Introduction to Algorithmic Game Theory

Course Logistics

- Instructor: Alan Kuhnle
- Course website: https://www.alankuhnle.com/teaching/fall-23-csce-689-AGT/
- Tuesday / Thursday, 9:35 -- 10:50 in HRBB 126
- Lecture format: in person only
- Office hours: Monday, 9am; Thursday; 11 am. In person only, in 421 Peterson Building

What is Algorithmic Game Theory?

- Consider the internet
  - Transformed, informed, accelerated markets
  - Created new markets
  - Itself is a kind of market
- “the Internet is an equilibrium, we just have to find the game” -- Scott Schenker
- Computer scientists turned to game theory for inspiration

Game Theory

- Models strategic interactions between *n* players or agents
- Each player has their own utility function
- There usually isn't an optimal solution, as players have conflicting utilities
- "Solution concepts" -- ways to understand / predict equilibrium behavior
- But game theory traditionally unconcerned with *how* the players reach an equilibrium

Equilibrium computation

- One of the earliest research goals of algorithmic game theory was to provide algorithms for computing equilibria: Nash equilibria, correlated equilibria, price equilibria
  - Efficient computability
  - Computational intractability -- what good is an equilibrium if no one can compute it?
- What computational models should be used to reflect the realities of the Internet or markets?

Mechanism Design

- In arbitrary games, equilibrium computation might be intractable
- But, can we design a game, where an equilibrium provably attains the designer's goals, even without knowing agents' utilities?
- E.g. how to recover cost of an Internet service from customers who value the service by amounts known only to them?

The Price of Anarchy

- On the other hand, suppose we have a game, and suppose selfish rational agents find an equilibrium
- How inefficient is this equilibrium compared to if all agents were to cooperate? Or compared to an optimal equilibrium?
- E.g. in routing with linear delays, overhead of anarchy is at most 33% of the optimal solution

What is Algorithmic Game Theory?

- Convergence of algorithms and game theory
- Topics of this course:
  - Equilibrium computation
  - Mechanism design
  - Price of anarchy
  - Additional topics