Mock Auction of LaGuardia Arrival/Departure Slots

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Why Auctions?

- Efficiency
  - Short run: resources to best use
  - Long run: correct incentives for investment
- Auctions are robust
- Auctions are responsive
- Auctions are flexible
  - Easily accommodate any division of revenues

Auctions vs. High Density Rule

- Both limit quantity to avoid excessive congestion
- Auction uses efficient pricing to maximize social welfare
- Auction revenues can replace distortionary fees and taxes
- Annual auctions allow entry and exit in dynamic industry

Auctions vs. Congestion Pricing

- Both seek efficient pricing
- Auctions provide stability of long-term slot leases and predictable (low) congestion levels
- Congestion pricing gives airlines flexibility to quickly change schedules at expense of less predictability in airport loads and delays

Auctions vs. Congestion Pricing

- Congestion pricing: fix price; quantity determined by market
- Auction: fix quantity; price determined by market
- Absent uncertainty, two approaches are the same
- Better approach depends on what is most uncertain
  - Congestion pricing — if prices are known and quantities are uncertain
  - Auction — if quantity is known and prices uncertain
- Here we know quantity (maximum throughput of LaGuardia), but we don't know prices needed to achieve quantity

The Proposed Design

Simultaneous Clock Auction

- Simultaneous
  - All slots up for auction at the same time
- Ascending clock
  - Auctioneer announces prices and bidders respond with the quantity demanded at these prices
  - Prices increase on slots with excess demand
  - Provides essential price discovery during the auction
  - Auction ends when no excess demand
- Package bids
  - Allows bidders to buy what they want given the prices
  - No risk that you will win just part of what you need

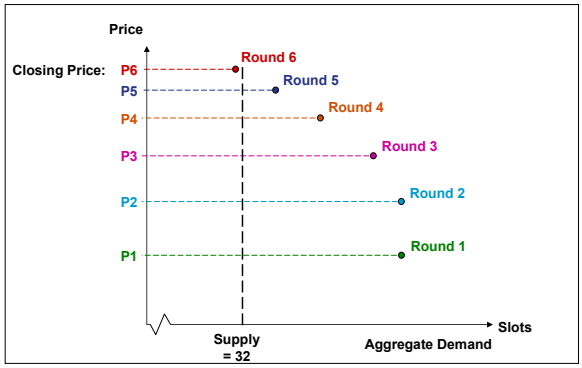
Auction Design

- Easy to use
  - Web browser and spreadsheet
- Price discovery focuses bidder decision making on relevant alternatives
- Activity rule protects against insincere bidding, enhancing price discovery
  - Bids must be roughly consistent with profit maximization
    - Reduce demands as prices increase
    - Can't shift quantity to slots that become relatively more expensive

Approach is well tested

- Spectrum auctions
- Electricity auctions
- Pollution permit auctions
- Experimental lab

Single Product Clock Auction – 0900 Slot

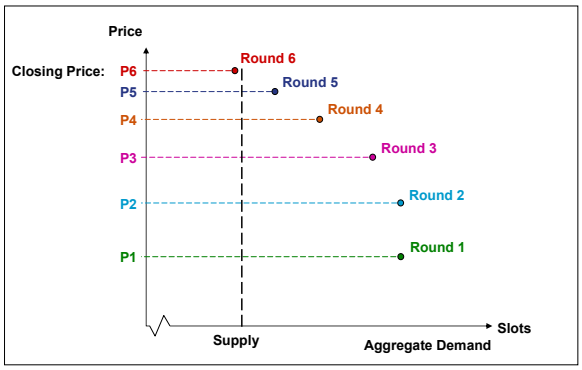


Many products: 0600, 0700, …, 2100

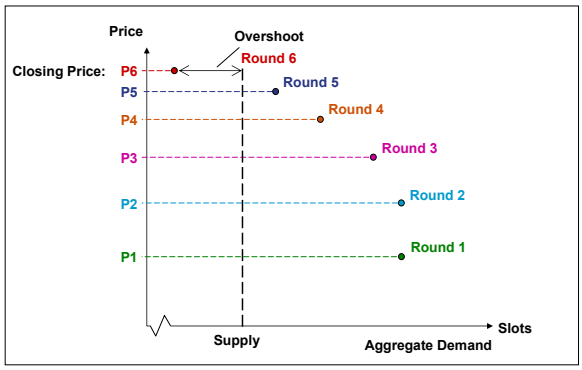
- Auctioneer specifies price vector
- Bidder responds with quantity vector
- As prices increase, bidders can:
  - Shift to less expensive hours
  - Reduce quantity (upgauge or reduce service)
  - Drop unprofitable markets

I: Single-Product Clock Auctions

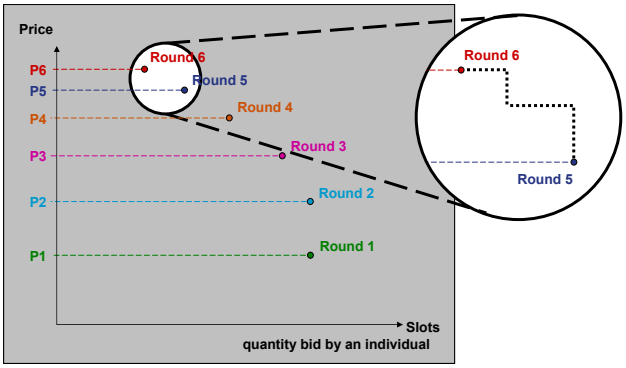
Single Product Clock Auction – Aggregate Demand



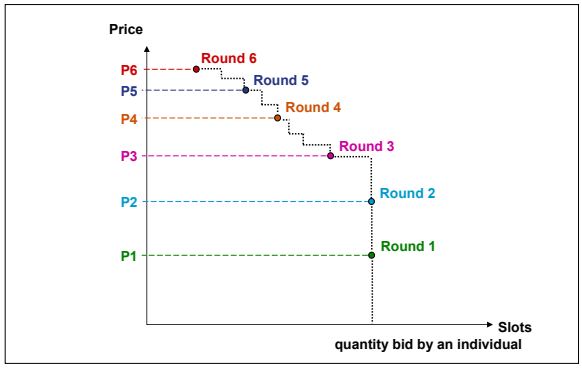
Single Product Clock Auction – Avoiding Overshoot



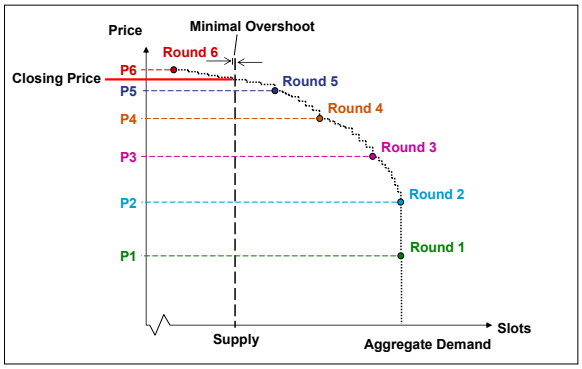
Single Product Clock Auction – Intra-Round Bidding



Single Product Clock Auction – Intra-Round Bidding



Single Product Clock Auction – Aggregate Demand with Intra-Round Bidding

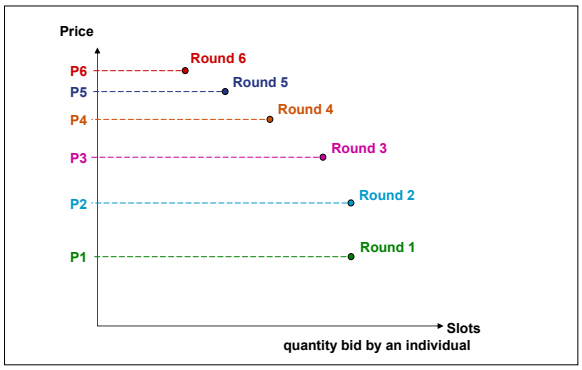


Single Product Clock Auction: Activity Rule

Activity rules

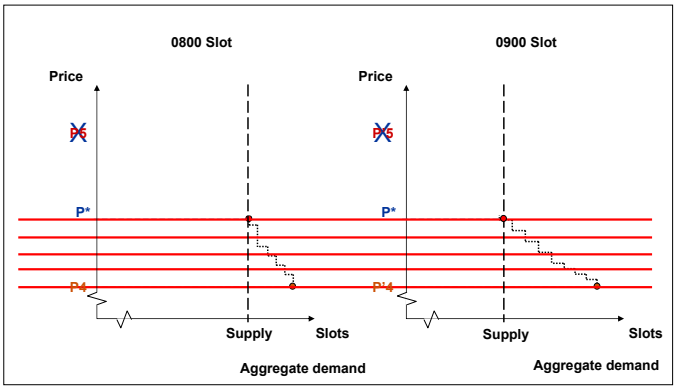
- The problem is that of a bidder hiding as a "snake in the grass" until near the end of the auction, to conceal its true interests / values from opponents
- Example / evidence: "bid-sniping" in eBay (auction lasts a week, but all meaningful bids occur in the last five minutes)

Single Product Clock Auction: Activity Rule: Quantity Bid at Higher Price ≤ Quantity at Lower Price

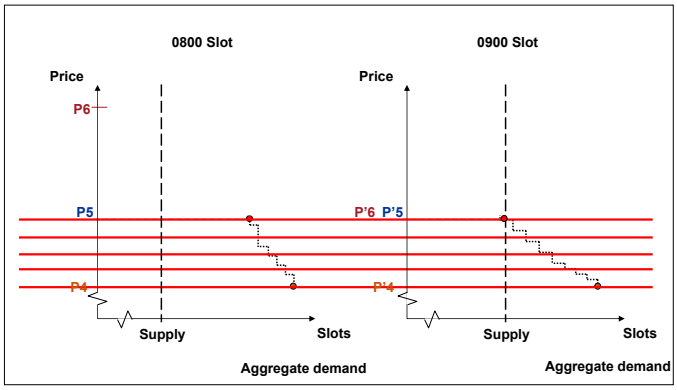


II: Multi-Product Clock Auctions

Multi-Product Clock Auction – Closing



Multi-Product Clock Auction – Closing



Multi-Product Clock Auction – Price Points

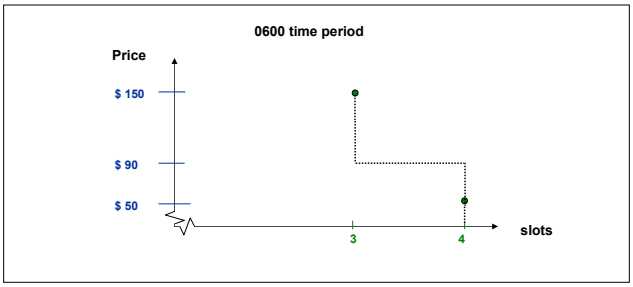
Time Period	Start of Round		Price-Point: 40 %		End of Round	
0600	$ 50	4 slots	$ 90	3 slots	$150	3 slots
0700	$100	4 slots	$160	2 slots	$250	2 slots
0800	$100	6 slots	$160	4 slots	$250	4 slots
0900	$100	4 slots	$160	4 slots	$250	4 slots
1000	$ 50	4 slots	$ 90	3 slots	$150	3 slots
1100	$ 50	3 slots	$ 90	3 slots	$150	3 slots

Multi-Product Clock Auction – Price Points

Time Period	Start of Round		Price-point: 40 %		Price-point: 75 %		End of Round	
0600	$ 50	4 slots	$ 90	3 slots	$125	2 slots	$150	2 slots
0700	$100	4 slots	$160	2 slots	$212.50	2 slots	$250	2 slots
0800	$100	6 slots	$160	4 slots	$212.50	4 slots	$250	4 slots
0900	$100	4 slots	$160	4 slots	$212.50	3 slots	$250	3 slots
1000	$ 50	4 slots	$ 90	3 slots	$125	3 slots	$150	3 slots
1100	$ 50	3 slots	$ 90	3 slots	$125	3 slots	$150	3 slots

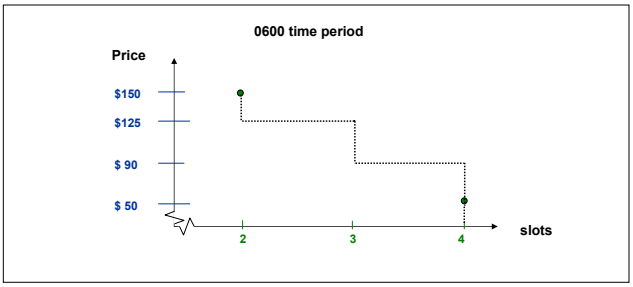
Step Function Meaning of a Bid

Time Period	Start of Round		Price-point: 40 %		End of Round	
0600	$ 50	4 slots	$ 90	3 slots	$150	3 slots



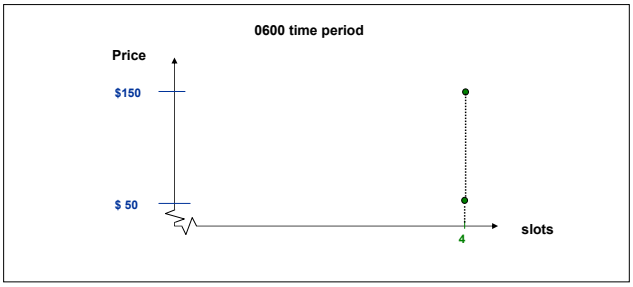
Step Function Meaning of a Bid

Time Period	Start of Round		Price-point: 40 %		Price-point: 75 %		End of Round	
0600	$ 50	4 slots	$ 90	3 slots	$125	2 slots	$150	2 slots



Maintaining the Quantities from Previous Round

Time Period	Start of Round		Price-point: 100 %		End of Round	
0600	$ 50	4 slots	$150	4 slots	$150	4 slots



Multi-Product Clock Auction – RP Activity Rule

- Would like an activity rule (for same reasons as in a single-product clock auction)
- But simple monotonicity rule is inappropriate, as bidders may want to substitute from one product to another
- Quantities for given products should be weighted by the prices of the respective products, in the correct way

Revealed Preference Activity Rule (RPA)

- Example of bidding permitted under Revealed Preference Activity Rule:

Time Period	Price p_1	Quantity q_1	Price p_2	Quantity q_2
0700	$120,000	8 slots	$150,000	8 slots
0800	$120,000	8 slots	$150,000	6 slots
0900	$100,000	4 slots	$110,000	6 slots

- The 0700 and 0800 slots became relatively more expensive than the 0900 slots, so it makes sense for the participant to engage in *substitution* from 0700 or 0800 slots into 0900 slots

Revealed Preference Activity Rule (RPA)

- Example of bidding *not* permitted under Revealed Preference Activity Rule:

Time Period	Price p_1	Quantity q_1	Price p_2	Quantity q_2
0700	$120,000	8 slots	$150,000	8 slots
0800	$120,000	8 slots	$150,000	10 slots
0900	$100,000	4 slots	$110,000	2 slots

- The 0700 and 0800 slots again became relatively more expensive than the 0900 slots, yet the participant responded by attempting to substitute from the relatively cheaper 0900 slots into the relatively more expensive 0800 slots

Revealed Preference Activity Rule (RPA)

- Any new bid that a bidder attempts to place at time *t* must satisfy the RPA rule with respect to all its existing bids at times *s*:

(RPA) $\quad (p_t - p_s)\cdot q_t \le (p_t - p_s)\cdot q_s$

- If the bidder is bidding according to any consistent set of valuations, then the RPA rule should never prevent a bidder from placing its desired bid
- The web-based auction software enforces a relaxed version of the revealed-preference activity rule — for details, see "Backup Material on RPA Rule"

Revealed Preference Activity Rule (RPA)

- Example of bidding permitted under Revealed Preference Activity Rule:

Time Period	Price p_1	Quantity q_1	Price p_2	Quantity q_2
0700	$120,000	8 slots	$150,000	8 slots
0800	$120,000	8 slots	$150,000	6 slots
0900	$100,000	4 slots	$110,000	6 slots

- Satisfies (RPA) since:

(30,000 × 8) + (30,000 × 6) + (10,000 × 6) ≤
≤ (30,000 × 8) + (30,000 × 8) + (10,000 × 4)

Revealed Preference Activity Rule (RPA)

- Example of bidding *not* permitted under Revealed Preference Activity Rule:

Time Period	Price p_1	Quantity q_1	Price p_2	Quantity q_2
0700	$120,000	8 slots	$150,000	8 slots
0800	$120,000	8 slots	$150,000	10 slots
0900	$100,000	4 slots	$110,000	2 slots

- Violates (RPA) since:

(30,000 × 8) + (30,000 × 10) + (10,000 × 2) >
> (30,000 × 8) + (30,000 × 8) + (10,000 × 4)

Backup Material on RPA Rule

Derivation:

- Based on standard analysis in consumer theory. Consider two times, *s* and *t*. Let the associated prices be p_s, p_t and let the associated demands be q_s, q_t. Let $v(q_s)$ denote the bidder's value for q_s and let $v(q_t)$ denote the bidder's value for q_t. Note:

$$v(q_s) - p_s\cdot q_s \ge v(q_t) - p_s\cdot q_t$$

and:

$$v(q_t) - p_t\cdot q_t \ge v(q_s) - p_t\cdot q_s .$$

Adding the inequalities yields the RPA rule:

(RPA) $\quad (p_t - p_s)\cdot q_t \le (p_t - p_s)\cdot q_s .$

Backup Material on RPA Rule

- It is often helpful to relax the (RPA) rule.
- Case 1: $(p_t - p_s)\cdot q_s$ is positive.

The new bid q_t is said to satisfy the *relaxed* revealed preference activity rule if:

(RPA_+) $\quad (p_t - p_s)\cdot q_t \le \alpha(p_t - p_s)\cdot q_s$, for $\alpha > 1$.

- Case 2: $(p_t - p_s)\cdot q_s$ is negative.

The new bid q_t is said to satisfy the *relaxed* revealed preference activity rule if:

(RPA_-) $\quad (p_t - p_s)\cdot q_t \le \frac{1}{\alpha}(p_t - p_s)\cdot q_s$, for $\alpha > 1$.

Mechanics of Mock Auction

Mechanics of bidding

Auction System
(Web browser)

Bidding Tool
(Excel spreadsheet)

Steps in every round

Auction System (Web) | Bidding Tool (Excel)

Determine bids and **Create** bid file using Bidding Tool

↓

Upload bid file into Auction System before round ends

↓

Monitor Auction System for results of current round and prices for next round

↓

Download Combined Download file when prices are announced for next round

↓

Import Combined Download file into Bidding Tool

Demonstration of Auction System and Bidding Tool

Web-Based Auction Software

- **Modified version of the PowerAuction™ software, commercial, web-based software designed for clock auctions.**
- **The commercial version of the software is used for 11 high-stakes auctions per year:**
  - **Electricité de France capacity auctions (France)**
  - **Electrabel VPP capacity auctions (Belgium)**
  - **Ruhrgas natural gas auctions (Germany)**
  - **ETS greenhouse gas emission reduction auction (UK)**
- **Software made available for NEXTOR Strategic Simulation 2 by Market Design Inc. (www.marketdesign.com). All other intellectual property rights reserved by Power Auctions LLC.**