Computer Networks: Algorithms in networking

Ankit Singla
Where we are in the course ...

Part 1: Overview & Principles

Part 2: Applications

Part 3: Transport

Part 4: Algorithms
Algorithms in networking

#0 Three example algorithmic problems in networking

#1 Linear programming: a powerful, generic tool

#2 Exploiting randomness for networking

#3 Distributed decision-making
Algorithms in networking

#0  Three example algorithmic problems in networking

#1  Linear programming: a powerful, generic tool

#2  Exploiting randomness for networking

#3  Distributed decision-making
Traffic engineering
Maximum traffic from S to T?

[Example adapted from Amir Ali Ahmadi, Princeton]
My first attempt

3 + 2 + 2 = 9
Improve it: you have 5 minutes!
Maximum possible = 11
Maximum possible = 11
Try a larger graph …
Destroying an enemy rail network …

“… a method intended to help the specialist who is engaged in estimating railway capabilities, so that he might more readily accomplish this purpose …”

- RAND, 1954 [Declassified: 1999]
The Internet is today’s critical infrastructure!
The maximum-flow problem

Max-flow: how much traffic can a network carry?

Min-cut: how reliable is a network?
  • How many edges do I have to remove to break it?

Max-flow and min-cut duality

Ford-Fulkerson / Edmonds-Karp
  • You should know at least one of these!

What if there are many sources / destinations?
Many sources, destinations
Add a “fake” source
... and a “fake” destination
Many different flows?

Multi-commodity flow (MCF)
Common problem in networking!

Scenario A: You are an ISP

- Swisscom, DT, Level 3, …
- Many customers
- No control over sources, destinations
Common problem in networking!

Scenario B: Between your own data centers

- Microsoft, Google, Facebook …
- Control sources, destinations — additional flexibility!
Matchings & circuits
How many simultaneous circuits?

Each node has at most one circuit
How many simultaneous circuits?

Each node has at most one circuit
How many simultaneous circuits?
How many simultaneous circuits?
Inside a circuit switch

[Patent US6445841 B1]
How many simultaneous circuits?

Each node has at most one circuit
You can adapt max-flow to this!
Shortest paths
Shortest path from S to T?
Shortest path from S to T?
Shortest path from Zürich to London?