



# Computational Market Design

R. Preston McAfee



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# Problem

- Exchange systems becoming increasingly complex
- Increased complexity makes thorough testing and fixing more difficult
- Increased complexity makes systems more game-able



# Outline

- FCC Auctions...1995 and 2007
- Antipodean Auctions
- SO<sub>2</sub> Permits
- Internet Auctions
- Strategy for Automating Design



# 1995 FCC Auctions

- Synergies between individual goods create problem for bidding
- Usual designs likely to be inefficient
- Several novel designs formulated
- Inauguration of the 'mechanism design era'



# 1995 FCC Auctions

- Software which embodies new rules
- FCC Software didn't work properly
- Caltech prof Charlie Plott writes new software
- Debugged by paying Caltech undergrads \$100 per bug found



# 1995 FCC Auctions, Cont'd

- Permitted substitution across licenses
- Encouraged efficient grouping of licenses
- Withdrawal of bids key issue
  - Low penalty encourages grouping attempts
  - Two low and bids are meaningless
- Substitutability within the auction is key
  - Risk of getting stuck with incomplete groups
- Design balances these issues



# Licenses Sold in AWS 2007 Auction

Market Area	Frequency Bands	Bandwidth	Number of Licenses	Bidding Units
<b><u>Cellular Market Area (CMA) Licenses</u></b>				
Channel Block A	1710-1720 / 2110-2120	20 MHz	734	259,332,500
<b><u>Economic Area (EA) Licenses</u></b>				
Channel Block B	1720-1730 / 2120-2130	20 MHz	176	259,342,000
Channel Block C	1730-1735 / 2130-2135	10 MHz	176	129,678,000
<b><u>Regional Economic Area Grouping (REAG) Licenses</u></b>				
Channel Block D	1735-1740 / 2135-2140	10 MHz	12	129,672,000
Channel Block E	1740-1745 / 2140-2145	10 MHz	12	129,672,000
Channel Block F	1745-1755 / 2145-2155	20 MHz	12	259,341,000
<b>Totals</b>	1710-1755 / 2110-2155	90 MHz	1,122	1,167,037,500





# AWS Auction Prices

Block	Total	If Sold at DEF Prices
A	\$2,268,029,200	\$3,836,274,000
B+C	\$3,938,533,000	\$5,754,411,000
DEF	\$7,672,548,000	\$7,672,548,000
<b>ALL</b>	<b>\$13,879,110,200</b>	<b>\$17,263,233,000</b>

- Inability to substitute probably cost US over \$3B
- Reduced competition on smaller licenses



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# Australian Satellite TV

- Simultaneous Sealed Bid
- No Deposits
- Withdrawals took a year to complete

Australian Auction Outcomes (No Deposit)

Initial Winning Bid	Final Price After Withdrawals
A \$212,000,000	A \$ 117,000,000
A \$177,000,000	A \$ 77,000,000

Source: John McMillan, "Selling Spectrum Rights," *Journal of Economic Perspectives*, Summer, 1994



# Simultaneous Sealed Bid

- Identical items can sell for very different prices
- Risk of winning too many items
  - Lowers prices



# Simultaneous Vickrey

## New Zealand 8 MHz UHF License Rights Second Price Simultaneous Auction

Lot	Winning Bidder	High Bid	Second Bid
1	Sky Network TV	2,371,000	401,000
2	Sky Network TV	2,273,000	401,000
3	Sky Network TV	2,273,000	401,000
4	BCL	255,124	200,000
5	Sky Network TV	1,121,000	401,000
6	Totalisator Agency Board	401,000	100,000
7	United Christian Broadcast	685,200	401,000

Source: Tom Hazlett, "A Brief History of Spectrum Auctions," unpublished, 1994.



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Source: Tom Hazlett, "A Brief History of Spectrum Auctions," unpublished, 1994.



# Demand Revelation

## New Zealand Auction Outcomes (No Reserve)

High Bid	Second-Highest Bid
NZ \$100,000	NZ \$6
NZ \$7,000,000	NZ \$5,000

Source: John McMillan, "Selling Spectrum Rights," *Journal of Economic Perspectives*, Summer, 1994



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# SO<sub>2</sub> Permit Auction

- Right to pollute
- Concern that permit holders wouldn't offer to sell
- Encourage permit holders by trading at highest buyer bid prices

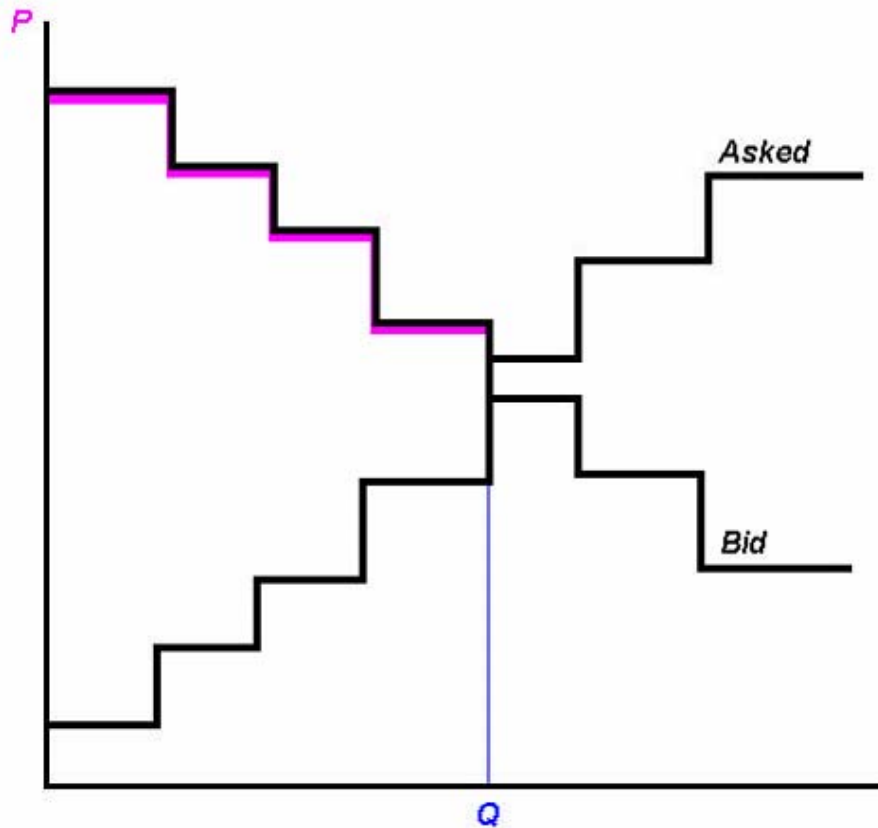


# Quirky Mechanism

- Buyers pay bids
- Sellers are matched to buyers, paid buyer bid
- Buyers bid low, sellers bid zero



# SO<sub>2</sub> Permit Auction



Weird pricing scheme led to bids that didn't reveal values



# Other Examples of Mechanism Design

- National Residency Matching Program
- NYC public school assignment
- Bidding for congested airport landing rights
- Kidney exchange as incentive problem
- **Internet search marketing**
- **Internet display advertising**



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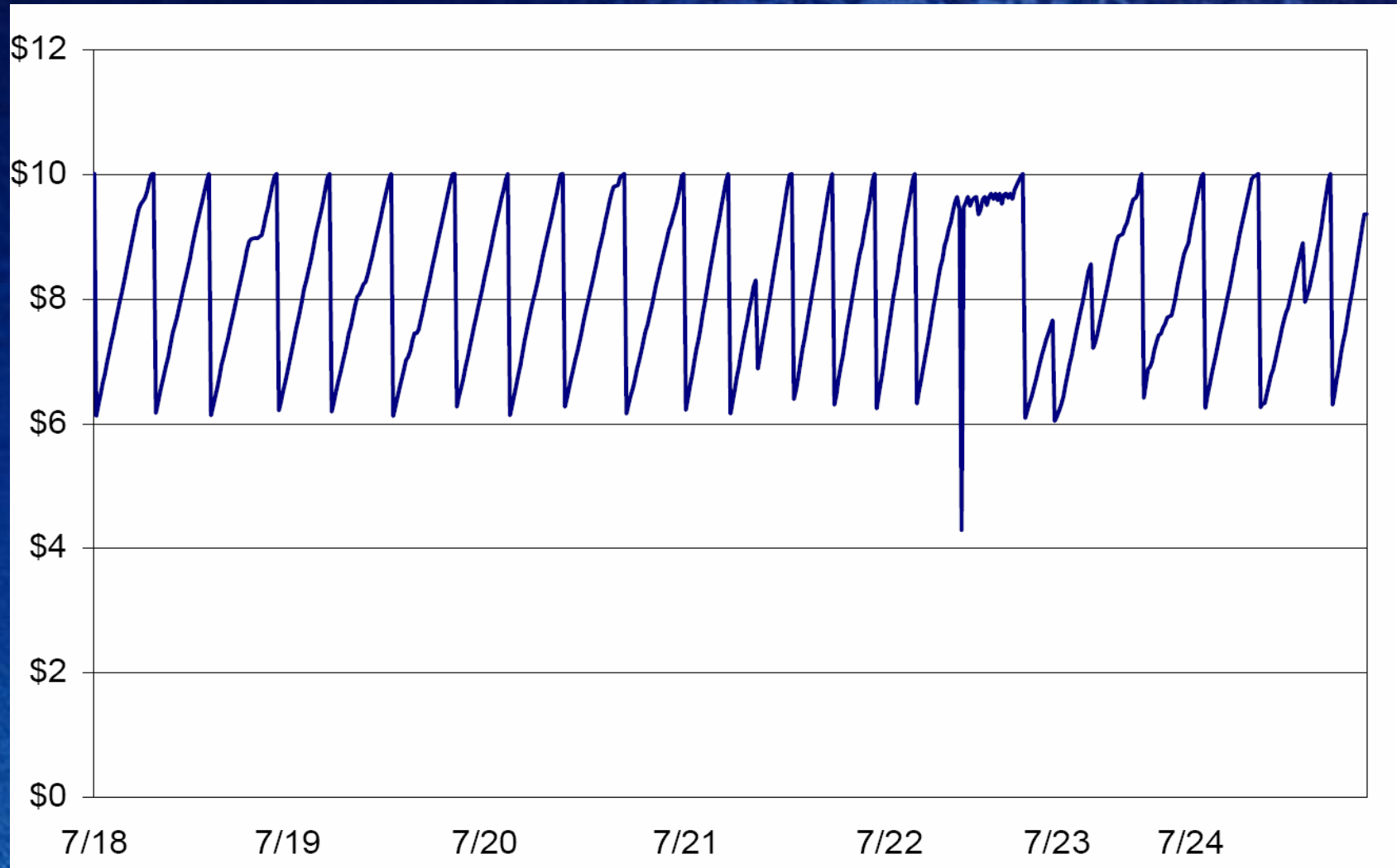


# Original Search Marketing

- Overture used “first price auction”
- High bidder(s) win, pay their bids
- Problem: High bidder would like to be 1¢ above second high bidder
- Lowered bid may induce leap-frogging
- Often no stable solution



# Real Data



# Keyword Auctions Solution


- Use second price
- Effectively conditional bid
- Doesn't "cure" all problems
  - **Not** incentive compatible due to multiple positions (substitutes)
- eBay bidding with similar items






# Display Advertising

HOME PAGE | MY TIMES | TODAY'S PAPER | VIDEO | MOST POPULAR | TIMES TOPICS | TimesSelect Free 14-Day Trial | Welcome, broder | Member Center | Log Out

The New York Times **Health**    
 Health  All NYT

WORLD | U.S. | N.Y. / REGION | BUSINESS | TECHNOLOGY | SCIENCE | HEALTH | SPORTS | OPINION | ARTS | STYLE | TRAVEL | JOBS | REAL ESTATE | AUTOS  
FITNESS & NUTRITION | HEALTH CARE POLICY | MENTAL HEALTH & BEHAVIOR




PERSONAL HEALTH  
**Growing Older, and Adjusting to the Dark**  
By JANE E. BRODY  
Published: March 13, 2007

How well do you see at night? If you're over 50, probably not as well as you think, no matter how many carrots you eat. The typical 50-year-old driver needs twice as much light to see as well after dark as a 30-year-old. Yet few of us compensate adequately for the reduction in nighttime acuity that occurs in the aging eye.

- E-MAIL
- PRINT
- SINGLE PAGE
- REPRINTS
- SAVE
- SHARE

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# Right Media Display Advertising

- Separate auction held for each opportunity
  - In background as page loads
- Billions per day
- Bids may be per impression, per click or per action
- Millions of rules created by machine learning
- Smart “black hats” incessantly gaming
  - Hiding bad ads among good ads



# Exchange Dials & Levers

- Auction form (second price...)
- Performance bidding (price per click)
- Reserve prices
- Quality scoring
- Transaction fees
- Multiple ads on page
- Storyboarding
- Statistics revealed



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# Simulation Strategy

- Test mechanisms using a mix of humans and automated agents
- Endow agents with utility functions
- Use genetic algorithms for agents to evolve
- Expand their capacity with human strategies



# Example: Spam Filtering

- Filter utility:
  - ★100 for each legitimate mail that gets through
  - ★1 for each spam that does not
- Random mix of legitimate mail
- Automated spamming agents
  - ★100 for each spam that gets through, cost ★1
- Agents use genetic algorithms to update



# Example: Display Advertising

- Mechanism matches ads to opportunities
  - Target: proof matching against gaming
- Black hat advertisers
  - Bad landing pages
  - Attempt to exhaust rivals' budgets
  - Hiding porn ads
- Black hat publishers
  - Optimize pages to exploit placement mechanism



# Conclusions

- Mechanism design has a brilliant future
- Computational burdens have disappeared
  - Ubiquitous computing
- Complex systems are offer greater opportunities for gaming and manipulation
- Modeling exploitation using artificial agents is a great tool
  - Utility and learning

