# KTH Challenge 2016 Solutions

June 16, 2017

# Jury

- Per Austrin (KTH)
- Jan Elffers (KTH)
- Lukáš Poláček (Google)
- Johan Sannemo (KTH)
- Marc Vinyals (KTH)

# B – Another Brick in the Wall

## Problem

Find if first $h$ sequences of numbers with sum $\geq w$ have sum $= w$

## Solution

While not done:

- If sum $< w$: add next brick
- If sum $= w$: begin new row
- If sum $> w$: impossible

$\geq 31$ submissions, $\geq 27$ correct, first at 0:05:01.

# C – Zoning

## Problem

Find 1 square furthest from all 3 squares

## Solution

- BFS starting from each 1 square? Too slow!
- BFS starting from every 3 square.
- Add all 3 squares to the queue at the same time.
- Answer is last 1 square that we visit.

$\geq$ 51 submissions, $\geq$ 14 correct, first at 0:16:54.

# F – Hay Bales

## Problem

Find the minimum number of moves to sort the sequence

## Solution

Repeat the following until sorted:

- Try to undo 2 inversions at a time (sort `PCC` or `PPC`).
- Otherwise sort any substring not yet sorted.

$\geq$ 41 submissions, $\geq$ 10 correct, first at 0:37:16.

# D – Dice Betting

## Problem

Calculate the probability that at least $k$ distinct values appear when $s$-sided die is thrown $n$ times.

## Solution

- Suppose we saw 5 distinct value on a 12-sided die. In the next throw, 7 outcomes are unseen and 5 already seen.
- Unseen value appears with probability $1 - \ell/s$ after seeing $\ell$ distinct values.
- Dynamic programming:
  - $p_{ij}$: probability we saw $j$ values after $i$ throws.
  - Update $p_{i+1,j}$ and $p_{i+1,j+1}$ using the above rule.

$\geq$ 21 submissions, $\geq$ 5 correct, first at 0:36:52.

# G – Racetrack

## Problem

Simulate the race and print the finish times

## Solution

- Only do work when someone passes the finish.
- Maintain a queue of trains of drivers.


$\geq 9$ submissions, $\geq 3$ correct, first at 0:56:11.

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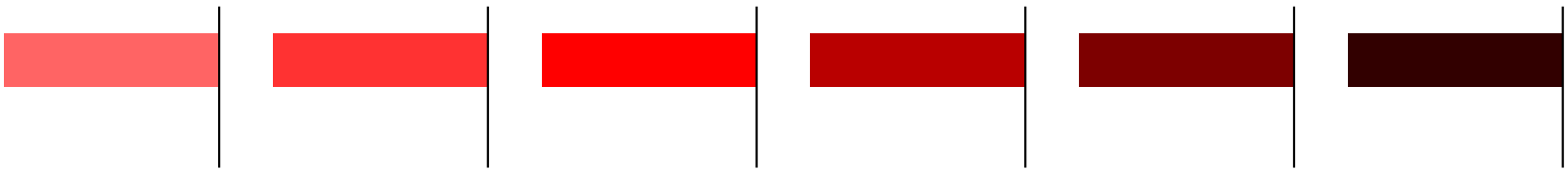

$t = 256$ $t = 223$ $t = 201$ $t = 191$ $t = 167$ $t = 161$

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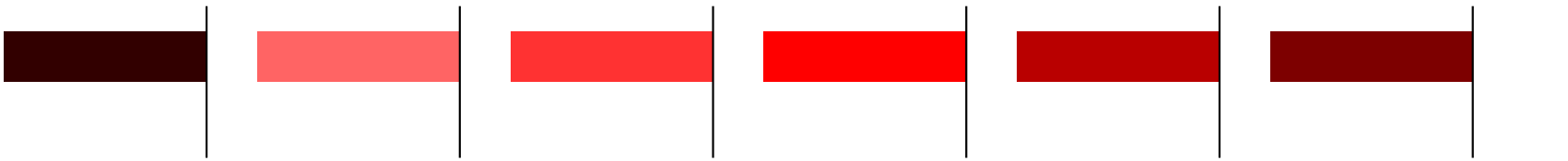

$t = 322$ $t = 256$ $t = 223$ $t = 201$ $t = 191$ $t = 167$

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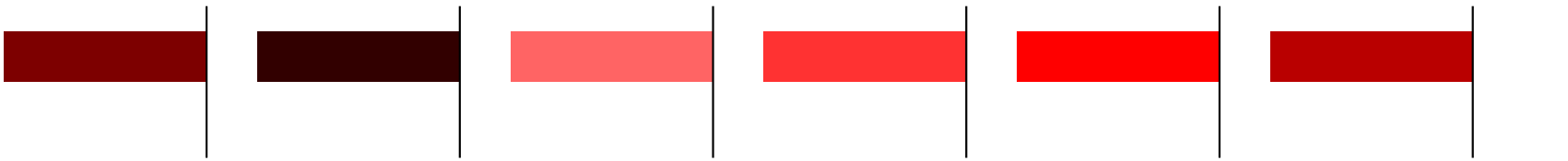

$t = 334$ $t = 322$ $t = 256$ $t = 223$ $t = 201$ $t = 191$

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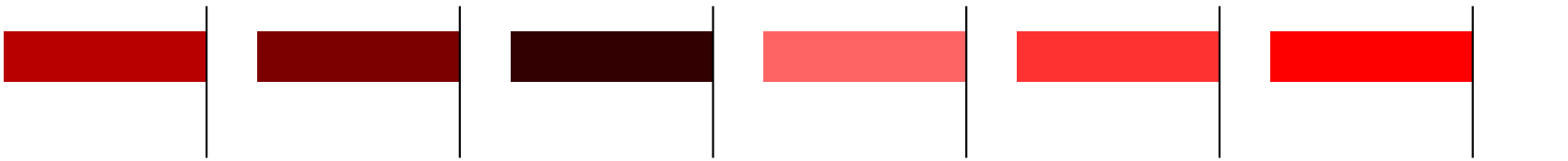

$t = 382$ $t = 334$ $t = 322$ $t = 256$ $t = 223$ $t = 201$

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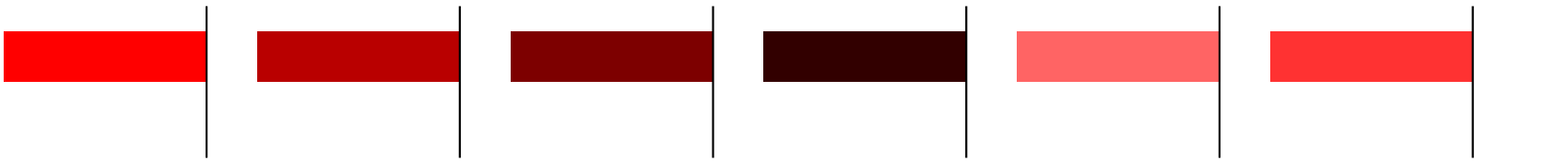

$t = 402$ $t = 382$ $t = 334$ $t = 322$ $t = 256$ $t = 223$

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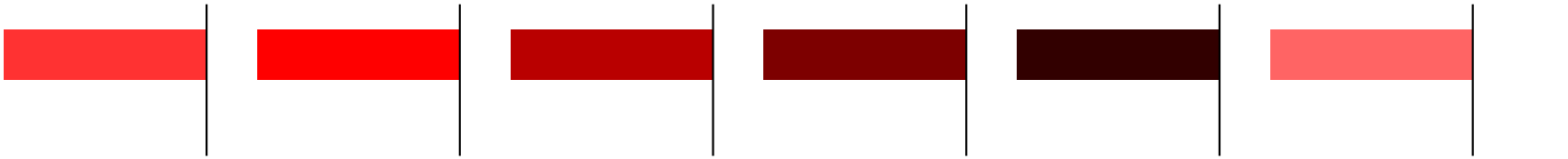

$t = 446$ $t = 402$ $t = 382$ $t = 334$ $t = 322$ $t = 256$

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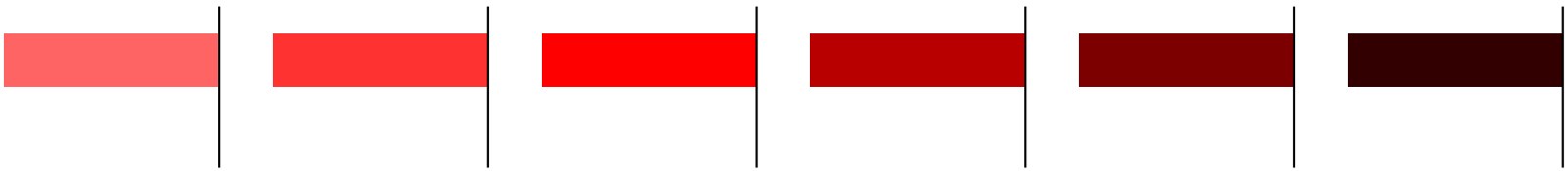

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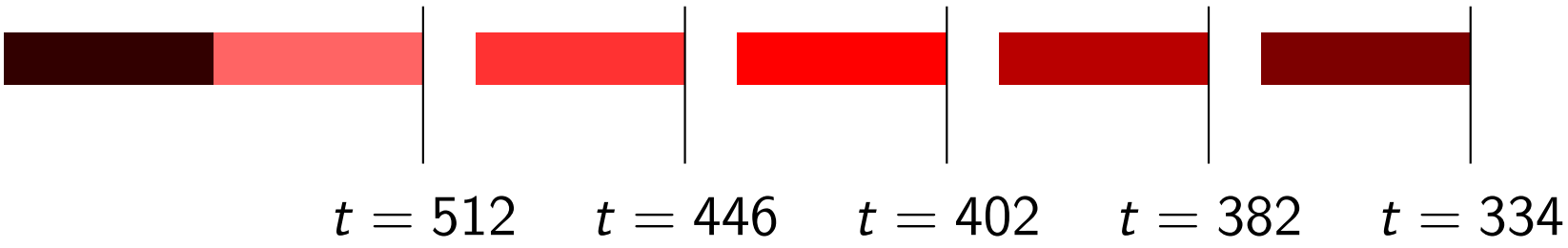


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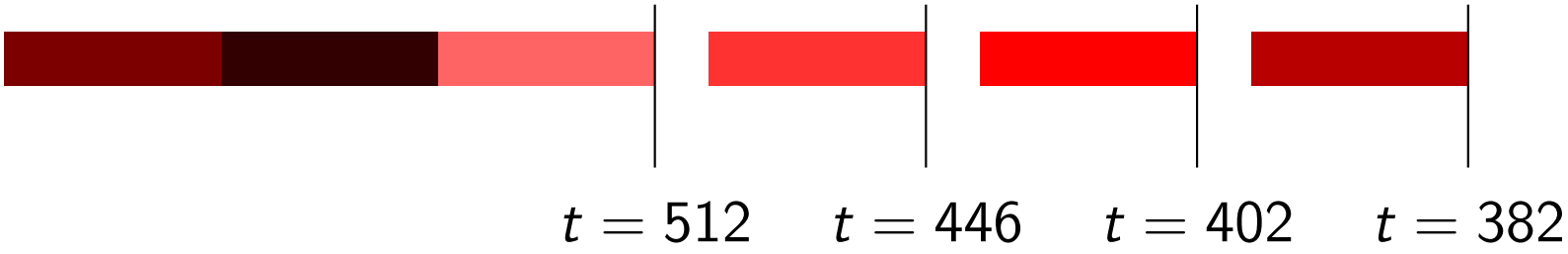


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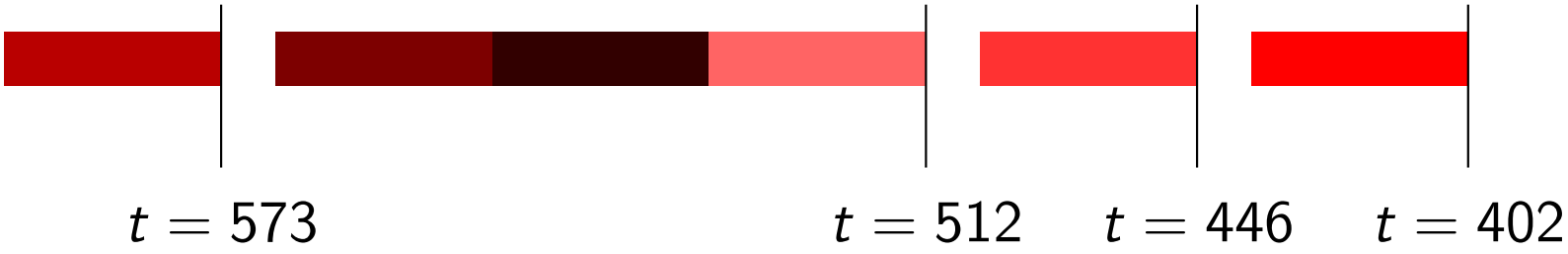


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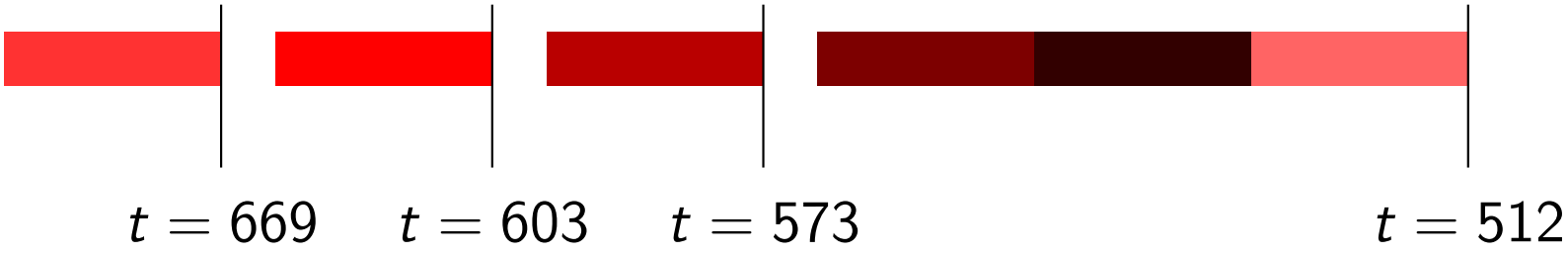


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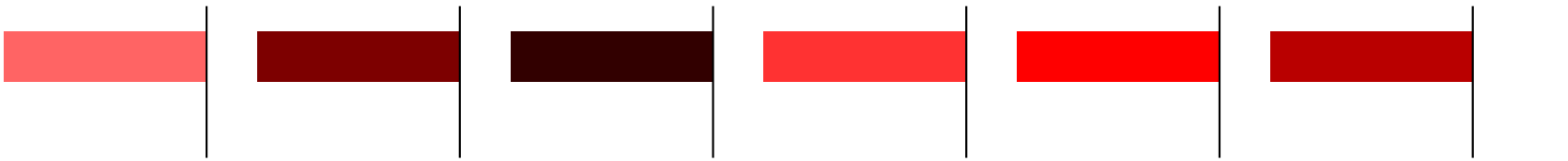

$t = 768$ $t = 679$ $t = 673$ $t = 669$ $t = 603$ $t = 573$

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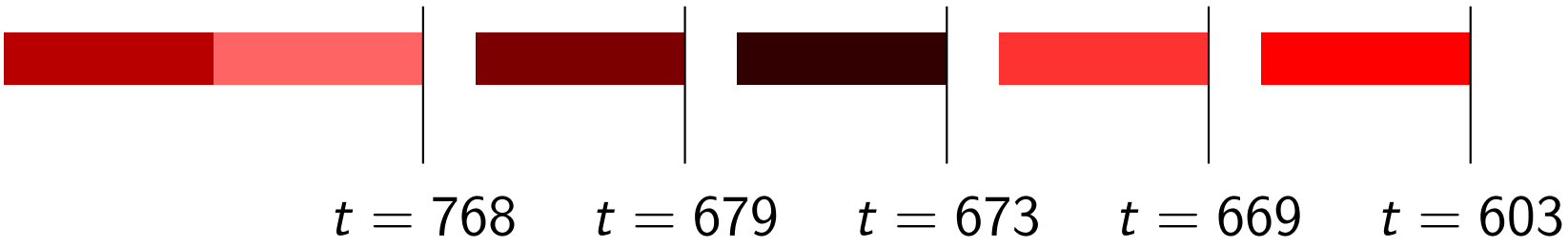


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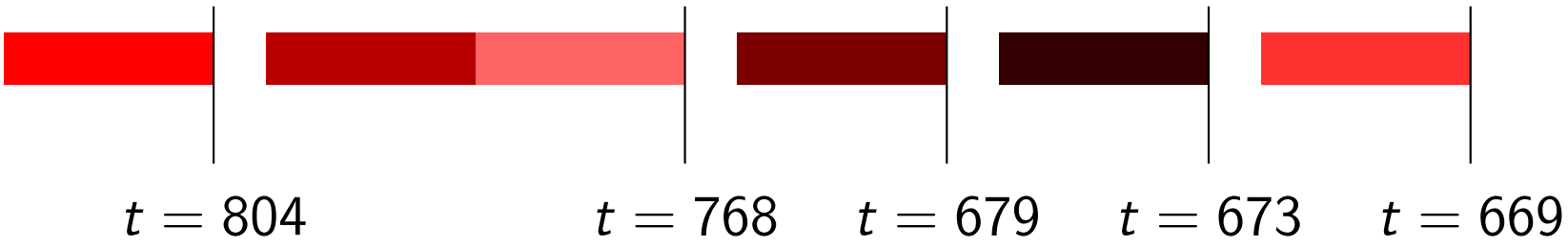


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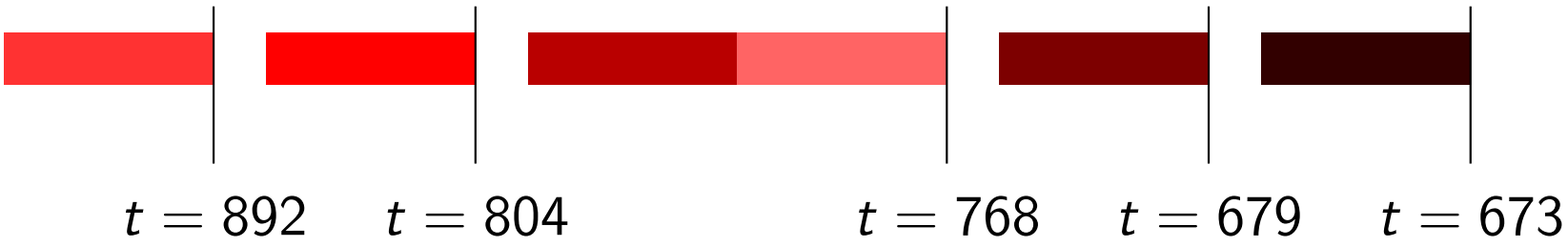


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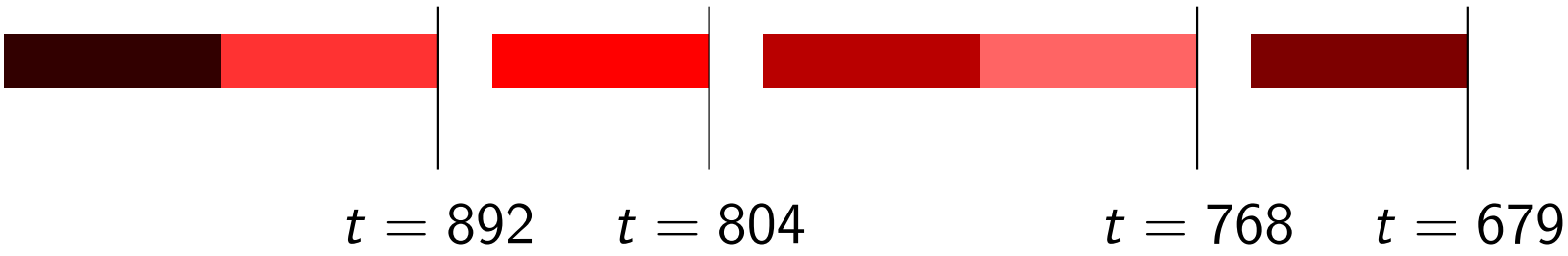


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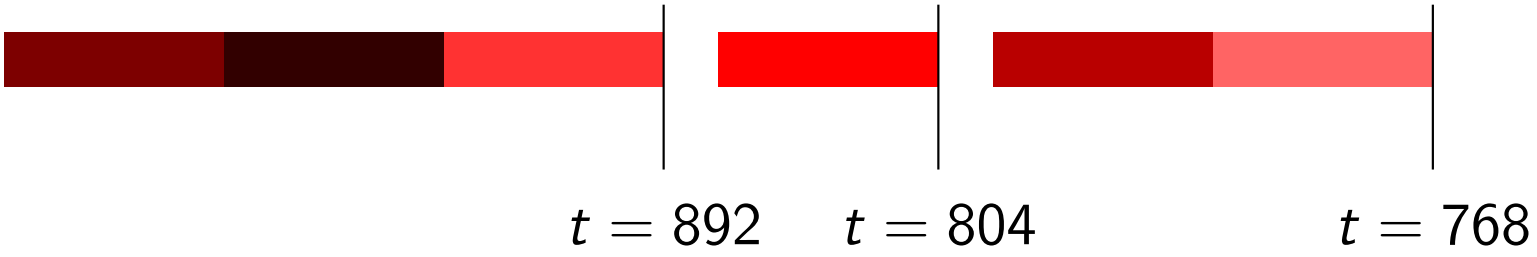


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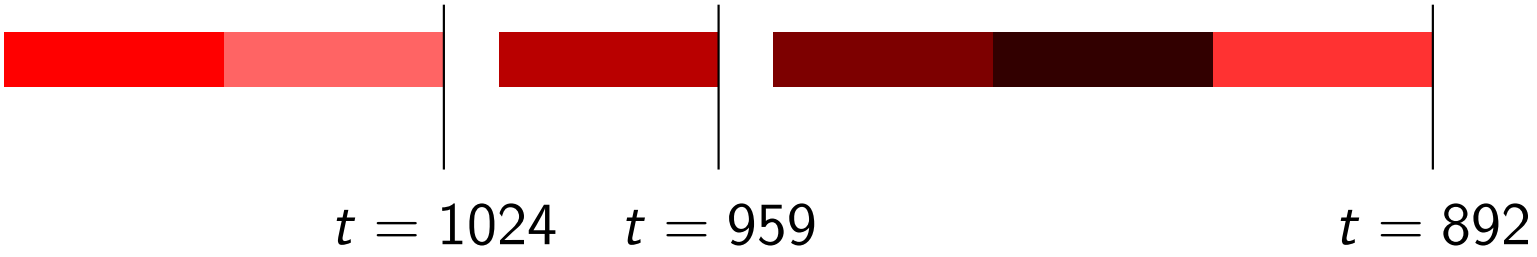


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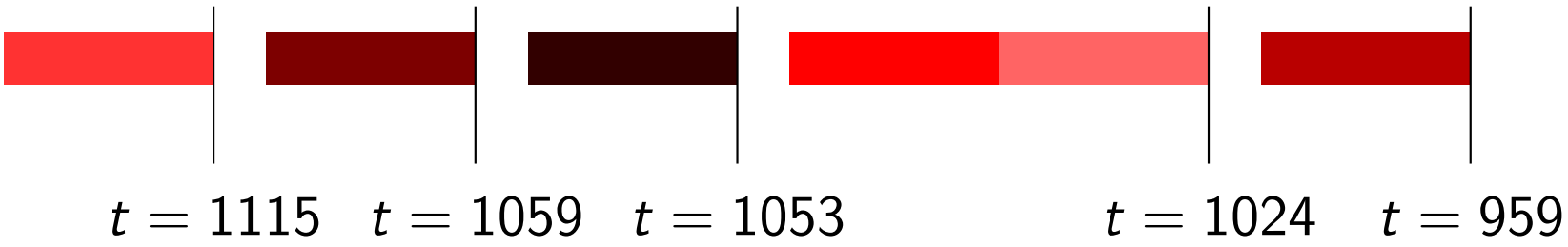


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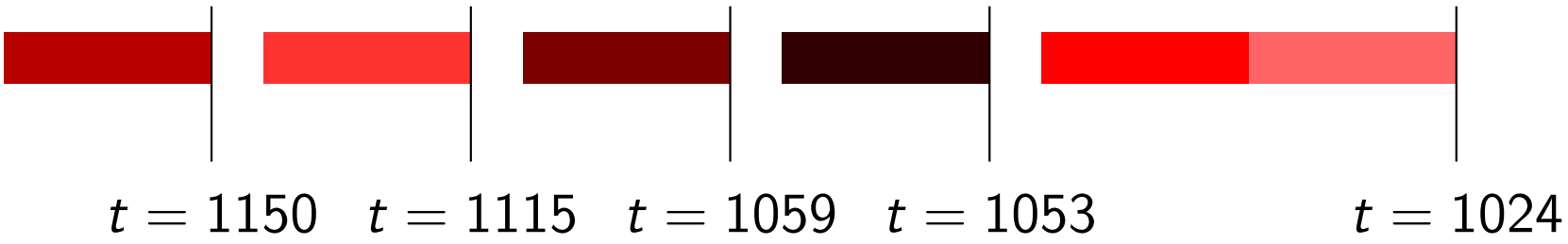


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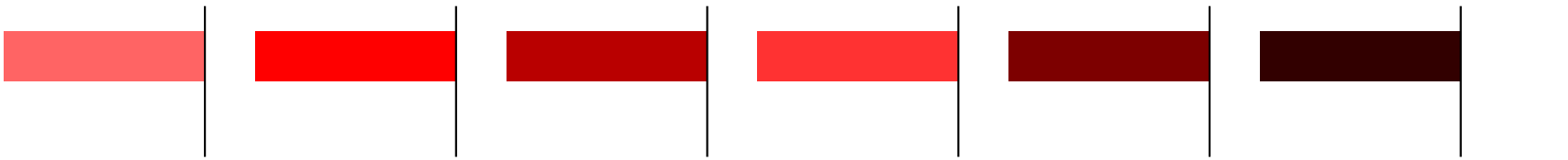

$t = 1280$ $t = 1225$ $t = 1150$ $t = 1115$ $t = 1059$ $t = 1053$

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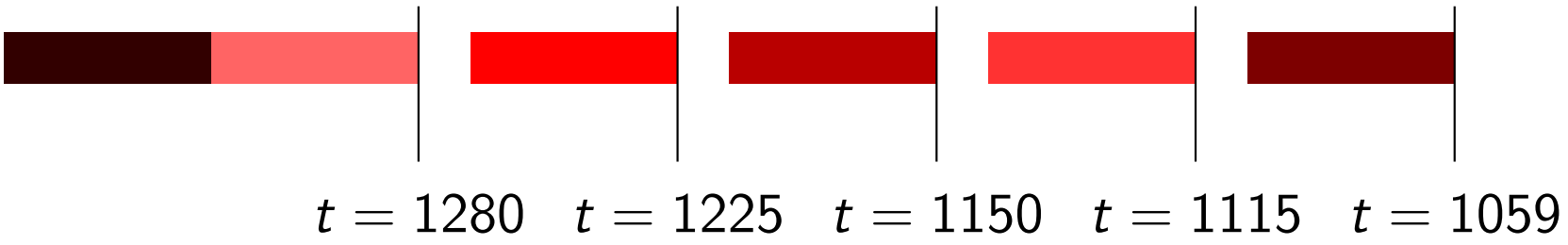


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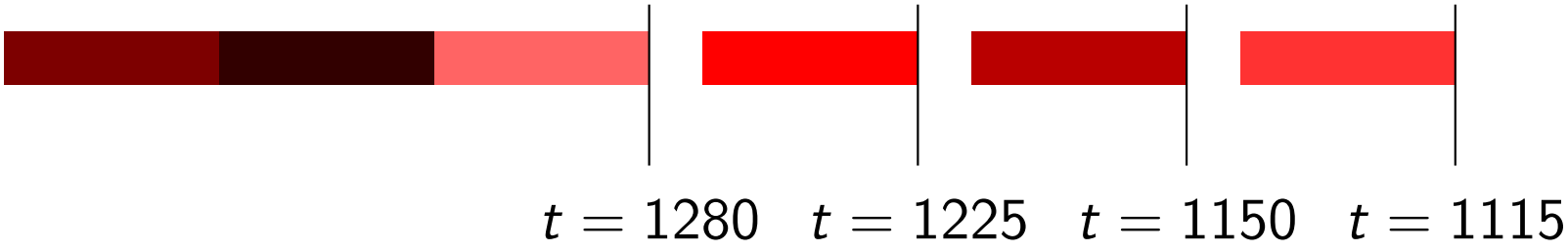


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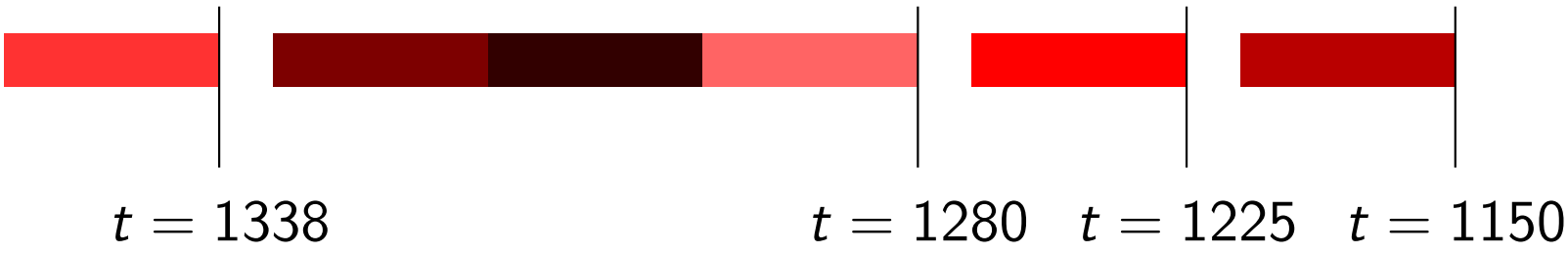


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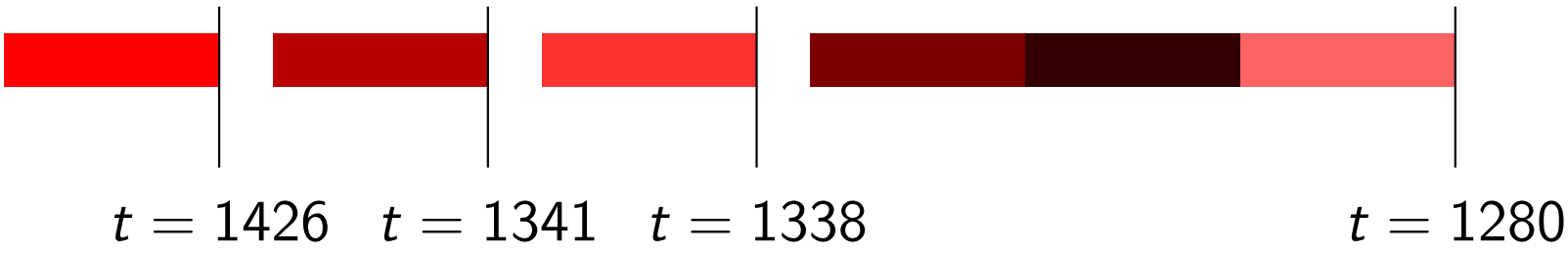


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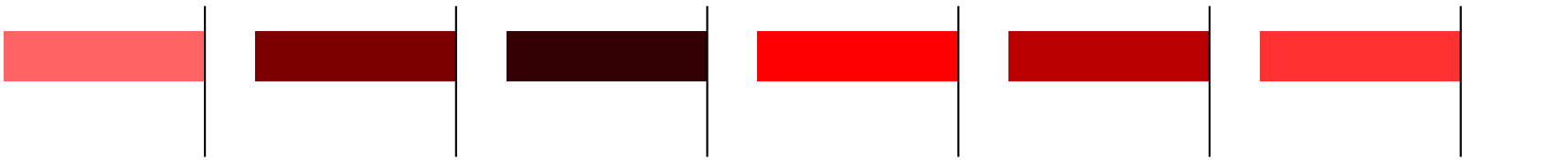

$t = 1536$ $t = 1447$ $t = 1441$ $t = 1426$ $t = 1341$ $t = 1338$

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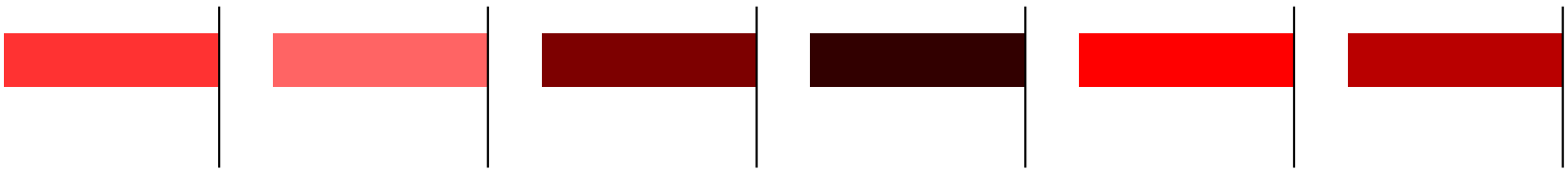

$t = 1561$ $t = 1536$ $t = 1447$ $t = 1441$ $t = 1426$ $t = 1341$

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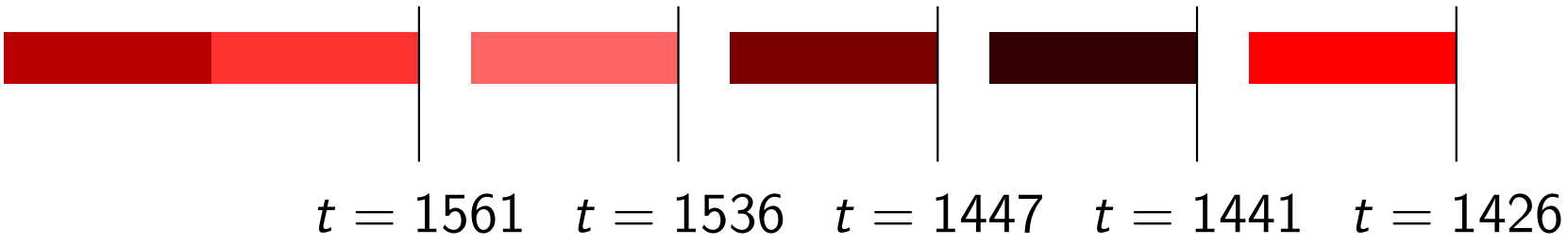


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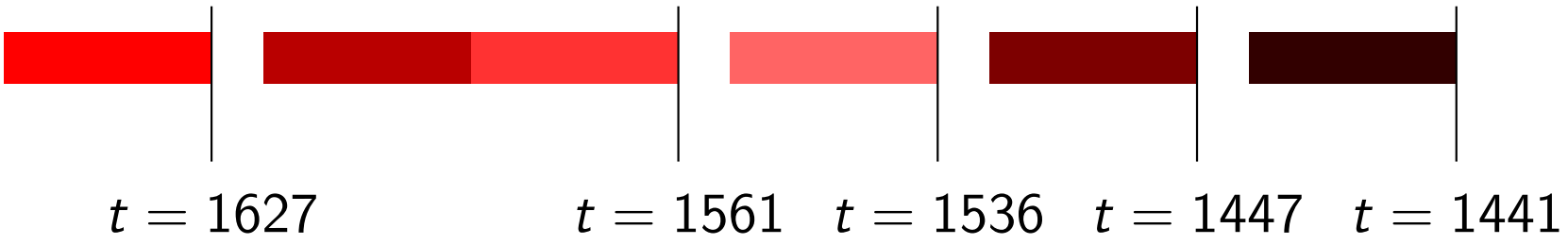


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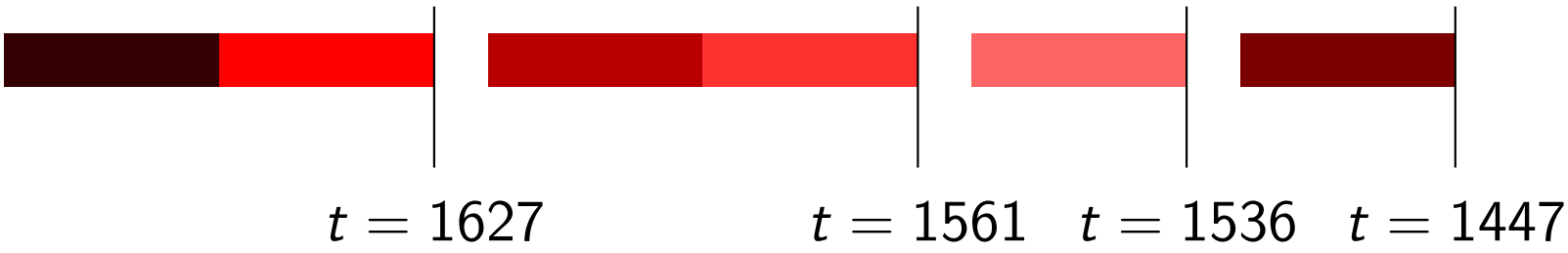


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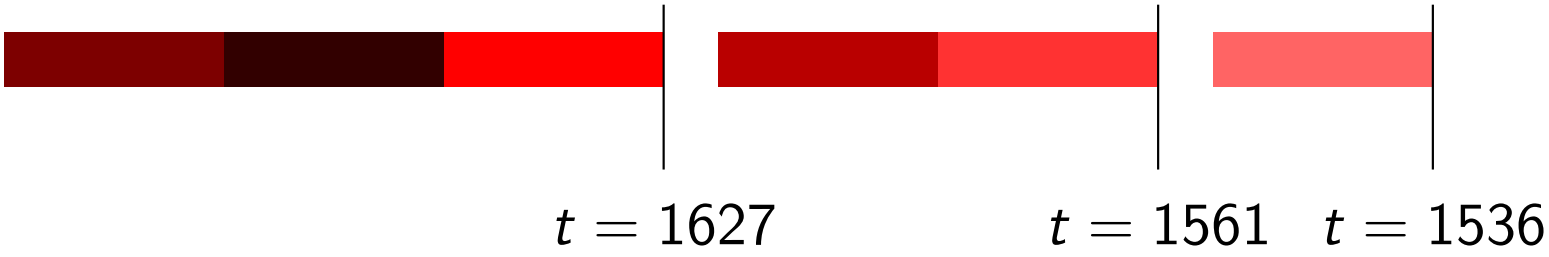


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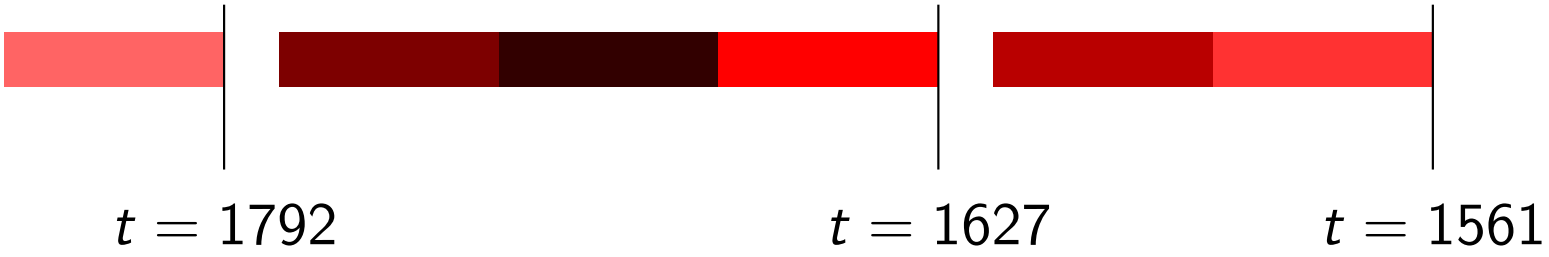


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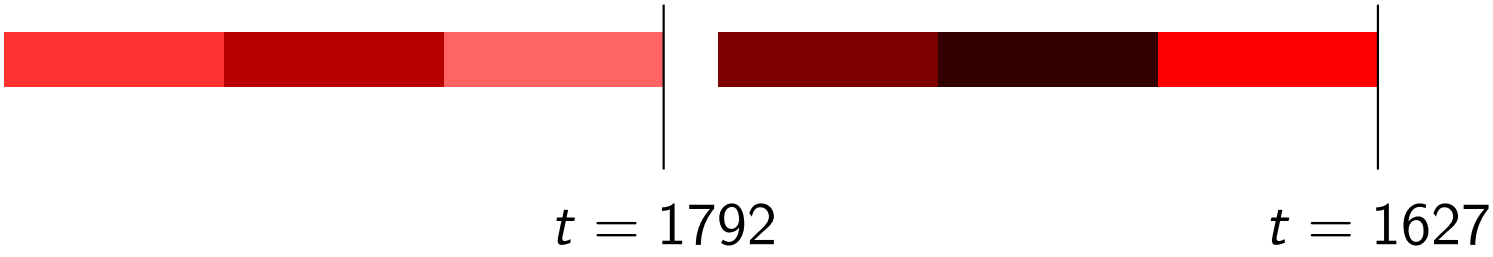


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$t = 2048$ $t = 2015$ $t = 1983$ $t = 1828$ $t = 1794$

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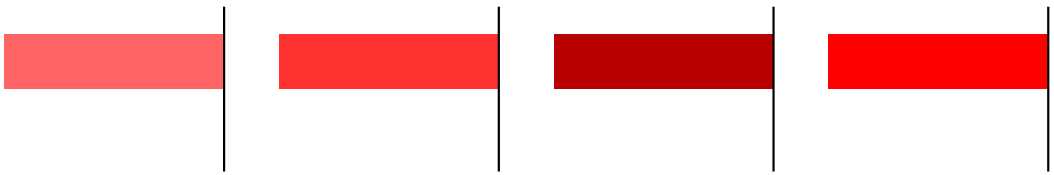
- Only do work when someone passes the finish.
- Maintain a queue of trains of drivers.



$t = 2048$ $t = 2015$ $t = 1983$ $t = 1828$

$\geq 9$ submissions, $\geq 3$ correct, first at 0:56:11.

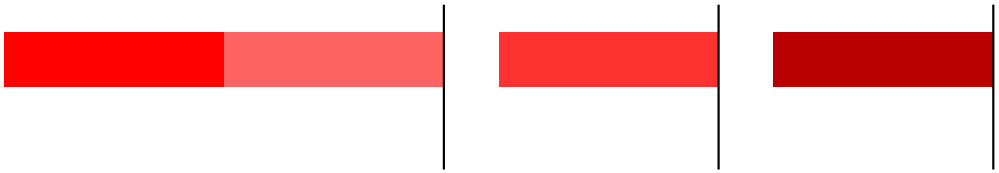
# G – Racetrack

## Problem

Simulate the race and print the finish times

## Solution

- Only do work when someone passes the finish.
- Maintain a queue of trains of drivers.



$t = 2048 \quad t = 2015 \quad t = 1983$

$\geq$ 9 submissions, $\geq$ 3 correct, first at 0:56:11.

# G – Racetrack

## Problem

Simulate the race and print the finish times

## Solution

- Only do work when someone passes the finish.
- Maintain a queue of trains of drivers.

$t = 2048 \quad t = 2015$

$\geq$ 9 submissions, $\geq$ 3 correct, first at 0:56:11.

# G – Racetrack

## Problem

Simulate the race and print the finish times

## Solution

- Only do work when someone passes the finish.
- Maintain a queue of trains of drivers.

$t = 2238$ $t = 2048$

$\geq 9$ submissions, $\geq 3$ correct, first at 0:56:11.

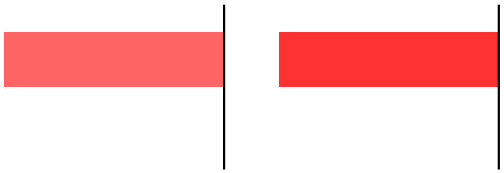
# G – Racetrack

## Problem

Simulate the race and print the finish times

## Solution

- Only do work when someone passes the finish.
- Maintain a queue of trains of drivers.



$t = 2304$ $t = 2238$

$\geq 9$ submissions, $\geq 3$ correct, first at 0:56:11.

# G – Racetrack

## Problem

Simulate the race and print the finish times

## Solution

- Only do work when someone passes the finish.
- Maintain a queue of trains of drivers.

$t = 2304$

$\geq 9$ submissions, $\geq 3$ correct, first at 0:56:11.

# G – Racetrack

## Problem

Simulate the race and print the finish times

## Solution

- Only do work when someone passes the finish.
- Maintain a queue of trains of drivers.

$t = 2560$

$\geq 9$ submissions, $\geq 3$ correct, first at 0:56:11.

# A – Ironman

## Problem

Find shortest path across layers with different speeds

## Insight

Light always takes the ~~shortest~~ fastest path

## Solution

- Assume initial angle known
- Snell's refraction law: $\sin\theta_1/v_1 = \sin\theta_2/v_2$
- Binary search

$\geq 6$ submissions, $\geq 6$ correct, first at 1:06:53.

# H – nnnnn

## Problem

Given number $L = N \cdot D \leq 10^{10^6}$ with $D = \lceil \log_{10}(N+1) \rceil$, find $N$

## Insight

For a given $N$,
$length(input) \approx \log(ND) = \log(N) + \log(D) \approx D + \log(D)$
$\log(D)$ is very small, so $D \approx length(input)$

## Solution

- Try all values of $D$ from $length(input)$ to $length(input) - 7$
- Check if $D \cdot 10^{D-1} \leq L < (D+1) \cdot 10^D$
- If so, this is the correct $D$
- **Denominator is small, so division is** $O(length)$

$\geq$ 17 submissions, $\geq$ 2 correct, first at 1:32:34.

# E – Climbing

## Problem

Find sequence of safe peg placements

## Solution

- There is a safe sequence on a path with $\log n$ pegs
- Lay unsafe sequence on a line
- Simulate safe sequence: $s_i = \bigcup u_j$ if $\text{line}_j$ has peg at time $i$
- Max #pegs $|\bigcup_{j \in J} u_j| \leq |J| \max |u_j| \leq \log n \cdot u \leq 10u$

$\geq 0$ submissions, $\geq 0$ correct.

# This was fun! When is the next contest?

- We train every two weeks at KTH, check www.csc.kth.se/contest
- Next training in September
- Nordic Championships in October, North-western Europe qualifier in November
- Plenty of other online competitions every week
- Subscribe to our calendar

# Guide To Programming Contests

- `http://contest-wiki.csc.kth.se/`
- Written by Lukáš.
- The first training program for programming contests.
- Well received in the contest community.