CS 466 Fall 2004
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Outline

Below is a list of topics to be covered in the class, along with relevant chapters and sections in the readings on reserve (full details of the names of sources are available on the Web). Listings for CLR refer to the old edition and for CLR2 refer to the new edition. The outline may not correspond exactly to what is covered in class; depending on time, topics may be added or deleted.

1. Invent or augment a data structure
   (a) Binomial heaps
      - Problem 1: Single-source shortest paths [CLR, CLR2 25.2]
      - ADT mergeable heap [CLR 20; CLR2 19]
      - Using a binary heap data structure [CLR 20; CLR2 19]
      - Binomial trees [CLR 20; CLR2 19]
      - Binomial heaps [CLR 20; CLR2 19]
   (b) Amortized analysis
      - Review of three methods of analysis [CLR 18; CLR2 17]
      - Dynamic tables [CLR 18; CLR2 17]
   (c) Fibonacci heaps [CLR 21; CLR2 20]
   (d) Disjoint sets (union/find)
      - Problem 2: Connected components [CLR 22.1; CLR2 21.1]
      - ADT disjoint set [CLR 22.1; CLR2 21.1]
      - Disjoint-set forests [CLR 22.3; CLR2 21.3]
      - Union by rank [CLR 22.4; CLR2 21.4]
      - Path compression [CLR 22.4; CLR2 21.4]
2. Lower bounds
   (a) Information theory lower bounds
      - Sorting
      - Decision trees [BG 1.6.4], [BB 12.2], [BB 12.2.1]
      - Haase diagrams
      - Information theory lower bound [BG 1.6.4]
   (b) Adversary lower bounds [BG 5.1.3], [BB 12.3]
      - Adversary strategy for sorting
   (c) Reductions [BB 12.4]
      - Integer problems [BB 12.4.1]

- Matrix problems [BB 12.4.2]
- Primality testing?
- Reductions involving sorting

(d) Lower bounds for selection problems

- Adversary lower bound for max and min [BG 5.2]
- Reduction lower bound for median
- Adversary lower bound for selection [BG 5.5]

3. Approximations

- Definition of optimization problems, NPO, PO
- Types of error (absolute error, performance ratio, relative error) [H 0.1]
- Classes: APX, Max-SNP [H 10.3.1]
- Approximation-preserving reductions [H 10.1]
- Approximations schemes, PTAS, FPTAS [H 0.2]
- Paradigm 1: partitioning
- Example: scheduling
- Graham's list scheduling [H 1.1]
- Paradigm 2: local search
- Example: maximum cut

4. Parameterized complexity [DF][Mars]

- Definitions [DF 1,2]
- Relation to approximation algorithms [DF 4.2]
- Bounded search trees [DF 3.1]
- Reduction to a problem kernel [DF 3.2]

5. Randomized algorithms

(a) Framework for randomized algorithms

- Models of computation [MR 1.5.1]
- Types of error [MR 1.2], [K 3.1],
- Types of analysis [BB 10.3]

(b) Monte Carlo algorithms [BB 10.6]

- Example 1: min-cut [MR 1.1, 10.2]
- Amplification of probabilities [BB 10.6.4]
- Example 2: primality testing [MR 14.6], [K 3.2], [BB 10.6.2]
- Technique 1: abundance of witnesses

- Technique 2: fingerprinting [MR 7.1]
- Example 3: verifying matrix multiplication [MR 7.1], [BB 10.6.1]
- Example 4: string matching [MR 7.4, 7.6], [K 5]
- Conversion to Las Vegas

(c) Las Vegas algorithms

- Example 1: game tree evaluation [MR 2.1]
- Technique 3: foil adversary
- Example 2: selection [MR 3.3], [K 6.1], [BB 10.7.2]
- Technique 4: random sampling
- Example 3: sorting [MR 1], [K 6.2], [BB 10.7.2]
- Yao's minimax principle [MR 2.2.2]

(d) Other topics

- Complexity classes [MR 1.5.2]
- Interactive proof systems [MR 7.7], [K 10]

6. Online algorithms

- Introduction and ski rental example [H 13.1]
- Paging, LRU [H 13.2.1], [MR 13.1]
- Competitive analysis [H 13.1], [MR 13.1]
- Upper bound techniques [H 13.3.2]
- Lower bound for paging [H 13.3.1], [MR 13.1]
- Potential function technique [H 13.3.3.1]
- LRU cost [H 13.1]
- Adversaries for randomized algorithms [H 13.4], [MR 13.2]
- Randomized Marker algorithm [H 13.4.1], [MR 13.3]
- The k-server problem [H 13.2.2]
- Lower bound for k-server [H 13.3.1]
- Balance algorithm [H 13.3.2.2]