A Gentle Introduction to Zero Knowledge Languages

Kostas Ferles
CRO, Veridise

Welcome!

- First and foremost a big welcome!
  - Thank you for attending Veridise's ZK-focused Secureum Workshop
  - Congratulations to the winners of RACE-23
- We have an exciting week planned for you
  - Daily lectures from Veridise about ZK technology and our tooling
  - Guest lectures by industry leaders

About Veridise

- Veridise is a blockchain security company
  - Founded by a team of world-class researchers
  - **Our obsessions**: 1. reasoning about code 2. creating tools that help us find bugs or prove properties about code

Our team

About Veridise

- We performed audits for many ecosystems (e.g., Ethereum, NEAR, StarkWare) and for different kinds of use cases (e.g., AMMs, stablecoins, auctions, etc.)

Leader in auditing ZKP Circuits

MANTA NETWORK

Succinct

Scroll

==>circom CIRCUIT COMPILER

Semaphore

Trusted by leading projects

ankr

RIBBON

DOGECHAIN

Our audits

About Veridise

We are developing state-of-the-art automated security tooling

SaaS Platform

We will dive into two zk-related tools this week:
1. zk-Vanguard 2. Picus

Workshop Logistics

Few things before we begin!

- Each will have a Veridise lecture followed by a guest lecture
  - This will be followed by a quiz for RACE-23 winners

Schedule

Our discord

Veridise.

Guidelines for RACE-23 Winners

- We will use ***zk-secureum-private*** for general communication (e.g., quiz announcements)
- Any non answer-revealing question can be sent on ***zk-secureum-private***.
  - For general-interest questions use ***zk-secureum-public*** *(open to all)*
- If you are unsure about sending a message publicly, send it to your personal support channel (you'll be added by us)
- Discussing quiz answers on the public channel is not allowed!
- Quizzes deadlines are listed in the official schedule.
- The registration on SaaS must be done with the same e-mail address you provided Rajeev with.
- You'll receive an e-mail (if you haven't already) with a unique user ID. Don't share the user ID with anyone (except us)!

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Prizes

1st

2k USDC

2nd 3rd

1k USDC

4th 5th

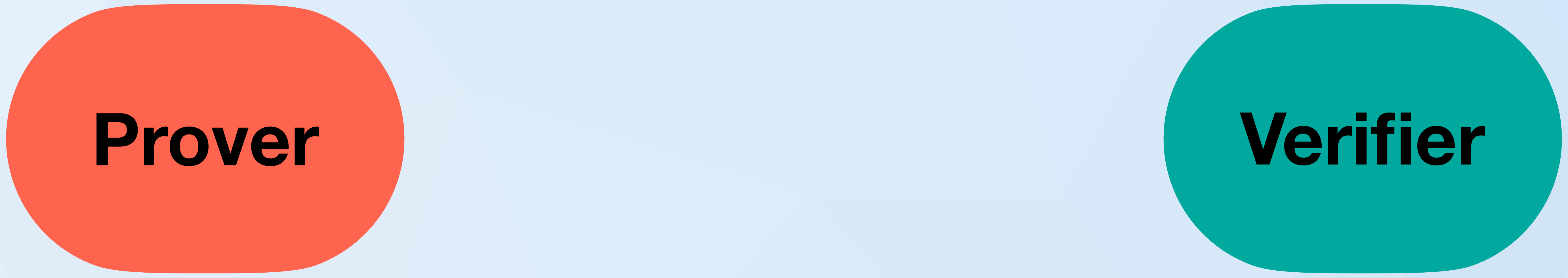
500 USDC

Top-performers will also be considered for an auditing position at Veridise :)

Let’s Cut to the Chase

An Introduction to
ZK Languages and Frameworks

What is a ZK protocol?



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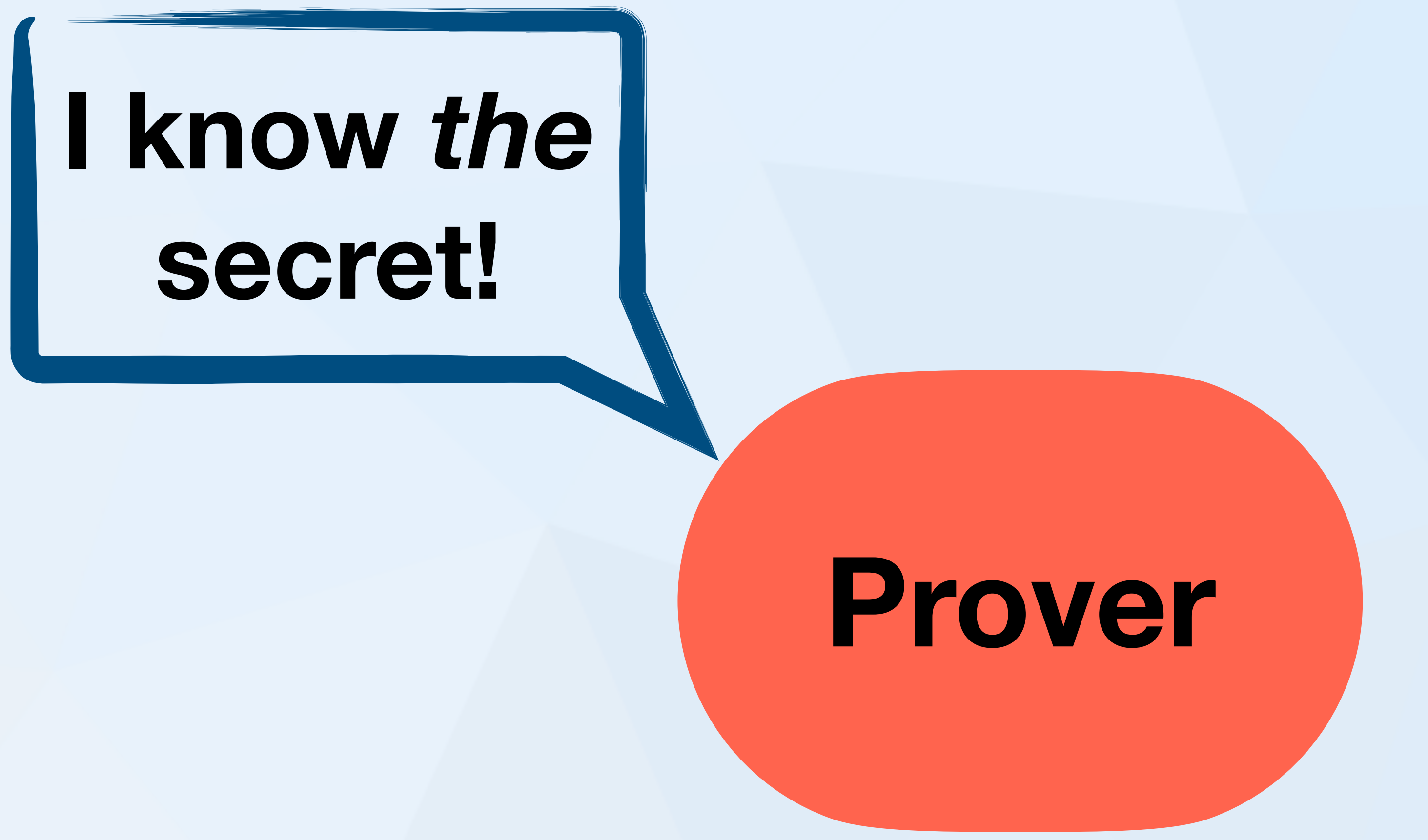

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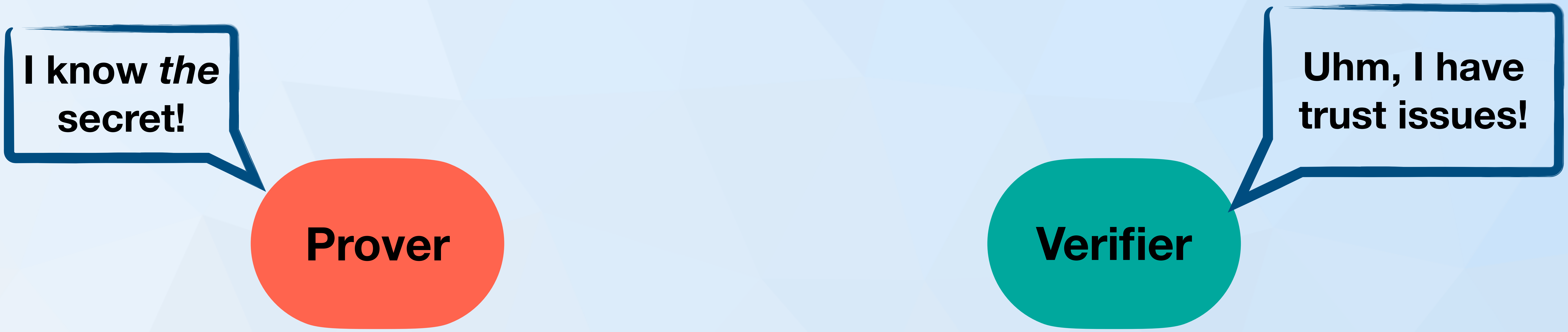

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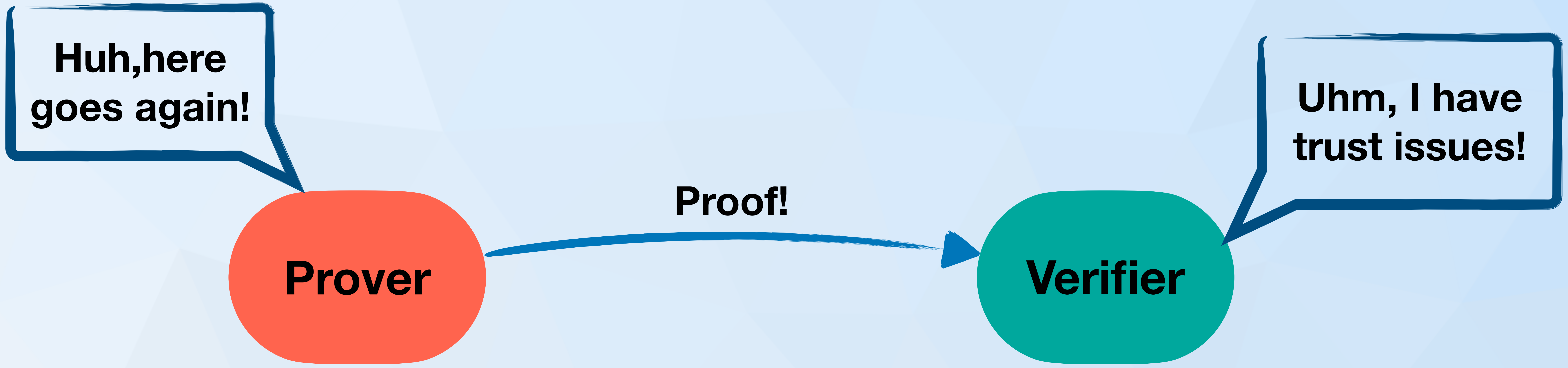

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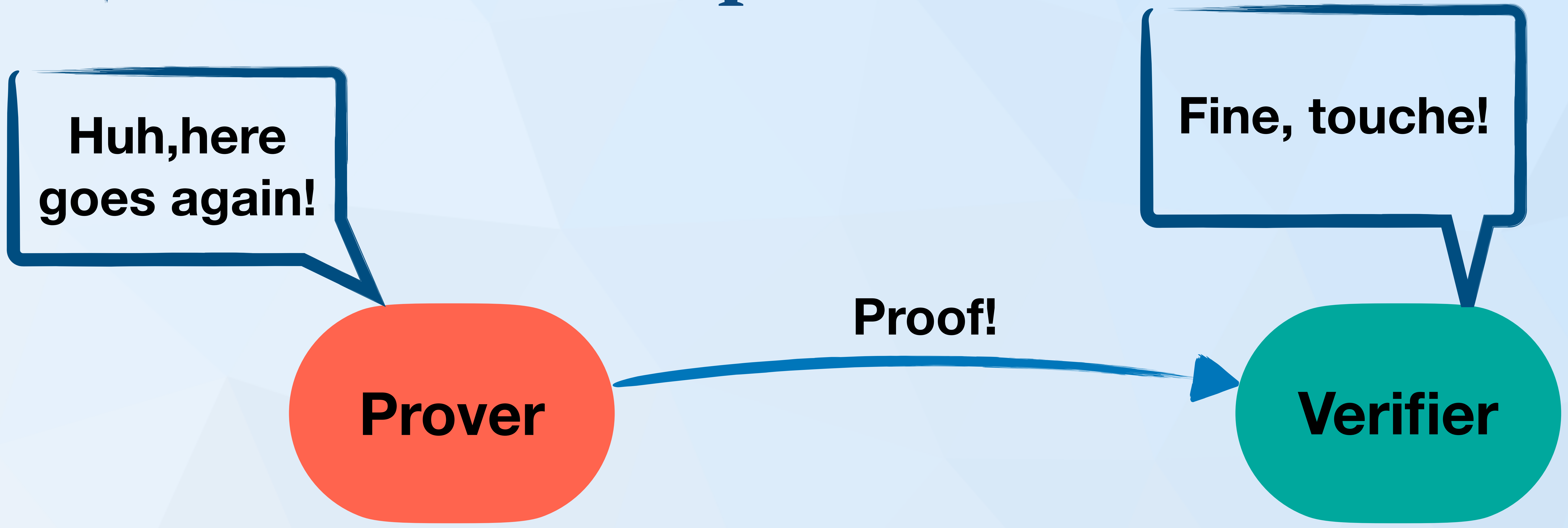

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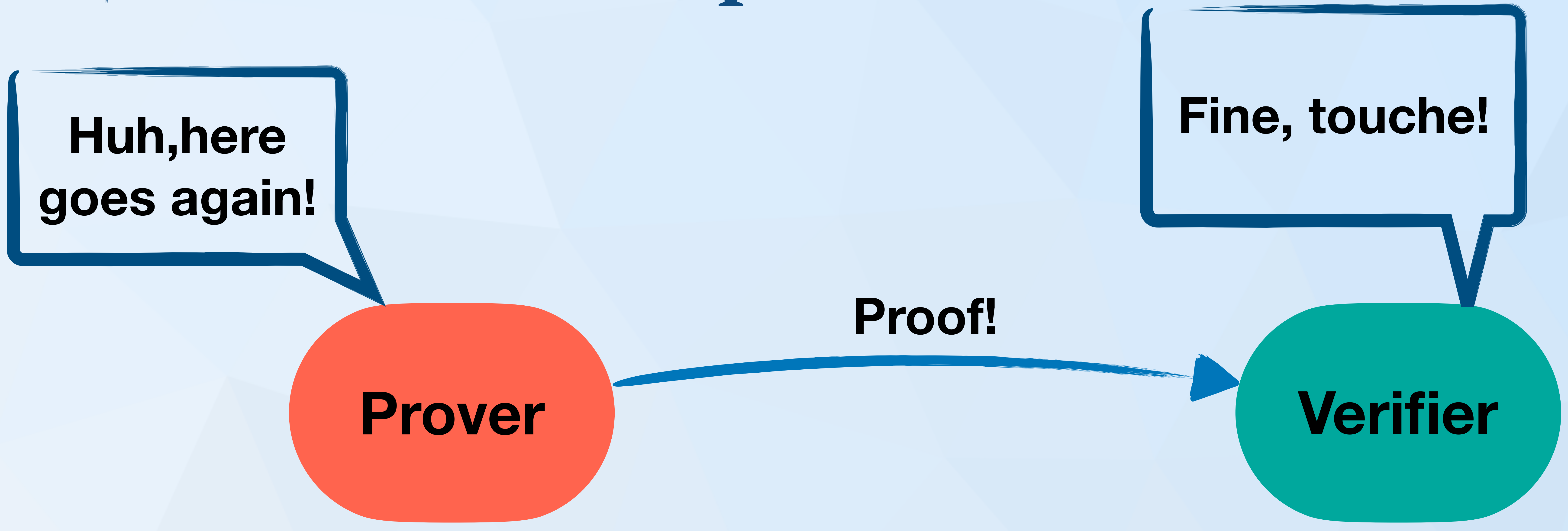
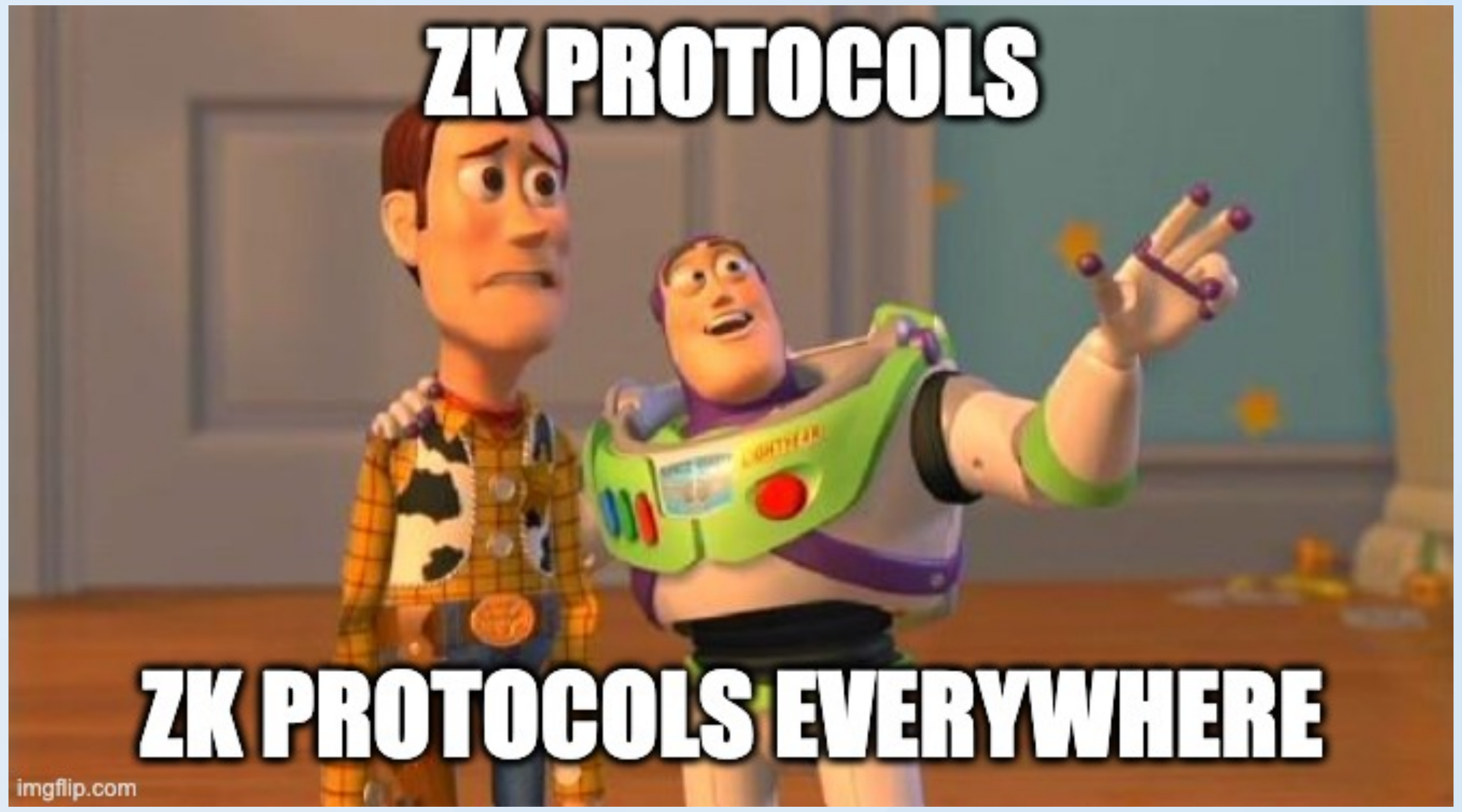


- **Some *important* properties**
  - The prover doesn't reveal the secret
  - The verifier can always detect false proofs

The ZK Scene is Complex

Several Categories of Protocols and Multiple Members per Category



Our Focus: zk-SNARKs

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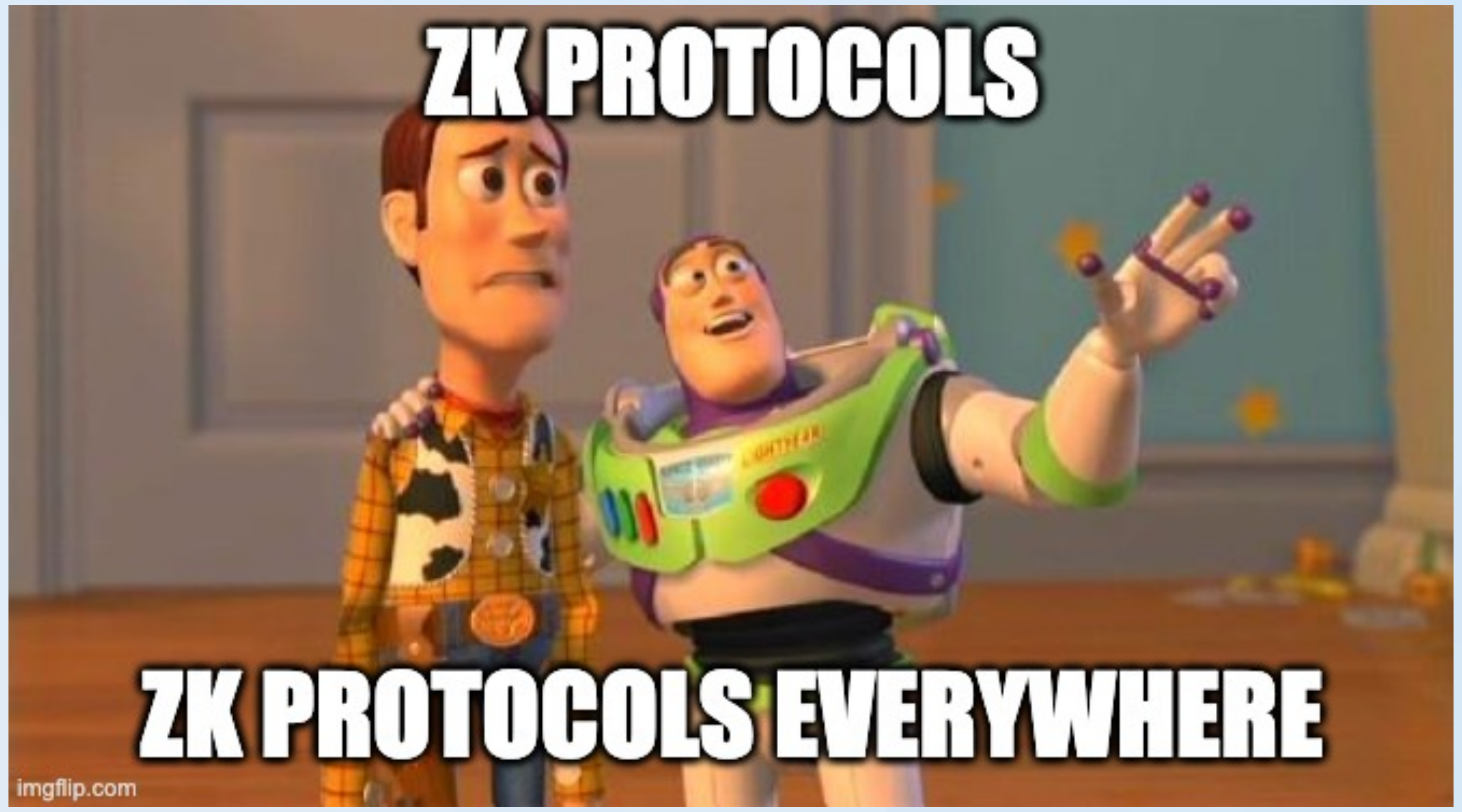


Our Focus: zk-SNARKs

But what does this mean?

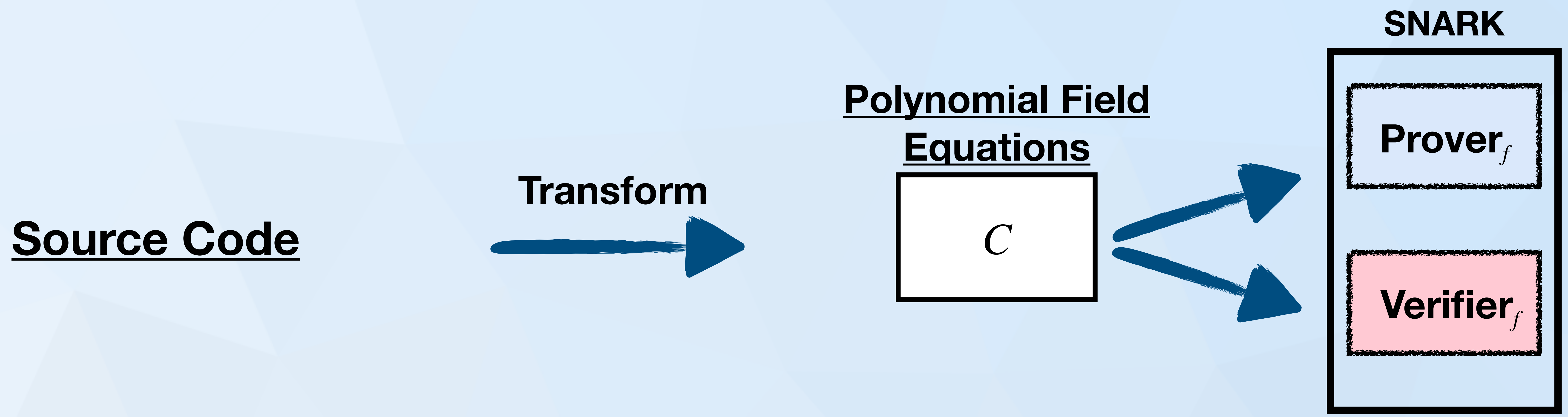
Why ZK Languages or Frameworks?

- **ZK proofs can significantly enhance Dapps**
  - The verifier can live on the blockchain while proofs can be submitted by anyone
  - But prover and verifier need to be customized on a Dapp basis
  - Need for creating custom "ZK protocols" without being a cryptography expert

Privacy

Scalability

How they work



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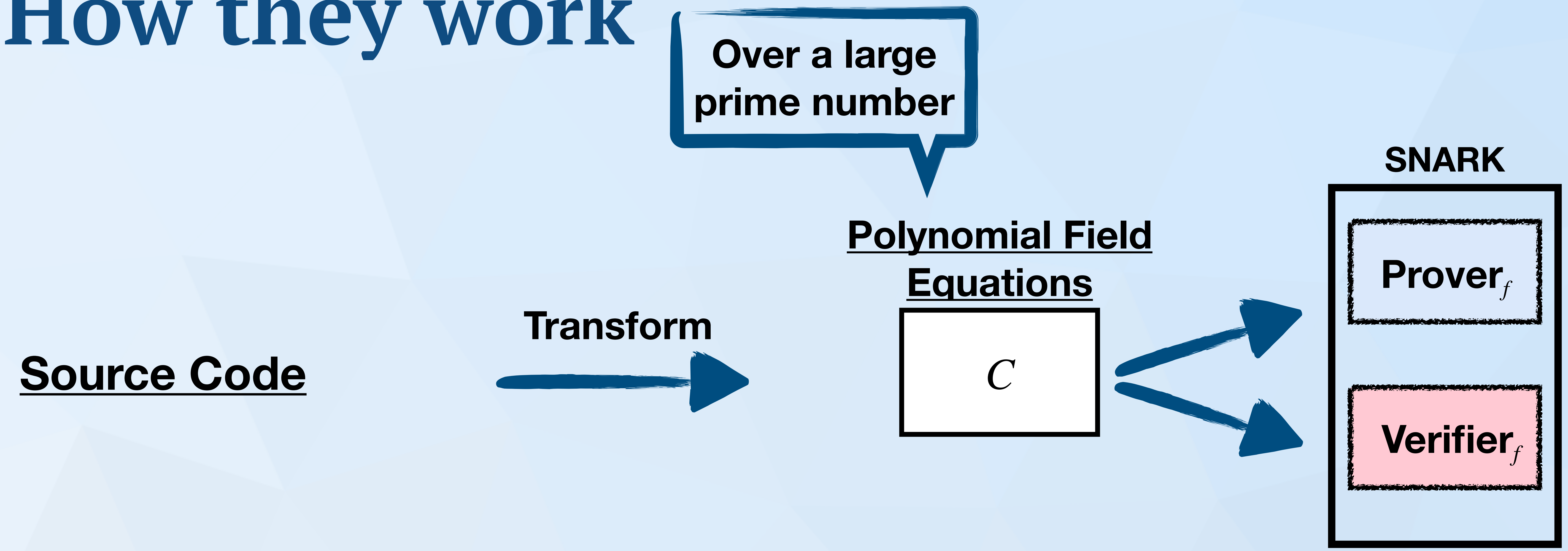

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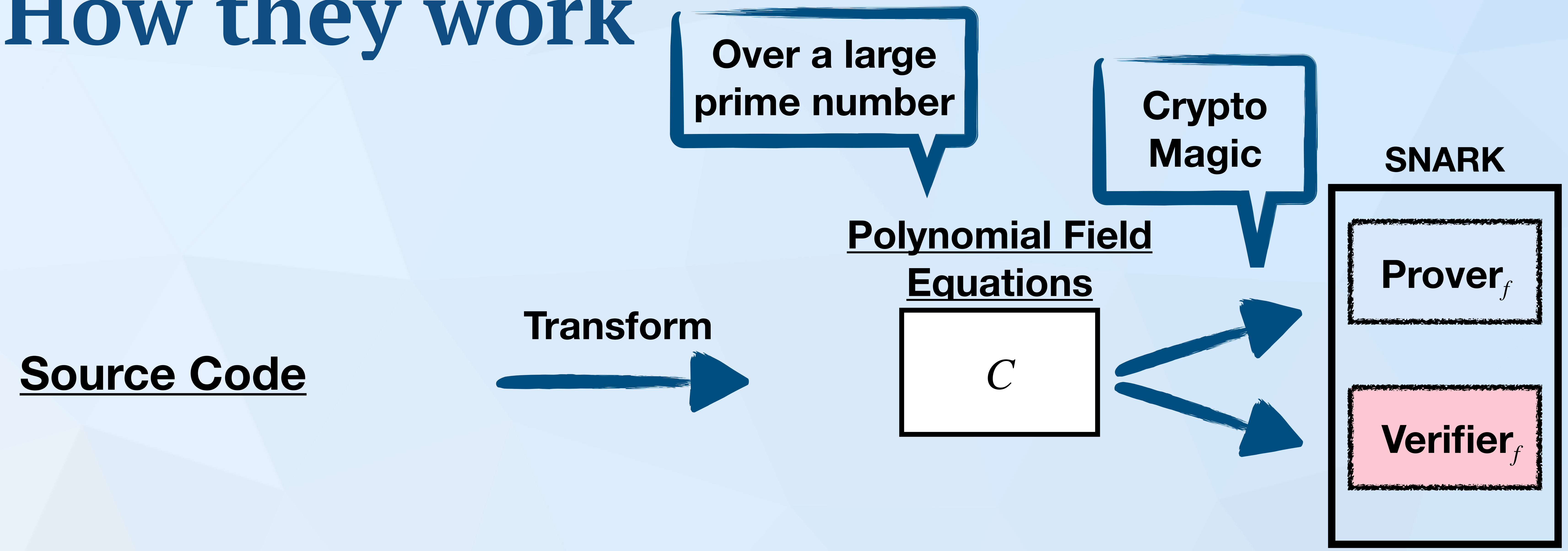

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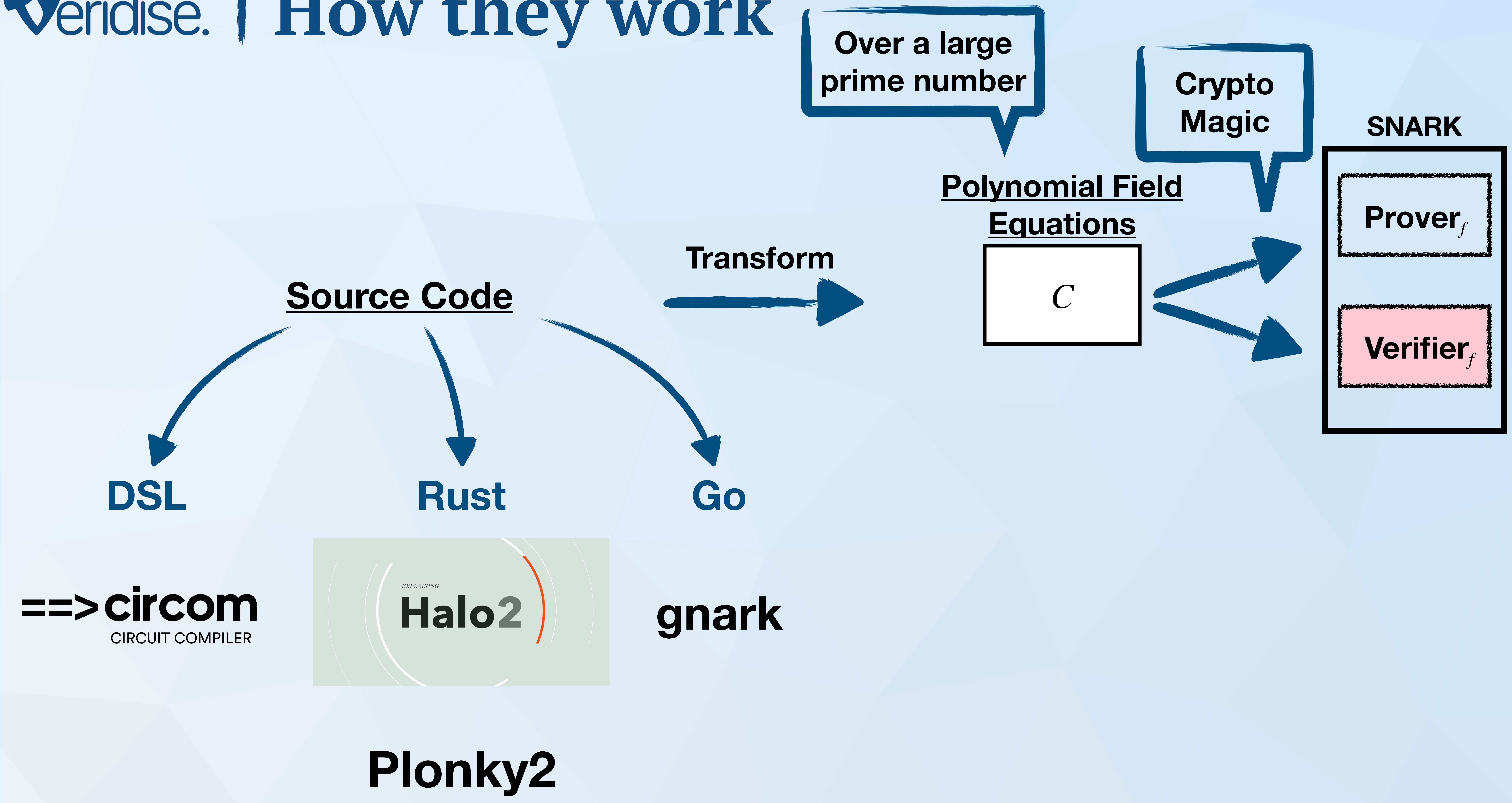

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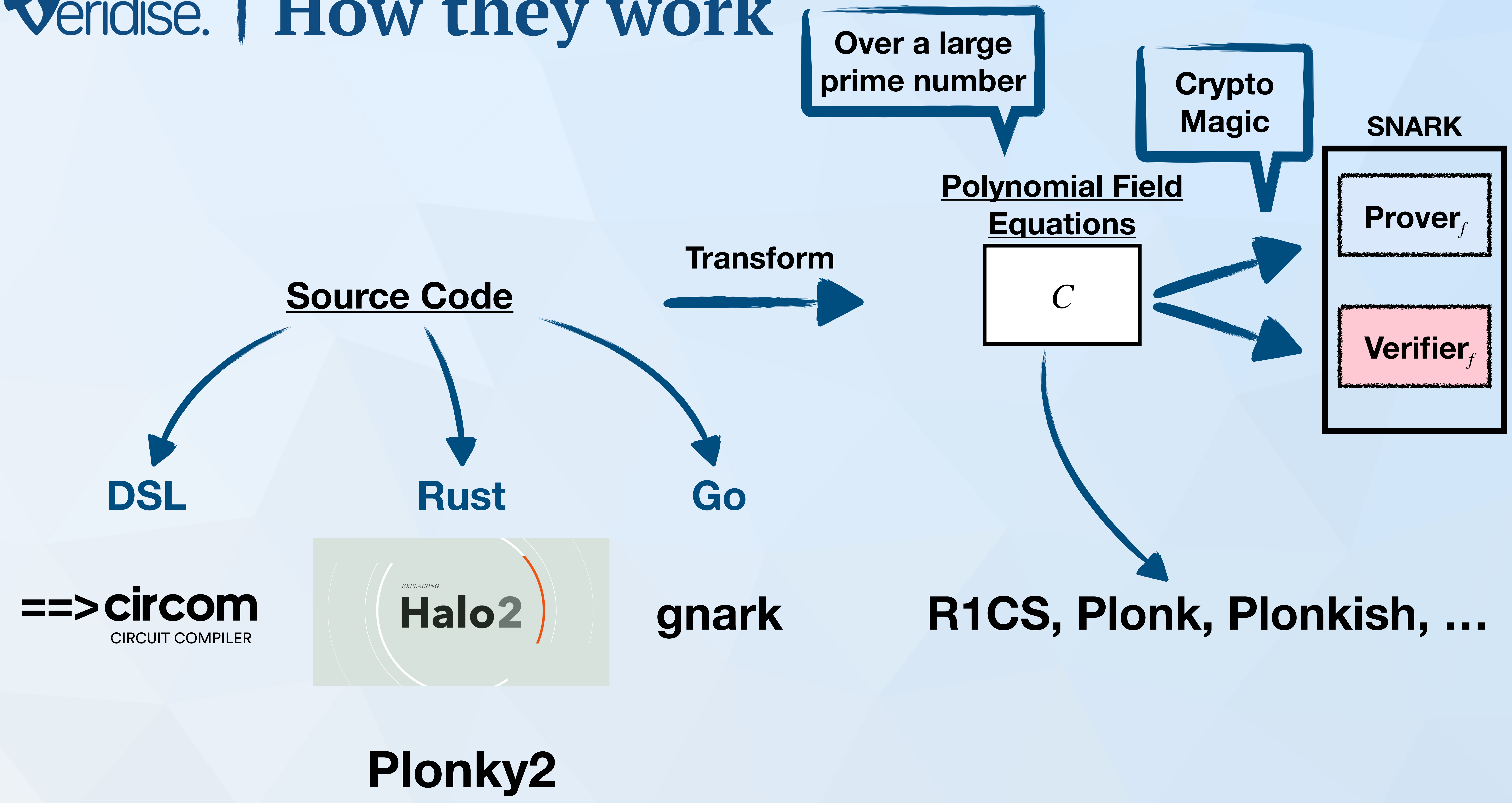

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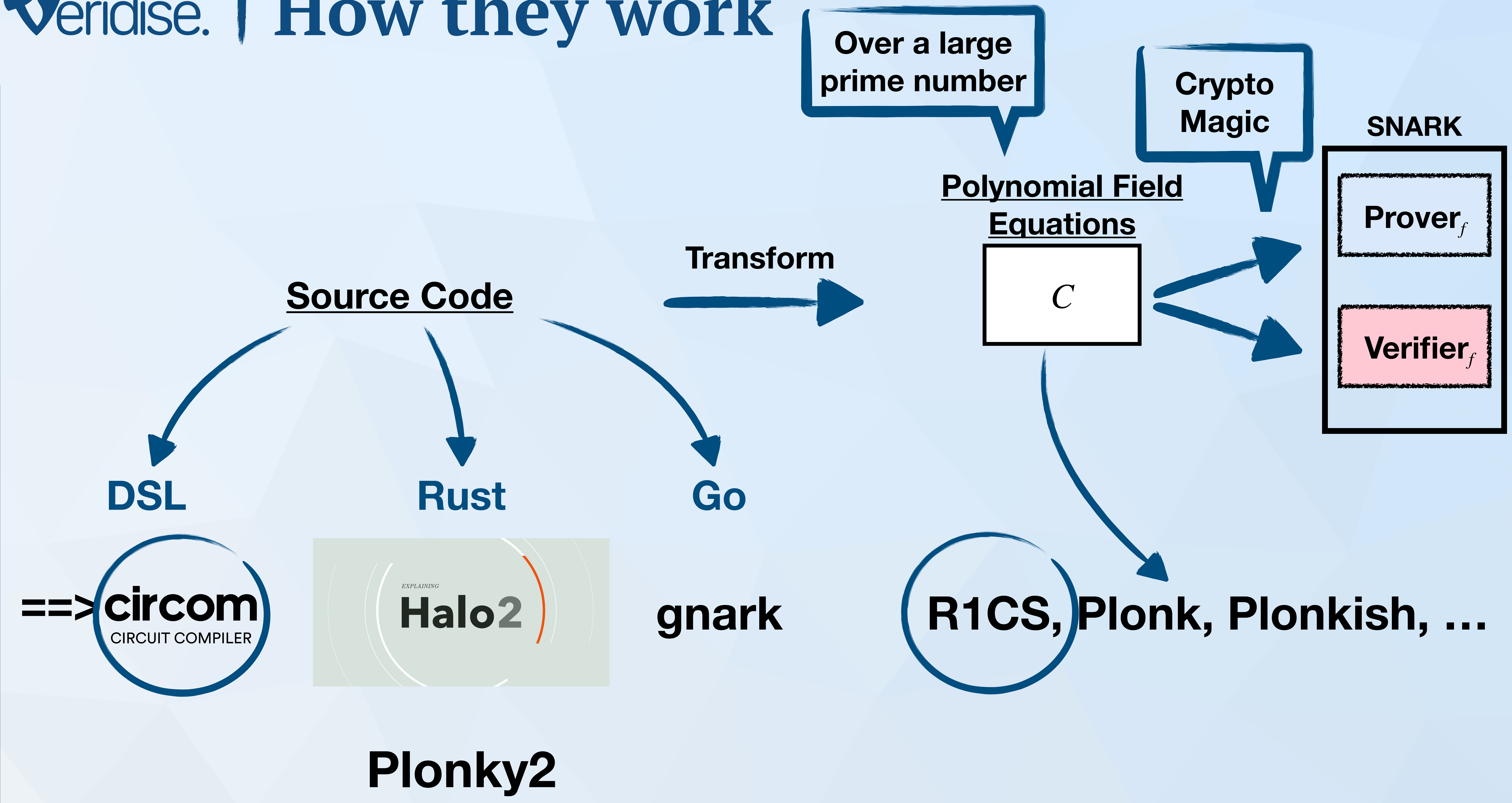

Circom 101

```
pragma circom 2.0.0;

template Multiplier2 () {

   // Declaration of signals.
   signal input a;
   signal input b;
   signal tmp;
   signal output c;

   // Witness generation
   c <-- a * b;

  // Constraints.
  c === a * b;
  tmp === 0;
}

component main {public [a]} = Multiplier2();
```

- Computation in circom is encoded as circuits
  - A circuit is a composition of templates
- Each template defines two things over signals
  - Constraints (checked by the verifier)
  - Witness generation (used to generate the proof)
- ***Attention:*** **ALL** operations are modulo a big prime. That is, a **op** b is really a **op** b % p
  - Therefore, all signals are between 0 and p-1

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Zooming In The Circuit

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Output signals must have a witness assignment

- Constraints must be expressible as A*B - C = 0, where A,B,C are linear expressions (at most quadratic)
  - This limitation stems from R1CS

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Output signals must have a witness assignment

Signals not in this list are private

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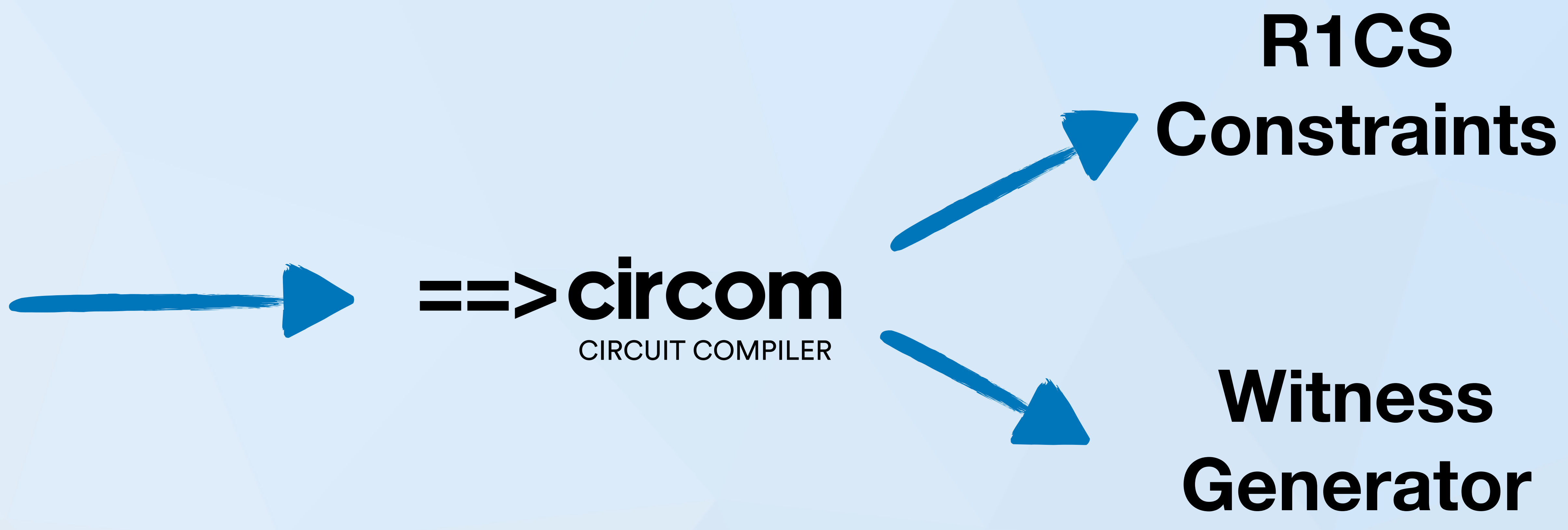

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Can be used with a framework like snarks to generate/verify proofs

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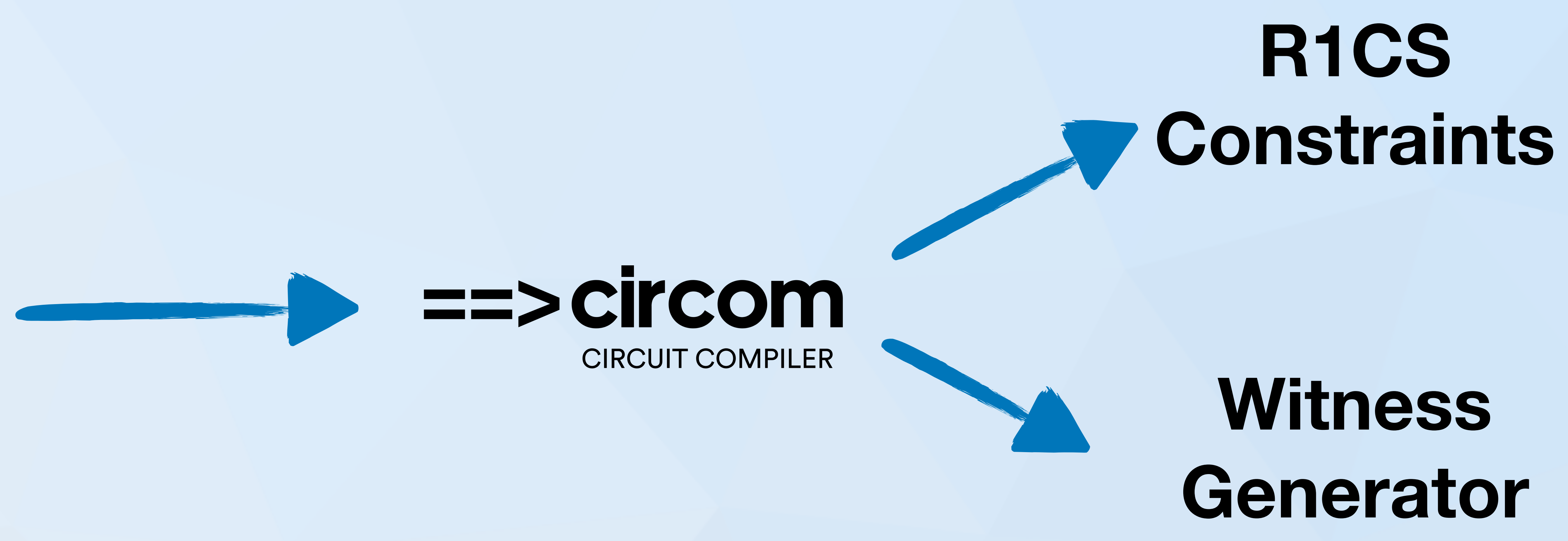

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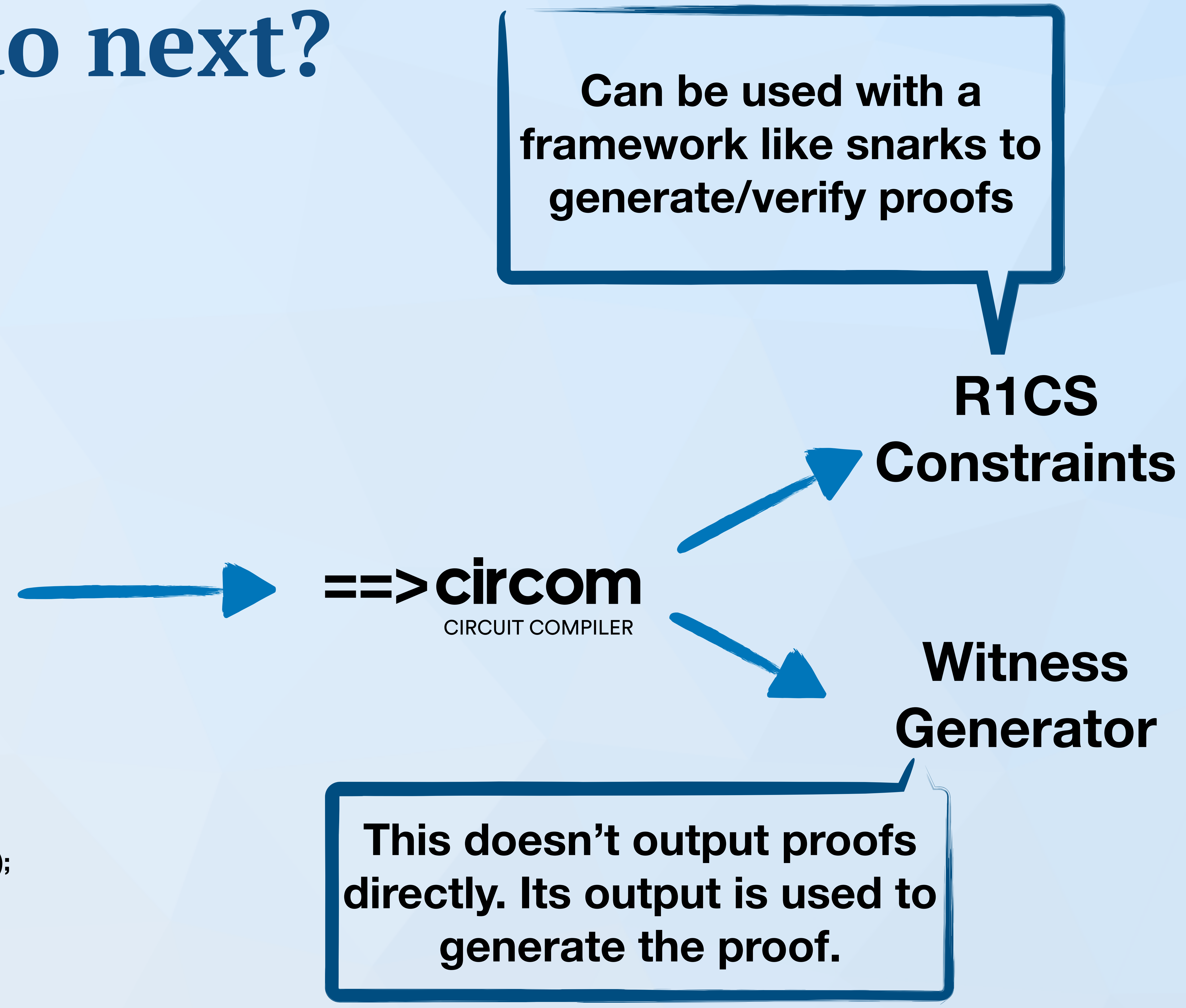

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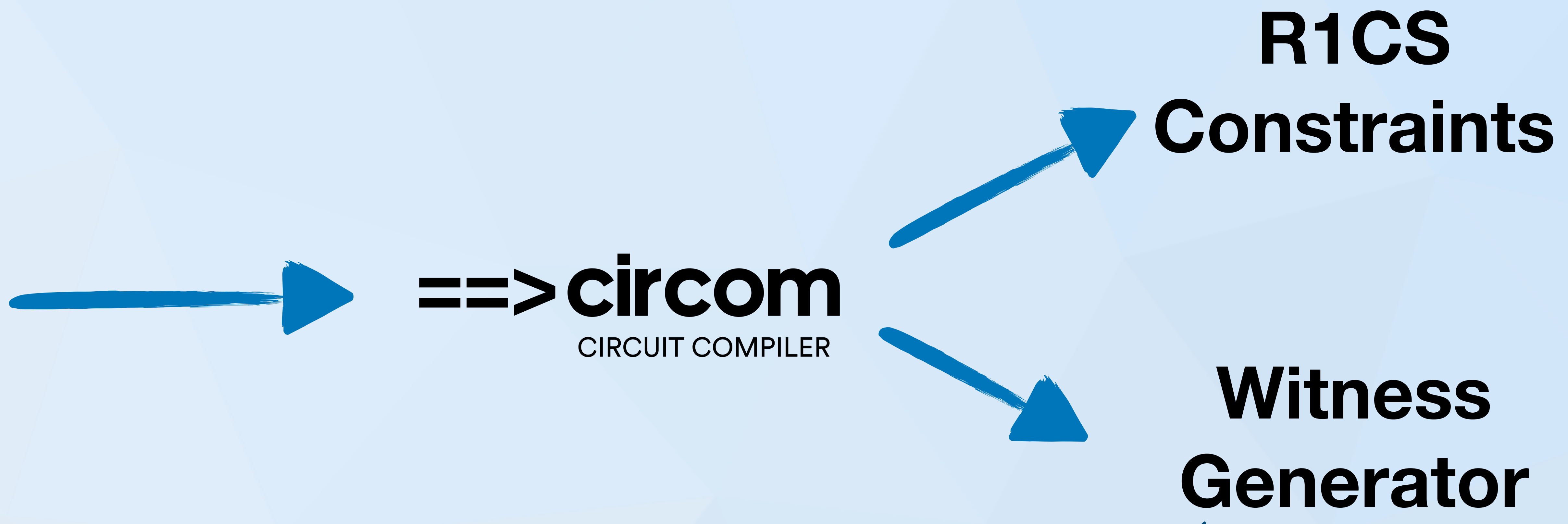

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Detailed Instructions

More circom features

```
template SumN(n) {
   signal input ins[n];
   signal output out;

   var sum = 0;

   for (var i = 0; i < n; i++) { sum += ins[i]; }

   out <== sum;
}

template Foo() {
  signal input ins[5];
  component sum5 = SumN(5);

  for (var i = 0; i < 5; i++) { sum5.ins[i] <== ins[i]; }
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component main = Foo();
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More circom features

Templates can have parameters

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We simply need to constraint/initialize all the inputs of the sub-component

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Then, we can also constraint their output

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Start Thinking in Circom

One of the most common mistakes is that people think in terms of traditional programming

```
void AssertBinary(int in) {

  assert(in == 0 || in == 1);

}
```

```
template AssertBinary {
  signal input in;



}
```

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```
void AssertBinary(int in) {

    assert(in == 0 || in == 1);

}
```

```
template AssertBinary {
   signal input in;
   in * (1 - in) === 0;

}
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void AssertBinary(int in) {

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template AssertBinary {
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Can more things go wrong?
Well, of course :)
More on this later…

What's next?

- Even though circom seems like a small and simply language, we merely scratch the surface here.
- The best way to learn a language is to play with it!
  - We encourage you to do that by following the circom docs
    - Generate proofs, run the verifier, and generally poke around :)
  - If you are one of the RACE winners, you'll have to do so for the QUIZ
    - More info on the private discord channel
  - If you get stuck or have any question, just shoot a message on one of the discord channels (private or public)!