A Heuristic Bidding Strategy for Multiple Heterogeneous Auctions

Patricia Anthony & Nicholas R. Jennings
Dept. of Electronics and Computer Science
University of Southampton, UK

from International Conference on Electronic Commerce (ICEC) 2003, Pittsburgh, PA

presented by Marcin Szczodrak  (marcin@ieee.org)
Problem:

- number of auction sites increases
- consumers want to track and bid multiple auctions
- consumers want to get the best deal
- need to adopt varying strategies for different auctions
- consumers need a **bidding agent** to help them
Simple Bidding Proxies Limitations:

- sites like eBay and Yahoo!Auction provide bidding proxies
- will bid in a stated auction up to some predefined limit
- fixed to operate at a single auction
- fixed to operate with a particular auction protocol
- bidding decisions are left to the human users
Goals / Expectations:

- participate in multiple heterogeneous auctions
- make purchases autonomously
- never bids above the private value
- consistent with consumer’s preferences
  (eg. earliest time, lowest price)
Previous Work:

- different types of protocols for English, Dutch, and Vickrey
- multiple heterogeneous auction environments
- environment is complex, dynamic, and unpredictable
- strategies are heuristic
- strategies are heavily influenced by the nature of environment
- search for strategy using genetic algorithm

A genetic algorithm (GA) is a search technique used in computing to find exact or approximate solutions to optimization and search problems. Genetic algorithms are categorized as global search heuristics. Genetic algorithms are particular class of evolutionary algorithms (also know as evolutionary computation) that use techniques inspired by evolutionary biology such as inheritance, mutation, selection, or crossover (also called recombination).

- strategies are heavily influenced by the nature of environment
- search for strategy using genetic algorithm
Design Environment:

- auctions: English, Dutch, Vickrey
- known start time of all auctions
- known end time of English and Vickrey
- deadlines to purchase: $t_{max}$
- private value: $p_r$
- types of intentions: bargain, desperate, combination
- buy no more than one instance
Intelligent Bidding Strategy:
a collection of strategies for a single agent

while \( t < t_{\text{max}} \) && item\_is\_not\_acquired do

build active action list \( L(t) \)

calculate current maximum bid based on **bidding constraints**

select from \( L(t) \) the potential auctions to bid in

select target auction that maximizes agent’s expected utility

bid the target action, but less than \( p_r \)

end
Bidding constraints:

- remaining time left
- remaining auctions left
- desire for bargain
- level of desperateness

we put weight on each constrain

ex. (0.25, 0.25, 0.25, 0.25) all constraints are equal
ex. (0.5, 0, 0.5, 0) agent considers only remaining time and desire for bargain
Function with two parameters
k - range [0..1] starting bidding value (k * pr)
β - range [0.005..1000] rate of concession to pr
A Heuristic Bidding Strategy for Multiple Heterogeneous Auctions
A Heuristic Bidding Strategy for Multiple Heterogeneous Auctions
Early experiments results:

• $p_r$ is the most effective factor
• successful strategies require precise definition of the environment’s characteristics
• the key defining characteristics of environment is the number of auctions that are active before $t_{\text{max}}$
Evolving Strategies:

• performance relates to strategy
• strategy is based on $k$, $\beta$, and weights on bidding constraints
• so number of strategies is infinite!
• use GAs to search for strategy
• do the search assuming that agent knows which strategies are effective in which environment, and can assess the environment accurately
Categories of Environments:

1. agent private value
   
   RP1 → Low       RP2 → Medium       RP3 → High

2. agent behavior
   
   FE1 → Desperate       FE2 → Bargain       FE3 → Balance

3. bidding **Time** and number of **Auctions**
   
   x T y A       x → Short; Medium; Long   y → Less; Many

Ex: RP1 FE2 STMA
A Heuristic Bidding Strategy for Multiple Heterogeneous Auctions
Intelligent Bidding Strategy:
a collection of strategies for a single agent

while $t < t_{\text{max}}$ && item\_is\_not\_acquired do

build active action list $L(t)$

calculate current maximum bid based on bidding constraints

select from $L(t)$ the potential auctions to bid in

select target auction that maximizes agent’s expected utility

bid the target action, but less than $pr$

end
Experimental Evaluation:

1. to show that intelligent bidding strategy perform effectively in wide range of bidding contexts

2. to understand what will happen when there are multiple such agents in the environment
Experimental Evaluation Model:

1. Accurate Agent – correctly determine environment
2. Inaccurate Agent – incorrectly determines environment

<table>
<thead>
<tr>
<th>Actual Environment</th>
<th>Inaccurate Prediction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short</td>
<td>Medium</td>
</tr>
<tr>
<td>Medium</td>
<td>Short</td>
</tr>
<tr>
<td>Long</td>
<td>Medium</td>
</tr>
</tbody>
</table>

3. Agent C – fixed strategy

- bargain: RP2 FE2 MTMA
- desperate: RP2 FE1 MTMA
- both: RP2 FE3 MTMA
A Heuristic Bidding Strategy for Multiple Heterogeneous Auctions
Average Utility Comparison

A Heuristic Bidding Strategy for Multiple Heterogeneous Auctions
Agent’s Performance with Varying Environment Prediction Accuracy

A Heuristic Bidding Strategy for Multiple Heterogeneous Auctions
Experimental Evaluation:

1. to show that intelligent bidding strategy perform effectively in wide range of bidding contexts

2. to understand what will happen when there are multiple such agents in the environment
Market Model:

1. Dummy Bidder
   - have intention and poses behavior
   - maintain information about target, private value starting bid, and increment
   - values generated randomly from standard probability distribution

2. Intelligent Agent
   - have individual an environmental parameters
   - values generated as in dummy bidders

3. Set equilibrium: price at 81 and quantity at 25
Supply and Demand Curve for the Market

A Heuristic Bidding Strategy for Multiple Heterogeneous Auctions
Effectiveness of the Market:

Allocative efficiency is defined as the total actual profit earned by all the sellers divided by the maximum total profit that could have been earned in an ideal market (expressed as percentage).

Smith’s Alpha coefficient measures how close the actual trade prices are to the equilibrium, $\alpha = 100 \times \sigma_0 / P_0$, where $\sigma_0$ is the standard deviation of trade prices around $P_0$. 
### The Bidder’s Average Utility

<table>
<thead>
<tr>
<th>Number of Intelligent Agents</th>
<th>Intelligent Agents</th>
<th>Dummy Bidders</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Utility</td>
<td>Average Utility</td>
</tr>
<tr>
<td>0</td>
<td>0.007401</td>
<td>0.003419</td>
</tr>
<tr>
<td>30</td>
<td>0.006180</td>
<td>0.002807</td>
</tr>
<tr>
<td>60</td>
<td>0.006836</td>
<td>0.002593</td>
</tr>
<tr>
<td>90</td>
<td>0.004716</td>
<td>0.002509</td>
</tr>
<tr>
<td>120</td>
<td>0.004584</td>
<td>0.002490</td>
</tr>
<tr>
<td>150</td>
<td>0.004507</td>
<td>0.002254</td>
</tr>
<tr>
<td>180</td>
<td>0.004343</td>
<td>0.002090</td>
</tr>
<tr>
<td>210</td>
<td>0.003819</td>
<td>0.001846</td>
</tr>
<tr>
<td>240</td>
<td>0.003407</td>
<td>0.001410</td>
</tr>
</tbody>
</table>

- total 300 agents
- start with 0 intelligent agents and then increase by 30
Number of Intelligent Agents vs. Allocative Efficiency

Efficiency can be improved by adding even small number of intelligent agents
Number of Intelligent Agents vs. Smith’s Alpha

market is slowly converging to its equilibrium
Number of Intelligent Agents vs. Average Utility

- Intelligent agents are competing against each other.
- Intelligent agents are competing against dummies.
Experiment Summary:

• intelligent bidding strategy can perform effectively in a wide range of environments
• achieves high success rate and average utility
• achieves high utility between many intelligent agents
Conclusion:

“... as the number of on intelligent agents increases, the market efficiency increases which, in turn, leads to an increase in profit to the sellers.”

Future Work:

Determine methods such that agent can quickly and accurately determine the type of trading environment
Questions?

Thank You,

marcin (marcin@ieee.org)