Introduction to Competitive Programming

By CPPoliTO

CPPoliTO

- Competitive Programming PoliTO (CPPoliTO) was founded in 2020
- Purpose: developing a community of competitive programmers in our university
- In the future make PoliTO a serious contender for ICPC World Finals qualifications

What is competitive programming?

- Mind sport: participants try to solve algorithmic puzzles as fast as possible, implementing a working solution with a programming language of choice
- Solving a problem: submitting a solution which passes all test cases, which are mostly hidden to the participant

Which are the prerequisites? (1)

- Being able to code with any language of choice
  - Python, Java and especially C++ are the most commonly used languages
- C++ is by far the best language for competitive programming
  - It's faster than the other mentioned languages
  - Provides the STL, which contains by default certain useful algorithms and data structures (set, map, queue, priority queue, sorting, etc..)

Which are the prerequisites? (2)

As you progress in competitive programming:

- Knowledge of specific algorithms, data structures and techniques will be needed
- 99% of your skills (rough, non scientific estimate) is determined by your mathematical/logical problem solving and implementation abilities.

Structure of competitive programming problems

You are given two arrays $a_1, a_2, \ldots, a_n$ and $b_1, b_2, \ldots, b_n$.

In one operation, you can choose any integer i from 1 to n and swap the numbers a_i and b_i.

Determine whether, after using any (possibly zero) number of operations, the following two conditions can be satisfied simultaneously:

- $a_n = \max(a_1, a_2, \ldots, a_n)$,
- $b_n = \max(b_1, b_2, \ldots, b_n)$.

Here $\max(c_1, c_2, \ldots, c_k)$ denotes the maximum number among $c_1, c_2, \ldots, c_k$. For example, $\max(3, 5, 4) = 5$, $\max(1, 7, 7) = 7$, $\max(6, 2) = 6$.

Input/output (2)

Example

input

```
7
3
7 9 7
7 6 9
4
10 10 15 15
10 16 15 15
2
100 99
99 100
1
1
1
9
1 2 3 4 5 6 7 8 9
9 9 9 9 9 9 6 6 6
7
1 1 2 2 1 1 2
1 2 1 2 1 2 1
2
30 4
5 30
```

output

```
Yes
No
Yes
Yes
Yes
No
No
```

Note

In the first test case, you can swap the numbers a_3 and b_3, after which the array a becomes equal to $[7, 9, 9]$, and the array b becomes equal to $[7, 6, 7]$, and both conditions are met.

In the second test case, it can be proved that it is impossible to satisfy both conditions.

In the third test case, you can swap the numbers a_1 and b_1, after which the array a becomes equal to $[99, 99]$, and the array b becomes equal to $[100, 100]$, and both conditions are satisfied.

In fifth test case, you can swap a_7 and b_7, a_8 and b_8, a_9 and b_9, after which the array a becomes equal to $[1, 2, 3, 4, 5, 6, 6, 6, 6]$, and the array b becomes equal to $[9, 9, 9, 9, 9, 9, 7, 8, 9]$, and both conditions are satisfied.

Which are the main competitions?

- Online contests with rating systems (ELO):
  - Codeforces, Atcoder, Leetcode, Codechef, etc…
  - Usually they host weekly contests
- Yearly-ish competitions organized by tech companies:
  - Google CodeJam, Meta Hacker Cup, Codeflows (Bending Spoons), Reply Code Challenge, Quora Programming Challenge, etc…
  - Usually have prizes
- Yearly competitions for high school students:
  - Olympiads in informatics, CEOI, etc…
- And for University students:
  - International Collegiate Programming Contest (ICPC)

Codeforces rating system (1)

- Main platform for competitive programming
- One or more contests per week
- Internal blog system:
  - It’s the Reddit/Twitter/quora for competitive programming related content.
- The rating is the accepted value to determine a competitor’s skill and status inside the community

Codeforces rating system (2)

Rating Bounds	Color	Title	Division	Number	Number (by color)
≥ 3000	Red	Legendary Grandmaster	1	14	261
2600 — 2999	Red	International Grandmaster	1	90	
2400 — 2599	Red	Grandmaster	1	157	
2300 — 2399	Orange	International Master	1	134	792
2100 — 2299	Orange	Master	1	658	
1900 — 2099	Violet	Candidate Master	1/2	2101	2101
1600 — 1899	Blue	Expert	2	5186	5186
1400 — 1599	Cyan	Specialist	2/3	10408	10408
1200 — 1399	Green	Pupil	2/3	15584	15584
≤ 1199	Gray	Newbie	2/3	6250	6250

Codeforces ratings range from 0 to infinity (although the current max is around 3800) and certain ranges have a color and title attached to them

Codeforces rating system (3)

Rating

	Who	#	=
1 (118)	dario2994	93	2835
2 (685)	TheScrasse	83	2400
3 (1060)	simpatine	26	2278
3 (1060)	fedez	17	2278
5 (1704)	Kaey	73	2178
6 (1786)	cip999	43	2169
7 (2113)	lorenzoferrari	47	2139
8 (2622)	N.N_2004	118	2106
9 (3125)	franfill	34	2038
10 (3591)	AlesL0	25	1986
11 (3606)	CuteLittleGhost	11	1984
12 (3765)	Virv	9	1971
13 (4358)	armypellegrini	44	1926
14 (5261)	franv	13	1861
15 (5593)	Ventu06	46	1839
16 (6707)	dp_1	49	1773
17 (6735)	jamesbamber	13	1772
18 (6965)	Darkeld	33	1761
19 (7067)	Ghassane	176	1757
20 (7107)	Ati_tm	14	1755

Rating: users participated in recent 6 months

	Who	#	=
1	Benq	136	3783
2	jiangly	130	3772
3	tourist	238	3706
4	maroonrk	141	3609
5	Um_nik	265	3591
6	fantasy	52	3526
7	ko_osaga	142	3500
8	inaFSTream	30	3477
9	cnnfls_csy	38	3427
10	zh0ukangyang	20	3423
11	ksun48	246	3413
12	Ormlis	99	3410
13	orzdevinwang	56	3393
14	ecnerwala	159	3391
15	djq_cpp	56	3370
16	fivedemands	36	3350
17	Rebelz	70	3348
18	greenheadstrange	44	3347
19	Petr	199	3331
20	noimi	160	3328

Top 20 active Italian (left) and global (right) competitors. The number on the right (=) is the current rating.

ICPC (International Collegiate Programming Contest)

- Team competition for teams of 3 eligible students
- Most prestigious competition for University students worldwide
- For our region, the competition is divided in a regional qualifier: SWERC, and world finals for the best 3 or 4 teams in the region
- SWERC (Southwestern European Regional Contest):
  - Onsite participation, hosted by one of the SWERC universities
  - Usually a big event, with very prestigious sponsors attending and even more for the ICPC world finals!
  - Generally, participation to ICPC, including hotel, travel expenses and fees is covered by universities
  - PoliTO's participations to ICPC-SWERC 2022 and 2023 were funded

Latest ICPC world finals in Dhaka, Bangladesh

How to practice in competitive programming?

Some general ideas on how to improve your skills:

- Participation in contests (very important);
- Upsolving, meaning solving problems that you tried and couldn’t solve during contests, using editorial if strictly needed;
- Solving problems slightly above your level on Codeforces problemset;
- Take part in our training contest and upsolve (highly advised!).

How to leverage competitive programming skills in the outside world? (1)

Almost every elite software/trading/etc.. company which employs software engineers has at least one algorithmic coding round, usually referred to as “Leetcode style interviews”, since Leetcode is the most used platform to prepare for this kind of interviews.

Good competitive programmers are expected to perform extremely well in these type of interviews.

How to leverage competitive programming skills in the outside world? (2)

Good competitive programmers are generally very highly appreciated by these companies, and many many people we personally know of got extremely lucrative jobs because of their competitive programming skills (and also the networking you create inside this community).

Example of these companies (to our knowledge) are: Google, Meta, Amazon, Microsoft, Quora, Huawei and other tech companies, Jane Street and other trading firms…

Thank you!

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