ANALYSIS OF BIDDER AGENTS PERFORMANCE IN SIMULATED ENGLISH AUCTIONS

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**SCHOOL OF ENGINEERING AND INFORMATION TECHNOLOGY
UNIVERSITI MALAYSIA SABAH**

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ABSTRACT

ANALYSIS OF BIDDER AGENTS PERFORMANCE IN SIMULATED ENGLISH AUCTIONS

Online auctions have provided an alternative trading method to exchange items without the geographical and time constraints. However, buyers would face difficulties in searching, monitoring, and selecting an auction to participate. As a consequence, agent technology is introduced to overcome these pitfalls. In this thesis, the performance of these intelligent agents are first evaluated with different groups of standard bidders (risk-aversion, risk neutral and risk seeking) separately. Next, these heuristic agents are tested against heterogeneous standard bidders in a marketplace. From the simulated results, by using intelligent bidder agents to participate in online auctions, it benefits the bidders in terms of winner's utility and closing price. Next, a market populated with different groups of standard bidders and different groups of intelligent agents (Greedy agents, Heuristic agents and Sniping agents) is simulated. From the results obtained, the market economy is affected by implementing agent technology. One of the most obvious observations is the auction closing price decreases significantly as more agents are found in the market. Besides that, from the simulations conducted, it is observed that when the demography of the bidder agents is relatively smaller than the population of standard bidders, the bidder agents procured higher percentage of winning auctions. In the experiments conducted, the number of auctions and the number of participants are finite. Thus, sellers may not welcome bidder agents in joining their auctions since their revenues are reduced. Conversely, bidders would welcome the usage of these intelligent agents since these agents help them in purchasing the desired goods with greater savings.

ABSTRAK

Lelong atas talian telah menyediakan kaedah perniagaan alternatif untuk penukaran barangan tanpa batasan geografi dan masa. Namun, pembeli akan mengalami kesulitan dalam pencarian, pemantauan lelong-lelong dan pemilihan lelong untuk disertai. Ekoran daripada kesulitan tersebut, teknologi agen diperkenalkan. Dalam tesis ini, pertama sekali, prestasi agen-agen yang cerdik akan dinilai dengan pelbagai kumpulan peserta piawai (risiko-kebencian, risiko neutral dan risiko mencari) secara berasingan. Selanjutnya, agen heuristik ini juga diuji terhadap pelbagai jenis peserta piawai di pasaran. Dari hasil simulasi, dengan menggunakan agen yang cerdik untuk menyertai lelong atas talian, ia memanfaatkan penggunanya. Seterusnya, pasaran diisi dengan pelbagai kumpulan peserta piawai dan kumpulan yang berbeza daripada agen cerdik ("Greedy agent", "Heuristic agent" dan "Sniping agent") disimulasikan. Dari hasil yang diperoleh, ekonomi pasaran dipengaruhi oleh penerapan teknologi agen. Pengamatan yang paling jelas adalah harga penutupan lelong menurun dengan ketara apabila bilangan agen bertambah. Selain itu, dari simulasi-simulasi yang dijalankan, didapati bahawa agen cerdik mencapai peratusan kemenangan lelong yang lebih tinggi apabila demografi mereka adalah kecil berbanding dengan populasi peserta piawai. Dalam eksperimen yang dilakukan, jumlah lelong dan bilangan peserta adalah terhad. Dengan demikian, para penjual mungkin tidak mengalu-alukan agen cerdik dalam lelong mereka kerana pendapatan mereka berkurangan. Sebaliknya, peserta lelong akan menyambut penggunaan agen cerdik sebegini kerana agen ini membantu mereka dalam pembelian barang yang dikehendaki dengan penjimatan yang lebih besar.

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LIST OF DIAGRAMS

LIST OF ABBREVIATIONS

ARIMA	Autoregressive Integrated Moving Average
CSR	Consumer Surplus Ratio
RET	Revenue Equivalence Theorem
CIDIM	Cooperating Intelligent Systems For Distribution System Management
SIPV	Symmetric Independent Private Values
iid	Independently and identically
ANOVA	Analysis of variance
Sig.	Significance level
RA	Risk-averse/ risk aversion
RN	Risk neutral
RS	Risk seeking
SB	Standard bidders

LIST OF SYMBOLS

Δy_1	First difference on y-axis
Δy_2	Second difference on y-axis
$P_i(v)U_i(v)$	Expected utility
$P_i(v)$	Probability of winning an auction i at a bid v
$U_i(v)$	Utility of an auction i at a bid v
Pr	Private valuation
t	Current universal time across all auctions
t_0	Start time
t_{max}	Maximum time allocated
$U_{ij}(v)$	Winner's utility of auction j gained by winners of type i
Pr_i	Private valuation of the winner of type i
v_j	Winning bid of auction j
c	Constant value
$\overline{U}_i(v)$	Average winner's utility of type i
n_i	Number of auctions won by winners of type i
$\overline{W}_i$	Average number of auctions won by winners of type i
C_{ij}	Winning bid of auction j submitted by winners of type i
V_{H_i}	Winner's private valuation in auction i
V_{F_i}	Final winning bid in auction i
N_i	Number of bids of item i
N_m	Median number of bids across all the auctions conducted
H_0	Null hypothesis
H_1	Alternative hypothesis
p	Significance level

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CHAPTER 1

INTRODUCTION

1.1 Overview

When considering the agents mediated electronic marketplace, agents play an active role in both sellers and buyers sides. A seller agent may advertise its products in the market, placing the selling price and looking for the potential buyers in the market. On the other hand, a buyer agent would look for the desired goods or services requested by its user and it has a task to bargain about the price of the products and find the best deal (Dignum, 2001). Nevertheless, economic transactions can be organized through two mechanisms: hierarchy or market (Dignum, 2001). In the hierarchy mechanism, both sellers and buyers have a special relationship. In this mechanism, the negotiation phase can be skipped during the individual transaction. According to Beer *et al.* (1999), negotiation is a key form of interaction that enables groups of participants to arrive at a mutual agreement regarding some belief, goal or plan. Here, the negotiation process such as finding an appropriate party, bargaining on prices offered and etc is skipped. All negotiations are done at the time both parties enter into the frame contract. By using this mechanism, one of the advantages is a tight integration between the production processes of the buyer and seller is achieved while one of the disadvantages is the dependency on few suppliers or buyers. When problems occur in one of the parties, it immediately creates undesired consequences in the production line. One of the examples that use this mechanism is the car manufacturing industry.

Meanwhile, the second mechanism is the market mechanism. In this mechanism, it considers many sellers of a product and buyers who want to purchase the product. Normally, the parameters of the transaction such as the price are not fixed for a long time, but determined for each single transaction. One such example would be the online auction. Due to the rapid growth of Information Technology and popularities of the Internet, more trading such as online banking are accomplished in this virtual world. One of the most beneficial advantages of this virtual environment is the ability to gather both buyers and sellers together effectively without the spatial and temporal constraints (Hahn, 2001), where buyers and sellers from different parts of the world need not be physically present to participate in the auctions conducted and these auctions can be conducted around-the-clock. Trading that could be done in bricks and mortar is now available by using the computer and the Internet (Talluri and Ryzin, 2004). Both parties that come from around the world need not gather at a specified location to perform trading. They are now free from the geographical limitation. Therefore, sellers are now looking for a larger group of potential buyers while buyers are looking for a better offer of their desired goods in the online marketplace. There are many types of pricing mechanisms available on the Internet such as online auction mechanism and fixed posted price mechanism. Online auction mechanism is very similar to the traditional auction mechanism in the sense that an auctioneer would offer an item to be auctioned and would reward it to the bidders with the highest price. In other words, the final price is determined by the demand and supply conditions at a specific moment of time, influenced possibly by prospective market developments (McAfee and McMillan, 1987), not the sellers or auctioneers. However, online auctions usually have longer periods than traditional auctions and these online auctions last for days and weeks based on the sellers' requirements (Lim *et al.*, 2007).

An auction is a bidding mechanism, described by a set of auction rules that specifies how the winner is determined and how much to be paid (Wolfstetter, 1999). By auctioning, sellers find a way to determine the actual values of the items being auctioned especially those items which are hard in valuation process. By auctioning also, items are allocated to the bidders who have the highest valuation. Therefore, auction mechanism is an interesting topic to be studied since it provides an approach to the price formation of the item. Moreover, as online auctions become increasingly popular and accepted by the trading community, many subsequent issues may arise like the market efficiency and allocation (Hu and Bolivar, 2008; David *et al.*, 2005; Sow *et al.*, 2010a, 2010b), bidding behaviours and their performances (Ockenfels and Roth, 2002; Yang and Lu, 2007; Lim *et al.*, 2008; Ford *et al.*, 2010; Sow *et al.*, 2011a, 2011b, 2011c) and many others. Many researchers such as Hu and Bolivar (2008) and David *et al.* (2005) study the design of online auctions mechanisms in order to optimize the item allocation and pricing discovery. In addition, there are researchers such as Ockenfels and Roth who study the bidders' behaviours or strategies in online auctions that would eventually benefit the bidders. Besides, McAfee and McMillan (1987) argued that studying auction is closer to applications than other mathematical economics. The auction theory explains the existence of certain trading institutions and may suggest improvements in these institutions.

1.2 Online Auctions

In the virtual marketplace which sells a single object, there are basically four types of online auction protocols, namely the ascending-price (English) auction, the descending-price (Dutch) auction, the first-price sealed bid auction and the second-price sealed bid (Vickrey) auction. In the ascending-price (English) auction, sellers start at a low price and the price is successively raised by bidders until the auction end time is reached. The bidder with the highest bid wins the auction and pays based on the bid submitted. Sometimes, sellers may set a reserve price to their item. If the closing price is below the reserve price, then the auction is said to be incomplete and the item remains unsold (Chatterjee and Samuelson, 2001).

The descending-price (Dutch) auction is the opposite of an English auction. An auctioneer starts announcing an auction with an initial high price. This high price is normally higher than the item's actual price and the auctioneer does not expect bidders to accept this price. The initial bid will be lowered progressively until there is an offer from a bidder to claim the item. The winner will pay the price equivalent to the current bid.

Thirdly, in the first-price sealed bid auction, bidders submit their bids privately. These bids are concealed until the auction ends. When the auction ends, those concealed bids are disclosed. The winner will be the bidder who submitted the highest bid and he pays for the item with his bid. The basic difference between the English auction and this auction is that, with the English auction, bidders may somehow observe their rivals' bids and may revise their own bids if they choose to do so (McAfee and McMillan, 1987).

Lastly, in the second-price sealed bid (Vickrey) auction, bidders submit their bids and these bids are sealed until the auction is closed. Similar to the first-price sealed bid auction, when bids are observed openly, bidder with the highest bid will be identified as the winner. However, the winner pays only the second highest bid in that auction.

Regardless of which auction protocols are used in the online auctions, there are many online auction sites that are available on the Internet. Moreover, as this mechanism is accepted by more people, the number of auctions conducted in this virtual marketplace is increasing drastically. Thus, a bidder would find it very hard to find a suitable auction to participate. It is even more difficult to monitor multiple auctions concurrently. This problem leads to a question, is there any alternative method to overcome this dilemma? The answer can be found by using agent technology.

1.3 Agent Technology

The advent of software agents has raised an issue of what an agent is. To date, there is no formal definition for a software agent. However, some concepts are widely accepted by researchers to differentiate between an agent and a computer program. First of all, it must be situated in some environment and be part of it. This environment can be domain specific such as a manufacturing system, an online auction marketplace and others (Jennings and Wooldridge, 1998). According to Franklin and Graesser (1997), when changes happen in the environment in which an agent is situated in, the agent may no longer exist. It is because once the environment is changed, the agent may not be capable to sense the world and react accordingly. Secondly, in this environment, the agent must be able to perform relevant actions autonomously. In other words, after receiving all the necessary information of its owner such as time, cost, quantity and others, it must be capable of performing a series of actions to achieve its goal without the direct intervention of its owner. It should have control over its own actions and internal states (Jennings and Wooldridge, 1998).

To this end, an agent system may seem to be similar to an object-oriented system. For example, an object in the object –oriented system encapsulates some states and has control over these states. These states can only be accessed or modified via the methods provided by the object. So does the agent. An agent encapsulates more than that (Jennings and Wooldridge, 1998). The behaviours of an agent are also encapsulated. For example, if there is an object *X* that invokes a method *m* on object *Y*, then *Y* has no control over whether *m* is executed or not. In this sense, *Y* is not autonomous since it has no control over its own actions. On the other hand, agent does concern on its actions. The interaction among the agents is more in the request and response manner. An agent may request an action to be done by another agent. But the decision of whether the action is performed lies solely with the recipient agent.

1.3.1 Intelligent Agent

An intelligent agent is a computer entity that is capable of flexible autonomous action in order to meet its design objectives (Jennings and Wooldridge, 1998). The term flexible here means that an intelligent agent should be proactive, responsive and social. As integrated from the agent technology, these intelligent agents should inherit the capability of an agent to solve their problems encountered in their environment without direct intervention of human or other agents, which indicates the autonomy of intelligent agents. Furthermore, as intelligent agents, they have their own goals to be achieved (Dignum, 2001). So, when the outside world is changed, they should not simply react to these changes; they should also exhibit opportunistic, goal-directed behaviours and take initiatives where appropriate to achieve their primary objective. In other words, by inheriting the attribute of pro-activeness, these agents should involve actively in achieving their respective aims by various approaches even though the changes happen in their environment. On the other hand, they should perceive their environment and respond consistently to changes that occur. This property somehow neutralizes the pro-activeness of intelligent agents. It prevents agents from trying to achieve their goals without considering the achievability of the goals, whether the current plan is the best, according to the current state of environment. Sometimes, they must interact socially with one another (other agents or human) in order to complete their goals and help others with their problems.

Usually, agents are used to perform tasks which are hard or time consuming if they were to be conducted by human. Some of these tasks are collecting and filtering information, negotiating in simple ways over resources and other tasks to be performed, solving a complex problem and monitoring long term processes.

In online auction, intelligent agents can play many roles on behalf of bidders or sellers. For instance, agents can act as search agents which return several available auctions from different auction houses to their users for further action. Moreover, agents can also be deployed as bidding agents which submit bids in the targeted auctions. Regardless of the roles played by each agent, agents will only be used as user representative if the benefits of using an agent are high and the trust an agent will realize them are high enough (Dignum, 2001).

Furthermore, intelligent agents are suitable to be deployed in online auctions because auctions follow certain protocols which are well defined and procedures are clearly stated. This is also one of the main reasons why auctions became a popular and acceptable form of electronic commerce (Dignum, 2001). First of all, with a well defined protocol, agents can consider finite elements that are relevant to the protocol in modelling their environment. The level of uncertainty is reduced to those possibilities stated in the protocol. Secondly, with clear procedures stated, users know exactly the steps and flow of the auction. Thus, the trusts assigned by those users to their respective agents in delegating certain tasks become bigger.

Besides that, another advantage of applying intelligent agents in online auctions is they never overbid. According to Lee and Malmendier (2007), human bidders often overbid their private valuations on items desired even though they may be aware of the maximum reasonable price that is associated to the same item.