (1) to continuously update buyers and suppliers with the changes in market conditions, and (2) to advise them how to reach the most acceptable transactions. The intelligent clearinghouse proposed in this paper constitutes guidelines towards the design of computer-mediated electronic market systems.
References


