PAST, PRESENT AND FUTURE: THE EVOLUTION AND DEVELOPMENT OF ELECTRONIC FINANCIAL MARKETS

by

Allan D. Grody

Hugues Levecq

STERN #IS-95-21

Past, Present and Future: The Evolution and Development of Electronic Financial Markets

Allan D. Grody

Financial InterGroup

Hugues Levecq

Department of Information Systems
Stern School of Business
New York University

November 1993

Working Paper Series
STERN IS-95-21

Past, Present and Future: The Evolution and Design of Electronic Financial Markets

Allan D. Grody
Financial InterGroup

Hugues Levecq
Department of Information Systems
Stern School of Business
New York University

The Evolution of Electronic Markets

A Touch of History

The origins of today's principal exchange markets date back to the early seventeenth century. The Amsterdam Stock Exchange traces its roots back to 1602 when the United East India Company successfully marketed the world's first public share offering. The Japanese lay claim to the origins of the first futures exchange, tracing its roots to 1603 and the Yodoya Rice Market, a shop where buyers and sellers of rice met. This cash market naturally developed a forward market for future delivery and, in turn, developed into a futures market. The London Stock Exchange (LSE) evolved from the tea houses that were used to organize the financing of expeditions to the New World. In the New World, the New York Stock Exchange (NYSE) began as a collection of financiers and traders under the buttonwood tree.

The application of modern technology to these markets began with the telegraph in the nineteenth century to communicate changing price information. Reuters Holding Ltd., the large British news and market information company had its origins back then. In 1850, its founder, Paul Julius Reuter, began his business by using pigeons to fly stock prices between the only remaining gap in the European telegraph system.

At about the same time, Dow Jones & Co. began in the U.S. as a financial news provider, creating stencilled copies of its Dow Jones Report and distributing it among brokers.

In 1867 the Morse code ticker was developed. It leased for $6 a week and was the mainstay of electronic price dissemination well into the twentieth century, when telephonic communication displaced telegraph technology. The Translux Corporation introduced the moving electronic display board in 1925, and in 1959, a predecessor to Quotron Systems, the Scantlin Electronics Corporation, introduced the electronic quote terminal.

Complementing the electronics applied to these financial news and price dissemination systems was the development of order placement mechanisms, first via telegraph, then telephonic and now digital. These evolved from point-to-point 30 character per second teletype speed to today's global fault-tolerant computer switched order placement, trade execution and trade reporting systems operating at speeds of over a million giga-bytes a second.

The first switched, order routing system was developed by Control Data Corporation on CDC 8000 computers, a specialized communications switching computer, for Hornblower & Co. Other systems were individually built on general purpose computers, starting with IBM 1400 technology using an early telecommunications control system called CCAP, modified as BCCAP (Brokerage Communications Control Applications Processor) for the brokerage industry. Later installations of this technology evolved around IBM's 360 line of computers, with its TCAM (TeleCommunications Access Method) and SOM (Securities Order Match) applications specifically designed for the brokerage industry. Today, Shearson Smith Barney operates the largest network of this kind.

Later developments included the use of mini-computers. Digital Equipment Corporation's PDP 1170's still support one of the U.S. securities industry's largest order routing networks run by Automatic Data Processing. Fault tolerant computers were also used for both order routing, news and price dissemination. Merrill Lynch has one of the largest such networks, running on Tandem computers.

Entrepreneurs Introduce the First Electronic Markets

With the capability now in place to route and return electronic orders to and from a central point, it was only left to computer application developers to mimic the matching algorithms of a marketplace in order to create an electronic market. The first such effort took place at the New York Stock Exchange with the automation of the corporate bond market. This effort, begun in the late sixties, resulted in the first automated market developed by an existing exchange. Known as the Automated Bond

System it was built on Univac computers. Inaugurated in 1974, it still survives today.

During this time, entrepreneurs, who saw the opportunity that technology allowed to bring together disparate investors in the block trading market, launched two services, Instinet and Autex, in 1969. Instinet was predicated on anonymous dealing between brokers and institutions and contained automated execution capabilities maintaining strict time and price priority within a consolidated limit order book. The system used an existing time-shared computer service and connected CRT Teletype terminals to local telephone lines which, in turn, were connected to the nearest communication hub. In 1978 Instinet built an in-house system on Digital Equipment computers and provided real-time updating of last sale and quote information in addition to its automated execution facilities.

Instinet. Instinet's founders were initially financed by Weeden and Co., which was to become a pioneer in off-exchange trading systems by automating the Cincinnati Stock Exchange in 1974. This allowed it to trade electronically in New York Stock Exchange securities even though Weeden was not a member of the NYSE. This system was sold to Control Data Corporation which, in turn, sold it to the Chicago Board Options Exchange (CBOE). The CBOE now operates the system as the National Securities Trading System with the status of any other U.S. exchange, while being completely electronic. Additional ownership in Instinet was sold in 1985 to five large brokerage firms, including Merrill Lynch, E.F. Hutton and Dean Witter before it was sold to Reuters in 1986. It survives today as the only global equity trading system, electronic or otherwise, with terminals located throughout the world.

Autex. From its inception Autex was different. It did not contain an automated execution facility, but rather was a screen-based bulletin board with telephone negotiation required to close the deal. It also had a feature to allow any participant to exclude other parties from seeing its bids or offers. Autex, too, survives today, having gone through a number of owners.

Ariel. In this early period of technology experimentation, driven largely by the marriage of telephone and computer technologies, a number of electronic markets were attempted, with varying degrees of success. In Europe in 1971, a group of London merchant banks invited Instinet to start a block trading system in response to the unwillingness of the British stock exchanges to lower commissions on larger orders. Named Ariel, it failed as an electronic market but was operated for some time as a telephone market. It ceased operation in 1976 after succeeded, by threat alone, in lowering rates in the conventional London exchange market.

NYSE's Block Automation System and NASDAQ. In response to Instinet and Autex, the New York Stock Exchange created the Block Automation System. Without any additional benefit over the dealer-to-dealer telephone network or the

anonymity offered by Instinet, it found few users and was soon discontinued. In 1971 the National Association of Securities Dealers, the overseer of the over-the-counter market in the U.S., inaugurated their Automated Quotation Service (NASDAQ). This service applied the computer and terminal (a Univac central host and Harris terminals tied together over telephone lines) as a direct replacement for the daily publication of its paper quotation service. The best bid and offer was displayed to the public, but the multiple bids and offers from the many market makers in each stock were only available to the dealers. The transactions still had to be negotiated and confirmed by telephone. In 1985, the service was expanded to handle automated executions of small orders, primarily in response to Instinet's similar service.

Increasing Volumes and Competition Speed the Adoption of Technology

The NASDAQ system was a direct outgrowth of the push for a National Market System, a concept that evolved from the back office crush of the late 1960's when the NYSE was forced to close one day a week and the over-the-counter markets were clogged with volume. Recognizing the need to create a more efficient process other than point-to-point telephone and teletype, the NYSE inaugurated the DOT (Designated Order Turnaround) service as a means of directing orders electronically to and from the specialist booths and from member firm computer terminals. In 1969, the Pacific Stock Exchange implemented COMEX, a similar system later renamed Scorex. These systems were able to handle additional volume from smaller retail orders, and later, from large institutional orders and programs.

The Intermarket Trading System. The Securities Acts Amendments of 1975, which resulted from congressional hearings on the operational problems of the securities industry, eventually called for the consolidation of price and quote information among all regional exchanges into a single stream of data. In addition, it demanded a guarantee that all orders, regardless of their origin, receive the best price, wherever that price was offered. It also allowed for all securities listed after 1979 on the national market to be traded both on an exchange and in the over-the-counter market.

The NYSE and the regional exchanges responded to the SEC's calls for a single source of price and quote information with a jointly-owned high speed data communications service known as the Consolidated Quote and Consolidated Tape Service. In responding to the best price guarantee, the Intermarket Trading System was created as an extension of a routing system originally built by the NYSE to handle odd-lot orders (orders under 100 shares). It now serves as the backbone of the DOT system. This system offered a common set of interfaces for member firms (the Common Message Switch) and was to be built on the scalable, fault tolerant Tandem computers. Its order entry point, initially limited to the NYSE floor, was electronically extended to the other regional exchanges for price improvement.

Toronto Stock Exchange's CATS and London's SEAQ. In Canada, the Toronto Stock Exchange was also experimenting with combining communications and computers. It began pilots and prototypes in the early 1970's that resulted in the first exchange-based central limit order file system, trading 90 of the exchange's inactive stocks. Terminals were located both on and off the floor and supported multiple traders assigned as designated market makers. The Computer-Assisted Trading System (CATS) was built on IBM 370 computers. The terminals had the first appearance of multiple windows in any application in the securities industry at that time. Today's version of CATS is being installed with the expectation that the floor of the Toronto Stock Exchange will be permanently closed in 1994.

The original IBM version of CATS was sold multiple times, beginning with the Paris Stock Exchange in 1985. At that time, it provided a quick means for European exchanges to change their floor-based call markets to enable continuous market making. Sales of CATS systems in Europe accelerated after October 1986, as the LSE abandoned its floor in favor of a NASDAQ-like system called the Stock Exchange Automated Quote System (SEAQ). Sales of these systems now extend throughout the world and accelerate the introduction of electronic trading systems in both mature and evolving economies. (See Table 1 for the major vendors.)

Table 1 - Leading Electronic Market Systems Vendors

Insert table 1 about here

Fully Automated Exchanges for Futures and Options Markets

In 1985, two fully electronic futures exchanges were launched: INTEX in Hamilton, Bermuda, and the New Zealand Futures and Options Exchange. An upgraded version of the latter still operates today, but INTEX no longer exists. These exchanges represented a radical shift in thinking about exchange automation. For the first time an entire exchange was to be created (in the case of Intex) or replaced (in the case of New Zealand) by automation. The concept of black box trading was born.

The New Zealand Futures And Options Exchange. New Zealand had been trading via telephone conference calls connecting disparate traders throughout the country. New Zealand turned to the International Commodity Clearing House for the technology. It was a natural request to a company which was clearing and guaranteeing trades for its own market in Britain and for the French, Australian and Hong Kong markets as well. Aside from its guarantee function, it was a technology processing company. The system used networked Datapoint mini-computers and a terminal partitioned into four sections: a market section showing the best bid and

offer, the broker's own order book, an order entry section and an area to receive administrative messages and executed trades. The primary matching logic was based on the submission of a trade at a specific price with the request to either "fill" (execute against the bid or offer in the market shown at that time) or "kill" (cancel) the order if it could not be executed at the requested price at that time. Few limit orders were submitted although they were allowed. The system, known as ATS/1 began operation in 1985 and survives today as ATS/2000. The New Zealand Futures And Options Exchange was acquired by the Sydney Futures Exchange in 1992.

INTEX. INTEX's Bermuda location was chosen to avoid lengthy regulatory filings required by the U.S. and British regulators. The motivation for its creation began in the 1970s when Merrill Lynch sponsored the formation of a venture capital group to finance the undertaking. INTEX also began operation in 1985. It was designed under a strict time and price priority, central limit order file concept. The terminals were DEC PDP-11 mini-computers and contained the traders' working order files and connections to a local printer. Each order or execution was both written to the local disk and printed for audit trail purposes. Traders complained that this activity would tie up the terminal and cause them to wait before they could submit an order or request a cancellation.

INTEX attempted to trade gold contracts in competition with the more liquid Commodity Exchange (COMEX) market in New York, after that market had closed. It failed to attract much interest; at its peak it had thirty terminals located in Chicago, New York and London trading 200-300 contracts a day. After attempts to initiate trading in the new contracts (none of which created sufficient liquidity), and the sale of its software to other start-up ventures, INTEX ceased operation in 1988. But the mold had been created and other start-up futures and options exchanges began to proliferate, driven by the financial communities' interest to hedge their cash market purchases and trade for speculative profits.

A Growing Number of Electronic Futures and Options Exchanges. The overwhelming acceptance of electronic trading systems as a basis for new futures and options markets can be demonstrated by the 28 electronic futures and options markets that have come into existence since the first ones were opened in 1985. The Tokyo International Financial Futures Exchange and Osaka Futures and Options Exchange in Asia, the Deutsche Terminborse and Swiss Options and Financial Futures Exchange in Europe are completely electronic. Other electronic trading systems support after hours or experimental, lower volume contracts. These include Globex (the Chicago Mercantile Exchange, Chicago Board of Trade, Marche a Terme International de France and Reuters joint venture) and Access (the New York Mercantile Exchange and AT&T joint venture) in the U.S., and the Automated Pit Trading (APT) system of the London International Financial Futures Exchange. Each of these systems has been designed using various technology platforms and trading

styles. APT attempts to simulate on-floor pit trading via a screen and was developed on SUN RISC-based workstations under UNIX. Globex is a time and price priority matching system supported on a DEC host under the VAX/VMS operating system. Access, also a matching system, is built on networked PC's and STAR Processors (AT&T's renamed Tandem computers).

Technology Also Penetrates Securities Markets

Not to be outdone by newly created futures markets, the established and emerging securities markets of the world began to embrace trading technology to improve or establish their own markets. The less developed countries, and the re-emerging capital market economies of the newly emancipated Eastern European countries began to turn their attention to establishing sound secondary markets for trading newly-privatized enterprises. The Asian markets, following the boom in trade with the more industrialized nations, embarked upon ambitious deregulation of their financial markets to capture more of the world's capital flows. The Asian economies were preparing to benefit from the concept of global asset diversification

Emerging Markets Rely Heavily on Technology. The Asian markets have principally adopted technology to support centralized, order-driven systems to replace the centralized telephone-based floor markets. Most of these systems have been installed since 1988. These include the completely automated second tier Japanese Stock Exchange, the Korean Stock Exchange, the Philippine Stock Exchange, the Singapore Stock Exchange, and the Thailand Stock Exchange; and the semi-automatic first tier Japanese Stock Market (the 150 largest stocks trade in this manner), the Hong Kong Stock Exchange, the Kuala Lumpur (Malaysia) Stock Exchange, and the Taiwan Stock Exchange.

Electronic Systems Support New Trading Needs. Into this mix of changing attitudes toward electronic markets, entrepreneurs, keen on creating change, began to re-emerge. The early pioneering efforts of Instinet led to its involvement with some large institutional investment management companies. One such firm, Batterymarch Financial Management was an early experimenter with market inventory funds. By making a telephone call to a market inventory fund manager, and later via the Instinet trading system, managers could swap securities at the market closing price without incurring additional commissions and with zero market impact.

When coupled with the growing interest in passively managed index funds, this concept created a new demand for informationless, passive trading technology: the "crossing" systems. Today's prominent crossing systems are Instinet's Crossing Network, POSIT (a joint venture of Jeffries & Co, and Barra, Inc.) and the Arizona Stock Exchange, a start-up exchange built around a crossing system known as the Wunsch Automated System. They principally match lists of securities left in their

systems over a given period of time. A given security is usually traded at the posted closing price of the principal market in which it trades.

Interconnecting Electronic Markets: The Concept of Open Systems

The U.S. Market. In the U.S., the evolution of electronic markets and innovation in new market structures has created the world's first open system for trading. Firms' internal order routing systems make decisions based upon best available price by reading real-time market data feeds from the reporting exchanges, NASDAQ market makers, and electronic information from the crossing networks, the Instinet Electronic Trading System, and the AUTEX electronic bulletin board/telephone trading system. Orders are further scrutinized based upon historical volatility and recent trading patterns to determine the overall market impact of executing the order through an exchange via a floor broker, a block dealer, an electronic execution system of an exchange, an electronic off-exchange market, or a crossing network.

The primary and regional exchanges are tied together electronically by the Intermarket Trading System. The NASDAQ markets are tied together to the exchange markets through the dealers' proprietary trading systems. They have become intertwined, along with the off-exchange markets, in an electronic highway of electronic inquiry and trading. Prices are still set initially by orders flowing to the specialist for exchange listed-stocks, or quotes being changed by dealers in the NASDAQ market. Moreover, the interaction of computer-driven dealer quoted markets and order flows to specialists brings prices discovered in each market instantaneously to the others' attention for either price improvement or pricing at the current best bid or offer.

The World's Currency Market. The world's currency markets are evolving on a similar global scale towards this open model. With over $1 trillion in daily turnover, the currency market has evolved from bulletin board/telephone trading to a competing electronic inter-dealer market. The three major electronic trading systems, Reuters Dealing System 2000, MINEX (managed by Dow Jones/Telerate) and Electronic Brokers System (EBS) (sponsored by Quotron), rely on contributing dealers to place their bid and offer quotes into their systems. Augmenting this primary market are the electronic inter-dealer brokering systems and the institutional dealing systems that the largest of dealers are offering to clients to provide quotes and execute trades.

Technology Can Better Serve Market Participants

New Market Structures and Trading Mechanisms. With the global acceptance of electronic markets, there is increasing impetus to apply new techniques to improve upon existing markets, to develop new markets and to create completely

new ways of trading. Already we have seen attempts at trading bonds and money market securities in innovative electronic markets. The U.S. Treasury has recently automated the treasury trading auction. MMX, a U.S. start-up sponsored by the Chicago Stock Exchange tries to combine the best of crossing systems with auction markets. Another start-up venture in London, the Trade Point Financial Network, attempts to marry the best of a periodic electronic call market with the best of a centralized electronic auction market. The diversity of technology in these new systems is noteworthy. For example, Trade Point is developed around a system built for the Vancouver Stock Exchange by TCAM Systems, running on Stratus Computers using the VOS operating system. MMX, by contrast, is being built from scratch on PCs under OS/2.

In Germany the IBIS off-exchange dealing system, which now exists alongside the Frankfurt Stock Exchange and the multiple regional exchanges, will soon replace existing floor markets. Similarly, Switzerland will be closing its floor exchanges in Basel, Geneva and Zurich in favor of an electronic market. In France a private initiative is underway to provide the ability for a fund of corporate treasury stock to interact with the opening call market procedure to attempt to counter any supply/demand imbalances that might destabilize prices in that security.

Thus, over the past quarter century, changes in market technology have led to the creation of numerous fully or partially electronic markets. (See Table 2). The ensuing changes brought by technological capabilities in market structures have been significant. However, they have primarily affected the large institutional trader rather than the individual investor. The next period of innovation could very well be focused on the retail customer in the form of retail electronic trading systems.

Table 2 - Electronic Market Systems Worldwide

Insert table 2 about here

Trading From Home? The approaches to date at the retail level have relied upon personal computers or touch-tone telephones interfaced to telephone networks that bring delayed information on market prices into the home. They have also allowed order placement for execution at tomorrow's opening price or more immediate pricing, if the customer is willing to wait for execution at the prevailing market price. The orders are either placed manually into another system or routed electronically to an exchange or dealer execution system, after approval by a registered broker. In the U.S. the prominent networks that provide these services include Prodigy, American On-line, Genie and Compuserv. In Japan, a brokerage firm uses a Nintendo game machine with special software. In France, the

videotex-based Minitel is the primary home terminal.

Already, firms such as Fidelity Investments and Charles Schwab, respectively the largest American mutual fund company and discount broker, have won the right to provide price quotes without paying exchange fees to access this information in real-time. (In the U.S. price information is owned by the originating exchanges, but deemed to be in the public domain after 15 minutes; prior to this ruling, exchanges expected to receive a monthly fee from each home user.) The ability to interrogate the markets in real-time and the increasing availability of ISDN high speed data services and cable services creates the potential for limit price placement of mutual fund and individual share orders. The increased number of limit orders thereby generated should tremendously impact the creation of liquidity on the market.

The Design of Electronic Markets

We have seen how technology has evolved to augment existing markets and make new ones possible. The users of these markets view these systems as black boxes of technology. While the systems themselves are understandable as markets, (that is they serve market participants and perform specific functions to support the trading and investment interests of the financial intermediaries and their clients) their users generally do not understand how they actually accomplish these tasks. While technology is becoming more user-friendly and flexible, it is important to recognize that a lot of structure is embedded in an electronic system.

Therefore, when applying technology to markets, critical issues regarding the system architecture and functional design have to be addressed. What hardware and software platforms will be used? Which components of the existing market structure should be incorporated into the system?

Components of an Electronic Trading System

An electronic trading system typically contains three major components; hardware, software and the communications network.

Hardware. The hardware includes both the machine on which the software is running, and the terminals through which information is entered and accessed. Increasingly the terminals are being replaced by local computers. They share the functionality of the entire system with components operating at the user site and other components operating at a host, and in the case of the communications network, at the hub site. Each of the major functions of an electronic trading system, order placement, order monitoring, order matching, trade execution, trade reporting, administrative query and messaging, and market information (price, volume, quotes, etc.) dissemination can be dedicated to a specific machine, a series of machines or

centralized on one host. Their is no shortage of choices in this area with almost every vendor represented in the current list of electronic market systems.

Software. The principal application components of the system are the user's presentation and entry application, the order matching or trade execution software, and the server application that provides messages to and from the host and updates the host databases. User access is increasingly available through PC or workstation graphical user interfaces, which operate as client applications. (See Figure 1).

These applications are typically supported by database management software which stores both dynamic information (orders, cancellations, queries, trade executions, etc.) and static information (glossary of securities or contracts traded, historical market information, authorized users, destination codes, etc.). Information is stored at both the client and server sites.

Figure 1 - Order Entry Windows on NASDAQ's New Workstation II

Insert figure 1 about here

The network management software handles the broadcast of market data to market participants and outside vendors, and the interactive message handling and routing associated with the order placement and trade execution components of the system.

Network. The network itself links the different system components together. Like hardware and software, different categories of networks fulfill specific tasks. Separate networks are commonly deployed for the broadcast of market information to the secondary vendors (ADP, Dow Jones, Quick, Telekurs, etc.) as well as the primary market participants. In other cases both networks are combined. The Sydney Stock Exchange, for example, uses VSAT (Very Small Aperture Terminal) interactive technology for market information dissemination and trading interaction.

Looking at the topology of the network, the local area network (LAN) links components and market participants who are geographically close to the system and the wide area network (WAN) links geographically dispersed components and participants. Typically, LAN's are constructed around Token Ring or Ethernet technology, the WAN's around X.25, TCP/IP or, more recently ATM (Asynchronous Transfer Mode) and ISDN technology. In some cases the LAN network is the only means of access as the market is confined to a localized community of participants as in the case of the Luxembourg Exchange. The WAN can span geographical boundaries, as in the case of Globex in the futures and options market or Instinet in the equity markets. More commonly, it is confined to a particular territory or country

as is the case in Japan and Thailand.

The architecture of the new NASDAQ network is a good illustration of the typical architecture of a trading system.

Figure 2 - Architecture of NASDAQ Trading and Information System

---
Insert figure 2 about here

Design Considerations in the Electronic Trading System

While the important options available in the system's architecture are technological in nature, the design of the electronic trading system software reflects traditional market preferences and business decisions. Issues of efficiency, fairness, customer needs and regulatory constraints have to be addressed. If technology is introduced to support an existing market, the level of automation supported by the system as well as its coexistence with the traditional market structure have to be examined. If the system accompanies the creation of a new market, a wider range of options is available, but careful attention must be given to the system start-up, like the creation of liquidity, for example. In both cases, however, many facets of the market structure will be embedded in the system's design.

Market Structure Implemented. Financial markets around the world exhibit a variety of different market structures. Despite this diversity, market structures can be classified along two fundamental dimensions: the frequency of trading, and the type of price discovery process. Frequency of trading refers to the distinction between a continuous and a call market. In a continuous market, the securities or contracts traded are continuously priced. This means that a trade can occur at any time, providing that the incoming order matches the current price. Prices in a continuous market are characterized by the existence of a spread, the difference between the quoted bid and ask prices. In a call market, orders are batched over a predetermined period of time. They are then matched at a given time of the day, at the price that minimizes imbalances between buy and sell orders.

The other dimension, the price discovery process, opposes the auction market to the dealer market. In the auction market, buy and sell orders are matched continuously at a price that satisfies both parties. Such markets are also called order-driven. Toronto's CATS system, the proposed Swiss Stock Exchange's automated system and the NYSE's DOT system are examples of order-driven markets. In a dealer market, a market maker exposes quotes, a bid (sell) price and an ask (buy) price. The prices have to be matched for a trade to execute. Such markets are also called quote-driven.

NASDAQ and SEAQ are quote-driven markets. Figure 3 summarizes the principal market structures.

Figure 3 - Market Structures

Insert figure 3 about here

There are benefits and disadvantages associated with each market structure. In a call market, for example, investors may enjoy lower trading costs because they do not bear the bid-ask spread cost. However, they may suffer from a lack of immediate liquidity. The market structure is a strategic decision which depends on the type of customers the system is targeting. An electronic call market, for example, can complement a continuous auction floor market.

Type of Orders Allowed. There is a large diversity of orders allowed on financial markets. They can be divided into two broad categories: simple orders and contingent orders. Simple orders only depend on the security or contract of interest. Simple orders include market orders, limit orders, day orders, good till cancel (GTC) orders, stop limit orders, market on opening orders, market on closing orders. Contingent orders rely on the value of an external parameter to be executed. An example is an order where execution is contingent upon the value of an underlying instrument, such as an option priced versus an underlying stock, or a parameter, such as volatility. Contingent orders include: percentage orders, which are orders to buy or sell a percentage of the volume of the book, or of the volume of the last transaction; directional orders, which are dependent on market direction, as in the example that an uptick must occur before a short sell order will be accepted; combination orders, which imply simultaneous executions like buying a futures contract in one month and selling the same contract in another month, or buying one security and selling another at a stated price difference.

Contingent orders are more complex to handle than simple orders. It is often difficult to execute these orders electronically, because they rely on information which may be external to the system. Some systems, including the NYSE's Specialist Order Book System and the Belgium Futures and Options Exchange system allow contingent orders. However, they have been left out of the systems design, and are handled manually by specially designated brokers. Other exchanges support electronic contingent orders, viewing this capability as a new product. An example is Globex's trading of volatility contracts.

Priority Rules - Order Execution Algorithm. The priority rules determine the sequence in which orders are processed once they have been entered into the system.

Priority rules are based on the identity of the parties, the type of order, the quantity, the price, the submission time, and the transparency of the order. Table 3 presents a listing of priority levels found in electronic trading systems (Domowitz, 1992).

Table 3 - Priority Levels in Electronic Trading Systems

Insert Table 3 about here

Contrasting Globex with the Automated Pit Trading (APT) system of the London International Financial Futures Exchange provides a good illustration of the implementation of various priority rules. Globex uses a simple price/time matching algorithm: for similarly priced orders, older orders will be executed first. APT does not use the time rule: the algorithm allocates executions among all identically priced orders, without any consideration for the time of arrival.

In most systems, however, price is the highest priority, followed by time (Domowitz, 1992): if two orders are identically priced, the one submitted first will be executed first. It is also important to recognize that the order execution algorithm may not be unique for a given electronic trading system: different market structures may have been implemented, each with a specific order execution algorithm. For example, many markets use a call market procedure at the opening, while the regular trading session is a continuous auction market.

Price Discovery Rules. The price discovery process determines the efficiency of the market. It is directly linked to the order matching algorithm. For example, the Instinet Crossing Network executes trades against the closing price from the NYSE, or the mid-spread closing price from NASDAQ. The absence of price discovery here is a direct consequence of the execution algorithm implemented in the system.

The level of price discovery allowed in the system is important, because the ultimate goal of financial markets is to discover the true price of the negotiated security or contract. It also exhibits how much the electronic system depends on the ability of other markets to discover prices. Table 4 presents an ordered classification of price discovery rules, from the lowest to the highest level (Domowitz, 1992).

Table 4 - A Classification of Price Discovery Rules

Insert Table 4 about here

There are a number of systems that borrow prices from other markets. POSIT, the

NYSE's after hours crossing service, Instinet's Crossing Network, and the Arizona Stock Exchange borrow prices from the primary markets for equities in the U.S. There is an immediate benefit to use prices from other markets: it waives the costs associated with the price discovery process. This results in lower transaction costs to the investor. However, if a system which relies on prices from other markets draws a lot of volume, less trading will be left to discover prices on the original market. Prices will become less accurate, thereby generating more volatility. And in more fragmented markets, orders will have a lower probability of getting executed (Weber, 1993), which means less liquidity. Overall, investors may have to bear higher trading costs. The "free rider" aspect of systems borrowing prices from other markets is naturally of concern to regulators.

Time Stamping Issues. Time stamping of orders is an important issue, especially in the context of electronic trading. We have seen that most trading systems use time priority to sequence orders identically priced. But a fairness issue is raised if orders are not time stamped properly. Let us imagine two traders, one in New York, and one in Sydney, Australia. Both want to place a similar order in an electronic trading system located in New York. Due to transmission delays, it is possible that the Australian trader sends the order a few milliseconds before the New York trader, but that it arrives in the system after the American order. Clearly, the time stamp on the order is of critical importance here. Submitted orders can be recognized as time stamped at time of terminal entry, at time of receipt at the host site, or at time of entry or update in the book. In our example, a time stamp at terminal entry will allow the Australian order to be processed first, providing that the system has a mechanism for reordering the messages if they are not received in the sequence that their time stamp would suggest. Time stamping at reception at the host site would unfairly favor locally-based traders.

Similarly, order executions can be recognized as time stamped at time of execution, at time of order book removal, at time of acceptance on an outbound queue, or at time of release from the outbound queue.

Transparency - Information Dissemination. The last important design consideration for an electronic trading system concerns transparency and information dissemination. Access to information by market participants appears to be both desirable and fair. Desirable information access should be evaluated in the context of the "efficient markets hypothesis", which claims that equilibrium prices should fully reveal all available information. Information access is fair because private information allows its owner to make profits at the expense of less informed investors. However, this is not so simple, and decisions such as who should see specific elements of information impact the efficiency and fairness of the market. The major categories of market participants that should be considered relative to market transparency are market makers, those who make two-sided markets, dealers who

operate as principals on either side of the market, order book managers, agency brokers, and institutional and retail customers. The types of relevant information that can be seen by market participants are shown in Table 5.

Table 5 - Information Types Observable by Market Participants

---

Insert Table 5 about here

The transparency of the system, along with the order execution algorithm, are important issues from a regulatory perspective (Corcoran and Lawton, 1993). In the U.S., the Securities and Exchange Commission (SEC) has a number rules that govern the dissemination of information in the American markets. For example, Rule 11Aa3-1 requires that all U.S. securities exchanges, including NASDAQ, must report last sale information as promptly as possible through the Consolidated Tape System.

References

Corcoran, A. and Lawton, J., Regulatory Oversight and Automated Trading Design: Elements of Consideration, *The Journal of Futures Markets*, Vol. 13, No. 2, April 1993, pp.213-222.

Domowitz, I., A Taxonomy of Automated Trade Execution Systems, *Midamerica Institute Research Project*, Northwestern University, May 1992.

Securities and Exchange Commission, *U.S. Equity Market Structure Study*, International Series Release No. 420, 1992.

Weber, B., Information Technology in the Major International Financial Markets, in *Global Information Systems and Technology: Focus on the Organization and its Functional Areas*, P.C. Deans and K.R. Karwan (eds.), Middletown, PA: Idea Group Publishing, 1994.

Weber, B., Transparency and Bypass in Electronic Financial Markets, Working paper #93-15, *Center for Research in Information Systems, Stern School of Business, New York University*, June 1993.

Wells, S., Transparency in the Equity Market - The Publication of Last Trades, *Stock Exchange Quarterly*, London Stock Exchange, Spring 1993.

Amihud, Y. and Mendelson, H., Liquidity, Asset Prices, and Financial Policy, *Financial Analysts Journal*, Vol. 47, No. 6, Nov-Dec 1991, pp.56-66

Table 1 - Leading Electronic Market Systems Vendors

Chicago Stock Exchange, formerly Midwest Stock Exchange -Chicago, Ill

Amsterdam Stock Exchange
Philippines Stock Exchange
Midwest Stock Exchange
Thailand Stock Exchange

ICCH Financial Markets, Ltd. London, England

Brussels Futures & Options Exchange
Irish Futures & Options Exchange
Luxembourg Stock Exchange
New Zealand Futures & Options Exchange
Osaka Sugar Exchange
Tokyo Grain Exchange
Tokyo Sugar Exchange

Toronto Stock Exchange Toronto, Ontario

Brussels Stock Exchange
Paris Stock Exchange
Barcelona Stock Exchange
San Paola Stock Exchange
Toronto Stock Exchange

TCAM Systems, Inc. New York, New York

Istanbul Stock Exchange
Maracaibo Stock Exchange
Tradepoint Financial Network
Vancouver Stock Exchange
Caracas Stock Exchange

OM Group Ltd. Stockholm, Sweden

Curacoa Stock Exchange (proposed)
Swedish Futures & Options Exchange
Austrian Futures Exchange

Femcon Systems, Inc. Marlboro, Mass.

Athens Stock Exchange
Boston Stock Exchange (BEACON)
Pacific Stock Exchange (POETS)
Philadelphia Stock Exchange (PACE)

EFA Software Services, Inc. Calgary, Alberta

Alberta Stock Exchange
Bucharest, Bulgaria Exchange
Guatemala Stock Exchange (proposed)
Slovania Stock Exchange

Transvik, Inc. Geneva, Switzerland

Budapest Stock Exchange
Nordik Stock Exchange

Task Management, Inc. Winnipeg, Manitoba

New York Mercantile Exchange (ACCESS)
Sydney Futures Exchange

Table 2 - Electronic Market Systems Worldwide

Electronic Equity/Options Markets

AUTO-EX - American Stock Exchange
SEATS - Australian Stock Exchange
BEACON - Boston Stock Exchange
ATS/2 - Bourse de Luxembourg
Transvik - Budapest Stock Exchange
RAES - Chicago Board Options Exchange
NSTS - Cincinnati Stock Exchange
ELECTRA - Copenhagen Stock Exchange
IBIS - Frankfurt Stock Exchange
HKTS - Hong Kong Stock Exchange
Instinet - Reuters
SMATS - Korean Stock Exchange
SAEF - London Stock Exchange
MAX-OTC - Midwest Stock Exchange
GTB - Milan Stock Exchange
MORRE - Montreal Exchange
CAES - NASD
SELECTNET - NASD
SOES - NASD
OLS (Odd-lot System) - NASD
TRANSVIK - Nordic Exchange
STS - Osaka Securities Exchange
SCOREX (Stocks) - Pacific Stock Exchange
POETS (Options) - Pacific Stock Exchange
CAC - Paris Stock Exchange
PACE - Philadelphia Stock Exchange
AUTOM (Options) - Philadelphia Stock Exchange
CLOB - Singapore Stock Exchange
SIB - Spanish Stock Exchanges
SAX - Stockholm Automated Exchange
SOM - Stockholm Options Market
CATS - Toronto Stock Exchange
CORES - Toronto Stock Exchange
Trade-Point, Ltd. (London)
Matchmaker - Vancouver Stock Exchange

Electronic Futures/Futures Options Markets

ACCESS - The New York Mercantile Exchange
APT - London International Financial Futures Exchange
BELFOX - The Belgium Futures & Options Exchange
CERES - The Chicago Board of Trade
DTB - Deutche Term Bourse
GLOBEX - Chicago Mercantile Exchange & Chicago Board of Trade
IFOX - The Irish Futures & Options Exchange
MEFF - Spanish Futures Exchange
MEFF - Spanish Options Exchange
Milan Futures Exchange
Milan Options Exchange
New Zealand Futures & Options Exchange
SFTS (Futures) - Osaka Securities Exchange
OTS (Options) - Osaka Securities Exchange
Osaka Sugar Exchange
OTOB - Austrian Futures & Options Exchange
SOFFEX - Swiss Options & Financial Futures Exchange
Sydney Futures Exchange
Tokyo Grain Exchange
TIFFE - Tokyo International Financial Futures Exchange
Tokyo Stock Exchange - Options
Tokyo Stock Exchange - Futures
Tokyo Sugar Exchange

Electronic Portfolio Trading Systems

Arizona Stock Exchange's WASI System
Instinet's Crossing Network
NYSE OHT (Off hours trading system)
POSIT Jefferies & Co./ Barra

Electronic Foreign Exchange Trading Systems

Reuters Dealing 2000 System
Electronic Broker Services
MINEX
Chase Trader - Chase Manhattan
International Dealer FX System - Bank of America
FX Dealing System - Lloyds Bank
TAG FX Dealing System - Barclay's Bank
FX Dealer - Chemical Bank
Currency Trader - Citibank
FX Direct - Midland Bank
FX Dealing System - Morgan Guaranty

Electronic Bond Trading Systems

Bloomberg
Crosscom Network Services
Instinet
NYSE - ABS
Copenhagen Stock Exchange - ELECTRA
Frankfurt Stock Exchange - IBIS
Paris Stock Exchange - CAC
Stockholm Stock Market - SAX

Electronic Government Securities Trading Systems

DELTA - RMJ (Options on U.S. Treasuries)
GovTrade - First Boston
TAAPS - U.S. Treasury Bond Auction System

Other Proprietary Trading/Vendor Trading Systems

TRADE - Barclays de Zoette Wedd
Bernard L. Madoff & Co.
Electronic Execution Services, Inc.
Global Trade, Inc.
Investment Technology Group
ATS/2 - ICCH Financial Markets
BEST - Kleinwart Benson
TR-AID - TCAM Systems
COLT - Femcom
BRASS - Automated Computer Services, Inc.
Merrin Financial Systems
ATS 2000 - Sungard Capital Markets Inc.
Task Management
ATES - EFA Software Services

Table 3 - Priority Levels in Electronic Trading Systems

Price	priority is given to better prices
Price with improvement	the order is briefly exposed to the market maker to allow for possible quote improvement
Time	first come, first served
Order Type	priority is a function of the order type: market orders, limit orders, cross orders
Order Allocation	the order is routed to a dealer or market maker, independent of price
Quantity/Size precedence	priority given to larger or smaller orders
Quantity Allocation	similarly priced orders are equally allocated or pro-rated according to the order size
Quantity Identified	priority given to orders revealing the order size
Trader Identified	priority given to orders that reveal the identity of the trader
Trader Class	priority is given to the public investors over specialists, market makers, or agency brokers
Direct Execution	direct action of accepting the bid or taking the offer

Table 4 - A Classification of Price Discovery Rules

Price from another market	in this situation, there is no price discovery
Price from another market with price improvement	potential price improvement depends on the bid ask spread and on market conditions. It can be determined electronically by a trading algorithm
Price negotiation	some level of negotiation is allowed is the system between potential buyers and sellers
Electronic quote execution	executable quotes and quantities based on the best quotes entered into the system.
Matched auction	transaction occurs when the price of the offer to buy matches the price of the offer to sell. The price is: - determined by the system using a matching algorithm - affected by specialist / market maker interaction
Single-price auction	bids and offers are submitted over a period of time, and executed at a single price at a given time. The price is: - determined by system using a balancing algorithm - affected by specialist / market maker interaction

Table 5 - Information Types Observable by Market Participants

Last trade information	volume, price, identification of the dealer, identification of the counterparty
Trading session information (for a given instrument)	high price, low price
Best Bid/Ask quotes (for a given instrument)	bid/ask quote, quantity, dealer id, number of dealers
Book information	quotes, quantities, dealer identification, counterparty identification
Analytic information (for a given instrument)	sales history, volume history, data from other markets
News and research information	

Figure 1 - Order Entry Windows on NASDAQ's new Workstation II

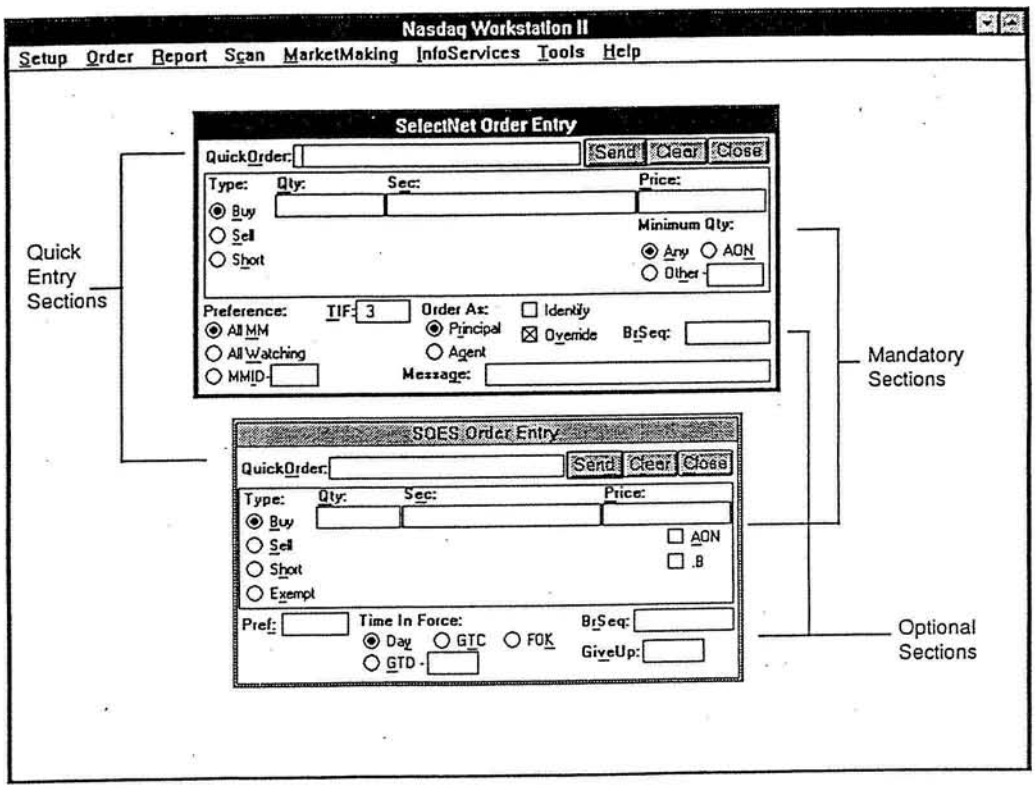

Figure 2 - Architecture of NASDAQ Trading and Information System

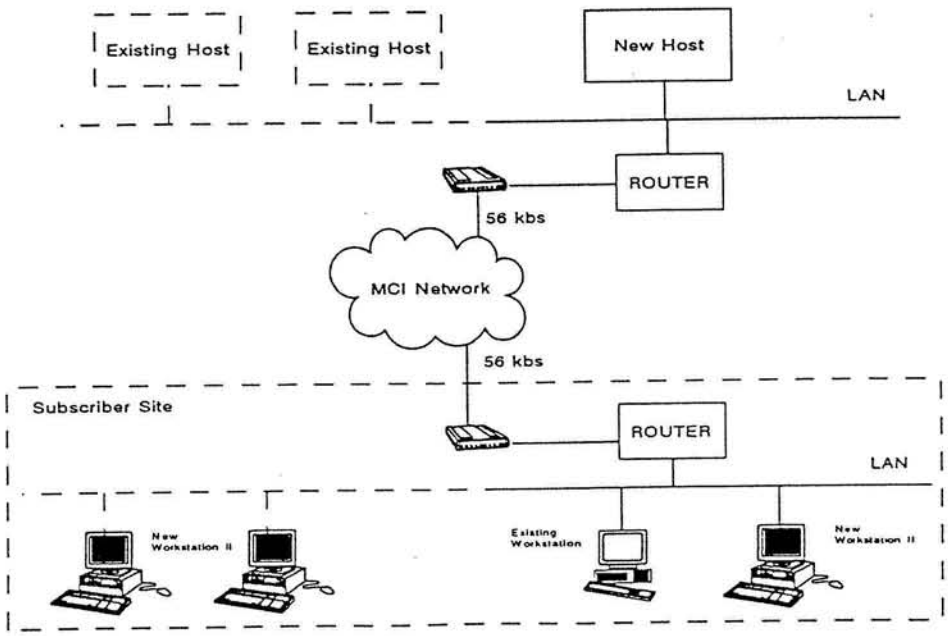

Figure 3 - Market Structures