Algorithm Design

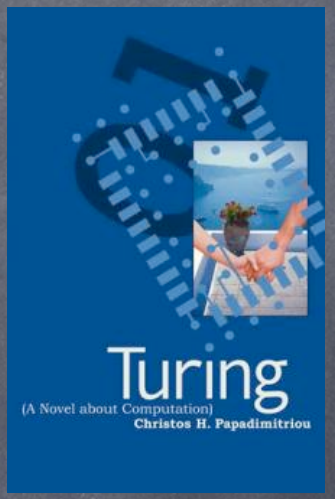
- Formulate the problem
- Design an algorithm
- Prove it is correct
- Analyze its running time

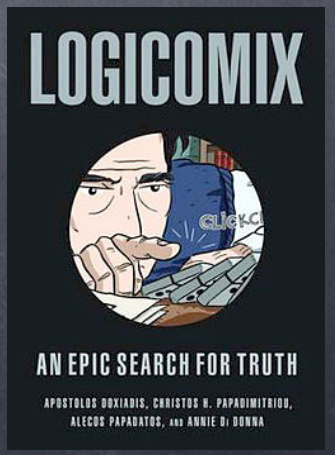
Topics we have not explored

- Problems not in NP: planning, chess
- Approximation algorithms
- Parallel algorithms

The Algorithmic Lens

- The Algorithmic Lens: How the Computational Perspective is Transforming the Sciences
- Christos Papadimitriou
  - Main premise: algorithmic thinking contributes to our understanding of the world, NOT just solving problems on computers
  - Eight vignettes about algorithmic thinking in math, physics, biology, economics and social science





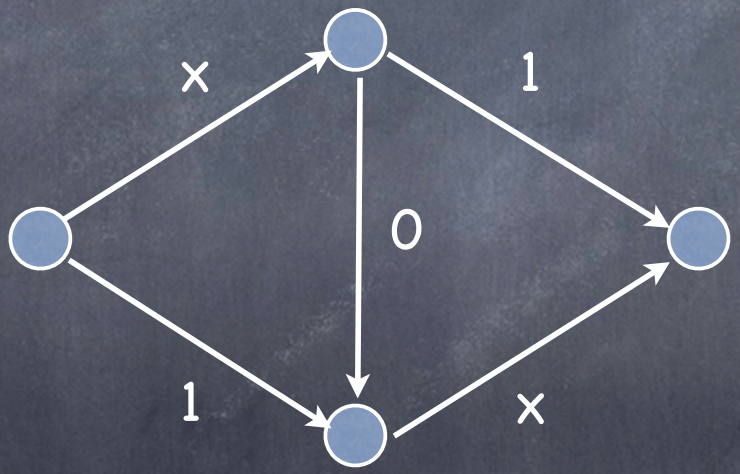
Vignettes

- Stable Matching: match doctors to hospitals
- Top-Trading Cycles: match kidneys to patients
- Six-degrees of separation: an algorithmic perspective [Kleinberg]
- Why would closing Broadway improve traffic in NYC?

Shapley & Roth, 2012 Nobel Prize

Braess's Paradox

- Selfish routing can hurt!



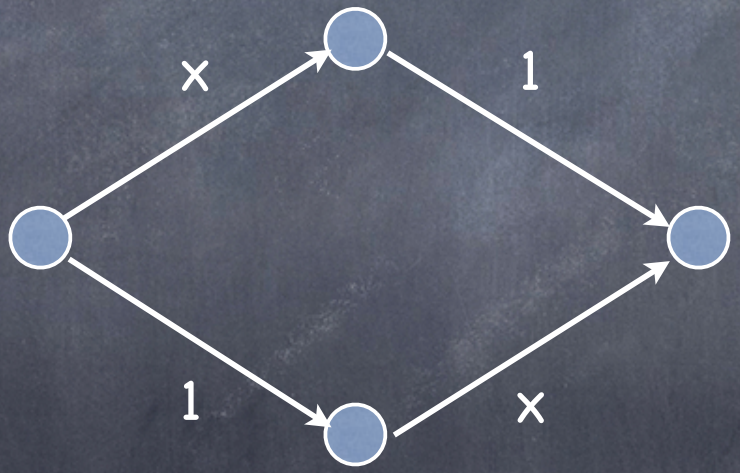
Average delay

Selfish: 2

Optimal: 1.5

Braess's Paradox

- Removing a shortcut can help!



Average delay

Selfish: 1.5

Optimal: 1.5

Broadway

NYC DOT

This "before" view of Times Square shows a streetscape that is not very friendly to pedestrians and bicyclists.

NYC DOT

This "after" shot of Times Square shows an area that is inviting to residents and visitors alike.

2009: Experimental road closures in NYC reduce congestion

Price of Anarchy

- Theorem [Roughgarden and Tardos, 2000]:

$$\frac{\text{cost of selfish equilibrium}}{\text{“socially optimum” cost}} \leq 4/3$$

- (i.e., “Price of Anarchy” = 4/3)
- One example of how computational game theory is shedding light on economics

Discussion

- What will you see differently through the algorithmic lens?
- Will you use this material again? Where?
- What are your favorite algorithmic ideas?

Thank You!!

(and please fill out evaluations!)