Electronic Auction with autonomous intelligent agents: Finding opportunities by being there

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Abstract

The overwhelming options conveyed by Internet exaggerated growth bring new issues for users engaged in buying and/or selling goods using the net as the business medium. Goods and services can be exchanged, directly sold or negotiated in auctions. In any of these situations, finding the required product by the right price is the big challenge for Internet users. Especially in e-auction, timing and strategic actions are vital to a successful deal.
In this paper, we propose a model for e-auction based on intelligent agents technology. The use of agents make possible to reflect better what happens in real auctions. Agents act together with buyers, sellers and auctioneers to assist them obtaining the best deal or at least finding Nash equilibrium point.

Keywords: agents, e-auction, e-commerce, negotiation.

1. Introduction

Generally consumers search products or services that partially or totally fulfil their needs at an affordable price. Whenever the number of vendors is small, buyers can make a good trade-off analysis selecting the best deal. However, as the number of opportunities grows, searching and comparing goods become a chaotic process. Indisputably, the Internet has brought opportunities for electronic commerce (e- commerce), but attached to it comes the challenge of managing the huge amount of offers and demands.

According to the *Consumer Buying Behaviour Model* [Maes at al,1998], there are six main stages of a sale transaction:

- **Identification**: defining the needs to be accomplished by a good, the constraints reducing opportunities and the evaluation criteria to guide the selection process.
- **Product Brokering**: searching for good that fulfils the needs.
- **Merchant Brokering**: gathering information from the merchant to augment the evaluation process.
- **Negotiation**: applying selected negotiation strategies to a transaction.
- **Final Sale**: transferring product/service ownership.

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- **Evaluation**: evaluating the transaction process (successful or not).

E-commerce has brought many advantages to consumers and vendors. Consumers can take advantage of product accessibility, leading to money savings; while vendors can increase their audience reach [Malone and Little, 1997]. However, e-commerce has brought the "too-many-options" problem to consumers. Consequently, the six stages described above get even more complex when in e-commerce.

In the case of electronic auction (e-auction), finding the goods is only part of the process. Negotiating the product, with no fixed price, in a competitive environment, becomes an even harder task to be successfully accomplished in a given amount of time. In addition, auction attendance is essential to grasp that opportunity to make a killing offer that guarantees ones winning the bid.

This paper presents an auction environment model (AgILE) using intelligent agents technology to assist each of the auction players, that is, the buyer, the seller and the auctioneer. The agents are always there to represent their owner's needs either to buy or sell a product or to set an auction. The vendor and buyer agents may act in special auctions created by our environment or act in existing Web auctions. In this last case, these agents need to understand the auction type to defines the strategy they may use. Our goal is to provide an efficient environment to improve Internet users satisfaction in e-auctions. We show the feasibility of the model by implementing a prototype system that works in Brazilian e-auction sites as well as in our own site.

2. Electronic Auction

An e-auction is an indirect sale transaction type of e-commerce. An e-auction increases competition among vendors in addition to broaden the set of potential consumers. E-auction has become very popular, even though, there are some aspects of an auction that its electronic version cannot encompass, such as seeing and touching the real product.

In an auction (electronic or not), buyers compete to get the right to buy a product. There are different types of auctions according to the intermediation, the participants' interaction format, and the winning value selection [Kumar and FeldMan, 1997]:

- **English Auction** (also called open-outcry or ascending-price): The auctioneer starts the bidding process with a minimum price for the product. The auction participants bid increasing the price until no more bids happen or some condition be satisfied. The highest price wins.
- **Dutch Auction**: The auctioneer starts the bidding process with a top price and keeps decreasing it until an auction participant accepts the price stated. It is interesting to notice that when more than one unit of the product is for sale, the first one is sold for a higher price, while the others are sold by a cheaper price.
- **American Auction or Closed Bid Auction**: Confidential bids are submitted. When the bid envelopes are opened, the highest bid wins.
- **Vickrey Auction or Uniform Second Price**: Similar to the American Auction; that is, the highest confidential bid wins. However, the winner pays the second highest price and not his own offer.

No matter the type of auction, an e-auction raises some issues that must be addressed:

- Finding the product and the proper auction to get enrolled;
- Being there during the entire auction;
- Dealing with many auctions at once to get a better deal or
- Defining a bid price among so many anonymous competitors.

Agents are computational systems that assist users to accomplish their tasks [Maes, 1994]. They should understand about their possible states and how to interact with their environment. They should work autonomously and should react to new scenarios without human intervention [Nwana, 1996]. Intelligent agents are agents that know to decide upon option actions based on rational decision-making process. Intelligent agents are an interesting technology to enhance Internet users dealing with e-auction issues such as: omnipresence, fast and optimizing decision-making.

An auction site is a place where goods are offered and bids are made and logged. Participants need to provide personal information to get enrolled. Furthermore, an auction site also works as an auctioneer in selling products. Enrolled users define the level of privacy they want. In other words, an auction may happen with totally, partially or none anonymous mode.

Action sites receive a list of products to be sold, with their characteristics, sale conditions and

bidding duration. Afterwards, the auction site announces the product to potential participants and waits for bids. Whenever the site receives an offer, the site broadcast it to the other participants. When the sale conditions are fulfilled the auction is closed and the site promotes a meeting between seller and buyer. If the sale conditions are not satisfied, the auction site notifies the owner that this product was not sold.

If there are doubts relating to a product or to a participant's bid, they are sent to the site that will transmit them to the responsible participant (indirect communication). The buyer only talks to the seller to actually close the deal (direct communication). Few auction sites can be responsible for both payment and shipping the product.

3. AgILE

AgILE is an e-auction model based on intelligent agents to assist buying and selling tasks during transaction stages except for final sale and evaluation stages. The agents interact with each other, with the environment and with their owners (humans). As shown in Figure 1, AgILE has three main components:

- Agent Generator (Vendor, Buyer and Auctioneer Agent Generators): its function is to generate agents (buyer, vendor or auctioneer agents) that fulfil users requirements to represent them in an auction. It contains a canonical representation of an agent and ways to configure its behaviour in the net.
- Agent (Vendor, Buyer and Auctioneer Agents): it represents the user. It acts in many auctions at the same time seeking the best opportunity to close the deal for the user. It behaves as configured by the agent generator; i.e., its autonomy, its searching for the auction sites, its lifetime are predefined.
- Auction Site (Web Auction and AgILE Auction sites): it represents the place the agents can act.

In the AgILE model, each agent has features that make it different from a simple program as summarized in Table 1.

Characteristic	**AgILE Agents property description**
Autonomy	Every agent must act autonomously; that is, without the user's interference.
Proactivity	The agents are configured to accomplish tasks based only on their search plans and strategies of negotiation.
Reactivity	The agents receive and process information sent by other components; They wait for other user's actions to decide which action to take; They build up their thinking based on the result of the processing made.
Sociability	Every agent interacts with the auction sites to search for information and sell or buy products; Some agents communicate with each other.
Mobility	The agents move themselves to the auction sites to search for information and to sell or buy products.

Table 1: AgILE Agents´ properties.

AgILE´s agents are rational decision-makers. Buyer Agents search for alternative sites that offer products that satisfy their needs, eliminate the ones that do not comply with existing constraints, order the remaining alternative from best to worst according to a set of evaluation criteria, and finally chooses the best one (it may hold more than one). Selecting the auction sites to enrol is the first step.

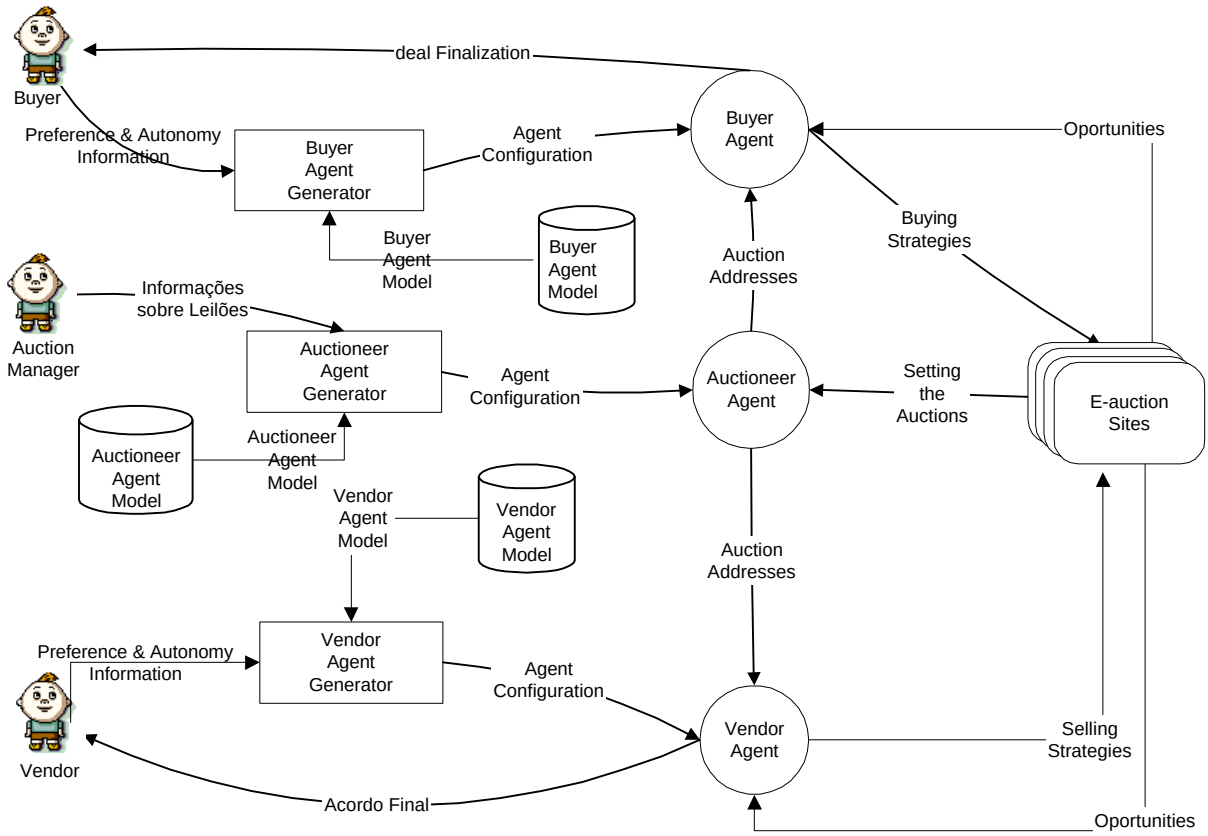

Figure 1: The AgILE model.

The Buyer Agent needs to decide what value to offer at a given time, considering the status of the other sites it is enrolled, its money autonomy, the existing bids, the shown interests of other participants, and how much its owner desires that good. Decision theory supports and justifies individual agent behaviour. However, to enrich the process, we should also consider game theory to let agents look not only at their best option, but also at the other bidders behaviour.

The Vendor Agent also starts searching for the place in which it should offer its product. Afterwards, it should pay attention to the bids its products receive to decide when to withdraw from one site or when to give more time to get a better price for them.

The Auctioneer Agent plays an important role searching or creating auctions that provide Vendor and Buyer Agents with a good environment to act.

3.1 The Buyer Agent

The Buyer Agent (BAg) is a user representative for bidding a product in an e-auction. It visits e-auction sites, chooses the auctions to participate, autonomously, and makes offers in the name of its owner.

We can define four basic functions performed by the buyer agent:

- **Registration:** The agent must register in an auction site autonomously, using its own identification.
- **Product Search and Selection:** It must be able to choose the best available goods at existent e-auctions and search for products that best satisfy its owner's needs. The choice is made considering existing constraints and criteria given by the user and formalized by the agent generator.
- **Negotiation Strategy Selection:** The agent must be able to plan the set of actions to win a bid based on its knowledge about the specific type of auction. It uses a linear utility function that varies as it reaches the bidding closing time. The agent may have different strategies for each auction it gets enrolled.
- **Bids:** The agent must be able to make real offer for several products and close the buying deal.

- **Auction Synchronization:** Besides the individual strategy used to act in an auction, the agent must be able to handle multiple auctions offering its owner the best global deal.

3.2 The Vendor Agent

The Vendor Agent (VAg) receives information on products being sold, and visits the auction sites to verify which sites offer the best conditions. After that, a VAg advertises its products in the sites and waits until they are sold. The VAg may leave the product for sale in more than one site, and then make a global monitoring of the bids received to decide in which auction actually to sell its products.

The Vendor agent (VAg) is responsible for representing the salesman in the bidding process. It has three main functions:

- **Registration:** The agent must register in an auction site autonomously, using its identification.
- **Site Search and Choice**: It should choose satisfactory sites to offer its products. This search is similar to the one made by the Buyer Agent. VAg visits several auction sites to find out the best ones (lower fees, great variety of products, etc.).
- **Product Information Delivery**: The agent is responsible for providing information on the product when requested by the auctioneer or the auction site. The agent must be able to store and organize the information about its products making it available when necessary.
- **Monitoring:** The agent can monitor current auctions it is enrolled to verify the bids proposed and decide when to close the deal.
- **Action Synchronization:** this feature is similar to the synchronization required by a BAg; however, it concerns handling the multiple places a vendor exposes its product for sale.

3.3 The Auctioneer Agent

The Auctioneer Agent mediates communication among the different types of agents in the bidding process. It creates new auctions or selects the ones where BAgs and VAgs should play. The auctioneer agent clusters products in groups to attract buyers to more than one deal, trying to keep their attention. For example, people that buy a car are willing to buy a sound system for the car as well. Consequently, having a car and a sound system at the same place may happen to be more profitable.

The Auctioneer Agent's first task is to find out the relationship between product offer and demand. Then, the AAg visits the vendor agents to try to convince them to let their products be traded, adopting some strategies. The Vendor Agent analyses AAg´s proposals and decide to engage or not in the play.

From that moment on, the AAg acts as a vendor agent, enrolling in auction sites and trying to sell the products. After that, the AAg must return to the other vendor agents to account for the sale and guarantee that each vendor agent will meet with the respective buyers for their products. AAgs increase competition among vendors and buyers by maximizing the visibility of both.

For the buyer, the great advantage of having an auctioneer agent is to be able to buy several products at one single negotiation. The advantage of AAgs increases even more, when we consider the tendency the auction sites have of charging fees for services done.

Users interact with an agent generator module defining their product needs and their expected behavior for the agent representing them in either buying or selling activities. Buying and selling agents bid in existing e-auctions and in AgILE generated plays (special e-auction sites), business sites that emerge from a perceived opportunity to match supply and demand.

Users interact with the Seller Agent Generator to configure behavioral parameters such as agent autonomy level, utility functions, expected selling values. The Seller Agent is responsible for selecting the e-auction sites to announce its products; for observing the bidding process to detect opportunities; for modifying its strategic selling plan whenever necessary, for instance, a seller agent may decide to accept a lower closing price when bids are rare on a product. It is also responsible for providing product information to the auctioneer (sometimes the e-auction site itself).

The buyer agent has a more complex model since it is completely involved in the bidding process. Figure 2 illustrates the Buyer Agent Model. According to this model, a buyer agent contains a Search Engine and Bidder modules. The Search Engine gets the users specification and looks for e-auction sites that may offer a product or similar that maximizes the user's satisfaction. The search engine considers a linear utility function to represent the user's behavior to select the e-auction sites to get enrolled. The process consists on obtaining alternative e-auction sites, eliminate the sites that

offer products that violate user's specified restrictions, and evaluate the ones that best fit the user's specified selection criteria.

The Bidder acts based in its buyer agent strategic model. It must decide in which e-auction to play, when to bid and how much should be the bidding value for a product. The Bidder checks the bidding status on its selected e-auction sites; i.e. information such as the current bidding value, the players bidding behavior, and the closing time.

An automatic bidding process should act rationally, correctly, and fast. In addition, it should behave properly when an unexpected situation occurs [Cass, 1999]. The strategic behavior model of the Buyer Agent is based on the Absent-minded Driver metaphor [Piccione, 1997] [Aumann, 1997], in which at each intersection the driver should decide to go on or to take the next exit. We adapt this model considering an intersection a moment in which the buyer agent is prompt to, by either its own monitoring module or a change in an e-auction scenario, either bid, modify its action plan or simply stay in an stand-by position. This process continues until the buyer agent: close the deal or leave the auction.

Deciding to bid is a decision modeled in the Buyer Agent as a strategic Bayesian game with imperfect information [Osborne, 19994]. Even though in an e-auction we have a finite number of players, we cannot estimate a priori the amount of bidders. We also consider a finite number of decisions since there is time limitation in the bidding process.

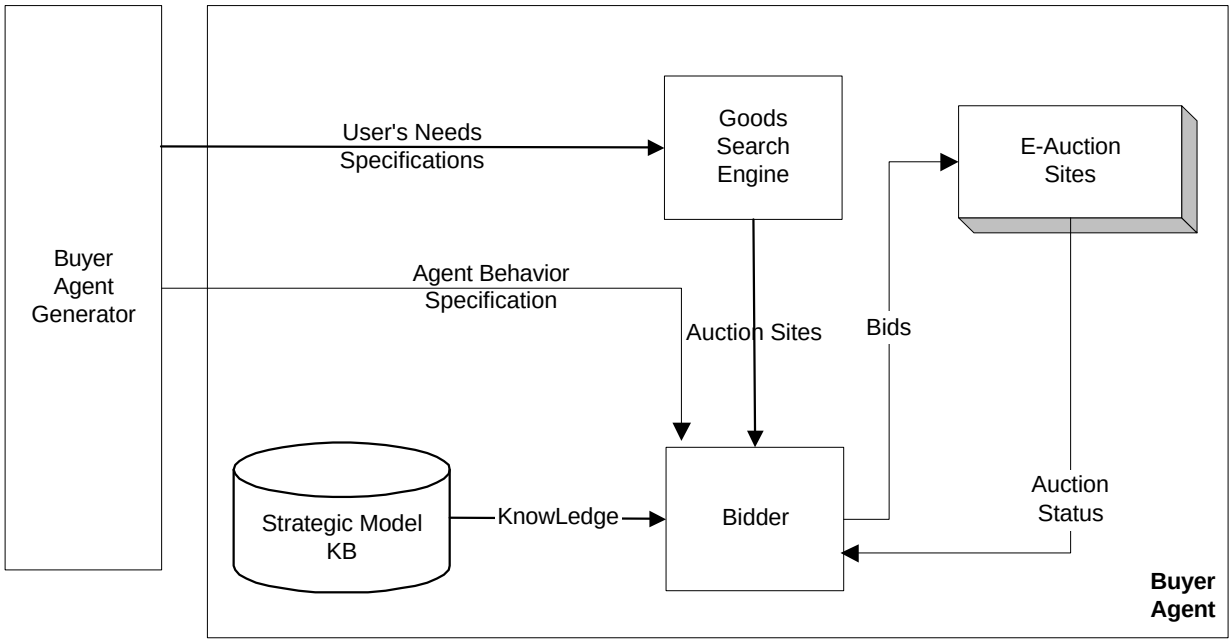

Figure 2: The Buyer Agent model.

The bid decision can be divided in two parts. First of all, the agent decides whether the e-auction is still interesting. It considers if the last bid value is still lesser than what it is allowed to play and if it is still interested in the product being negotiated.

Considering the Nash equilibrium for this game, as illustrated in Figure 3, the Buyer agent should always bid when the product is still on. Even though, for both buyers it would be more interesting not to bid in order to get a lower price, the risk to lose push players to always bid.

		Agent $_2$	
		Not Bid	Bid
Agent $_1$	Not Bid	1, 1	-4, 4
	Bid	4, -4	2, 2

Figure 3: To bid or Not to Bid question—the Nash equilibrium is BID/BID

This situation may change when we consider the other players bidding profile. This information may cost money that should be considered when calculating the bidding value for a product.

4. Discussion

We are implementing an AgILE Model prototype using JAVA and JSP languages. This prototype is in

a WEB page format where the user can create the agents, configure them, and define their autonomy when representing him/her on e-auction sites.

Regarding the agents autonomy, they can be configured in two different ways: they can either act without user's intervention, or with a minimum autonomy, which implies asking the user's approval whenever they may accomplish certain action. Our prototype deals with two types of main auctions: the English and the Dutch auctions. In regard to the Auctioneer Agent and the Vendor Agent, the negotiation occurs similarly in both English and Dutch auctions: the agent waits for the end of the auction to decide whether it should close the deal or not.

The possibility of the AgILE agents participate in several auctions at the same time brings some advantages for both buyers and sellers. Buyers have a better chance to close the deal at a better (cheaper) price and sellers have a better chance to sell their products at a highest price. This business leverage will be greater at the beginning, when few users take advantage of these agents will certainly get the better buying and selling deal.

AgILE is a good alternative to e-auction. It encompasses one important stage that current approaches do not: "the Identification Stage." In [Maes et al,1998], Maes *et al* made a comparison between three e-auctions systems with agents, AuctionBot [Wurman et al ,1998], Magma Auction[Tsvetovatyy et al ,1997] and FishMarket [Sierra et al, 1997] systems with auction agents. In Table 2 we present a similar comparison, but including AgILE among the other systems. Our comparison, however, includes some other points like: **Bidder** - that specifies who bids (buyer, vendor or both); **#Vendors** - that is the number of auctions a vendor can be enrolled at the same time for the same product (one or many); **#Buyers** - that is the number of auctions a buyer can get enrolled at the same time for the same product (one or many).

None of the projects mentioned in this work include the identification stage, but AgILE. We use a simple communication interface to interact with auction sites. Through this interface the agents register using its owner information that enable them to continuously interact with any auction site.

	Magma	**AuctionBot**	**Fish Market**	**AgILE**
Identification	No	No	No	Yes
Product Brokering	Yes	No	No	Yes
Merchant Brokering	Yes	Yes	Yes	Yes
Negotiation	Yes	Yes	Yes	Yes
Change	Yes	No	No	No
Evaluation	Yes	No	No	No
Bidder	Buyer	Buyer, Vendor	Buyer	Buyer
# Vendors	One	One	One	Several
# Buyers	Several	One	One	Several

Table 2: E-auction models comparison.

Comparing AgILE to other e-commerce systems the product search stage in AgILE is similar to what is done in SMACE [Oliveira, 1999] and FireFly [FireFly, 2000], where product and partner may be searched at the same time. This is a big task by itself. Projects such as Persona Logic [PersonaLogic, 2000] are used exclusively for this stage.

AgILE agents consider a negotiation strategies knowledge base to guide their behaviour in the bidding process. This is the most important stage of the purchase process. Some projects, such as Kasbah [Chavez et al, 1996], use fixed strategies defined by the user; others, such as in AgILE, use strategies that can be changed through the time.

AgILE model can be placed together with other systems comparatively considering the following features:

- **Bid:** It indicates which agent accomplishes the offers. For example, AuctionBot has an auction style in which the buyer agent as well as the vendor agent can make the offers. In the AgILE model, the buyer agents just accomplish the offers, whereas the vendor and the auctioneer agents just register the products to be auctioned in the sites;
- **Number of Partners for a Vendor:** It indicates the number of partners it can handle at the same time in a transaction. The SMACE system has a model in which the vendor agent looks for possible buyer partners and negotiates with several agents at the same time. However it handles one auction at a given time. AgILE model, besides presenting this characteristic, lets vendor agents control several auctions at the same time;
- **Number of Partners for the Buyer:** It indicates how many partners the buyer agent uses to work with at the same time. The buyer agents of AgILE can negotiate with several partners, represented by the auction sites. The agent should make a global

management of the strategies used in the auctions in which it is simultaneously acting.

We believe, AgILE offers an interesting environment to assist all players of an e-auction. We are deploying the first version of the site to get used by first a computer science class, then to our university and finally to all. We expect that AgILE adjusted model will assist people to actually take advantage of this new marketing place to achieve the most of it.

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