CS 886: Multiagent Systems

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Cheriton School of Computer Science
University of Waterloo

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Outline

Outline

Introduction

- Kate Larson
  - Faculty Member in CS
  - Member of the AI research group
- Research Interests: Multiagent Systems
  - Strategic Reasoning
    - bounded rationality/limited resources
    - argumentation
  - Electronic market design

Introduction

- Focus of this course is *self-interested* Multiagent Systems
  - aka competitive Multiagent Systems
- Study of autonomous agents
  - Diverging information
  - Diverging interests
- Issues
  - Cooperation
  - Coordination
  - Overcoming self-interest of agents in order to achieve system-wide goals

Introduction

- Growth in settings where there are multiple *self-interested* interacting parties
  - Networks
  - Electronic markets
  - Game playing...
- To act optimally, participants must take into account how other agents are going to act
- We want to be able to
  - Understand the ways in which agents will interact and behave
  - Design systems so that agents behave the way we would like

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Two Communities

Economics

- Traditional emphasis on game theoretic rationality
- Describing how agents should behave
- Multiple self-interested agents

Computer Science

- Traditional emphasis on computational and informational constraints
- Building agents
- Individual or cooperative agents

New Research Problems

- How do we use game theory and mechanism design in computer science settings?
- How do we resolve conflicts between game-theoretic and computational constraints?
- Development of new theories and methodologies

Explosion of Research

Explosion of research in the area (Algorithmic game theory, computational mechanism design, Distributed algorithmic mechanism design, computational game theory,...)

- Papers appearing in AAAI, AAMAS, UAI, NIPS, PODC, SIGCOMM, INFOCOMM, SODA, STOC, FOCS, ...
- Papers by CS researchers appearing in Games and Economic Behavior, Journal of Economic Theory, Econometrica,...
- Numerous workshops and meetings,...

This Course

- Introduction to game theory, social choice, mechanism design
- Study how they are used in computer science (in particular in AI)
- Study computational issues that arise

Course structure

- Introductory lectures
- Current research papers

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Prerequisites

- **No formal prerequisites**
- Students should be comfortable with mathematical proofs
- Some familiarity with probability
- Ideally students will have an AI course but I can provide background material when needed
- **I will cover the game theory and mechanism design required**

Grading

- 2-3 assignments on game theory and mechanism design: 10%
- In class presentation(s): 20%
  - Peer-reviewed
- Class participation: 20%
- Research project: 50%

Presentations

Every student is responsible for presenting a research paper in class

- Short survey + a critique
- Everyone in class will provide feedback on the presentation
- Marks given on coverage of material + organization + presentation

Class Participation

You must participate!

- Before each class (before 6:00 am the day of the presentation) you must submit a review of one of the papers being discussed
  - What is the main contribution?
  - Is it important? Why?
  - What assumptions are made?
  - What applications might arise from the results?
  - How can it be extended?
  - What was unclear?
  - ...

Projects

The goal of the project is to develop a deep understanding of a topic related to the course.

- The topic is open
  - Theoretical, experimental, *in-depth* literature review,...
  - Can be related to your own research
  - If you have trouble coming up with a topic, come and talk to me
- Proposals due October 20
- Final projects due December 1st[1]
- Students will present projects in class

[1] I will likely be flexible with this.

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Other Information

- Class times: Monday-Wednesday 10:00-11:30
- Office Hours: By appointment (just send me email or talk to me after class to set up an appointment)
- Course website
  - http://www.cs.uwaterloo.ca/~klarson/teaching/F08-886

Outline

Selfish Routing

- We want to find the least-cost route from S to T.
- Costs are private information – we do not know them
- We do know that agents (nodes) are interested in maximizing revenue
- How can we use this to figure out the least-cost route?

Outline

London Bus System[2]

- 5 million passengers daily
- 7500 buses
- 700 routes
- The system has been privatized since 1997 by using competitive tendering
- *Idea*: Run an auction to allocate routes to companies

[2] As of April 2004

Auction Protocol

- Let G be set of all routes, I be the set of bidders
- Agent i submits bid $v_i(S)$ for all bundles $S \subseteq G$
- Compute allocation S^* to maximize sum of reported bids

$$V^*(I) = \max_{(S_1,\ldots,S_n)} \sum_i v_i(S_i)$$

- Compute best allocation without each agent

$$V^*(I \setminus i) = \max_{(S_1,\ldots,S_n)} \sum_{j \neq i} v_j^*(S_j)$$

- Allocate each agent S_i^*, each agent pays

$$P(i) = v_i^*(S_i^*) - [V^*(I) - V^*(I \setminus i)]$$

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London Bus System

- Mechanism: Generalized Vickrey Auction
  - Specifies the rules
  - Describes how outcome will be determined
- Strategies
  - Policies which specify what actions to take
  - Agents are self-interested and rational
- GVA is efficient and strategy-proof

Computational Issues

- Winner determination problem: Select bids to maximize sum of reported values
  - Maximum weighted set packing (NP-hard)
  - Solve this problem $I + 1$ times
- Agent valuation problem
- Communication complexity
  - Each agent has to communicate 2^{700} bids to the auctioneer

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