Intelligent Electronic Trading for Commodity Exchanges

Commodity exchanges offer potential market structures for electronic trading. The Intelligent Electronic Trading (IET) system aims to provide advanced market functions with more advanced features than currently existing electronic market systems. IET is a combination of an economic auction model with a social choice model. It maximizes the total transaction volume while satisfying qualitative preferences of traders. Constraint Logic Programming is used as a new information technology to structure and implement the trade match algorithms of IET.

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The exchange of commodities has several chacteristics that can be summarized in three points. First, trades of commodity items like cotton or grain can be characterized as frequent and high-volume transactions. Electronic trading can be implemented to facilitate those frequent and high-volume exchanges through on-line transactions. Second, commodities have simple product descriptions. If products require complex descriptions like business insurance policies or complicated computer systems, it may be difficult to trade those products via computer-based markets.

Moreover, the attributes of commodity products are well standardized. In cotton markets, for instance, the grade of cotton is formally evaluated and determined by government organizations. The standardized attributes allow buyers to purchase commodity items through computer terminals without seeing them.

Research Objectives

The objective of the study is to design an intelligent electronic trading (IET) system that automatically executes commodity exchanges by matching commodity buy and sell orders. The IET system aims to provide more advanced market functions than do currently existing electronic trading systems. The electronic trading systems which are under operation in financial and commodity markets just automate the role of human auctioneers: it books buy and sell orders for financial and commodity items and matches those orders on a first-come first-serve basis. Examples of these systems include Instinet in New York Stock Exchange and TELCOT in cotton markets.

The motivation to design the IET system stems from the idea that the use of information technology may provide electronic trading with more intelligent features than just automating the role of human auctioneers. IET optimizes the realization of buying and selling intentions of traders through intelligent trade matches between commodity buy and sell orders: it enables traders to maximize their exchanged volume within their ask or bid prices and to be matched with the most preferred trading partners in terms of product characteristics or delivery conditions.

Intelligent Electronic Trading (IET)

The IET system consists of communications technologies and a central processor (see Figure 1). Bids and offers for a commodity item are submitted by traders via computer terminals to a central processor. Terminals located at traders' places are connected to the central processor through standard commercial networks such as the telephone network, packet-switched networks and leased lines. Buyers and sellers can place their orders using standards and protocols provided by the IET system.

When order messages are received at the central processor, they are automatically entered into the database. The trade match algorithms then transform the streams of bids and offers into transactions.

Standards and Protocols for Product Description

IET enables traders to enter their buy or sell orders using more diverse attributes than just price. Traders can specify the characteristics of commodities they want to sell or purchase. Those attributes may include product characteristics such as price, quality, grade as well as delivery conditions, such as warehouse location and delivery time. Moreover, traders can place their preferences on those product dimensions. Since a single commodity market is made up of many heterogeneous goods that are close to each other but different in grade, quality and delivery conditions, preference satisfaction plays an important role in improving trade matches.

In cotton markets, for instance, a cotton merchant may want to specify his preferences like "I prefer early delivery," or "I prefer cotton from a special region." IET provides extended standards and protocols for product descriptions so that traders can represent their utilities in terms of preferences as well as prices.

Intelligent Trade Match

The trade match algorithms of IET link commodity buy and sell orders in a way that

1. not only maximizes the total transaction volume based on an economic theory of price and quantity (economic auction model)
2. but also satisfies qualitative preferences based on a social choice model.

We combine an economic auction model with a social choice model to develop the trade match algorithms. The economic auction model matches buyers and sellers in an economic way: it determines the optimal trade quantity between buyers and sellers, together with their optimal transaction prices in order to maximize the total exchanged volume in the market.

The economic auction model employs a linear programming method to find this market equilibrium point. The economic auction model is in principle a mathematical approach using only price and quantity. The satisfaction of qualitative preferences requires a logical inference approach based on a social choice model. The social choice model assumes that

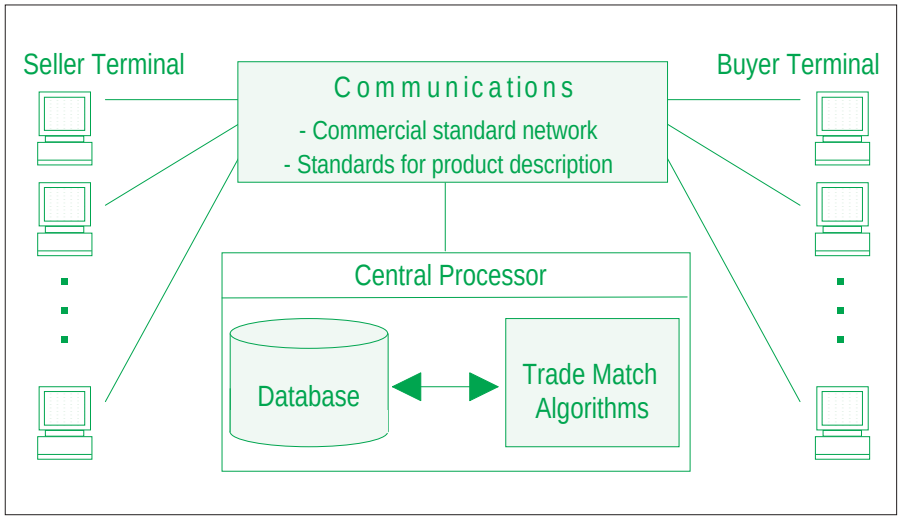

Figure 1: Intelligent electronic trading system

people can express their preferences only in terms of ordering among a set of things. If a person is given a choice between A and B, he can say:

1. he prefers A to B, or
2. he prefers B to A, or
3. he is indifferent between the two.

Given these expressions of individuals, the social choice model derives a market choice that optimizes the satisfaction of preferences of individual traders.

Constraint Logic Programming

CLP (Constraint Logic Programming) is employed as new information technology to structure and implement the trade match algorithms of IET. CLP is an extension of logic programming where unification (symbolic pattern matching) is replaced by constraint satisfaction. In CLP qualitative preferences are expressed as symbolic relations and are logically inferred to draw conclusions. On the other hand, a mathematical solver like the simplex method searches for market equilibrium using price and quantity. It should be noted that satisfaction of qualitative preference is difficult to achieve after optimal transaction price and quantity are found. The qualitative preference should be satisfied while the economic model simultaneously maximizes the total exchanged volume. For this reason, the trade match algorithms of IET integrate both approaches in a dynamic way so that the logical inference approach for preference satisfaction can interweave with the mathematical computation for market equilibrium during the market process. The dynamic integration of logical inference and simplex method in CLP allows us to apply complex trade match rules in order to satisfy qualitative preferences, while the economic model simultaneously searches for market equilibrium.

Concluding Remarks

This study illustrates how an economic theory can be integrated with a social choice theory in order to improve the trade matches of commodity orders in electronic trading. We are currently developing a prototype of IET. We plan to do market simulations with the prototype in order to validate its market performance. The IET system is a new form of market: it aims to create a new market microstructure for commodity exchanges. Thus this study is significant to trading system developers for commodity items such as cotton, grain, cattle, hogs, coffee, tea, and sugar. During the past decade, organizations in various industries have captured a significant portion of their markets through the strategic use of information technologies. The IET system enables organizations involved in commodity exchanges to increase their market share by applying information technology earlier than their competitors.

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How Financial Markets are Going On-line

Discussions of electronic securities markets in the 1970s revolved around the question of whether computers could support the processing requirements of modern, high-volume trading. In the 1980s, we asked when will screen-based markets replace traditional floor exchanges. The questions of whether and when have been answered. In the 1990s the question is who will be left behind.

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Many industries today claim to be in the midst of an "Information Technology (IT) Revolution." Purchasing airline tickets, making hotel, or theater reservations, and withdrawing cash from the bank after business hours are nearly certain to occur through on-line systems. Manufacturers and their suppliers are creating electronic links for ordering parts, maintaining inventories, and distributing design details for new products and components. Many of these initiatives began within the past 15 years as the price-performance characteristics of computers and telecommunications networks improved dramatically.

IT in Financial Markets

In financial markets, the IT Revolution began over 150 years ago. The telegraph, invented in 1838 by Morse and Vail, was quickly used to transmit prices between New York and Philadelphia and New Orleans, replacing horse and train journeys, thus accelerating market news from a week to half a day. The Transatlantic cable, which in 1866 established telegraph communication between New York and London, affected pricing and changed trading practices in those cities' currency, stock, and bond markets [3]. Time lags of 20 days were reduced to minutes, and the average absolute price differences for identical securities traded in the two cities' markets dropped 69 percent from their previous levels. Thomas Edison's electromechanical stock ticker (1867), and Alexander Graham Bell's telephone (1876), were also rapidly adopted and enabled financial markets to extend their reach and importance in the economy. New York-based brokerage houses that established a presence in other parts of the country became known as "wirehouses" for their reliance on telegraph communications. IT will maintain its crucial role in supporting market activities: no trader today ope-rates without real-time data services and computer-based analytical tools. Market information about prices, interest rates, transactions, investor supply and demand, and company and economic news is at the heart of any trading operation. Consequently, the major international markets from Japan to Switzerland are making increased use of IT. While IT is capable of making the traditional trading floors obsolete and supporting 24-hour international markets, no consensus is emerging on the design of an integrated global financial market, and many technological and regulatory issues remain unsolved. Multiple, fragmented markets may be a consequence of the lack of coordination. Despite its long presence, IT's influence on financial markets themselves continues to be a subject of debate and controversy.

Financial Market Functions

Financial markets perform four functions in the economy:

1. Raising capital: Expanding into new markets, building roads and plants, and initiating the development of new products and services requires funding that often comes from issuing debt or equity securities.
2. Enabling wealth to be transferred across time periods: For instance, a new home buyer borrows money today to be repaid in the future, while those with net savings can invest or lend money today to provide themselves with greater wealth in the future.
3. Meeting the demand for resales that match investors wishing to sell with those wishing to buy. A purchaser of