Introduction to Competitive Programming

What is Competitive Programming

- A mind sport
- Solving a set of problems
  - Often related to computation, algorithms and data structures
    - Most of the contestants are EECS students.
    - Some problems are also used for job interview.
  - By using programming languages
    - C++ is the most popular choice.
  - With certain restrictions and limited resources
    - Time
    - Memory
    - Length of code

International Collegiate Programming Contest

- The most important collegiate programming contest.
- Multi-layer
  - World Finals
  - League Championship or Playoff Round (2020/12/21~23 @Hanoi)
  - Regional Contest (2020/10/31-11/2 @NTUB)
  - Preliminary Contest
    - Taiwan Online Programming Contest (expected host: NCTU)
    - National Contest for Private Universities
    - National Contest for Technology Universities

ICPC-Style Contests

- 3 contestants form a team
  - Share one computer
- Typically 5 hours
  - Some preliminary contests only last for 3 or 4 hours
- 8 to 13 problems
  - No partial credit
- Penalty:
  - (minutes passed after begin) + 20*#(unsuccessful submission before accepted)
- Winner solve most problems
  - Tie-breaker: least total penalty, then earliest last solution.

National Collegiate Programming Contest

- The most important domestic ICPC-style contest in Taiwan.
- At most 6 teams per university in the final.
- The NCTU representatives are selected by NCTU annual programming contest.
  - Expected time: 1 week before 2020 fall semester
  - Must commit at least 5 hour for team practice per week in the contest season
  - Being the top 2 universities in Taiwan in recent 5 years.

Open Contests

- Google Code Jam
  - Kickstart
  - Google Code Jam to I/O for women
- Facebook Hacker Cup
- TopCoder
- CodeForces
- AtCoder

Online Judges

- UVa
- Kattis
- CodeForces
- AtCoder
- vjudge
- NCTU OJ

Contest Problem

- Description
- Input Format
- Output Format
- Specification
  - Input size
  - Time limit
  - Memory limit
  - Output limit
  - Compilation limit

Judge Responses

- Yes / Correct / Accepted
- CE: Compilation Error
- WA: Wrong Answer
- TLE: Time Limit Exceeded
- RE: Run Time Error
- MLE: Memory Limit Exceeded
- OLE: Output Limit Exceeded

Sample Problem: 3n+1 (UVa 100)

- https://onlinejudge.org/index.php?option=onlinejudge&Itemid=8&page=show_problem&problem=36

Sample Problem: n-Queens

- https://onlinejudge.org/index.php?option=onlinejudge&Itemid=8&page=show_problem&problem=691

Computational Complexity

- Time complexity
  - TLE
- Space complexity
  - RE or MLE
- Descriptive complexity (Kolmogorov complexity)
  - Too late
- Communication complexity
- Circuit complexity

Word RAM Model

- RAM = Random Access Machine
  - Turing machine is not a RAM.
- Word RAM
  - Access a w-bit word with a single operation
  - Perform bitwise operations, including addition and shift, in constant time
  - U, the number of possible values, is bounded by 2^w.
- We assume word RAM model in this class.
  - Sometimes, we also assume multiplication and division can be done in constant time.

Asymptotic Notations

- Big-Oh: $f(n)=O(g(n))$
- Little-Oh: $f(n)=o(g(n))$
- Theta: $f(n)=\Theta(g(n))$
- Big-Omega: $f(n)=\Omega(g(n))$
- Little-Omega: $f(n)=\omega(g(n))$

Sample Problem: Josephus Problem

- https://en.wikipedia.org/wiki/Josephus_problem

Sample Problem: Majority Vote

- **Description**
  Suppose you are given n numbers a_1, …, a_n. More than half of them equal x. Please write a program to find out the value x.
- **Input format**
  The first line of the input contains an integer n, and the second line contains n numbers a_1, …, a_n separated by blanks.
- **Output format**
  Output x on a line.
- **Specification**
  a_1, …, a_n are 32-bit integers, and $n < 10^7$. Time limit is 1 second, and memory limit is 50 megabytes.