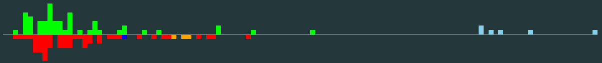
BAPC 2022

Solutions presentation

October 22, 2022

E: Equalising Audio

Problem Author: Abe Wits



- **Problem:** Normalise the amplitudes $a_1, \ldots, a_n$ to a perceived loudness of $\frac{1}{n}\sum_{i=1}^{n} a_i^2 = x$.

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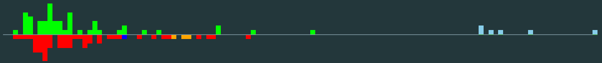

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  Then, output $\sqrt{x/x'} \cdot a_1, \ldots, \sqrt{x/x'} \cdot a_n$ with sufficient precision.

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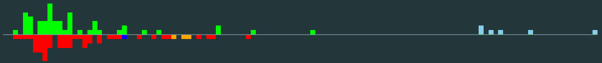

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  Then, output $\sqrt{x/x'} \cdot a_1, \ldots, \sqrt{x/x'} \cdot a_n$ with sufficient precision.
- Verification:

$$\frac{1}{n}\sum_{i=1}^{n}\left(\sqrt{x/x'}\,a_i\right)^2 = \frac{x}{x'} \cdot \frac{1}{n}\sum_{i=1}^{n} a_i^2 = \frac{x}{x'} \cdot x' = x.$$

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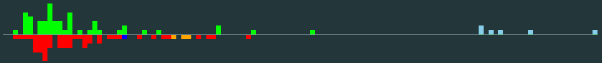

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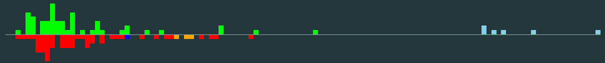

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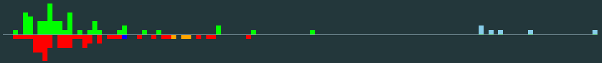

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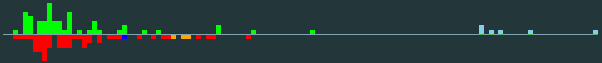

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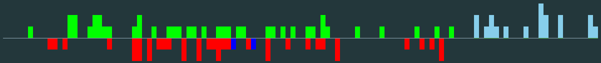
Statistics: 127 submissions, 50 accepted, 6 unknown

B: Bellevue

Problem Author: Ragnar Groot Koerkamp



- **Problem:** Given the profile of an island, find the point with the largest viewing angle of the sea.

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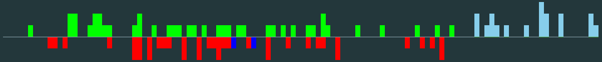

- **Problem:** Given the profile of an island, find the point with the largest viewing angle of the sea.
- **Observation:** If point P is blocking the view of the edge of the island from point Q, you can see more sea in P than Q.

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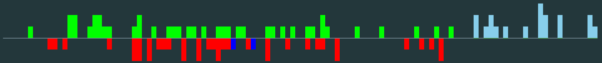

- **Problem:** Given the profile of an island, find the point with the largest viewing angle of the sea.
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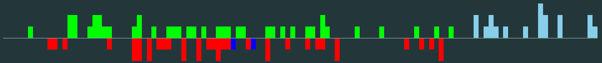

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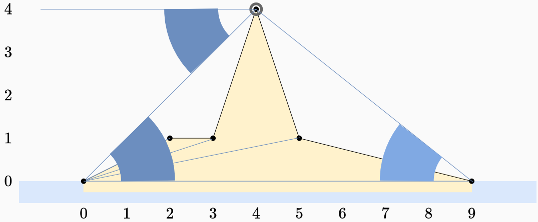

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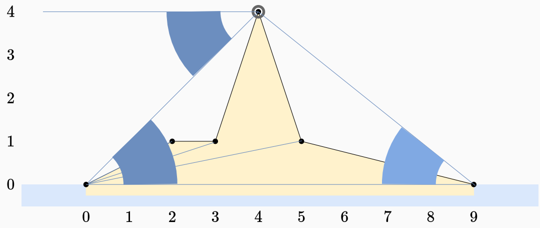

- **Alternative solution:** compute the convex hull and iterate over it.

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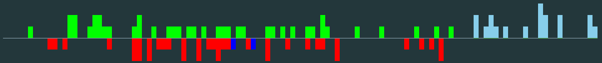

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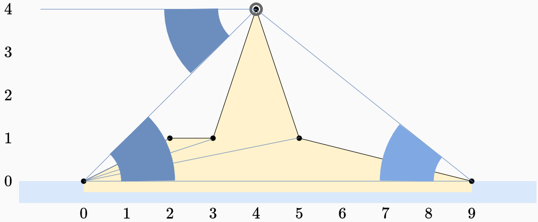


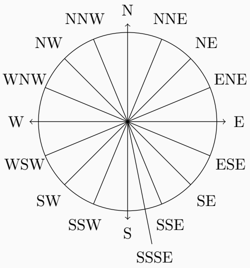
- **Alternative solution:** compute the convex hull and iterate over it.

Statistics: 102 submissions, 41 accepted, 18 unknown

F: Failing Flagship

Problem Author: Ruben Brokkelkamp

- **Problem:** Compute the minimum angle in degrees between two wind directions.



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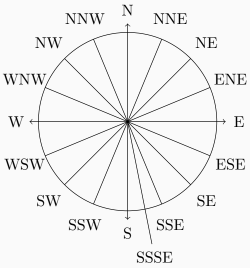

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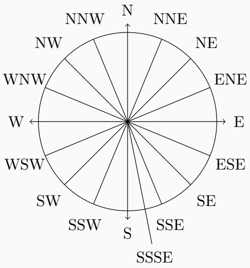
- **Solution:**
  - Convert both wind directions into degrees $d_1 \geq d_2$.



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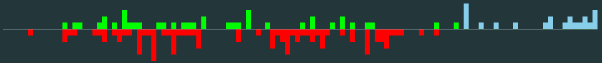

- **Problem:** Compute the minimum angle in degrees between two wind directions.
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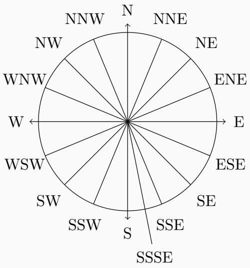

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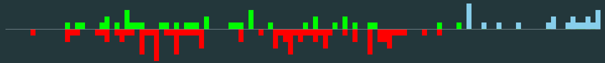

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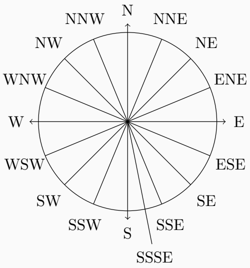
  - Return $\min(d_2 - d_1, 360 + d_1 - d_2)$.



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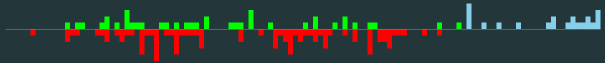

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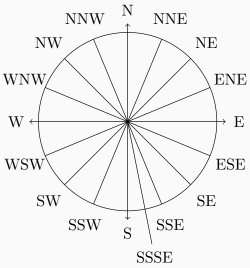
- **Remark:** Only 29 characters are needed for the required precision.



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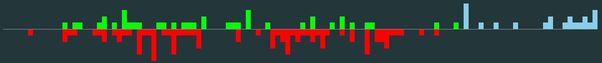

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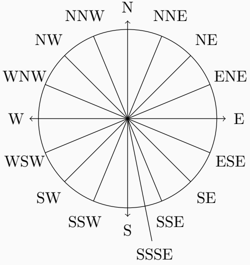
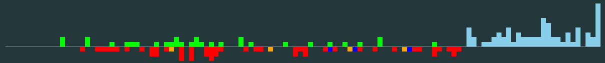


Statistics: 144 submissions, 39 accepted, 21 unknown

I: Imperfect Imperial Units

Problem Author: Abe Wits



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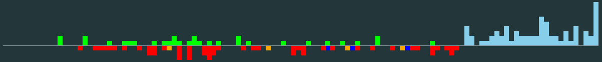

- **Problem:** Convert values from one unit to another.
- **Solution:** For every query, do a breadth-/depth-first search, multiplying all conversion ratios on the path from the one to the other unit.
  - Runtime: $\mathcal{O}(q \cdot n)$, which is fast enough.

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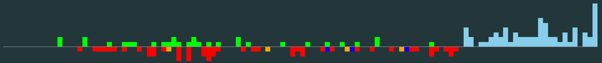

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- **Faster solution:** Precalculate (or cache) the conversion ratio between all pairs of units.
  - Runtime: $\mathcal{O}(n^2)$ to precalculate and $\mathcal{O}(1)$ per query, so $\mathcal{O}(n^2 + q)$.

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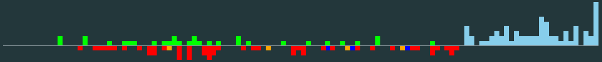

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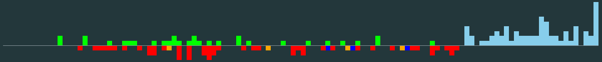

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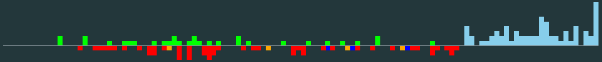

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Statistics: 163 submissions, 31 accepted, 69 unknown

D: Dividing DNA

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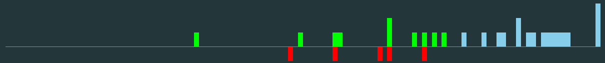

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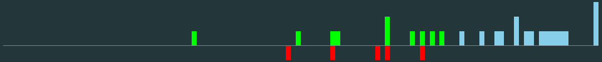

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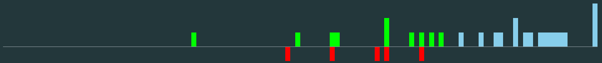

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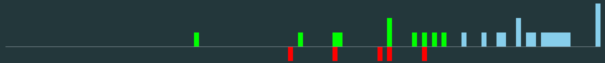

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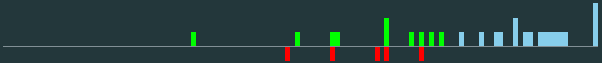

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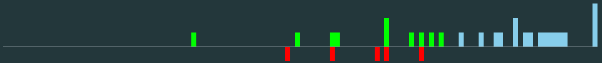
- Then start a new interval $[a, a + 1)$, and keep growing it until it is allowed, say $[a, b)$.

D: Dividing DNA

Problem Author: Ragnar Groot Koerkamp



- **Problem:** Given a set of *forbidden* (*present*) intervals, partition $[0, n)$ into as many disjoint (*absent*) intervals as possible.
- **Observation 1:** If an interval is forbidden, all shorter intervals are also forbidden!
- **Observation 2:** Each interval only needs to be *just* long enough to be allowed (*absent*).
- **Greedy solution:** Start with $[0, 1)$, and keep growing the interval until it is allowed, say $[0, a)$.
- Then start a new interval $[a, a + 1)$, and keep growing it until it is allowed, say $[a, b)$.
- Continue until reaching the end. This uses exactly n queries in total.

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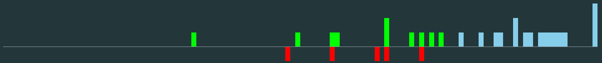

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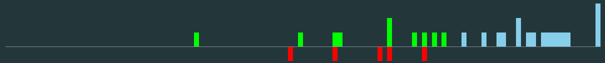

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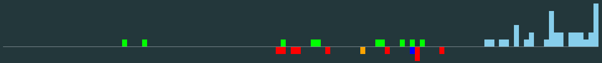
Statistics: 32 submissions, 10 accepted, 17 unknown

C: Crashing Competition Computer

Problem Author: Jorke de Vlas



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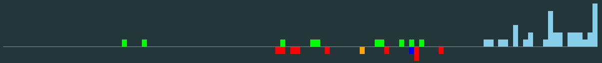

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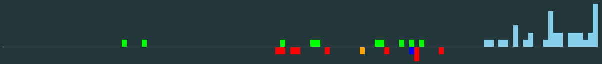

- **Problem:** What is the expected time to write c characters of code on a crash-prone computer?
- **Solution:** Dynamic programming over the length of the code.
- Time to code any x consecutive characters (without saving) $=$
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$$T(x) = T(x-1)+1+p\cdot(r+T(x)) = \frac{T(x-1)+1+p\cdot r}{1-p} \quad \textbf{or} \quad T(x) = \frac{r+1}{p}\cdot((1-p)^{-x}-1)$$

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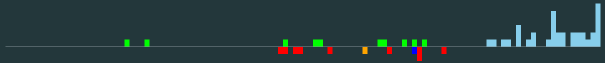

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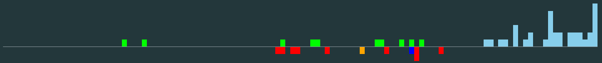

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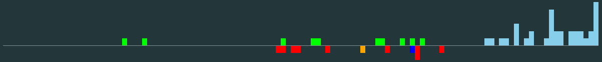

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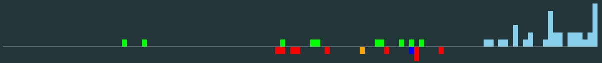

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Statistics: 56 submissions, 10 accepted, 35 unknown

K: Kiosk Construction

Problem Author: Reinier Schmiermann

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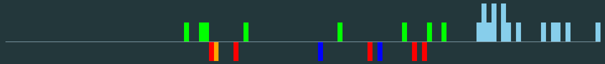

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- **Optimisation:** Calculate distances the other way around: from every plot to every kiosk location.
  - The rules of walking between plots are fixed given a destination plot p, so do floodfill (BFS/DFS) starting from every destination plot p.
  - From a plot a, walk to neighbouring plots b if, according to the procedure, you can walk from b to a given the destination plot p.

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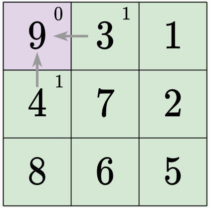

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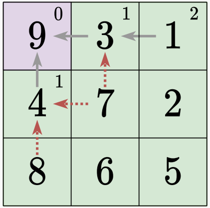

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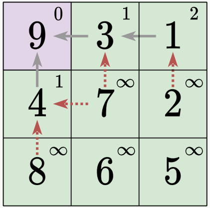

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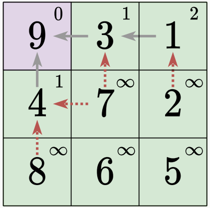

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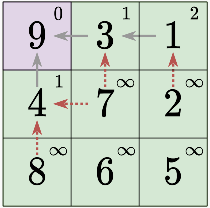

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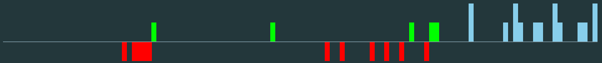

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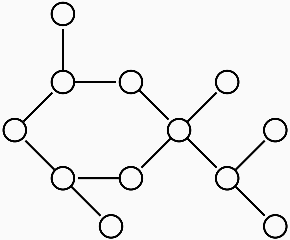
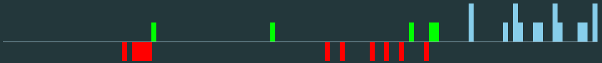


H: House Numbering

Problem Author: Reinier Schmiermann



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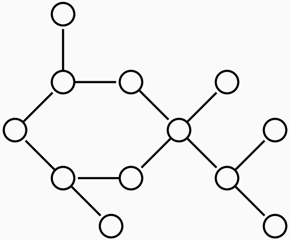

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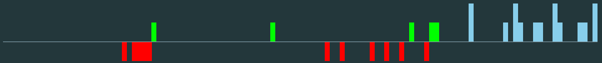

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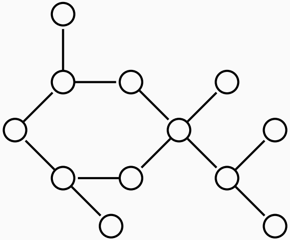

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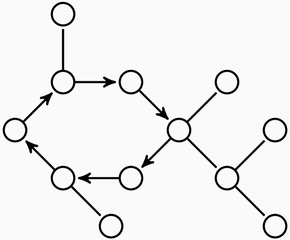

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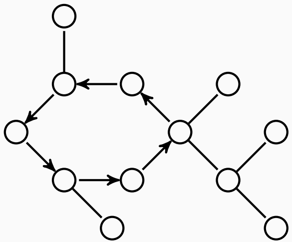

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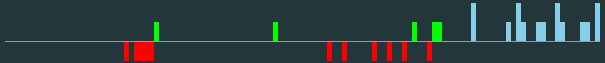

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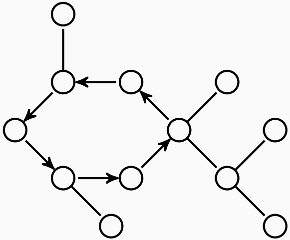

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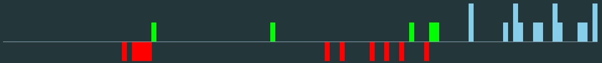

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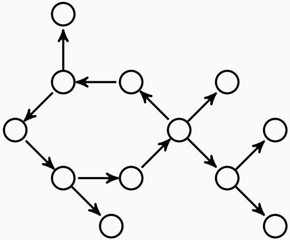

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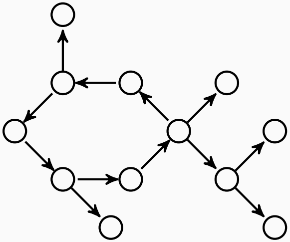

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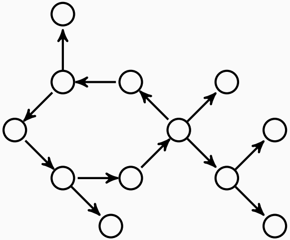

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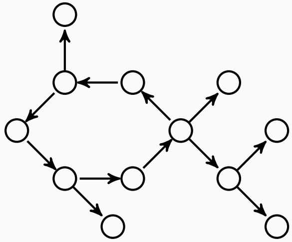

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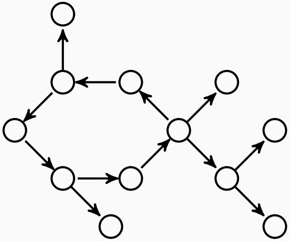

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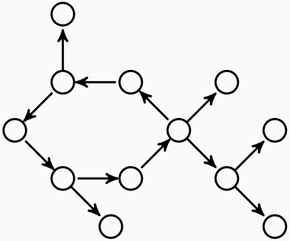
  - If one of the two works, print it. Otherwise, print “impossible”.



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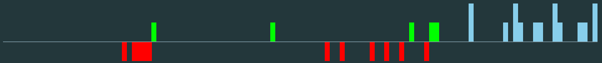
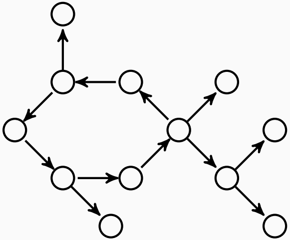


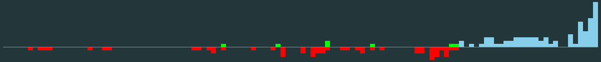
- **Problem:** Given a graph with n nodes and edges, and h house numbers for an edge, determine whether house numbers can be assigned such that there is no intersection where two edges start with the same house number.
- **Solution:**
  - First, find the cycle.
  - Orient cycle clockwise and propagate house numbers through trees. Check if this is valid, i.e., there are no two equal high house numbers at a node.
  - If not ok, orient cycle counter clockwise and check validity.
  - If one of the two works, print it. Otherwise, print "impossible".



Statistics: 31 submissions, 5 accepted, 15 unknown

J: Jagged Skyline

Problem Author: Reinier Schmiermann



- **Problem:** Given $w \leq 10\,000$ integers $0 \leq h_i \leq 10^{18}$, find the maximum in at most $12\,000$ queries: “`Is integer` h_i `less than` y?”

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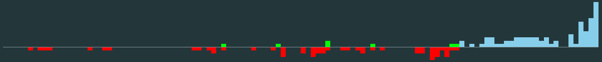

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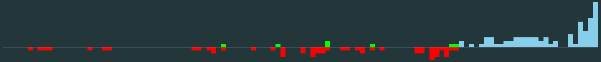

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Statistics: 140 submissions, 7 accepted, 80 unknown

L: Lowest Latency

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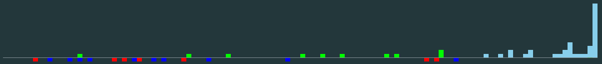

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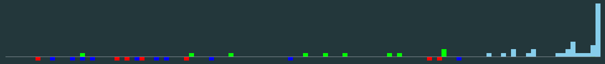

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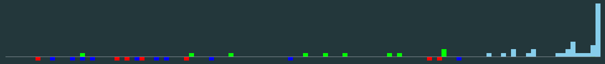

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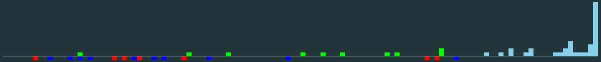

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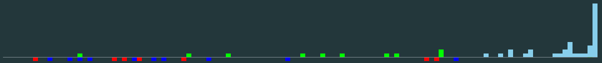

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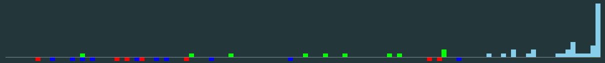

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  - Note: due to the birthday paradox, there will practically always be a box with at least 2 points.

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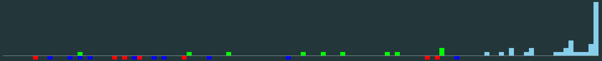

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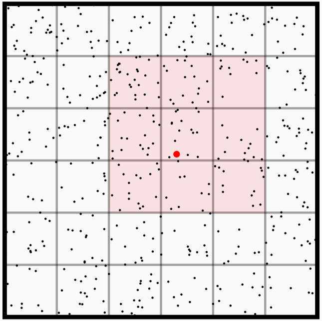

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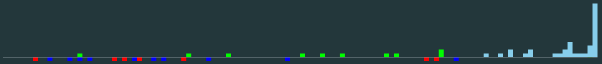

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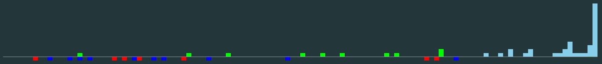

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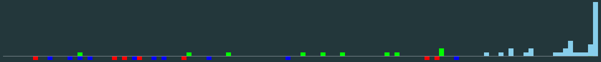

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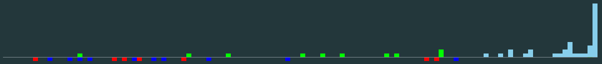

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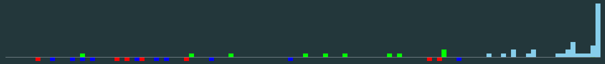

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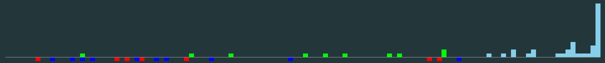

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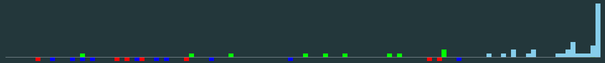

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Statistics: 63 submissions, 10 accepted, 35 unknown

A: Adjusted Average

Problem Author: Ludo Pulles

- **Problem:** Given $n \leq 1500$ integers a_i, remove at most $k \leq 4$ of them to get an average as close as possible to the target $\overline{x}$.

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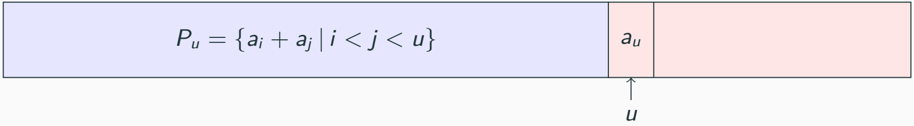

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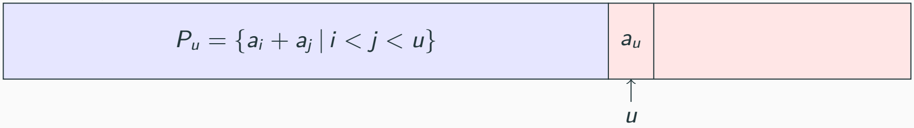

- For $\ell = 3$: loop over $u = 1, \ldots, n$, update P_u and then take $s \in P_u$ closest to $S_\ell - a_u$.

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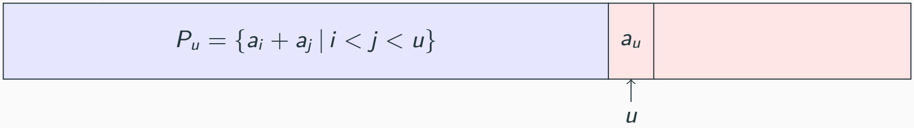

- For $\ell = 3$: loop over $u = 1, \ldots, n$, update P_u and then take $s \in P_u$ closest to $S_\ell - a_u$.
- Use an ordered set (BBST) for P_u, giving the time complexity $\mathcal{O}(n^2 \log n)$.

A: Adjusted Average

Problem Author: Ludo Pulles

- **Problem:** Given $n \leq 1500$ integers a_i, remove at most $k \leq 4$ of them to get an average as close as possible to the target $\overline{x}$.
- When removing exactly $0 \leq \ell \leq k$ numbers, we need to find ℓ integers with sum as close as possible to $S_\ell = \sum_i a_i - \ell \cdot \overline{x}$.
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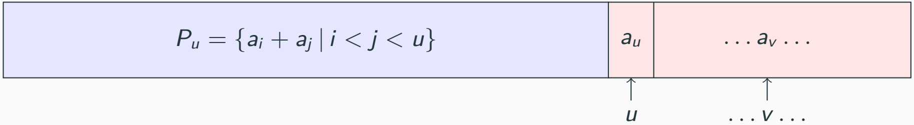

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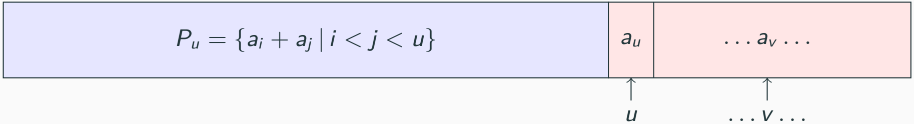

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Statistics: 25 submissions, 3 accepted, 13 unknown

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Problem Author: Daan van Gent, Onno Berrevoets

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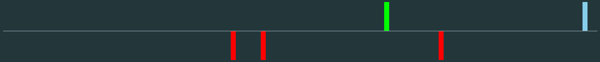

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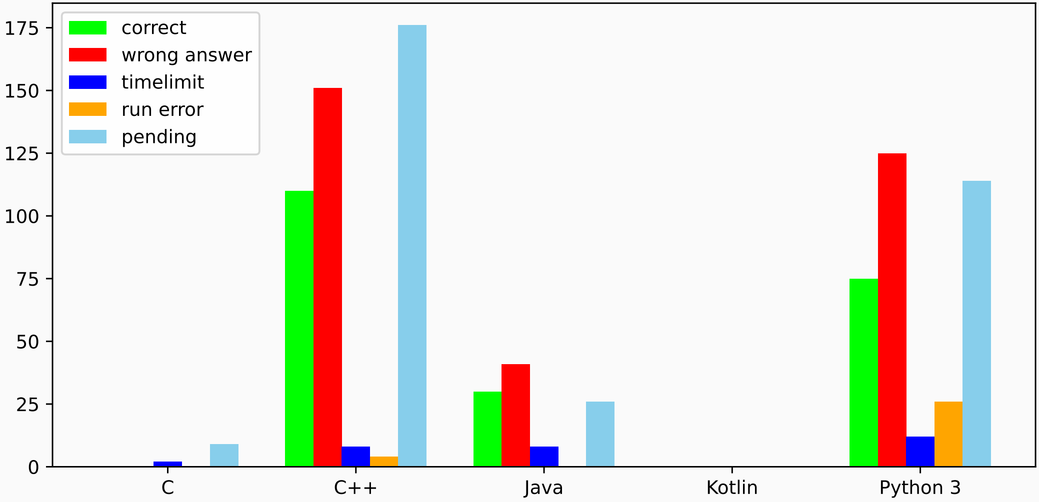
Statistics: 5 submissions, 1 accepted, 1 unknown

Language stats



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- 165 jury solutions (last year: 177)
- The minimum[2] number of lines the jury needed to solve all problems is

$$14 + 3 + 5 + 1 + 4 + 4 + 27 + 34 + 14 + 15 + 18 + 4 = 143$$

On average 11.9 lines per problem, up from 9.6 in BAPC 2021 or 6.6 in preliminaries 2022

[2] *After* codegolfing

Thanks to:

The proofreaders

Jaap Eldering
Kevin Verbeek
Mark van Helvoort
Nicky Gerritsen
Thomas Verwoerd

The jury

Boas Kluiving
Jorke de Vlas
Ludo Pulles
Maarten Sijm
Ragnar Groot Koerkamp
Reinier Schmiermann
Ruben Brokkelkamp
Wessel van Woerden

Want to join the jury? Submit to the Call for Problems of BAPC 2023 at:

`https://jury.bapc.eu/`