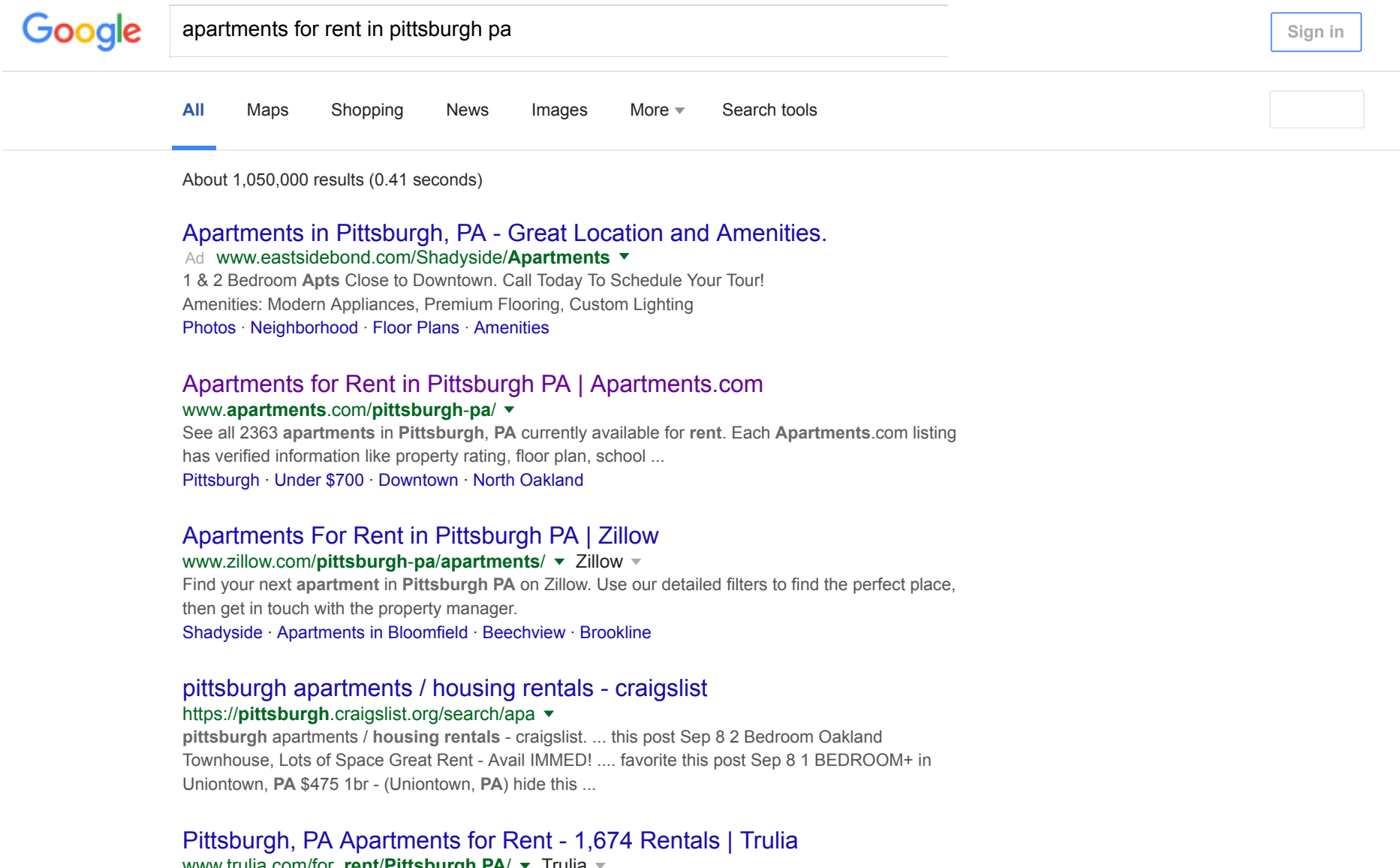
CS698W: Topics in Game Theory and Collective Choice

Teacher: Swaprava Nath

Introduction

Sponsored Search Advertisements



Sponsored Search Advertisements (contd.)

Google | apartments for rent in pittsburgh | Sign in

All | Images | Maps | **Shopping** | More

Your location: Pittsburgh, PA

Sort: Default | View: List | My Shortlist (0)

Merchant links are sponsored

Show only

- Available nearby
- New items

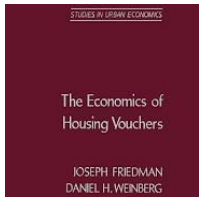
Price

- Up to $70
- $70 – $250
- $250 – $500
- Over $500
- $ [ ] to
- $ [ ] Go

Category

- DVDs & Videos
- Bullhorns
- Jacks & Lift Trucks
- Laser Levels
- Vehicle Repair Pullers & Separators

More



The Economics of Housing Vouchers [Book]

$58.36 from 4 stores

by Joseph H. Friedman, Daniel H. Weinberg · Elsevier Science · Ebo

The Economics of Housing Vouchers is a seven-chapter text that ex... in two metropolitan areas ...

Reebok James Neal Pittsburgh Penguins Black H...

$59.99 from 3 stores

Get the perfect look **to let** everyone know who you cheer for! Show ... Neal Replica Player jersey ...

Other size options: Size M ($60) Size XL ($60)

Majestic Athletic - Pittsburgh Pirates Mens Cooperstown Cool Base Je...

$100.00 from 5+ stores

1 product review

Get the perfect look **to let** everyone know you are a loyal **Pittsburgh** Pirates fan! This Cooperstown jersey will keep you comfortable with its Cool ...

Other size options: Size S ($100) Size M ($100) Size XL ($100) More

Reebok Olli Maatta Pittsburgh Penguins Men's Black Home Premier J...

$101.99 from 3 stores

Products and offers that match your query. Google is compensated by these merchants. Payment is one of several factors used to rank these results. These results are based on your current search terms and may be based your visits to other websites. Visit Google's Consumer Ads Help Center to learn more. To block specific advertisers, opt out of personalized ads, or confirm your opt out status, visit Google's Ads Settings.

Social Network Advertisements

Advertisement Revenues

- Google's revenue from the AdWords: US$ 67.39bn (2015)
- Facebook's revenue from advertisements: US$ 17.08bn (2015)

Source: statista.com

Resource Allocation

1800 MHz

Circle / Operator	Vodafone	Airtel	Rel Jio	Idea	Aircel	Uninor	RCom	Tata	Total
Andhra Pradesh	✓	✓	✓	✓	✗	✓	✗	✗	5
Assam	✗	✗	✓	✗	✗	✓	✗	✗	2
Bihar	✗	✗	✗	✗	✗	✓	✗	✗	1
Delhi	✓	✓	✓	✓	✗	✗	✗	✗	4
Gujarat	✓	✗	✓	✓	✗	✗	✗	✗	3
Haryana	✓	✗	✗	✓	✗	✗	✗	✗	2
Himachal Pradesh	✗	✓	✗	✗	✗	✗	✗	✗	1
Jammu & Kashmir	✗	✓	✗	✗	✓	✗	✗	✗	2
Karnataka	✓	✓	✓	✓	✗	✗	✗	✗	4
Kerala	✓	✓	✓	✓	✗	✗	✗	✗	4
Kolkata	✓	✓	✓	✗	✗	✗	✗	✗	3
Madhya Pradesh	✗	✓	✓	✓	✗	✗	✗	✗	3
Maharashtra & Goa	✗	✗	✓	✓	✗	✗	✗	✗	2
Mumbai	✓	✓	✓	✓	✗	✗	✓	✗	5
North East	✗	✓	✓	✓	✓	✗	✗	✗	4
Orissa	✗	✓	✓	✗	✗	✗	✗	✗	2
Punjab	✓	✓	✗	✓	✗	✗	✗	✗	3
Rajasthan	✓	✓	✗	✗	✓	✗	✗	✗	3
Tamil Nadu	✗	✓	✓	✗	✗	✗	✗	✗	2
Uttar Pradesh (East)	✓	✗	✗	✗	✓	✓	✗	✗	3
Uttar Pradesh (West)	✗	✗	✗	✗	✗	✓	✗	✗	1
West Bengal	✗	✓	✓	✗	✓	✗	✗	✗	3
Total	11	15	14	11	5	5	1	0	62

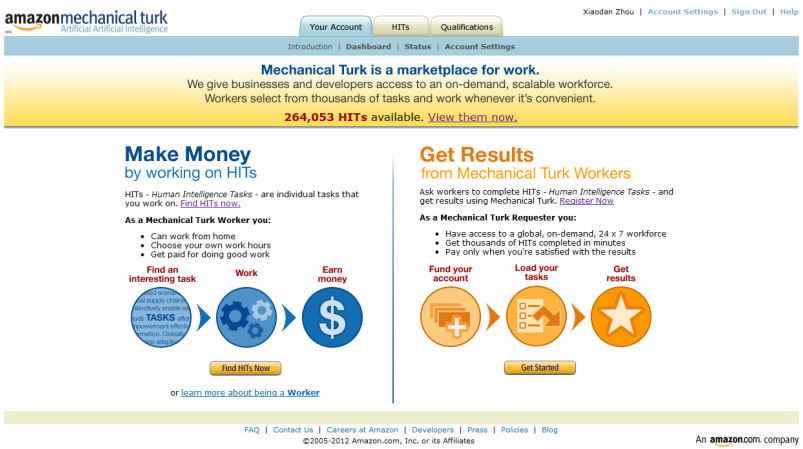
2015 spectrum auction [edit]

The 2015 spectrum auction concluded on March 25, after 19 days and 115 rounds of bidding.[29] Spectrum in the 800 MHz, 900 MHz, 1800 MHz and 2100 MHz bands was auctioned. The Government accrued a total of ₹109874 crore (US$16 billion)[30] from the auction. Approximately, 11% of the spectrum available for auction remained unsold.[31]

Source: wikipedia.org

Crowdsourcing

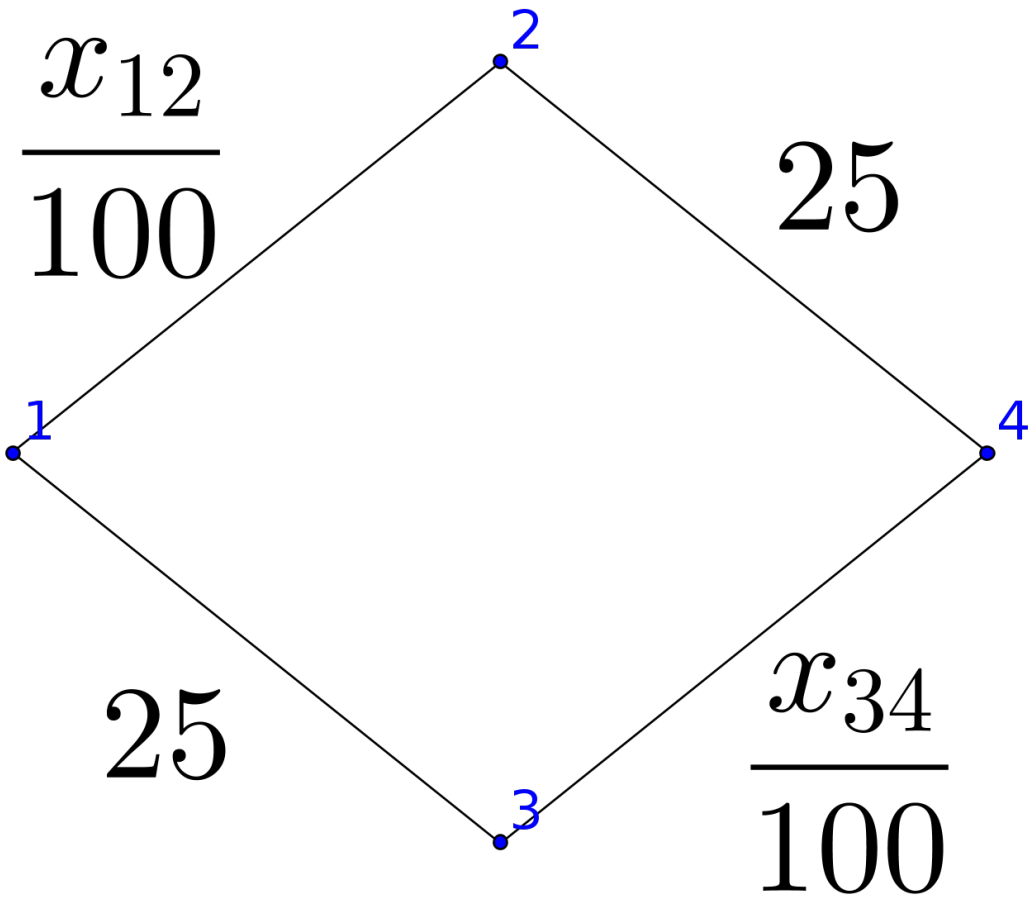
"Crowdsourcing is a type of participative online activity in which an individual, an institution, a non-profit organization, or company proposes to a group of individuals of varying knowledge, heterogeneity, and number, via a flexible open call, the voluntary undertaking of a task." [1]



[1] Enrique Estellés-Arolas and Fernando González-Ladrón-de Guevara. Towards an integrated crowdsourcing definition. Journal of Information science, 38(2):189200, 2012.

Traffic Routing

2000 cars every day travels from node 1 (source) to 4 (destination)



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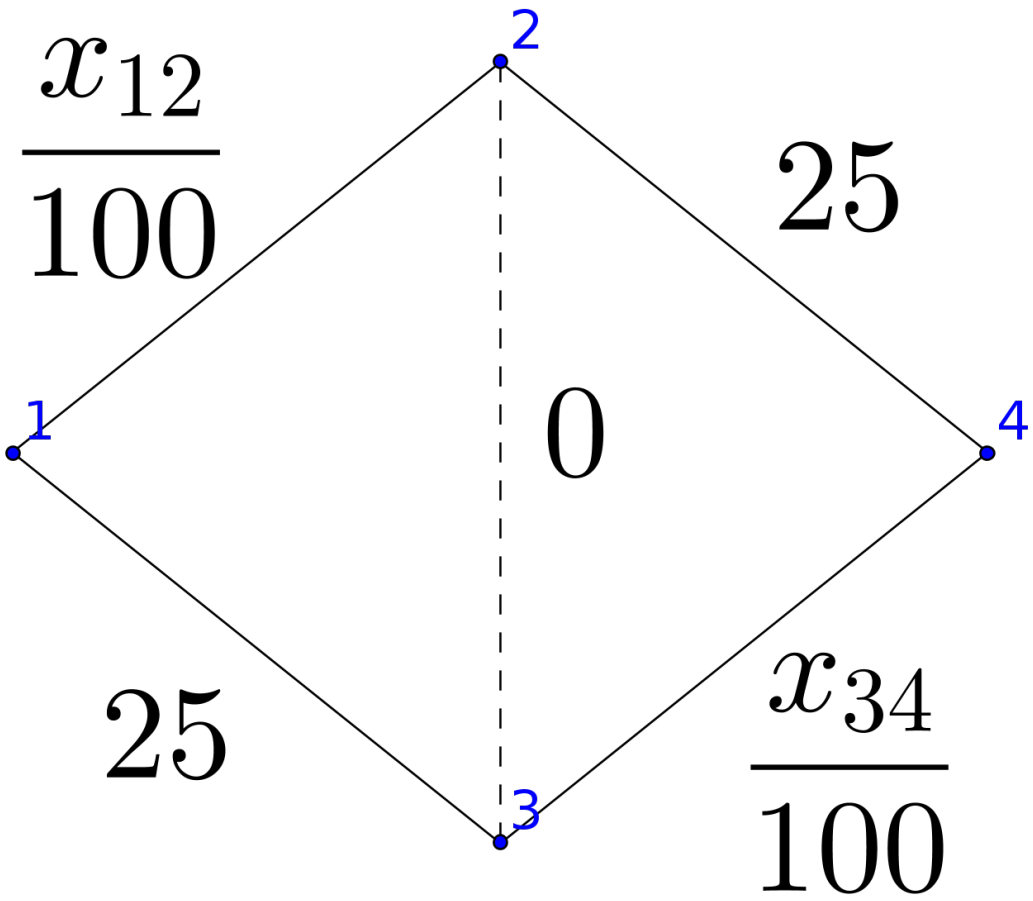


Fair Division

- One cake: two kids
- Mother decides how to divide the cake
- **Question:** ensure that each kid is happy with his/her portion?

Fair Division (Contd.)

- Kid 1 thinks he got at least half in his view
- Kid 2 thinks she got at least half in her view
- The division is "fair" – envy-free
- Notions of fairness is subjective
- If the mother knows that the kids see the division the same way as she does, the solution is simple – She can divide it and give to the children

Fair Division (Contd.)

- What if Kid 1 has a different notion of equality than that of the mother
- Mother thinks she has divided it equally
- Kid 1 thinks his piece is smaller than Kid 2's
- **Difficulty:**
  - Mother wants to achieve a fair division
  - But does not have enough information to do this on her own
  - Does not know which division is fair
- **Question:**
  - Can she design a mechanism under the incomplete knowledge that achieves fair division?

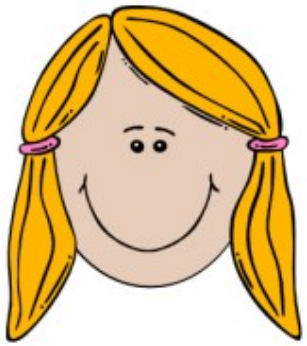
Fair Division: Solution

- Ask Kid 1 to divide the cake into two pieces
- Ask Kid 2 to pick her piece
  Why does this work?
- Kid 1 will divide it into two pieces which are equal in *his* eyes
  - Because if he does not, Kid 2 will pick the bigger piece
  - So, he is indifferent among the pieces
  - 
- Kid 2 will pick the piece that is bigger in *her* eyes
  - 

Voting

Alice

Bob



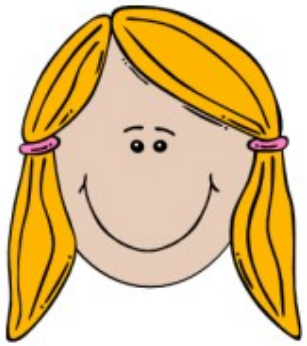
Carol

Dave

Voting

Alice

Bob



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7 voters

Voting

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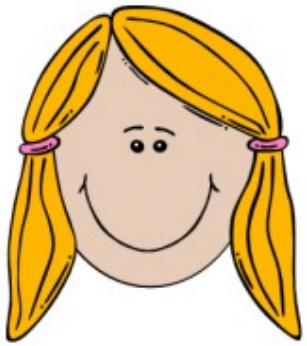


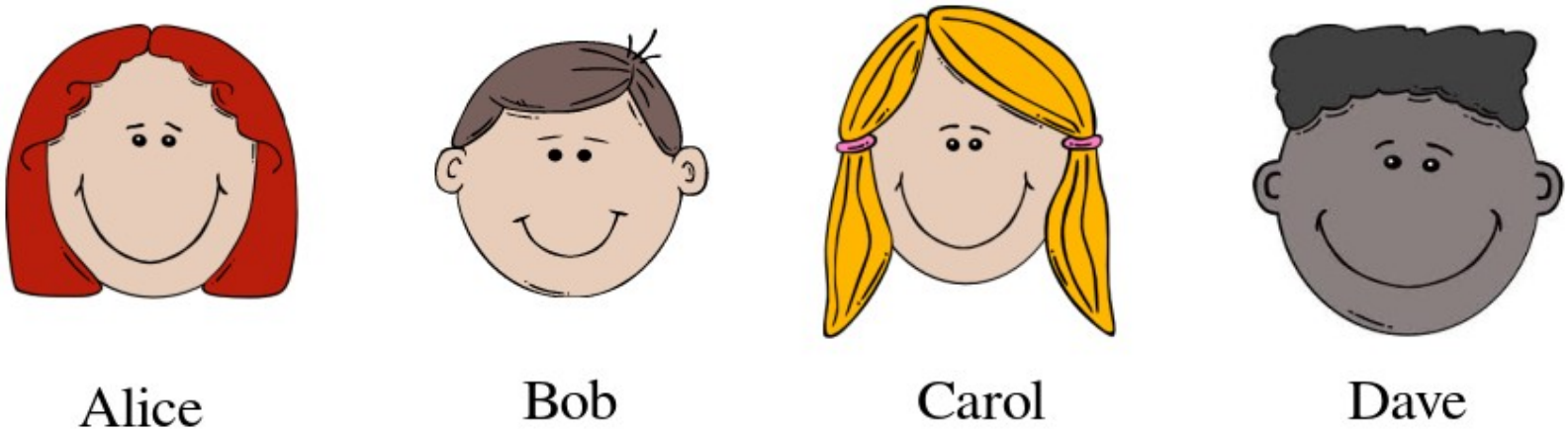
Carol

Dave

7 voters

3 voters	2 voters	2 voters
$A \succ D \succ B \succ C$	$B \succ A \succ C \succ D$	$C \succ D \succ B \succ A$

Voting



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And the winner is:

Voting

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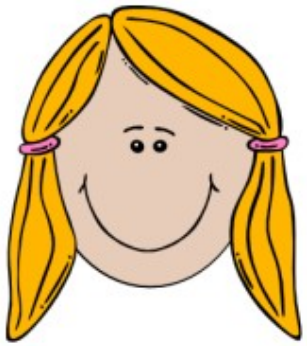

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And the winner is: A (plurality)

Voting (contd.)

$$\begin{array}{ll} 3 \text{ voters:} & A \succ D \succ B \succ C \\ 2 \text{ voters:} & B \succ A \succ C \succ D \\ 2 \text{ voters:} & C \succ D \succ B \succ A \end{array}$$

- Give each of the voters a ballot
- Ask to pick one candidate
- Run the *plurality rule*

Voting (contd.)

3 voters:	$A \succ D \succ B \succ C$
2 voters:	$B \succ A \succ C \succ D$
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- A wins!

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- Voters could be strategic
- Notice the preferences of the last 2 voters
- They prefer B over A

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Perhaps the voting rule is flawed? 

Voting (contd.)

3 voters: $A \succ D \succ B \succ C$
2 voters: $B \succ A \succ C \succ D$
2 voters: $C \succ D \succ B \succ A$

- How about a different voting rule
- Ask the voters to submit the whole preference profile
- Give scores to the ranks:
  - $m-1$ for top, $m-2$ for the next, ... , 0 to the last
  - Here $m = 4$

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- **Borda voting (1770)**
- A $= 13$, B $= 11$, C $= 8$, D $= 10$
- A wins!

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Is it manipulable?

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- **Borda voting (1770)**
- A $= 13$, B $= 15$, C $= 8$, D $= 10$
- B wins!

Is it manipulable?

Coincidence?

3 voters: $A \succ D \succ B \succ C$
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- **Question:** can we design any *truthful* voting scheme that *aggregates* all voters' opinions?

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Mark Satterthwaite

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- **Answer:** No!

Allan Gibbard

Mark Satterthwaite

Theorem (Gibbard 73, Satterthwaite 75): With unrestricted preferences and three or more distinct alternatives, no rank order voting system can be unanimous, truthful, and non-dictatorial

Why Design a Game?

- In sports: world cup football, cricket, and many more has round robin tournament, not in lawn tennis
- Teams are put in groups – every team plays each other in the group, top 2 teams advance to knock-out stages
- Is this a good tournament design?

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- QW was considered the strongest team in the tournament

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- In group A: whoever wins the group will face QW in quarterfinals – losers will face them only in the final

Similar Applications

- Combinatorial auctions – agents' preferences over combinations of items
- Matching – one sided (students to hostel rooms), two sided (candidates to universities)
- Facility location – placing a hospital / public school in a locality
- Social networks – flow of information, elicitation of private skills

Course Outline and Goals

- **Economics**: study of consumption, production and the balance between the two
- Branches – Macro and Micro
- Focus: Microeconomics – individual decisions – agents having personal objectives, central planner having a collective goal, the interaction is strategic
  - What happens in an equilibrium? Does it exist?
  - **Can the planner ensure his goal in the equilibrium?**

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- **Computer science**: representation and processing information in 'efficient' manner
- Design algorithms, analyse using mathematical tools, deploy in real world
- A lot of applications have economic flavors and those problems need different algorithm design techniques

Course Plan

- Part 1: Refresher on Game Theory

  Inverse Game Theory OR Engineering approach to Economic Theory

- Part 2: Social choice theory (mechanisms without money) – classical and computational
  with and without threats of manipulation – impossibilities
  - voting
  - matching
- Part 3: Mechanism Design with money
  Money as transferrable utility
- Part 4: **Back to Game Theory**: Cooperative Games – agents are forming teams and playing together against other groups of agents
- Part 5: Applications to real life – online advertising, recommender systems, reputation systems, prediction markets, combinatorial auctions

Take aways from this class

- Apply principles of economics and computation to
  - Understand the interplay between incentives and computation in the design of socio-economic systems
  - Develop applicable models of complex Internet systems
  - Analyze the behavior of systems that include people, computational agents, and firms, and involve strategic behavior
  - Solve both mathematical and conceptual problems involving such systems, including problems you have not seen before
  - Write programs that implement strategic agents and mechanisms

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- Build a taste for mathematical description of a social problem
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- Make a deployable AI system that does this automatically
  - As a product or a deliverable for industrial applications – building systems that are guaranteed to perform
  - Research front: push the frontiers of research with the knowledge of current state-of-the-art

Expectations

- What you can expect from us
  - We will work hard to make this course useful for you (but we cannot do the work and learn the material for you)
  - We will be available for assistance throughout the semester and look forward to meeting you in person
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- What we expect from you
  - Attend classes regularly, come to class on time, and ask questions if something is unclear
  - Return the assigned tasks, i.e., scribe notes etc., on time
  - Adopt academic integrity (see: https://www.cse.iitk.ac.in/pages/AntiCheatingPolicy.html)
  - Have a positive attitude towards learning topics of this course

Logistics

Class times and venue: Tue Fri 12.00 – 13.00, Wed 14.00 – 15.00, KD 102

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Teaching staff:

- Instructor: Swaprava Nath, office hours: by appointment, send email: swaprava@cse.iitk.ac.in with subject [CS698W]
- TA: Rahul Jain and Prem Raj
- Course homepage: https://swaprava.wordpress.com/game-theory-collective-choice/

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- Two tests – midterm and final (30% on each) and a course-project (30%)
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Virtual classroom:

- Piazza: register yourself and post questions/clarifications there – check the course homepage for details

Thank you! Questions?