Introduction

1 Why study CS 6001?

Games $\Rightarrow$ Strategic Interactions between Rational Agents

- *Game Theory:* Analysis of Games
- *Mechanism Design:* Designing Games with Desirable Outcomes

Traditionally studied in economics and politics...

Computer science meets game theory:

- Proliferation of computing technologies (e.g. Internet) into economic settings (e.g. e-markets)
- Many problems in distributed computing involves strategic agents making selfish decisions.

This led to two new disciplines in computer science:

- Theoretical computer science focused on studying the algorithmic aspects (e.g. computational complexity, inefficiency) of finding equilibria in different game theoretic settings.

- Designing strategic mechanisms for computing applications which produce desired outcomes.

However, there is a third area hidden within the game-theoretic literature which involves learning utilities of agents from data...

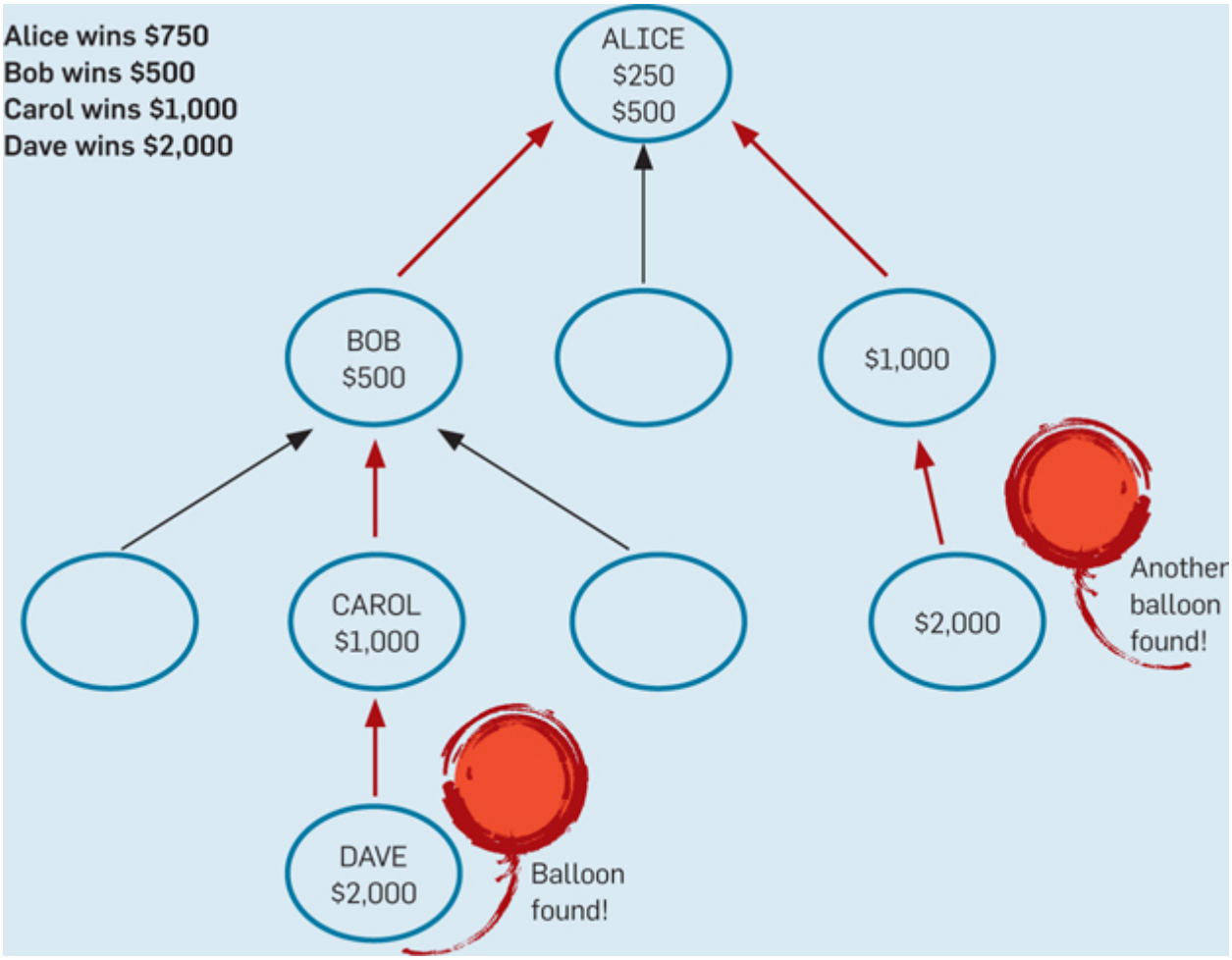
This course covers the three broad areas...

2 Algorithmic Game Theory: Its Impact

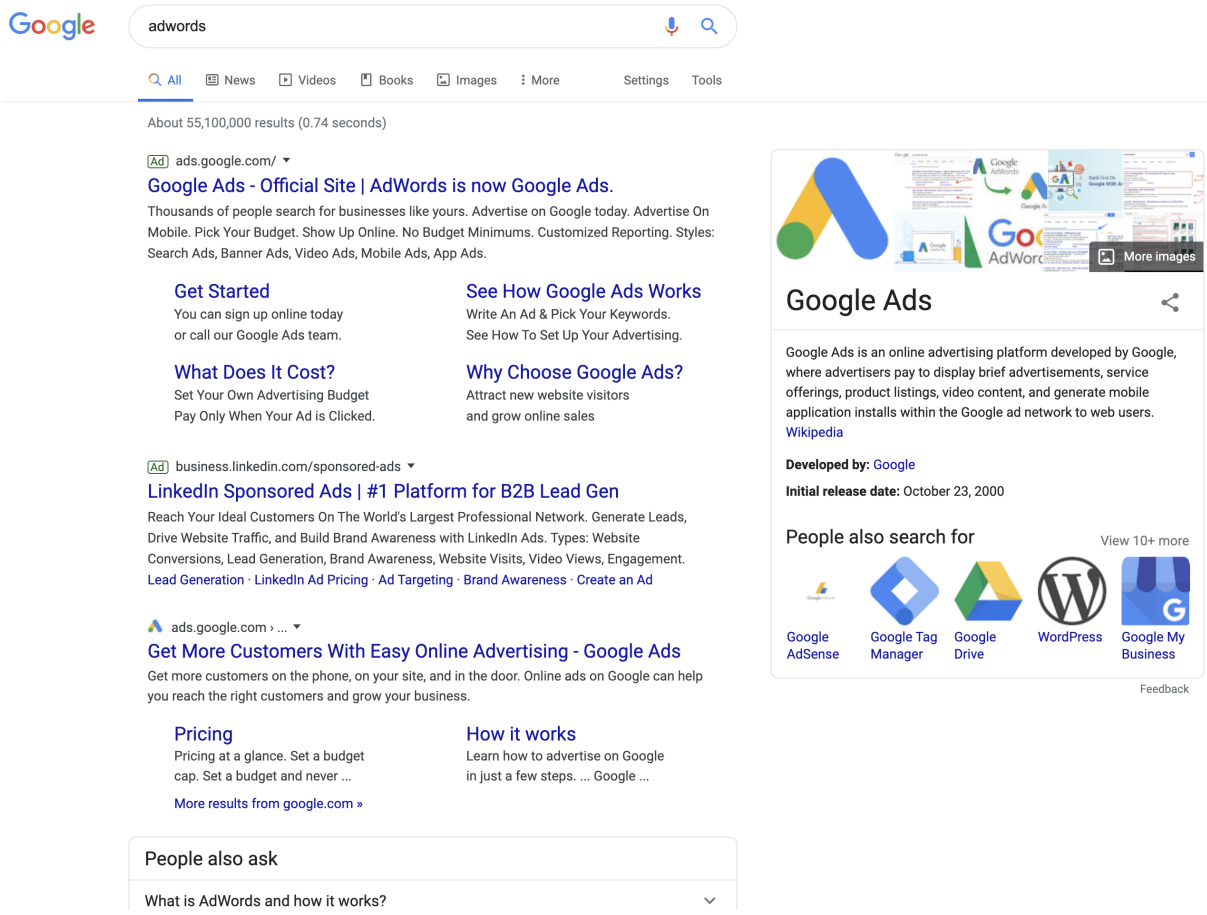
2.0.1 DARPA's Red Balloon Challenge

- Occassion: 40th anniversary of Internet

- 10 red balloons randomly deployed in US in unknown locations.
- Contestants should leverage **social networks** to locate all the ten balloons within a week.
- Prize: $40,000
- MIT Red Balloon Challenge Team: 8 hrs, 52 mins, 41 secs.
- Strategy: Multi-level incentives in crowdsourcing



2.1 Keyword Auctions



- Prior to 1994: Price charged per click... (less competition)
- 1994: Overture (GoTo.com in 1998) replaced pay-per-click system with a first-price auction.
- Late 1990s: Yahoo and MSN adopt first price auctions.

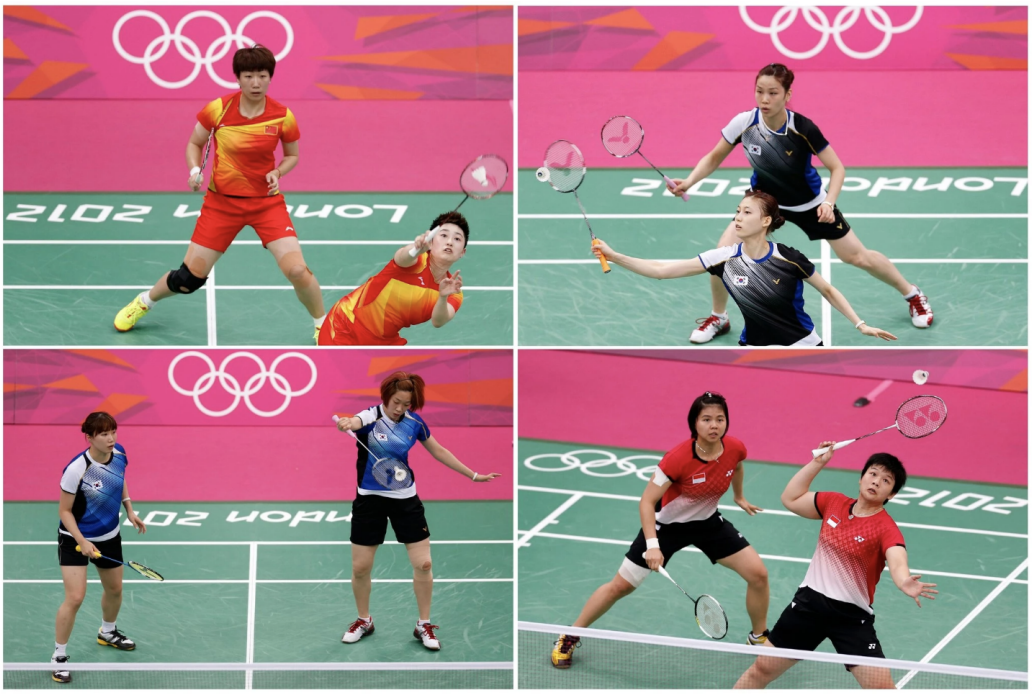
- 2002: Google Adwords adopted a second-price auction for one advertisement per page.
- Shortly, adopted a generalized second-price auction to accommodate multiple advertisements per page.
- GSP auctions are not truthful => huge burden on servers
- Later, most search engines adopted VCG auctions.

2.2 2012 London Olympics – Women's Badminton

- Teams segregated into four groups (A, B, C, D) before Quarterfinals...
- Quarterfinal 1: A1 vs. C2
- Quarterfinal 2: B1 vs D2
- Quarterfinal 3: A2 vs. C1
- Quarterfinal 4: B2 vs. D1
- Group D: Danish team Pedersen and Juhl (PJ) beats Chinese team Tian and Zhao (TZ)

The New York Times

Olympic Ideal Takes Beating in Badminton



Clockwise from top left, the women's badminton doubles pairs: China's Wang Xiaoli, left, and Yu Yang; South Korea's Jung Kyung-eun, top, and Kim Ha-na; Indonesia's Greysia Polii and Meiliana Jauhari; and South Korea's Ha Jung-eun and Kim Min-jung during matches in London. The players were charged with misconduct by the World Badminton Federation. Bazuki Muhammad/Reuters

By Ken Belson

Aug. 1, 2012

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- TZ is the favorite...
- Last day of Round-robin competition:
  - Group A: Chinese team Wang and Yu (WY) and South Korean team Jung and Kim (JK)

have equal points in the round-robin competition.

  - Knockout tie-breaker $\Rightarrow$ Both did not want to win this game..
  - https://www.youtube.com/watch?v=7mq1ioqiWEo

- This was just the start...
- A classic example of bad tournament design.

3 How is this different from CS 5001?

In this course, we will follow a rigorous approach and will adopt theorem-proof style. The vision behind designing this course is to help **advanced graduate students** become independent research scholars in the area of algorithmic game theory. Therefore, the course shall have the following objectives:

- Develop mathematical rigor in modeling individual rationality using revealed preferences.
- Become proficient in analyzing the complexity of computing Nash equilibria.
- Develop deeper insights about the design of strategic mechanisms and their limitations.

- Gain mastery with designing various types of markets.

4 Prerequisites

Students are expected to have a strong foundation in the following (non-exhaustive) list of topics:

- Algorithms ('C' or better grade in CS 5200),
- Artificial Intelligence ('C' or better grade in CS 5400, or CS 5401)
- Game theory ('C' or better grade in CS 5001).

5 Textbook

There is **no textbook** for this course. However, students are encouraged to refer to one or more recommended books[1] from the following (non-exhaustive) list:

- **Noam Nisan *et al.* (Editors), "Algorithmic Game Theory, " Cambridge University Press, 2007.**
- Tamer Başar and Geert Jan Olsder, "Dynamic Noncooperative Game Theory," SIAM, 2nd Ed., 1999.

[1]Links to free electronic copies of the books will be provided in the website, if available.

- John von Neumann and Oskar Morgenstern, "Theory of Games and Economic Behavior," 60th Anniversary Commemorative Edition, Princeton University Press, 2007.
- Yoav Shoham, Kevin Leyton-Brown, "Multiagent Systems: Algorithmic, Game-Theoretic, and Logical Foundations," Cambridge University Press, 2008.
- Y. Narahari, "Game Theory and Mechanism Design," IISc Press and the World Scientific Publishing Company, March 2014.
- T. Roughgarden, "Twenty Lectures on Algorithmic Game Theory," Cambridge University Press, 2016.

6 Prospective List of Topics

In this course, we will tentatively cover six topics, each with mathematical rigor in a lecture format, followed by a case study on some practical state-of-the-art paper(s) presented by students. The order in which these topics shall be covered are highlighted in red.

- ***Mechanism Design***
  - Revelation Principle
  - Impossibility Theorems

  - Quasi-Linear Environments

- ***Markets***
  - Auctions
  - Stable Matching
  - Dynamic Pricing and Bandits

- ***Learning in Games***
  - Ficticious play
  - Regret Minimization

- ***Inefficiency***
  - Price of Anarchy
  - Selfish Routing
  - Braess Paradox

- ***Games and Complexity***
  - PPAD Class
  - Non-Linear Complementarity
  - Lemke-Howson Algorithm

7 Grading Information

All the grades will be posted and maintained on Canvas.

Assignments:	50% of total grade
Case Study:	20% of total grade
Project:	30% of total grade

Final Grade:

A: $[85 - 100]$, B: $[75 - 85)$, C: $[60 - 75)$, F: < 60.