## CHAPTER 14: ALLOCATING SCARCE RESOURCES

# **Multiagent Systems**

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Overvi	ew
<ul> <li>Allocation of scarce resour agents is central to multiag</li> </ul>	ces amongst a <i>number of</i> ent systems.
Resource might be:	
<ul> <li>– a physical object</li> </ul>	
– the right to use land	
<ul> <li>– computational resources</li> </ul>	(processor, memory,)
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• If there is no competition for the resource, then there is no trouble allocating it.

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Chapter 14
In practice, this means we will be talking about auctions.
These used to be rare (and not so long ago).
However, auctions have grown massively with the Web/Internet
Frictionless commerce
Now feasible to auction things that weren't previously profitable:

eBay
Adword auctions
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<ul> <li>Limit prices clearly have an ef traders.</li> </ul>	fect on the behavior of
<ul> <li>There are several models, em assumptions about the nature</li> </ul>	bodying different of the good.
<ul> <li>Three commonly used models</li> </ul>	5:
– Private value – Common value – Correlated value	
<ul> <li>These are the models you'll fin the literature.</li> </ul>	nd most often adopted in

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Private valu	IP
T Trate Val	
Good has an value to me that	t is independent of what
it is worth to you	is independent of what
it is worth to you.	
<ul> <li>Textbook gives the example of</li> </ul>	f John Lennon's last
dollar bill	
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Common value	
<ul> <li>The good has the same value to a</li> </ul>	all of us, but we have
differing estimates of what it is.	
• Winner's curse	
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Correlated value
<ul> <li>Our values are related.</li> </ul>
<ul> <li>The more you are prepared to pay, the more I should be prepared to pay.</li> </ul>
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- Absolute value of the money component divided by the good component.
- Traders with positive good component are *buyers*
- Traders with negative good component are sellers
- One way traders are either buyers or sellers but not both.

 Chapter 14
 Yes, but what is an auction?

 Yes, but what is an auction?

 An auction is a market institution in which messages from traders include some price information—this information may be an offer to buy at a given price, in the case of a *bid*, or an offer to sell at a given price, in the case of an *ask*—and which gives priority to higher bids and lower asks.

 This definition, as with all this terminology, comes from Dan Friedman.



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[	The zoology of auctions
<ul> <li>We can split categories.</li> </ul>	auctions into a number of different
<ul> <li>Being good o taxonomy.</li> </ul>	omputer scientists, we draw up a
– This gives be.	us a handle on all the kinds there might
– It suggests	parameterization.
– It can help	us to think about implementation.
<ul> <li>This particular classification is a bit zoological, but it is a good place to start.</li> </ul>	
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<ul> <li>Single-side</li> </ul>	Single versus double-sided ed markets
– Either of and mar – The latte auction.	ne buyer and many sellers, or one seller ny buyers. er is the thing we normally think of as an
• Two-sided	markets
– Many bi	iyers and many sellers.
<ul> <li>Single side are "sell-si</li> </ul>	ed markets with one seller and many buyers de" markets.
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• Single-sided markets with one buyer and many sellers are "buy-side".

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	Open-cry versus sealed-bid
<ul> <li>Open cry</li> </ul>	
– Traders	announce their offers to all traders
<ul> <li>Sealed bic</li> </ul>	1
– Only the	auctioneer sees the offers.
<ul> <li>Clearly as more infor</li> </ul>	a bidder in an open-cry auction you have mation.
<ul> <li>In some an to information</li> </ul>	uction forms you pay for preferential access tion.



- How many units of the same good are we allowed to bid for?
- Single unit
  - One at a time.
  - Might repeat if many units to be sold.
- Multi-unit
  - Bid both price and quantity.
- "Unit" refers to the indivisible unit that we are selling.
  - Single fish versus box of fish.







- Not so much quantity as heterogeneity.
- Single item
  - Just the one indivisible thing that is being auctioned.
- Multi-item
  - Bid for a bundle of goods.
  - "Two red chairs and an orange couch, or a purple beanbag."
  - Valuations for bundles are not linear combinations of the values of the constituents.



#### **English auction**

- This is the kind of auction everyone knows.
- Typical example is sell-side.
- Buyers call out bids, bids increase in price.
- In some instances the auctioneer may call out prices with buyers indicating they agree to such a price.
- The seller may set a *reserve price*, the lowest acceptable price.
- Auction ends:
  - at a fixed time (internet auctions); or
  - when there is no more bidding activity.

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24

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• The "last man standing" pays their bid.

- Classified in the terms we used above:
  - Single-dimensional
  - Single-sided
  - Open-cry
  - Single unit
  - First-price
  - Single item
- Around 95% of internet auctions are of this kind.
- Classic use is sale of antiques and artwork.



#### Unlikely tales

The former president of Parke-Benet reports that a dealer attending a sale of eighteenth-century French furniture had arranged to unbutton his overcoat whenever he wished to bid; buttoning the overcoat again would signal that he had ceased bidding. The dealer, coat unbuttoned, was in the midst of bidding for a Louis XVI sofa when he saw someone outside to whom he wished to speak and suddenly left the room. The auctioneer continued to bid for the dealer who, when he returned to the room, found he had become the owner of the sofa at an unexpectedly high price. An argument then followed as to whether an unbuttoned coat in the auction room.

(Cassady, 1969)

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Dutch auction	on
<ul> <li>Also called a "descending cloc</li> </ul>	ck" auction
<ul> <li>Some auctions use a clock</li> </ul>	to display the prices.
<ul> <li>Starts at a high price, and the descending prices.</li> </ul>	auctioneer calls out
<ul> <li>One bidder claims the good by price is acceptable.</li> </ul>	y indicating the current
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30



• The winner pays the price at which they "stop the clock".

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<ul> <li>Classified in the terms we used a</li> </ul>	above:
Single-dimensional; Single-sided unit; First-price; Single item	; Open-cry; Single
<ul> <li>High volume (since auction proce</li> </ul>	eeds swiftly).
<ul> <li>Often used to sell perishable god</li> </ul>	ods:
<ul> <li>Flowers in the Netherlands (eg</li> <li>Fish in Spain and Israel.</li> <li>Tobacco in Canada</li> </ul>	J. Aalsmeer)
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### First-price sealed bid auction

- In an English auction, you get information about how much a good is worth.
- Other people's bids tell you things about the market.
- In a sealed bid auction, none of that happens
  - at most you know the winning price after the auction.
- In the FPSB auction the highest bid wins as always
- As its name suggests, the winner pays that highest price (which is what they bid).

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<ul> <li>Classified in the terms we used a</li> </ul>	bove:	
<ul> <li>Single-dimensional</li> </ul>		
<ul> <li>Single-sided</li> </ul>		
- Sealed-bid		
– Single unit		
– First-price		
<ul> <li>Governments often use this mech treasury bonds.</li> </ul>	nanism to sell	
– UK still does.		
– US recently changed to SPSB.		
<ul> <li>Property can also be sold this way</li> </ul>	y (as in Scotland).	
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## The Amsterdam auction

- Since medieval time, property in the low countries has traditionally been sold using the "Amsterdam" auction.
- Start with an English auction.
- When down to the final two bidders, start a Dutch auction stage.
- Dutch auction starts from twice the final price of the English auction.

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- Again, classified as above, it is:
  - Single-dimensional
  - Single-sided
  - Sealed-bid
  - Single unit
  - Second-price

Chapter 14
Why does the Vickrey auction work?
Suppose you bid *more* than your valuation.
You may win the good.
If you do, you may end up paying more than you think the good is worth.
Not so smart.

Suppose you bid *less* than your valuation.
You stand less chance of winning the good.
However, even if you do win it, you will end up paying the same.
Not so smart.

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#### Japanese fish auction

• The auction form used to sell fish in Tokyo is different:

[The] distinctive aspect [of this auction form] is that all bids are made by prospective buyers at the same time, or approximately the same time, using individual hand signs for each monetary unit. ... The bidding starts as soon as the auctioneer gives the signal, and the highest bidder, as determined by the auctioneer, is awarded the lot.

This is thus *simultaneous bidding* and rather like an FPSB auction.

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- If we design the auction, we get to say how the allocation is determined.
- How should this be?
- One natural way is to *maximize social welfare*.
  - Sum of the utilities of all the agents.
- Define a social welfare function:

$$sw(Z_1,\ldots,Z_n,v_1,\ldots,v_n)=\sum_{i=1}^n v_i(Z_i)$$



How do we do this?
Well, we could get every agent *i* to declare their valuation v̂<sub>i</sub>
The hat denotes that this is what the agent says, not what it necessarily is.
The agent may lie!
Then we just look at all the possible allocations and figure out what the best one is.



**Bidding languages** 

- Rather than exhaustive evaluations, allow bidders to construct valuations from the bits they want to mention.
- Atomic bids (Z, p) where  $Z \subseteq \mathcal{Z}$ .
- A bundle Z' satisfies a bid (Z, p) if  $Z \subseteq Z'$ .
- In other words a bundle satisifes a bid if it contains at least the things in the bid.

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- To construct more complex valuations, atomic bids can be combined into more complex bids.
- One approach is XOR bids

 $B_i = (\{a, b\}, 3) XOR (\{c, d\}, 5)$ 

- XOR because we will pay for at most one.
- We read the bid to mean:

I would pay 3 for a bundle that contains a and b but not c and d. I will pay 5 for a bundle that contains c and d but not a and b, and I will pay 5 for a bundle that contains a, b, c and d.

• From this we can construct a valuation.

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## Winner Determination

- The basic problem is intractable.
- But this is a worst case result, so it may be possible to develop approaches thatare optimal and run well in many cases.
- Can also forget optimality and either:
  - use heuristics; or
  - look for approximation algorithms.
- Common approach: code the problem as an integer linear program and use a standard solver – often works in practice.

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The	VCG Mechanism
<ul> <li>In general we don valuations.</li> </ul>	't know whether the $\hat{v}_i$ are true
<ul> <li>Life would be easi</li> </ul>	er if they were!
– Well, can we ma	ake them true valuations?
<ul> <li>Yes, in a generaliz</li> </ul>	ation of the Vickrey auction.
– Vickrey/Clarke/0	Groves Mechanism
<ul> <li>Mechanism is incertain a dominant strateg</li> </ul>	e <i>ntive compatible</i> : telling the truth is gy.
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- Need some more notation.
- Indifferent valuation function:

$$v^0(Z) = 0$$

for all Z.

•  $sw_{-i}$  is the social welfare function without *i*:

$$sw_{-i}(Z_1,\ldots,Z_n,v_1,\ldots,v_n) = \sum_{j\in Ag, j\neq i} v_j(Z_j)$$

• And we can then define the VCG mechanism.

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Chapter 14 An Introduction to Multiagent Systems 2e **1. Every agent simultaneously declares a valuation**  $\hat{v}_i$ .













- eBay runs a variation of the English auction.
- Vulnerable to *sniping*.
- To counter this, eBay offers a automated bidding agent.

– Reduces the auction to a FPSB.

- Many companies offer sniping services.
- BTW, there is an easy fix to sniping, but eBay chose not to use it.

– Activity rule

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Types of House Siding Materials - Aluminum Siding Aluminum siding comes in strips and has perforated holes at the top fastening into the exterior wall and interlocking flanges top and bottom  homerepair.about.com/od//ss/siding types 3.htm - <u>Cached</u> - <u>Similar</u>	for to seal	Aluminum building 70% OFF Select Models & Sizes Free Online Quotes & Info Here! www.SteelMasterUSA.com
Shopping results for aluminum siding h) 568 photo of corrugated aluminum siding corrosion \$195.00 new - painetworks.com \$13002 Northwest Meta Siding Corners Northwest Meta \$203.96 new - Ace Hardware Superstore <b>8:</b> Aluminum Smooth Primed Outside Hardboard Siding \$12.58 new - Store.capitolcitylumber	tin rust il Products Corners 10/pack	Building metal Find building metal here. We offer local search in your area. www.local.com New York, NY <u>New Clear Awning by Zorox</u> You Never Saw an Awning Like This Impact Resistant! See the Video.
		WWW.2010A.COM

To decide which ads get shown in which position for which searches, an adword auction is run.
This is run *in real time*.
(Though clearly bids are placed beforehand.)
Auction is a variation on the Vickrey auction.
85% of Google's revenue (\$4.1 billion) in 2005 came from these auctions.
Very active area of research.
Not clear what the best auction mechanism is for this application.
Not clear what the best way to bid is.

Chapter 14
Summary
Allocating scarce resources comes down to auctions.
We looked at a range of different simple auction mechanisms.
English auction
Dutch auction
First price sealed bid
Vickrey auction
The we looked at the popular field of combinatorial auctions.

- We discussed some of the problems in implementing combinatorial auctions.
- And we talked about the Vickrey/Clarke/Groves mechanism, a rare ray of sunshine on the problems of multiagent interaction.