Market Design

COMPSCI223: Computational Microeconomics

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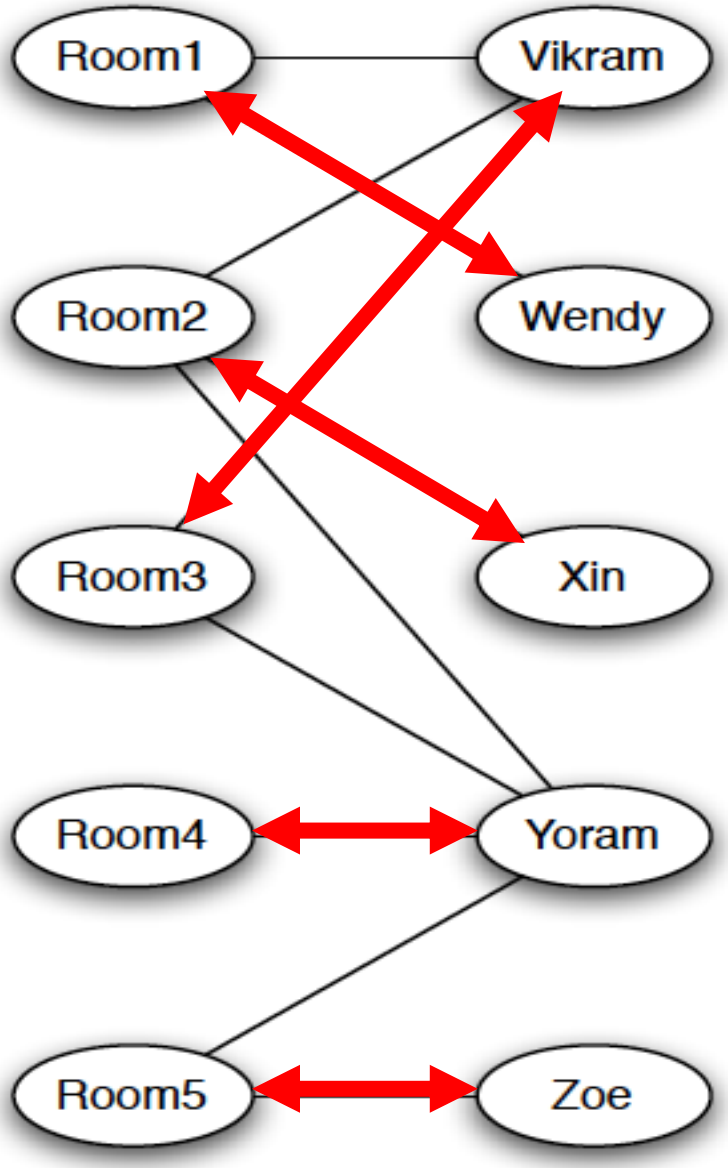
- Market matching
- Market clearing prices
- Standard auctions (+ GSP auction, if time)

Matching

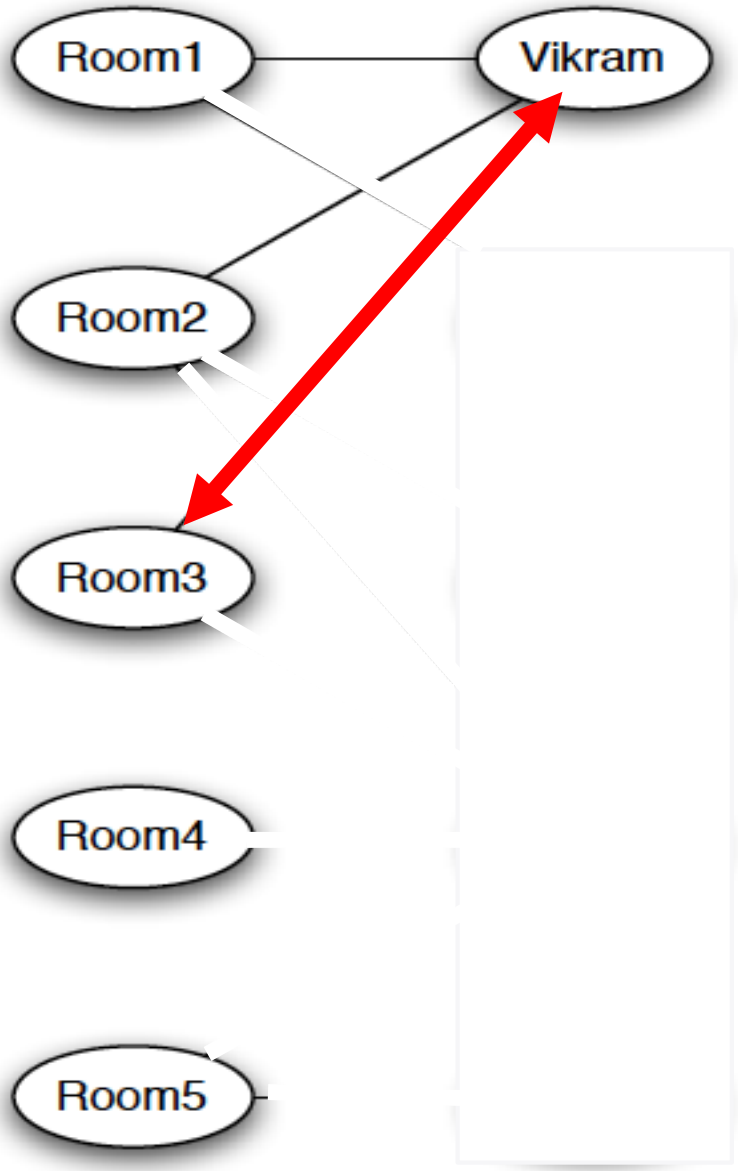


Myopic approach:

- Easy
- Suboptimal

Could do better: (also "easy" in computational sense)

Matching



Myopic approach:

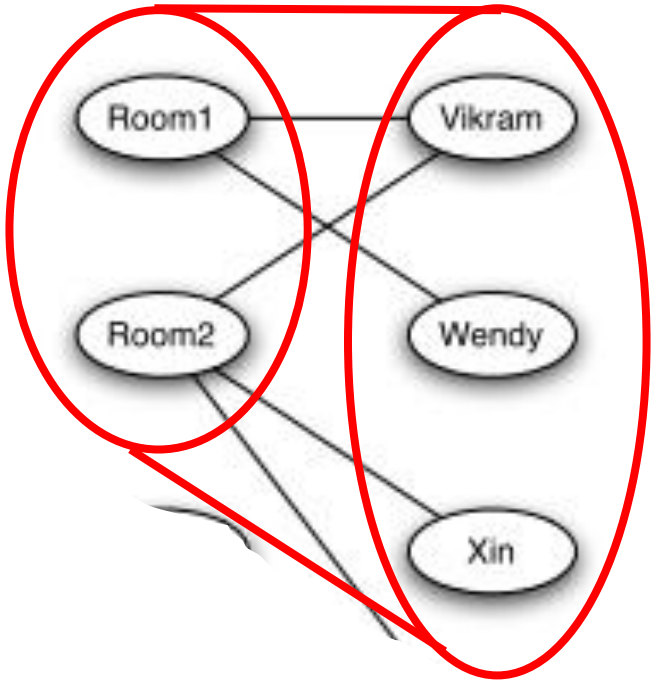
Easy

Suboptimal

Could do better: (also "easy" in computational sense)

Problematic if decisions made dynamically.

Matching: Perfect or Constricted Set

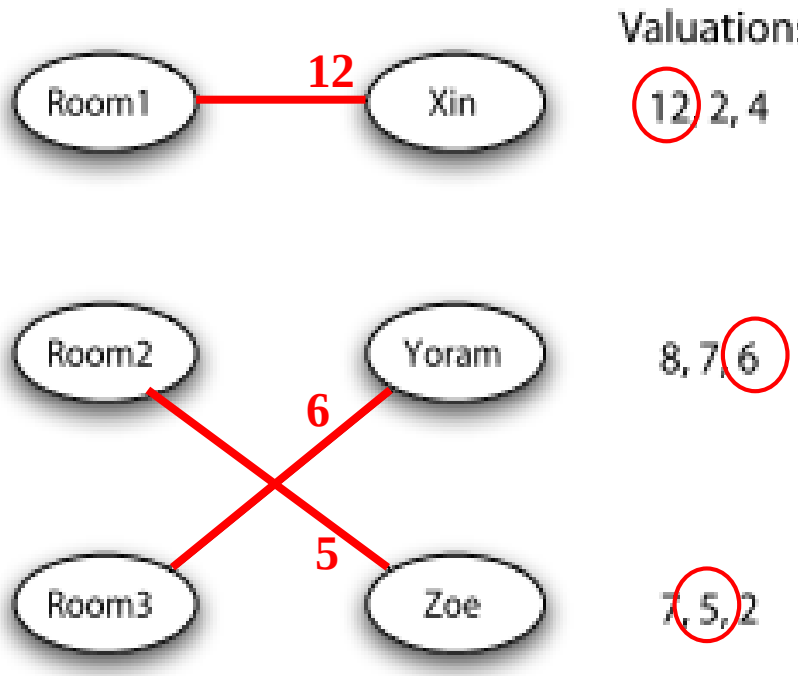


An obstacle to a perfect match:

Constricted Set

If no perfect matching, there exists a constricted set (bottleneck)

Matching with Valuations



Maximize overall value

Computationally "easy" (but not myopic)

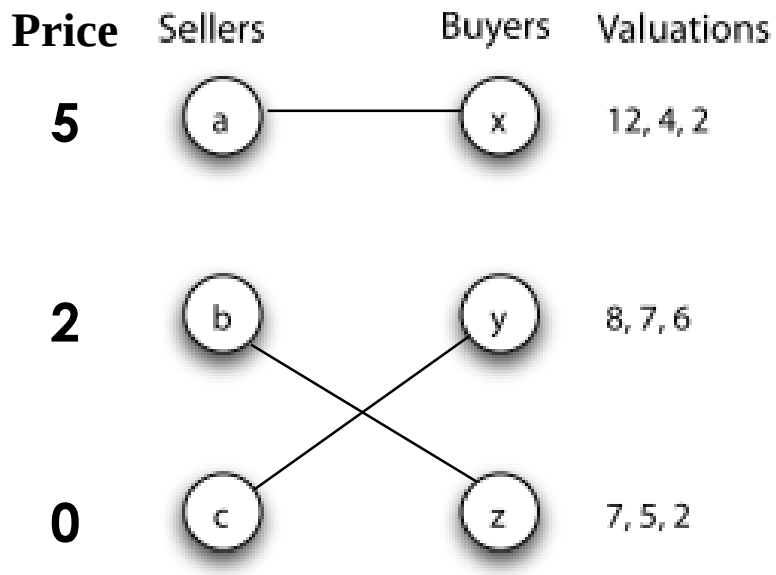
Max weight matching

12+6+5=23

Maximizing overall value does not maximize value for each individual participant.

- Raises market participation concerns
- Invites strategizing, misreporting, etc.
- Hurts market functioning: could lead to unraveling

Market-Clearing Prices



Every buyer wants the item that maximizes their payoff:

value-price

Overall value:

(12-5)+(5-2)+(6-0) (buyers)

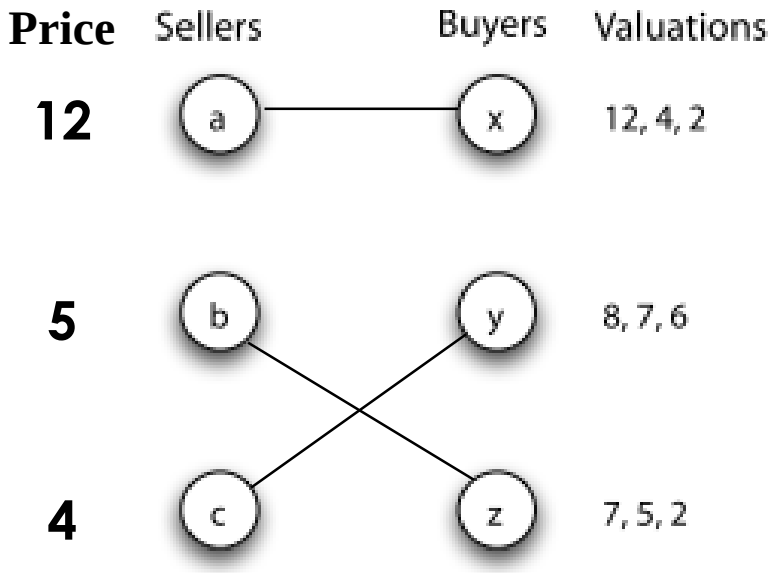
+5 +2 +0 (sellers)

=23

Market-clearing prices:

- Maximize overall value
- Maximize buyer payoff

Market-Clearing Prices



Overall value:

(12-12)+(5-5)+(6-4) (buyers)

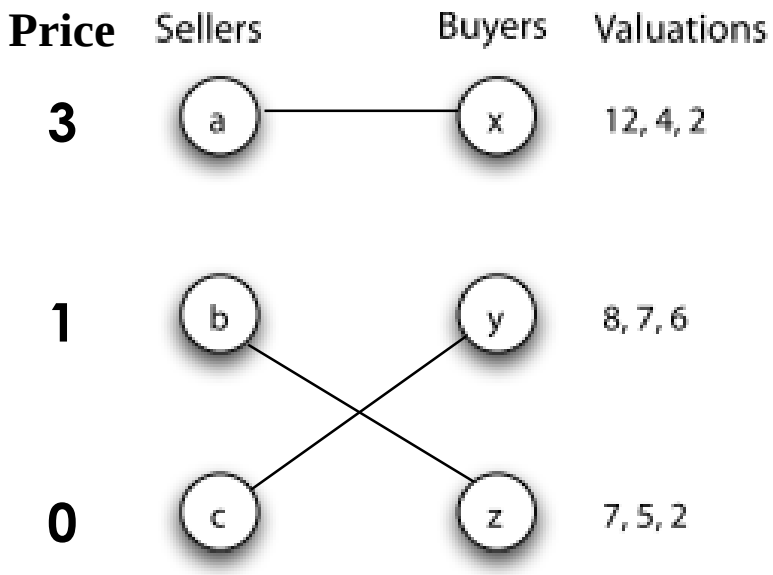
+12 +5 +4 (sellers)

=23

Market-clearing prices:

- Maximize overall value
- Maximize buyer payoff

Market-Clearing Prices



Overall value:

(12-3)+(5-1)+(6-0) (buyers)

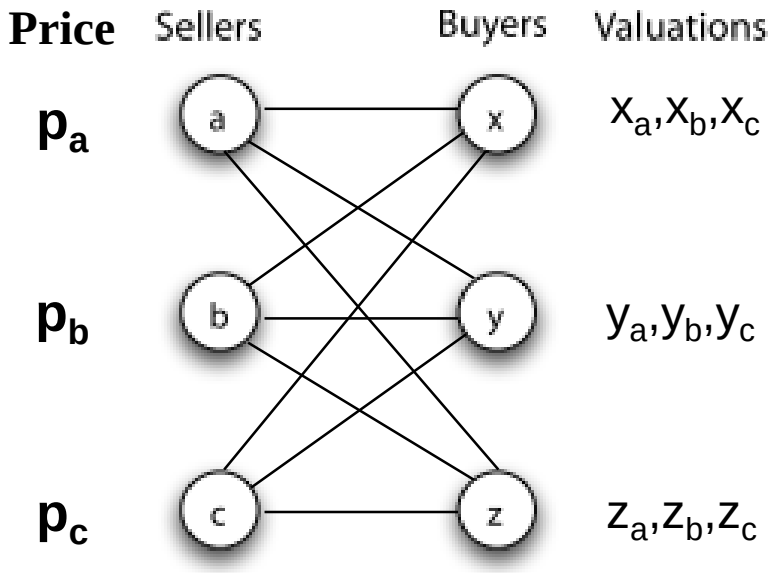
+3 +1 +0 (sellers)

=23

Market-clearing prices:

- Maximize overall value
- Maximize buyer payoff
- Not unique
- Differ across items

Market-Clearing Prices



Market-clearing prices:

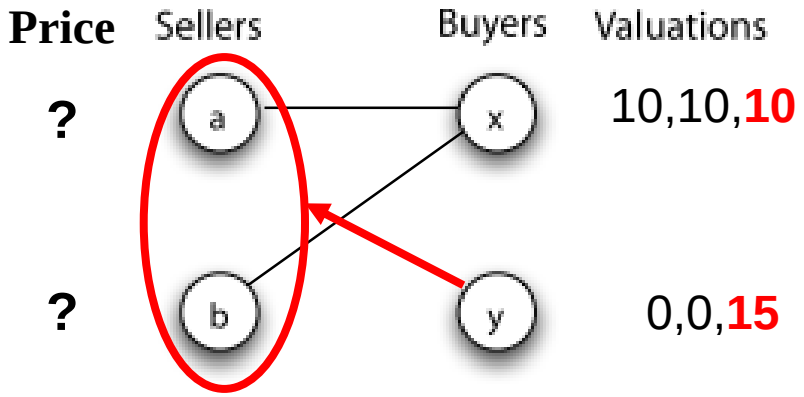
- Maximize overall value
- Maximize buyer payoff
- Not unique
- Differ across items

Do they always exist?

For any set of buyer valuations for items, market-clearing prices exist.

- "easy" to compute (not myopic)
- could choose to optimize buyer (or seller) payoffs only
- can't do it in general with a single price.

Market-Clearing Prices

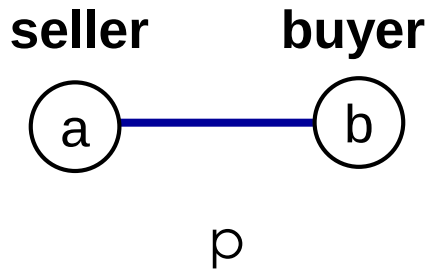


- Market-clearing item prices might not exist
  Need bundle prices
  (exponentially many, "hard" to compute)

- Even bundle prices might not clear the market.
  Need non-anonymous prices
  (price discrimination by buyer identity)

Serious fairness, regulatory, etc. issues

Trade



Buyer payoff: b-p
Seller payoff: p-a
Gains of trade: (b-p)+(p-a)= b-a

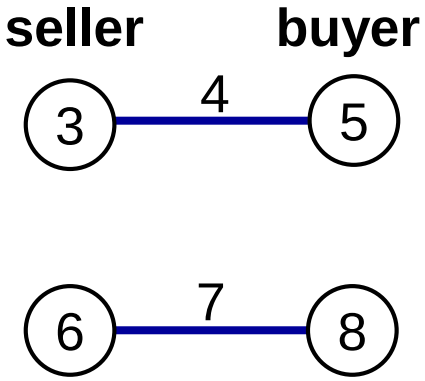
Gains of trade is the difference between buyer's and seller's valuations (or zero if trade not possible)

- Note: price is transactional

Market-maker's monetization:

- Transactional? subscription?
- Flat fee (per trade)? % price ? nonlinear schemes?
- Charge buyer? charge seller? Charge both?
- Other???

Trade



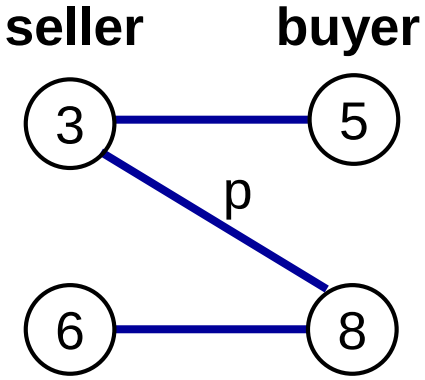
Buyer payoff: (5-4)+(8-7)=2
Seller payoff: (4-3)+(7-6)=2
Gains of trade: 2+2=4

- Market cleared. Maximized # of trades.
- How do (3) and (8) feel about the market-clearing outcomes?

  They prefer trading directly or in a market that would match them.

  - market instability, possible unraveling.

Trade



Buyer payoff: (8-p)
Seller payoff: (p-3)
Gains of trade: (8-p)+(p-3)=8-3=5

Objective: maximize overall gains of trade

Any p in [3,8] works.

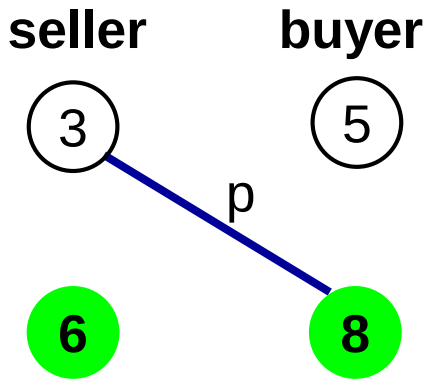
p=3 maximally favors buyer side

p=8 maximally favors seller side

p=5.5 splits gains of trade evenly across two sides

(Note: could be more than one trade with possibly different transaction prices)

Trade



Buyer payoff: (8-p)
Seller payoff: (p-3)
Gains of trade: (8-p)+(p-3)=8-3=5

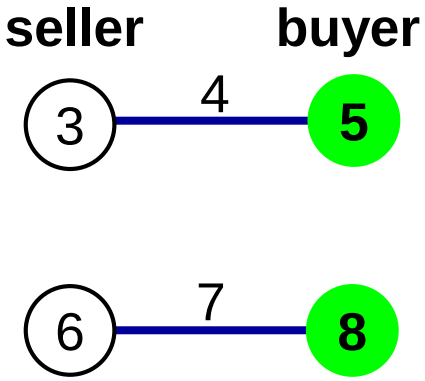
Objective: maximize overall gains of trade

Who gets the items?

Those who value the items the most.

- **Allocative efficiency**

Trade



Buyer payoff: (5-4)+(8-7)=2
Seller payoff: (4-3)+(7-6)=2
Gains of trade: 2+2=4

Objective: maximize # of trades

- Inefficient allocation

  Note that inefficiency involves (6) and **5** but both made gains in this outcome.

  Thus, (3) and **8** not only absorb the loss of efficiency, but also pay for the undeserved gains of others.

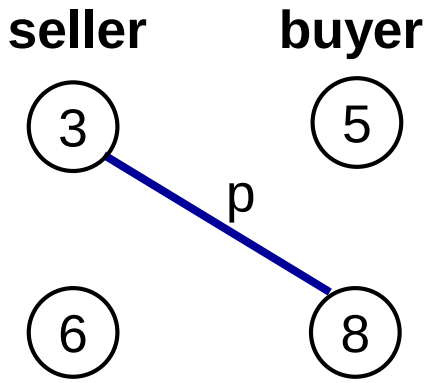
Market Design Objectives

- Liquidity (#of trades)
- Profit maximization (maximize own payoff)
- **Efficiency** (maximize overall gains of trade)
- **Stability** (protect functioning of the market)

Ensure that everyone has an incentive to participate:

- should not be able to get a better deal elsewhere

Trade



Buyer payoff: (8-p)
Seller payoff: (p-3)
Gains of trade: (8-p)+(p-3)=8-3=5

Objective: maximize overall gains of trade

Any p in [3,8] works?

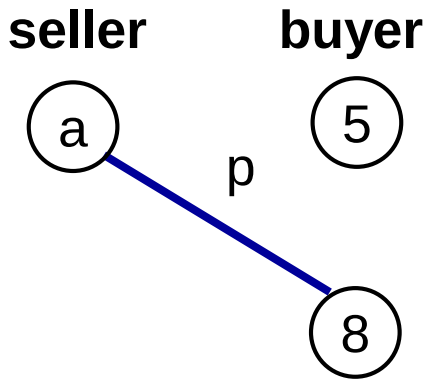
But… if p<5, there is another potential buyer.

if p>6 there is another potential seller.

So, any p in[5,6] works.

Other market participants matter for price setting even if they don't gain anything from the outcome

Monopolist Seller



Who should get the item?
At what price?

Market-clearing: p in [5,8]

Best for seller: p=8

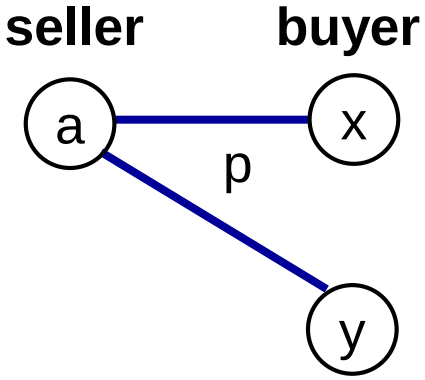
Depends on buyer's reported value

Best for buyer: p=5

Depends on the value of others

Should buyer report differently?

Market-Clearing



Who should get the item?
At what price?

Buyers might not want to reveal their values.

Auctions to the rescue:

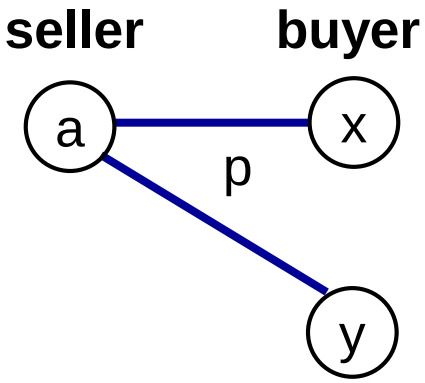
Dutch

1st Price Auction

English

2nd Price Auction
(a.k.a. Vickrey Auction)

English Auction



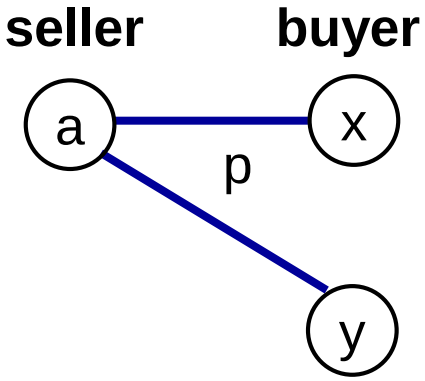
Who should get the item?
At what price?

Buyers might not want to reveal their values.

Ascending price:

- Price starts at, e.g., zero.
- Price increases until only one interested buyer left.

Dutch Auction



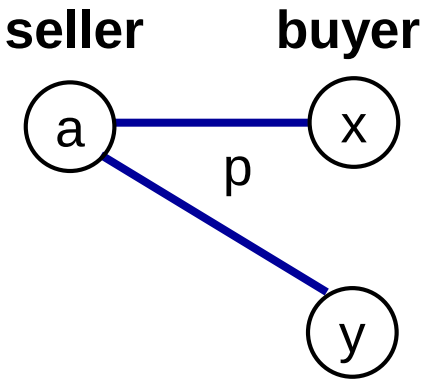
Who should get the item?
At what price?

Buyers might not want to reveal their values.

Descending price:

- Price starts at high p
- Price decreases until a buyer accepts.

1st Price Auction

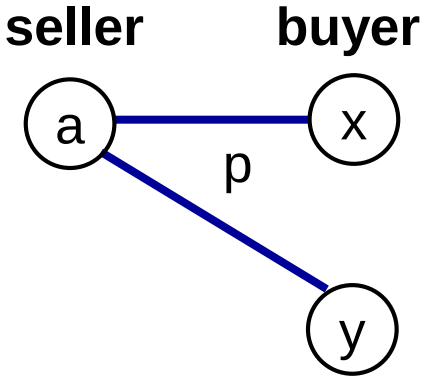


Who should get the item?
At what price?

Buyers might not want to reveal their values.

- Buyers submit their bids simultaneously (sealed-bid)
- Highest bid gets the item (wins), pays its bid

2nd Price Auction (Vickrey Auction)



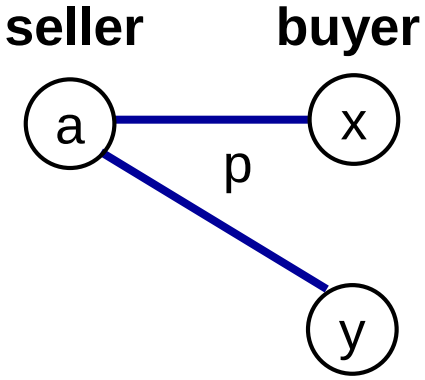
Who should get the item?
At what price?

Buyers might not want to reveal their values.

- Buyers submit their bids simultaneously (sealed-bid)
- Highest bid gets the item (wins)
  But pays the amount of the 2nd highest bid.

William Vickrey
(1996 Nobel Prize in Economics)

Market-Clearing



Who should get the item?
At what price?

Buyers might not want to reveal their values.

Auctions to the rescue:

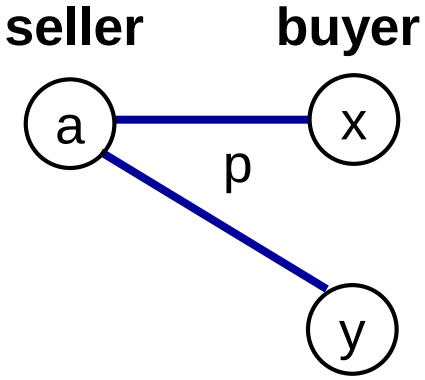
Dutch ~ 1st Price Auction

- buyers should not report truthfully
- complicated equilibrium bidding strategies

English ~ 2nd Price Auction
(a.k.a. Vickrey Auction)

- truthful report is a dominant (and simple) strategy

2nd Price Auction (Vickrey Auction)



- **Highest bid wins** (**efficient!**)

- **Pays the 2nd highest bid**

(this simplifies life for buyers because)
Bidding truthfully is dominant str. **(easy)**

- Truthful report is dominant strategy regardless of the information on rivals (number of rivals, their values).
- Simplicity is possible because the seller is committing to the market-clearing price that benefits buyers the most.
- Revenue implications for the seller?
  - Revenue equivalence in some settings, so no loss
  - Could be an issue in complex markets
  - Reserve prices (loss of efficiency)

Remember importance of efficiency.

Generalizing Vickrey

- Generalizes for multiple items, buyers valuing bundles.

  "Vickrey-Clarke-Groves (VCG) mechanism"

  efficient, truthful reporting dominant strategy

  However:

  - Unreasonable informational demand on buyers
  - Computationally hard (understatement)
  - Accentuated revenue deficiency

- Important (but incorrect) "generalization"

  Generalized Second Price Auction

Click-Through Rate (CTR)

- Webpage real estate:

  location, location, location!

- CTR: a measure of quality of the location

  #clicks / #pageviews

- Fixed ad slots:

  Top > … > Side Top > … > Side Bottom

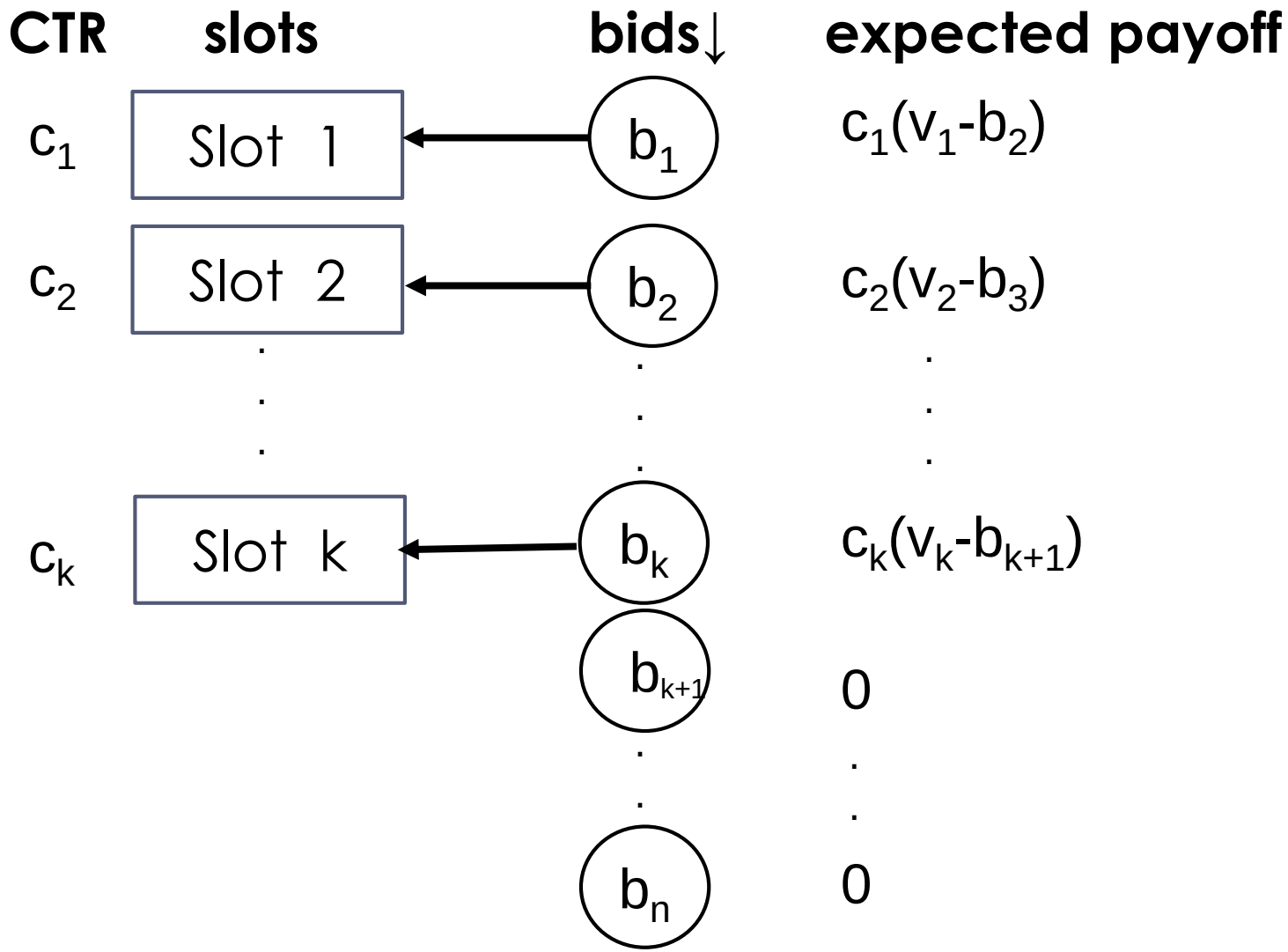
  CTR: c_T > … > c_{ST} > … > c_{SB}

- Advertiser value:

  v if click,

  0 if no click.

GSP Auction


CTR
slots
bids↓
expected payoff
c_1
Slot 1
b_1
$c_1(v_1-b_2)$
c_2
Slot 2
b_2
$c_2(v_2-b_3)$
c_k
Slot k
b_k
$c_k(v_k-b_{k+1})$
b_{k+1}
0
b_n
0

GSP Auction

- Highest bidder gets top ad slot,
  pays 2nd highest bid value (only if user clicks)
- 2nd highest bidder gets second ad slot,
  pays 3rd highest bid value (only if user clicks)

…

In practice, some additional enhancements:

- Bidder specific CTRs
- Bids adjusted for advertiser "quality": q*b
  (low quality bidders have to bid higher)
- Reserve prices
- Advertiser budgets
- Bidding on keyword combos, negative keywords, etc.

GSP Auction

- Highest bidder gets top ad slot,
  pays 2nd highest bid value (only if user clicks)
- 2nd highest bidder gets second ad slot,
  pays 3rd highest bid value (only if user clicks)

…

If only two slots: exactly 2nd Price (Vickrey) auction.

- Efficiency?

- Truthful reports?

Digital Ad Markets

- If valuations known: market-clearing prices

- If valuations private:
  - Vickrey computationally intractable
    - communications burden on bidders
    - non-transparent
  - GSP not truthful

- If buyers have budgets, or value bundles:
  - Hard market design problem

Emergence of multiple markets

heterogeneous advertiser valuation structures

fragmented supply (webpages with ad slots)

Digital ad markets

- **heterogeneity:** both on supply side and on demand side
- **large volume** (far from single item demand)

  ► points to market fragmentation

- **uncertainty, volatility**:

  future supply is hard to forecast and is exposed to frequent shocks

  heterogeneous demand adds complexity to modeling uncertainty

  non-standard models for uncertainty (relative to standardly used models in finance)

Some practical obstacles

- Heterogeneity of goods
- Heterogeneity of market participants' preferences
- Multiple demand (demand for bundles)
- "Incumbent" market-clearing practices
- Constraints due to outdated regulation and "customary" ways of conducting (similar) business.