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Abstract

We describe an application for auctioning goods on the Internet. A variety of commonly used auction mechanisms that are supported by the application, security requirements, and pre-auction and post-auction interactions needed to complete auction based trading are discussed. Then we present a software architecture and describe the various processes that comprise the auction application. Finally, we discuss how the delay, security, and easy collaboration aspects of the Internet will cause auctions on the Internet to be different than the traditional auctions.

1. Introduction

Most business activity on the Internet is limited to publicizing the business opportunity and catalog based sales, but it will rapidly expand to include the negotiations conducted to settle the price of the goods or commodities being traded. These negotiations are currently conducted by human intermediaries through various forms of auctions, bidding systems for awarding contracts, and brokerages. The role of the intermediaries can now be performed by Internet trading applications at a fraction of the cost. Trading on the Internet allows a business to reach a larger number of potential customers and suppliers in a shorter time and a lower cost than possible by other modes of communication, and to settle business transactions with lower cost overhead in a shorter time. Hence the rapid emergence of Internet based trading applications. Lee discusses the factors behind the success of Internet auction of second hand automobiles in Japan [1] supporting our belief.

Auctioned or brokered sales are the norm in the business world for negotiating trades of large value. But consumer sales and small scale purchases typically stay with fixed prices, perhaps because of the high overhead cost of using the auction or brokerage method. The new economics of the Internet will make auctions popular in consumer and small business transactions also. Lee and Clark present economic forces underlying this transition [2]. Several success stories about Internet auctions are cited by Turban [3].

Many types of auctions are practiced in different real world situations to achieve different business objectives such as best price, guaranteed sale, minimum collusion possibility, etc. Ralph Cassady presents an extensive survey of auction practices around the world [4]. Game theoretic treatments of the different kinds of auctions can be found in [5,6,7], while some experimental results are reported in [8]. In this paper we describe the design of an Internet auction system that can support most of the auction types and other business negotiation models.

In this paper we first briefly review the requirements of an Internet auction application. Some of the important requirements are support for a wide variety of commonly practiced auctions and ease of integrating auctions with business's existing back end applications to create a completely automated trading process. Security mechanisms, based on cryptographic methods and audit trails, are needed to prevent hackers from sabotaging auctions and buyers and sellers from cheating or disrupting the auctions. Efficient notification mechanisms to inform bidders of the latest bids are required to scale the auction application to large number of bidders.

We have implemented an auction system that is operational now. It supports the breadth of auction styles, interaction requirements, and other attributes. We present the design for this auction application which implements these auction types and allows the seller to choose any of them and further fine-tune the rules to maximize his business objective. We describe key

features of the underlying object, process, and interaction models. In a companion paper we discuss various types of auctions in detail [9]. There we also discuss how auctions relate to other types of commonly used trading models such as brokerages, two party negotiations, and competitive bid-based procurement.

2. Requirements for an Internet auction application

An auction application must support the various types of auctions practiced routinely around the world. In this section we first briefly review the different kinds of auctions. Given the unique characteristics of Internet, it is highly likely that other forms of auctions will also emerge. Next we discuss the steps of a complete auction based trading process., and then we discuss some requirements for security and access control. In addition to these requirements, the auction application should integrate with the back end ERP (enterprise resource planning) applications of an organization (or spreadsheets for small business and home businesses) in a straightforward manner. ERP applications are the transactional programs that automate a business's various activities such as procurement, sales, invoicing, payments, human resources, etc.

Different auction methods:

The commonly used auction types are the open-cry auctions, single and multiple round sealed bid auctions and Dutch auctions. In an open-cry auction, also called an 'English auction', the buyers gather at a common location, physical or virtual, at the pre-specified time. Each buyer can hear the bid submitted by a rival buyer and has a limited time to respond to it with a higher counter-bid. In physical auctions the responses must be received within seconds, while in Cyber auctions it is conceivable that several minutes or hours will be allowed for the response.

In a sealed bid auction the buyers are required to submit their bids by a specified deadline. The auctioneer keeps the bid information secret until the deadline, at which time the bids are evaluated and the winners are declared. Single round sealed bid auctions lack the competitive atmosphere (bidding frenzy) in open cry auctions which encourages the bidders to outbid their rivals. Multiple round sealed bid auctions rectify this situation. In a multiround sealed bid auction there is a deadline for each round of bids, and at that deadline either the auction is closed or the bids from the current round are publicized and a fresh round of bids is solicited by some new deadline.

Dutch auctions are better suited for perishable items such as vegetables or airplane seats. Here the auctioneer starts with a very high asking price. Then he gradually decreases his asking price until buyers emerge with bids specifying how many items they will purchase at the current asking price. He can continue lowering his bid to maintain a stream of buyers while the inventory lasts. Furthermore, he can control how fast he depletes his inventory by controlling the rate at which he lowers the bid.

Each of these auction methods has subtle variations such as:

- Anonymity, i.e., what information is revealed during the auction and after the auction closes. For example, the identity of the bidders could be concealed. In a sealed bid auction the final winning prices could be kept confidential. In all auctions the amount of inventory may or may not be announced in advance.

- Rules for ending Dutch and open cry auctions. Open cry auctions may end at a posted closing time. Alternatively the auctions could be kept open so long as new bids continue to arrive within some time interval of the preceding bid. This interval would be several minutes in an Internet auction and a few seconds for an auction being conducted in a meeting room. One could also choose to close the auction if either of the above two conditions is met or only when both conditions are met. Dutch auctions could close at a pre-specified time, when all the inventory has been sold, when the price has fallen to a pre-specified level, or at some combination of these three conditions.

- Once the bidding phase is over, the bidders with the highest bids get the item being auctioned, but the price they pay could be the same as what they bid or lower. In a *Discriminative Auction*, also known as *Yankee Auction*, the winners pay what they bid. In a *non discriminative* auction people with winning bids pay the price paid by the winning bidder with lowest bid. Finally, in an auction for a single item, in a *Vickrey Auction* [10] the winner pays the price bid by the second highest bidder. Vickrey auctions are also referred to as second price sealed bid auctions.

- Restrictions on bid amount: In all auctions the seller can specify the minimum starting bid. To

speed up the bidding process minimum bid increments are often enforced. The bid increment is roughly proportional to the current bid, i.e., they are smaller for lower bids and larger at higher bids. The seller may also be allowed to specify a reserve price, which is a lower limit on price acceptable to seller. The buyers may know that a reserve price exists but they may not know what the reserve price is.

Though counterintuitive, Vickrey, Dutch, open cry and sealed bid auctions yield the same revenue for the seller when one item is being sold, the bidders are risk neutral, their valuations are independent draws from the same probability distribution, and each bidder knows only his valuation and the distribution function from which the other bidders draw their valuation. The result is known in literature as the *Revenue-Equivalence Theorem*, and the assumptions about the valuation are known as the *independent private value model*. Another interesting property of Vickrey auctions is that they are incentive compatible, i.e., it is in the best interest of the bidder to bid their true valuations.

However, experimental observations of the outcomes of various types of auctions differ from the strategic behavior predicted by the game theory based analysis because of psychological factors such as preference reversal and misjudged revision of valuation and winning probability during an auction [11]. Though the Dutch and first-price sealed bid auctions are strategically equivalent, Dutch auctions fetch a lower price. The Dutch auction price is lower than that predicted by the strategic behavior in traditional analysis. The two plausible explanations presented in [11] are that: 1) bidders derive a positive utility from suspense (they play against the odds to remain at the gambling table); 2) They update (lower) their estimate of other bidder's valuations as the offering price moves down. Similarly, though the Vickrey and English auctions are strategically equivalent, Vickrey auctions fetch a price higher than the English auction. The Vickrey auction bidders bid above their true valuations. The plausible explanation presented in [11] is that the bidder's mistakenly believe that by bidding marginally above the true valuation they increase their chances of winning without risking negative payoff.

In this paper we focus on auctions of single or multiple copies of indivisible goods where the goods being sold come from a single seller, or are aggregated before the auction process begins and are sold with the same set of rules such as reservation or asking price. Beam et.al. address the problem of scheduling auctions for periodically arriving goods where arrival of bids from buyers follows a Poisson process [12]. Many market mechanisms exist to match multiple sellers directly with multiple buyers. Various types of stock exchanges, secondary markets for financial instruments, and commodity exchanges fall in this category. Detailed discussion of these is beyond the scope of this paper. Some interesting examples are the reverse unilateral auctions offered by CXN *(www.cxn.com)* and also discussed by Beam and Fusz in [13], Generalized Vickrey Auctions [14], and continuous double auctions [15]. In the CXN auctions all sellers specify their asking price and the auctioneer communicates the lowest asking price to the potential buyers. In a Walrasian auction each bidder specifies a bid schedule consisting of multiple price points and the quantity demanded at each price [16]. The trading mechanisms of New York and NASDAQ stock exchanges are described in [17].

Complete auction process:

A complete auction-based trading process comprises six basic activities:

1. **Initial buyer and seller registration:** This step deals with the issues relating to authentication of trading parties, exchange of cryptography keys, and perhaps creation of a profile for each trader that reflects his interest in products of different kinds and possibly his authorized spending limits.

2. **Setting up a particular auction event**: This step deals with describing the item being sold or acquired and setting up the rules of the auction. The auction rules explain the type of auction being conducted (open cry, sealed bid, Dutch), parameters negotiated (price, delivery dates, terms of payment, etc.), starting date and time of the auction, auction closing rules, etc.

3. **Scheduling and advertising:** To attract potential buyers, items of the same category (art, jewelry, rare coins) should be auctioned together at a regular schedule. Popular auctions can be mixed with less popular ones to force people to be present in the less popular auctions. Items to be auctioned in upcoming auctions are advertised, and potential buyers are notified in this step.

4. **Bidding:** The bidding step handles the collection of bids from the buyers and implements the bid control rules of the auction (minimum bid, bid increment, deposits required with bids) and for open cry

auctions notifies the participants when new high bids are submitted.

5. **Evaluation of bids and closing the auction:** This step implements the auction closing rules and notifies the winners and losers of the auction.

6. **Trade settlement**: This final step handles the payment to the seller, the transfer of goods to the buyer, and if the seller is not the auctioneer, payment of fees to the auctioneer and other agents (appraisers, consignment agents, etc.).

Security Requirements:

The auction house policy and the instructions from the seller dictate whether the auction is accessible to the public at large, to the buyers/sellers registered with the auction services, or only to buyers registered to participate in the current auction. Access control mechanisms are needed to enforce these rules. Security mechanisms are needed to ensure that the site announcing the auction and the auction rules is not sabotaged by an outsider. This includes preventing unauthorized postings and alterations as well as preventing denial of service attacks. A trusted third party service for enforcing access control rules and digital signing of contracts to ensure non-repudiation, is discussed in [18].

Cryptographic mechanisms that prove that a particular auction notice was posted and accessible during a certain time period will be very useful in government auctions. During the bidding phase cryptographic mechanisms are needed to ensure that a bid submitted is not tampered with, or disclosed to other bidders in violation of the auction rules. In open cry auctions spurious bids, injected by the seller or auctioneer to prompt the highest bidder to further increase his bids, must be prevented by establishing a verifiable connection from every bid to a known bidder. In the real world such unethical behavior is called taking bids off the wall, or ceiling. A shill is a human agent deployed to inject spurious bids into an auction.

Franklin and Reiter describe a secure protocol for eliminating fraudulent activity by the auctioneer [19] in a sealed bid auction. It employs multiple auction servers, at least some of which are trusted to stay honest. This certainly is useful to control employee fraud within a large auctioneer's organization. However, for mass trading on the Internet where many small organizations are involved, placing trust in the organization itself is an issue. In simplistic terms, it is reasonable to expect that, say three out of five employees (servers or server administrators) in a government organization or *xyz_megacorp* will be honest. But it is difficult to assume that three out of five servers deployed by the relatively small *xyz_little_corp* will not collude.

Spurious or phantom bids are possible in real auctions because knowledgeable or well known buyers often want to remain anonymous (when Leonardo DeVinci's diary was won by Bill Gates; the buyer's identity was discovered only after the auction was over). The presence of knowledgeable bidders in an auction prompts other bidders to bid high undermining the interest of the knowledgeable bidder. Accommodation of anonymous bidders gives the auctioneer an excuse to pick bids from 'nowhere'. Internet auctions cannot overcome this mechanism design constraint. The problem is further aggravated because Internet auctions will have much larger participation from geographically dispersed bidders and cyber identities can be created easily. The possible solution approaches to this problem are *caveat emptor,* requiring mechanisms to let bidders establish the identity of other bidders, or an independent third party trust rating system which can investigate the ethical behavior of the auctioneer and assign a trustworthiness rating to it. Shills are detectable by experienced bidders because when shills are the winner in an auction, which happens some times accidentally, the items reappear on the auction block. Shills appear more frequently at auctions and tend to bid on unrelated items. However, it is easy to hide these clues on the Internet.

3. Design of Auction Software

In this section we describe the design of an auction application. Figure 1 shows the object model and Figure 2 shows the data flow diagram of a generic auction application. It supports the various types of auctions discussed in the previous section.

Object Model for auction application:

In Figure 1 multiple products, traders, and auctions are part of the auction house. Each auction is for one or multiple copies of a single product and a subset of traders participate in it. The product object describes the product or service being auctioned. It is separate from the auction object because the same product can be auctioned in different quantities in different auctions held at different times. For example, a

seller with 500 widgets may wish to sell 100 widgets on each day of a chosen week. The search object supports various search methods on the products in the store. Its attributes will be the different classifications of products required by the search methods.

In addition to products and participants, the auction object comprises messages created by participants, terms of the final sale, rules of the auction, and the final trade generated at the end of the auction. The important message types in an auction are query, create, update, and delete bid messages send by the buyers; and messages sent by the seller to close the auction manually or change the asking price in a Dutch auction.

The *state* attribute of auction restricts the type of messages a participant can create when the auction is in that state. For example a simple open cry auction can be in one of three states, active, closed, or not-started. Changing rules and parameters of the auction, like adding or changing the reserve price or minimum starting bid, would be allowed only by the seller while the auction is in the not-started state. Similarly, buyers may be allowed to submit bids while the auction is in not-started or active state, but they may be allowed withdraw bids only when the auction is in not-started state. The *accept-message* method of *auction* object queries the auction rules external to the auction object to determine if a message can be accepted.

Each message, for example, bid from a buyer or closing of auction by the seller, results in updates or notifications being sent to all or some of the other participants. Different participants may get different notifications. For example, when a bid is submitted in an open-cry auction the bid submitter gets a simple acknowledgment, the bidders whose bids are lower than the newly submitted bid will be informed that a higher bid has been submitted, while bidders whose bids are already higher than the newly submitted bid may get no notification at all. Similarly, when the auction closes, the winners and losers will get different notifications. The notification object encapsulates multiple transport methods to send the notifications to the participants. E-mail, online notification via a push or pull mechanism, and manual polling by the bidder are possible. The rules object provides the method to determine which notification methods must be used with each message.

The rule object contains methods which modify the behavior of other objects. Two examples cited

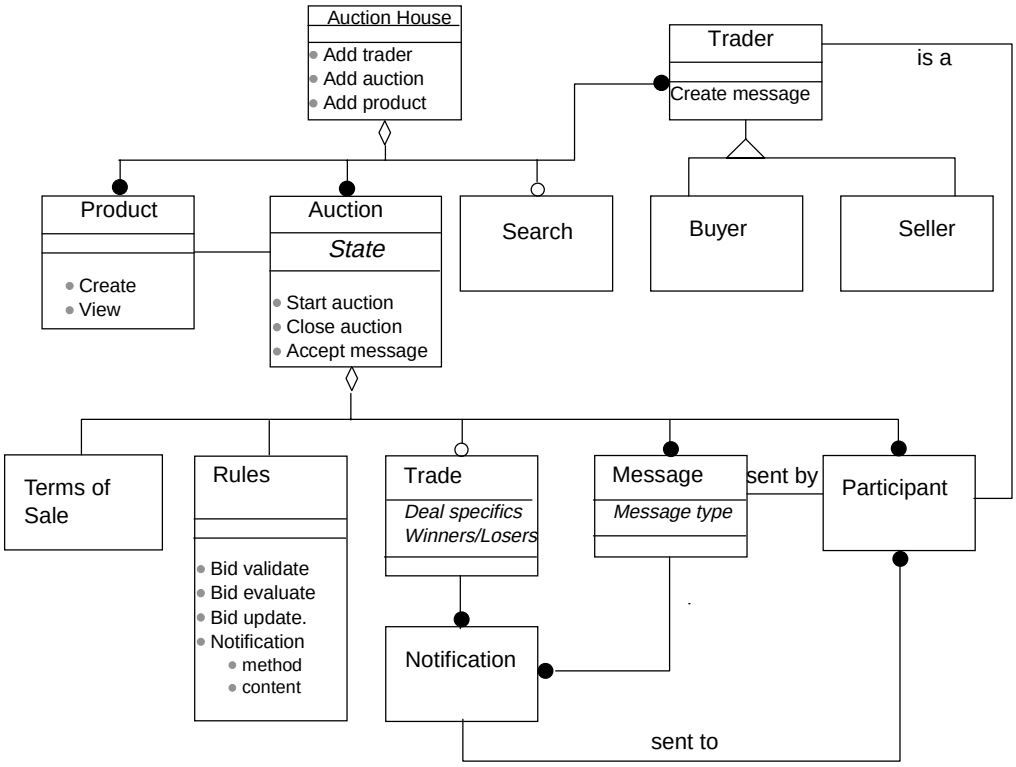

Figure 1

earlier are rules governing when a certain type of message is accepted by the auction object and the rule governing the method used to notify participants. Rules which need to be set or fine-tuned by the auctioneer or seller are specified in the rule object and methods are provided to review and set these rules.

The trader object basically contains the registration information for the buyers and sellers. In addition to name, address etc., it may contain buyer preferences for products, preferred method for being notified of auction updates, and passwords. It also contains a list of auctions on the auction site that a bidder has participated in or has expressed an explicit interest in. We refer to this short list as the bidder's personal auction gallery.

The auction object and the rules object would be subclassed to support different kinds of auctions. For example, the Dutch auction object derived from the basic auction object would provide a method to accept a message from the seller which revises the asking price downwards. Similarly the bid objects can be subclasssed. All bids would share common sending, receiving, and archiving methods, but the Dutch auction bids would not allow a non null value for price (the Dutch auction bid contains amount, the price being quoted by the auctioneer/seller).

Process flow model:

In the process flow diagram in Figure 2, the three rectangles (buyers, sellers, and settlement system) are the active producers or consumers of information at the boundary of the data flow graph. The disk symbols are information repositories internal to the data flow model. Ovals represent processes, solid arrows represent flow of information, and dashed arrows represent control signals. A hollow triangle at the end of a line indicates a repository created by a process, some of which can be temporary. The five steps of the auction process mentioned in the previous sections are identified in the data flow model at the bottom of Figure 2.

As shown in Figure 2, buyers and sellers can register themselves to create trader objects. Additionally, buyers register their preferences through the preference process and sellers can use this information to create target lists to promote to promote a product or class of product to buyers in a target list. The sellers use the define/update process to create a description of the product being auctioned and use the Setup auction process to describe the type of auction and various rules that go along with it. If the auction rules permit they can cancel the auction or update some of its parameters such as closing time. The alert process notifies a buyer when a product is placed on auction that matches his preference, or if the auction rules or product information changes for such products. The search process provides various search metaphors to help the buyer find/select an auction. The selected auction can either be entered in a list of interesting auctions or the buyer can proceed to bid on it. In the latter case notifications may be sent to bidders whose bids are superseded.

The seller can also select an auction, and in case of Dutch auction use the offer process to change the asking price. This again results in notifications being sent to people who are participating in the Dutch auction (participation in a Dutch auction by buyers who have not bid at all can be recorded by keeping a zero quantity bid in the bid table). Finally the close (auction) process normally closes the auction automatically based on auction rules, but supports manual closing by the seller. When an auction is closed, all the bids submitted for that auction are evaluated and the winners and losers are notified (Dutch auctions, by definition have winners only). Shipping and payment instructions pertaining to each wining bid are sent to the back-end ERP system for final settlement.

Each buyer can maintain a list of auctions that are of interest. This list is maintained at the auction server. The auctions in which a buyer participates are added automatically to the short list. The buyers select auctions from the list or through the search processes provided and submit bids for auctions in progress. In auctions of multiple items, buyers are allowed to submit multiple bids. Depending on the cutoff price for winning bids, and the cutoff time for bids sharing the cutoff price, all, some or none of them could be the winning bids. Currently we do not implement the ability to bid on a bundle of goods. We also do not support the ability to submit a set of bids for the same or different items where only one of the bids, the best one based on the evaluation criterion deployed, will be considered. The buyers can review the bids they have submitted and increase/modify the bids. In open cry and Dutch auctions the buyers can review the bids submitted by other bidders.

The Auction application is fundamentally driven by the auction rules repository. It includes the schedule for the auctions, templates for creating the popular kinds of auctions, and the rules governing individual auctions. Different product in the product repository can be auctioned using different auction types

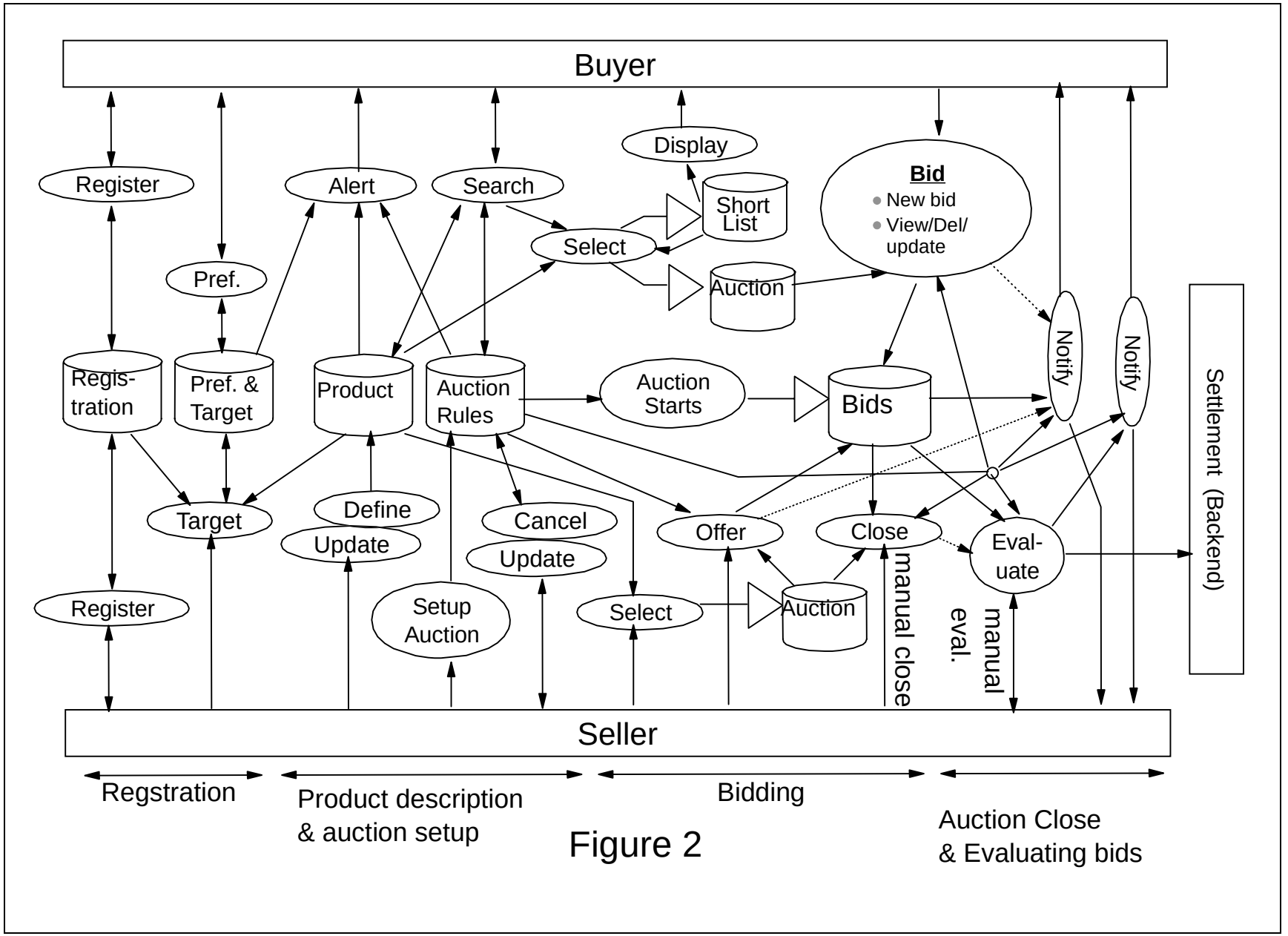
Buyer
Register
Alert
Search
Display
Short List
Select
Auction
Bid
New bid
View/Del/ update
Pref.
Regis-tration
Pref. & Target
Product
Auction Rules
Auction Starts
Bids
Notify
Notify
Settlement (Backend)
Target
Define
Update
Cancel
Update
Offer
Close
Eval-uate
manual close
manual eval.
Register
Setup Auction
Select
Auction
Seller
Regstration
Product description & auction setup
Bidding
Auction Close & Evaluating bids

Figure 2

and policies. As shown in Figure 2, the auctions rules define:

Bidding process:

1. What is the content of a bid, i.e., price and quantity for a regular auction or quantity only for a Dutch auction.
2. Under what conditions can a previously submitted bid be withdrawn.
3. The minimum bid, bid increments, and deposits required with bids.
4. The information sent back to the buyers and sellers in response to bids received. For example, in an open cry auction the notification to the buyers in response to a bid would be some subset of highest bids, and a subset of information from each bid. For example, the bidder's identity could be dropped. In a sealed bid auction only the bidder sending the bid will get a simple acknowledgment.
5. In open cry and Dutch auctions, which subset of the bidding history is accessible to the bidders.
6. How the notifications are sent back: e-mail, live sockets, etc.
7. Which subset of buyers are eligible to submit bids.
8. Are bidders allowed to submit multiple bids when multiple items are on sale.

Seller's options:

1. The seller's ability to modify the sell offer by lowering published price in a Dutch auction, or the inventory being auctioned.
2. Auction closing rules, i.e., whether the auction ends by seller's manual intervention, at a fixed time automatically, after a fixed period of bidder inactivity, or some combination of the three.
3. Under what conditions, if any, can the seller change the auction rules or withdraw the auction.
4. Rules for resolving tied bids, i.e., whether an earlier bid gets the priority or repeat customers are given higher priority.
5. Complex bid evaluation rules like giving weight to bids specifying large product quantities or prompt payment.

Navigation

Figure 3 shows how the bidders navigate the auction web site. Each bubble shows a web page and arcs from one page to another indicate that a hot link is available from the first page to the second. The seven pages marked with asterisk can be accessed any time from the side bar. The auction site URL puts a bidder on the Welcome page from where a registered user can authenticate himself to the web site and initiate a secure session (login). An unregistered user will get the opportunity to fill in a registration form which may be processed online or off-line. After registering, the bidders can browse through or search the products in the auction house which will possibly result in a product being selected and its description presented to the bidder. If the product is on auction, the rules of auction can be viewed, and bids can be submitted for that product.

From the home page the bidder can also see a list of all auctions at the auction site or a subset of these which are in his personal auction gallery. From either list, the bidder can select an auction and access the description of the product being auctioned, see the rules of the auction, or bid on the product. For open-cry auctions he can also see a subset of the previously submitted high bids for that product. In both these lists, the entry for an auction also includes the auction type, quantity being auctioned (if the rules permit), best bid or current asking price for open cry and Dutch auctions respectively, and auction closing time if determined.

From the list of high bids for a product mentioned above, a buyer can increase his existing bid, submit a new bid, review the auction rules or access the product description. Similarly, from the home page a buyer can access the list of all his bids and perform the same functions. Finally from the home page a buyer can access his message box which contains all the notifications sent by the auctioneer to the buyer. When ever there is an unread message in the mailbox of the buyer, an icon flashes in the side bar on all web pages. This icon is in a small frame which refreshes itself every few seconds (Netscape client pull feature. Refresh time is specified in the HTML header).

Notification:

Currently two notification mechanisms are provided in the auction prototype. First one is the simple e-mail. The second one is through the message box mentioned in the previous paragraph. E-mail is necessary to communicate with buyers who are not looking at one of the auction site pages when a message need to be delivered. Message box is more convenient for those who are on some auction site page when the message is to be delivered.

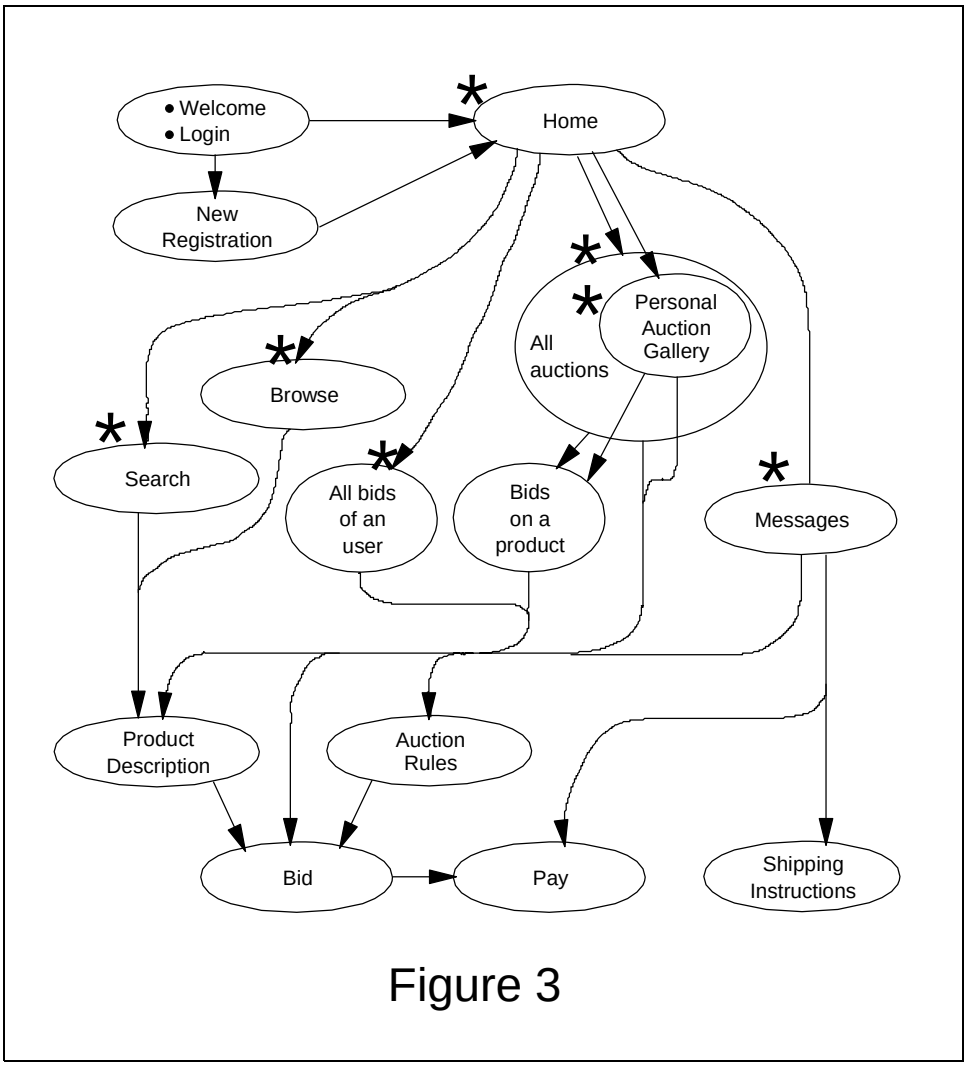

Figure 3

Other than the mailbox icon in the side bar mentioned in the previous page, only the bid submission page is updated dynamically to show the current highest bid or current asking price for open cry and Dutch auctions respectively. This update is also accomplished by putting the bid/asking-price information in a separate small frame and specifying a short refresh time for it. Because the page refresh mechanism is a client side polling mechanism, it is not very scalable. Most of the time the server will be repeating its old information to the client. In a future implementation we plan to use server-side push to a java applet sitting on the client browser. On the server side an optimized notification process would update messages only to clients which require the update. Most of the time an identical update will be sent to multiple clients. The notification process would allow a message to be sent repeatedly to different clients by stepping through the socket addresses (or an equivalent network address entity) in the inner loop of the code.

4. Internet-specific design issues

Auctions in the real world are well understood and studied extensively. However the Internet changes the auction environment, mitigating some constraints of the real world and introducing some new problems of its own. In this section we discuss how auctioning on the Internet could differ from auctioning in the real world.

Bidder collusion:

A set of bidders in an auction can collude to form a ring, where the members of the ring agree not to outbid each other. At the end of the auction, if the item is won by a ring member, it is resold among the ring members using a separate auction, or some other allocation procedure. The surplus created in the second sale is the loss inflicted to the seller. It is split among

the ring members. Internet makes the formation of rings much easier. Just like hacker's web sites and chat rooms, one can conceive of bidder's chat rooms with cyptographically secure mechanisms for creation of rings. Even in the absence of such centralized chat rooms, if the identities of bidders are known to other bidders, a desirable situation to reduce phantom bids by the seller, the formation of rings is facilitated. Aggressive use of reserve prices can reduce the incentive to form rings by reducing the gains expected by their creation.

Luckily, rings are illegal, though not necessarily unheard off. Under commerce laws disruption of a fair market process is illegal and forming rings amounts to disrupting a fair market process. One can expect some debate on applicability of today's outmoded commerce laws to the cyber world, but history indicates that legal apparatus will move to protect the interest of commerce.

Choosing the right kind of auction:

There are reasons for choosing one form of auction over other. Vickrey auctions eliminate the effort on the part of the bidder to speculate on the minimum bid he needs to submit. Dutch auctions provide the seller a better control on (liquidating) inventory by giving him the controls to revise the prices downwards and thereby manage his inventory level more directly. Dutch auctions also discourage the formation of rings because in a Dutch auction a ring member stands to gain by defecting from the ring while the auction is in progress and the rest of the ring is playing by its rules. Open cry auctions do not encourage defection because the defecting ring member does not increase his gains by defecting. After the defection of one (or few) ring members the rest of the ring can continue to operate as if the defecting ring members were not part of the ring to begin with.

Choice of auction method also depends on the industry in which it is being used. Governments (democracies) are likely to lean towards auction methods which have higher transparency. Sealed bid auctions are likely to be used when preparing the bid is time consuming, or it is impractical for the bidders to collect at a common location at the same time. Since the Internet frees the bidders from this constraint, open cry auctions are likely to be preferred on the Internet (with bidder anonymity if needed).

In practice, open cry auctions are usually for one item. If multiple items are to be sold, they are sold one at a time. That is acceptable in the real world because each item sells fast, and it is impractical to take multiple bids for the items simultaneously. On the Internet one can sell multiple items simultaneously. This is also necessary to some degree because each auction takes a longer time. Therefore, we expect to see an increase in use of auctions for multiple items.

Withdrawing bids in an open cry auction:

In a traditional open cry auction, which lasts usually for minutes, the bids submitted by a buyer are binding, i.e., he simply can not back of from his bid. Since open cry cyber auctions can take hours or days to conclude, the potential bidders will be hesitant to make such an open-ended commitment to buy. Hence, the Internet open cry auction mechanisms must give the bidder an opportunity to ask the seller for a commitment or withdraw his bid. Decision support tools would be needed on the seller's side to help him decide whether to commit to the sale in this situation.

Usability:

Traditionally the buyers and the sellers in an auction have been seasoned professionals of an industry with intimate knowledge of the auction mechanism and of the relevant bidding strategies. However, Internet brings auctioning to the masses, and a typical participant may know very little about the often complex auction mechanisms. Thus the usability issues in the design of auction application are extremely important. Not only should the navigation within the application be simple and intuitive, as discussed in the previous section, help should be available on the finger tips on:

- How to use the application software
- Explanation of the auction mechanism deployed
- Bidding options available to the buyer and strategic implications of each option
- For sellers the auction mechanisms available and the implications of choosing one or the other.

Bidding agents:

An obvious area of extension to electronic auctions is buying agents, which would be programs that can search for auction sites of interest to a buyer and automatically bid on his behalf. These programs could also potentially search the Internet for the final sales prices for a particular product in recently closed auctions and base their bidding strategy on these prices and trends in them.

When both software agents and humans are bidding in an open cry auction it would be desirable to ensure that software agents have similar response time in submitting a new bid as humans. This is based on the belief that bidding is not totally rational and people develop an emotional tie with the product after participating in the bidding phenomenon for a while. If agents were allowed to bid with their millisecond response time, the bids would reach a level very quickly where the humans may be disinclined start bidding.

5. Summary and future research

We have implemented an auction application which closely follows the design outlined above and are looking forward to field trials. We are currently exploring practical ways of meeting the security requirements in section 2. Additional tools are needed to make auctions attractive to real business users. They include mechanisms to archive closed auctions for record keeping, support for electronic bidding proxies (order bids), and integration with back-end ERP systems.

Strategic behavior by bidders and equilibria in various auction methods has been studied extensively in economic literature. However, Internet auctions are intended for ordinary people who are not fond of rational or highly strategic behavior. Otherwise, people would not play slot machines or lottery, and they would not stand in long lines to get a ticket for the first show of a blockbuster movie. It is important to investigate the psychological and emotional aspects of behavior of people in an auction and factor the results in the design of auctions.

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