Autonomous Multiagent Systems

Peter Stone

Week 12, Tuesday (11/12)

Any Questions?

Reading Overview — Auctions

- FCC spectrum auctions design
- The trading agent competition
- Comparison of eBay and Amazon mechanisms (optional)

Department of Computer Sciences
The University of Texas at Austin

Student-led discussion

- Game theory cannot correctly be used to predict agent behavior in auctions, since agents can easily be manipulated by other agents and the auctioneer into believing an irrational action is rational.

- Agree or disagree?

Spectrum licenses

- Worth **a lot**
- But how much to whom?
- Used to be assigned
  - took too long
- Switched to lotteries
  - too random
  - clear that lots of value given away

So decided to auction

Department of Computer Sciences
The University of Texas at Austin

Goals of mechanism

- Efficient allocation (assign to whom it's worth the most)
- Promote deployment of new technologies
- Prevent monopoly (or close)
- Get some licenses to designated companies
- No political embarrassments

Revenue an afterthought (but important in end)

Choices

- Which basic auction format?
- Sequential or simultaneous auctions?
- Combinatorial bids allowed?
- How to encourage designated companies?
- Up front payments or royalties?
- Reserve prices?
- How much information public?

Problems from New Zealand and Australia

$\boxed{\text{Second price, sealed bid}}$

- High bidder's willingness to pay is public
- No reserve prices
- No penalties for default, so many meaningless high bids

Any oversight in auction design can have harmful repercussions, as bidders can be counted on to seek ways to outfox the mechanism.

Department of Computer Sciences
The University of Texas at Austin

License interactions

- Complementarities: good to be able to offer roaming capabilities
- Substitutability: several licenses in the same region
- Need to be flexible to allow bidders to create aggregations
- Secondary market might allow for *some* corrections
  - Likely to be thin
  - High transaction costs

Limits of Theory

- Identify variables, but not relative magnitudes
  - When there are conflicting effects, can't tell which will dominate
- Ignores transaction costs of implementing policies
- May depend on unknown information
  - e.g. bidder valuations
- Doesn't scale to complexity of spectrum auctions

Used laboratory experiments too

Department of Computer Sciences
The University of Texas at Austin

Open vs. Sealed Bid

- Open increases information, reducing winner's curse
  - Leads to higher bids
- **But. . .**
  - Risk aversion leads to higher bids in sealed bid auctions
  - Sealed bid auctions deter colusion
- Decided former outweighed latter
- Went with announcing bids, but not the bidders
  - Circumvented!

Department of Computer Sciences
The University of Texas at Austin

Simultaneous vs. Sequential

- Sequential prevents backup strategies for aggregation
- Sequential also allows for budget stretching
- Simultaneous needs a stopping rule
  - Closing one by one is effectively sequential
  - Keeping all open until all close encourages sniping
- Stopping rule should:
  - End auction quickly
  - Close licenses almost simultaneously
  - be simple and understandable

Went with activity rules

Department of Computer Sciences
The University of Texas at Austin

Combinatorial Bids

- Nationwide bidding could decrease efficiency and revenue
- Full combinatorial bidding too complex
  - Winner determination problem
  - Active research area

Aiding Designated Bidders

- Give them a discount

- Circumvented!

Department of Computer Sciences
The University of Texas at Austin

Royalties vs. Up-front Payments

- Royalties decrease risk, increase bids
- But royalties discourage post-auction innovation
- Decided against

Reserve Prices

- Not necessary in such a competitive market
- Did include withdrawal penalties

Department of Computer Sciences
The University of Texas at Austin

Results

- Big successes
  - Lots of bidders
  - Lots of revenue
- Also some problems
  - Strategic Demand Reduction
- Incremental design changes
  - New problems always arise
  - Bidders indeed find ways to circumvent mechanisms
- Lessons to be learned via agent-based experiments

FCC Spectrum Auction #35

- 422 licences in 195 markets (cities)
  - 80 bidders spent $8 billion
  - ran Dec 12 - Jan 26 2001
  - licence is a 10 or 15 mhz spectrum chunk
- Run in rounds
  - bid on each licence you want each round
  - simultaneous; break ties by arrival time
  - current winner and all bids are known
- Allowable bids: 1 to 9 bid increments
  - 1 bid incr is 10% – 20% of current price
- Other complex rules

Model

- Agent goals
  - desire 0, 1, or 2 licences per market
  - desired markets have unique values
  - subject to budget constraint

Assumption: no inter-market value dependencies

- Utility is profit: $\Sigma_l(value - cost)$

- modeled 5 most important bidders
  - others served mainly to raise prices
  - modeled as several small bidders
  - lower valuations (75% $\rightarrow$ pessimistic)

Department of Computer Sciences
The University of Texas at Austin

Bidding Strategies

- Considering self only
  - Knapsack
  - best self-only approach
- Strategic bidding (consider others)
  - threats
  - budget stretching
  - Strategic Demand Reduction (SDR)

Explicit communication not allowed

Randomized Strategic Demand Reduction

- **Figure out allocations dynamically**
  - round 1: bid for everything you want
  - first big bidder winning bid owns licence
  - satisfaction = owned value / desired value

- **Random ⇒ uneven allocation**
  - get small share ⇒ incentive to cheat
  - fair: own satisfaction close to average
  - if unlucky, take licences until fair

- **Small bidders take licences from owners**
  - remember licence's owner
  - allocate while small bidders active

RSDR vs. Knapsack

Method	*Agent*	*Profit ($M)*	*Ratio*	*Cost*
Knapsack	0	980 (±170)	1.00	.82
	1	650 (±85)	1.00	.82
	2	830 (±91)	1.00	.84
	3	170 (±20)	1.00	.84
	4	550 (±96)	1.00	.86
RSDR	0	1240 (±210)	1.26	.76
	1	820 (±83)	1.25	.77
	2	1300 (±290)	1.58	.74
	3	300 (±44)	1.78	.79
	4	930 (±240)	1.68	.76

44% more profit; avg. ratio 1.51

Robustness

- What if someone cheats?
  - cheat: defect back to knapsack
  - others stay out of its way $\Rightarrow$ big win
- Solution: Punishing RSDR (PRSDR)
  - cheater takes your licence $\Rightarrow$ take it back
  - take it back first while still have money
  - aggressively punitive: skips optimizers

$\boxed{\text{Simplification: pointing out cheaters by hand}}$

Department of Computer Sciences
The University of Texas at Austin

Robustness

Method	*Ratio*	*Cost*
Knapsack	1.00	.84
RSDR	1.51	.76
RSDR Cheater	1.63	.76
RSDR Victim	1.22	.79
PRSDR Cheater	1.02	.83
PRSDR Enforcer	1.17	.81

Extensions

- **Change small bidder valuations**
  - test robustness
  - RSDR is optimal for preserving profit
- **Multiple cheaters**
  - current punishment too aggressive
  - collapse back to knapsack instead

Department of Computer Sciences
The University of Texas at Austin

Extentions

Method	*Ratio*	*Local Ratio*	*Cost*
Multiple Cheater	1.03	1.03	.84
Multiple Enforcer	1.01	1.01	.83
50% Knapsack	1.70	1.00	.74
50% RSDR	3.42	2.02	.51
75% Knapsack	1.00	1.00	.84
75% RSDR	1.51	1.51	.76
85% Knapsack	0.68	1.00	.89
85% RSDR	0.81	1.25	.87

Future Work

More complex value functions

- inter-market dependencies

Automatic cheater detection

- partial cheating vs. detection arms race

Generalization to other auctions

- more robust to tie-breaking procedure variations
- Recall Roth-Ockenfels:
  - late bidding on Ebay = randomized strategy

Last-minute bidding [Roth,Ockenfels, 2001]

– eBay: first-price, ascending auction
– Amazon: auction extended if bid in last 10 minutes
– eBay: bots exist to incrementally raise your bid to a maximum

- Still people *snipe*. Why?
  - There's a risk that the bid might not make it
  - However, common-value $\Longrightarrow$ bid conveys info
  - Late-bidding can be seen as implicit collusion
  - Or . . . , lazy, unaware, etc. (Amazon and eBay)

- Finding: more late-bidding on eBay,
  - even more on antiques rather than computers

Small design-difference matters

Late Bidding as Best Response

- Good vs. incremental bidders
  - They start bidding low, plan to respond
  - Doesn't give them time to respond
- Good vs. other snipers
  - Implicit collusion
  - Both bid low, chance that one bid doesn't get in
- Good in common-value case
  - protects information

Overall, the analysis of multiple bids supports the hypothesis that last-minute bidding arises at least in part as a response by sophisticated bidders to unsophisticated incremental bidding.

Next Week's Readings – Agent Modeling

- Recursive Modeling
- Team modeling in air combat
- Strategy assessment in robotic soccer