Freshmen Programming Contest 2023

Solutions presentation

May 27, 2023

A: Admiring Droplets

Problem Author: Davina van Meer and Maarten Sijm

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- **Observation:**
  - $E[X+Y] = E[X] + E[Y]$, for any independent X and Y
  - $E[\text{dice with k faces}] = \frac{1}{k}\sum_{x=1}^{k} x = \frac{k+1}{2}$

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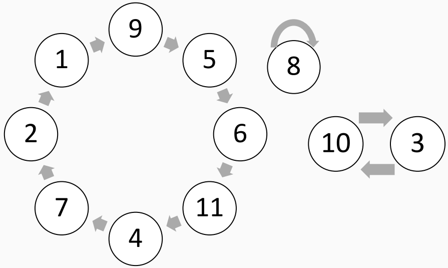
F: Feline Friendship

Problem Author: Jeroen Op de Beek

- **Problem:** Given a special functional graph, change the least number of edges such that there is a maximal path of length k.
- **Observation 1:** The array in the input is a permutation $\rightarrow$ the favourite cat relations form disjoint cycles.



Cats are visualised as circles, with arrows being the favourite playing cat relations

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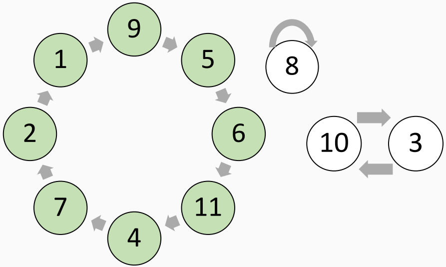
- **Observation 2:** If there is a cycle of length k, 0 operations suffice.



Take whole cycle as team.

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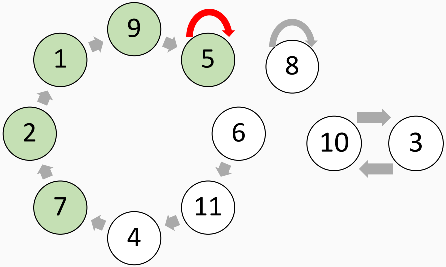
- **Observation 3:** Else if there is a cycle of length $> k$, 1 operation is enough.



Make cycle into a path, and then choose where to start.

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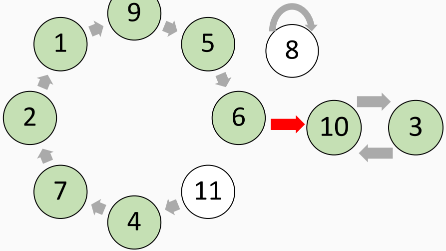
- **Observation 4:** If you can make teams of length a and b, can make team of length $a+1, a+2, \ldots, a+b$ in 1 operation.



Merge two cycles.

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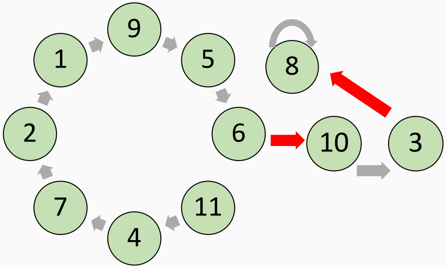
- **Solution:** Greedily merge largest cycles in this way, until sum becomes $\geq k$.
- **Complexity:** $\mathcal{O}(n)$ for finding the disjoint cycles and $\mathcal{O}(n \log n)$ or $\mathcal{O}(n)$ for sorting the cycle sizes.



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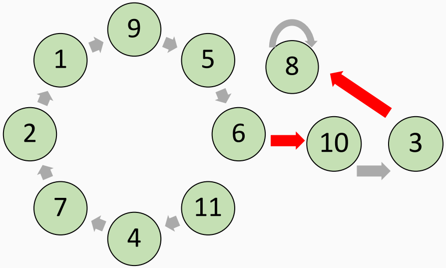

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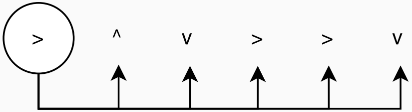
- This means that the arrow that we want to remove has a bunch of dependencies.



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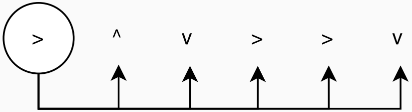

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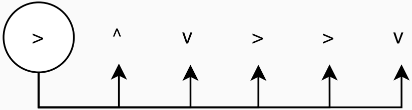

- **Naive Solution:** We can build a graph with all the dependencies, then compute the topological sorting.
  - If one such sorting exists, we have a solution.
  - If one does not exist, then it is impossible to solve the puzzle.

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- **Naive Solution:** We can build a graph with all the dependencies, then compute the topological sorting.
- **Complexity:**
  - Since an arrow points to an entire row or column of arrows, a cell has $\mathcal{O}(h)$ or $\mathcal{O}(w)$ dependencies, therefore, we have $\mathcal{O}(hw)$ nodes and $\mathcal{O}(hw(h+w))$ edges.

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  - Since the topological sorting has $\mathcal{O}(V+E)$ complexity, then this solution yields $\mathcal{O}(hw(h+w))$ complexity, which is not enough to pass the time limit.

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- **Observation:** Maybe we can try to solve this in the opposite way.
- Instead of starting from a cell and recursively solving all of its dependencies, we can instead start from the trivial nodes, with no dependencies and then solve the nodes with more dependencies.

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- **Solution:** Start from the margins of the puzzle and remove the cells one by one.
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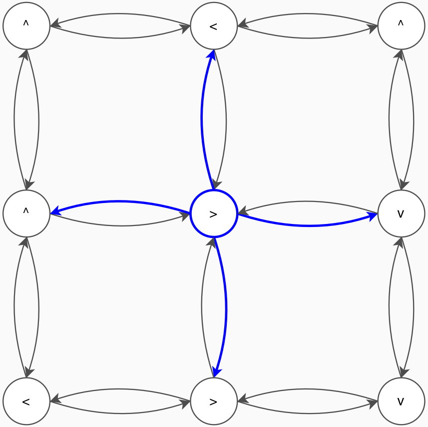
- To find the neighbours of a cell quickly, we can maintain for each cell a link to its neighbours.



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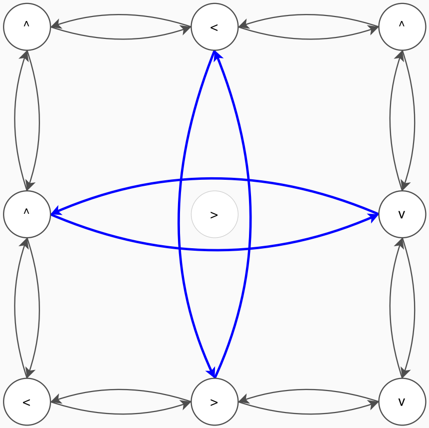
- When removing a cell, we must link its left and right neighbours between each other. The same goes for the neighbours from above and below.



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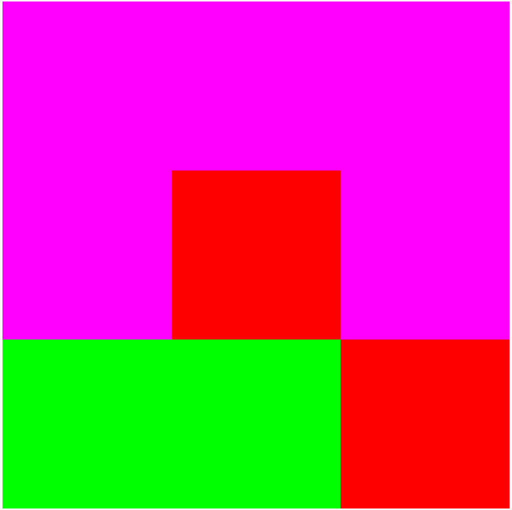

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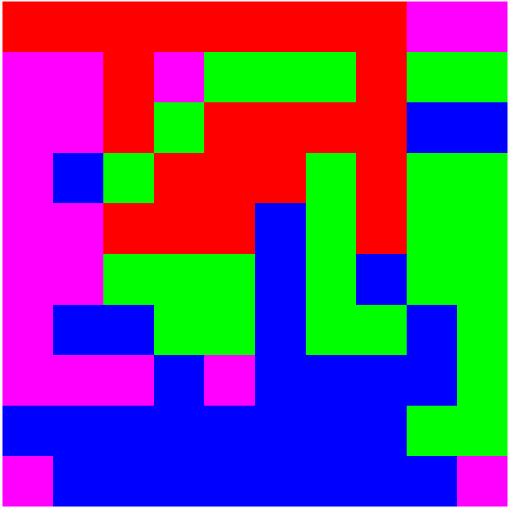

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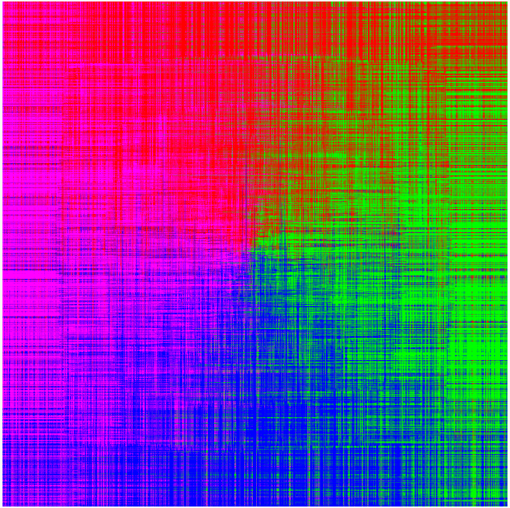

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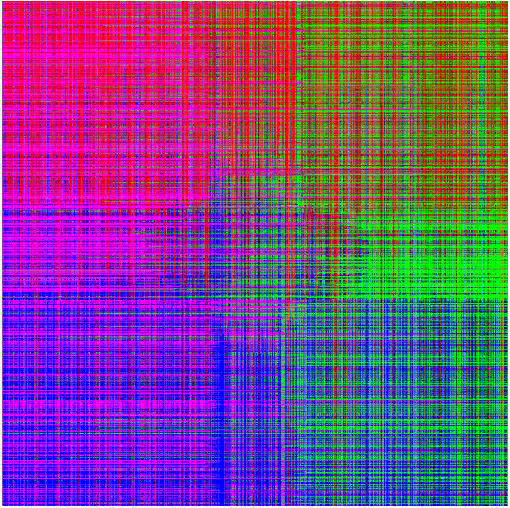

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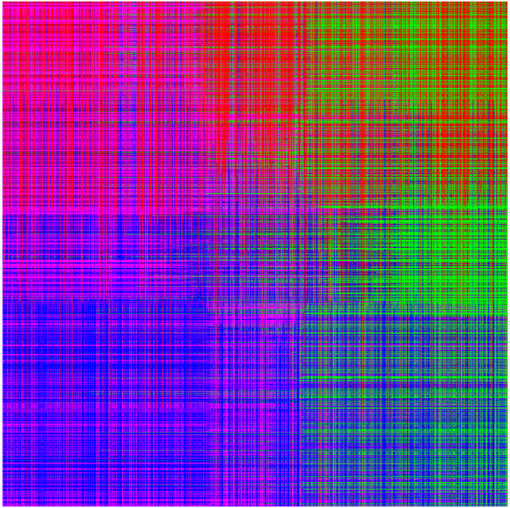

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Problem Author: Angel Karchev

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  - Determine how many upgrades you would miss by starting at level 1 and store this in a variable ans.

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Statistics: ... submissions, ... accepted, ... unknown

I: Industry Improvements

Problem Author: Cristian-Alexandru Botocan

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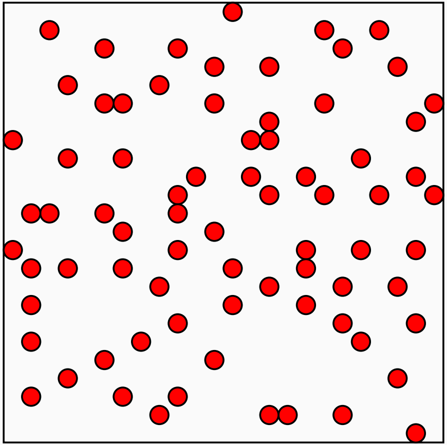

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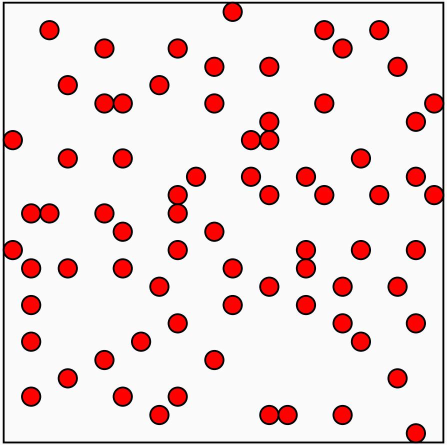

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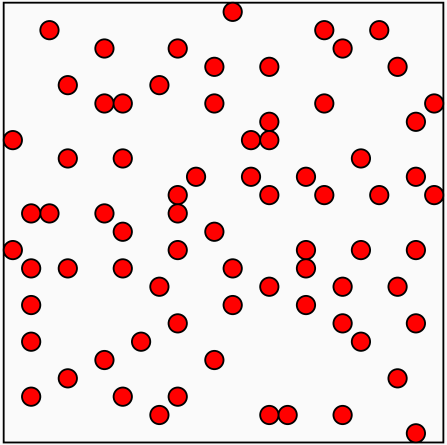

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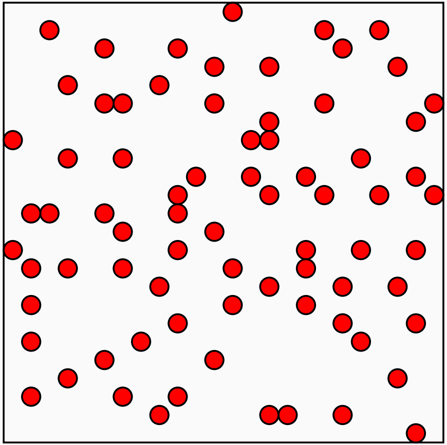
- **Observation:** The points are randomly distributed, so there are no nasty testcases.
- How can we make use of this fact?



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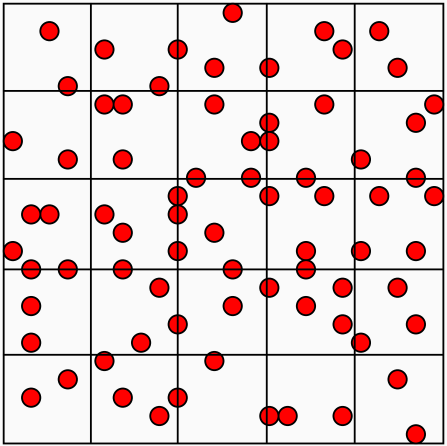

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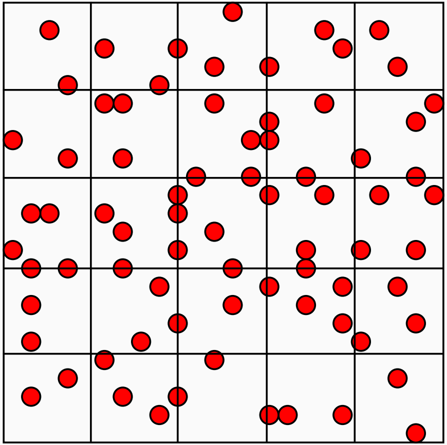

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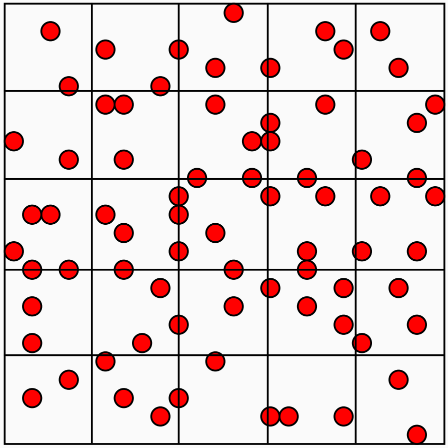
- **Observation:** The smallest perimeter is hence at most $\left(2+\sqrt{2}\right)\ell$.



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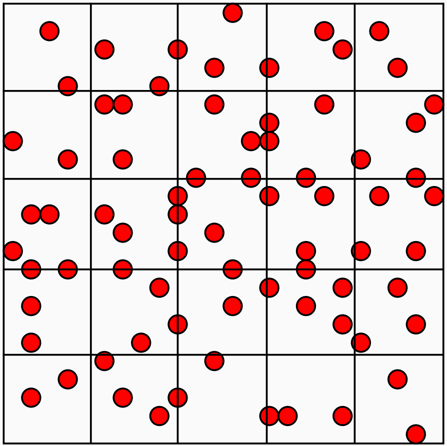

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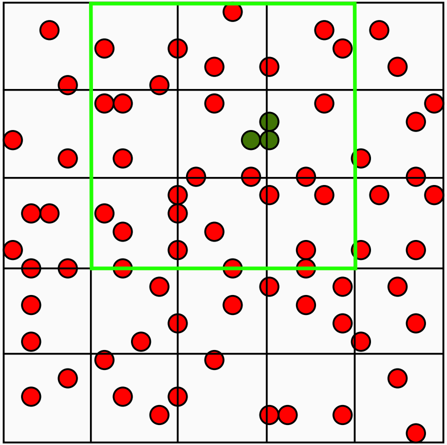
- **Solution:** Calculate the perimeter of the triangles contained in all blocks of 3×3 tiles.



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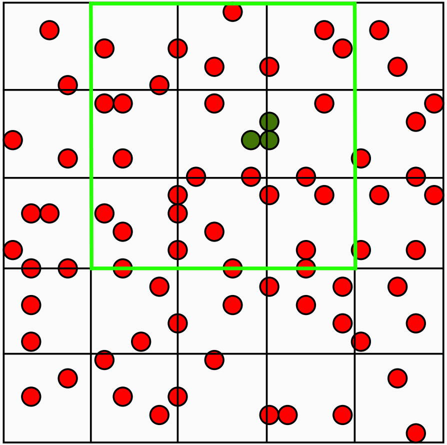

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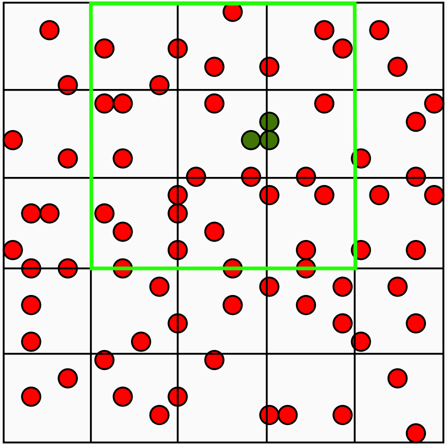
- **Solution:** Calculate the perimeter of the triangles contained in all blocks of 3×3 tiles.
- **Solution:** Because the points are uniformly distributed, the number of points inside the blocks is small with high probability.
- **Complexity:** $\mathcal{O}(n)$, with high probability.



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- **Problem:** Given a set of **uniform random** points in a square, find the smallest perimeter among all triangles.
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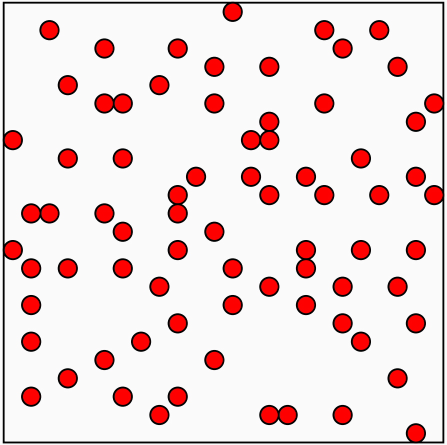
- **Challenge:** Try to make an algorithm that does not use randomness, and runs in $\mathcal{O}(n \log(n))$ time.



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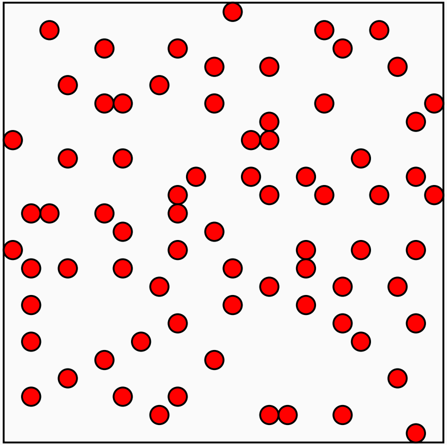

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Random facts

Jury work

- 360 commits (last year: 371)

[1] *After* codegolfing

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- The minimum[1] number of lines the jury needed to solve all problems is

  $$4 + 6 + 5 + 9 + 1 + 22 + 24 + 5 + 3 + 5 = 84$$

  On average 8.4 lines per problem, down from 10.4 last year

[1] *After* codegolfing

Thanks to:

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- Thomas Verwoerd 🎈 (TU Delft)
- Wietze Koops (RU Groningen)

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and AAPJE (VU Amsterdam)**

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- Angel Karchev (TU Delft)
- Jeroen Op de Beek (TU Delft)
- Leon van der Waal (TU Delft)
- Maarten Sijm (TU Delft)
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- Red Kalab (VU Amsterdam)