Algorithmic Game Theory

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General Information

Winter 2019/20

What is this course about?

Dynamic systems with rational users and interaction, e.g.

- Rational Behavior, Incentives, and Stability in Resource Allocation (in Computer Networks)

- Mechanism Design, Allocation, and Pricing in (Online) Markets (Auctions, Sponsored Search, Platform Markets...)

- Algorithmic Aspects of Social Networks

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- ... a variety of **mathematical tools** for analysis.

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We study **algorithmic optimization** and **search problems** in game theory and foundational models for applications.

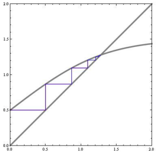
Topics and Applications

Traffic Routing

- Users are units (e.g., cars or packets)
- Each user routes in a selfish way
- Is there a stable routing they agree upon?
- What if users dynamically react to delays?

Convergence and Learning

- What is a natural behavior for rational agents?
- Does such behavior lead to convergence?
- How long does it take to converge?
- Can agents learn to play optimal and stable?



Topics and Applications

Matching and Allocation with Preferences

- Users strive to match up in pairs (Dating, Kidney exchange, etc)
- They have preferences over their matches
- Does a stable matching exist?
- Can it be computed efficiently?

Market and Mechanism Design

- Selling and Buying of Goods and Services
- Dynamic arrival of market participants
- Design good (online) allocation algorithms
- Avoid manipulation of users

Methods and Analysis

We are interested in properties, models and algorithms for scenarios involving dynamic decision making.

- **Stability:** Is there a stable state in a system?
- **Learning:** What if users use learning to adapt their actions?
- **Convergence:** Does the interaction of users lead to stability?
- **Design:** How to optimize in the presence of incentives and uncertainty?
- Approximation Algorithms and Computational Complexity

This is a **theory course**, so...

- Fundamental models capturing the essence of competition
- Agent behavior governed by game-theoretic assumptions
- Analysis of equilibrium properties and algorithm design
- Mathematically rigorous analysis by proving lemmas and theorems

Organizational

- Prerequisites:
  Introductory-Level Background in Algorithms, Graphs, Probability, and Linear Programming.
- Course sessions on Tue + Thu, 10:15am - 11:45am in H9.
- Lecture will mostly be given by writing on the board.
- Course Webpage:
  Algorithms & Complexity → Lehre Winter 19/20 → AGT

Organizational

- Teaching Assistant: Daniel Schmand
- Exercises every week.

- Sheet published online on Tuesday of week i.
  (first sheet: next week, Oct 22)
- Solutions due Tuesday week $i+1$, **before 10:15am**.
  (lecture hall or mailbox between office 115 and 116, RMS 11-15).
- Discussion in week $i+2$.

- Solutions can be discussed, but must be **written down individually**.
- 50% - 75% of total points $\rightarrow$ one step (e.g. 3.3 $\rightarrow$ 3.0, 1.7 $\rightarrow$ 1.3)
- $\geq$ 75% of total points $\rightarrow$ two steps (e.g. 3.3 $\rightarrow$ 2.7, 1.7 $\rightarrow$ 1.0)