# CS378
# Autonomous Multiagent Systems
# Spring 2005

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Week 13a: Tuesday, April 19th

# Good Afternoon, Colleagues

Are there any questions?

# Logistics

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  - Hand them in with your final reports
- Final projects due in 2 weeks!

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  - Use undergraduate writing center
- Enough detail so that Mazda or I could reimplement

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  - How? Why? What alternatives?

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- Slides on resources page

# Class Discussion

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Vickrey strategy clear?

# Bidding for Multiple Items

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| camera alone | $50 |
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- $\in [10, 50]$ — **Depends on the price of the camera**

# Spectrum licenses

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So decided to auction

# Goals of mechanism

- Efficient allocation (assign to whom it's worth the most)
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Revenue an afterthought (but important in end)

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- How much information public?

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

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- Need to be flexible to allow bidders to create aggregations
- Secondary market might allow for *some* corrections
  - Likely to be thin
  - High transaction costs

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Used laboratory experiments too

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Went with activity rules

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- Full combinatorial bidding too complex
  - Winner determination problem
  - Active research area

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- 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

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  - 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)

# 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 SDR

- **Figure out allocations dynamically**
  - round 1: bid for everything you want
  - first big bidder winning bid owns licence
  - satisfaction = owned value / desired value
- **Random $\Rightarrow$ uneven allocation**
  - get small share $\Rightarrow$ 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 ($M)* | *Ratio* | *Cost* |
|---|---|---|---|---|
| Knapsack | 0 | 980 ($\pm 170$) | 1.00 | .82 |
| | 1 | 650 ($\pm 85$) | 1.00 | .82 |
| | 2 | 830 ($\pm 91$) | 1.00 | .84 |
| | 3 | 170 ($\pm 20$) | 1.00 | .84 |
| | 4 | 550 ($\pm 96$) | 1.00 | .86 |
| RSDR | 0 | 1240 ($\pm 210$) | 1.26 | .76 |
| | 1 | 820 ($\pm 83$) | 1.25 | .77 |
| | 2 | 1300 ($\pm 290$) | 1.58 | .74 |
| | 3 | 300 ($\pm 44$) | 1.78 | .79 |
| | 4 | 930 ($\pm 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

Simplification: pointing out cheaters by hand

# 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

# 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