TheEmpireStrikesBack
SRM 678 D1 500 Pointer

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The Problem

- Darth Vader wants to destroy all N planets in the galaxy.
- Darth Vader is aboard the Death Star, which has M missiles.
- Darth Vader needs to install a missile booster with strength S to use the missiles.
- Darth Vader wants to use the minimum strength booster $min(S)$ to destroy all planets.
- Given the planets' locations and M, find $min(S)$.

Galaxy Details

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- The galaxy is in a 2D plane (first quadrant).
- Planets are located at some coordinate (x, y).
- The Death Star is always located at $(0, 0)$.
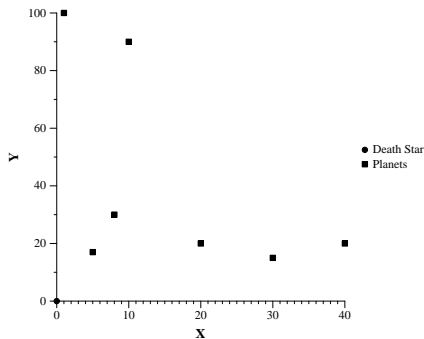
Missile Details

- Missiles can only target a planet's location.
- When a missile strikes (x, y), it destroys all planets within the bounding box specified by $(0, 0)$ and (x, y), inclusively.

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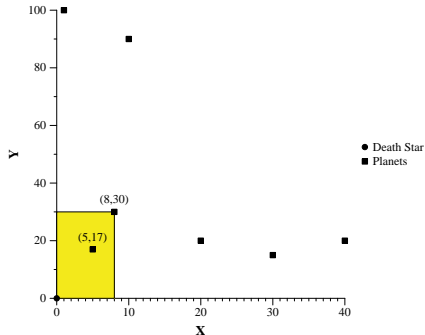
Booster Details

- The missile booster strength S may change the bounding box.
- The bounding box is now specified by $(0,0)$ and $(x + S, y + S)$.

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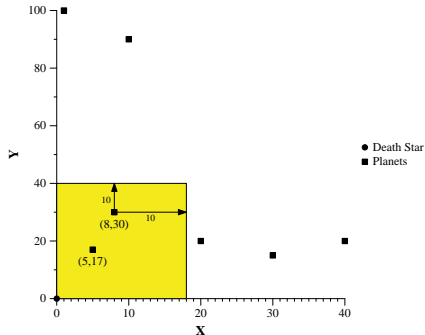
Prototype

- **Class name:** TheEmpireStrikesBack
- **Method:** find()
- **Parameters:**

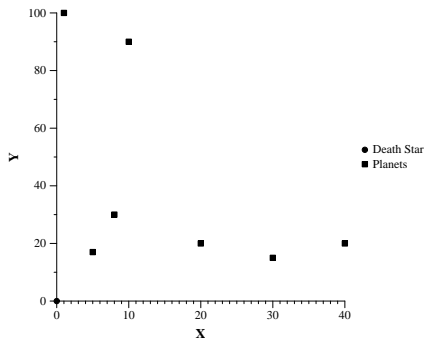| AX	int	determines planets' locations
BX	int	determines planets' locations
CX	int	determines planets' locations
AY	int	determines planets' locations
BY	int	determines planets' locations
CY	int	determines planets' locations
N	int	number of planets
M	int	number of missiles

- **Return Value:** int

Constraints

- AX, BX, CX, AY, BY, CY is between 0 and 10^9.
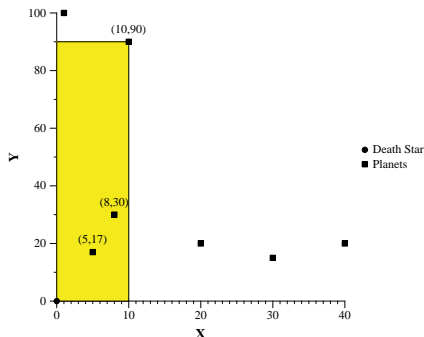
- N is between 1 and 10^5.

- M is between 1 and N.

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Example

Planets are at locations $(1, 100)$, $(5, 17)$, $(8, 30)$, $(10, 90)$, $(20, 20)$, $(30, 15)$, $(40, 20)$.

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Example

What happens if we strike planet at $(10, 90)$ with a missile? Booster
strength $S = 0$.

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Example

If we want to eliminate most of the planets, we can strike the outer planets of the galaxy.

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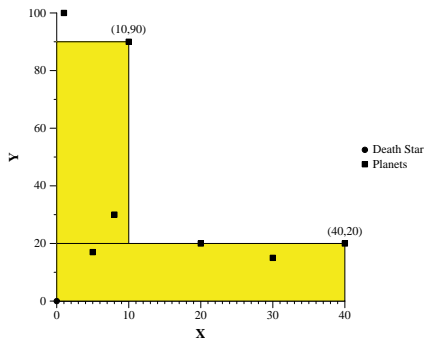
Example

We don't really care about planets within the strike of other planets.

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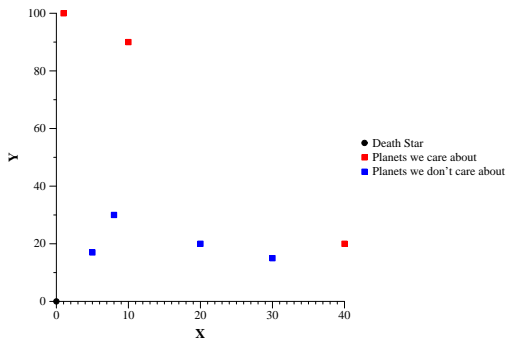
Example

This simplifies the problem. Now we only have planets at locations $(1, 100), (10, 90), (40, 20)$.

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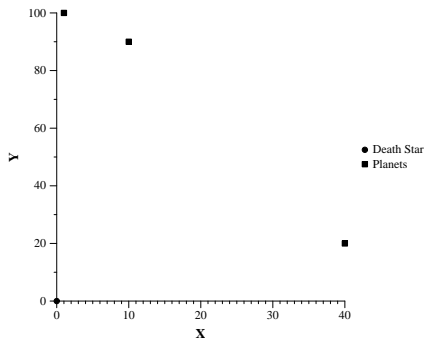
Example
What if we are given $M = 1$ missiles?

$min(S) = 30$

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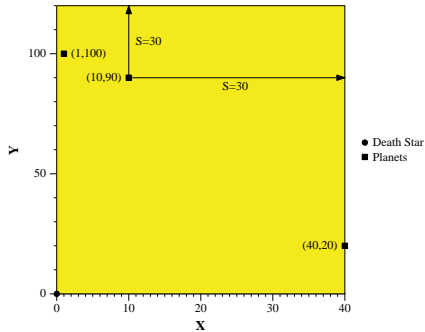
Example
What if we are given $M = 2$ missiles?

$min(S) = 10$

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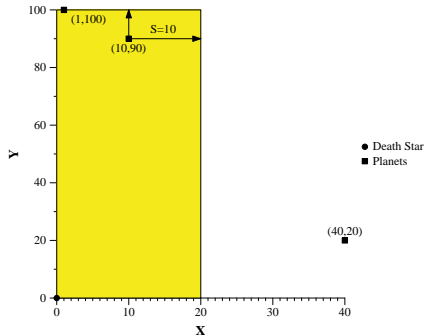
Example
What if we are given $M = 3$ missiles?
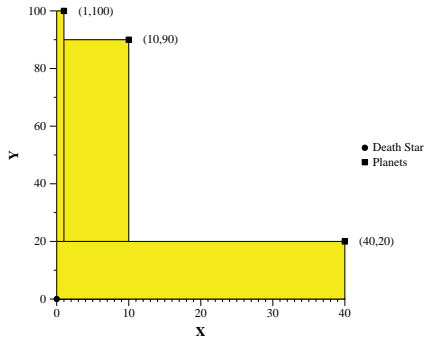
$min(S) = 0$

Something to notice

- We know N is between 1 and 100,000
- Since we can only do roughly 10,000,000 operations, N^2 is too slow

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Algorithm

- Find all the planets locations given N, AX, BX, CX, AY, BY, and CY. $O(N)$
- Insert the planets into a multimap keyed on x. $O(Nlog(N))$
- Eliminate planets that we do not care about. $O(N)$
- Put the remaining planets into a deque. $O(N)$
- Perform binary search to find $min(S)$. $O(Nlog(maxsize(S)))$
    - Determine for a given S whether we can destroy all planets.

Performance

- Frobnitzem, my Linux machine
- Intel i5 at 2.6GHz

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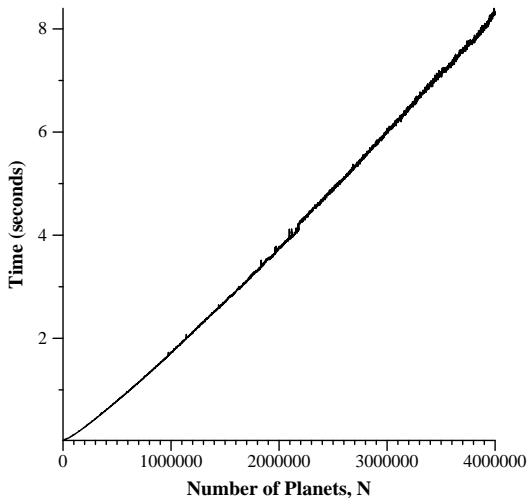
Test Galaxy
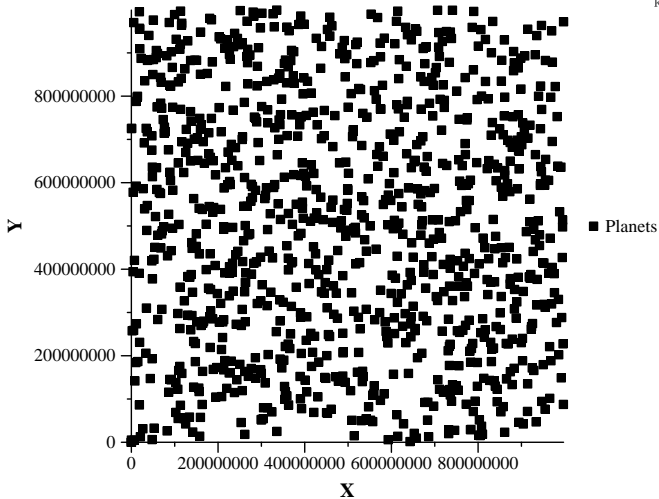
Galaxy for AX=10, BX=20, CX=30, AY=40, BY=50, CY=60, N=1000

How did the Topcoders do?

- 255 Topcoders opened the problem.
- 119 (46%) submitted a solution.
- 99 (83%) of the submissions were correct.
- Success rate was 38%
- Best time was 8:11
- Average correct time was 29:35

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