An introduction to agent-based negotiation and auctions

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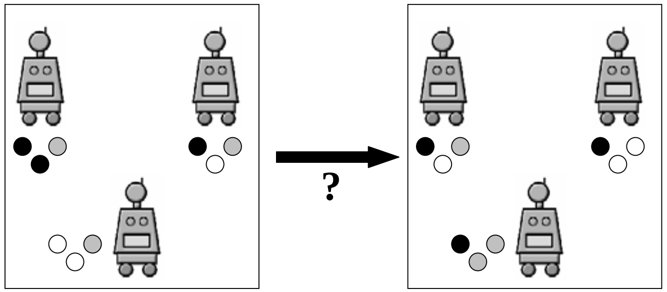
Outline

- Introduction to negotiation protocols
- Auctions
  - Basic terminology
  - Classification
  - Single-side auctions: English, Dutch, FPSB, Vickrey
  - Double auctions
  - Multi-attribute auctions
  - Combinatorial auctions
- Issues in auction design
- Auction platforms
  - AuctionBot, e-Game, Trading Agent Competition
  - Online auction systems

Negotiation



Negotiation

- Agents may have incompatible goals and resources to achieve these goals may be limited; in such cases competition and conflicts may arise
- The effects of the agents' antagonistic behaviour need to be limited
- Agents must be able to reach compromises, resolve conflicts, allocate goods and resources by way of an agreement

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Negotiation protocols

- Agents' interactions are governed by a set of rules: an interaction protocol
- A negotiation situation is characterized by three elements:
  - A negotiation set which represents the space of possible offers/proposals that the agents can make
  - The protocol which defines the rules that govern the agents' interactions
  - The set of strategies that the agents can use to participate in the negotiation process:
    - These are private
    - They are not dictated by the protocol itself
    - May take into account the other agents' strategies

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Protocols include the following types of rules:

- Admission rules
- Interaction rules
- Validity rules
- Outcome determination rules
- Withdrawal rules
- Termination rules
- Commitment rules

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Factors that determine the type of protocol to be used:

- Number of attributes: one, many
- Number of agents:
  - One-to-one
  - One-to-many
  - Many-to-many
- Number of units: one, many
- Interrelated goods: one good or a number of goods that are substitutable or interdependent

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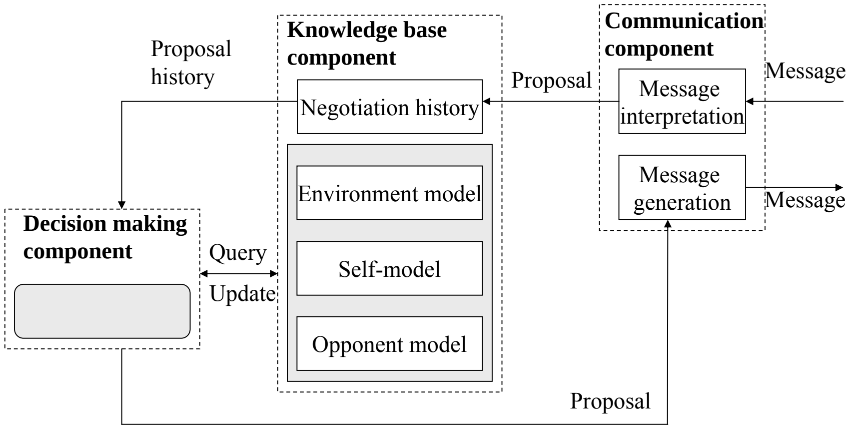
Desired properties for negotiation protocols

When designing protocols or mechanisms for strategic interaction, we are interested in those that enjoy certain properties:

- Social welfare
- Pareto efficiency
- Individual rationality
- Stability
- Budget balance
  - Strict
  - Weak
- Computational efficiency
- Distribution and communication efficiency

Abstract architecture for negotiating agents



Auctions

- A class of negotiation protocols which provides us with methods for allocating goods/resources based upon competition among self-interested parties

Where are auctions used?

- Telecommunication and TV licenses, government procurement, mining rights, emission permits, airport gates and takeoff/landing slots
- Extremely popular as a means for conducting consumer-to-consumer (C2C) negotiations online (eBay, yahoo)
- Collectibles (paintings, books, antiques)
- Agricultural produce (Flowers, Fish, …)

Why use an auction rather than some other mechanism?

- Markets may not exist for what the seller wants to sell (spectrum, oil drilling rights)
- The seller does not know how much an item is worth
- Create competition; enhances the seller's bargaining power
- Flexibility
- Less time consuming and expensive than negotiating a price
- Simplicity in determining market-based prices
- Efficiency and revenue: auctions can yield a more efficient outcome than other allocations schemes

The auctioneer:

- A seller (or the representative of one) who wants to sell goods at the highest possible price, or
- Someone who wants to subcontract out contracts at the lowest possible price, or
- A buyer who wants to buy a good

The bidders:

- Buyers who want to acquire goods at the lowest possible price, or
- Contractors who want to get a contract at the highest price, or
- Sellers who want to sell their goods

Agents are:

- Self-interested: they are seeking to maximise their own payoffs
- Rational: they always prefer a larger payoff than a smaller one.

Different attitudes towards risk:

- Risk-neutral: agents who bid conservatively and will never exceed their true valuations
- Risk-prone: agents who are likely to raise their bids so that they are more likely to win

Term	Meaning
Bid	Bids are offered by the bidders to buy or sell the auctioned item.
Buy bid	The price that a bidder is willing to pay to own an item.
Sell bid	The price a bidder is willing to accept to sell an item.
Reservation price	The maximum (minimum) price a buyer (seller) is willing to pay (accept) for an item. This is usually private information.
Process bid	The auctioneer checks the validity of a bid according to the rules of the auction protocol and updates its database (manual or electronic).
Price quote generation	The auction house via the auctioneer or by other means may provide information about the status of the bids.
Bid quote	The amount a seller would have to offer to sell an item.
Ask quote	The amount a buyer would have to offer to buy an item.
Clearance	Through clearance buyers and sellers are matched and the transaction price is set.
Clearing price	The final transaction price that the buyer pays and the seller receives.

Typical auction process

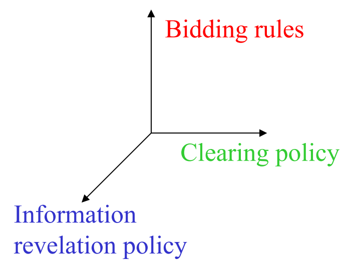
- Buyers and sellers register with the auction house
- The auction event is set up
- The auction is scheduled and advertised (local press, internet etc.)
- The actual bidding phase takes place according to the rules of the auction
- Information may be revealed to participants to some extent during the bidding phase (ask and bid quotes)
- The bids are evaluated and the auction closes with a winner being determined if any of the bids are successful
- The transaction phase takes place: the buyer pays for the goods and the seller ships/delivers them

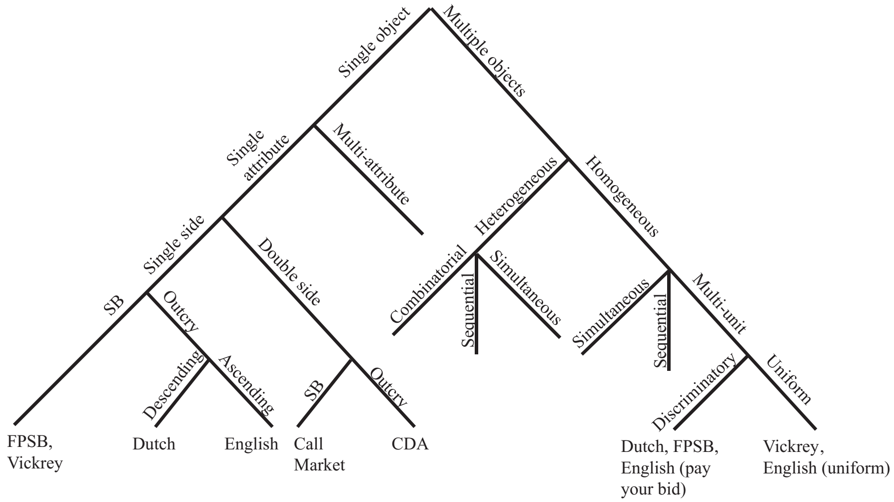
Classification of auctions

Auctions can be characterised along three dimensions:

(1) Bidding rules:

- Single good or combinatorial
- Single attribute or multi-attribute
- Single or double
- Open (outcry) or sealed-bid
- Ascending or descending
- Single unit or multi-unit





(2) Information revelation policy:

- When to reveal information: on each bid, at predetermined points in time, on inactivity, on market clears
- What information
  - Bid: the price a seller would have to offer in order to trade
  - Ask: the price a buyer would have to offer in order to trade
  - Auction closure: known, unknown, after a period of inactivity
- To whom: participants only, everyone

(3) Clearing policy

- When to clear: on each bid, on closure, periodically, after a period of inactivity
- Who gets what (allocation and winner determination problem)
- At what prices: first, second price or other; uniform or discriminatory

Classification: According to the bidders' evaluation of the good

- *Private value*: the value of the good depends only on the bidders' own preferences.
- *Common value*: a bidder's value of an item depends entirely on the others' value of it. Bidders have different private information about what the true value is
- *Correlated value*: a bidder's value depends partly on his/her own preferences and partly on what s/he thinks the others' valuations are

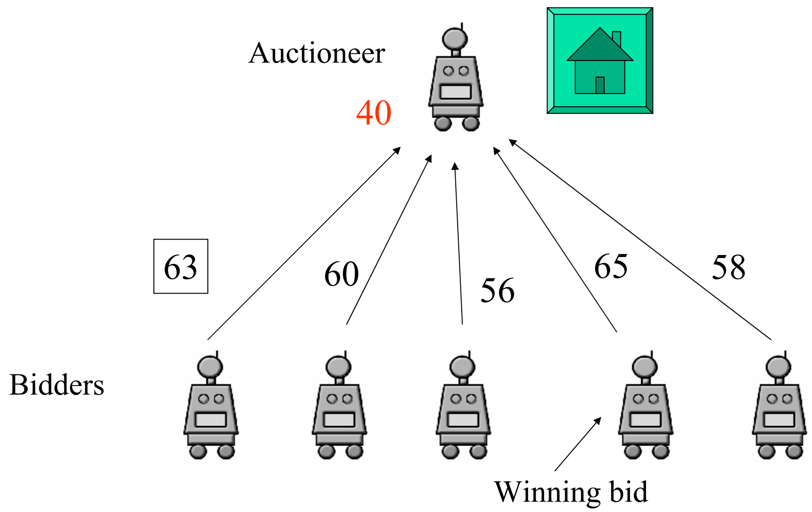
Basic auction formats

Basic formats:

- Single sided
  - English
  - Dutch
  - FPSB
  - Vickrey
- Multi-unit versions
- Double
- Multi-attribute
- Combinatorial
- Reverse

English auction

- Open-outcry and ascending-price auction
- The auctioneer announces an opening or the reserve price
- Bidders raise their bids and the auction proceeds to successively higher bids
- The winner of the auction is the bidder of the highest bid
- The best strategy (dominant) is to bid a small amount above the previous high bid until one reaches its private value and then stop
- The bidders gain information by observing the others' bids
- A bidder may exit the auction with/without a re-entering option



Disadvantages

- The reserve price may not be met and the item may remain unsold
- The auctioneer may cheat by overstating a reserve price or present a reserve price that does not exist
- Susceptible to rings (collusions)
- In real life it can become complicated (voices, signals)
- Bidders can become carried away and overbid
- The seller may not receive the maximum value for an item
- Vulnerable to *shills*
- *Phantom bidders*

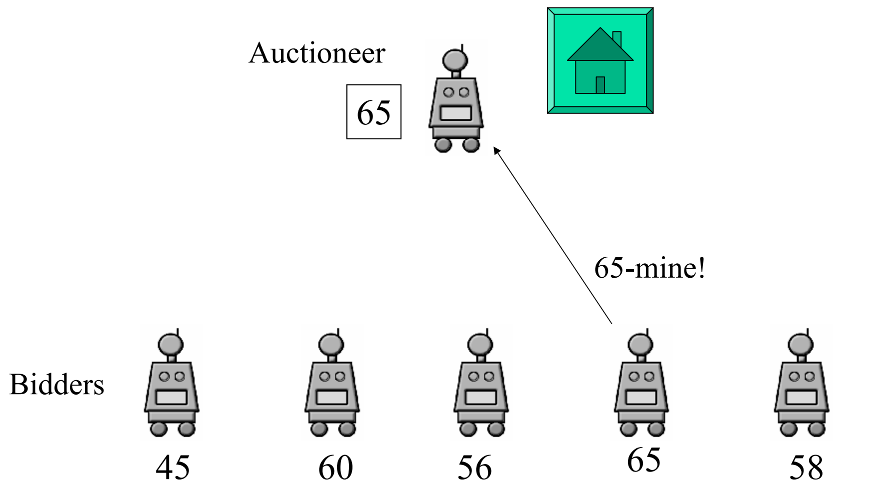
Multi-unit English auctions

Multi-unit English auctions are not straightforward:

- Different pricing policies:
  - Using the Mth price (uniform pricing)
  - Pay your bid (discriminatory)
- Different tie-breaking rules
  - Price
  - Quantity

Dutch auction

- Open and descending-price auction
- The auctioneer announces a very high opening bid
- Then the auctioneer keeps lowering the price until a bidder accepts it – the winner pays the price of their bid
- Bidders need to decide in advance the maximum amount that they are willing to bid
- A bidder must decide when to stop the auction (bid) based upon their own valuation of the commodity and their prior beliefs about the valuations of the other bidders
- No relevant information on the valuation of the other bidders is disclosed during the process of the auction until it is too late



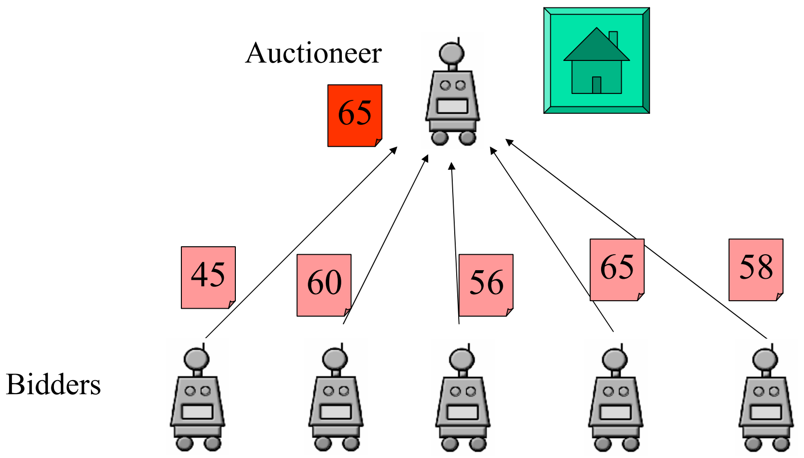
- Very efficient in real time: used in The Netherlands for selling fresh flowers, Ontario tobacco auction, fresh produce auctions
- The effect of competition on the buyers is stronger in the Dutch auction than the English
- The Dutch multi-unit auction is discriminatory

First-price sealed-bid auction

- Each bidder submits their own bid (usually in writing) without knowledge of the bids of others
- Two phases:

  (i) the **bidding phase** in which participants submit their bids

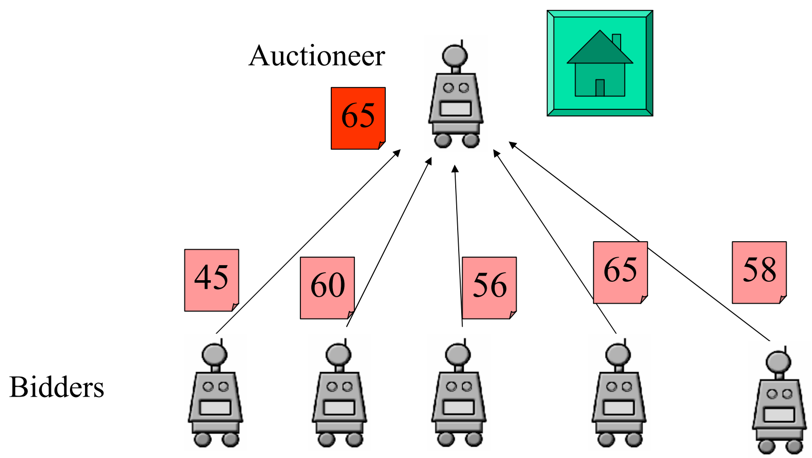
  (ii) the **resolution phase** in which the bids are opened and the winner is determined
- The highest bidder wins and pays the amount of their bid



- An agent's strategy depends on its own valuation and prior beliefs about the other bidders' valuations
- No dominant strategy: a higher bid raises the probability of winning, but lowers the bidder's profit if they win
- Bidders are better off not bidding their true valuations but a small amount below it
- In a multi-unit auction sealed bids are sorted from high to low, and the items awarded at highest bid price until the supply is exhausted, i.e. FPSB is a discriminatory auction

Vickrey auction

- A second-price sealed-bid auction, also known as uniform second-price sealed-bid or the philatelist auction
- Two distinct phases: the **bidding phase** and the **resolution phase**
- The highest bid wins but the bidder pays the amount of the **second-highest** bid



But, the bidder has to pay 60!

Why does it work?

- Although it seems that the auctioneer would make more money out of a first-price sealed auction this is not the case
- Bidders adjust their bids upwards since they are not deterred by fear that they will have to pay too much
- Even aggressive bidders pay a price closer to the market consensus
- The price that the winning bidder pays depends on the others' bids alone and not on any action that the bidder undertakes

- The best strategy (dominant) is for the agent to bid its true valuation
- Truth-telling in the Vickrey auction ensures that:
  - globally efficient decisions are being made
  - the bidders do not waste time in counter-speculating what the other bidders will do
- In multi-unit Vickrey auctions all bidders pay the same price, the highest losing price: (M+1)st price if there are M units available

A bidder has a dominant strategy to bid an amount equal to their valuation, that is: $b_i = v_i$

Proof

- Consider bidding $v - x$ if your true value is v
- Suppose the highest bid other than yours is w
- If $v - x > w$ you win the auction and pay w, just as if you bid v
- If $w > v$ you lose the auction and get nothing, just as if you bid v
- But if $v > w > v - x$ bidding $v - x$ causes you to lose the auction, whereas if you had bid **v**, you would have won the auction and paid w for a net surplus of $v - w$
- Hence you can only loose, and never gain, by bidding $v - x$
- What if you consider bidding $v + x$ and the highest bid other than yours is w?

Allocation and revenue comparisons

- An auction is **incentive compatible** if the agents optimize their expected utilities by bidding their true valuations for the good, i.e. truth-telling is a dominant strategy for the agents
- An auction is **individual rational** if its allocation does not make any agent worse off than had the agent not participated
- An allocation of goods is **efficient** if there can be no more gains from trade
- No mechanism is individual rational, efficient and incentive compatible for both sellers and buyers
- Incentive compatibility for both parties means that some party is willing to subsidise the auction

Example: Maria is selling her house using an auction protocol

Assume only one bidder

- Both have quasilinear utility functions (i.e. of the form $u_i(o)=v_i(g)+p_i$)
- Each party knows his/her valuation, but not the other's valuation
- Probability distributions of valuations are common knowledge

We would like an auction mechanism that is:

- Budget balanced: Maria gets what bidder pays
- Pareto efficient: House changes hands if and only if $v_{buyer} > v_{seller}$
- Individually rational: Both Maria and the bidder get higher expected utility by participating than by not

- Theorem. No such auction mechanism exists [Myerson-Satterthwaite]

Strategic equivalence of Dutch and FPSB

- The 'strategy space' is the same in the Dutch and FPSB auctions, hence they are strategically equivalent
- The payoff functions and hence the equilibrium outcomes are the same
- What are the equilibrium strategies in the Dutch and FPSB auctions?
  - If there are $N>=2$ bidders, and each bidders' value is seen as uniformly distributed, the Bayesian-Nash equilibrium is for a bidder to bid: $b(v_i)=v_i(N-1)/N$
  - The term $(N-1)/N$ shows how much the bidder 'shades' his bid below his true valuation

Equivalence of English and Vickrey auctions

- A **truth-revealing** strategy where one always bids one's own valuation is a **dominant strategy**
- Although the format is different, bidders have the dominant strategy to bid an amount equal to their own true valuation in the English and Vickrey auctions
- Therefore, the two auctions are not strategically equivalent, they are equivalent
- Important: unlike in the Vickrey auction, in an English auction bidders can respond to rival's bids

Comparisons: Private value auctions

If agents are risk-neutral

- Dutch strategically equivalent to FPSB
- Vickrey and English are equivalent
- All four protocols allocate items efficiently
- English & Vickrey have dominant strategies => no effort is wasted in counter-speculation and opponent modelling
- Which of the four auction mechanisms gives highest expected revenue to the seller?

  Revenue equivalence theorem: Assuming valuations are drawn independently & agents are risk-neutral: the four mechanisms yield the same revenue on average!

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If agents are risk-prone:

- Risk-prone bidders: the Dutch and the FPSB yield higher revenue than the English and the Vickrey
- Risk-prone auctioneer: the English and the Vickrey yield higher revenue than the Dutch and the FPSB

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Comparisons: Non-private value auctions

- The Dutch is strategically equivalent to the FPSB auction
- The Vickrey is not equivalent to the English auction
- All four protocols allocate items efficiently
- Theorem (revenue non-equivalence): With more than 2 bidders, the expected revenues are not the same: English $\geq$ Vickrey $\geq$ Dutch = FPSB

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Which auction is better?

- Auctions with dominant strategies (e.g. English,Vickrey) are more efficient
- FPSB & Dutch may not reveal truthful valuations:
  - Lying
  - No dominant strategy
  - Bidding decisions depend on beliefs about others
- From the auctioneer's perspective, in second-price auctions the revenue is less than the true price, however in first-price auctions the bidders tend to underbid

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Advantages/disadvantages of auctions

- **Advantages**
  - Flexibility, as protocols can be tailor-made
  - Less time-consuming and expensive than negotiating a price
  - Simplicity in determining the market prices
- **Disadvantages**
  - Collusion
  - Winner's curse
  - Lying auctioneer
  - Sniping

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Collusion

Collusion among bidders (rings, cartels)

- What if bidders collude and form an auction ring?
- For rings to be successful, agreement has to be self-enforcing

First-Price Sealed-Bid and Dutch auctions:

- The designated "winner" is recommended to place a bid equal to the seller's minimum price
- All other ring members are asked to refrain from bidding
- However, each of those asked to abstain can gain by placing a slightly higher bid in violation of the ring agreement
- Therefore agreement is not self-enforcing

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In the English and second-price sealed-bid auctions:

- Designated "winner" is recommended to bid his own valuation and everyone else to refrain from bidding or bid lower
- No-one can gain from breaching the agreement, because no one will ever exceed the designated bidder's limit, i.e. self-enforcing

Example: Assume two bidders A and B, with v_A=100, v_B=50 and the agreement that A will bid and the item for 40

- In an English auction, A can observe every other bidders' bids, if B decides to bid more than the agreed 40, A can observe this and adjust his bid
- In a Vickrey auction, A will submit his true valuation (100) while B has to submit 40. If B exceeds the agreed price 40, he has nothing to gain from it.

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Winner's curse

- What bidders suffer when they win an auction by overestimating how much something is worth and therefore bidding too much
- More severe in common and correlated value auctions as one's valuation depends on the others'
- A win may actually mean a loss …

Four firms are bidding on the drilling rights to a piece of land

- Suppose there is \$10M worth of oil in the ground
- Firms get their estimates as follow: Firm A: \$5M, Firm B: \$10M, Firm C: \$12M and Firm D: \$15M

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What to do in the face of the winner's curse:

- Anticipate the effects of the winner's curse before bidding:
  - Assume that you have the highest estimate
  - When incorrect, the assumption costs nothing
  - Rational bidding: correct downwards or discount your own bid
- Any piece of information is useful to the bidder
  - How aggressively others bid
  - How many remain in the bidding
  - When others apparently drop off the bidding

Lying auctioneer

- Overstate reserve price or state non-existent reserve price
- Use of shills that constantly raise the bids – especially a problem in English auctions
- “Phantom” bidders
- In the Vickrey auction the auctioneer may overstate the second highest bid to the winner in order to increase revenue
- Bid verification mechanisms, e.g. cryptographic signatures
- Trusted third party auction servers (reveal the 2nd highest bid to the bidder in the Vickrey auction after closing)

Sniping

Sniping: bidding very late in the auction in the hope that other bidders do not have time to respond and you can snatch a bargain.

Bidders may bid late in order to avoid:

- increasing the price of the item early on in the auction
- revealing their preferences early in the auction (especially experts)
- bidding wars with other like-minded agents

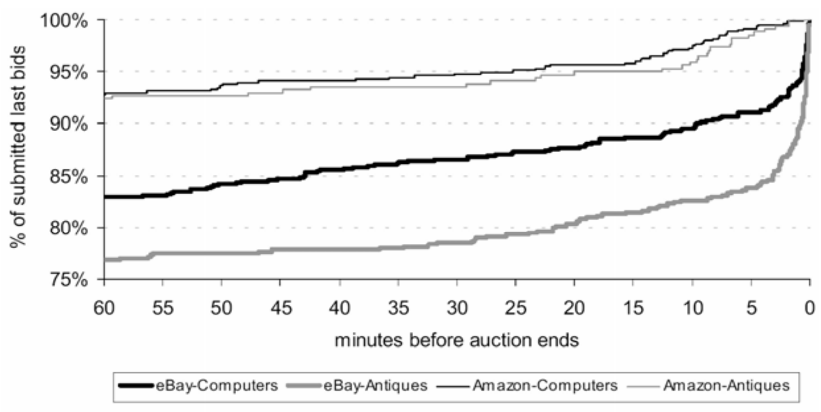


Figure 1a–Cumulative distributions over time of bidders’ last bids

[from Roth & Ockenfels]

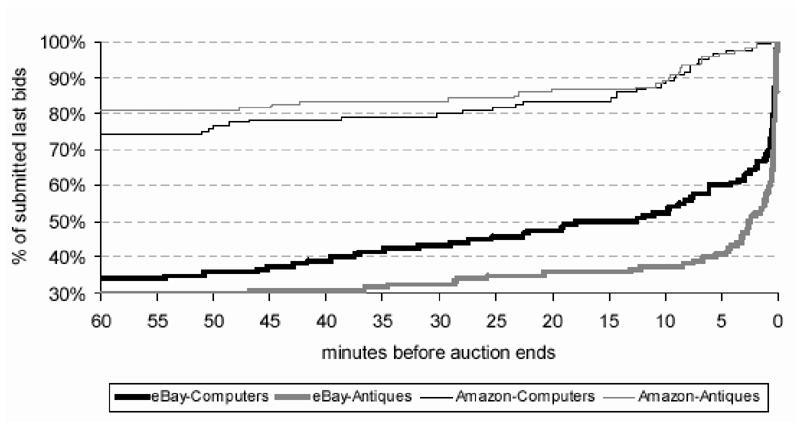


Figure 1b–Cumulative distributions over time of auctions’ last bids

[from Roth & Ockenfels]

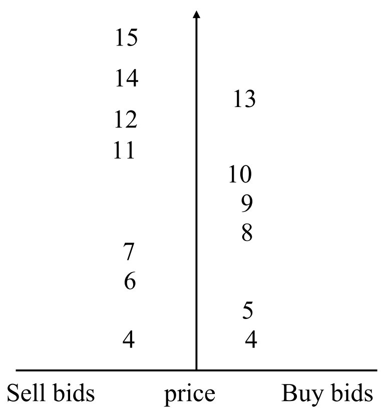
Double auctions

- Two-sided or double auctions: multiple sellers and buyers
- The sellers' and buyers' bids are ranked highest to lowest to generate demand and supply profiles
- From the profiles the maximum quantity exchanged can be determined by matching selling offers with demand bids
- The transaction price is set and the market clears

Two issues:

- How is the clearing price set?
- How are the winners determined?

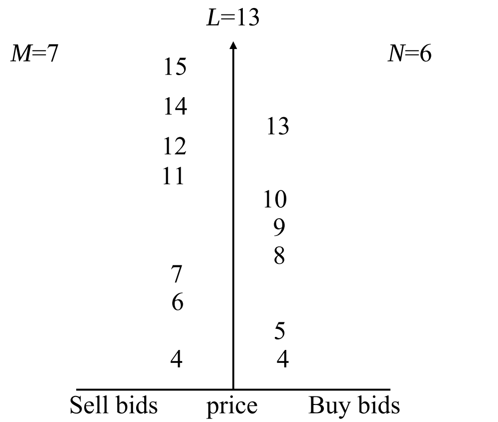
- Continuous double auctions: buyers and sellers are matched immediately on detection of compatible bids
- Periodic double auctions: also known as call market or clearing house, bids are collected over specified intervals of time and then the market clears at the expiration of the bidding interval



Mth and (M+1)st price rules

- Consider a set of single unit bids L. M of these bids are sell offers and the remaining N=L-M are buy offers
  - The Mth price rule sets the clearing price at the Mth highest price among all L bids
  - The (M+1)st price rule sets the clearing price at the (M+1)st highest price among all L bids
- The Mth and (M+1)st clearing price rules determine the price range
- The Mth price is undefined if there are no sellers
- The (M+1)st price is undefined if there are no buyers

- Selection of successive bids
  - While the highest remaining buy bid is greater than or equal to the lowest sell bid, remove these from the set of outstanding bids (breaking the ties arbitrarily) and add them to the set of matched bids
- The price quote reveals information to the agents as to whether their bids would be in the transaction set
  - Bid quote: the price that a seller must offer in order to trade, that is the (M+1)st price
  - Ask quote: the price that the buyer must offer in order to trade, that is the Mth price



L={15, 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, 4}

Mth ↑ ↑ (M+1)st

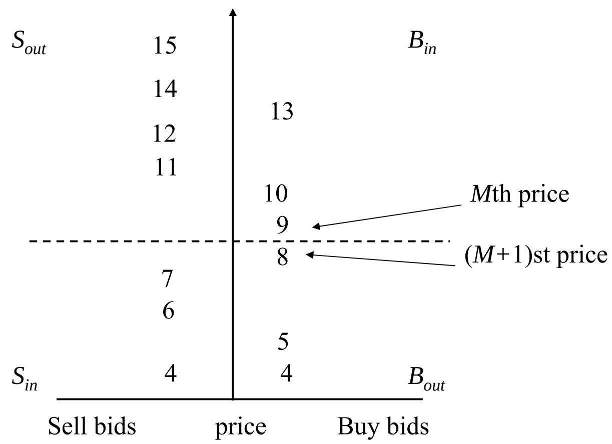
- The organisation of the bids is based upon four shorted lists*
- Bids are distinguished by whether they represent sell or buy bids and whether or not they are in the current transaction set
- B_{in}: All the buy bids that are in the current match set, the lowest price is the head of the list
- B_{out}: All the buy bids that are not in the current match set, the highest price is the head of the list
- S_{in}: All the sell bids that are in the current match set, the highest price is the head of the list
- S_{out}: All the sell bids that are not in the current match set, the lowest price is the head of the list

*In the AuctionBot system four heaps were used instead

- Mth and (M+1)st price rules are generic rules that can be applied in single-sided auctions (and multi-unit auctions) as well
- English auction: the Mth price is the highest bid submitted which determines the winner. The auctioneer either submits a reservation price or a bid of 0, i.e. is willing to sell for whatever is the highest price
- Dutch auction: the auctioneer can be thought of as withdrawing the current bid and resubmitting a new bid every time that he reduces the price. When a buyer bids, the Mth price is the price of the bid which equals that of the auctioneer
- FPSB: Works in exactly the same way as the English
- Vickrey: The winning bid is the Mth price, but the clearing price is the (M+1)st, i.e. the second highest bid

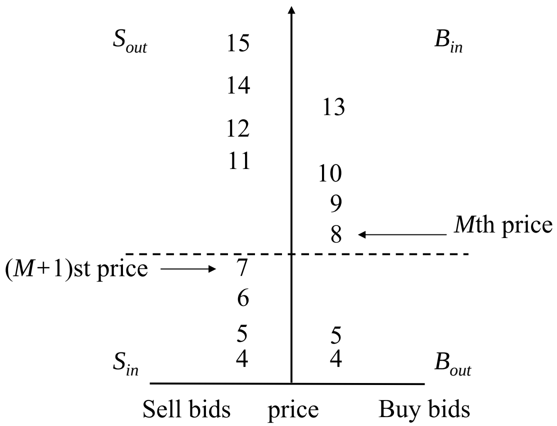
Constraints

- The number of bids in B_{in} must equal the number of bids in S_{in}
- If b_{in}, b_{out}, s_{in} and s_{out} are the heads of each list:
  - Value(b_{in})≥Value(b_{out})
  - Value(s_{out})≥Value(s_{in})
  - Value(s_{out})≥Value(b_{out})
  - Value(b_{in})≥Value(s_{in})
- The Mth price is min(Value(s_{out}),Value(b_{in}))
- The (M+1)st price is max(Value(s_{in}),Value(b_{out}))
- A price quote is generated by just looking at the heads of the lists
  - bid quote: (M+1)st price
  - ask quote: Mth price



Bid insertion

Insert the sell bid 5



The algorithm for the insertion of a new bid needs to consider three distinct cases:

- The transaction set changes: the new s_{new} bid is in S_{in} list, but another bid in the S_{in} list needs to be transferred to the B_{in} list as well, as S_{in}=B_{in} is a constraint
- The transaction set changes in that the new s_{new} bid replaces one of the bids in the S_{in} list which now needs to be moved to the S_{out} list
- The transaction set does not change, the new s_{new} bid is not in the transaction set and is simply placed in the S_{out} list

Similarly for the insertion of a new buy bid b_{new}

Sell bid insertion:

If ((Value(s_{new}) ≤Value(b_{out})) and (Value(s_{in})≤Value(b_{out}))

put(s_{new},S_{in})

b←get(B_{out})

put(b,B_{in})

else if (Value(s_{new})<Value(s_{in}))

s←get(S_{in})

put(s,S_{out})

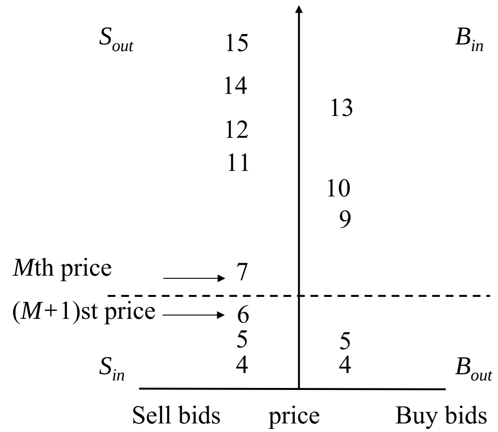
put(s_{new},S_{in})

else

put(s_{new},S_{out})

Bid removal

Remove buy bid 8



- The bid is located in one of the lists
- If the the bid is in one of the *out* lists it is simply removed
- If it is in S_{in} or B_{in} then the top bid from the other *in* list is transferred to the corresponding *out* list

Buy bid removal:

If ((Value(b_{old}) ≥Value(b_{in}))

get(b_{old})

s←get(S_{in})

put(s,S_{out})

else

get(b_{old})

Multi-attribute auctions

- Often buyers and sellers are interested in other attributes rather than price alone
- Example: suppose you are interested in buying a car. The attributes that you are interested in may include price, and other extras such as warranty, free insurance, CD player, etc.
- Multi-attribute or multi-dimensional auctions allow bidders to submit bids on more than one attributes or dimensions of a good
- Very common in procurement situations
- The attributes under negotiation are usually defined in advance and bidders can compete in open-cry or sealed-bid auctions

Example: a procurement (reverse) auction

- Consider a manufacturer which uses raw materials A, B, C, D and E from a number of suppliers to produce finished goods
- Assume the manufacturer requires 1000 units of A by 30/09/05
- The manufacturer sends Request For Quotes (RFQ) to all potential suppliers of A
- Suppliers reply with a bid b_i<*quantity, delivery_date, price*>
- The *delivery_date* and the *quantity* may deviate from those requested by the manufacturer.
- The *price* offered by the various suppliers will differ too.
- The manufacturer's request could be covered by one or more bids in combination (*sole* or *multiple sourcing*)

When designing such auctions, *winner determination* is crucial:

- Preference elicitation through an appropriate scoring function
  - A multi-attribute offer received has the form

  $v_i=(v_{i1},\ldots,v_{ij})$ where v_{ij} is the level of attribute j offered by i
  - Each bid is evaluated through a scoring function $S(v_i)$ which is an additive scoring function
  - Problem: determine appropriate scoring functions and weights
  - Attributes may be interdependent: an additive scoring function does not suffice => could use multi-linear expression
  - The scoring function if revealed, serves as a guideline to the bidder
  - The winning bid is the one with the highest score
  - Single sourcing or multiple sourcing => commitments

- Multi-attribute auctions have been envisioned to extend the scope of auctions beyond the dimension of price
- They allow more degrees of freedom for bidders: price may not be the only attribute of interest
- More abstract attributes such as reputation can also be taken into account
- More efficient information exchange between the market participants
- Currently the subject of extended research and experimentation

Combinatorial auctions

- Auctioning multiple *distinguishable* items when bidders have preferences over combinations of items: *complementarity & substitutability*
- Goods may be worth to individuals in combinations
- Applications
  - Allocation of transportation tasks, bandwidth
  - Manufacturing procurement
  - Electricity markets
  - Retail e-commerce: collectibles, booking a holiday, or city break
- Example: auctioning a dining set consisting of a table and 12 chairs
  - What's the best way to sell it? As a complete set? Each item separately? Allow combinations, i.e. the table and four chairs?

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- Sequential auctions: run individual auctions one after the other
  - Impossible to determine best strategy because game tree is huge
  - Inefficiencies can result from future uncertainties
- Parallel auctions: run individual auctions in parallel
  - Inefficiencies can still result from future uncertainties
  - Difficult to keep track of several simultaneous auctions with substitutable and interdependent goods (at least for human agents)
- Combinatorial or combinational auctions: bids can be submitted on combinations (bundles) of items
- Example: the dinning set
  - Bundle1: four chairs and the table
  - Bundle2: six chairs and the table
  - Bundle3: all twelve chairs, etc.

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- Bidder's perspective
  - Avoids the need for lookahead
- Auctioneer's perspective:
  - Optimal bundling of items
  - Winner determination problem: Decide on the winning bids so as to maximize the sum of bid prices (i.e. revenue)

Issues:

- Should the combinations of items on which bids are allowed be restricted? If so to what?
- Single shot or iterative combinatorial auctions?
- In an iterative auction what information should be made available to bidders from round to round?
- What is the objective of the auctioneer? To maximise revenue from the auction, or economic efficiency?

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- Iterative auctions have certain advantages
  - The bidders do not have to specify their bids for every possible combination in advance
  - They are suited for dynamic environments where bidders and goods arrive and depart at different times
  - Appropriate feedback mechanisms allow for information to be revealed to the bidders, thus making the market more efficient
- Iterative combinatorial auctions: Quantity and Price setting

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Quantity setting:

- Bidders submit their prices on various bundles on each round
- The auctioneer makes a provisional allocation based on prices
- Bidders are allowed to readjust their offer prices from the previous round and the auction continues
- Hard to analyse as they offer more freedom to the bidders

Price setting:

- The auctioneer sets the price and the bidders announce which bundles they want at the posted prices
- Auctioneer receives requests and adjusts the prices
- Price adjustment is driven by the need to balance supply and demand
- Easier to analyse as bidders are restricted to announcing which bundles meet their needs at the posted prices

Problems:

The complexity of communicating bids:

- Bidders could potentially be interested in every possible combination, although rare in practice
- How to communicate this list of bids so that it can be of use to the auctioneer
- Bid expression language may be required

Winner determination problem or CAP:

- Identify which collection of bids to accept to maximise some criterion
- Problem can be usually expressed in terms of an integer program

Incentive implications of the above two decisions:

- Need to provide incentives to the bidders to reveal true preferences, so that we have socially desirable outcomes – efficient allocations

- Combinatorial auctions are the focus of intense research, but currently rare in practice
- Problems with efficient and computationally tractable mechanism design for such auctions
- But also, such auctions are cognitively complex and therefore difficult to comprehend by participants

Issues in auction design

- Mechanism design: the development of protocols that are stable and individually rational for the agents
- Problem: how privately known preferences of a set of self-interested agents can be aggregated towards a social choice => efficient outcomes
- Choice of a good auction protocol depends on the setting in which the protocol will be used

Issues:

Collusion

- Participants may explicitly/implicitly collude to keep prices artificially low
- What if bidders collude and form an auction ring?
- Repeated auctions => collusion may consist of explicit agreements or implicit understandings about which bidder is allowed to win any particular auction
- But agreement among ring has to be self-enforcing

Entry deterring and predator behaviour

- Auction needs to attract bidders, since an auction with too few bidders risks being unprofitable for the auctioneer and potentially inefficient
- Aggressive bidders may drive weaker bidders out

Reserve prices

- Failure to set a proper reserve price – minimum amount the winner is required to pay
- Inadequate reserves may encourage collusion
- A stronger bidder in an English auction can either implicitly collude to end the auction at a low price, or force the price up to drive out weaker bidders
- The lower the reserve price at which the auction can be concluded, the more attractive collusion is

Political problems

- Serious reserve prices are often opposed by government officials for whom the worst outcome is that the reserve price is not met – object is not sold – auction is seen as a "failure"
- "Inside" information

Credibility of rules

- Committing to future behaviour is a particular problem to firms – it may be difficult to auction a license if the regulatory regime may change – but binding future governments to a particular regulatory regime is almost impossible
- Credibility of reserve prices

Dilemma: English (Vickrey) or sealed-bid (Dutch) auction?

- Ascending auction allows for collusion, entry deterrence, and predation, but is likely to achieve an efficient outcome
- Sealed-bid auction may prevent collusion, allows entry of weaker bidders, but leaves probability of inefficient outcome

Solution: **C**ombine the two – "Anglo-Dutch" auction

- Auctioneer first runs an English auction in which the price is raised continuously until all but two (or *n*) bidders have dropped out
- The remaining bidders are then required to make a final sealed-bid offer that is no lower than the current asking price, and the winner pays the bid

Advantages of Anglo-Dutch auction:

- The first stage of the auction (English) means less loss of efficiency than might result from pure sealed-bid auction
- Sealed-bid at the final stage induces some uncertainty about which of the finalists will win, and entrants are attracted by the chance to make it to the final

Other issues in auction design

- Communication and computational efficiency in some auction formats
- Advanced auction formats may be cognitively complex and difficult to understand by participants
- Need to provide incentives for bidders to reveal true preferences

Objections to auctions

Price Effects

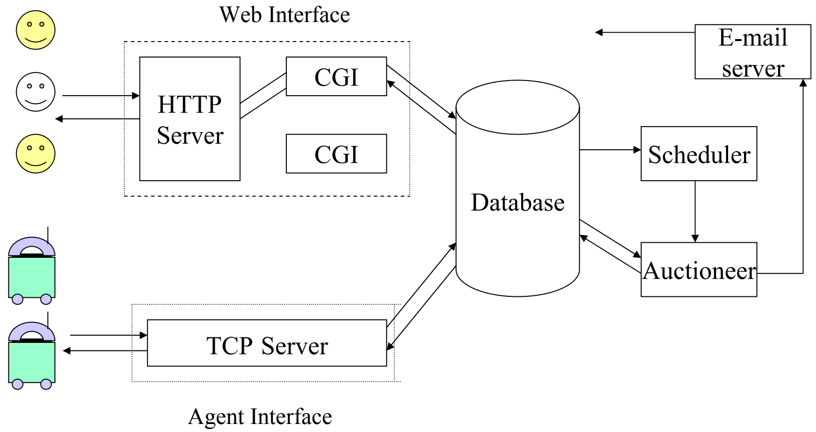
- Most common fear: a firm's cost in an auction will be passed on to consumers in the form of higher prices. May be the case if firms bid royalties, but not if firms bid for once-and-for-all lump-sum payments:
  - Firms will charge the prices that maximise their profits, independently of what auction fees they incurred at the time of auction => sunk costs
  - Firms would be irrational to lower their price below what the market is able to bear
  - However, firms may convince regulators into believing that an auction is a reason for allowing artificially high prices

Investment effects

- Large auction fees may slow investment because of capital-market constraints? Theoretically possible => a firm's cash flow can be significantly affected by upfront payments
- Practically unlikely that many profitable investments are being foregone because of difficulty raising funding for them. For instance, within one year, at least four of the five winners of the UK 3G licenses had arranged the necessary funding for their new networks
- In general =>auctions treat firms fairly and transparently, and yield greatest possible benefits for consumers and taxpayers

AuctionBot

- Flexible, scalable, robust auction server implemented at the University of Michigan, USA



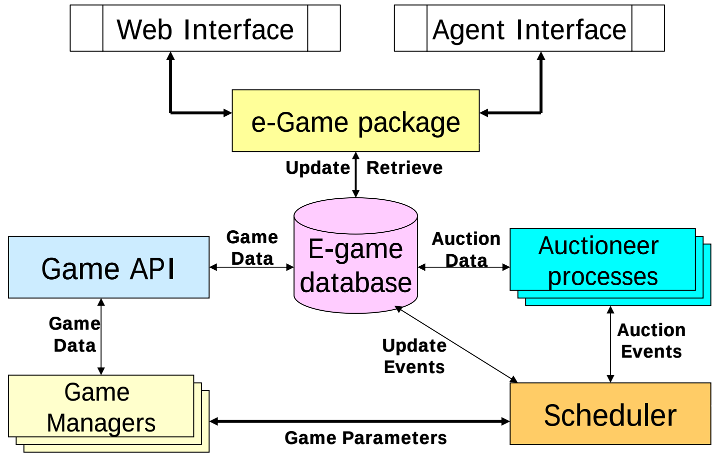
- Web interface: interface for humans via web forms
- TCP/IP interface: interface for software agents
- Database: stores bids
- Scheduler: a daemon process that continually monitors the database for auctions that have events to process or bids to verify
- Auctioneer: it loads the auction parameters and the set of current bids from the database. It validates bids as necessary and may do one clear and/or one price quote each time it is run
- Bidding Restrictions
  - Participation: {1:many}, {many:1}, {many,many}
  - Discrete goods, non-integer quantities are rejected
  - Bid rules: an agent's new bid must dominate its previous bid, thus withdrawal is not allowed

- Information revelation
  - Price Quote, consists of
    - bid quote: the price a seller-agent must offer in order to trade
    - ask quote: the price that a buyer-agent must offer in order to trade
- Transaction history, auctions may publicise information about past transaction
- Schedule information, auctions may or may not reveal the timing of clear and/or quote events

- Mth and (M+1)st price rules are implemented by maintaining a sorted list of bids: 4-heap algorithm

e-Game: electronic Generic Auction MarketplacE

- A configurable online auction server
- Main features:
  - Can be accessed both by human and artificial agents
  - Supports a range of auction protocols that can be parameterised
  - More auctions and other negotiation protocols can be developed
  - Supports the development of market scenarios by third parties



- When designing a new game, the developer should have in mind the following key points:
  - Realism
  - Efficient use of e-Game
  - Fairness with regards to specification
  - Fairness with regards to agent design
  - Computational efficiency
- A game involves the following phases:
  - Set up
  - Generation of parameters
  - Execution
  - Score calculation
  - Close down

- Game development is done in Java
- Developers cannot call directly methods from the other components of the platform or the database
- Game development is facilitated through extending the *GenericGame* class. The methods provided can:
  - Schedule auctions, retrieve information for auctions, submit bids (Dutch)
  - Retrieve ids of participant agents
  - Associate parameters and score with an agent
- A developer can also provide
  - A sample agent
  - An applet that can be loaded at runtime, so users can monitor the progress of a game

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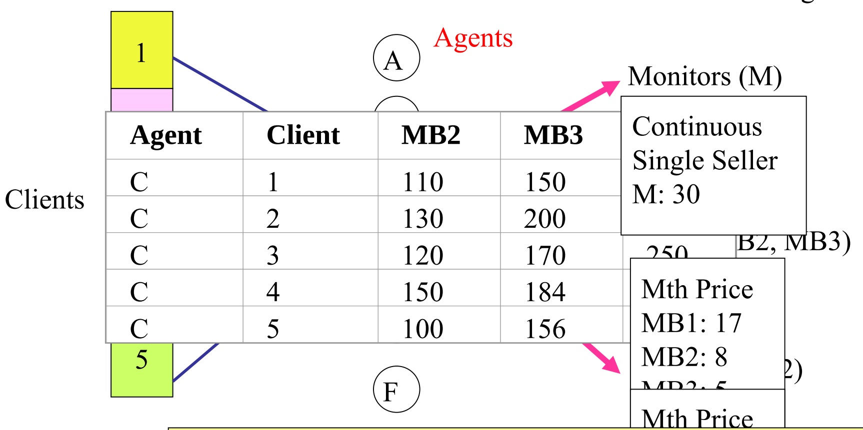
The CMG game



Agent	Client	MB2	MB3
C	1	110	150
C	2	130	200
C	3	120	170
C	4	150	184
C	5	100	156

$$CU_i = 1000 + \text{Motherboard Bonus} + \text{Case Bonus}$$

$$AU = (CU_1+CU_2+CU_3+CU_4+CU_5) - \text{Expenses-Penalties}$$

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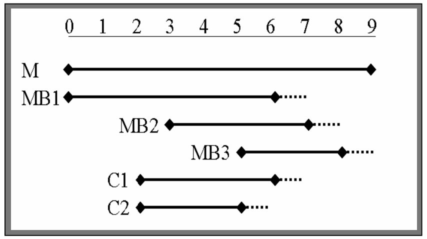
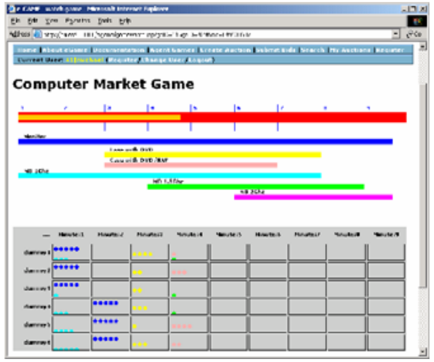
Auction scheduling in CMG



The CMG Applet showing game progression, and acquired goods for each player



http://csres43:8080/egame/index.jsp

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Trading Agent Competition

- A non-profit organisation that aims to promote research in market mechanisms and trading agents
- The effort was started in 2000
- Three benchmark problems have been created as testbeds to test one's approaches and strategies:
  - The Travel Agent game (Classic) – no more in use
  - The Supply Chain Management game (SCM)
  - The Market Game (CAT)

http://www.sics.se/tac/page.php?id=1

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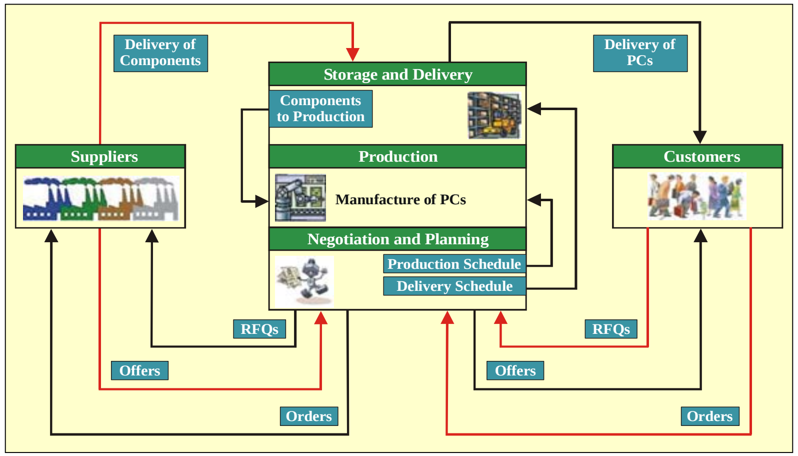
TAC: SCM

Dynamic Supply Chain Management (since 2003)



- Six agents play in the game and start with no orders from customers, no inventory, 0 bank balance
- Agents do not know who they are playing against, i.e. no information is revealed about the identity of the other players
- Objective: maximise profit through assembling PCs from different types of components and selling them at a profit to customers. Highest bank balance wins!
- 16 different types of PCs can be manufactured from 10 components which can be purchased from suppliers:
  - CPUs: Pintel and IMD; each available in 2.0 and 5.0 GHz varieties
  - Motherboards: Pintel and IMD
  - Memories: 1 GB and 2 GB
  - Hard disks: 300 GB and 500 GB
- Factory capacity is limited

An agent needs to perform the following tasks every day (D):

- Negotiate supply contracts with suppliers (3 steps):
  - Send RFQs to suppliers (limited to 5 per product per day)
  - Receive offers on the RFQs send on day D-1
  - Decide which offers to accept from the suppliers
- Bid for customer orders (3 steps)
  - Receive RFQs from customers
  - Decide which of these to bid on and send offers
  - Receive confirmations to orders for those offer sent on D-1
- Manage assembly line and delivery schedule

A number of interrelated problems

- Suppliers: obtain components when needed for production at lowest possible prices => limited supplies, you compete with other agents; demand affects prices
- Inventory costs in terms of storage
- Suppliers consider agents' reputation when making offers
- Customers: need to compete against other agents for sales; pricing; predict customer demand; specialise in particular market segments
- Factory scheduling: Limited cycles; 100% utilisation; needs to be adaptive => connected to the delivery schedule; minimise penalties

Online auction systems

- Online auctions increasingly popular: last minute package holidays, C2C negotiations (eBay,onSale), B2B negotiations
- eBay proxy bidding takes away the inconvenience of having to monitor constantly an auction. Simple mechanism: define reservation price, proxy bidder bids on your behalf by bidding a small amount over the current ask price – works as a Vickrey auction!
- Sniping!
- Popularity and success of online auctions can be attributed to:
  - Simple mechanisms used
  - Allow millions of people with no specialist knowledge of negotiation protocols and strategies to exchange goods

Auctions are here to stay!