Probabilistic Automated Bidding in Alternative Auctions

Marlon Dumas, Lachlan Aldred, Guido Governatori, Arthur ter Hofstede, Nick Russell

Queensland University of Technology, Australia

m.dumas@qut.edu.au
Vision

Nokia 8260 in box at most 200$ before 10 days 90% eagerness

Probabilistic Bidding Agent

Auction House

Auction

English proxy ends at 4:45

FPSB ends at 4:47

Vickrey ends at 4:40

English no proxy ends at 4:43

English proxy ends at 4:45

Palm VII
Goal

To obtain one unit of an item at the lowest price, given the following parameters:

\( M \): The maximum bidding price
\( D \): The deadline for obtaining the item
\( G \): The *eagerness* to obtain the item
Goal

To obtain one unit of an item at the lowest price, given the following parameters:

$M$: The maximum bidding price
$D$: The deadline for obtaining the item
$G$: The eagerness to obtain the item

Auctions are single-unit with fixed deadlines:
- eBay-style auctions with or without proxy bids
- FPSB and Vickrey auctions
Approach

A bidding agent operates in 4 phases:

- **Preparation**
  - Get connection time
  - Get bid histories
  - Estimate probabilities

- **Planning**
  - Compute bid plan

- **Revision**
  - Update probabilities

- **Execution**
  - Place bids

Additional details:

- Probability functions \((w_a)\)
- Bidding delay \((\delta_a)\)
- Bidding plan
- Bidding price \((r)\)

New auction quote rise
Preparation: Probability estimation

Given the history of Winning Bids (W.B.) and the quote $q$ of an auction, the probability of winning with a bid of $r$ can be computed in two ways.

Histogram method

$$w(r) = \frac{\text{# of auctions with W.B. between } q \text{ and } r}{\text{# of auctions with W.B. greater than } q}$$
Preparation: Probability estimation

Given the history of Winning Bids (W.B.) and the quote $q$ of an auction, the probability of winning with a bid of $r$ can be computed in two ways.

**Histogram method**

$$w(r) = \frac{\text{# of auctions with W.B. between } q \text{ and } r}{\text{# of auctions with W.B. greater than } q}$$

**Normal distribution method**

$$w(r) = \frac{\int_{q-\mu}^{\frac{z-\mu}{\sigma}} e^{-x^2/2} dx}{\int_{q-\mu}^{\infty} e^{-x^2/2} dx}$$

$\mu = \text{average W.B.}$

$\sigma = \text{std. dev. of W.B.}$
Planning: Problem statement

Given a set $A_a$ of announced auctions, find:

- A set of auctions $A_s \subseteq A_a$
- A bidding price $r < M$
Planning: Problem statement

Given a set $A_a$ of announced auctions, find:

- A set of auctions $A_s \subseteq A_a$
- A bidding price $r < M$

such that:

- Auctions in $A_s$ are mutually compatible
  \[ \forall a_1, a_2 \in A_s \ | \text{end}(a_2) - \text{end}(a_1) | \geq \delta_{a_1} + \delta_{a_2} \]

- Probability of winning 1 auction is satisfactory
  \[ 1 - \prod_{a \in A_s} (1 - w_a(r)) \geq G \]

- $r$ is minimal w.r.t. the previous constraints
Planning: Computing the best plan

For a given price $r$, it is possible to compute the best bidding plan using a critical path algorithm.

Prob. of loosing in best plan $= .2^2 \times .1^2 = .004$

Prob. of winning in best plan $= 1 - .004 = 99.6\%$
Planning: Minimising the bidding price

For each \( r \) between 1 and \( M \)

Compute the best bidding plan at price \( r \);
If the prob. of winning with this plan is \( \geq G \),
stop iterating

If no appropriate \( r \) is found, notify the user.
Otherwise, take \( r \) as the bidding price.

Note: Binary search can be used as optimisation
Plan execution

The agent places bids of amount $r$, using proxy bidding and sniping tools if applicable.
Plan execution

The agent places bids of amount $r$, using proxy bidding and sniping tools if applicable.

The agent requests quotes of ongoing auctions and retrieves new auctions.
Plan execution

The agent places bids of amount $r$, using proxy bidding and sniping tools if applicable.

The agent requests quotes of ongoing auctions and retrieves new auctions.

A plan revision is triggered in the following cases:

- A new auction for the required item appears
- The quote of an auction in the plan rises above the bidding price
Heterogeneity between auctions

Alternative auctions are often heterogeneous:

- Different item characteristics
- Different settlement and shipping conditions
- Different sellers
Heterogeneity between auctions

*Alternative auctions* are often heterogeneous:

- Different item characteristics
- Different settlement and shipping conditions
- Different sellers

Two approaches to deal with heterogeneity:

- Price differentiation. The user sets a different maximum price for each auction
- Utility differentiation. The user provides a multi-attribute scoring system
Experimentation

Auction simulation platform

Auction data from eBay and Yahoo!

Market Generator → Local Bidding Agent → Local Bidding Agent → Probabilistic Bidding Agent

Auction Creations creates

Local Bidding Agent creates bids

Probabilistic Bidding Agent creates bids

Java RMI

Auction House

Auction 1, Auction 2, Auction 3

Recorded bid histories → Results Analyser
Experimentation

Tested claims

1. The percentage of times that a probabilistic bidder wins is equal to its eagerness
Experimentation

Tested claims

1. The percentage of times that a probabilistic bidder wins is equal to its eagerness
2. Probabilistic bidders pay less than local ones
Experimentation

Tested claims

1. The percentage of times that a probabilistic bidder wins is equal to its eagerness
2. Probabilistic bidders pay less than local ones
3. The welfare of the market increases with the number of probabilistic bidders
Experimentation

Validation of Claim 2

![Bar Chart]

- Y-axis: Average Winning Price for Simulation Bundle
- X-axis: Local Bidders Per Auction
- Colors: Blue for Probabilistic Bidder, Red for Local Bidder

Values:
- 2 bidders: [Price Data]
- 3 bidders: [Price Data]
- 4 bidders: [Price Data]
- 5 bidders: [Price Data]
- 6 bidders: [Price Data]
- 7 bidders: [Price Data]
- 8 bidders: [Price Data]
Experimention

Validation of Claim 3

![Graph showing the relationship between total welfare and the number of probabilistic bidders per simulation. The graph includes data points and a trend line.]
Conclusion

Probabilistic bidding agents:

- allow bidders to make tradeoffs between price and eagerness;
- increase the payoff of their users and the welfare of the market

Future extensions:

- Multiple units of an item / multi-unit auctions
- Interrelated items (all-or-none transactions)