Overview

Lecture 1

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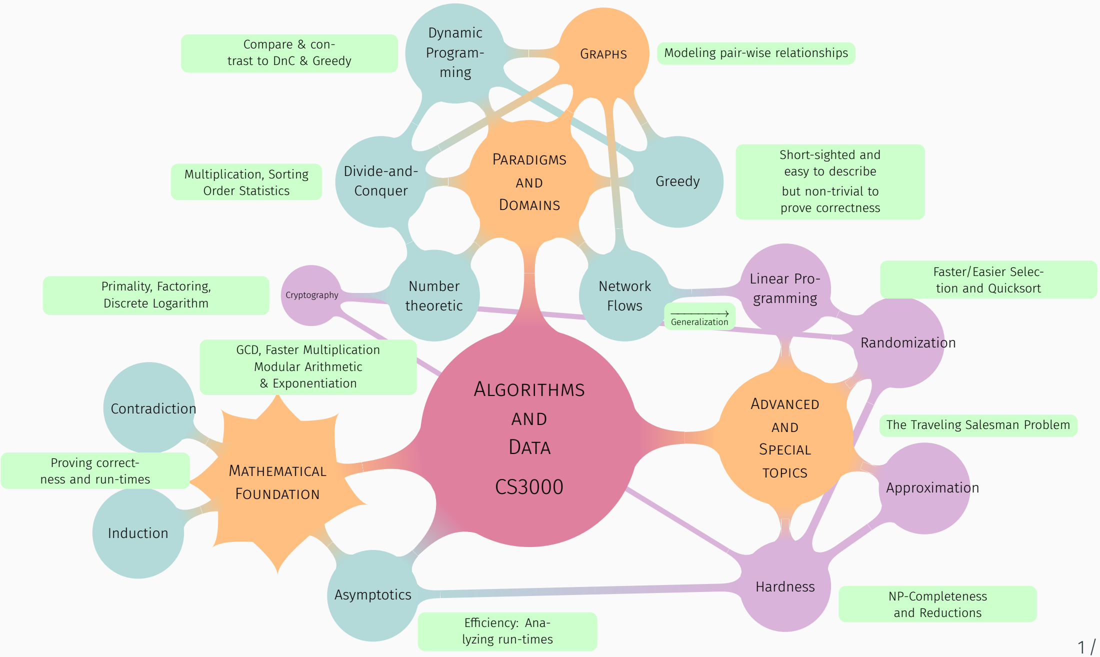
CS3000 Algorithms and Data

Map of CS3000 Algorithms Landscape

Goals and expected outcomes

1. Map of CS3000 Algorithms Landscape

“Algorithms are the computational content of proofs.” — Robert Harper, Benjamin C. Pierce et al.


Algorithms and Data
CS3000
Paradigms and Domains
Graphs
Modeling pair-wise relationships
Dynamic Programming
Compare & contrast to DnC & Greedy
Divide-and-Conquer
Multiplication, Sorting Order Statistics
Greedy
Short-sighted and easy to describe but non-trivial to prove correctness
Number theoretic
Cryptography
Primality, Factoring, Discrete Logarithm
GCD, Faster Multiplication Modular Arithmetic & Exponentiation
Network Flows
Generalization
Linear Programming
Faster/Easier Selection and Quicksort
Randomization
Advanced and Special topics
The Traveling Salesman Problem
Approximation
Hardness
NP-Completeness and Reductions
Mathematical Foundation
Contradiction
Proving correctness and run-times
Induction
Asymptotics
Efficiency: Analyzing run-times

2. Goals and expected outcomes

Course Goals

Algorithms:

- Well-specified procedure (recipe) for turning some *input* into some *output*.
- Efficiency in terms of resource constraints like time and space; parameterized by size of input (typically denoted using n).

This course will focus on

- various algorithm design strategies;
- proving correctness of algorithms;
- and analyzing efficiency (run-time) of algorithms.

Learning Outcomes

- **Create and Validate:** Efficient/performant algorithms for unseen but “everyday” problems.
- **Compare and Choose:** Among different algorithmic paradigms to choose most appropriate strategy.
- **Analyze and Evaluate:** Problem statements and constraints to determine their impact on algorithm design.
- **Modify and Employ:** Known algorithms and examples to new scenarios.
- **Research and Select:** Existing algorithms/implementations based on resource constraints.
- **Read, Examine, Recognize and Duplicate:** Algorithm descriptions given a reasonable amount of detail.

Drone Drop Durability

- *Question:* From what height can a drone fall without breaking apart?
- We want height $x \in \{1, 2, \ldots, n\}$ such that drones break when falling from height $\geq x$. There is a known maximum height n after which the drone definitely breaks.

- *Test setup:* Try dropping a drone from height h, if it breaks, $x \leq h$ otherwise $x > h$.
- Assume that repeated dropping doesn't harm drone at all. No RSI (Repetitive Strain Injury).

- We'll look at what's minimum drops needed to find x when:
    1. No limit on number of drones. If one breaks, use next.
    2. There is only one test drone. If it breaks, you're done.
    3. There are two test drones. You have a *single* spare.

Drone Drop Durability – solutions (derived in-person)

1. No limit on number of drones. If one breaks, use next.

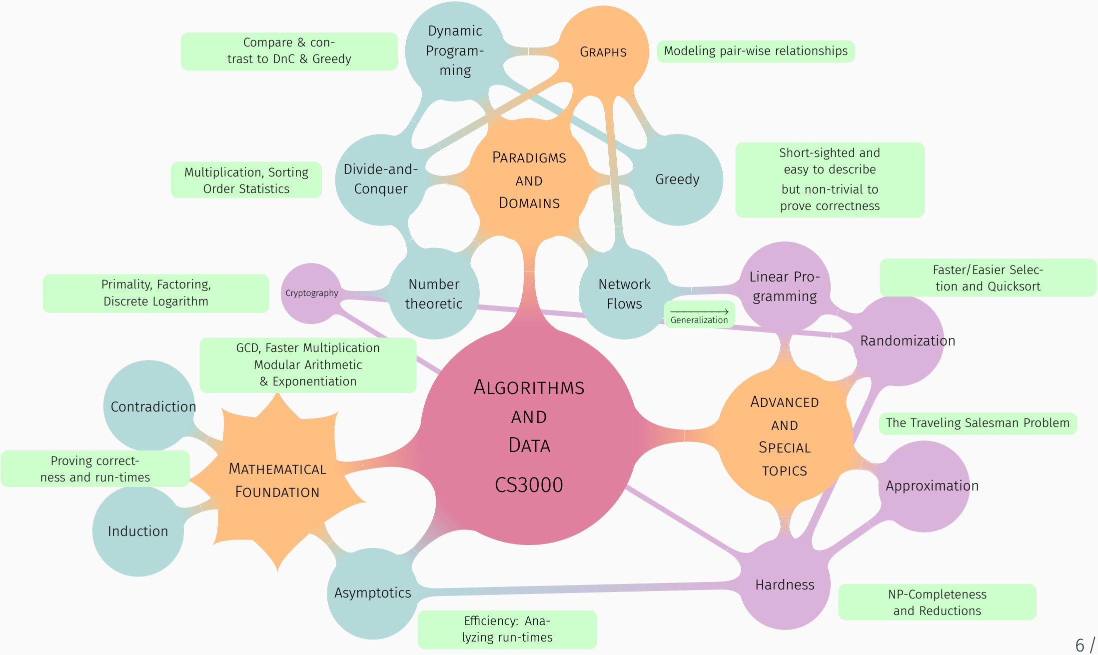
   Binary search.
   Need potentially $\log n$ drones, but drops also bounded by $\log n$.

2. There is only one test drone. If it breaks, you're done.

   Cannot do better than testing heights one by one. Potentially need n drops.

3. There are two test drones. You have a single spare.

   Use bracketing/binning. First drone tries at multiples of $\sqrt{n}$. Whenever it breaks, we have found a $(i \cdot \sqrt{n}, (i+1) \cdot \sqrt{n}\,]$ bracket/bin in which to test spare drone.



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