zk-SNARK

Distributed Lab

Sep 5, 2024

Plan

1. What the zk-SNARK is?
2. Linear Algebruh Preliminaries
   - Inner product
   - Outer product
3. Arithmetic Circuits
4. Rank-1 Constraint System
5. Quadratic Arithmetic Program

What the zk-SNARK is?

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Definition

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- **Succinct** - the proof size is relatively small and does not depend on the size of the data or statement.
- **Non-interactive** - to produce the proof, the prover does not need any interaction with the verifier.
- **Zero-Knowledge** - the verifier learns nothing about the data used to produce the proof, despite knowing that this data resolves the given problem and that the prover possesses it.

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Imagine you're part of a treasure hunt...

...and you've found a hidden treasure chest...

...but how to prove that without revealing the chest location?

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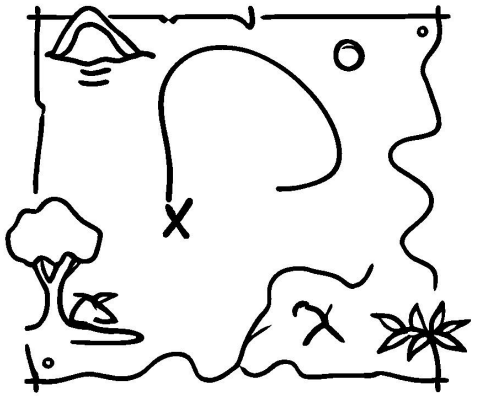
The Problem: you have found a hidden treasure chest, and you want to prove to the organizer that you know its location without actually revealing that.



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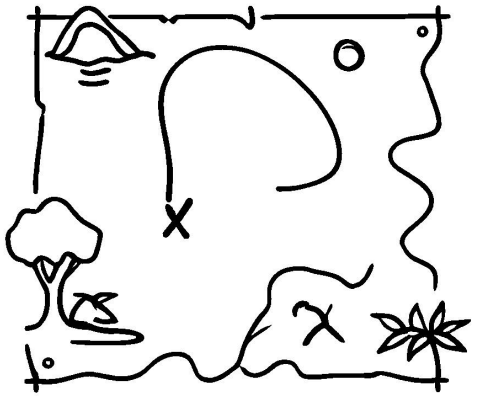

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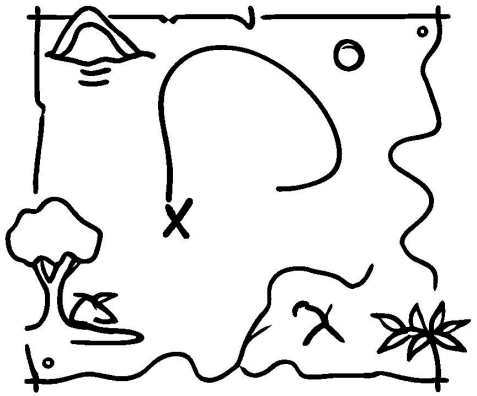

We can retrieve some information from that:

Question #81673

What is a secret data? Who is a prover and who is a verifier?

The Secret Data: the exact treasure location.

The Prover: you.

The Verifier: the treasure hunt organizer.

Ohh... Got it!

Here is how we can apply the zk-SNARK to our problem:

- Argument of Knowledge: You need to create a proof that demonstrates you know the chest is.
- Succinct: The proof you provide is very small and concise. It doesn't matter how large the treasure map is or how many steps it took you to find the chest.
- Non-interactive: You don't need to have a back-and-forth conversation with the organizer to create this proof.
- Zero-Knowledge: The proof doesn't reveal any information about the actual location of the treasure chest.

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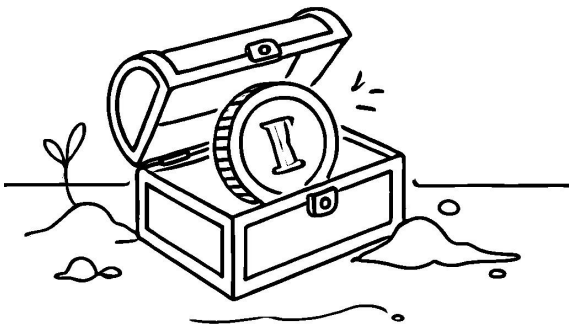

Well... The golden coin where the pirates' sign is engraved is our zk-SNARK proof!

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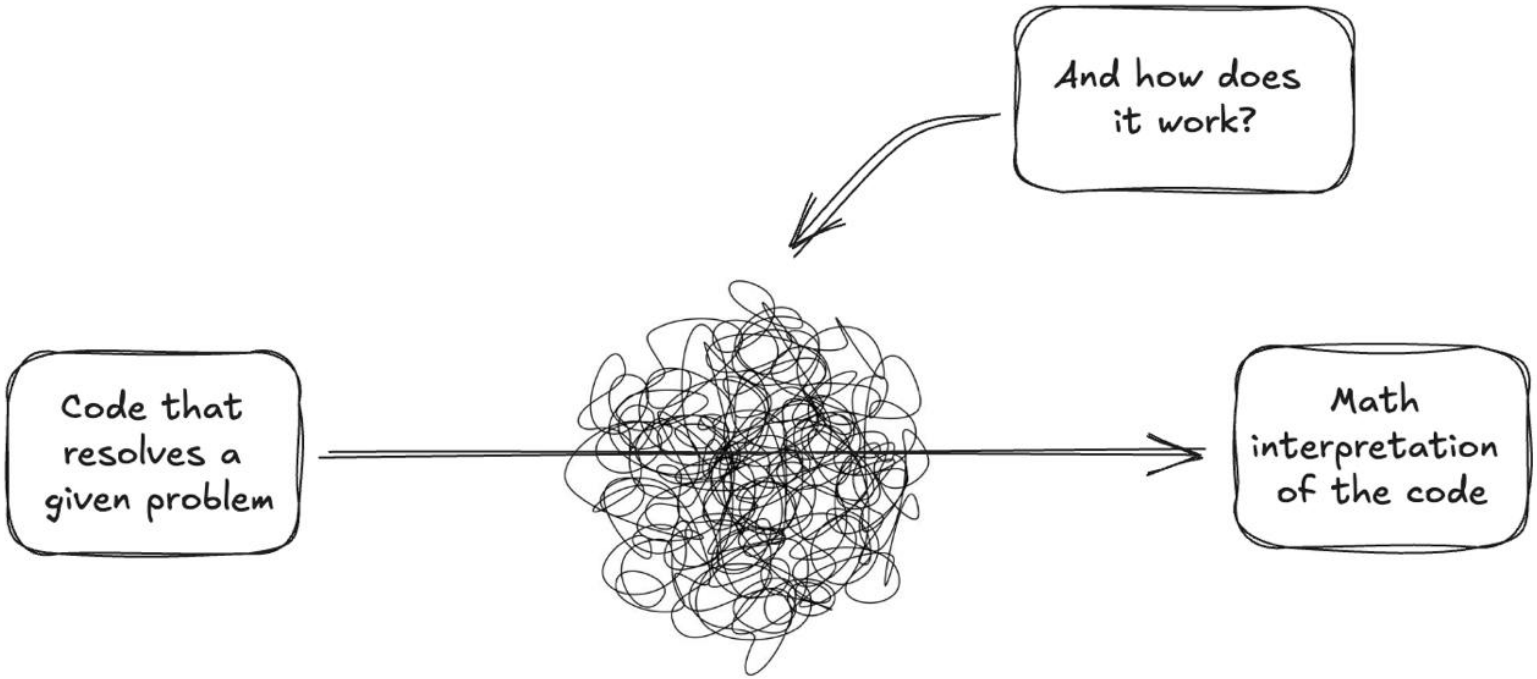

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TODO

Outer product

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Rank-1 Constraint System

Quadratic Arithmetic Program