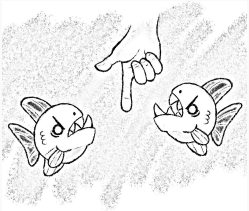

Aquarium

?? correct • solved at: ??:?? by

??

University of ??

Author: **Freek Henstra**

Overview

- We need to line some piranhas up for a group photo.
- Putting a finger in the tank causes adjacent piranhas to start swimming toward the finger.
- Find the number of seconds of finger exposure needed to put every fish in its specified place.

Aquarium - Solution

Techniques

- Intervals
- Greedy algorithms
- Amortisation

Algorithm

- Each fish needs to move by X_i places.
  - The number of finger placements to the right must be $\mathbf{X_i}$ more than the number to the left.
- Assume the number of placements to the left of the leftmost fish is $-\mathbf{X_0}$.
  - Then the next number must be **0**, the next after that must be $\mathbf{0+X_1}$, then $\mathbf{0+X_1+X_2}$, etcetera.
  - We need all values to be non-negative. Take the minimum of value and subtract it from everything.
- Now we need to check if this number of placements is feasible
  - The answer is guaranteed to be at most $O(N*K^2)$.
  - So we can just go from left to right making all valid moves.

B — Big Brother

Problem

Given polygon-shaped map of a room, find region from which all parts of the room can be seen.

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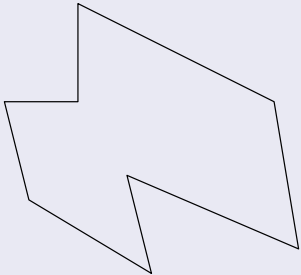

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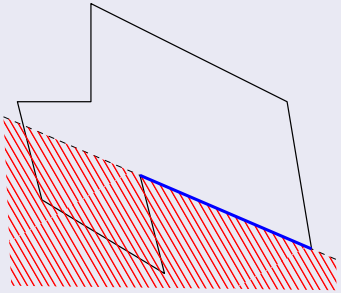
Line segments of the polygon induce *half-planes*: In order for points along that wall not to be obscured, we cannot be behind that wall.



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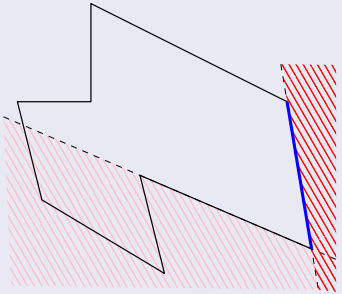

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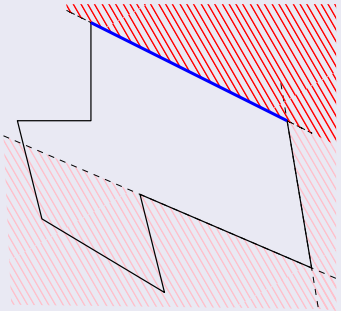

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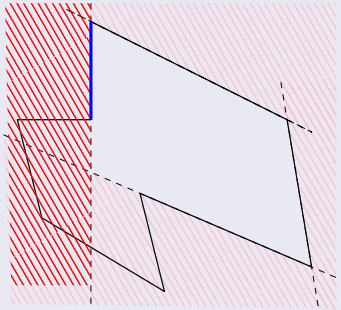

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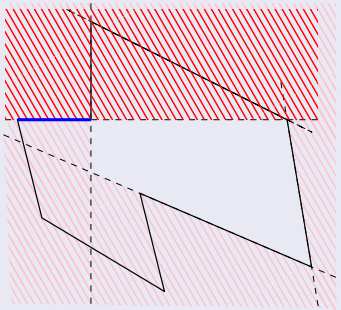

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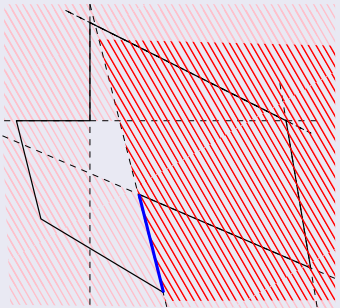

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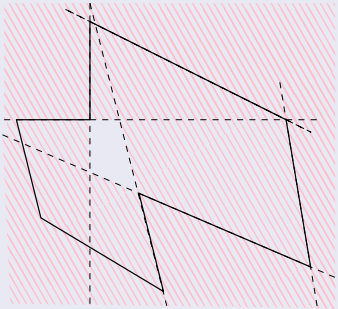

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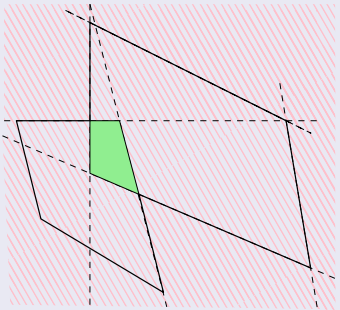
Seeing all parts of the room

⇕

Not "behind" any wall

⇕

Inside the intersection of the n half-planes.



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Finding intersection of half-spaces

- Divide and conquer algorithm for intersection of half-spaces:

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  1. Split the half-spaces into two groups H_1 and H_2 of roughly $n/2$ half-spaces each.

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  4. Compute intersection of K_1 and K_2

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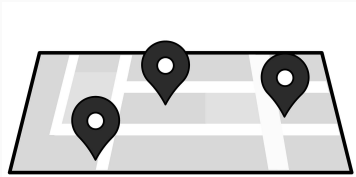
Statistics at 4-hour mark: 36 submissions, 11 accepted, first after 00:28



Kleptocrat

? correct • solved at: **??:??** by
??
??

Author: **Jorke de Vlas**

Overview

- Given a connected undirected graph, find a path from A to N that minimizes XOR of the values on the edges.

Kleptocrat - Solution

Techniques

- Linear Algebra
- Cycles

Algorithm

- Observation: walking back and forth does not change the XOR-value since $x \oplus x = 0$.
- When there is a cycle starting from c with XOR-value v , we may walk from a to c, around the cycle, back to a and then to b giving a value of $w \oplus v$ where w was the value of a path from a to b.
- This is an equation over \mathbb{F}_2 and the v_i can be reduced with Gaussian Elimination giving 64 values.

Kleptocrat - Solution (cont.)

Techniques

- Linear Algebra
- Cycles

Algorithm

- See v_i as vectors in F_2^64 by writing v_i in base 2.
- The linear combinations form a subspace of dimension at most 64: find a basis, which has at most 64 elements.
- Now, given an initial path w, for i from 63 to 0, look if w has a 1 in the ith binary digit and check if there is a basis element with i as most significant digit, in which XOR w with this value.

D — Dams in Distress

Problem

We get a rooted tree forming a system of $n \leq 200\,000$ dams. Overflowing a dam causes it to break and release all its water downstream. What is minimum amount of water we need to add at one dam in order for w units of water to reach the root?

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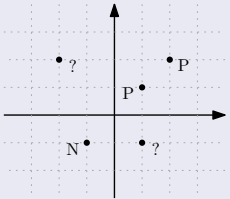
Statistics at 4-hour mark: 270 submissions, 90 accepted, first after 00:32

E — Exhaustive Experiment

Problem

We have n points which are potentially faulty. We can test points but tests only tell us if there is a faulty point within a cone above the test point. Given test results what is minimum number of faulty points?

Solution (1/2)



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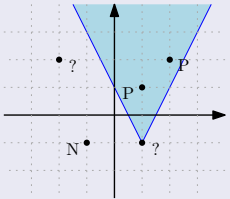

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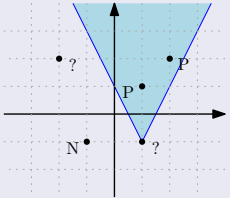

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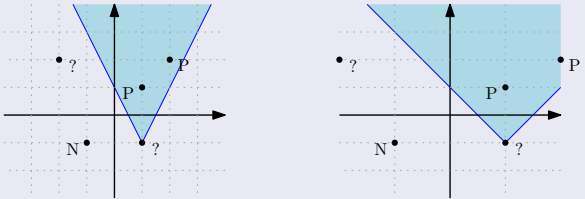

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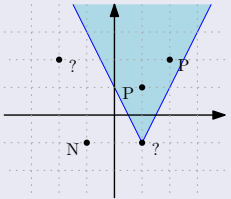

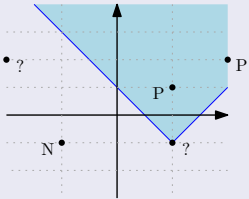

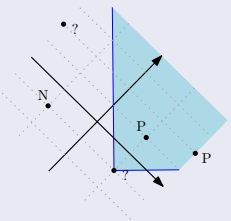

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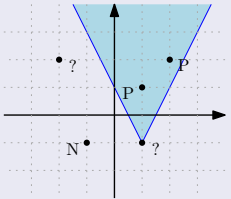
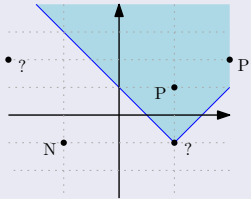
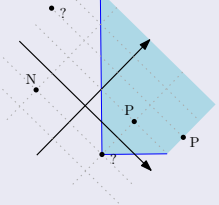


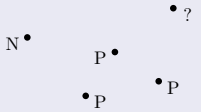




2. Now cone of points affected becomes a quadrant!

E — Exhaustive Experiment

Solution (2/2)



- Negative tests: nothing in upper right quadrant of negative test can be faulty.

E — Exhaustive Experiment

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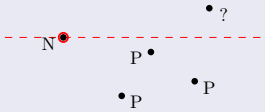

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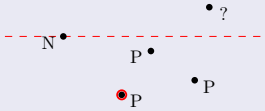

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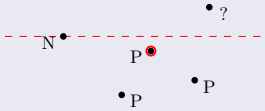

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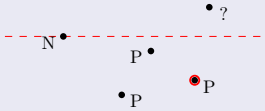

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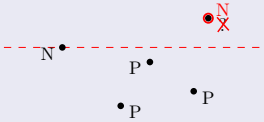

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E — Exhaustive Experiment

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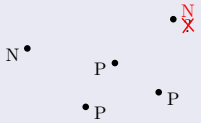

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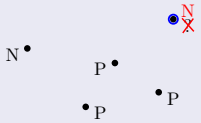

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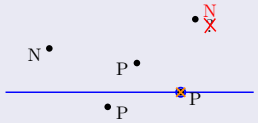

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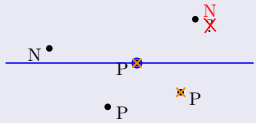

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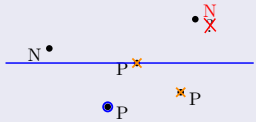

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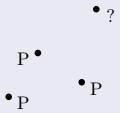

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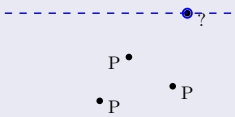

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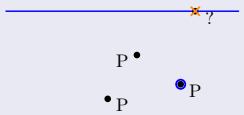

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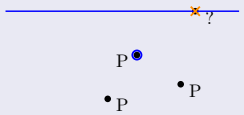

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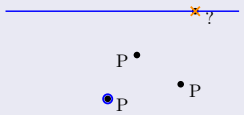

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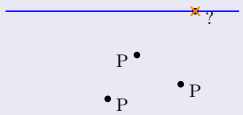

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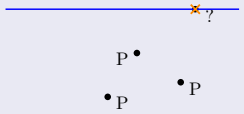

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Statistics at 4-hour mark: 18 submissions, 3 accepted, first after 01:14

F — Film Critics

Problem

We have one movie and n critics with opinions $x_1, \ldots, x_n$ on how good it is.

If current review average of the movie exceeds a reviewers opinion they will score it 0, otherwise they will score it m.

Order the critics so that the film ends up getting review average exactly k/n.

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1. Each review is either *positive* (score m) or *negative* (score 0).
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3. So k must be divisible by m (otherwise `impossible`), and we need exactly $p = k/m$ positive reviews.

F — Film Critics

Solution

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Statistics at 4-hour mark: 62 submissions, 21 accepted, first after 00:43

G — Gig Combinatorics

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Given sequence of $n \leq 10^6$ digits 1/2/3, count how many subsequences have the form "12+3" ("2+" means 1 or more twos)

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Statistics at 4-hour mark: 437 submissions, 78 accepted, first after 00:04

H — Hiring and Firing

Problem

A company hires and fires workers over up to 100 000 days. Assign an HR employee to each day so that for each worker a different HR employee is assigned the day they are hired and the day they are fired. Minimize number of HR employees used.

Solution (1/3)

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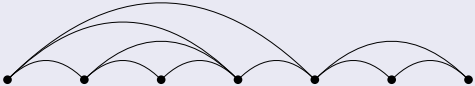
2. We seek the chromatic number of this graph.
3. Graph coloring is NP-hard in general and even in planar graphs.
   But these graphs are special... what do they look like?

Solution (2/3)

1. Mark the days on a timeline and draw an arc for each worker:



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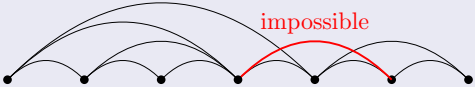

2. Because of last-in-first-out order of hirings and firings, cannot be any crossing arcs.

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   start with longest edge from leftmost vertex and color its endpoints arbitrarily
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   So if we have three colors, will always be a choice available for the middle vertex.
   In other words, 3 colors is always enough!

H — Hiring and Firing

Solution (3/3)

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Statistics at 4-hour mark: 22 submissions, 0 accepted, first after N/A

I — Infection Estimation

Problem

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$$100, \quad 100 \cdot 1.01, \quad 100 \cdot 1.01^2, \quad \ldots \quad 100 \cdot 1.01^i, \quad \ldots \quad 5 \cdot 10^6$$

(around $\log_{1.01}(5 \cdot 10^6) \approx 1500$ different values)

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Statistics at 4-hour mark: 46 submissions, 6 accepted, first after 01:03

Lost Map

?? correct • solved at: **??:??** by
??
??

Author: **Robin Lee**

Overview

- Two map fragments (strings) are badly damaged and some items are replaced by “?”s
- Find how many ways you can overlay the two fragments so that no non-”?” values conflict.

Lost Map - Solution

Techniques

- FFT
- Convolution

Algorithm

- We can treat the “?” and non-”?” values completely separately.
  - We make two separate binary strings
    - One encoding “?” as 0 values and everything else as 1 values
    - One encoding “?” as several -1s and everything else as its binary representation (takes LogK bits where K is the number of directions)
  - If we reverse one array, then the **convolution** of both versions of the binary strings from each map can be used to find the number of bits matching each time
    - We need the number of bits across both convolutions to exactly equal the length of the string.
- Pitfalls: FFT needs to be **fast**.

K — Keep Calm and Carry Off

Problem

Given two 1 000 000-digit integers A and B, find the smallest non-negative integer X such that $A + X$ and $B - X$ (or $A - X$ and $B + X$) can be added without carry.

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Simplifying assumptions:

1. A and B have the same number of digits (or zero-pad)
2. it is always the first integer we add to (try both options; take the best one)

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4. If i is the leftmost digit causing carry, turning it to 0 will turn all remaining digits to 0 as well and get rid of any carries there.
5. Lets us compute $A + X$ easily, subtract A to get X.

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$$A = 811765432113$$
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Statistics at 4-hour mark: 115 submissions, 11 accepted, first after 00:44

L — Language Survey

Problem

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Solution (1/2)

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   - For every cell (i, j) where two or more regions should overlap, extend the region from (i', j') into (i, j).

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Solution (2/2)

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