DESIGN CRITERIA FOR ELECTRONIC MARKET SERVERS

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ABSTRACT

This paper presents and discusses a number of criteria for the design and implementation of electronic market servers. It first briefly reviews a number of electronic markets currently operational over the internet then offers some ideas on the types of new markets that may become successful. It then presents the design criteria for market servers, necessary to support these virtual markets. Finally, it introduces the ECMarket server, an experimental server under development at Elecomm Corporation. This work emanates from the research conducted at McGill University and EURIDIS at Erasmus Universiteit during 1992 to 1995.

ELECTRONIC MARKETS ON THE INTERNET

The past two years has seen explosive growth in the number of virtual markets and trades conducted over the internet. One of the more successful online auctions is eBay's Auction Web (www.ebay.com/aw/.) In January 1997 Auction web claimed to execute over 2000 trades per day with an average value per trade of $25. eBay says that they are the largest and longest running person-to-person auction on the Web. They have over 99,247 items for sale in 340 categories as of September 1997. They claim to have had 2,537,450 items for sale since inception in January 1996, handling over 10,209,323 bids. Their site reports over 12,000,000 hits per week. Internet Liquidators (www1.internetliquidators.com) offers brand name products for sale over the internet using a Dutch auction approach. This is a novel approach to retailing. Auction Central (www.auctioncentral.com) offers an online English auction for new and used computers, reporting over 230,000 registered users. Bid N' Ask (www.bidnask.com) is another online retail alternative. Their site allows players to access multiple retailers through a Java based Trading Floor; where they can negotiate prices on a selection of nearly 80,000 brand new Computer, Electronics, Digital Audio, and Avionics products. Encore Computers (www.encorecomputers.com) is a small local computer store that sells computers on consignment using their website to post scheduled price reductions. It operates as a very simple and limited version of a Dutch auction. This auction is an example of a geographically constrained market. Finally, Auction Web's Auction Resource Page (www.auctionweb.com) provides listings of the many physical auctions and auction houses around the USA including the online auctions.

In a different market category, we see the emergence of securities offerings over the net, forming a quasi financial market, but (currently) without an alternative exchange mechanism in place. Venture capital firms, e.g. Lynx Capital (www.lynxcap.com), Wit Capital (www.witcap.com), and Direct IPO, Inc. (www.directipo.com) are now moving to raise IPO money over the internet. (See also the Yahoo IPO listings at www.yahoo.com/Business_and_Economy/Finance_and_Investment/Initial_Public_Offerings.). The emergence of numerous alternative exchanges to the existing stock exchanges, is constrained primarily by national and regional securities commissions as well as the vested interests of the brokerage community.

While the above virtual markets have met with some early success, nearly all present a single market regime in which to trade goods or services. Here we define 'market regime' as the collection of rules governing the exchange of goods and services. These include, for example, those legislated (rules by fiat), the pricing model used, the bidding rules, and security requirements. However, market regimes exist in many forms with many different rules, each unique in some aspect. Ideally, a market server should be able to run any type and number of markets and offer many different custom configurations to support the diversity of markets both in existence, and those which may be created in the future.

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CREATING NEW VIRTUAL MARKETS

What types of markets will emerge as electronic commerce expands on the internet? While many factors will contribute to the transformation of existing markets and the formation of new markets, we can expect to see virtual markets forming when any of the following factors are present: 1. perishability; 2. scarcity; 3. goods which may be moved electronically (e.g. securities); or 4. goods which are geographically constrained.

PERISHABILITY AND EXCESS SUPPLY:

If goods' values drop to zero (0) at some some known point in time, such as happens to unused container space when ships leave port, then the owners of the goods are willing to accept lower prices as the deadlines approach. Similarly, airline passengers with unused tickets, would be prepared to sell for anything above the ticket transfer cost. Airlines take advantage of this phenomenon by consistently over booking flights. From the airlines perspective, when commercial airliners take off, each vacant seat generates 0 revenue. The travel and tourism industry have numerous instances where an electronic market could help clear unused capacity.

An example: Container Space Trader Vancouver, Canada, moves container traffic approaching 1,000,000 Twenty Foot Equivalents (TEU) per annum. Assuming that between 1% to 5% of the containers leaving Vancouver have unused and hence re-sellable space, and considering that the cost of shipping 1 container from Vancouver to the Asia Pacific region is about

$1500, then if 5% of the space leaves empty, each 1,000,000 containers represent approximately $75 million in economic efficiency loss from the sellable but unused space.

In the above hypothetical example, each 1% gain in market efficiency represents a potential market value of $15 million dollars per year. Further, assuming that a web-based market could charge 10% commission for providing liquidity in this new market, each 1% efficiency gain could yield $1.5m per year in commissions. This is for one port. The worldwide ocean container traffic reached 100 million TEUs per annum in 1996. Similarly, efficiency gains would also be possible in the airline cargo, truck and rail markets. The conditions under which we would see these markets emerge is discussed elsewhere (Nault, et al. 1996, Wrigley, et al. 1994).

Another form of perishability exists in the telecommunications and ISP markets. Excess capacity or unused bandwidth in the long distance and IP routing infrastructure yield zero return to the carriers for each minute that passes. Therefore we would expect to see spot markets emerge in this sector.

SCARCITY AND EXCESS DEMAND

On the other side of the coin, short term inventory shortages in any market present the opportunity to create markets to resolve the excess demand. For example, some Seagate distrubutors may experience short term inventory outages for a particularly popular new hard drive. In this instance, needy buyers may be prepared to bid up the price if there were a market for such goods.

Some other candidates for markets emerging over the internet are:

- Collectibles: stamps, coins, comics etc.;
- Wine;
- Domain names;
- IP addresses;
- Commodities such as Electricity or Water;
- Communication frequencies;

SECURITIES MARKETS:

Whenever a good may be moved electronically we would expect to see virtual markets emerge. Perhaps the most promising area is in the securities area. However, security market regulators and existing stock exchanges (see e.g. The Vancouver Stock Exchange), are most concerned about protecting the "public interest". This means that for publicly traded assets such as stocks and bonds, publicly traded companies must meet strict reporting criteria, which allows members of the public to make informed decisions about where they put their money. Usually, the various Securities Exchange Commissions allow only a very few exchanges to exist within their jurisdictions. This forces securities markets to cluster around relatively few exchanges. However, apart from legislative restrictions, there are no technical limitations to providing numerous smaller exchanges. Also, it is feasible for each company to operate their own exchange by having their own Over The Counter (OTC) storefront for their shareholders and other potential investors.

Fortunately, many jurisdictions have "knowledgeable investor" and other exemption clauses, which allow individuals who meet certain net worth or who have special relationships with the private companies, to be issued stock and to transfer their stocks among other private investors. This, at least, provides the basis for creating and running small alternative private capital markets over the net.

GEOGRAPHIC PRODUCT MARKETS

The most common form of product markets we see on the internet today are for computers, both new and used. These new and used computer markets are driven by three factors: standard product names and numbers, which leads to price discovery across suppliers, and hence lower prices; perishability, which is created by the rapid decline in new computer prices; and scarcity, resulting from short term inventory shortages. However, a global market for used computers makes little sense if the buyer and supplier are so dispersed that the transportation costs exceed local search costs. In addition, the ability to preview and test the goods prior to final settlement is important for market confidence. Therefore we would expect to see a huge number of local niche markets emerge within the new and used computer marketplace.

Clearly we see the potential for a plethora of markets, each operating within differerent jurisdictions, each being of different size, each with their own particular product characteristics and trading rules. This heterogenity places challenging requirements on the design and implementation of market servers to run the above markets over the internet. In the next section we examine and discuss these design criteria.

DESIGN CRITERIA FOR MARKET SERVERS

The principle design criteria for an Electronic Market (EM) server to run the above market categories are that of:

- Flexibility, to handle multiple market regimes;
- Response time under load;
- Scaleability, and;
- Security.

FLEXIBILITY

Each market, physical or virtual, operates within a regime. A market regime defines and governs the behaviour of traders and the market mechanism itself. Market regimes differ from each other with respect to a number of parameters including: the market pricing model, which a) raises or lowers prices to allow the market to clear, and b) defines the commission structure applied to trades; the information provided by traders to the market; the information provided by the market to traders (buy and sell information may be symmetrical or asymmetrical); the bidding protocols, which control when and who may bid, the bid queue discipline, and which define the action of the market when bids are received; the lot matching rules, which usually include price and quantity but may also include partial lot rules, reservation

prices, or other lot attributes such as buyer and seller geographic location; and the payment terms and INCO logistic terms.

Ideally, an EM server should be able to offer a wide variety of coordinating and trade mechanisms to "fit" with existing markets. Further, due to the uncertain form of emerging EMs, the market server's design should allow markets to be configured relatively easily and quickly. Setup costs must be minimized if hybrid markets are to blossom forth.

Market pricing model

A central distinguishing criterion among markets is the pricing model used for price discovery, and distribution of market commissions. In all instances below, it is assumed that items are offered for sale (supply), however each price discovery mechanism equally applies to items wanted to buy (demand). In these cases the price change direction is simply reversed. Market servers should be able to view the supply/demand queues as approximately symmetrical.

Price discovery: The market server must be able to support the various price discovery mechanisms used in different markets. These are:

- English auction: where the auctioneer raises the price after each bid until there is only one bidder remaining;
- Dutch auction: where the auctioneer lowers the starting price in each time interval until the first bidder bids;
- Dutch/English auction: where the price falls until there is a bid,and then the price rises until there is only one bidder remaining;
- Continuous double auction: where buyers and sellers submit their lots at either "market price" or at a specified price. Trades occur when their lots match on both price and quantity. Stock markets fall into this category and type of market.
- Open/Sealed bid: where traders place bids, open or sealed, for items offered for sale or for purchase, and the owner of the items decide to either accept their highest bid, withdraw the item for sale or give the market the authority to trade if the highest bid exceeds the reservation price and quantity.

In addition to the above, many hybrid forms exist. For example, a market requirement may be that a minimum of three bids are required before an item becomes available for trade. A market server should be able to run any or all of the above pricing mechanisms.

Commission structure: Many different formulas are used to calculate the market's share of trade value. A market server should be flexible to specify, in each market:

- Buyer premium;
- Supplier discount;
- Flat fee per trade charged to either buyer or seller or both;
- Other setup fees.

Information provided by traders to the market

Every market differs with respect to the data required to specify lot attributes. There are some common data elements, such as price and quantity, but most are different. For example, the data elements (and integrity constraints) required to create a lot for the flower market differ greatly from the data definition for an airline ticket market. Therefore, a market server must be able to define and process multiple data structures and integrity constraints.

In addition, an important feature is giving the traders ability to provide reservation pricing and/or reservation quantity data (partial lots) to the market server. This allows for the possibility of a trade when bid/ask price and quantity do not match exactly. In essence, the more information the trader can give to the market about their preferences, or the more the server can elicit, the better the market engine will be able to either match or optimize on price, quantity or other attributes.

Even within certain markets their exist differences in pricing individual lots. Price movement should be controllable by specifying the price increment (or decrement) and the time interval between movements. For example, two airline tickets in a Dutch auction, one which perishes on one day and one which perishes in one week, require different time intervals to move the prices between the opening prices and the reservation prices.

Information provided by the market to traders

Documents: The market server's central coordinating role, and value, lies in the timely delivery of informative and performative documents to the traders. These should include digitally signed:

- Lot Order (bid) confirmation;
- Lot change confirmation;
- Transaction slips;
- Trade summaries;
- Payment notification;
- Logistic notification.

Market view: The market server acts as focal point for traders to observe market activity in real time. This creates the need to spend considerable time designing the user interface to match with familiar trading screens, or in the case of new markets, input from experts. Therefore, the ability to customize the "trading room" or "trading floor" view becomes desirable so that markets can be made to "fit" with users. It also reduces market setup costs.

Part of this fitting may be to filter out certain data elements to both sides of the market, or to just to one side. Information asymmetry may be desirable in some instances where the sellers prefer to remain anonymous until their trade occurs. However, information symmetry, with respect to trader's identity, introduces the free-rider problem.

Free rider problem: If a particular market allows visibility of the trader's identity (buyers or sellers), then there exists the possibility that traders will go outside the market mechanism to engage in bilateral exchanges based upon information revealed within the market. While this is a general problem (Reimers 1995), many markets exist where this free riding is ei-

ther minimized or eliminated. The first example is where the response time interval is so short that free riders cannot contact and negotiate with the other trader before the goods or services are traded. A second case is were the supplier's identity is revealed, as in the case of the Dutch auction. In many real instances the suppliers form into a cooperative, which may preclude outside trades. A third case we can see in open public auctions, currently in operation on the net (see e.g. http://www.ebay/com/aw). The suppliers' identities are visible, thus allowing the potential buyers to contact the suppliers directly. However, we observe that trades still occur through the market rather than around it. What incentive mechanism is at play here? There are two factors. First, it is in the suppliers' best interest to not trade with the free riders because a better offer may come along at any moment. Second, where a supplier has many lots up for bid, the market performs an automated coordination mechanism, whereas free riders require a series of bilateral exchanges. Bilateral exchanges introduce the very transaction costs that the market is designed to minimize. Hence, we see conformity to the market rules, even in the face of the free rider alternative.

Bidding protocols

The bidding protocols form the basic structure of any market regime. For each of the above auction types a rule base is required, which specifies, and then controls what traders can and cannot do. For example, in the case of an English auction the traders who put the items up for sale cannot be allowed to bid on their own lots. The bidding protocols enforced in the electronic market must conform to that which takes place in the "real" markets. For a more complete treatment of this topic see Reck 1997.

Lot matching rules

In most markets, price forms the basis of lot matching. Where bids are tied on price then time of bid arrival may be used. Over the internet, however, time creates a special problem for tightly synchronized markets (see discussion below.) In cases where partial lots are allowed or where reservation quantities are used then quantity becomes the second criteria for matching. In addition to these two basic lot attributes, other attributes such as geographic location of the traders, payment terms or shipping terms, may also be used to match and trade. The ability to perform these multi-attribute matches in real time is an ongoing research issue.

Settlement terms

Standard settlement terms (e.g. payment and INCO terms) may be either specified by the market regime (e.g. pre-payment to the market before goods are released ex-works), or may be specified by each trader as an attribute of the lots submitted to the market. The variety of terms make it desirable for them to be market configurable or user selectable.

RESPONSE TIME

Multimedia

The extent of these requirements depend upon the products' attributes (Lee, et al. 1995). Financial markets are unlikely to require media other than numeric or graphic, unless traders enjoy the sound of the market floor. Where other goods or services are traded electronically, the bandwidth needs may increase dramatically by a factor of 100. Trading room construction greatly affects the bandwidth needed to run mutli-media markets. If the view is cluttered with GIFs and JPEGs then both bandwidth requirements and response time grow exponentially.

Browser-server communication

The data transfer requirements between the browser and the server can be reduced greatly with the use of EDI. Typically, html based documents are 5k to 20k bytes depending on the complexity of the market view, are cumbersome to produce and slow to transfer. The same information transferred over a direct socket connection in the form of EDI, to a Java applet on the browser, can be achieved by using just 200 to 500 bytes. This is an enormous efficiency gain.

Peak loading

The load on the market server can easily vary by a factor of 10 depending on the time of day and day of week. Hence the hardware and communications architecture must take this range into consideration prior to market implementation. Response time must be tested and run under load conditions.

Real time protocols

One limiting factor to running markets over packet switched networks is the inherent lack of virtual circuits. Work is currently underway to extend IP protocols towards real time applications (RTP: RFC 1889). This will allow much tighter communications between the market server and the browsers, thus improving response time.

SCALEABILITY

Independent processes

Judging from the recent explosive growth of online markets the server(s) must be quickly scaleable to run on multiple machines. This requires that the market server be easily cloned with each of the logical servers operating independently from each other. In addition, each of the market server's compenents should be independent processes that communicate asynchronously over secure socket to socket connections.

Lot creation

For high volume markets, EDI plays an important role by facilitating the generation and submission of lots from the market suppliers to the market engine. The only way to scale the market is to allow for the EDI submissions directly over the Internet. Manual entry does not scale well.

SECURITY CONSIDERATIONS

Perhaps the most important consideration for achieving widespread acceptance of online markets is the trust that traders have in the market server, and the trust the market server has in the traders' identities. This can be achieved with the use

of public keys and certification authorities (see e.g. www.verisign.com.) From the traders' perspective it is necessary that the server digitally sign all documents coming out of the market, including Order Confirmations and Trade Summaries. Clear text digitally signed documents provide non-repudiation by the market and guarantees that the traders cannot modify the documents in order to make claims against the market. To achieve confidentially between traders and the market, it is necessary that the traders deposit their public key with the server so that the signed documents may be encrypted for transport over the net.

From the markets' perspective, traders must be authenticated and instructions to trade or not trade must be non-repudiable. Authentication may be achieved with the use of passwords, IP address reverse lookups and session level "cookie" exchanges. However, as the widespread use of public keys is still in an early stage of adoption, the requirement that traders sign their trade orders will retard growth. This represents a barrier to growth in the use of online markets. Fortunately digital IDs are now becoming more popular and should be in general public use within several years.

ECMARKET SERVER: DESIGN OVERVIEW

The current implementation of the ECMarket server approaches many of the design criteria discussed above and is currently capable of running (under controlled conditions) many of the the markets described previously. The ECMarket prototype market server is designed around, and offers, the following additional features:

- Trading rooms: The basic object in the ECMarket is a trading room in which one or more goods or services may be traded. Each trading room is constructed according to the requirements of the market in general or of the trader specifically. Trading rooms are classified and grouped into product markets, which in turn may be grouped into markets.
- Private markets and private trading rooms: Not all markets are open to the pubic. Many markets exist where trading is restricted to relatively few traders according to membership in a certain group. Access to these restricted markets are controlled by user authentication and provides secure private communication among the traders.
- Market availability: Although IT offers the ability to keep markets open around the clock, it may be the case that for some markets the traders prefer to have regular opening and closing times so that they may coordinate and focus their trading activity into a narrow time window. Seasonal markets also fall into this category. ECMarket allows for the specification of scheduled open and close times.
- Multimedia aspects: As the diversity of products bought and sold over the net increases, additional informational aspects of the goods, such as pictures, graphs, sound clips and even VRML support, are available for inclusion with trading room creation. These requirements greatly increase the load on the server and communications infrastructure, as when compared to numerical price and quantity data alone. The communication, hardware and software requirements to support large scale multimedia product markets, running over the Internet, are considerable and remain open research questions.
- Market liquidity (bringing in the traders): Every time a trading room is created its descriptors are automatically disseminated into the major search engines.
- Buyer or supplier authentication and rating (acting as Trusted Third Party.)
- Dissemination of trade results and completion of trade settlement, including payment and logistic directions.

The ECMarket server is in its second year of a five year development plan and is available for educational and research use. Please contact corporate@elecomm.net for further information.

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