

Algorithmic Game Theory

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CSCI 1440/2440

Game Theory

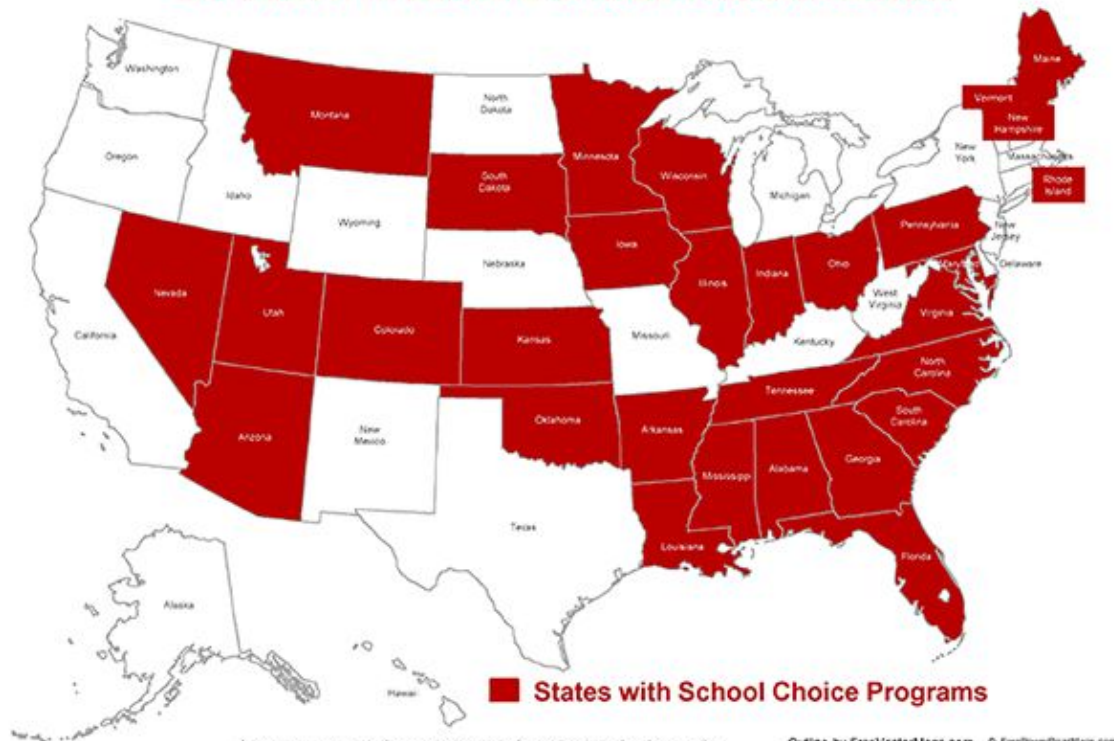
- Used to model multiagent interactions (multiagent systems)
 - Participants (agents, players, etc.) have partially competing & partially cooperative interests
 - Economics: agents are people, countries, etc.
 - AI: softbots, robots, etc.
- **Q:** How do agents play games?
- If we assume agents behave rationally, then **A:** equilibrium (stable outcome)
 - Computational game theory: algorithms that solve for equilibrium in games
 - Game-theoretic machine learning: learning algorithms that converge to equilibrium in games

Mechanism Design

- Inverse Game Theory
- Given assumptions about how agents play games (e.g., rationality), the goal is to design games that achieve a desired objective:
i.e., whose equilibria satisfy certain properties
- Typical approach: design games that are straightforward to play:
e.g., games with unique equilibria
- In practice: this goal is difficult to achieve
- Why? Because the agents' preferences are unknown, and must be elicited

School Choice

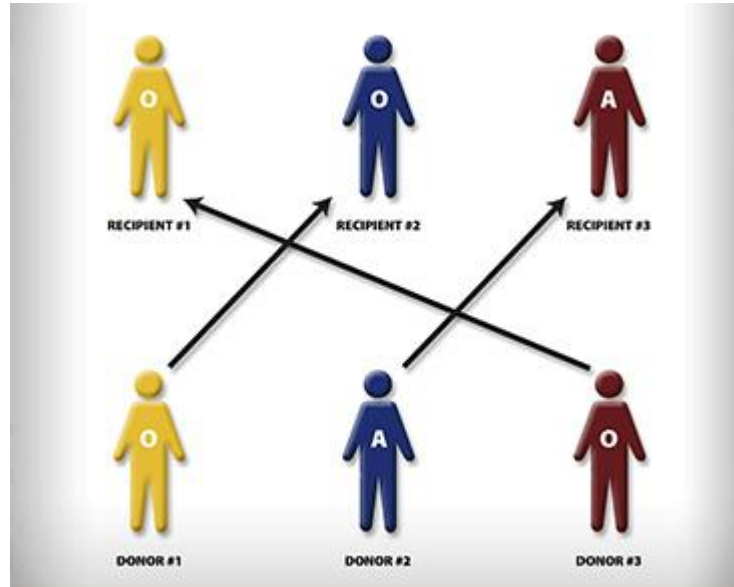
STATES WITH SCHOOL CHOICE PROGRAMS 2016



School Choice

- Milton Friedman
- Students: rank (a subset of) schools
- Schools: “rank” students (neighborhood, siblings, etc.)
- Objective: make students happy, make schools diverse, etc.
- Matching algorithm
 - Stable marriage
 - Gale & Shapley
- Are these mechanisms truthful?

Kidney Exchanges



Kidney Exchanges

- Al Roth
- An exchange announces a matching algorithm to find compatible kidneys for people whose donor's kidney is incompatible with theirs.
- Hospitals report incompatible donor-recipient pairs (e.g., blood type mismatch).
- Objective: to facilitate as many trades as possible.
- Matching algorithm
 - Stable marriage
 - Gale & Shapley
- Are these mechanisms truthful?

Auctions



Auctions

- An auction for some goods is announced.
- Bidders report their willingness to pay for the goods.
- Bidders' values for the goods are their private information.
- Utilities are the difference between the value to bidders of what is allocated to them and what they pay.
- An “optimal” auction is one that extracts maximal total payments from the participants.
- Another common objective (especially in government auctions) is to maximize social welfare.

Computational Advertising: Sponsored Search Auctions

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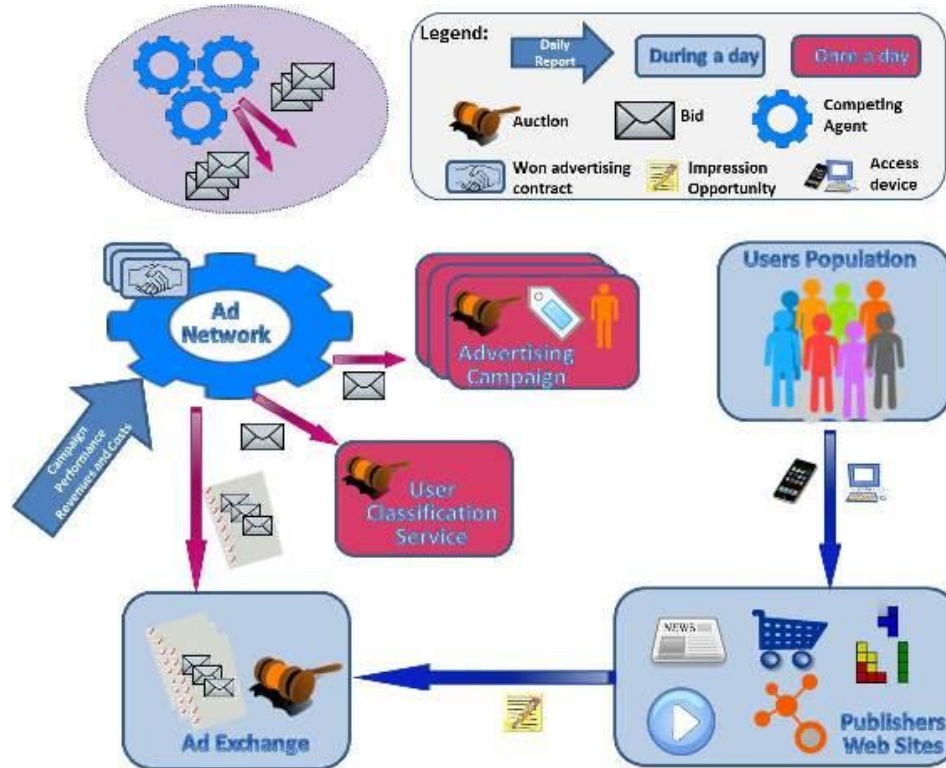
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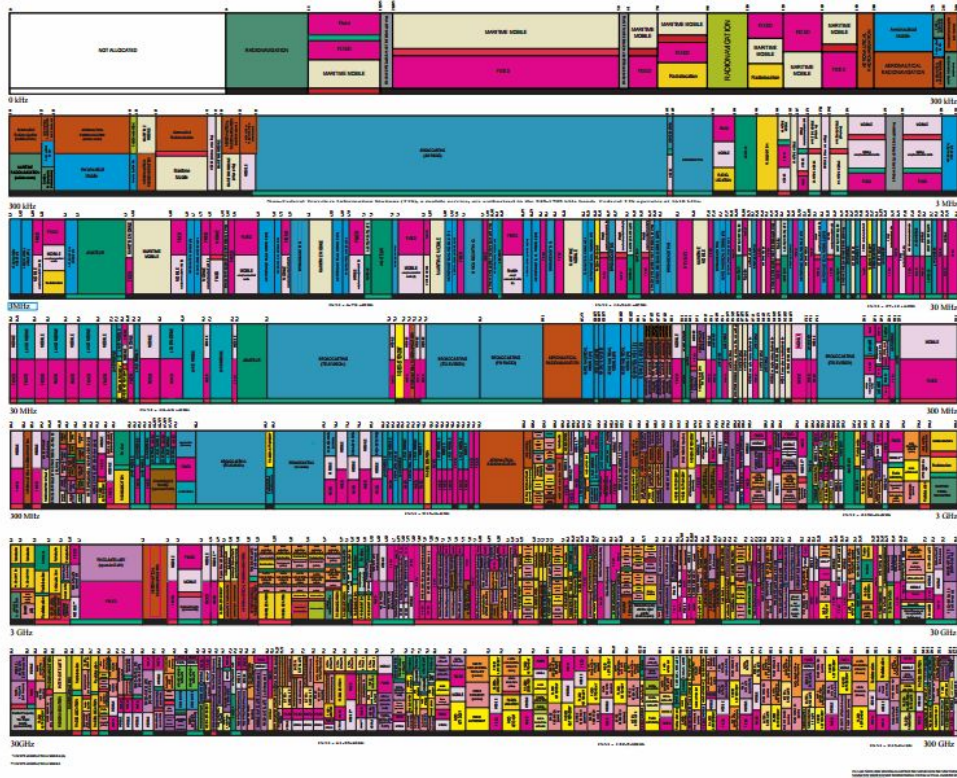
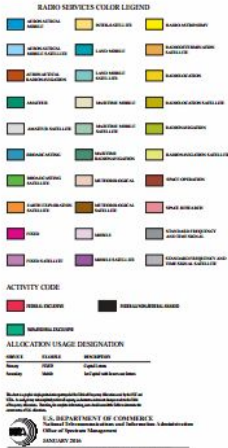
Computational Advertising: Ad Exchanges



Spectrum Auctions

UNITED STATES FREQUENCY ALLOCATIONS

THE RADIO SPECTRUM



Spectrum Auctions

- All wireless communication signals travel over the air via radio frequency: a.k.a. spectrum
- No two radio or TV stations transmit data over the same spectrum at the same time in the same area, because doing so would cause interference!
- Ditto for wireless communication: wireless operators also cannot transmit wireless signals over the same frequency at the same time in the same area
- Combinatorial resource allocation problem, because providers have preferences over sets of goods (e.g., MA, RI, and CT; or CT, NY, and NJ)
- Combinatorial auctions
 - 1990 New Zealand: simultaneous second-price auctions
 - 1999 Germany: simultaneous first-price auctions