CISC 320 Introduction to Algorithms Fall 2005

Review for final exam

Topics Covered

- Algorithm design paradigm: Greedy, Dynamic Programming, and parallel computing
- Algorithms covered:

  Algorithms on graphs
  Breadth-first search
  Depth-first search
  Topological sort
  Strongly connected components
  Minimum spanning trees
    Kruskal's algorithm
    Prim's algorithms
  Single source shortest path
    Dijkstra's algorithm
  All-Pair Shortest Path
    Floyd-Warshall

  Matrix chain multiplication

Parallel algorithms: CREW PRAM, CRCW (Common-Write) PRAM
  Max
  Logic OR

NP-Completeness

P: can be solved in polynomial time.
NP: solution can be verified in polynomial time.

NP-complete: as hard as any problem in NP. Known NP-complete problem can be polynomially reduced to this problem.

COOK's theorem

Polynomial reduction -- problem A to problem B: Shows B is hard.
If A is NP-complete and B is in NP, a polynomial reduction of A to B proves B is NP-complete too.

Method: Take any input x for A. Use it to construct an input y for B, such that
(1) the size of y is a polynomial in the size of x, and
(2) the correct A answer for x is true if the correct B answer for y is true and
(3) the correct B answer for y is true if the correct A answer for x is true.

How to prove a problem is in NP.
How to prove a problem is NP-complete

Familiarity with some well-known NP-complete problems:
CNF-SAT, CLIQUE, Vertex cover, Graph Coloring, Hamiltonian-Cycle, TSP (Traveling Salesman Problem).

Approximation algorithms
- approximation ratio
- TSP, Max-3-cnf-sat

Format of Exam

- The exam is closed book and notes. The exam will have a heavy emphasis on understanding and applying the concepts.

- There will be four problems.

Example questions:

- Describe an algorithm, e.g., Prim's algorithm for MST. (Main ideas, key data structure, and time complexity)
- Identify structural properties/features of a graph
  - SSC, topological order, DFS trees, MST, ..
- Show intermediate steps of running an algorithm.
  - What is next vertex Prim's algorithm will visit.

- Dynamic programming
  - Concepts (e.g., optimal solution to the problem can be composed by optimal solutions to the subproblems)
  - Procedure (find the recurrence equation, fill out the DP table, and do traceback)
  - Applications (matrix chain multiplication, e.g., hw5 q1)

- NP-complete
  - Concepts: P, NP, NP-Complete, NP-hard, polynomial reduction
  - Describe well-known NP-complete problems (decision/optimization)
  - Given a problem, prove it is NP complete
  - Given problems A and B, prove A is no harder than B: $A \leq_p B$

- Parallel algorithms
  - Description of PRAM
  - Definition of Class NC
  - Design parallel algorithms that solve a given problem using specified model (or variations).