Incentives in Computer Science

PROF. ANNA KARLIN

Your professor and TA

Anna
Karlin

karlin@cs
Office: CSE 586
Office hours: by appointment

Aditya
Saraf

sarafa@cs

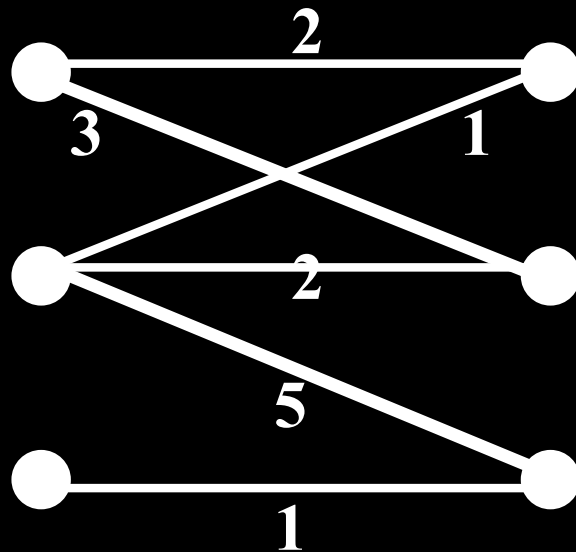Office hours: Tuesdays, 5:30-6:20 pm

An Example

Classical Optimization Problem:

Maximum Weighted Matching

Input: Weighted Bipartite Graph

Output: Matching that maximizes the sum of matched edge weights.
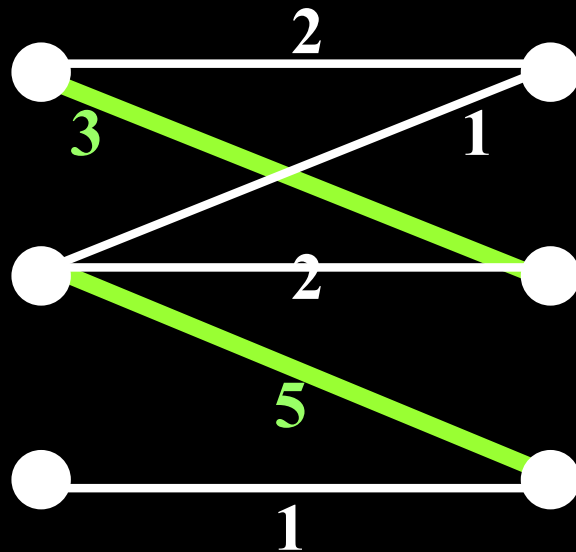
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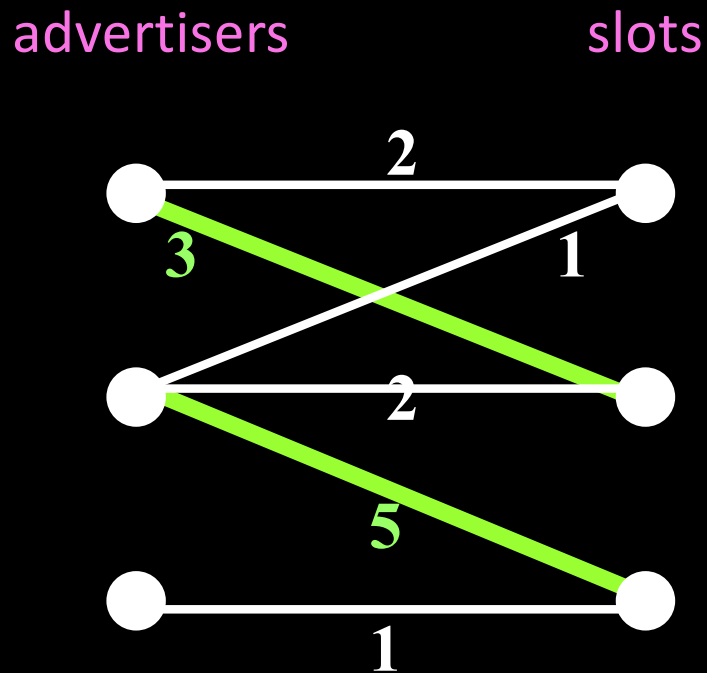
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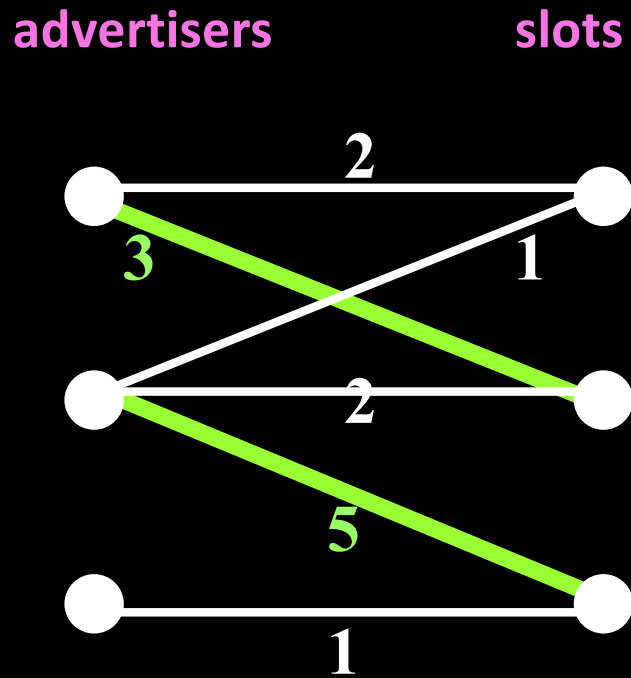
Example Application

Selling advertising slots

- A search engine has advertising slots for sale
- Advertisers are willing to pay different amounts to have their ad shown in a particular slot

advertisers   slots

Optimal Search Engine Revenue = maximum weighted matching

Private Values

- **Algorithm must solicit values**
- **Advertisers may lie to get a better deal**

advertisers   slots
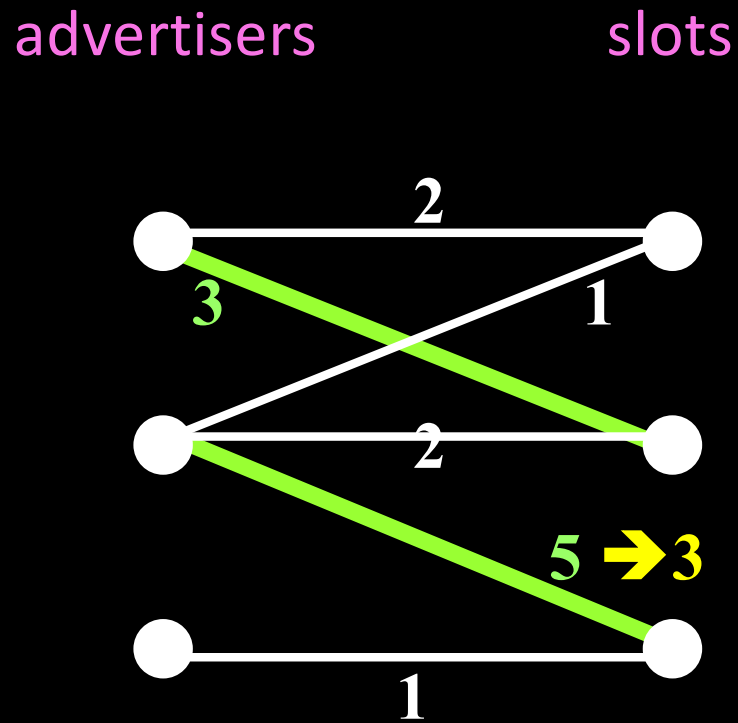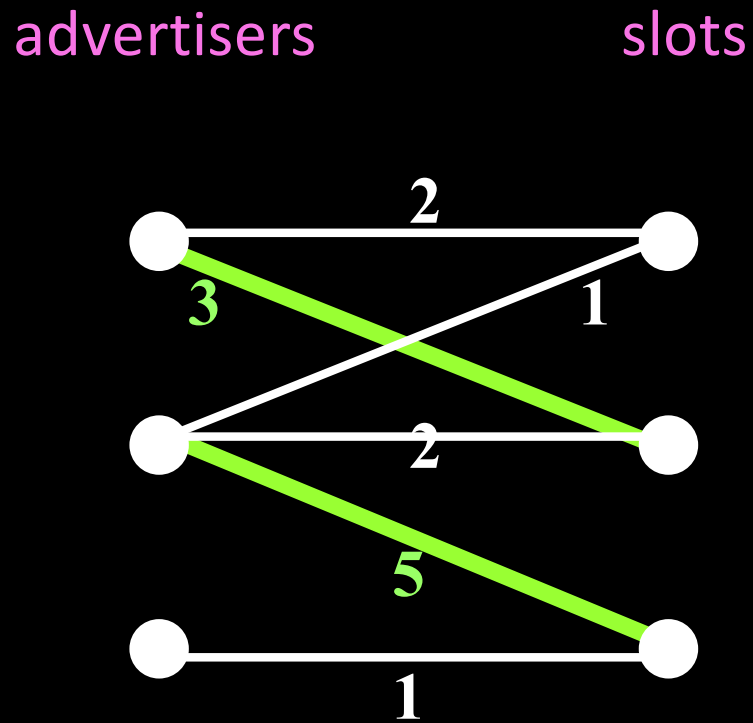
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Private Values

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advertisers   slots

Private Values

- Algorithm must solicit values
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What if all advertisers speculate?

Big Picture

Many problems where input is private data of agents who will act selfishly to promote best interests

- Resource allocation
- Routing and congestion control
- Electronic commerce

Fundamental Question:
How do we optimize in a strategic world?

Use ideas from game theory and economics.

Game Theory

Game Theory studies the interaction between competing or cooperating individuals.

Key notion: **equilibrium**

ALGORITHMIC GAME THEORY

Newish field at interface between theoretical computer science and game theory. Motivated by

- new applications in ecommerce, network applications, large scale resource allocation problems, myriad of nontraditional, computer-run auctions, etc.

- addresses fundamental problems about auctions, networks and human behavior using the tools of game theory, economics and algorithm design and analysis.

Companies/systems that can be studied from this perspective	Problems that can be studied from this perspective
• eBay, Amazon	• Auction design and analysis
• Google, Yahoo!, Microsoft	• Reputation systems
• Facebook	• Recommendation systems
• Twitter	• Crowdsourcing
• Uber, Lyft	• Resource allocation problems
• airBnb	• Routing and congestion control
• Quora	• Creating incentives in social and financial systems
• Farecast	• Prediction markets
• Wikipedia	• …
• …	

Themes

- Designing systems for strategic participants with good performance.

- Games that arise in the wild: when is selfish behavior benign?

- How do strategic players reach an equilibrium? Or do they?

- Goal: to expose you to a different way to think.

Tentative list of topics

- Matching and allocation problems
- Intro to game theory, Nash equilibrium, etc.
- Markets, market-clearing prices, first welfare theorem
- Auctions (ads, spectrum)
- Price of anarchy
- Incentives in cryptocurrencies
- Online learning in markets
- Scoring rules and prediction markets
- Voting

Note…

This is a theoretical class.

- "mathematical maturity"
- Basics of probability, some background in algorithm design and analysis.
- I do not expect you to know any game theory or economics.

The nuts and bolts

COURSE WEBSITE

http://www.cs.washington.edu/csep590b

GRADING

60% homework

40% project

About 4 homeworks of each type

THEORETICAL EXERCISES

PROGRAMMING PROJECTS

First homework is already posted,
Linked from web page (on Canvas)

Project

Many Possibilities:

• Pick a company and some aspect of their business and study it game theoretically.

• Study some research papers.

• Design and run some interesting game theoretic experiments. Formulate hypotheses.

Today's lecture

- Covers some of the major results that resulted in the awarding of the 2012 Nobel Prize in economics to Lloyd Shapley and Al Roth

- *"The Prize concerns a central economic problem: how to match different agents as well as possible. For example, students have to be matched with schools, and donors of human organs with patients in need of a transplant. How can such matching be accomplished as efficiently as possible? What methods are beneficial to what groups? The prize rewards two scholars who answered these questions on a journey from abstract theory on stable allocations to practical design of market institutions."*