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[Don‘t] share your data.
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github.com/TaceoLabs/noir_workshop_0625/

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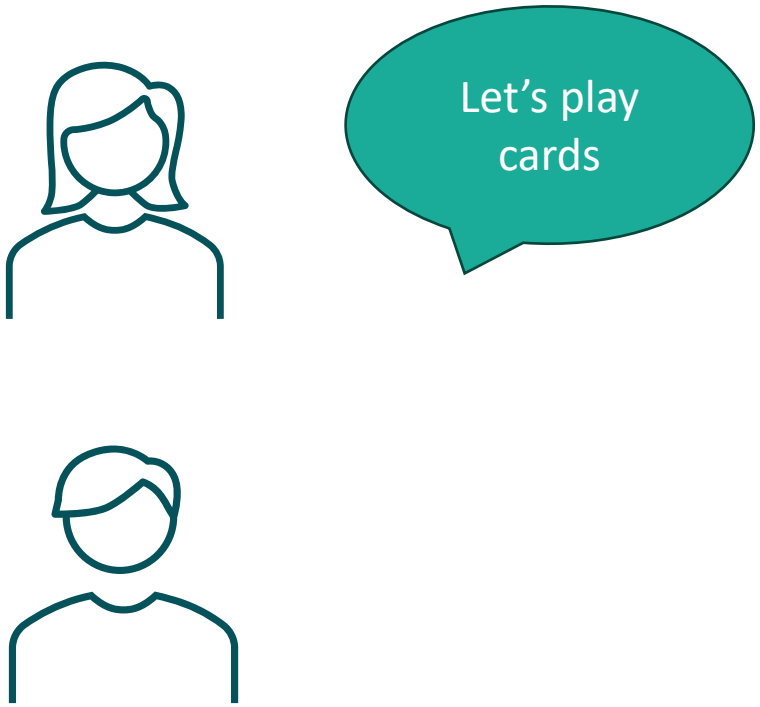
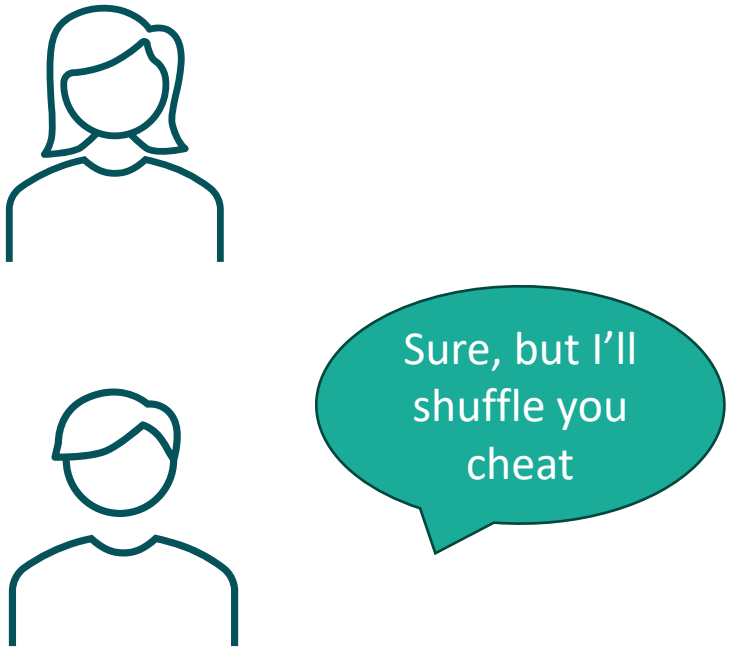
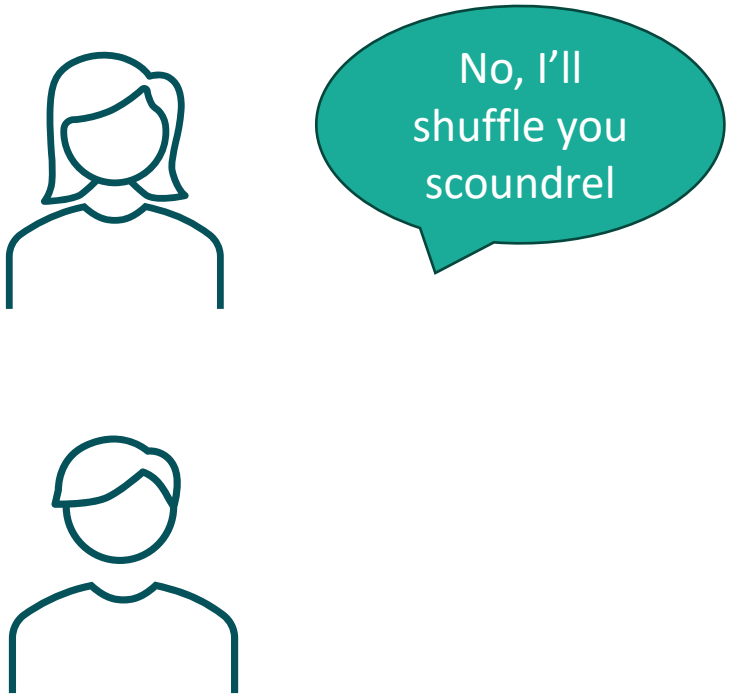
Building a coSNARK-powered DApp with coNoir

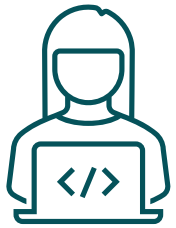
Shuffling Cards with MPC


Let’s play
cards


Sure, but I'll shuffle you cheat

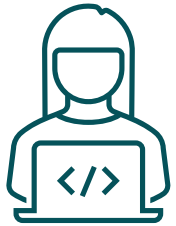

No, I'll shuffle you scoundrel

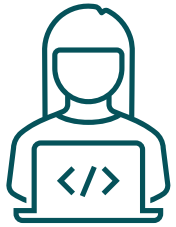

Please
shuffle the
cards for us




I like Alice more


hey
Charlette –
I’ll pay you
5$





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What now?

Private State only gets you that far

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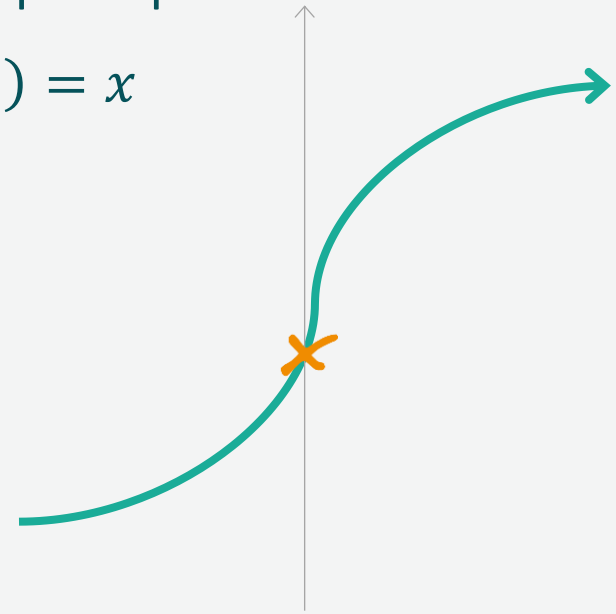
How to share a secret?

Shamir Secret Sharing

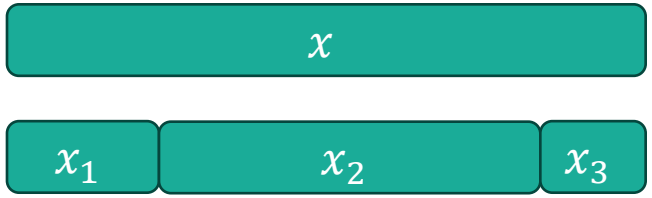
- Polynomial $f(X)$ of degree d
- Sample n points
- $f(0) = x$



Additive Secret Sharing

- Split x in n parts

$$\sum_{n} x_i = x$$



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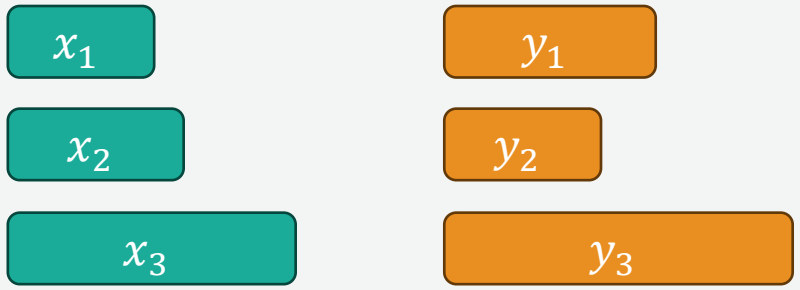
Computing on secrets

Addition

Two secrets x and y



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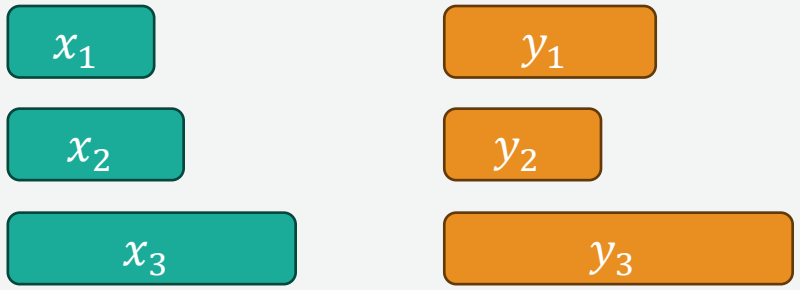
Computing on secrets

Addition

Two secrets x and y



$$\begin{matrix} x_1 + y_1 \\ x_2 + y_2 \\ x_3 + y_3 \end{matrix} \quad = x + y$$

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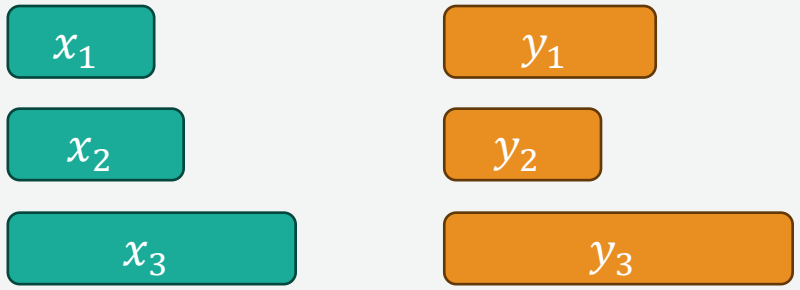
Computing on secrets

Addition

Two secrets x and y



$$\begin{matrix} x_1 + y_1 \\ x_2 + y_2 \\ x_3 + y_3 \end{matrix} \quad = x + y$$

Multiplication

?

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Non-linear Operations

- Beaver triples
  - Generate helper triples $([\mathrm{a}], [\mathrm{b}], [c])$ and $ab = c$
  - Open $[a + x] = A$ and $[b + y] = B$
  - Compute $A[y] - B\ [a] + [c] = [xy]$

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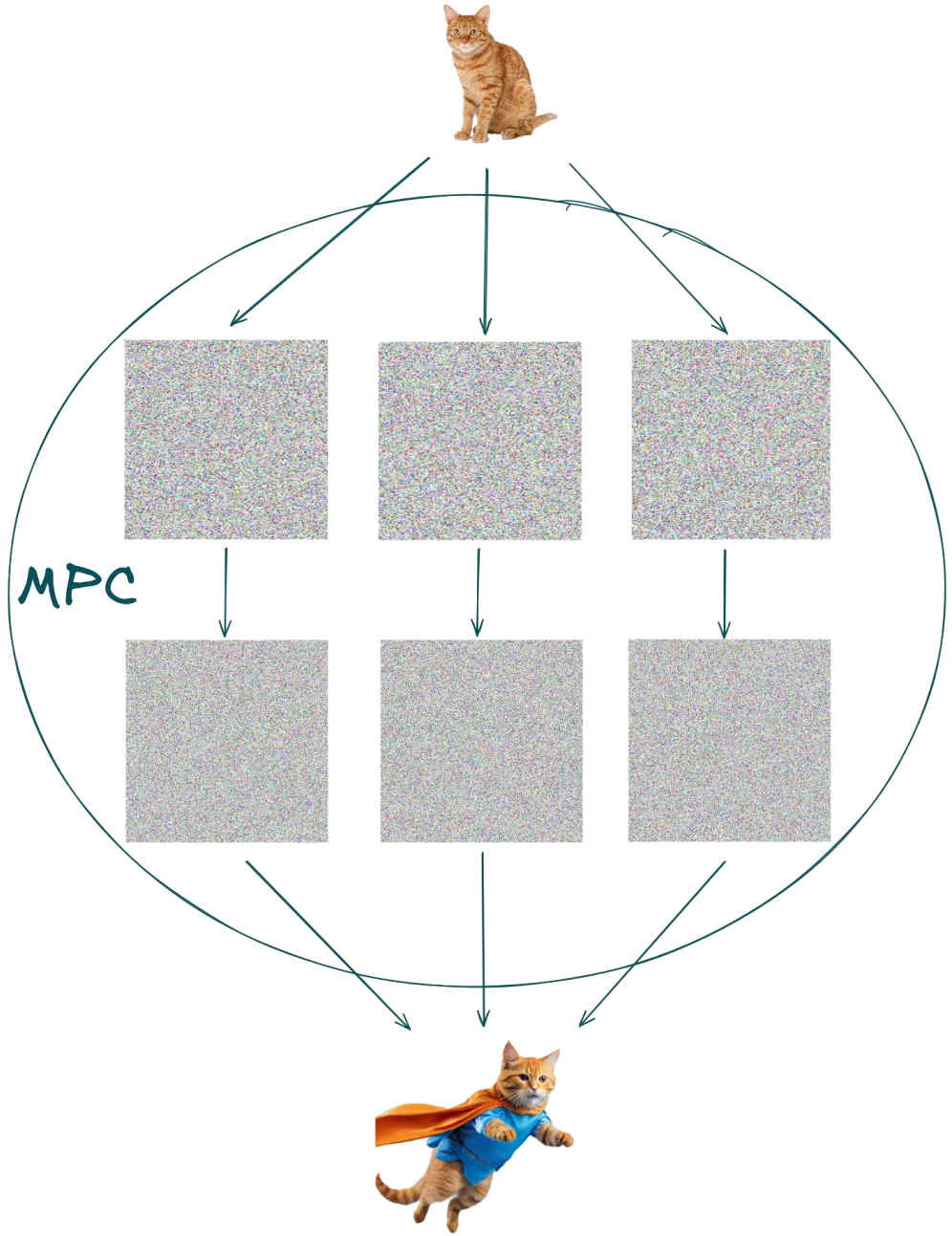
Non-linear Operations

- Beaver triples
  - Generate helper triples $([\mathrm{a}], [\mathrm{b}], [c])$ and $ab = c$
  - Open $[a + x] = A$ and $[b + y] = B$
  - Compute $A[y] - B\ [a] + [c] = [xy]$
- Replicated Secret Sharing (2 out of 3 sharing)
  - Parties hold two shares instead of one
  - Every party computes $x_a y_a + x_a y_b + x_b y_a + m$, where $m = [0]$
  - Reshare result


MPC

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Great – what now?

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zkSNARKs 101

Succinct proof for computational integrity

Keeping secret input hidden (potentially)

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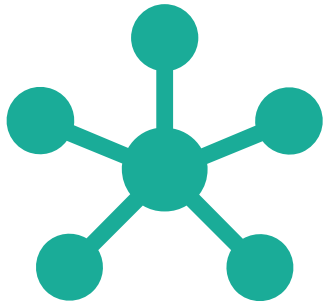
MPC 101



Mutually untrusting parties jointly compute a function

Inputs and intermediate values private (secret-shared)

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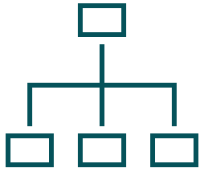
What are coSNARKs?

Zero-Knowledge

MPC



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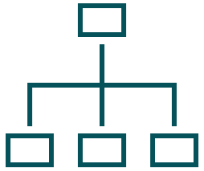
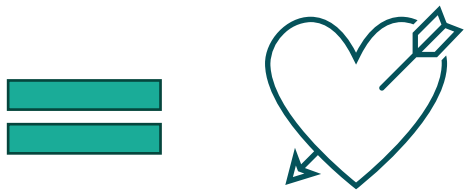


co-SNARKs



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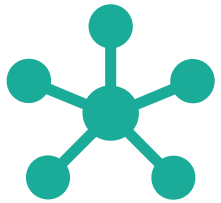
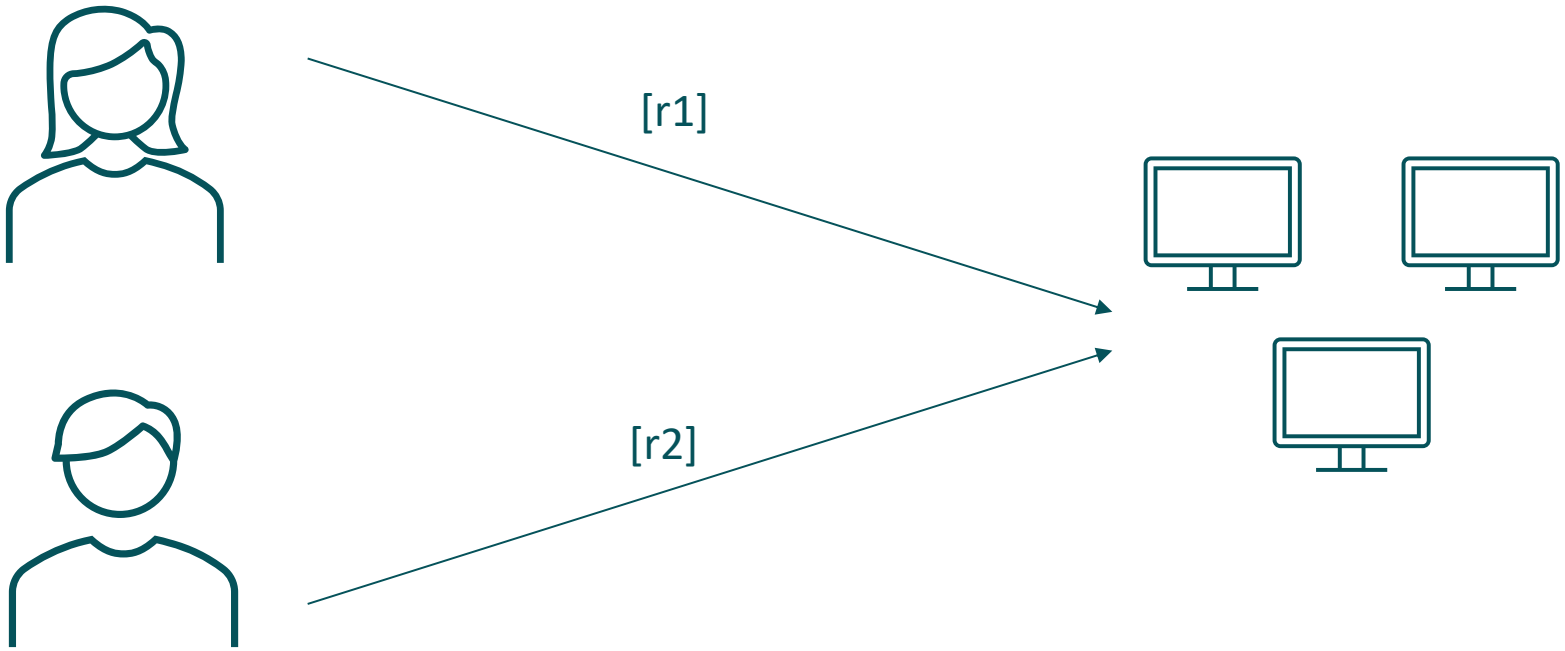
Co-SNARK 101



Mutually untrusting parties jointly compute a function

Succinct proof for computational integrity

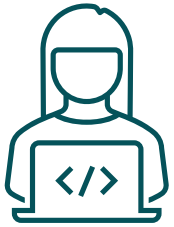
Keeping secret inputs and intermediate values hidden

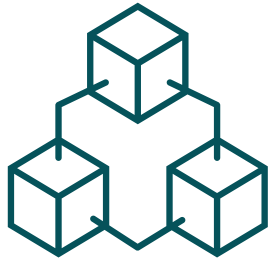

[r1]
[r2]


Here is a
shuffled deck
and a proof


Look we have a shuffled deck
And we don’t know what we’ll draw


Look we have a shuffled deck
And we don’t know what we’ll draw





We are done, right?

Let’s think this through

Let’s think this through

Playing a game of cards

- Shuffled the deck

Let’s think this through

Playing a game of cards

- Shuffled the deck
- Only distribute cards to respective players (verifiable encryption)

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No one knows the structure of deck!

Let’s think this through

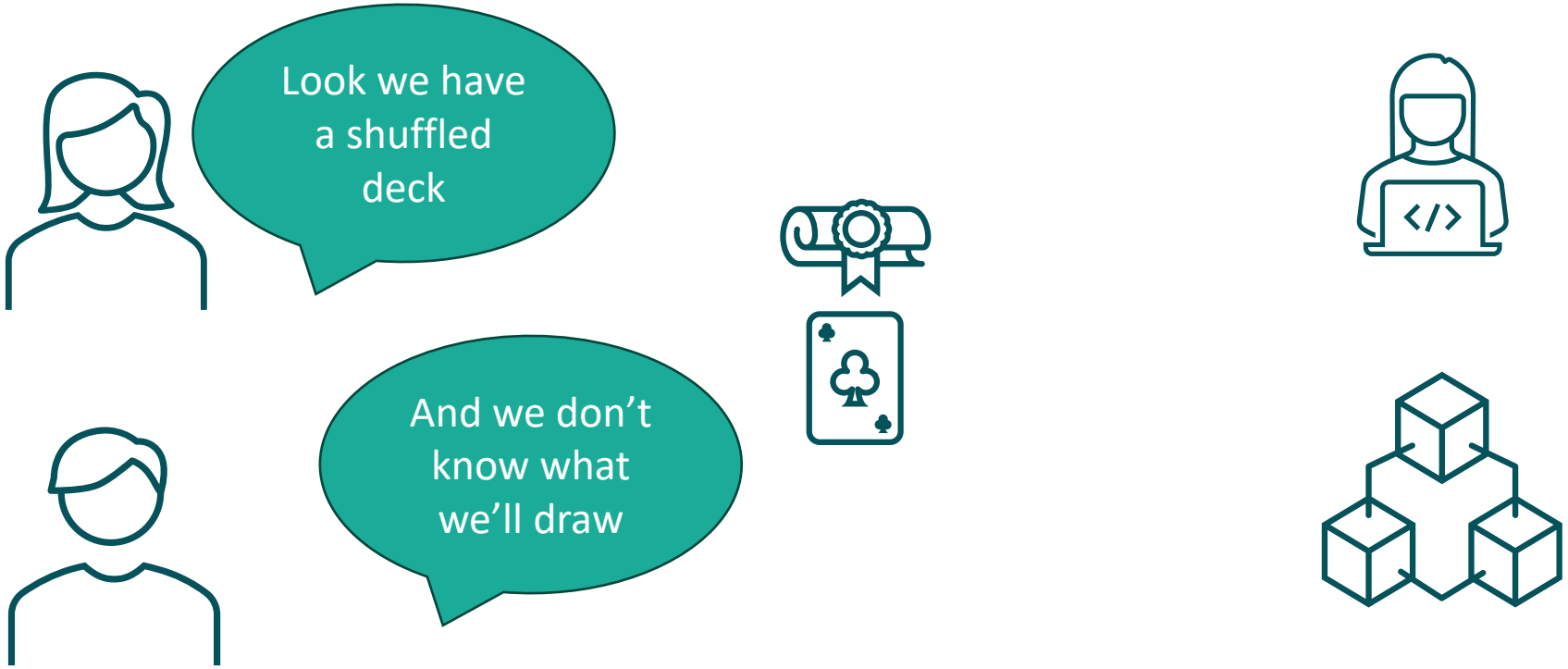
Playing a game of cards

- Shuffled the deck
- Only distribute cards to respective players (verifiable encryption)

No one knows the structure of deck!

Private Shared State

- Not simply composing Alice and Bobs private state
- We generate new private state that nobody knows
- But: No input verification so far!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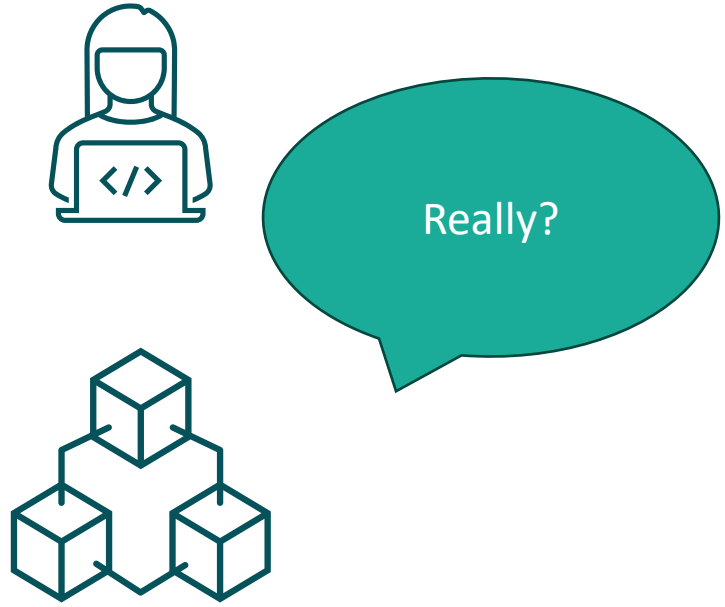
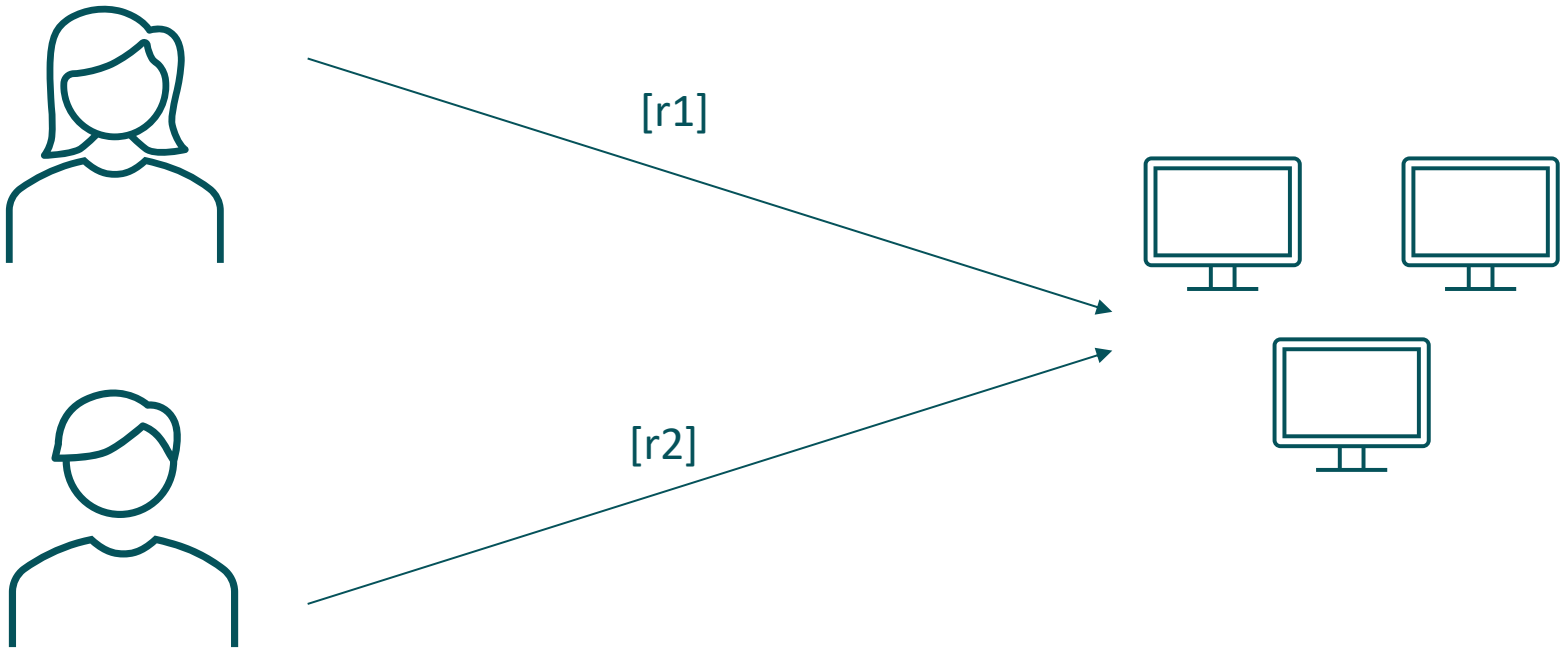

Really?

Towards publicly-auditable MPC



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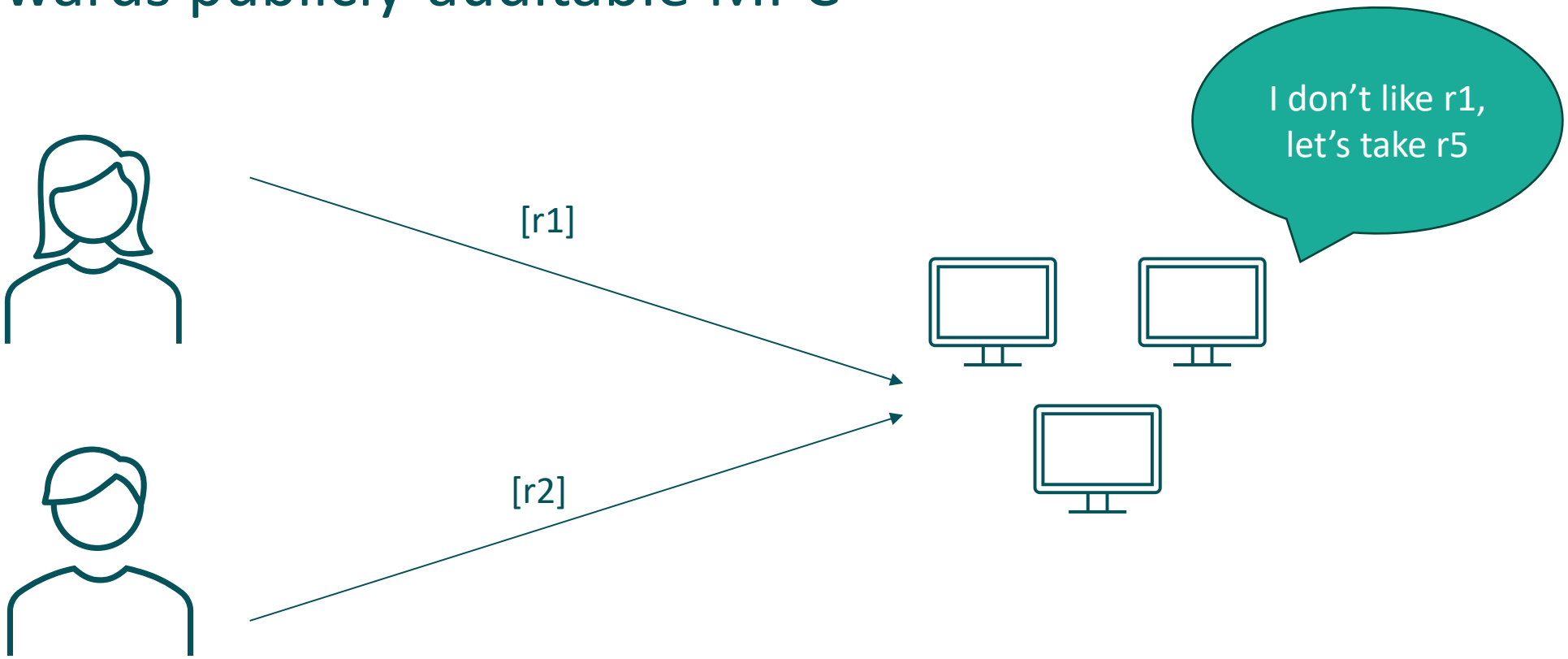
Towards publicly-auditable MPC



=> Solution: Always bind data to public commitments

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Towards publicly-auditable MPC

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Interop with Aztec

UltraHonk Proof System

- Currently supported by coNoir
- Recurse into smart contract

```
std::verify_proof(
    verification_key,
    proof,
    public_inputs,
    key_hash
);
```

Full Client-IVC Proof System

- Prove whole Aztec transactions in MPC
- Create Aztec keys that are secret-shared and own Private State

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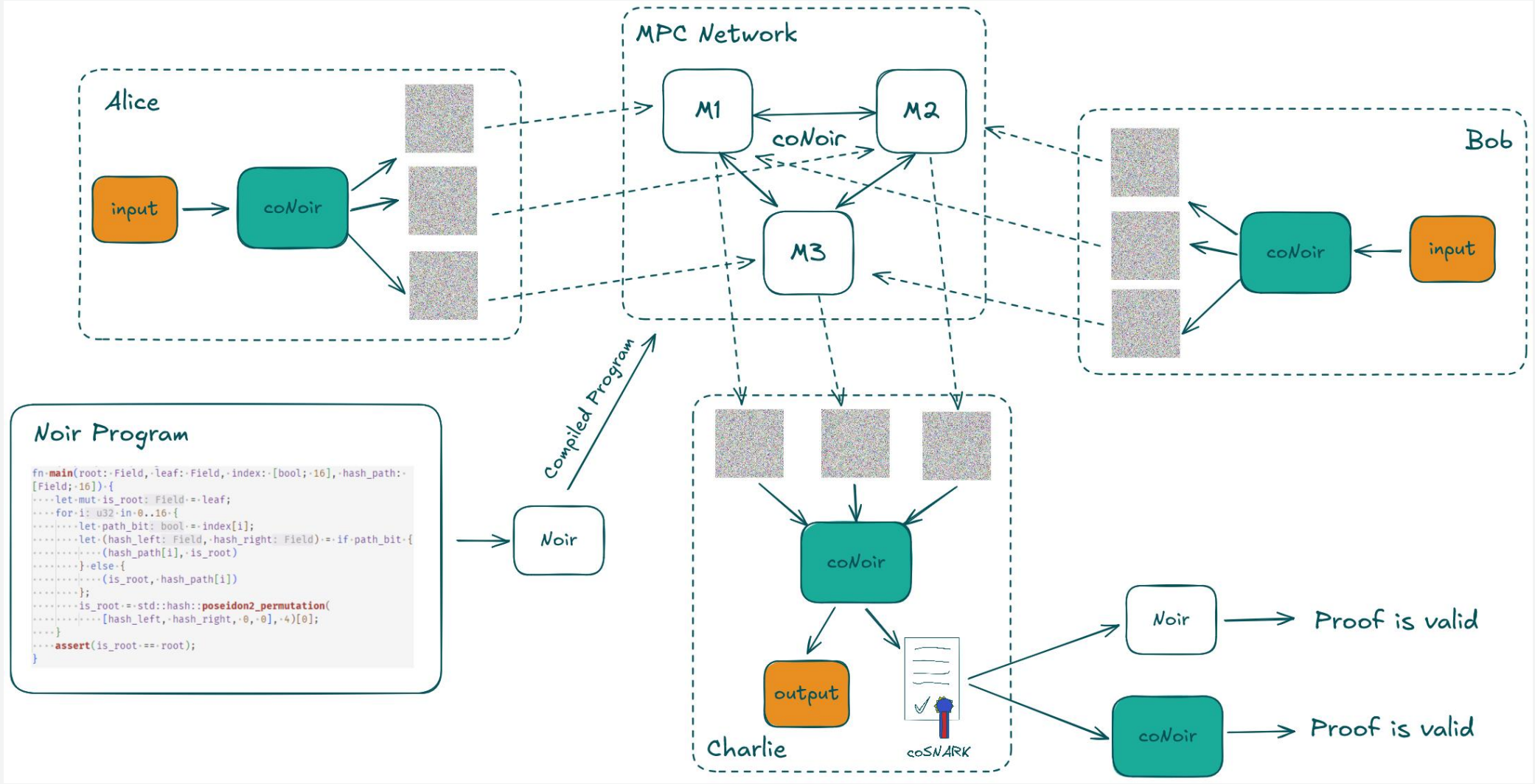
MPC Network
M1
M2
M3
coNoir
Alice
input
coNoir
Bob
coNoir
input
Noir Program
fn main(root: Field, leaf: Field, index: [bool; 16], hash_path: [Field; 16]) {
let mut is_root: Field = leaf;
for i: u32 in 0..16 {
let path_bit: bool = index[i];
let (hash_left: Field, hash_right: Field) = if path_bit {
(hash_path[i], is_root)
} else {
(is_root, hash_path[i])
};
is_root = std::hash::poseidon2_permutation(
[hash_left, hash_right, 0, 0], 4)[0];
}
assert(is_root == root);
}
Compiled Program
Noir
coNoir
output
Charlie
coSNARK
Noir
Proof is valid
coNoir
Proof is valid

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Graz | Austria

office@taceo.io