

# **CS698W: Topics in Game Theory and Collective Choice**

**Teacher: Swaprava Nath**

Introduction

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1 product review

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comfortable with its Cool ...

Other size options: [Size S](#) (\$100) [Size M](#) (\$100) [Size XL](#) (\$100) [More](#)

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#BengaluruFC meet #DSKShivajians in a key encounter in #HeroLeague  
<http://www.gcsstars.com/.../bengaluru-fc-meet-dsk-shivajians-...>



**Bengaluru FC meet DSK Shivajians in a key encounter**  
With only four games left to play for, Bengaluru are a just a point behind leaders Mohun Bagan, having played two games lesser. The Kolkata side, who conceded at the death in a 2-2 draw away to Shillong Lajong on Tuesday, have now...  
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# 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
<b>Total</b>	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.<sup>[29]</sup> 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)<sup>[30]</sup> from the auction. Approximately, 11% of the spectrum available for auction remained unsold.<sup>[31]</sup>

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.”<sup>1</sup>*

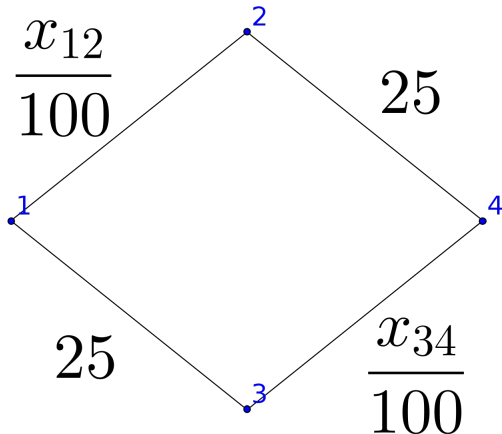
The screenshot shows the Amazon Mechanical Turk website. At the top, there's a navigation bar with links like 'Your Account', 'MTurk', and 'Qualifications'. Below this, a yellow banner states 'Mechanical Turk is a marketplace for work.' and 'We give businesses and developers access to an on-demand, scalable workforce. Workers select from thousands of tasks and work whenever it's convenient. 264,053 MTurks available. View them now.' The main content area is divided into two columns. The left column, titled 'Make Money by working on MTurks', lists benefits for workers: 'Can work from home', 'Choose your own work hours', and 'Get paid for doing good work'. It includes a diagram showing a cycle of finding an interesting task, working on it, and earning money. The right column, titled 'Get Results from Mechanical Turk Workers', lists benefits for requesters: 'Have access to a global, on-demand, 24 x 7 workforce', 'Get thousands of MTurks completed in minutes', and 'Pay only when you're satisfied with the results'. It includes a diagram showing a cycle of finding a task, assigning it, and getting results. At the bottom, there's a footer with links like 'FAQ', 'Contact Us', 'Careers at Amazon', 'Developers', 'Press', 'Policies', and 'Blog'.

The screenshot shows the Innocentive website. At the top, there's a navigation bar with links like 'My IC', 'Products/Services', 'For Solvers', 'Challenge Center', and 'Resources'. Below this, a large red handprint icon is visible. The main content area features a challenge titled 'USAID & Humanity United: How to Identify and Spotlight Intentional and Unintentional Enablers of Mass Atrocities?'. The challenge details include: 'TAGS: Computer Science/Information Technology, Public Good, Engineering/Design, Programming/Configuration', 'AWARD: \$10,000 USD', 'DEADLINE: 11/29/12', 'ACTIVE SOLVERS: 241', and 'POSTED: 10/30/12'. A red 'X' is drawn over the award amount. The challenge description states: 'Too often, the perpetrators of mass atrocities are enabled by the actions of third parties such as multinational corporations, financial institutions and others. This Challenge seeks ideas to identify and spotlight both intentional and unintentional third-party enablers of atrocities, especially those who are complicit in the'.

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

# Traffic Routing

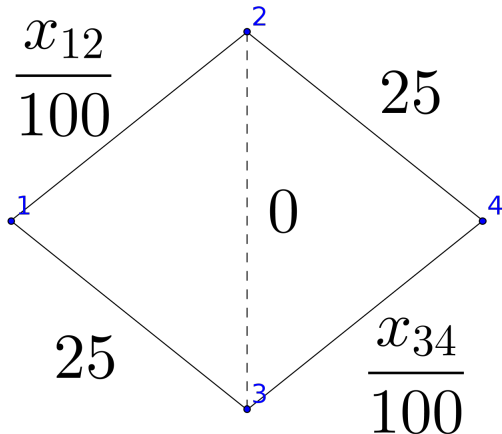
2000 cars every day travels from node 1 (source) to 4 (destination)





# Traffic Routing

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



# 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
  - ▶ 😊

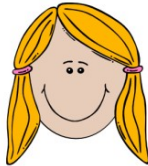
# Voting



Alice



Bob



Carol



Dave

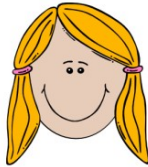
# Voting



Alice



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Carol



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7 voters

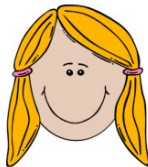
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Alice



Bob



Carol



Dave

7 voters

3 voters

$A \succ D \succ B \succ C$

2 voters

$B \succ A \succ C \succ D$

2 voters

$C \succ D \succ B \succ A$



# Voting



Alice



Bob



Carol



Dave

7 voters

3 voters

$A \succ D \succ B \succ C$

2 voters

$B \succ A \succ C \succ D$

2 voters

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**And the winner is:**

# Voting



Alice



Bob



Carol



Dave

7 voters

3 voters

$A \succ D \succ B \succ C$

2 voters

$B \succ A \succ C \succ D$

2 voters

$C \succ D \succ B \succ A$

**And the winner is: A (plurality)**

## Voting (contd.)

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

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

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

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

## Voting (contd.)

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

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

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- Run the *plurality rule*
- A wins!

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3 voters:  $A \succ D \succ B \succ C$   
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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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- $A = 13$ ,  $B = 15$ ,  $C = 8$ ,  $D = 10$
- **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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Allan Gibbard



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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- Trigger: Danish team of Pedersen and Juhl (PJ) beat the Chinese team of Qing and Wunlei (QW) – in group D
- 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
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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
  - ▶ We will do our best to promptly answer your questions – via Piazza
  - ▶ We will listen to constructive comments and be open to suggestions

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  - ▶ We will be available for assistance throughout the semester and look forward to meeting you in person
  - ▶ We will do our best to promptly answer your questions – via Piazza
  - ▶ We will listen to constructive comments and be open to suggestions
- 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](mailto: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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## Evaluation:

- Two tests – midterm and final (30% on each) and a course-project (30%)
- Scribing at most 2 lectures – the assignment will be done after the late registration deadline is over – details in the course homepage – 10%

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## Virtual classroom:

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

**Thank you! Questions?**