CS344M
Autonomous Multiagent Systems

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Good Afternoon, Colleagues

Are there any questions?
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Are there any questions?

• Why is the sequential auction difficult?

• Was there negative social utility in the Clarke Tax Algorithm?
Logistics

- Peer reviews due next Thursday
Logistics

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• Final projects due sooner than you think!
Logistics

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  – Code due Tuesday, November 30th.
  – Written reports due Thursday, December 2nd.
Logistics

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- FAI talk on Friday at 11 - poker: PAI 3.14
Distributed Rational Decision Making

Self-interested, rational agent
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- Self-interested: maximize own goals
  - No concern for global good

- Rational:
Distributed Rational Decision Making

Self-interested, rational agent

- Self-interested: maximize own goals
  - No concern for global good

- Rational: agents are smart
  - Ideally, will act *optimally*

The protocol is key
Auctions vs. voting

- Auctions: maximize profit
  - result affects buyer and seller
- Voting: maximize social good
  - result affects all
• Example: Bush, Gore, or Nader?
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- For whom should you vote?
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Gibbard-Satterthwaite

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3+ candidates $\implies$ only dictatorial system eliminates need for tactical voting
- One person appointed
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- Assumption: no restrictions on preferences
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What about Clarke tax algorithm?
Types of Tactical Voting

- Compromising: Rank someone higher to get him/her elected
  - e.g. Gore instead of Nader
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- Push-over: Rank someone higher to get someone else elected
  - e.g. in a protocol with multiple rounds
Arrow’s Theorem

Universality.
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**Universality.** The voting method should provide a complete ranking of all alternatives from any set of individual preference ballots.
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Pareto optimality. If everyone prefers X to Y, then the outcome should rank X above Y.
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Criterion of independence of irrelevant alternatives.


**Arrow’s Theorem**

**Universality.** The voting method should provide a complete ranking of all alternatives from any set of individual preference ballots.

**Pareto optimality.** If everyone prefers X to Y, then the outcome should rank X above Y.

**Criterion of independence of irrelevant alternatives.** If one set of preference ballots would lead to an overall ranking of alternative X above alternative Y and if some preference ballots are changed without changing the relative rank of X and Y, then the method should still rank X above Y.
Citizen Sovereignty.
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Non-dictatorship.
Citizen Sovereignty. Every possible ranking of alternatives can be achieved from some set of individual preference ballots.

Non-dictatorship. There should not be one specific voter whose preference ballot is always adopted.
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Pareto optimality. $X > Y$ if all agree
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**Citizen Sovereignty.** Any ranking possible

**Non-dictatorship.** No one voter decides

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Not all possible!
Condorcet Voting

• Strategy proof under weaker irrelevant alternatives criterion
Condorcet Voting

- Strategy proof under weaker irrelevant alternatives criterion
- A pairwise method
Condorcet Voting

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- Smith set: smallest set of candidates such that each candidate in the set preferred over each candidate not in the set
Condorcet Voting

• Strategy proof under weaker irrelevant alternatives criterion

• A pairwise method

• Smith set: smallest set of candidates such that each candidate in the set preferred over each candidate not in the set

• Every candidate in the Smith set is relevant
Condorcet Example

- 48: A > B > C
- 40: B > C > A
- 12: C > B > A
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- A vs. B:
Condorcet Example

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- A vs. B: 48 – 52 \implies B > A
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- A vs. C: 48 – 52 ⇒ C > A
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Overall: B > C > A

Peter Stone
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- Does that solve everything?
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Overall: B > C > A

- Does that solve everything? What about cycles?
Bargaining

small market, both can come out favorably
Bargaining

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- Two people bargaining, each with a preference over outcomes $O$
- Let $o^*$ be the selected outcome
Bargaining

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- Example: “split the dollar”
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  - Other rejects with probability $p(o)$ — based on offer
  - If rejects, both get nothing
Bargaining

- Two people bargaining, each with a preference over outcomes \( O \)
- Let \( o^* \) be the selected outcome
- Example: “split the dollar”
  - One person makes offer \( o \)
  - Other rejects with probability \( p(o) \) — based on offer
  - If rejects, both get nothing
- Another version
  - One person makes an offer
  - Other accepts, rejects, or counters
  - If counters, $.05 lost
  - Game ends with an accept or reject
Nash Bargaining Solution

Unique solution that satisfies:
Nash Bargaining Solution

Unique solution that satisfies:

- **Invariance**: only preference orders matter
- **Anonymity**: no discrimination
- **Pareto efficiency**: if one does better, other does worse
- **Independence of irrelevant alternatives**: removing outcomes doesn’t change things
Nash Bargaining Solution

Unique solution that satisfies:

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**Independence of irrelevant alternatives:** removing outcomes doesn’t change things

\[
\text{Maximize } u_1(o) \times u_2(o)
\]
General Equilibrium

Consumers: utilities, endowments
Producers: production possibility sets
Variables: prices on goods
General Equilibrium

**Consumers:** utilities, endowments

**Producers:** production possibility sets

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**Equilibrium:** allocation (prices) such that consumers maximize preferences, producers maximize profits
General Equilibrium

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- Assumption: agent doesn’t affect prices
General Equilibrium

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Equilibrium: allocation (prices) such that consumers maximize preferences, producers maximize profits

- Assumption: agent doesn’t affect prices
  - Only true if market is infinitely large
  - Else, strategic bidding (like bargaining) possible
General Equilibrium

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**Producers:** production possibility sets

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  – Braess’ paradox
Other DRDM

- Contract nets: task allocation among agents
Other DRDM

• Contract nets: task allocation among agents
  – Contingencies
  – Leveled commitment (price)
Other DRDM

• Contract nets: task allocation among agents
  – Contingencies
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• Coalitions
Other DRDM

• Contract nets: task allocation among agents
  – Contingencies
  – Leveled commitment (price)

• Coalitions
  – Formation
  – Optimization within
  – Payoff division
Contract Nets

Task allocation among agents
Contract Nets

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- OCSM-contracts: original, cluster, swap, multiagent
  - Hill-climbing leads to optimum
  - Without any type, may be no sequence to optimum
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Contract Nets

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  - Contingency (future events)
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Contract Nets

Task allocation among agents

• OCSM-contracts: original, cluster, swap, multiagent
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• Backing out of contracts
  – Contingency (future events)
  – Leveled commitment (price)
  – What are some of the tradeoffs?
Contingency vs. leveled commitment

Contingency problems:
Contingency vs. leveled commitment

Contingency problems:

1. Hard to track all contingencies
Contingency vs. leveled commitment

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1. Hard to track all contingencies
2. Could be impossible to enumerate all possible contingencies
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Contingency problems:

1. Hard to track all contingencies
2. Could be impossible to enumerate all possible contingencies
3. What if only one agent observes that relevant event happened?
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Leveled commitment problems:
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Leveled commitment problems:

1. Breacher’s gain may be smaller than victim’s loss
Contingency vs. leveled commitment

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1. Hard to track all contingencies
2. Could be impossible to enumerate all possible contingencies
3. What if only one agent observes that relevant event happened?

Leveled commitment problems:

1. Breacher’s gain may be smaller than victim’s loss
2. May decommit insincerely (wait for other) - inefficient contracts executed.
Coalitions

- Formation
- Optimization within
- Payoff division
DRDM Summary

For many agents: voting, general equilibrium, auctions

For fewer agents: auctions, contract nets, bargaining

Possible in all: coalitions
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All self-interested, rational agents