Competitive Programming

An introduction to the art...

University of Engineering and Technology UTEC

April 11, 2020

Introduction

What is Competitive Programming?

- It's a sport... a **mind sport**.
- It's simple: Participants are given problems and they have to create computer programs to solve them.
- The most important part is the **idea** behind the solution, not the program itself.
- There are many *paradigms* to solve problems, we will learn more about these later...

What is the ICPC?

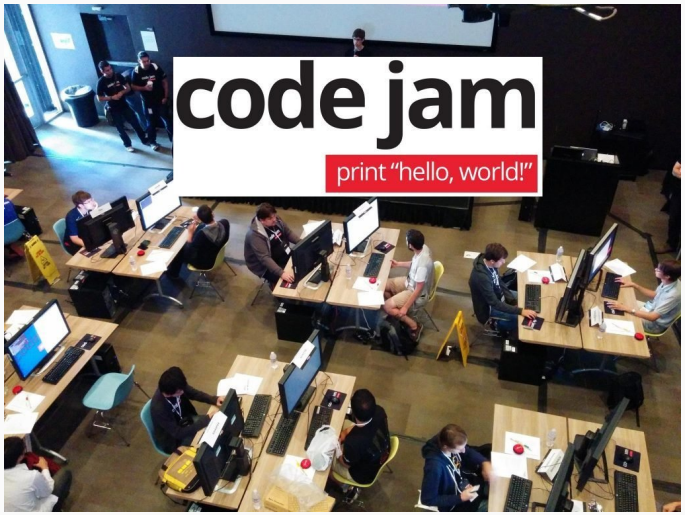
- **I**nterntational **C**ollegiate **P**rogramming **C**ontest
- Thousands of students from around the globe participate every year and attempt to became #1 in the world.
- Two rounds: Regionals $\rightarrow$ World Finals

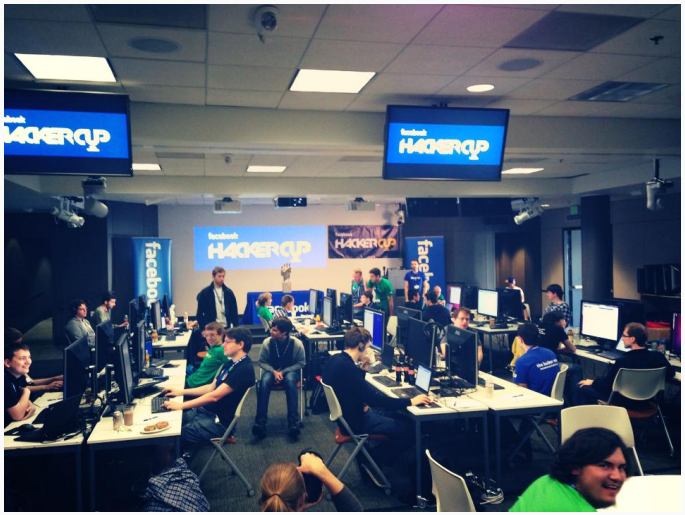
"Quite simply, it is the oldest, largest, and most prestigious programming contest in the world."

- ICPC Webpage

Other Competitions

- Google's Code Jam
- Facebook Hacker Cup
- IEEEXtreme
- TopCoder Open





Virtual Judges

- It is impossible that a human checks all of the users submissions.
- Virtual Judges (VJ) are the ones in charged of validating the correctness of your solution.
- They will run a lot of test cases with your code to make sure it **ALWAYS** work.

Useful Platforms

- Codeforces - `https://codeforces.com`
- Codechef - `https://www.codechef.com`
- AtCoder - `https://atcoder.jp`
- HackerRank - `https://www.hackerrank.com`
- UVA - `https://uva.onlinejudge.org`
- Vjudge - `https://vjudge.net`

Problem Structure

- Title and limitations
- Description
- Input and output (I/O)
- Examples

Lets see the real thing:

`https://codeforces.com/contest/1/problem/A`

Programming Languages

- They are the tool that allow us to give instructions to the machine.
- Every programming language has a purpose.
- In competitive programming some languages are *objectively* better than others.
- Not all PLs are allowed in the *ACM-ICPC* or other competitions.

Common Programming Languages

Why C++ is the Best

- Lower Level $\rightarrow$ More control
- Allows for better memory management.
- It has the **STL Library**, an extremely powerful tool.
- Almost all learning resources are oriented to C++.

Errors - Verdict Information

- **AC - Accepted**
- **WA - Wrong Answer**
- **TLE - Time Limit Exceeded**
- **RE - Runtime Error**

Others: `https://icpcarchive.ecs.baylor.edu/index.php?option=com_content&task=view&id=14&Itemid=30`

Setups & IDEs

- There are 3 main setups:
  - IDE
  - Text Editor
  - Console Text Editor
- What are some advantages and disadvantages of these?
- Which one should I use?

Topics we will cover

- Introduction to Programming
- Asymptotic Analysis
- Brute Force
- Divide and Conquer
- Graphs (Hopefully)

Summing up

- What is competitive programming?
- What is a Virtual Judge?
- Why are we learning C++?
- *Why do* **I** *want to get into competitive programming?*

Introduction to Programming

The Basics

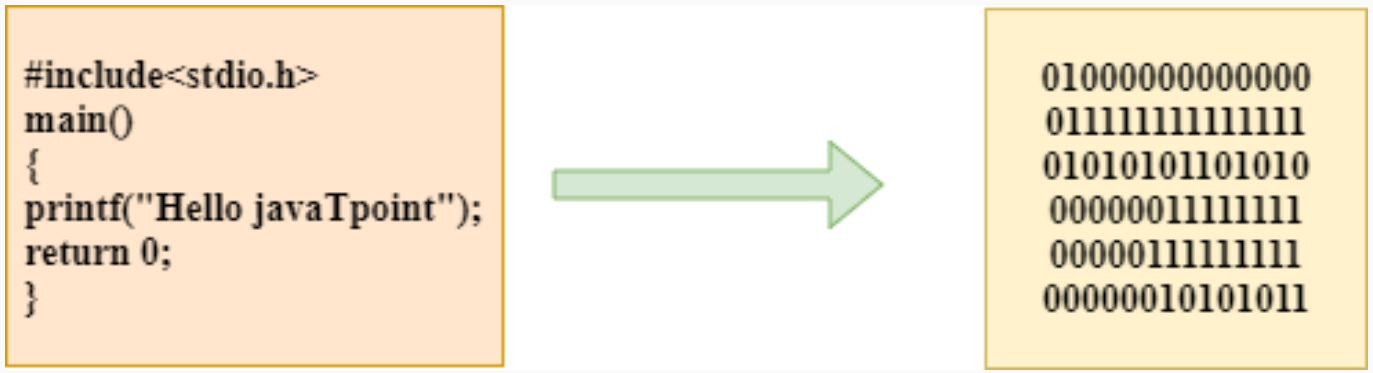
Objective: To form a basic understanding of what is a computer program and being able to make a simple one.

Introductory Questions:

- What can a computer do?
- How does a computer solves problems?
- What is an algorithm?

What is a Program?

- It a sequence of instructions the computer will execute.
- Programs are composed of *variables and instructions*.
- In practice we write programs as files that we then *compile* to make an *executable*.



Variables

- A variable is a value that can change.
- Variables need to be *declared*.
- It has a *unique name* so that the program can identify it.
- Variables are stored in *memory*, with a *fixed* size.
- There are different types of variables or *data types*.
- In C++ we need to specify the data type of our variables.

Data Types in C++

Type	Size	Range
`short`	16 bit	$[-2^{15}, 2^{15} - 1]$
`int`	32 bit	$[-2^{31}, 2^{31} - 1]$
`long long`	64 bit	$[-2^{63}, 2^{63} - 1]$
`float`	32 bit	$[-3.4 \times 10^{38}, 3.4 \times 10^{38} - 1]$
`double`	64 bit	$[-1.7 \times 10^{308}, 1.7 \times 10^{308}]$
`char`	8 bit	$[-2^{7}, 2^{7} - 1]$

Arithmetic Operators

- The name pretty much gives everything away.
- We need to be careful with data types.
- Operators obey the laws of order of operator.

Operators

- `10 + 5` $\rightarrow 15$
- `10 - 5` $\rightarrow 5$
- `10 * 5` $\rightarrow 50$
- `10 / 5` $\rightarrow 2$
- `10 % 5` $\rightarrow 0$

Lets see the real thing - Hello World

```cpp
#include <iostream>
using namespace std;

int main() {
    cout << "Hello World!" << endl;
    return 0;
}
```

Flow Control - if, else

```
int main() {
    int x;
    cin >> x;
    if (x < 0) {
        cout << x << " is smaller that 0!" << endl;
    }
    else {
        cout << x << " is greater than 0!" << endl;
    }
    return 0;
}
```

Flow Control - else if

```
int main() {
    int x;
    cin >> x;
    if (x < 0) {
        cout << x << " is smaller that 0!" << endl;
    }
    else if (x == 0) {
        cout <<x << " is equal to 0!" << endl;
    }
    else{
        cout << x << " is greater than 0!" <<endl;
    }
    return 0;
}
```

Loops - while

```
int main(){
    int i = 0;
    while (i < 5) {
        cout << i << ' ';
    }
    cout << endl;
    return 0;
}
```

Loops - for

```
int main() {
    for (int i = 0; i < 5; i++) {
        cout << i << ' ';
    }
    cout << endl;
    return 0;
}
```

Functions

```
int square(int n) {
    int answer = n * n;
    return answer;
}

int main() {
    cout <<square(5) << endl;
    cout << square(7) << endl;
    return 0;
}
```

Functions

```
int main() {
    int arr0[5];
    int arr1[4] = {1,2,3,4};
    int arr2[5] = {1,2,3,4};

    cout << arr0[0] << endl;
    cout << arr1[1] << endl;
    cout << arr2[4] << endl;
    cout << arr2[5] << endl;
    cout << arr1[5] << endl;
    return 0;
}
```

Problem Time

Problem - Description

Time Limit: 1s

Memory Limit: 256MB

There are n flowers in a park numbered from 1 to n. Each flower has a number that defines its beauty, in general the ith flower has a beauty of b_i for $1 \leq i \leq n$.

Leonidas is in this park flower picking. Because he loves this park so much, he has a rule of picking a maximum of 2 flowers per visit. In this occasion, he wants to pick the pair of flowers such that the sum of their beauties is maximum. Leonidas doesn't know which flowers to pick, can you help him out?

Problem - I/O

Input:

The first line contains n ($1 \leq n \leq 10^6$), the number of flowers in the park. The next line contains n integers, representing b_1, b_2, b_3, ... b_n ($0 \leq b_i \leq 10^6$).

Output

The maximum sum of the beauty of two flowers.

Problem - Examples

Example 1:

Input

5

12 23 45 25 8

Output

70

Example 2:

Input

4

1 1 1 1

Output

2