FPC 2019 problem presentation; spoiler alert!

A - Alternative Blockchain Algorithms

B - Balloon Party

C - Circus Tent

D - Darts

E - Encryptastrophy

F - Forest Run

G - Game Night

H - Hurry the Hedgehog

FPC 2019

Problem A - Alternative Blockchain Algorithms

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

Problem description

Problem A - Alternative Blockchain Algorithms

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

Problem description

For any block in the blockchain B there is an id i_n, parent p_n and money m_n. To verify the blockchain, we try to show the following holds:

Problem A - Alternative Blockchain Algorithms

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

Problem description

For any block in the blockchain B there is an id i_n, parent p_n and money m_n. To verify the blockchain, we try to show the following holds:

$$i_n = p_{n+1} \text{ for } 0 < n < |B|$$

Problem A - Alternative Blockchain Algorithms

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

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$$i_n = p_{n+1} \text{ for } 0 < n < |B|$$

And to check if the money never dips below 0:

Problem A - Alternative Blockchain Algorithms

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

Problem description

For any block in the blockchain B there is an id i_n, parent p_n and money m_n. To verify the blockchain, we try to show the following holds:

$$i_n = p_{n+1} \text{ for } 0 < n < |B|$$

And to check if the money never dips below 0:

$$\sum_{i=1}^{n} m_i \geq 0 \text{ for } 0 < n < |B|$$

Problem A - Alternative Blockchain Algorithms

A - Alternative Blockchain Algorithms

B - Balloon Party

C - Circus Tent

D - Darts

E - Encryptastrophy

F - Forest Run

G - Game Night

H - Hurry the Hedgehog

Solution

Problem A - Alternative Blockchain Algorithms

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

Solution

Run through the program line by line, checking if each node's parent is the same as the previous node.

Problem A - Alternative Blockchain Algorithms

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

Solution

Run through the program line by line, checking if each node's parent is the same as the previous node.
Keep a running tally of the account balance, returning "NO_MONEY" if the money ever is lower than 0.

Problem A - Alternative Blockchain Algorithms

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

Solution

Run through the program line by line, checking if each node's parent is the same as the previous node.
Keep a running tally of the account balance, returning "NO_MONEY" if the money ever is lower than 0.

Pitfalls

- Checking whether the balance is negative only at the end of the chain
- Forgetting to check the parent of the genesis block (Which should be 0)

Problem B - Balloon Party (1/2)

Problem description

How much helium can be trapped under the party tent?

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

Problem B - Balloon Party (2/2)

Store all tent sections that are reachable from outside in a priority queue

1	1	1	1	1
1	3	3	3	1
1	2	2	2	1
1	4	4	4	1
1	2	3	2	1

Problem B - Balloon Party (2/2)

A - Alternative Blockchain Algorithms

B - Balloon Party

C - Circus Tent

D - Darts

E - Encryptastrophy

F - Forest Run

G - Game Night

H - Hurry the Hedgehog

Get the highest section reachable from the outside

1	1	1	1	1
1	3	3	3	1
1	2	2	2	1
1	4	4	4	1
1	2	3	2	1

Problem B - Balloon Party (2/2)

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

Fill that part of the tent as far as possible, and update priority queue

1	1	1	1	1
1	3	3	3	1
1	2	2	2	1
1	4	4	4	1
1	2	3	2	1

FPC 2019

Problem B - Balloon Party (2/2)

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

Again find highest section reachable

1	1	1	1	1
1	3	3	3	1
1	2	2	2	1
1	4	4	4	1
1	2	3	2	1

Problem B - Balloon Party (2/2)

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

Again find that part of the tent

1	1	1	1	1
1	3	3	3	1
1	2	2	2	1
1	4	4	4	1
1	2	3	2	1

Problem C - Circus Tent

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

Problem description

Given diameter d of inner ring and height h, calculate the surface area of a cylindrical circus tent

Solution

Radius: $r = \frac{d}{2} + 5$
Area: $A = 2\pi rh + \pi r^2$

Pitfalls

- Not enough precision

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

Problem D - Darts

Problem description

Given vectors $\mathbf{h}, \mathbf{v}, \mathbf{p}, \mathbf{d}$, determine whether the (half-)line from $\mathbf{p}$ in direction $\mathbf{d}$ intersects the ellipse with axes $\mathbf{h}$ and $\mathbf{v}$.

FPC 2019

Problem D - Darts

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

Problem description

Given vectors $\mathbf{h}, \mathbf{v}, \mathbf{p}, \mathbf{d}$, determine whether the (half-)line from $\mathbf{p}$ in direction $\mathbf{d}$ intersects the ellipse with axes $\mathbf{h}$ and $\mathbf{v}$.

Where is the intersection?

Problem D - Darts

A - Alternative Blockchain Algorithms

B - Balloon Party

C - Circus Tent

D - Darts

E - Encryptastrophy

F - Forest Run

G - Game Night

H - Hurry the Hedgehog

FPC 2019

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Given vectors $\mathbf{h}, \mathbf{v}, \mathbf{p}, \mathbf{d}$, determine whether the (half-)line from $\mathbf{p}$ in direction $\mathbf{d}$ intersects the ellipse with axes $\mathbf{h}$ and $\mathbf{v}$.

Where is the intersection?

Determine $\mathbf{n} := \mathbf{h} \times \mathbf{v}$.

Problem D - Darts

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

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Given vectors $\mathbf{h}, \mathbf{v}, \mathbf{p}, \mathbf{d}$, determine whether the (half-)line from $\mathbf{p}$ in direction $\mathbf{d}$ intersects the ellipse with axes $\mathbf{h}$ and $\mathbf{v}$.

Where is the intersection?

Determine $\mathbf{n} := \mathbf{h} \times \mathbf{v}$. Then $\mathbf{n} \cdot \mathbf{i} = 0$ for all $\mathbf{i}$ in $\langle \mathbf{h}, \mathbf{v} \rangle$.

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

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Given vectors $\mathbf{h}, \mathbf{v}, \mathbf{p}, \mathbf{d}$, determine whether the (half-)line from $\mathbf{p}$ in direction $\mathbf{d}$ intersects the ellipse with axes $\mathbf{h}$ and $\mathbf{v}$.

Where is the intersection?

Determine $\mathbf{n} := \mathbf{h} \times \mathbf{v}$. Then $\mathbf{n} \cdot \mathbf{i} = 0$ for all $\mathbf{i}$ in $\langle \mathbf{h}, \mathbf{v} \rangle$. We want $\mathbf{n} \cdot (\mathbf{p} + l\mathbf{d}) = 0$,

Problem D - Darts

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

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Problem D - Darts

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

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FPC 2019

Problem D - Darts

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

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Problem D - Darts

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

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Is the intersection inside the board?

Problem D - Darts

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

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Is the intersection inside the board?

Linear algebra: $\mathbf{h}$ and $\mathbf{v}$ are orthogonal and generate $\langle \mathbf{h}, \mathbf{v} \rangle$.

Problem D - Darts

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

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Given vectors $\mathbf{h}, \mathbf{v}, \mathbf{p}, \mathbf{d}$, determine whether the (half-)line from $\mathbf{p}$ in direction $\mathbf{d}$ intersects the ellipse with axes $\mathbf{h}$ and $\mathbf{v}$.

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Is the intersection inside the board?

Linear algebra: $\mathbf{h}$ and $\mathbf{v}$ are orthogonal and generate $\langle \mathbf{h}, \mathbf{v} \rangle$.
$\mathbf{i} = a\mathbf{h} + b\mathbf{v}$

Problem D - Darts

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

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Where is the intersection?

Determine $\mathbf{n} := \mathbf{h} \times \mathbf{v}$. Then $\mathbf{n} \cdot \mathbf{i} = 0$ for all $\mathbf{i}$ in $\langle \mathbf{h}, \mathbf{v} \rangle$. We want $\mathbf{n} \cdot (\mathbf{p} + l\mathbf{d}) = 0$, so $l = -\frac{\mathbf{n} \cdot \mathbf{p}}{\mathbf{n} \cdot \mathbf{d}}$. This gives the intersection point $\mathbf{i} = \mathbf{p} + l\mathbf{d}$.

Is the intersection inside the board?

Linear algebra: $\mathbf{h}$ and $\mathbf{v}$ are orthogonal and generate $\langle \mathbf{h}, \mathbf{v} \rangle$.
$\mathbf{i} = a\mathbf{h} + b\mathbf{v}$ gives $\mathbf{i} \cdot \mathbf{v} = a(\mathbf{v} \cdot \mathbf{v})$,

Problem D - Darts

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

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Where is the intersection?

Determine $\mathbf{n} := \mathbf{h} \times \mathbf{v}$. Then $\mathbf{n} \cdot \mathbf{i} = 0$ for all $\mathbf{i}$ in $\langle \mathbf{h}, \mathbf{v} \rangle$. We want $\mathbf{n} \cdot (\mathbf{p} + l\mathbf{d}) = 0$, so $l = -\frac{\mathbf{n} \cdot \mathbf{p}}{\mathbf{n} \cdot \mathbf{d}}$. This gives the intersection point $\mathbf{i} = \mathbf{p} + l\mathbf{d}$.

Is the intersection inside the board?

Linear algebra: $\mathbf{h}$ and $\mathbf{v}$ are orthogonal and generate $\langle \mathbf{h}, \mathbf{v} \rangle$. $\mathbf{i} = a\mathbf{h} + b\mathbf{v}$ gives $\mathbf{i} \cdot \mathbf{v} = a(\mathbf{v} \cdot \mathbf{v})$, so $a = \frac{\mathbf{i} \cdot \mathbf{v}}{\mathbf{v} \cdot \mathbf{v}}$ and $b = \frac{\mathbf{i} \cdot \mathbf{h}}{\mathbf{h} \cdot \mathbf{h}}$.

Problem D - Darts

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

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Where is the intersection?

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Is the intersection inside the board?

Linear algebra: $\mathbf{h}$ and $\mathbf{v}$ are orthogonal and generate $\langle \mathbf{h}, \mathbf{v} \rangle$. $\mathbf{i} = a\mathbf{h} + b\mathbf{v}$ gives $\mathbf{i} \cdot \mathbf{v} = a(\mathbf{v} \cdot \mathbf{v})$, so $a = \frac{\mathbf{i}\cdot\mathbf{v}}{\mathbf{v}\cdot\mathbf{v}}$ and $b = \frac{\mathbf{i}\cdot\mathbf{h}}{\mathbf{h}\cdot\mathbf{h}}$. We must check $a^2 + b^2 < 1$.

Problem D - Darts

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

Problem description

Given vectors $\mathbf{h}, \mathbf{v}, \mathbf{p}, \mathbf{d}$, determine whether the (half-)line from $\mathbf{p}$ in direction $\mathbf{d}$ intersects the ellipse with axes $\mathbf{h}$ and $\mathbf{v}$.

Solution

Determine $\mathbf{n} := \mathbf{h} \times \mathbf{v}$. $l := -\frac{\mathbf{n} \cdot \mathbf{p}}{\mathbf{n} \cdot \mathbf{d}}$. This gives the intersection point $\mathbf{i} = \mathbf{p} + l\mathbf{d}$. $a = \frac{\mathbf{i} \cdot \mathbf{v}}{\mathbf{v} \cdot \mathbf{v}}$ and $b = \frac{\mathbf{i} \cdot \mathbf{h}}{\mathbf{h} \cdot \mathbf{h}}$. We must check $a^2 + b^2 < 1$.

FPC 2019

Problem D - Darts

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

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Given vectors $\mathbf{h}, \mathbf{v}, \mathbf{p}, \mathbf{d}$, determine whether the (half-)line from $\mathbf{p}$ in direction $\mathbf{d}$ intersects the ellipse with axes $\mathbf{h}$ and $\mathbf{v}$.

Solution

Determine $\mathbf{n} := \mathbf{h} \times \mathbf{v}$. $l := -\frac{\mathbf{n} \cdot \mathbf{p}}{\mathbf{n} \cdot \mathbf{d}}$. This gives the intersection point $\mathbf{i} = \mathbf{p} + l\mathbf{d}$. $a = \frac{\mathbf{i} \cdot \mathbf{v}}{\mathbf{v} \cdot \mathbf{v}}$ and $b = \frac{\mathbf{i} \cdot \mathbf{h}}{\mathbf{h} \cdot \mathbf{h}}$. We must check $a^2 + b^2 < 1$.

Pitfalls

Problem D - Darts

A - Alternative Blockchain Algorithms

B - Balloon Party

C - Circus Tent

D - Darts

E - Encryptastrophy

F - Forest Run

G - Game Night

H - Hurry the Hedgehog

FPC 2019

Problem description

Given vectors $\mathbf{h}, \mathbf{v}, \mathbf{p}, \mathbf{d}$, determine whether the (half-)line from $\mathbf{p}$ in direction $\mathbf{d}$ intersects the ellipse with axes $\mathbf{h}$ and $\mathbf{v}$.

Solution

Determine $\mathbf{n} := \mathbf{h} \times \mathbf{v}$. $l := -\frac{\mathbf{n} \cdot \mathbf{p}}{\mathbf{n} \cdot \mathbf{d}}$. This gives the intersection point $\mathbf{i} = \mathbf{p} + l\mathbf{d}$. $a = \frac{\mathbf{i} \cdot \mathbf{v}}{\mathbf{v} \cdot \mathbf{v}}$ and $b = \frac{\mathbf{i} \cdot \mathbf{h}}{\mathbf{h} \cdot \mathbf{h}}$. We must check $a^2 + b^2 < 1$.

Pitfalls

- What if $\mathbf{n} \cdot \mathbf{d} = 0$?

Problem D - Darts

Problem description

Given vectors $\mathbf{h}, \mathbf{v}, \mathbf{p}, \mathbf{d}$, determine whether the (half-)line from $\mathbf{p}$ in direction $\mathbf{d}$ intersects the ellipse with axes $\mathbf{h}$ and $\mathbf{v}$.

Solution

Determine $\mathbf{n} := \mathbf{h} \times \mathbf{v}$. $l := -\frac{\mathbf{n} \cdot \mathbf{p}}{\mathbf{n} \cdot \mathbf{d}}$. This gives the intersection point $\mathbf{i} = \mathbf{p} + l\mathbf{d}$. $a = \frac{\mathbf{i} \cdot \mathbf{v}}{\mathbf{v} \cdot \mathbf{v}}$ and $b = \frac{\mathbf{i} \cdot \mathbf{h}}{\mathbf{h} \cdot \mathbf{h}}$. We must check $a^2 + b^2 < 1$.

Pitfalls

- What if $\mathbf{n} \cdot \mathbf{d} = 0$?
- What if $l < 0$?

FPC 2019

Problem E - Encryptastrophy

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

Problem description

Problem E - Encryptastrophy

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

Problem description

The ciphertext definition can be given by the following equations:

$$c_0 = p_0 + k_0 \mod 26$$
$$c_n = p_n + k_n \mod 26$$

Problem E - Encryptastrophy

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

Problem description

The ciphertext definition can be given by the following equations:

$$c_0 = p_0 + k_0 \mod 26$$
$$c_n = p_n + k_n \mod 26$$

As $k_n = p_{n-1}$, we can rewrite this to:

Problem E - Encryptastrophy

A - Alternative Blockchain Algorithms

B - Balloon Party

C - Circus Tent

D - Darts

E - Encryptastrophy

F - Forest Run

G - Game Night

H - Hurry the Hedgehog

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$$c_n = p_n + p_{n-1} \mod 26$$

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A - Alternative Blockchain Algorithms

B - Balloon Party

C - Circus Tent

D - Darts

E - Encryptastrophy

F - Forest Run

G - Game Night

H - Hurry the Hedgehog

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Problem description

The ciphertext definition can be given by the following equations:

$$c_0 = p_0 + k_0 \mod 26$$

$$c_n = p_n + k_n \mod 26$$

As $k_n = p_{n-1}$, we can rewrite this to:

$$c_n = p_n + p_{n-1} \mod 26$$

$$p_{n-1} = c_n - p_n \mod 26$$

Problem E - Encryptastrophy

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

Solution

Problem E - Encryptastrophy

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

Solution

For a string c with length l, we are given p_{l-1}, therefore:

FPC 2019

Problem E - Encryptastrophy

A - Alternative Blockchain Algorithms

B - Balloon Party

C - Circus Tent

D - Darts

E - Encryptastrophy

F - Forest Run

G - Game Night

H - Hurry the Hedgehog

FPC 2019

Solution

For a string c with length l, we are given p_{l-1}, therefore:

$$p_{l-2} = c_{l-1} - p_{l-1} \mod 26$$

Problem E - Encryptastrophy

A - Alternative Blockchain Algorithms

B - Balloon Party

C - Circus Tent

D - Darts

E - Encryptastrophy

F - Forest Run

G - Game Night

H - Hurry the Hedgehog

FPC 2019

Solution

For a string c with length l, we are given p_{l-1}, therefore:

$$p_{l-2} = c_{l-1} - p_{l-1} \mod 26$$

$$p_{l-3} = c_{l-2} - p_{l-3} \mod 26$$

Problem E - Encryptastrophy

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
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Problem E - Encryptastrophy

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Problem E - Encryptastrophy

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Pitfalls

- Modulo with a negative number returns a negative number. Use `(x % n + n) % n`

Problem F - Forest Run (1/3)

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

Problem description

Traverse the trees in the forest from root to every leaf and back and sum the distance.

Solution

- Start at the leaves, give them length 0 and width 1
- For the parent nodes, sum the lengths of the children, and add the width of the children

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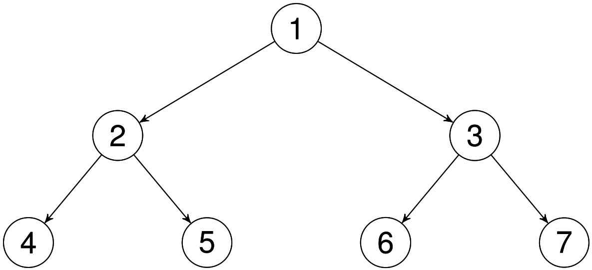
Problem F - Forest Run (2/3)

Solution

- Start at the leaves, give them length 0 and width 1
- For the parent nodes, sum the lengths of the children, and add the width of the children



Problem F - Forest Run (3/3)

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

Solution

- Start at the leaves, give them length 0 and width 1
- For the parent nodes, sum the lengths of the children, and add the width of the children

Pitfalls

- For Java and C++: `int` is too small, use `long` instead
- Recursion gives stack overflow, use your own stack.

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Problem G - Game Night

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

Problem description

How many letters can be re-used between two (pass)words?

Solution

- Keep a tally per letter that counts the amount of occurrences for each letter for both words
- Count how many letters are different between the two words

Pitfalls

- Input can be large (up to one million characters), solution must run in $\mathcal{O}(n)$.
- Letters can be used multiple times.

Problem H - Hurry the Hedgehog

A - Alternative Blockchain Algorithms
B - Balloon Party
C - Circus Tent
D - Darts
E - Encryptastrophy
F - Forest Run
G - Game Night
H - Hurry the Hedgehog

FPC 2019

Problem description

- Given a graph, find shortest path from v_1 to v_n
- Only use vertices that have a "Super Mushroom"

Solution

- A simple breadth-first search suffices
- Need to remember length of path

Pitfalls

- The case for $n = 1$.