

## BDI Agents for Bidding in English Auctions in Mobile E-commerce

Nandini Sidnal<sup>1</sup> and S. S. Manvi<sup>2</sup>

<sup>1</sup> Department of Computer Science and Engineering K.L.E.S. College of Engineering and Technology,  
Belgaum-590014, INDIA

<sup>2</sup> Department of Electronics and Communication Engineering REVA Institute of Technology and  
Management,  
Bengaluru-560064, INDIA

**Abstract.** On-line auctions have mushroomed and provided the bidders with surplus options to participate and bid in multiple concurrent auctions in order to procure the best deal for the desired good. This paper proposes a scheme to incorporate human intelligence and perspective (cognitive) in agents for bidding in multiple concurrent English auctions in mobile Ecommerce. The scheme operates in two phases: 1) belief set generation for each relevant site based on bidder desires, and 2) Executing the intentions – to bid, sleep or withdraw based on dynamic auction conditions. We validate the performance of system by simulation.

**Keywords:** BDI agent, mobile E-commerce, mobile bidders.

### 1. Introduction

To bid in multiple online auctions simultaneously using handheld devices the bidder needs to fetch the required information from all the relevant auction sites and process it to compute the bid value. Since these operations have to be performed in a highly dynamic, uncertain and unpredictable environment it is important that the bidding process be automated. To implement automation, auction service providers and consumers can naturally be viewed as software agents since these are exactly the properties and types of environment that lend themselves to an agent-based approach as given in [9]. This paper proposes a scheme to incorporate human intelligence and human perspective (cognitive) in agents [14] for bidding in multiple concurrent English auctions in mobile E-commerce. Some of relevant works in regards to the bidding strategies for on-line English auctions include the following. An automated and data-driven bidding strategy is presented in [1]. A bidding strategy for obtaining goods in multiple overlapping English auctions is discussed in [2]. The work given in [3] discusses the design of an autonomous agent that can alleviate some of the problems like getting better deals and selecting a better auction by participating across multiple on-line auctions. This work is used for comparison with the proposed work. Design of algorithms for agents to use when participating in multiple simultaneous English auctions, aiming to purchase multiple goods is explained in [4]. The authors in [5] investigate utility by maximising bidding heuristics for agents that participate in multiple heterogeneous auctions. A heuristic bidding strategy for buying multiple goods in multiple English auctions is presented in [13]. Novel bidding algorithm that a software agent can use to obtain multiple goods from multiple overlapping English auctions is presented. The work in [6] presents a decision theoretic framework that an autonomous agent can use to bid effectively across multiple, simultaneous auctions. An approach to develop bidding agents that participate in multiple alternative auctions, with the goal of obtaining an item with a given probability is demonstrated in [7]. The authors in [8]

develop a bidding agent for multiple heterogeneous auctions and build a heuristic decision making framework that an autonomous agent can exploit to tackle the problem of bidding across multiple auctions with varying start and end times and with varying protocols. Some of the drawbacks of existing bidding strategies are as follows: lack of intelligence in bidding, scalability for mobile bidders and efficient automation. This paper proposes a scheme to incorporate human intelligence and perspective (cognitive) in agents for bidding in multiple concurrent English auctions in mobile Ecommerce.

## 2. Proposed Work

This section provides description of the proposed work in terms of computational models and agencies.

### 2.1 Computational Models

This section describes the computations required to compute the bid increment for placing the bid value, withdrawal conditions and utility value for a relevant auction. The bid increment value and in turn the bid value at  $t_{i+1}$  from the allotted budget amount  $b$  is computed as given in equation 1. The budget is distributed equally to compute uniform and variable increments.  $bid\ value(t_{i+1}) = Max + (b - x)/n + D\ incr$  --- (1) where  $Max$  is current maximum bid value for the considered auction and  $x$  is given by equation 2 and  $n$  is total number of times the bidder is going to call in the relevant auction.  $D\ incr$  is given by equation 3.  $x = 1 - Nbm/Nb$  --- (2) where  $Nbm$  is number of times bid value is the maximum bid and  $Nb$  is number of calls.

$D\_incr = (Max\_bid\ value(t_i)) * (budget + risk + pcp)$  --- (3) Budget, risk and predicted closing price (pcp) factors are computations are given by equations (4), (5) and (6) respectively.  $budget = (b\_bid\ value(t_i))/b$  --- (4) where  $b$  is the allotted budget to participate in an auction,  $bid\ value(t_i)$  is the current bid value of the bidder.  $risk = y/n2$  --- (5) where  $y$  is the ratio of number of risk bidders to total number of bidders in the considered relevant auctions and  $n2$  is number of concurrent relevant auctions. Risk bidders are the co-bidders whose bid value is greater than the  $bid\ value(t_i)$ .  $pcp\ factor = (pcp(j)/avg\_pcp) * y$  --- (6) where  $pcp(j)$  is the predicted closing price of the considered  $j^{th}$  relevant auction,  $avg\_pcp$  is the average of predicted closing prices of all concurrent relevant auctions.

The following are the conditions to withdraw from the relevant auction sites. If either of the condition is satisfied the bidder has to withdraw from that respective relevant auction. (1) If the increment value is greater than the remaining budget. (2) If the sum of elapsed time since the beginning of the auction and the anticipated time required for the auction to close is greater than the bidders available time. (3) If the number of bids placed so far are greater than seventy percent of the total number of times the bidder is going to bid and if the number of times the bidder has bid the maximum value is lesser than twenty percent of the number of bids placed so far, then the bidder has to withdraw. (4) If difference between bid value and max bid value is greater than the bidder increment value. The utility value  $U_j$  of each relevant site at time  $t_i$  is the remaining budget for each of the relevant auction sites at time  $t_i$ .

### 2.2 Agency

In this section we discuss the gateway agency based on BDI model located in regional gateway.

### 2.3 Gateway Agency

The main task of this agency is to compute the bid value for English auctions. This process involves in two steps: 1) belief set generation for each relevant site based on bidder desires, and 2) Finalizing the intentions as bid, sleep or withdraw based on belief sets. Service directory identification and building is done using the scheme given in [10]. Case base reasoning [11] is used to identify relevant auctions for participation in bidding. The closing price prediction method [12] is used to predict the closing price before placing the bid value. 1) *BDI agent*: Figure 1 depicts the architecture of the bidder agent. It consists of bidders desires (products names and specifications), belief sets of each relevant site and intentions to achieve desires.

In brief, the BDI functionality of the agency is as follows. Based on the bidder desires, belief sets are developed consisting of relevant auction informations such as current max bid value, number of bidders, start

time etc. The intention module consists of module to create clones, compute payoff, withdrawal conditions and an inference engine. The clones are created with intelligence of computing and placing bid value and are dispatched to the respective relevant auction sites to participate in bidding. The withdrawal conditions given in computational model helps to decide to withdraw bidding from an auction. Pay off is computed as given in

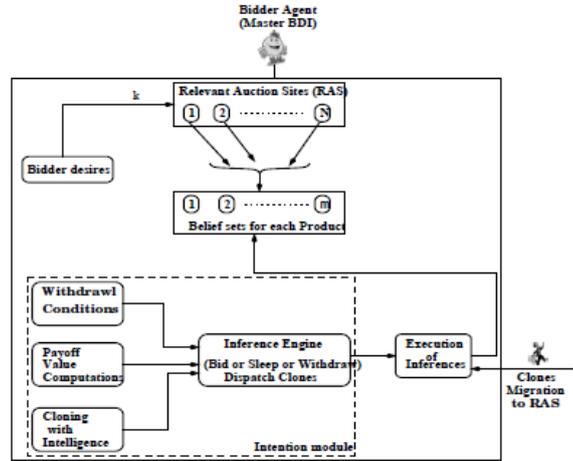


Fig 1: BDI Based Bidder Agent

computational model and is used to identify the relevant site that has better returns towards the end of participation. The inference engine identifies appropriate intention to be executed and decides whether to continue to bid, sleep or withdraw from participation and triggers the clones to act accordingly. This continues either till the bidder agent wins or withdraws from the relevant auctions. A clone is dispatched to each relevant auction to be stationed in the auction server either till the master wins the auction or withdraws from it. The clones initially communicate the history of the bidding information of the past auctions with the visited site for the product mentioned. This is based on bidder's desires and the opening bid of the current auction. As the auction progresses the clones compute the bid value using the computations (given in computational model) carried by them to the auction server and then communicate the bid value along with other required information such as the bid values of co bidders, current maxbid, number of co-bidders to the BDI master agent to decide on to bid, sleep or withdraw.

### 3. Simulation Model

The proposed frame work has been simulated in various network scenarios. It consists of  $N_c$  clusters , each consisting of  $N_k$  servers hosting  $N_u$  auctions in the fixed network,  $R_g$  regional gateways hosting  $N_m$  service directories and  $N_p$  BDI agents to bid on behalf of bidders.  $N_s$  servers subset of  $N_k$  are connected to the gateway within the region. The simulated virtual market place consists of  $N_{aa}$  number of active auctions offering  $S$  auction services in  $N_k$  auction servers.  $N_{ra}$  a subset of  $N_{aa}$  are relevant concurrent auctions auctioning the same product in a considered time window. Each auction auctions  $P_k$  products. The bidder participates in all the relevant auctions ( $N_{ra}$ ) concurrently. Each bidder is allotted a budget of  $RsBu$ . All the relevant auctions fix the opening bid value  $OB$ .

#### 3.1 Simulation Parameters and Procedure

To illustrate some results of the simulation, following data is considered:  $N_c = 1$  to 4,  $N_k = 1$  to 8,  $N_u = 50$  to 80,  $R_g = 1$ ,  $N_m = 1$ ,  $N_p = 2$  to 30,  $N_s = 1$  to 4,  $N_{aa} = 5$  to 500,  $N_{ra} = 2$  to 16,  $P_k = 10$  to 400,  $Bu = 25000$  to 35000,  $OB = 200$  to 700. The simulation procedure is as follows. (1) Create 'n' clones and allot budget to bid in the relevant auction sites. (2) Fill in bidding strategies in the clones and dispatch. (3) Master BDI agent will monitor bidding and decides weather to bid, sleep or withdraw from the site either till the master wins or with draws from the auction. Some of the performance measures considered in simulation are as follows. (1) Decision making - The BDI is trained to compute bid value and bid , to sleep or to withdraw appropriately. (2) Best possible winning bid (bid value): The scheme ensures that the BDI agent will get the best deal for

the desired product. (3) Bidders satisfaction: The bidder always wins the desired product with satisfaction. (4) Probability of winning in the relevant auction sites.

### 4. Results

In this section, the results obtained with proposed work is discussed. The simulation is carried on core2duo machine using 'C' language. The analysis of the performance parameters are given in this section. The BDI agent (master) is trained to participate in concurrent relevant auction sites and later to decide whether to participate or withdraw from the auction for more than fifty scenarios of the bidding process. Few of them are presented in this paper. The figures in 2 and 3 show the various scenarios considering the

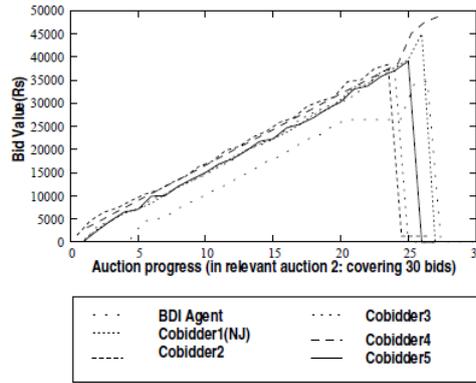


Fig. 2: Bid Value vs. Auction Progress

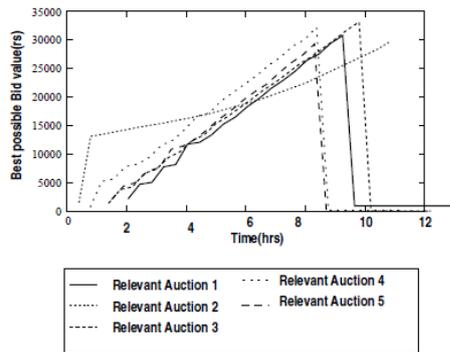


Fig. 3: Best possible winning bid vs. Time

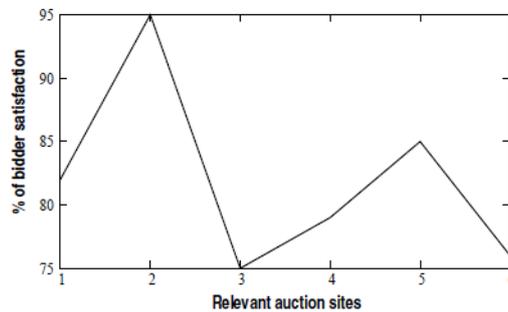


Fig. 4. % of satisfaction vs. relevant auction sites

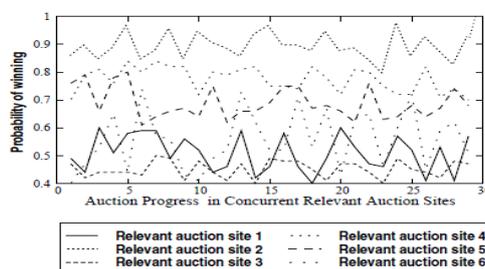


Fig. 5 Probability of winning vs. No. of times bid is placed

participation of bidders along with the BDI agent for bidding. This agent is being trained to get attuned to various possible scenarios of bidding and withdrawal. Figure 4 shows an instance of the bidding where the clones have participated concurrently in all the relevant auctions. The figures clearly showed that only one clone among all has won in an auction that has better closing price. Rest of the clones were withdrawn from bidding. Clone 2 in figure 4 has bid aggressively initially and later linearly till it has won. Figure 5 show the satisfaction of the BDI agent that represents a bidder. Figure 6 shows the probability of winning in concurrent relevant auctions.

## 5. CONCLUSIONS

This paper proposes a scheme to design a framework to incorporate human intelligence and human perspective (cognitive) in agents for bidding in multiple concurrent English auctions in mobile Ecommerce. The BDI agent is trained to compute bid value and bid along with the other bidders who may be risk averse or risk neutral while bidding. During the training process the BDI agent learns through simulation, to decide either to bid, sleep or withdraw from the relevant sites. Further plan of the work is to extend the proposed scheme for all types (dutch, yankee etc.,) of auctions.

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