Welcome to ASCrypto 2025!

Opening Remarks

Organizers

Javier Verbel

Arantxa Zapico

Speakers

Sophia Yakoubov

Alan Szepieniec

Benedikt Bünz

Monday

Now-10:30: Introduction to Proof Systems

Coffee Break

11:00-12:30: Folding and Accumulation Schemes

Lunch break

14:00-15:30: Introduction to zk-STARKs

Coffee Break

16:00-17:30: Secure MPC and applications to zk proofs

Tuesday

9:00-10:30: Folding and Accumulation Schemes

Coffee Break

11:00-12:30: Introduction to zk-STARKs

Lunch break

14:00-15:30: Secure MPC and applications to zk proofs

Coffee Break

16:00-17:30: Q&A Practical Session

Funded Students

50 participants
65 applications for funding
30 students
11 countries

Thanks!

ecosystem support program

Microsoft

International Association for Cryptologic Research

CROSSING

Introduction to Proof Systems

Arantxa Zapico
Ethereum Foundation

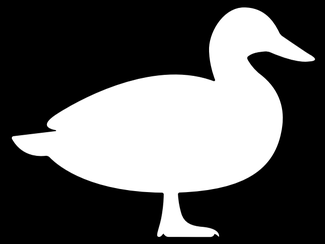
ASCRYPTO. Medellin, September 2025

This talk:

How to build SNARKs (Succinct Non-Interactive Arguments of Knowledge) or just SNARGs (without knowledge) from Interactive Proofs (what are Interactive Proofs?)

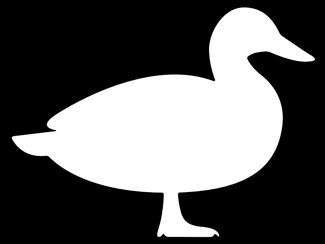
Interactive Proofs

Interactive Proofs



Prover

Interactive Proofs



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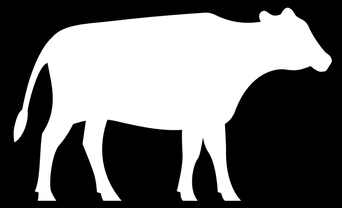
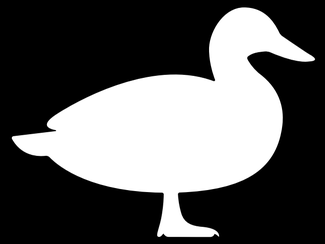
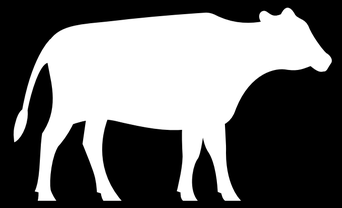


Verifier

Interactive Proofs

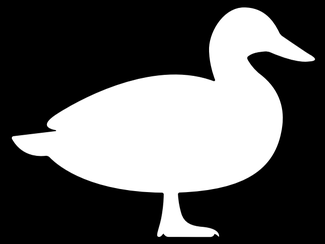


Peggy

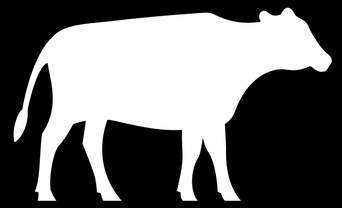


Victor

Interactive Proofs



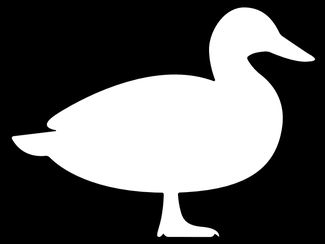
Pedrinho



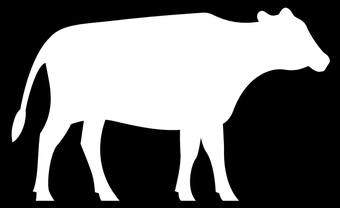
Valeria

Interactive Proofs

Something is true

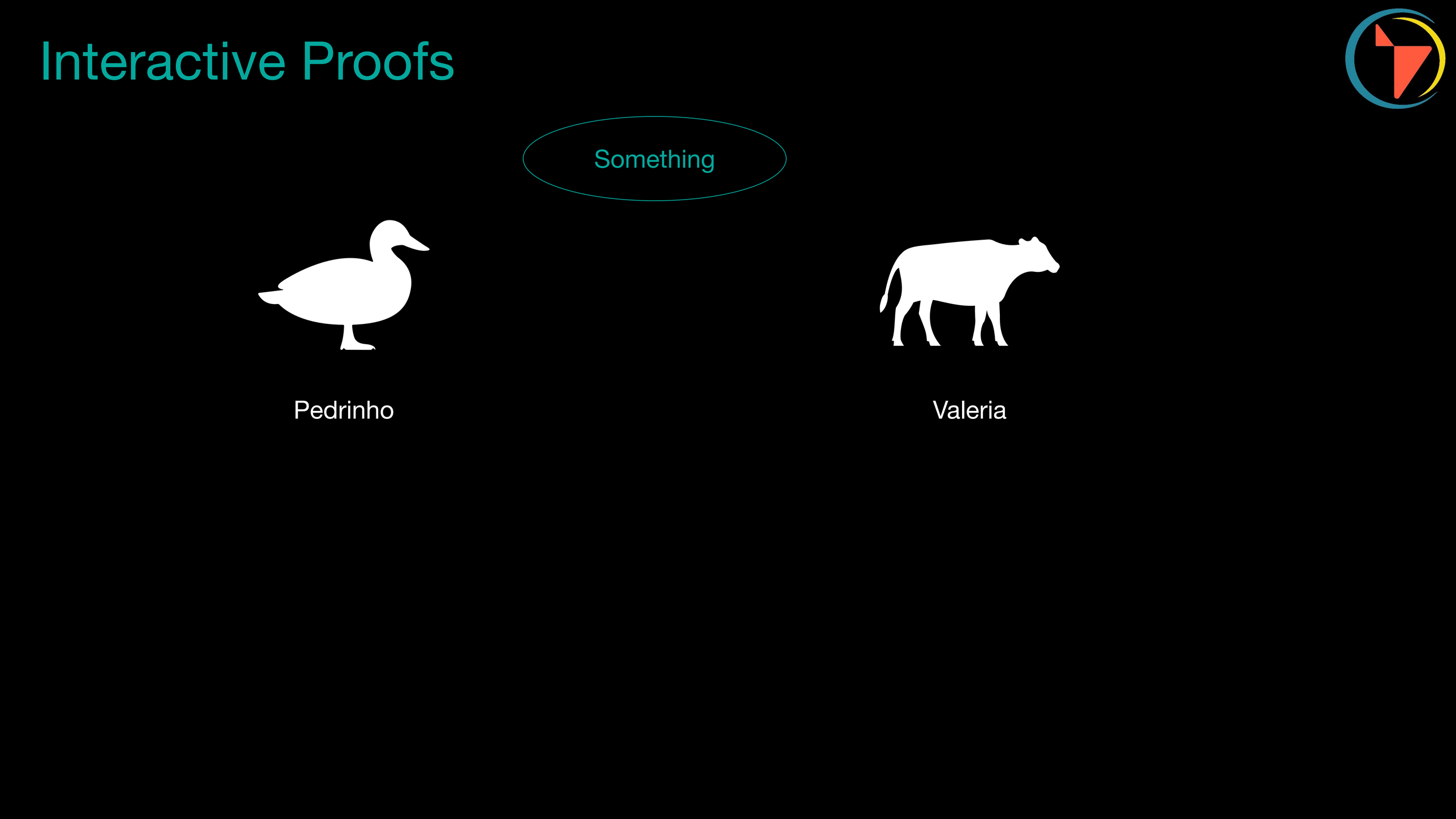


Pedrinho

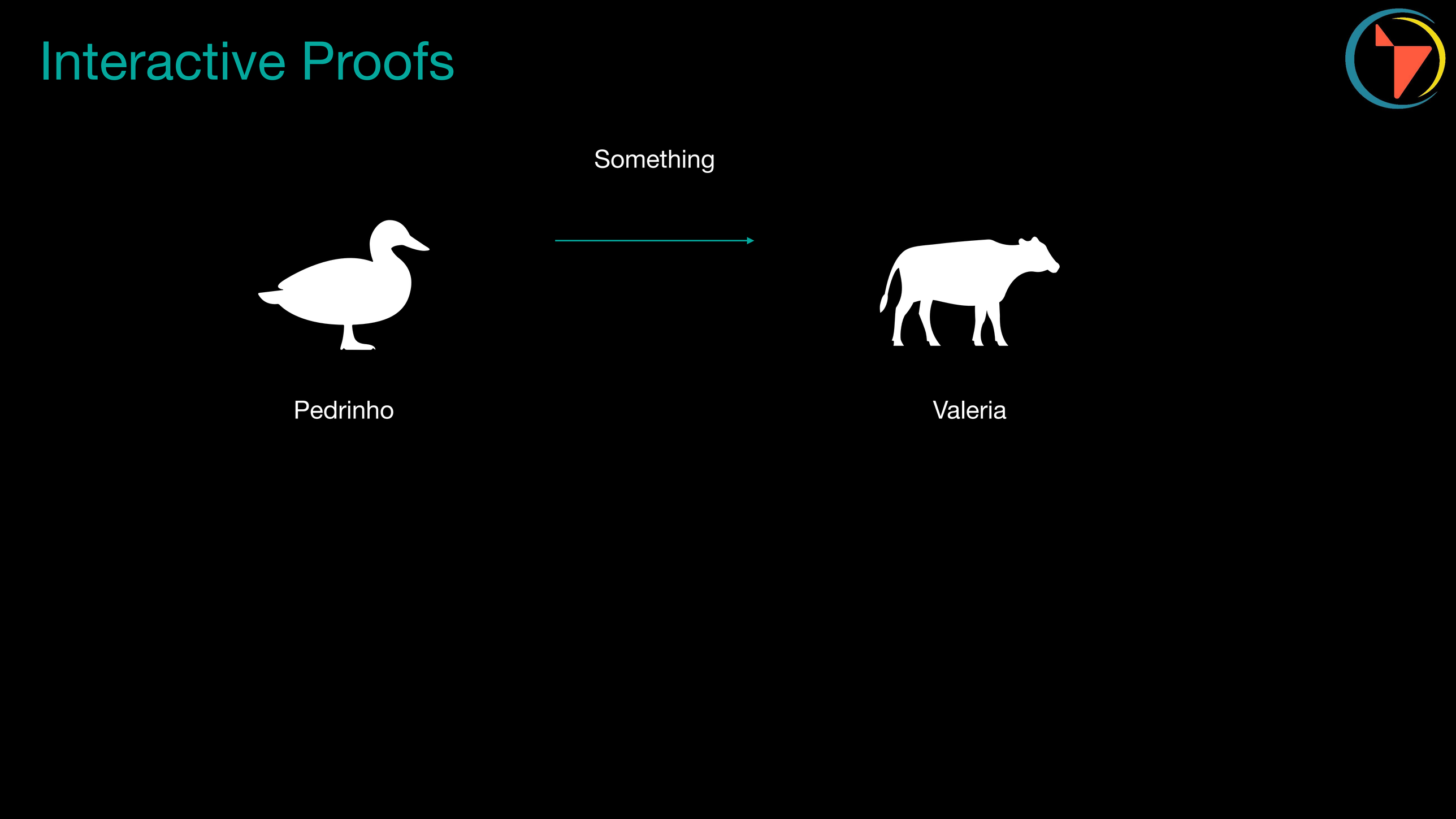


Valeria

Interactive Proofs



Interactive Proofs



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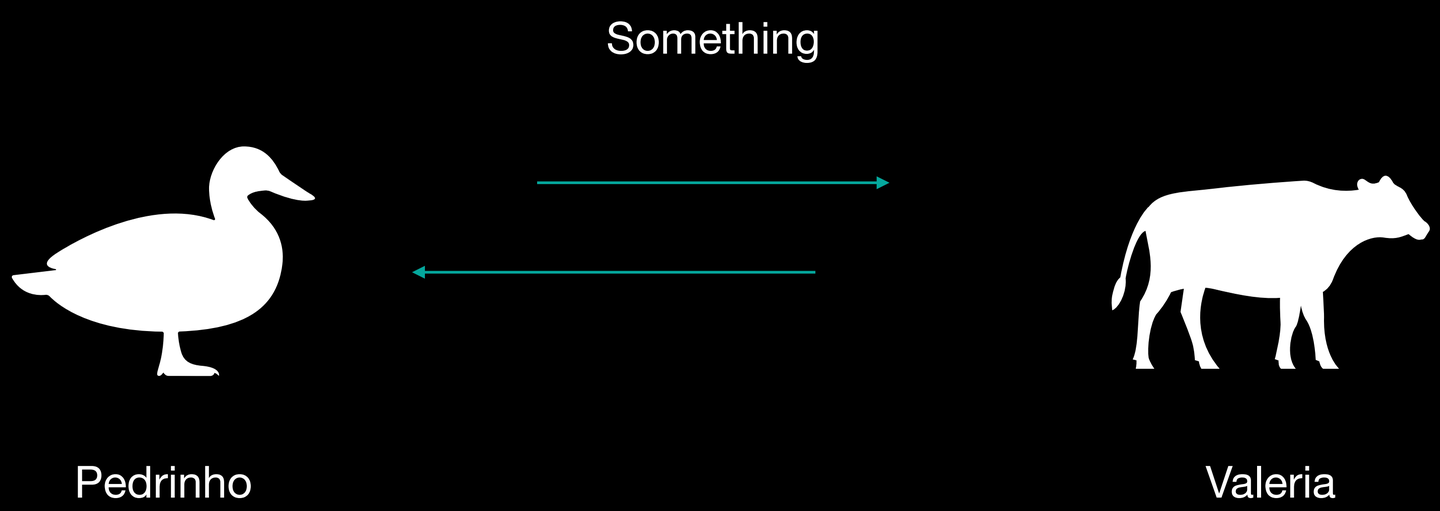
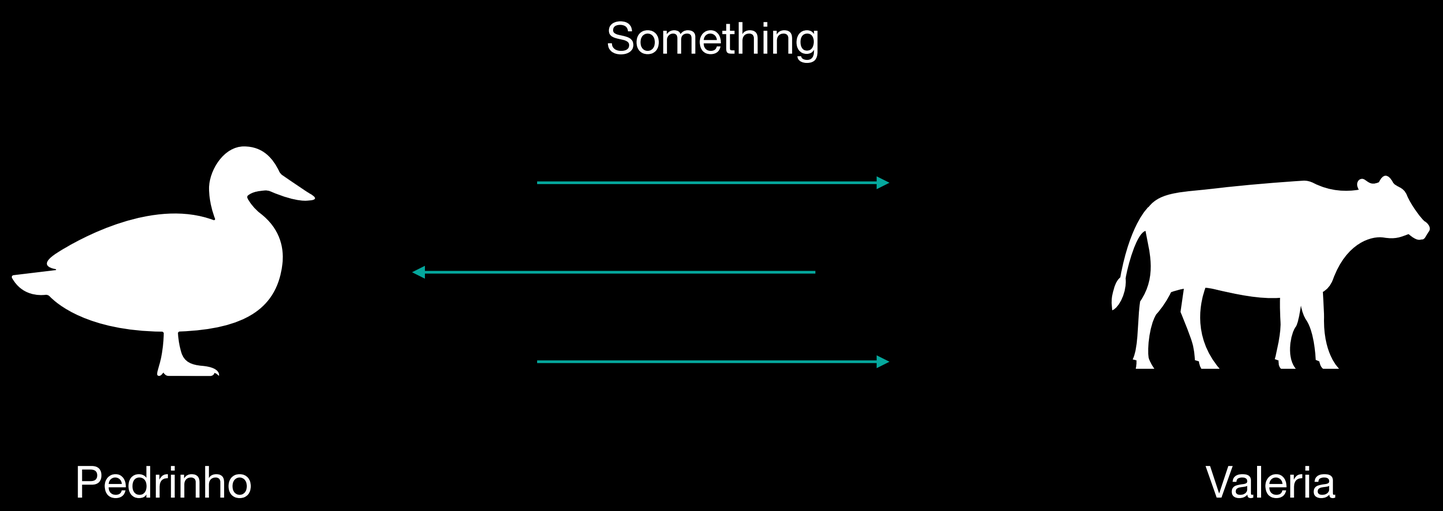
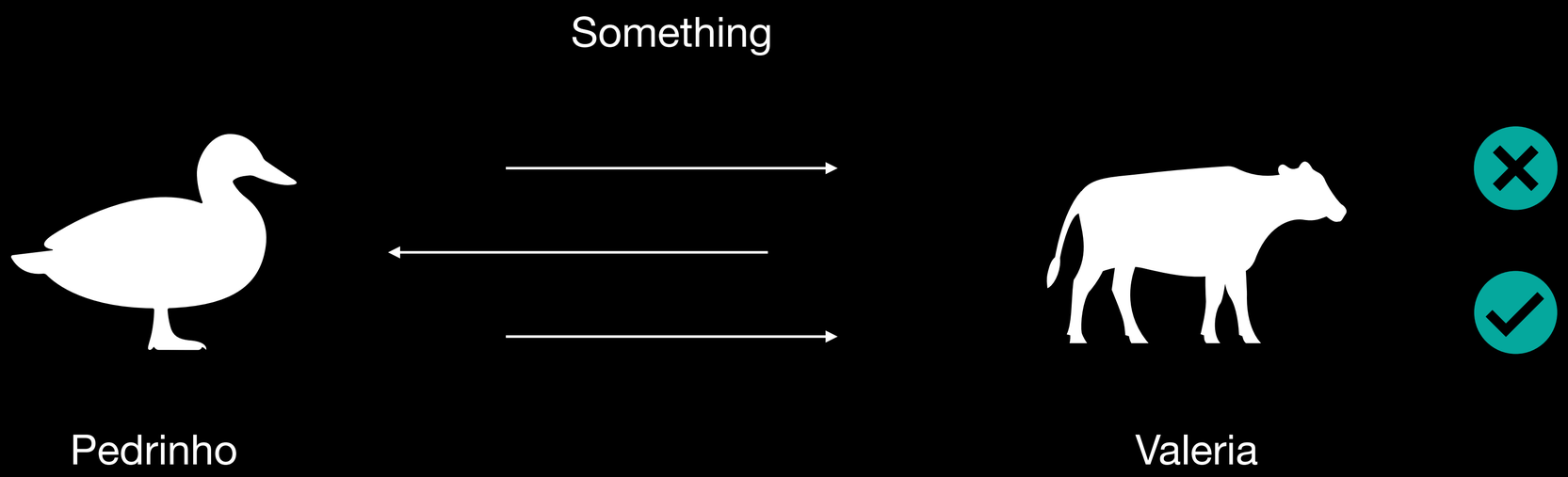


Interactive Proofs



Interactive Proofs



Examples of provers and verifiers

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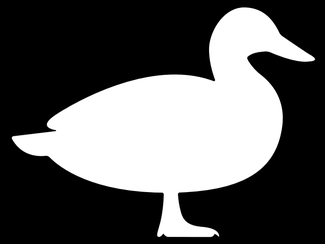
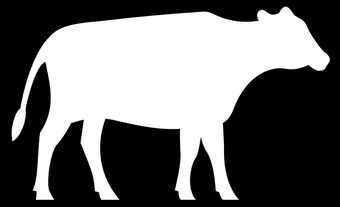
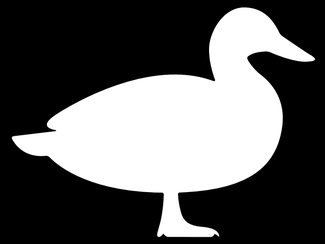


Me

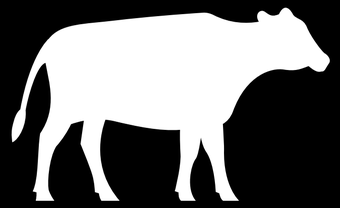


Gmail

Examples of provers and verifiers

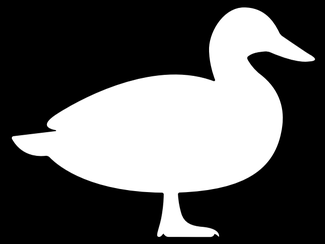


Google Cloud

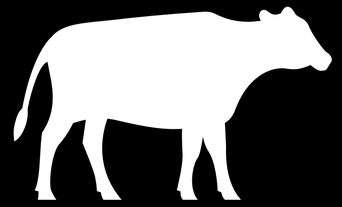


Mobil Phone

Examples of provers and verifiers

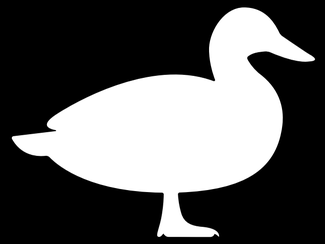


You

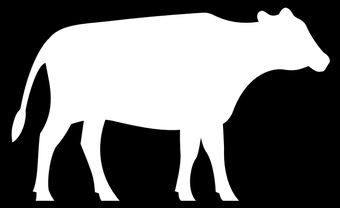


Security at Club

Examples of provers and verifiers

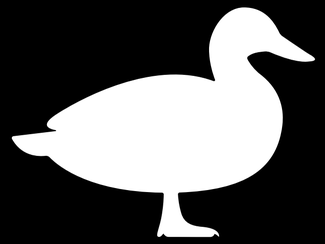


Cryptocurrency user

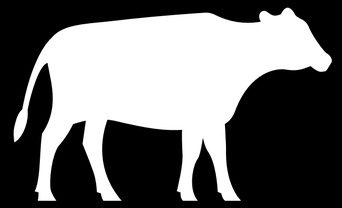


Block Builder

Examples of provers and verifiers

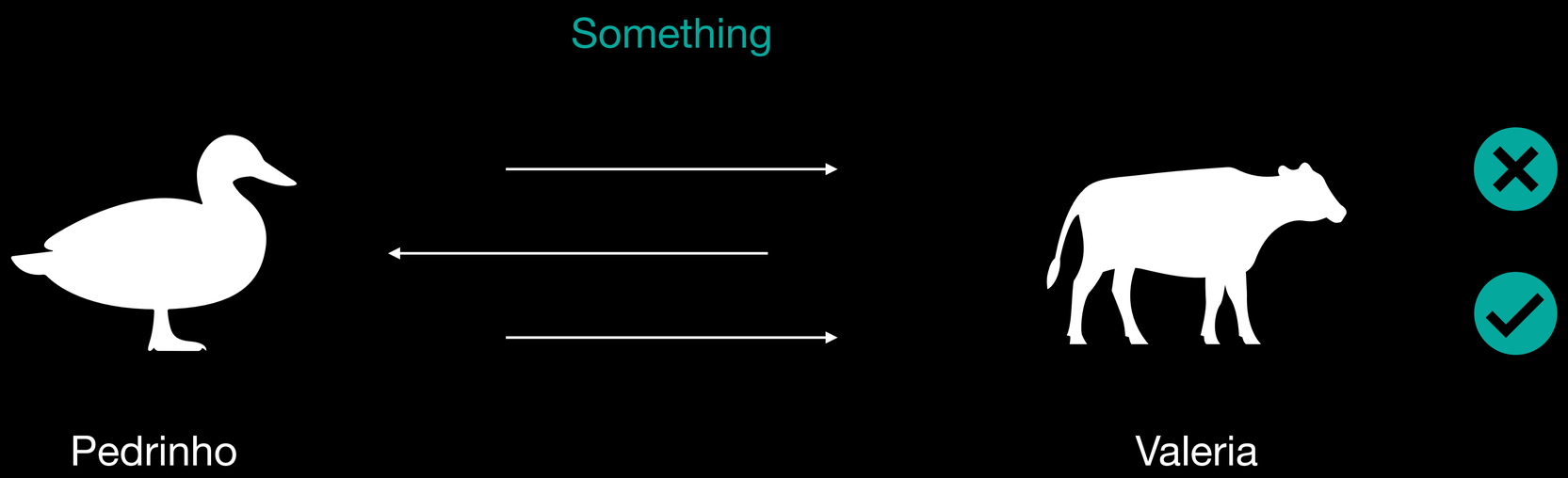


ZkVM

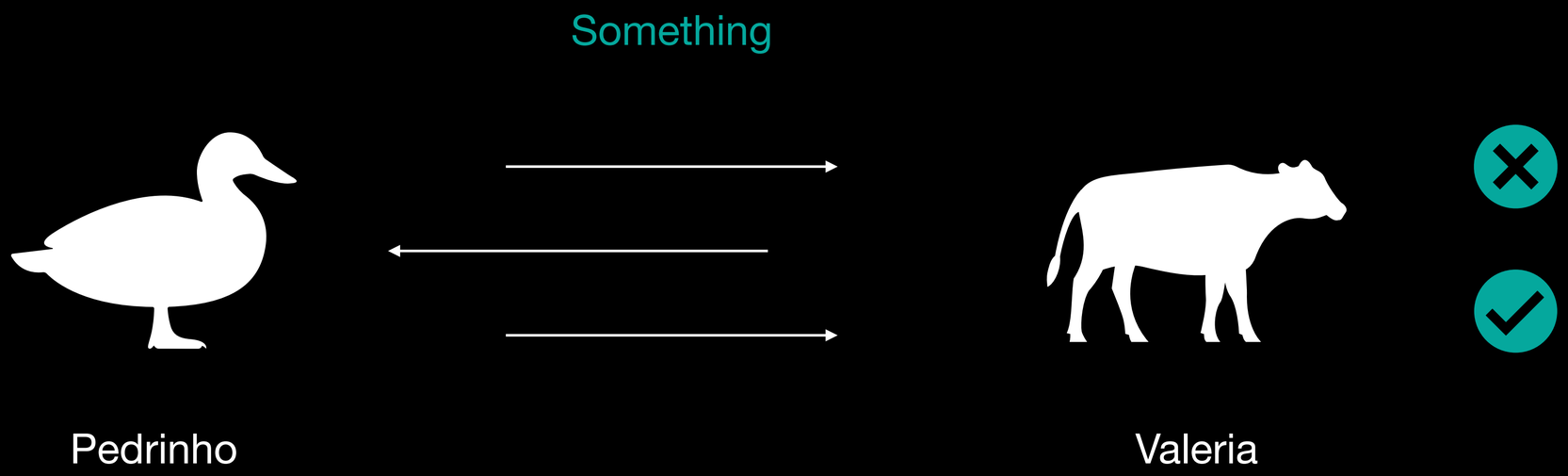


Smart Contract

Interactive Proofs

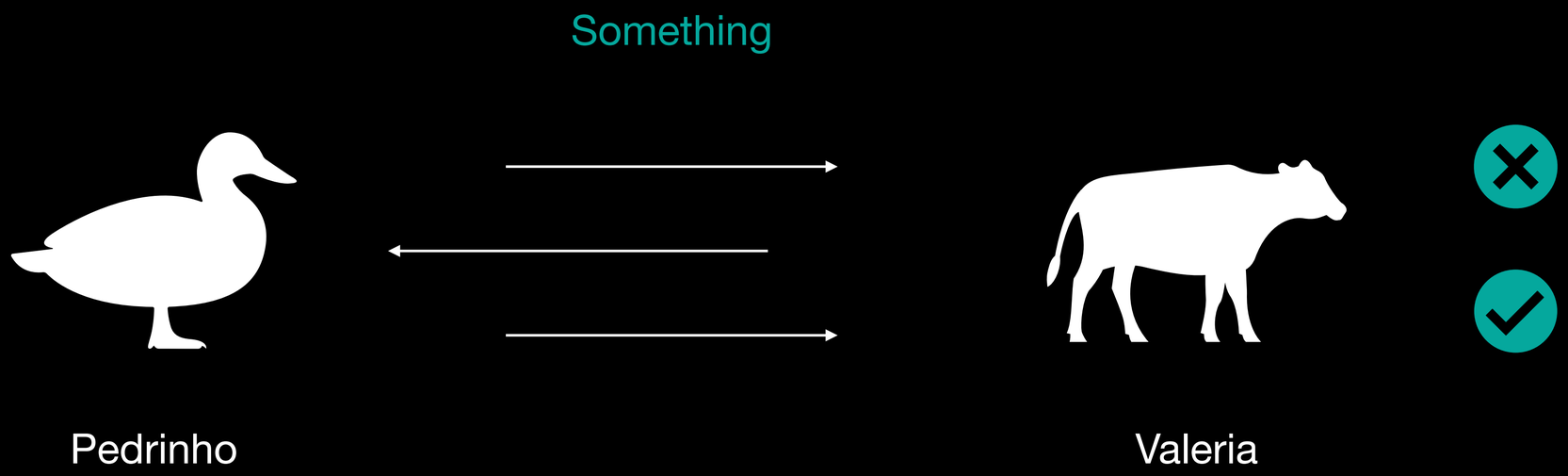


Interactive Proofs



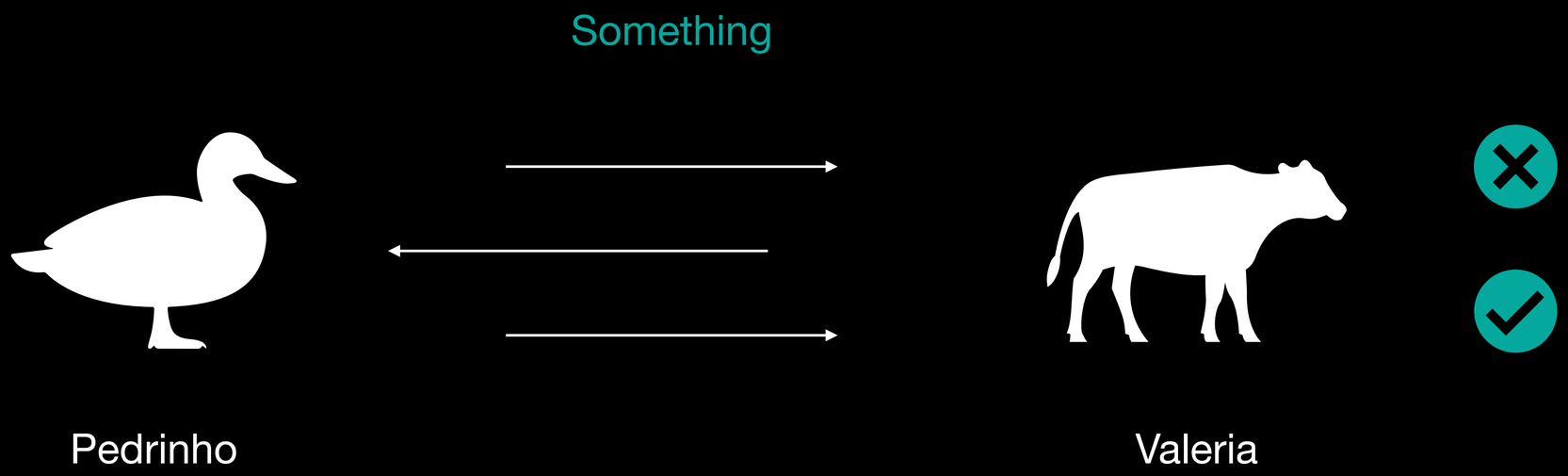
Completeness

Interactive Proofs



Completeness If Something is indeed true and both, Prover and Verifier, follow the procedure, Verifier accepts

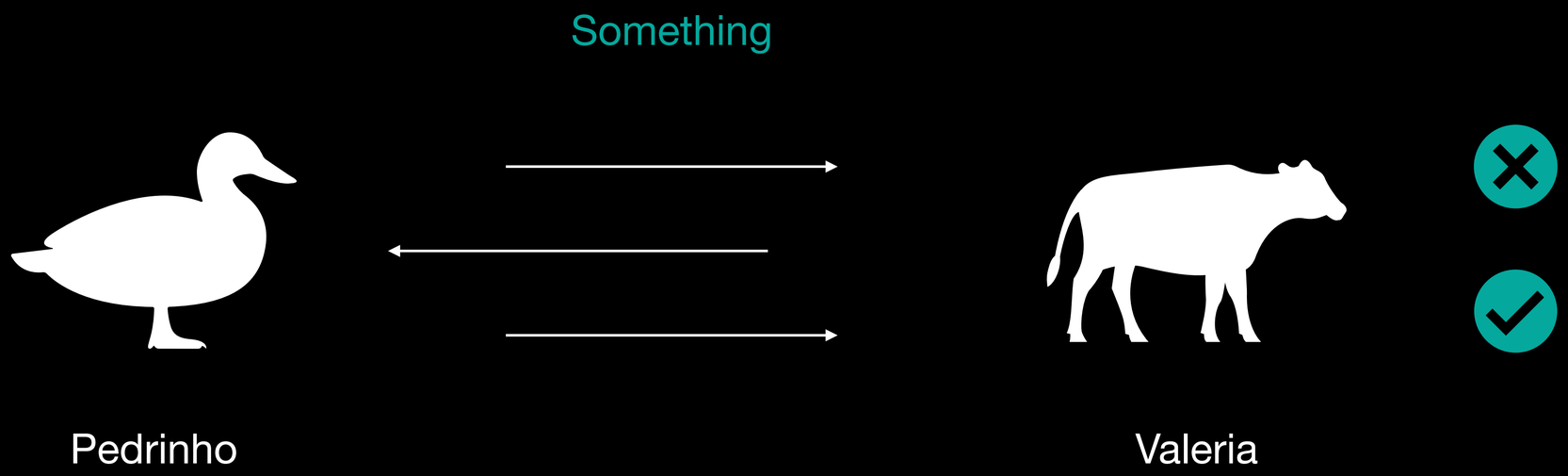
Interactive Proofs



Completeness If Something is indeed true and both, Prover and Verifier, follow the procedure, Verifier accepts

Soundness

Interactive Proofs



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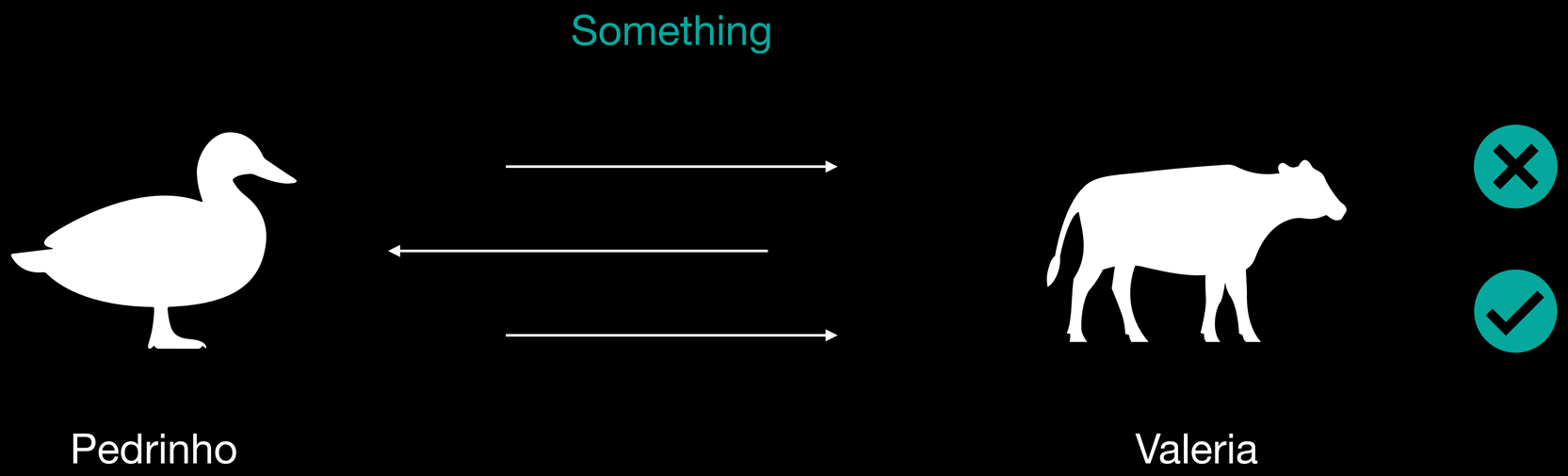
Interactive Proofs



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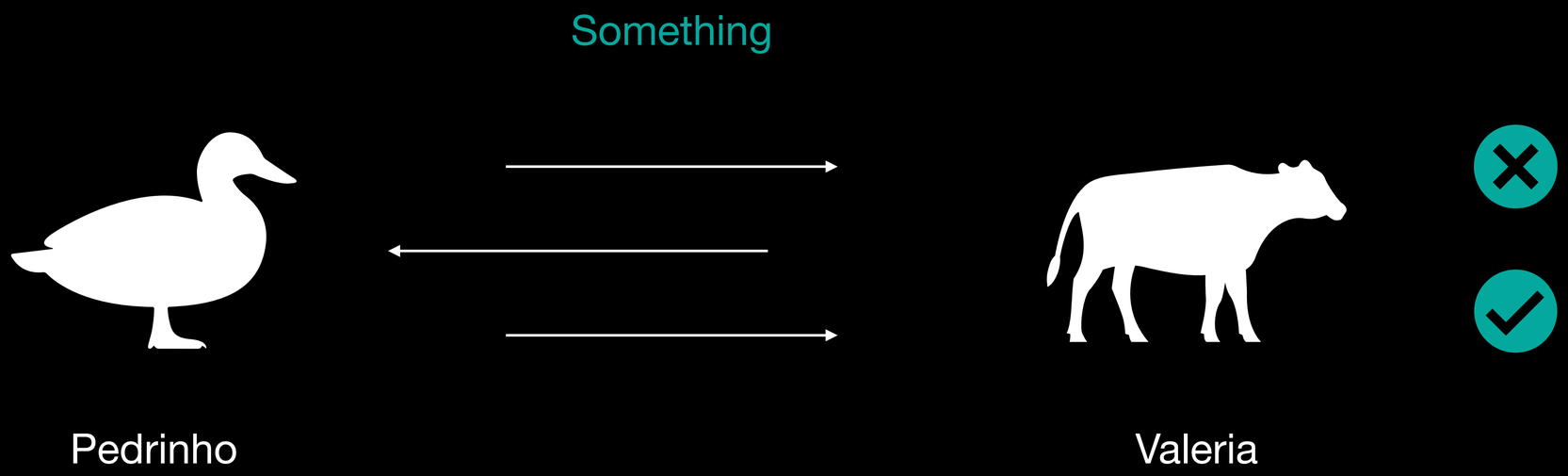
Zero-Knowledge

Interactive Proofs



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Something

Something

R is a PT decidable relation

$R = \{(x, w) : \ldots\}$ is a PT decidable relation

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Something is true

$R = \{(x, w) : \ldots\}$ is a PT decidable relation

$$x \in \mathscr{L}_R$$

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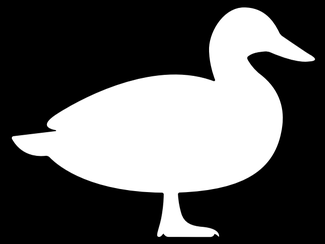
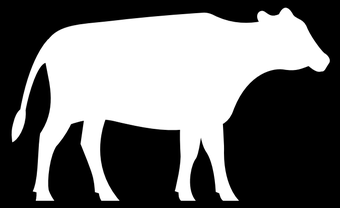
$$x \in \mathscr{L}_R$$

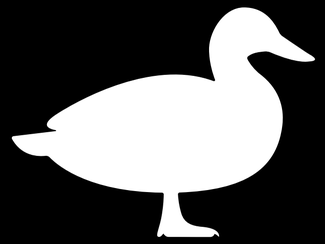
$$\mathscr{L}_R = \{x \ s \,.\, t \,.\, \exists w \ s \,.\, t \,.\, (x, w) \in R\}$$



You



Security at Club



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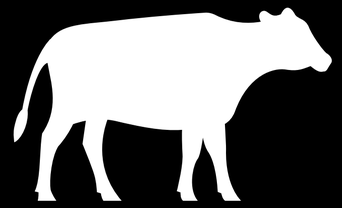
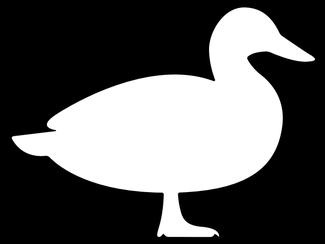


Security at Club

$$R = \{(x, w) : x \text{ is a name and } w \text{ an age above 18}\}$$



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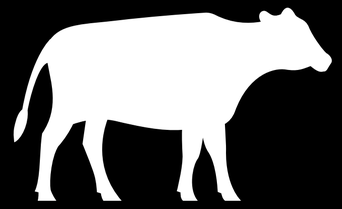

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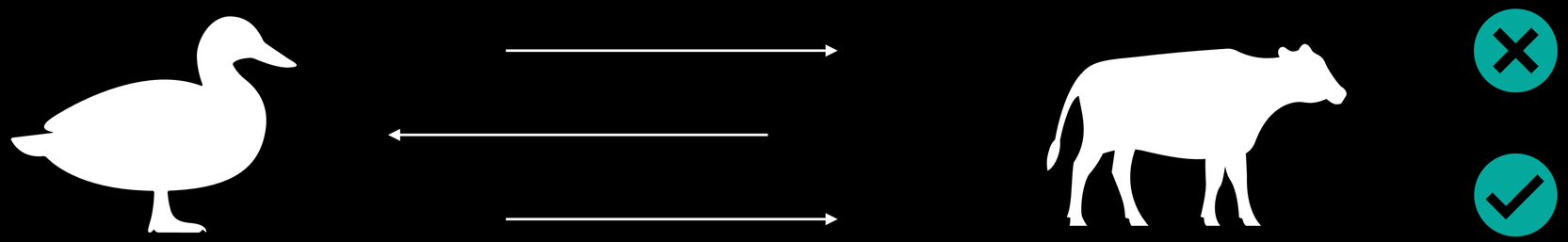
$$R = \{(x, w) : x \text{ is a name and } w \text{ an age above 18}\}$$

"I am in $\mathscr{L}_R$": there exists a w (my age) such that

(me, w) $\in R$

Something is true

Something



Pedrinho

Valeria

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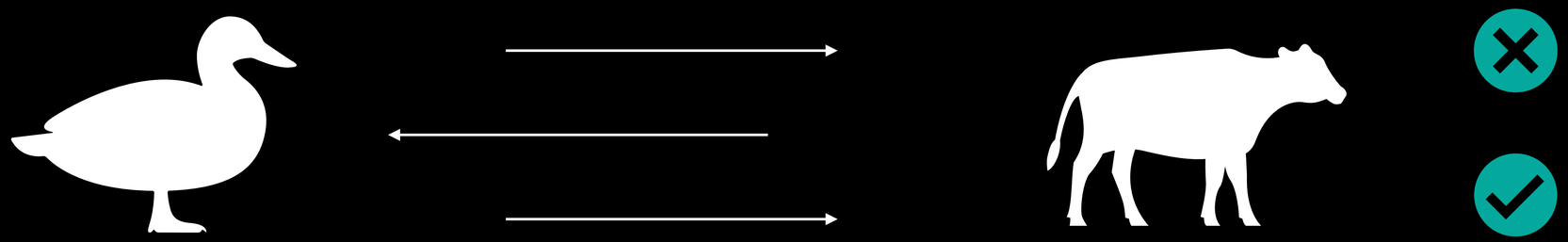
Zero-Knowledge The Verifier does not learn anything but the truth of *Something*

$$R = \{(x, w) : something\}$$

Something



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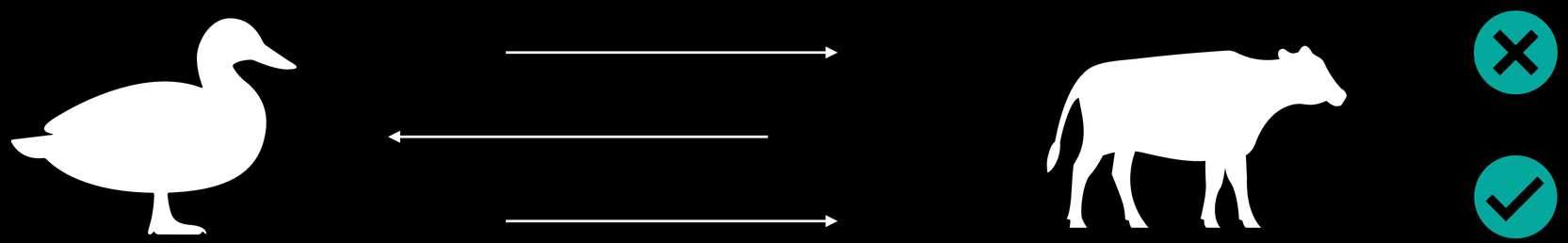
R, x



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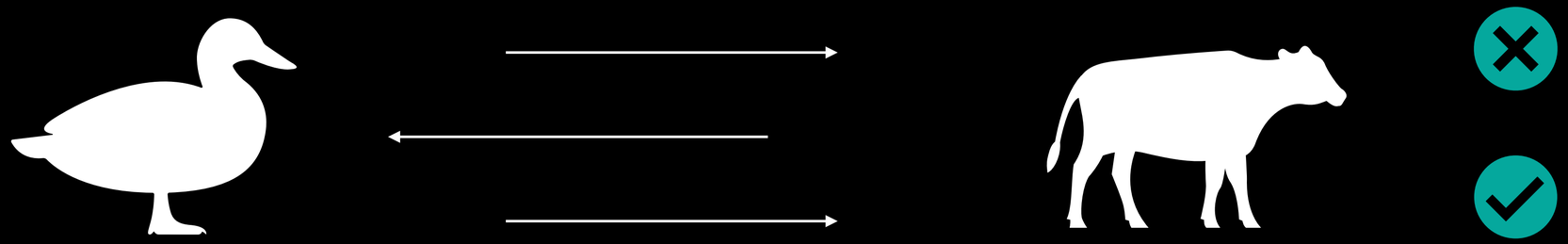
$$pp \leftarrow \mathcal{K}, x$$



Pedrinho$(pp, (x, w))$

Valeria (pp, x)

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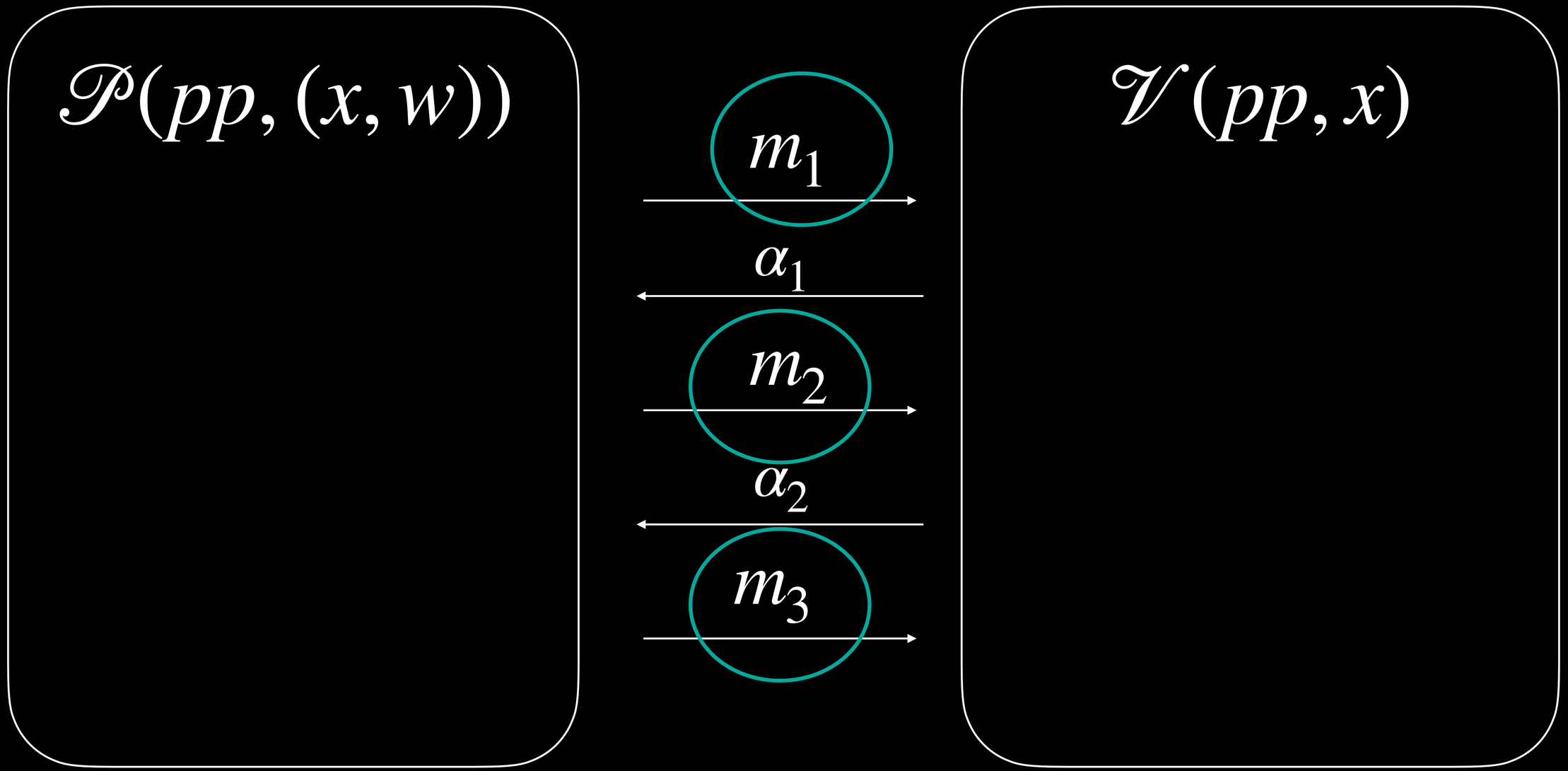
Probabilistic Polynomial Time Algorithms

$\mathcal{P}(pp, (x, w))$

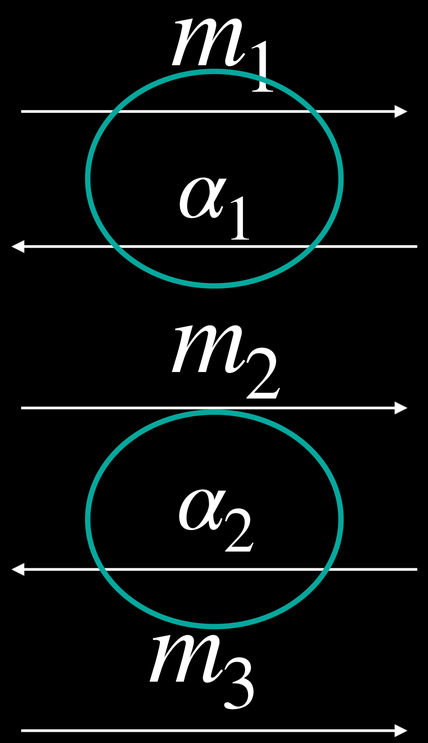
$\mathcal{V}(pp, x)$

Probabilistic Polynomial Time Algorithms



Probabilistic Polynomial Time Algorithms

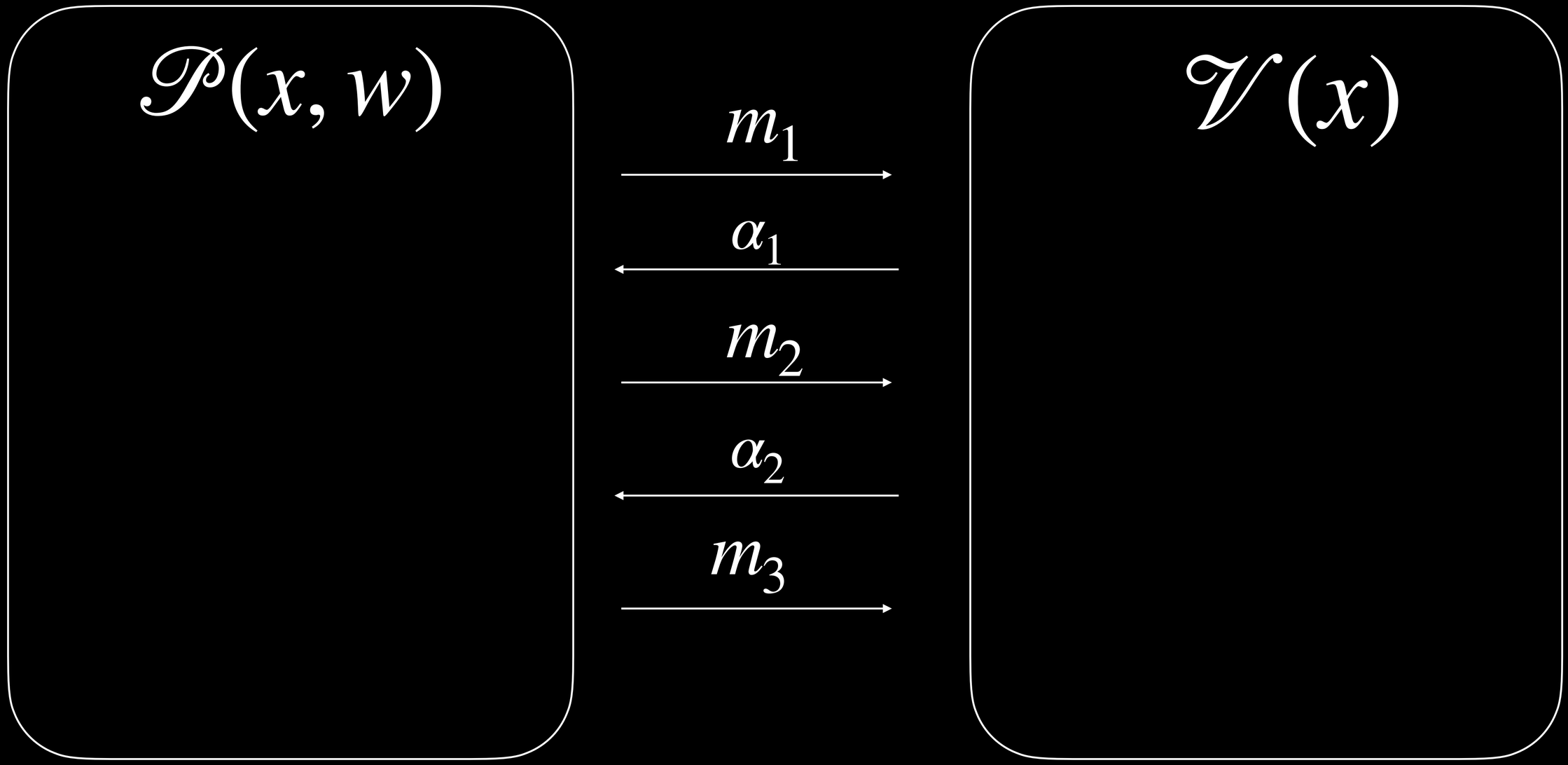
$\mathcal{P}(pp, (x, w))$



$\mathcal{V}(pp, x)$

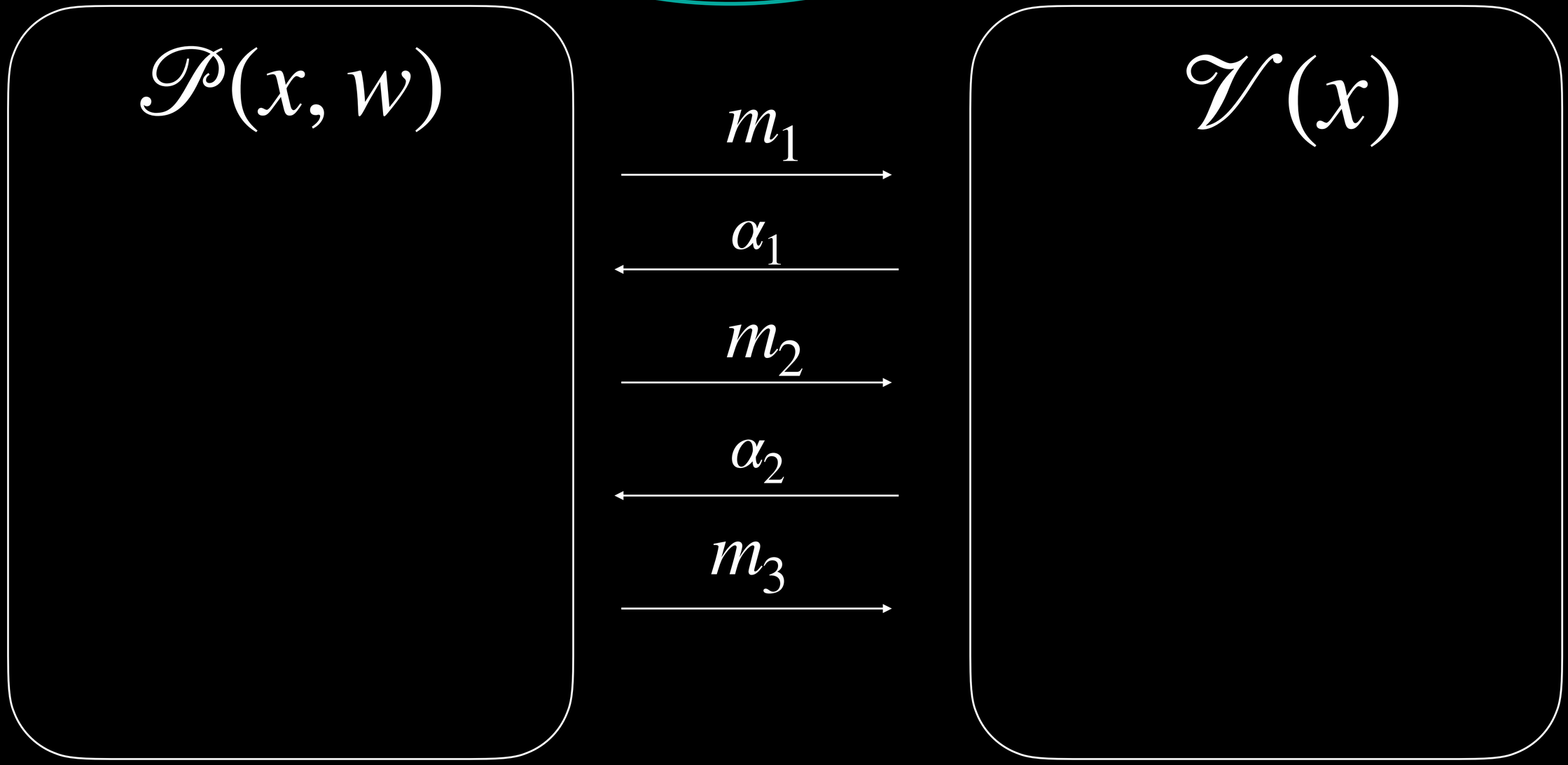
Verifier is public coin

Efficiency

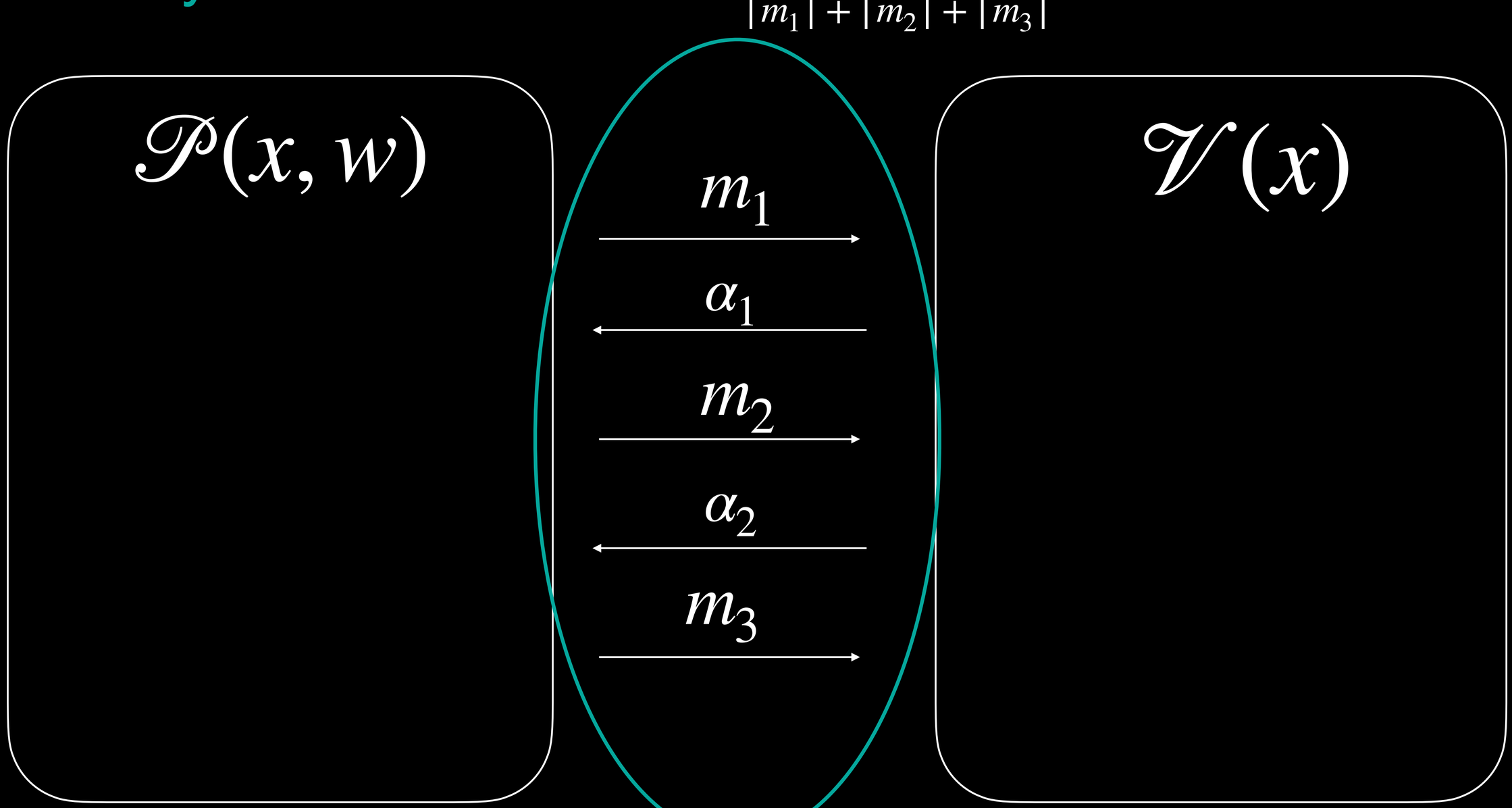


Efficiency

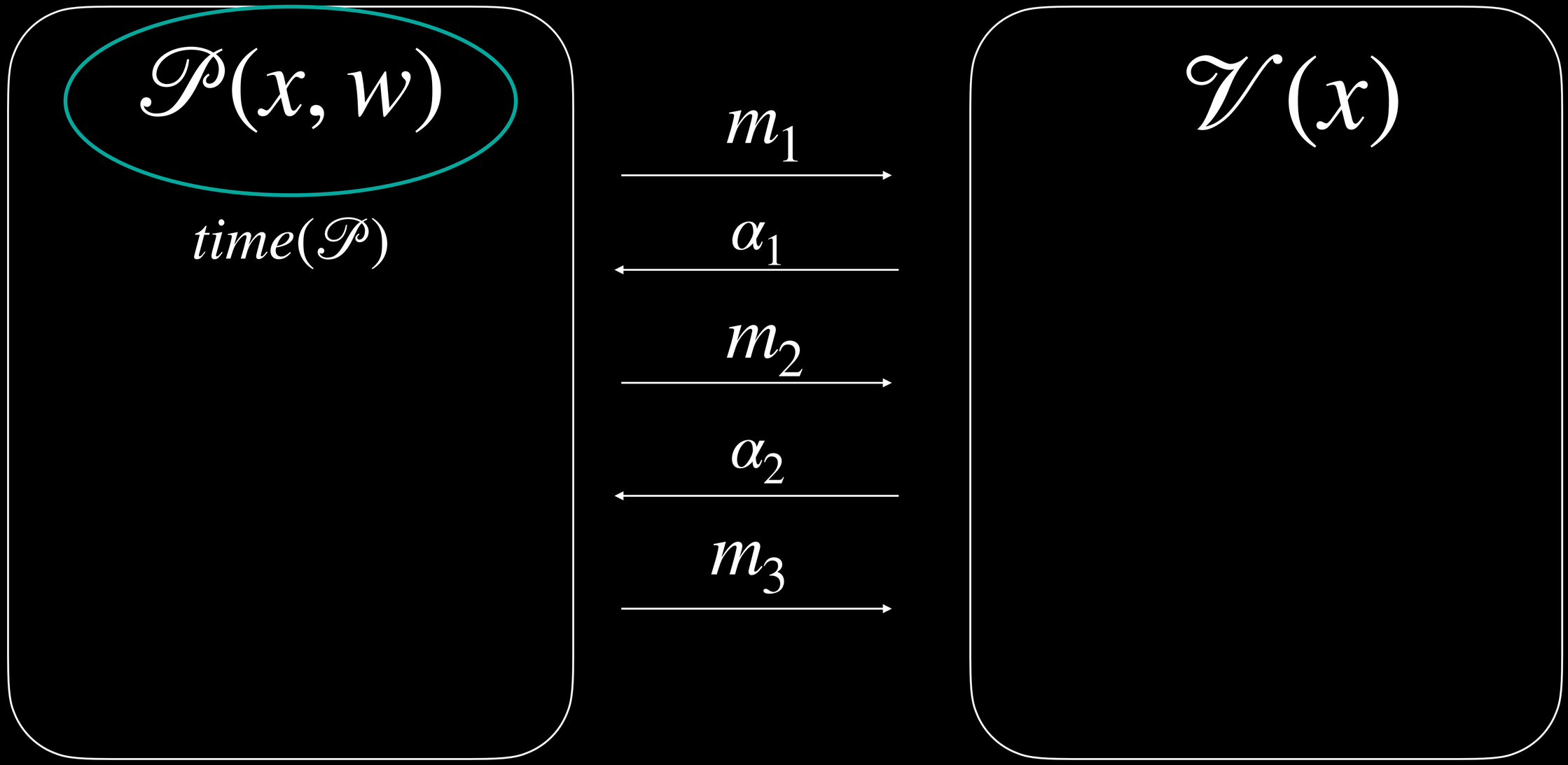
$pp \leftarrow \mathcal{K}$



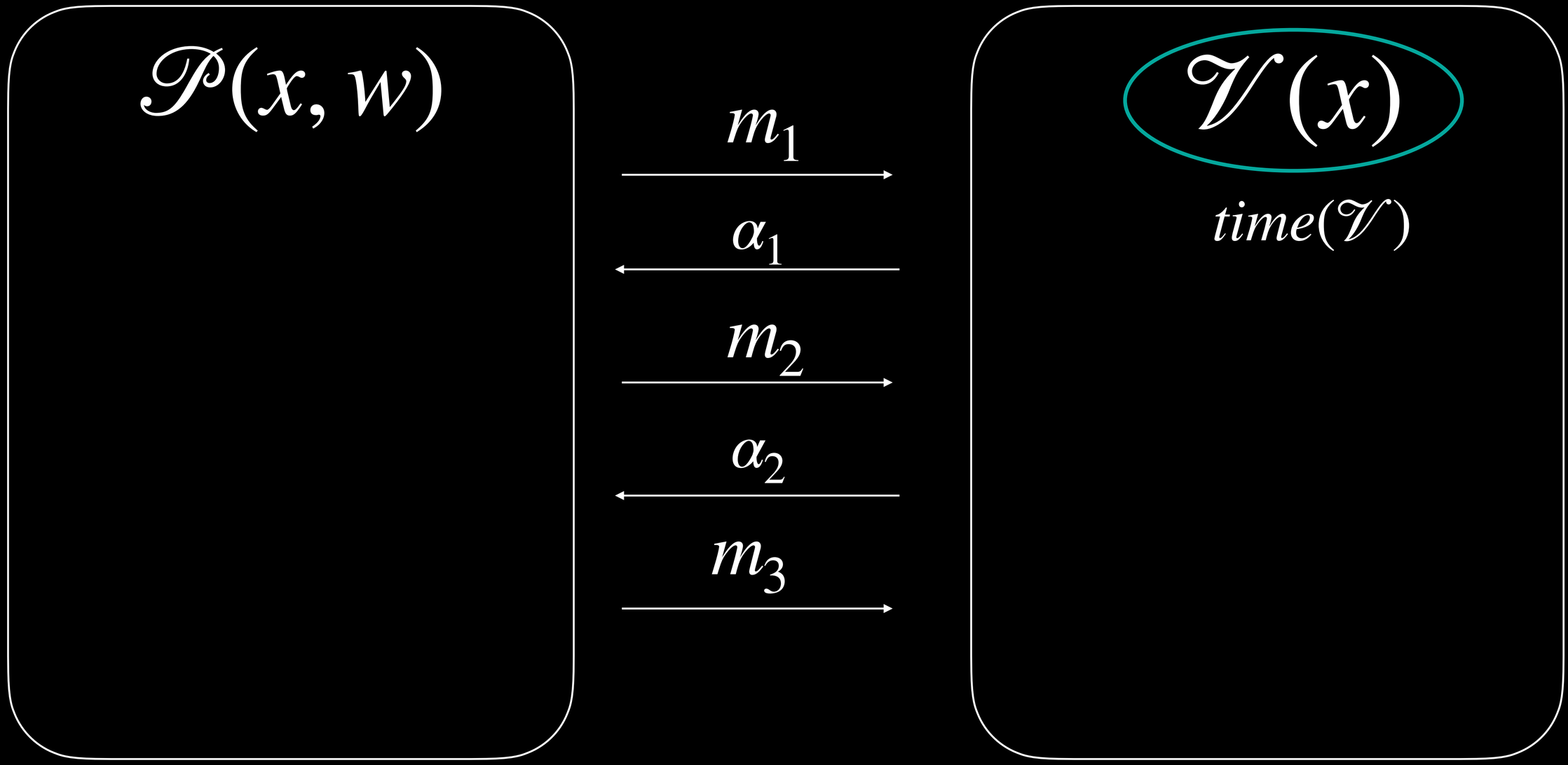
Efficiency: Proof Size



Efficiency: Prover time



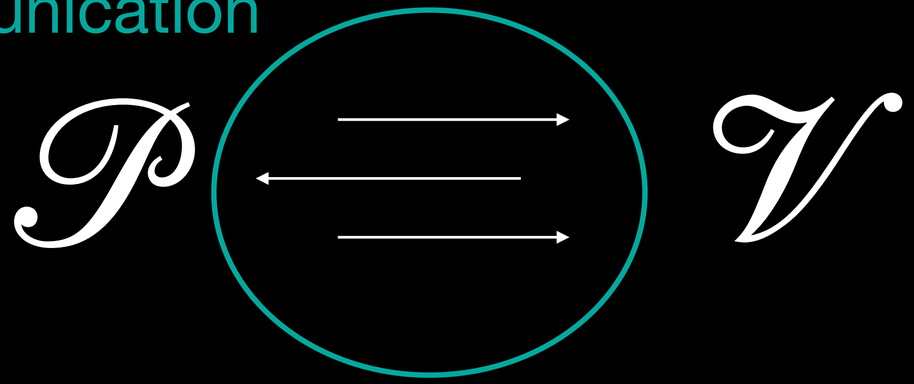
Efficiency: Verifier Time



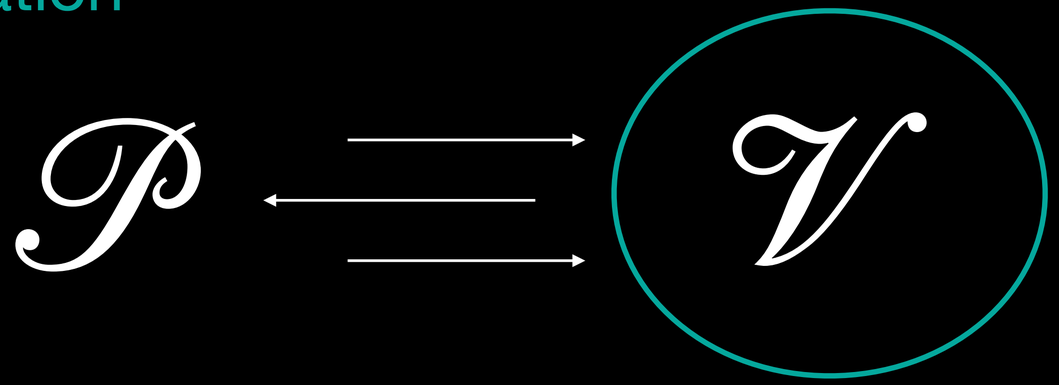
Succinctness

Succinctness

In communication



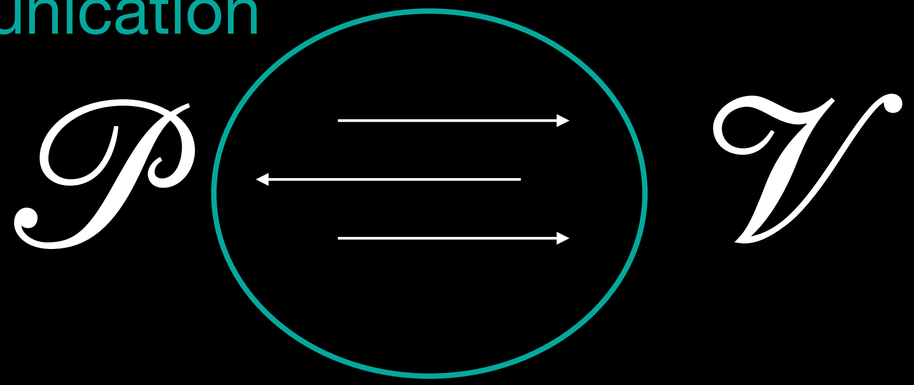
In verification



Succinctness

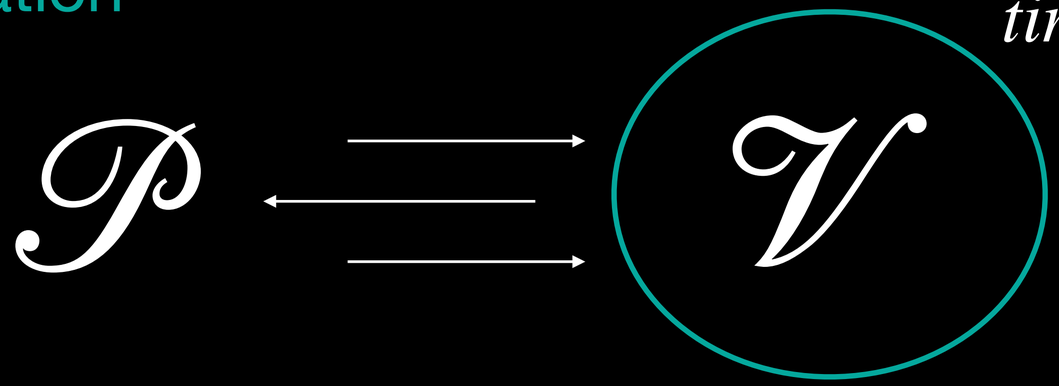
$$|m_1| + |m_2| + |m_3| << |w|$$

In communication



In verification

$$time(\mathscr{V}) << time_R(x, w)$$



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Arguments

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We are actually talking about arguments

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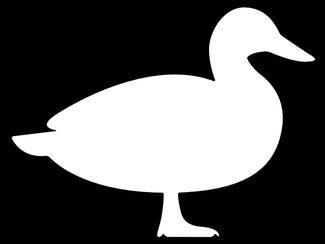
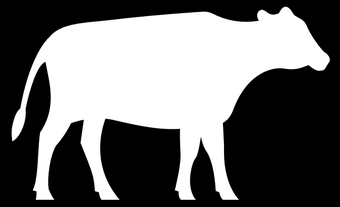
Examples of provers and verifiers



Me



Gmail

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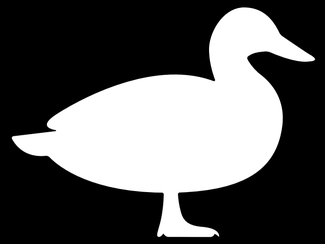

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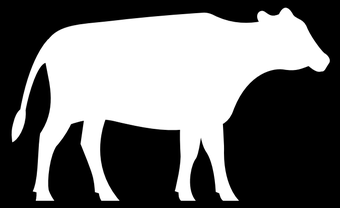

Gmail

There exists a password for this email address

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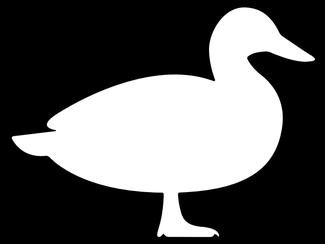

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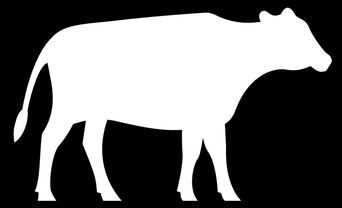

Gmail

There exists a password for this email address

Not enough!!!
I should *know* it

Arguments of Knowledge

Knowledge-soundness

There exists a PT algorithm $\mathscr{E}$, the extractor, such that for every malicious prover $\mathscr{P}^*$:

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An argument that satisfies knowledge-soundness is an argument of knowledge

Completeness $$Pr\left[\langle \mathscr{P}(pp,(x,w),\mathscr{V}(pp,x))\rangle\right] = 1$$

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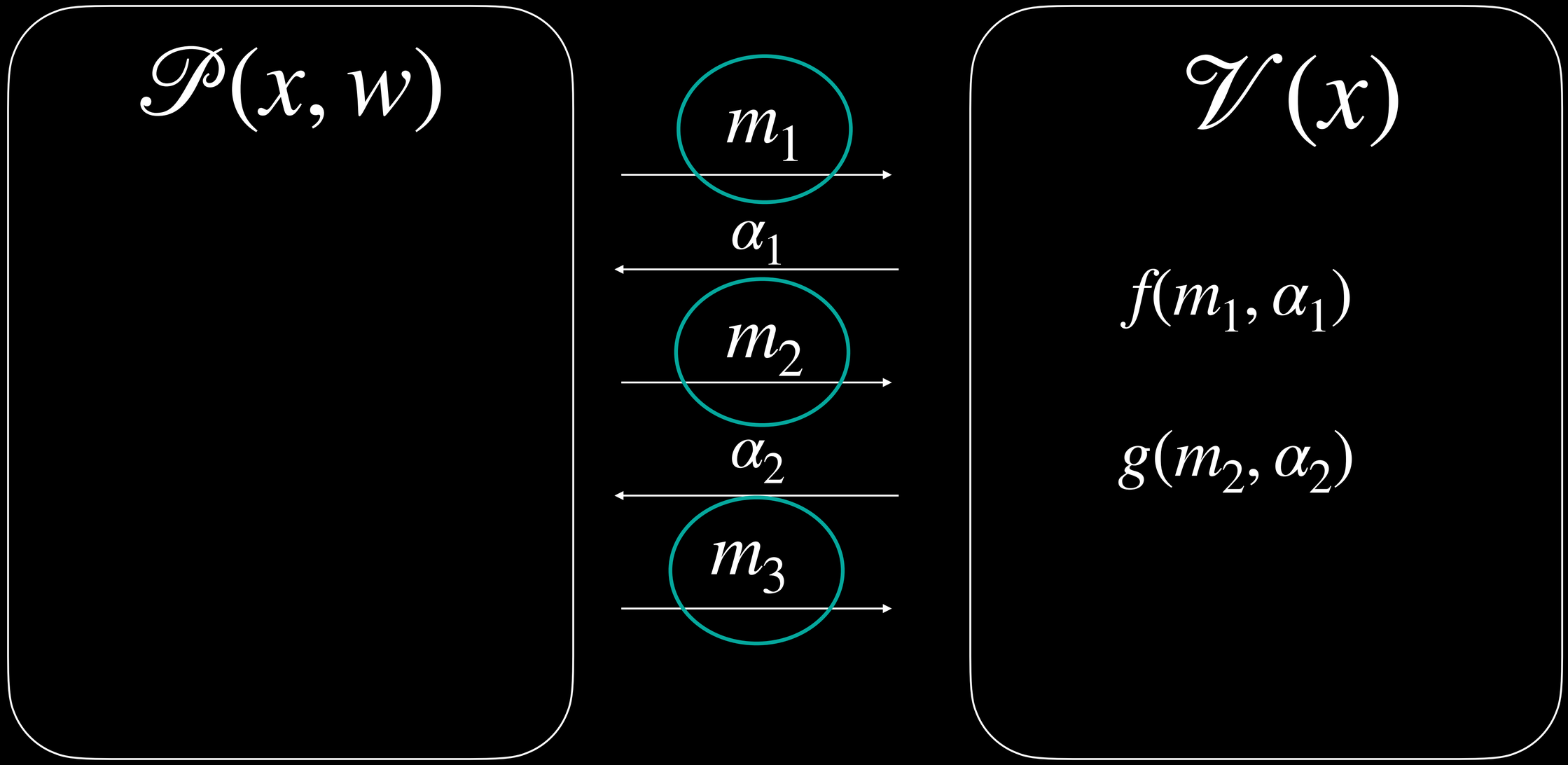
How to build SNARK(G)s?

Tool 1: Interactive Oracle Proof



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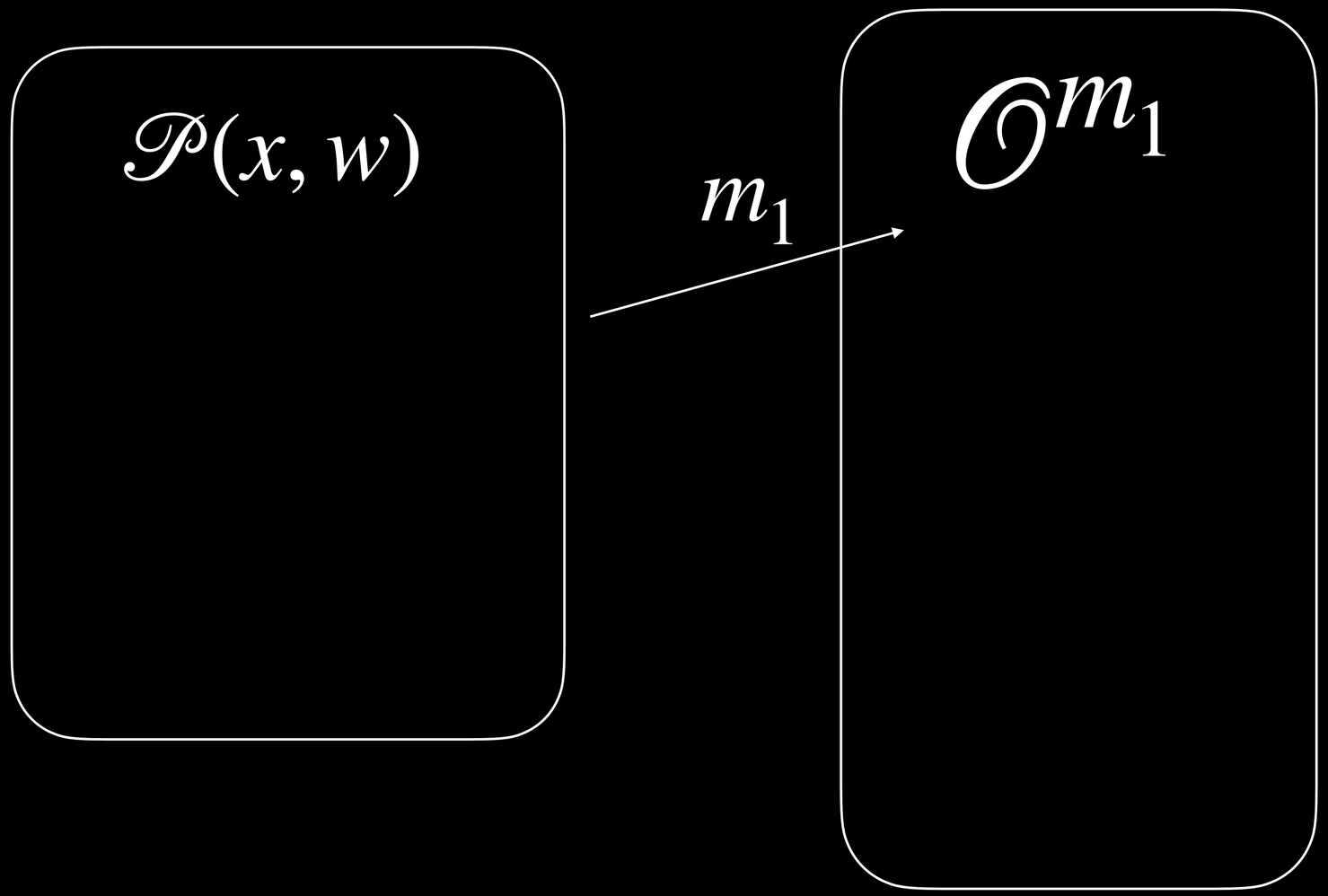

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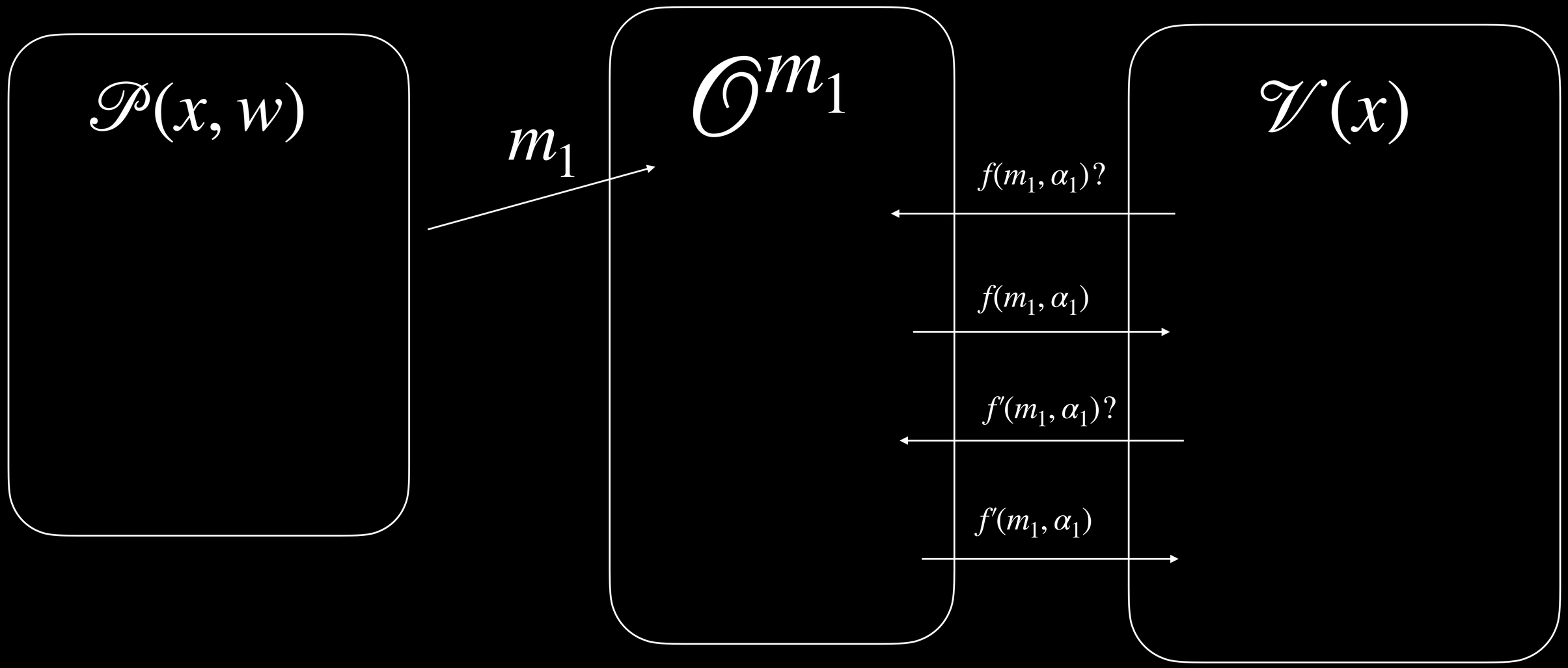
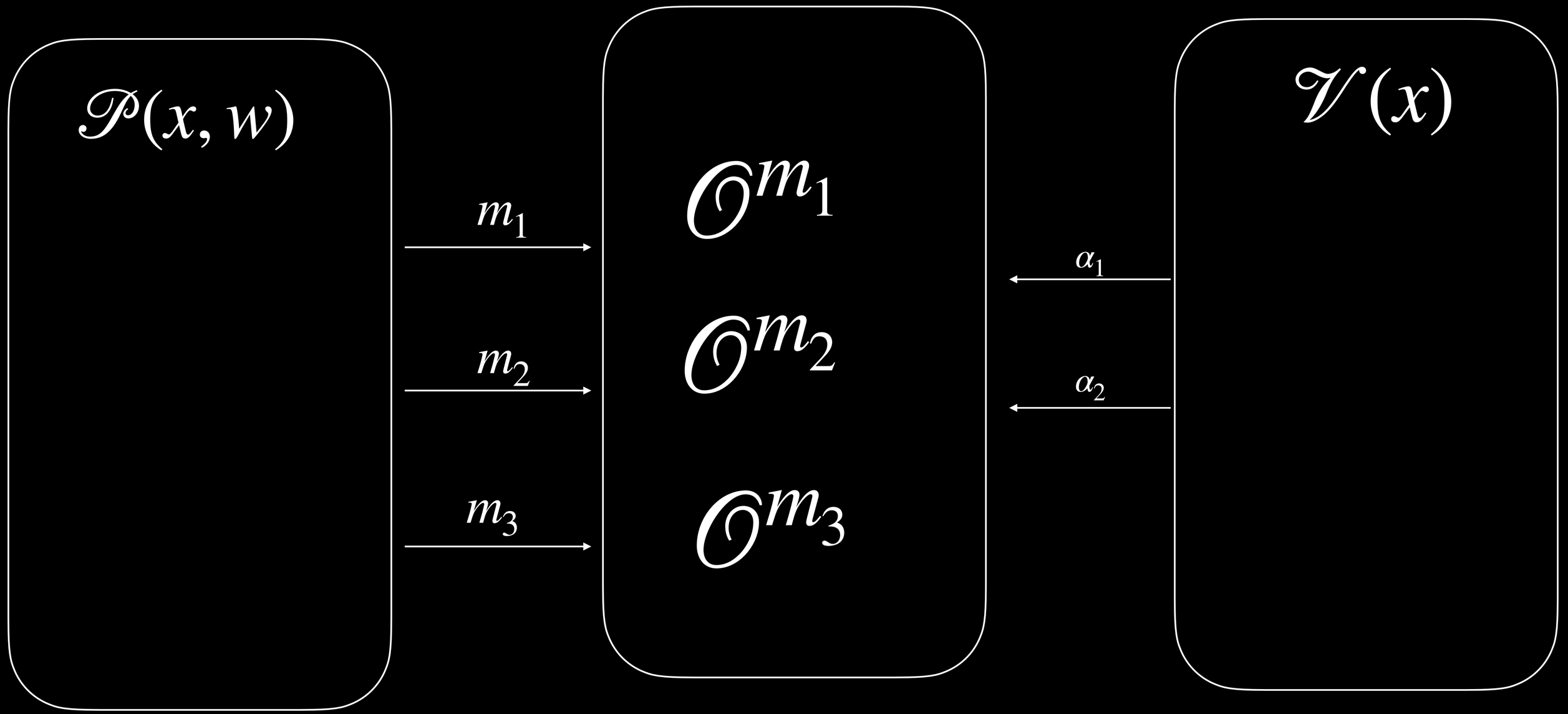


Tool 2: Functional Commitment Scheme



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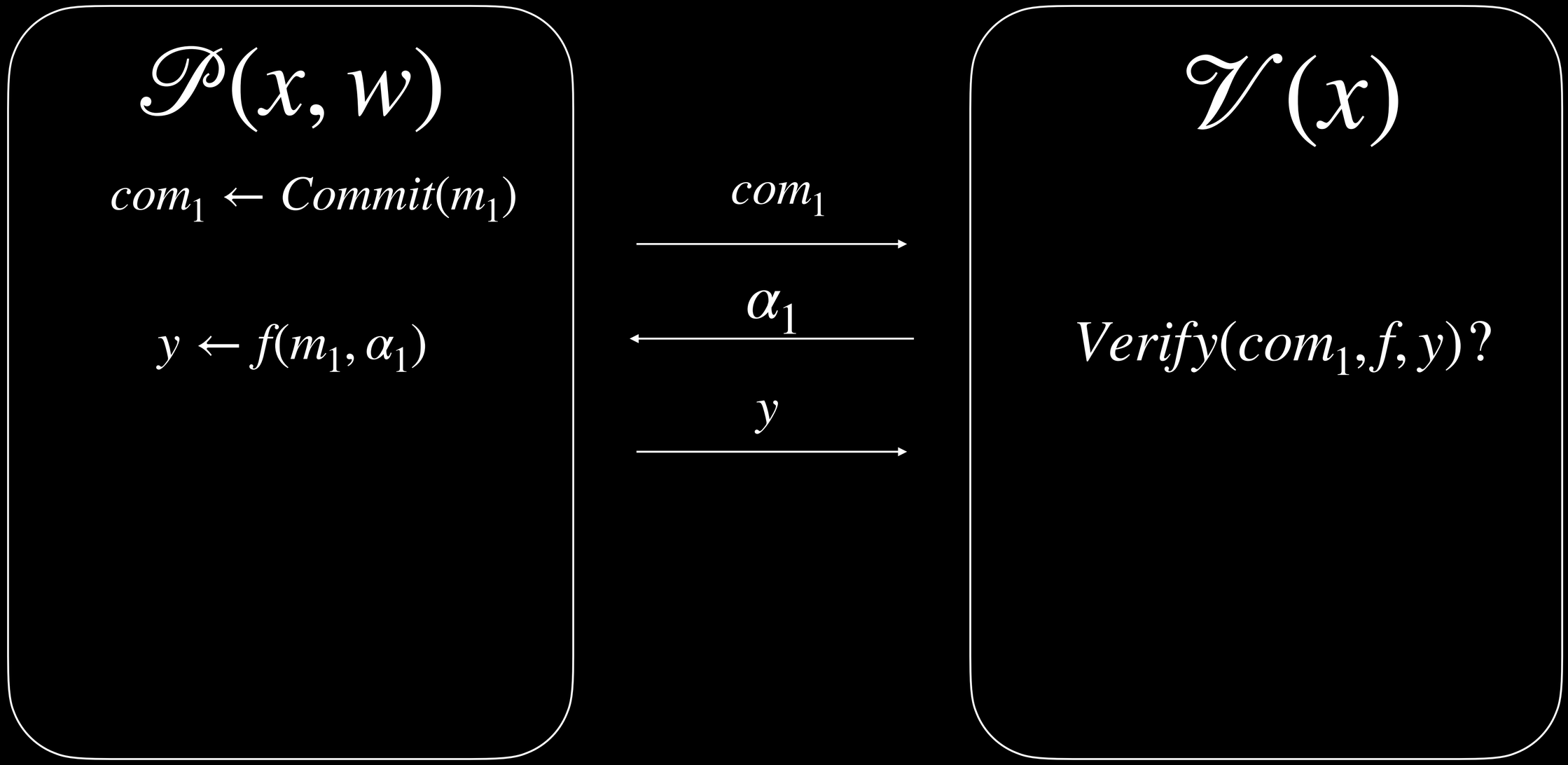

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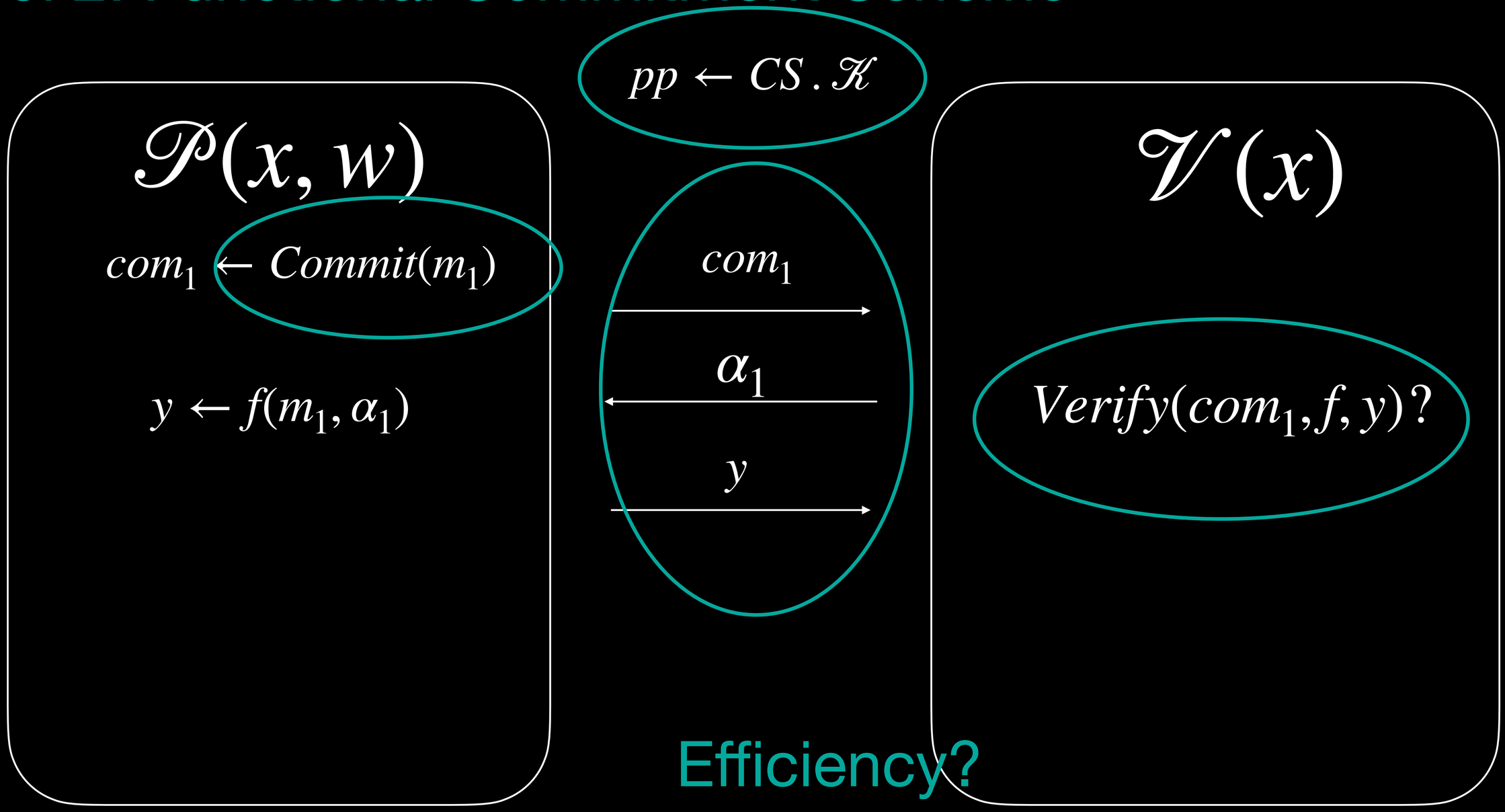
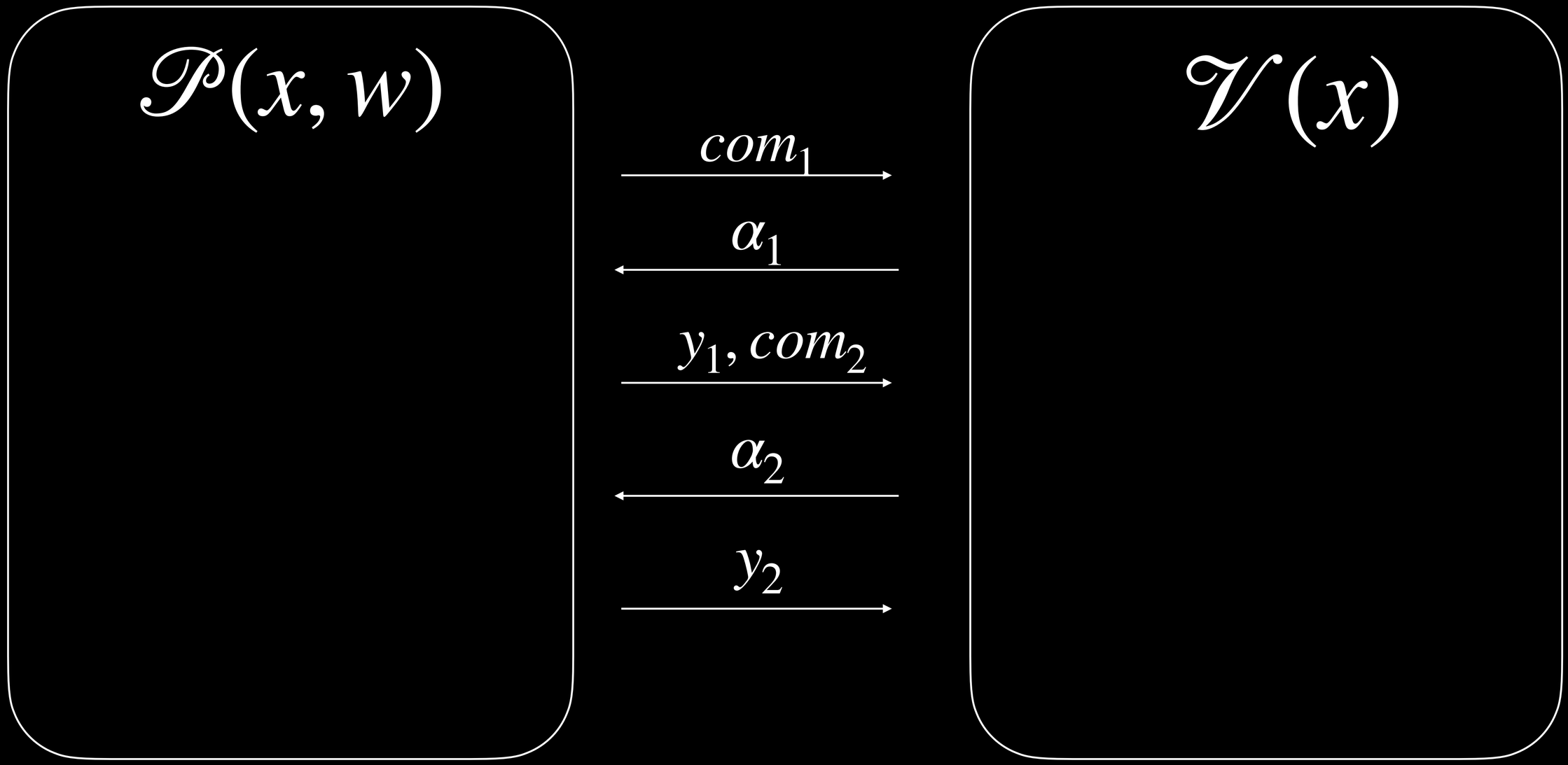
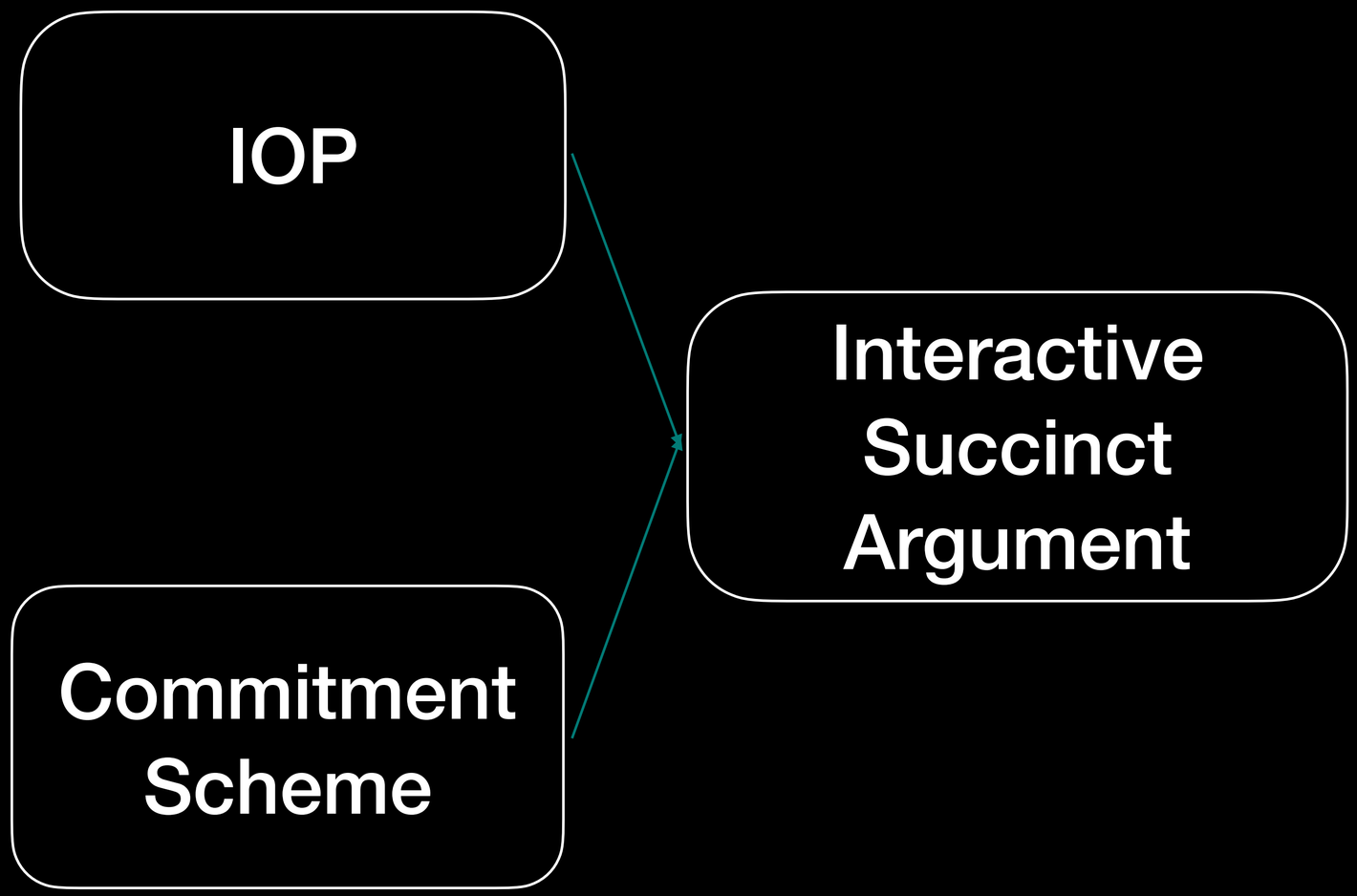


Efficiency?

Efficiency

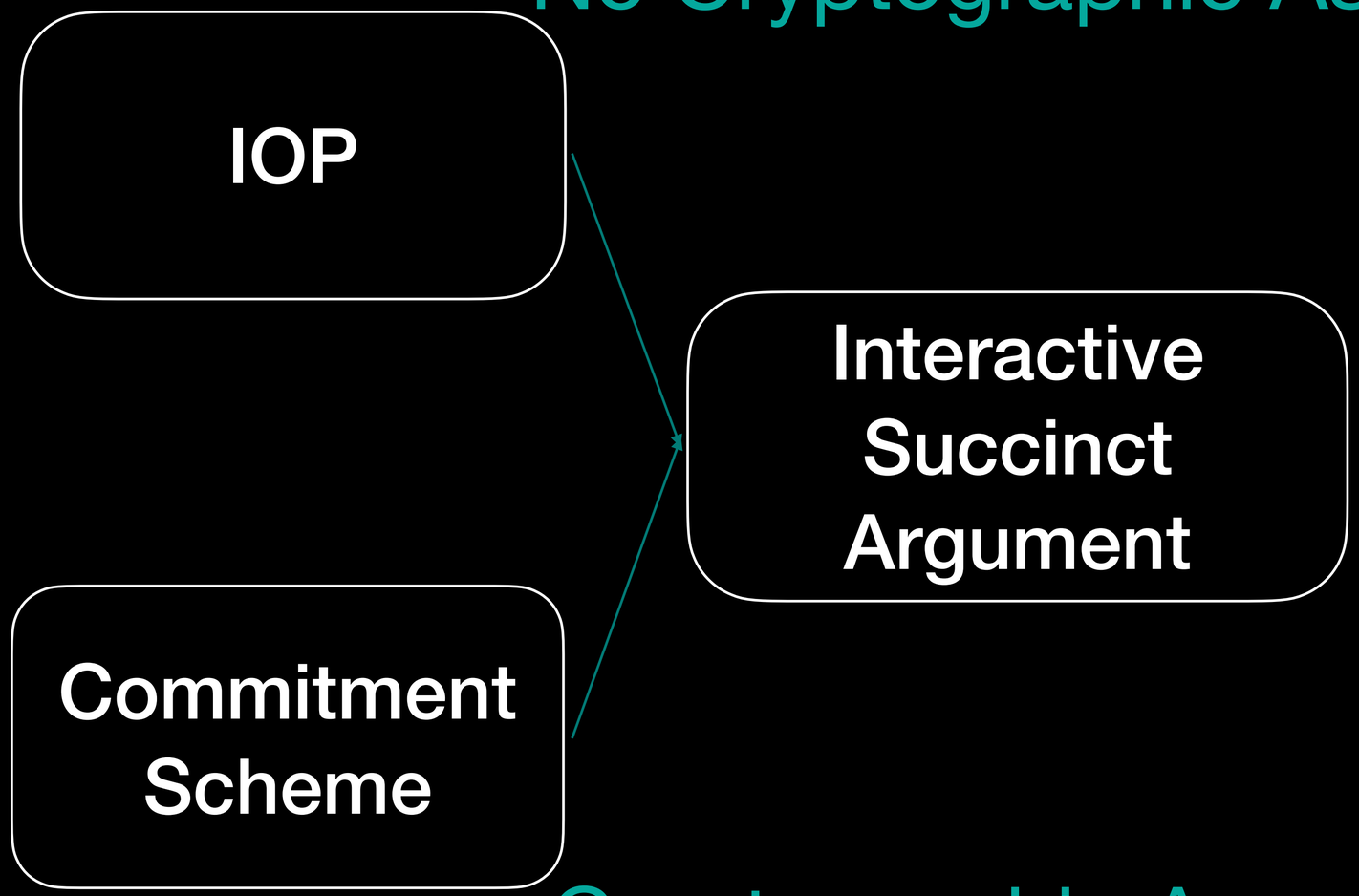


From Interactive to Non-interactive Proofs



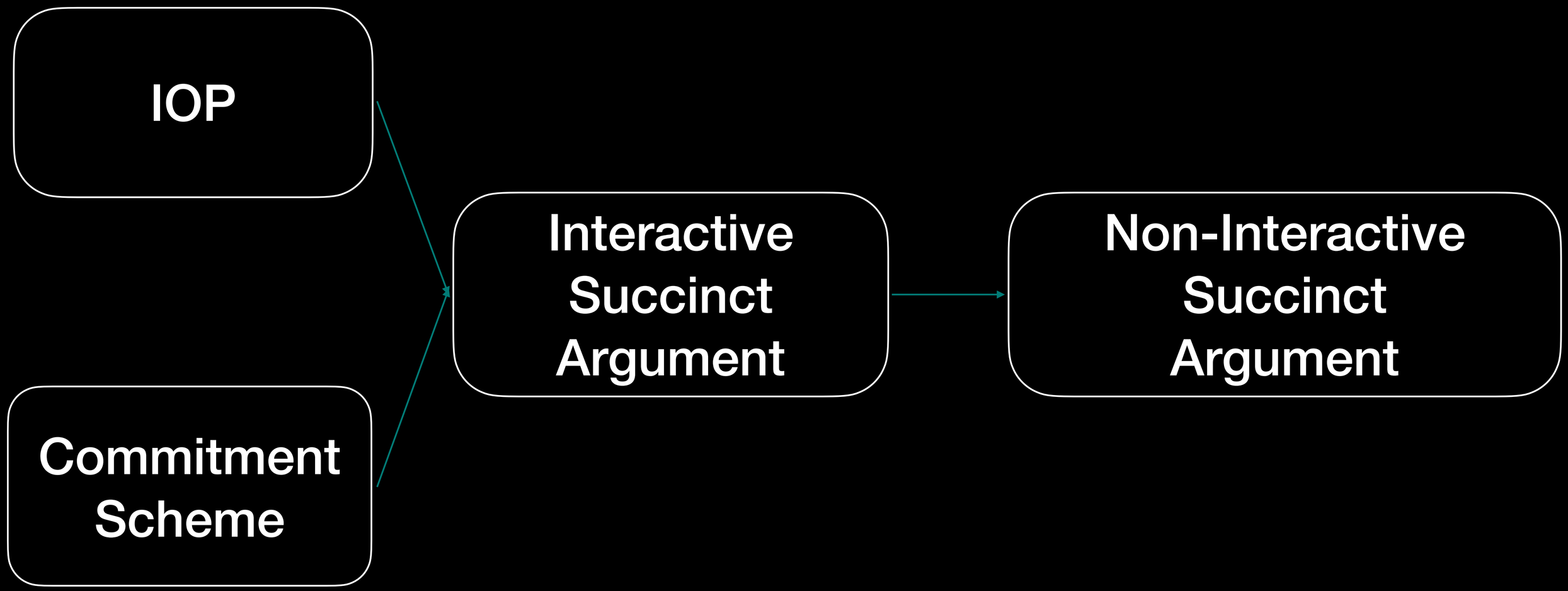
From Interactive to Non-interactive Proofs

No Cryptographic Assumptions



Cryptographic Assumptions here!

From Interactive to Non-interactive Proofs



Tool 3: Hash function

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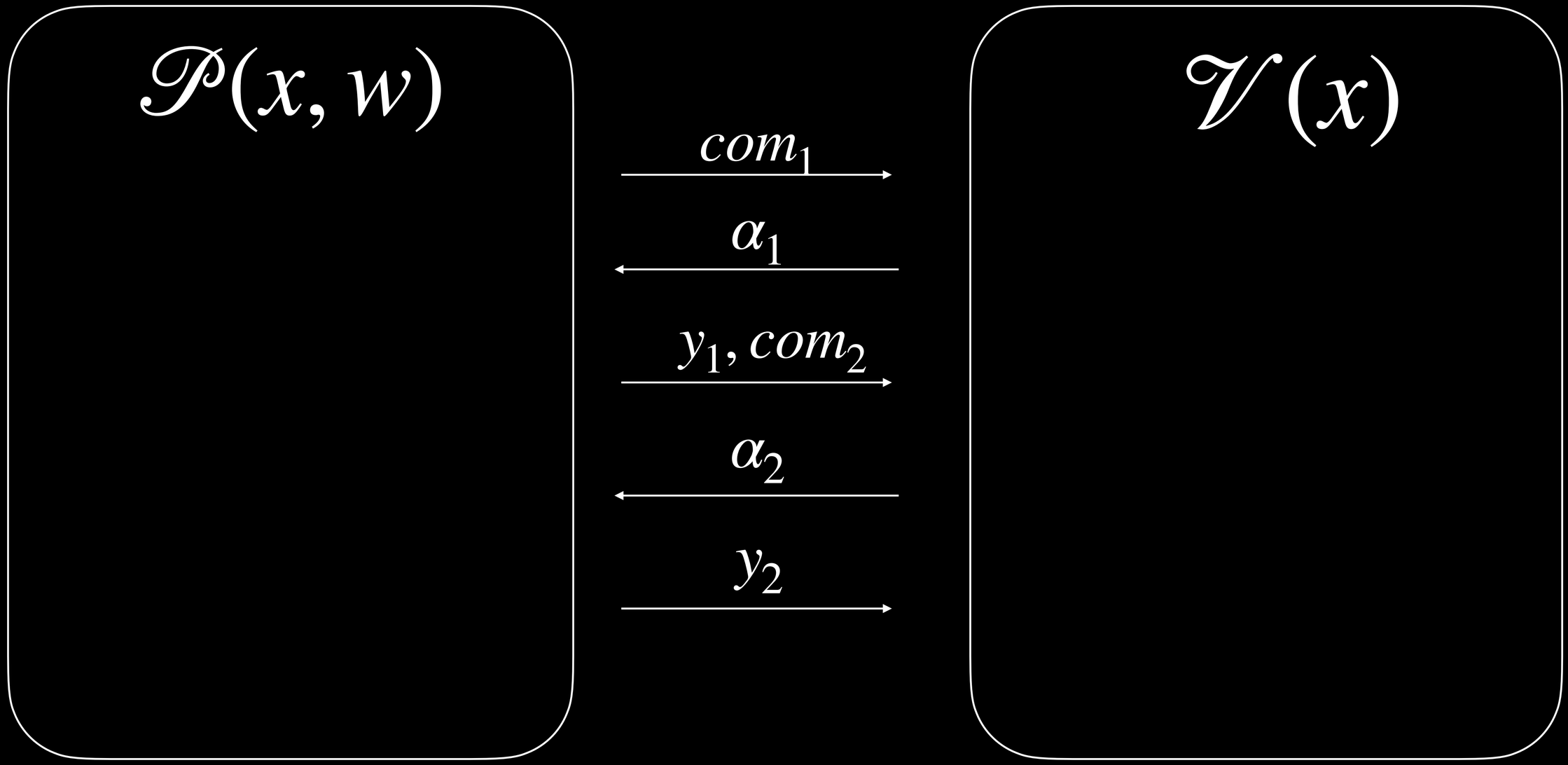

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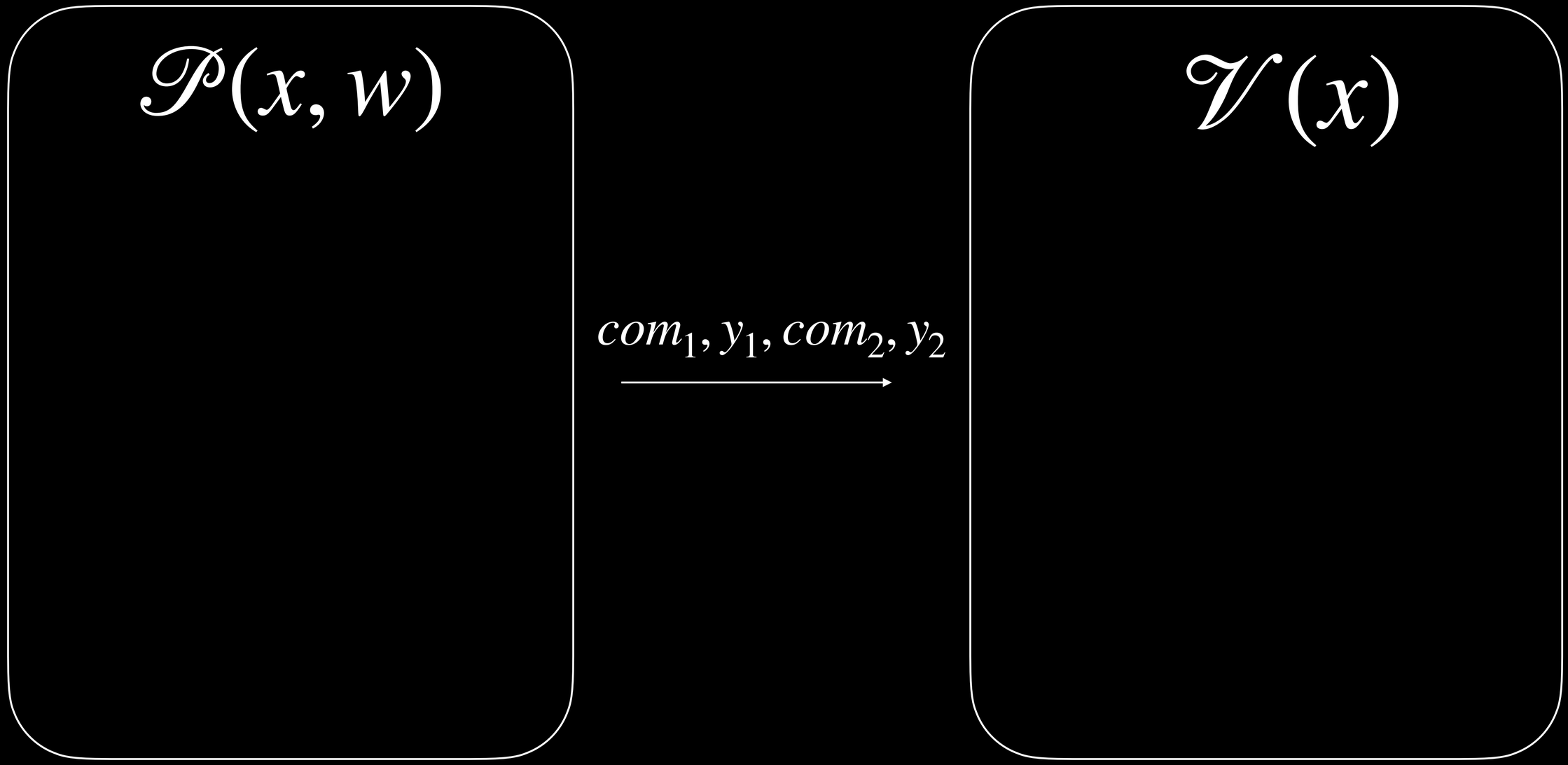

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$$H : \{0,1\}^* \rightarrow \{0,1\}^{256}$$

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Find x, y such that $H(x) = H(y)$

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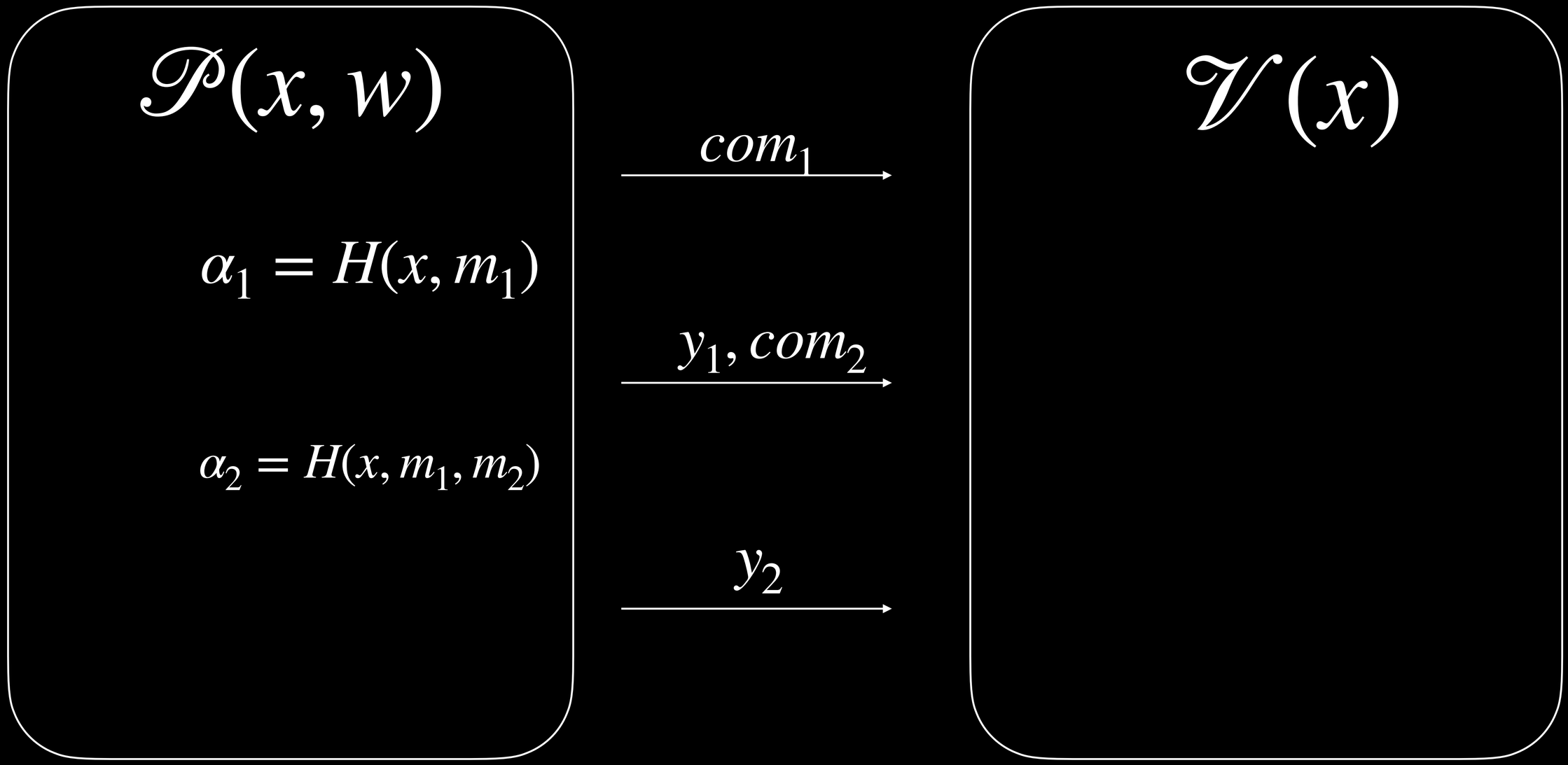
Second pre-image resistant:

Given x find y such that $H(x) = H(y)$

The Fiat-Shamir Heuristic



The Fiat-Shamir Heuristic

$\mathscr{P}(x, w)$

com_1

$\alpha_1 = H(x, m_1)$

y_1, com_2

$\alpha_2 = H(x, m_1, m_2)$

y_2

$\pi = com_1, y_1, com_2, y_2$

$\mathscr{V}(x)$

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$\longrightarrow$

$\mathscr{V}(x)$

Secure under the Random Oracle Model!!!!

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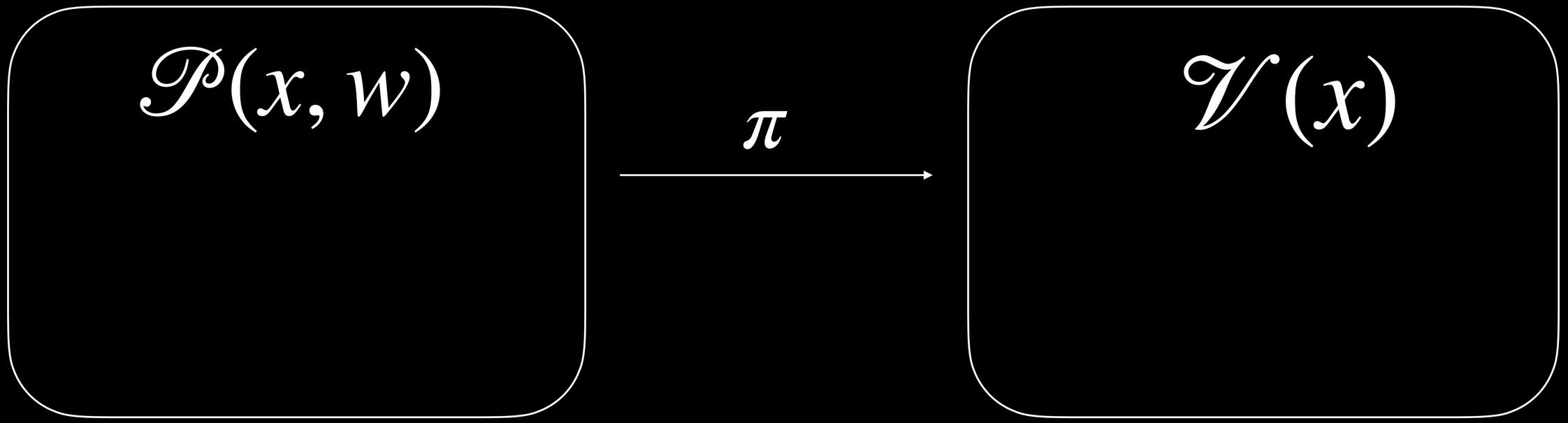

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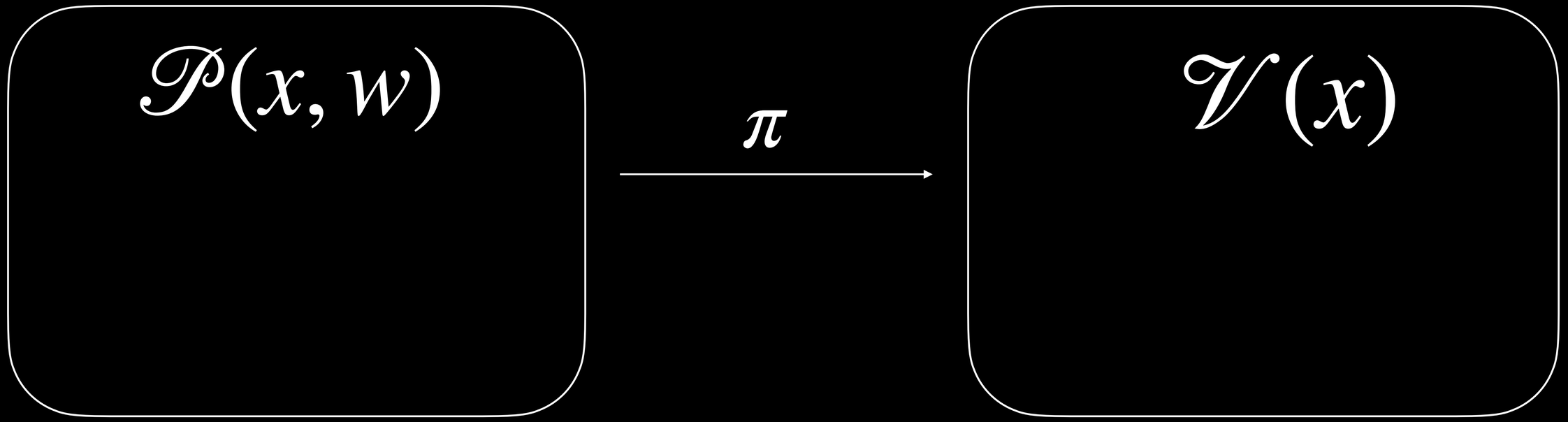

Knowledge soundness:

$$Pr\left[\begin{array}{c} (x,w) \notin R \wedge \\ \mathscr{V}(pp,x,\pi) = 1 \end{array} ; \begin{array}{c} pp \leftarrow \mathscr{K} \\ (x,\pi) \leftarrow \mathscr{P}^*(pp) \\ w \leftarrow \mathscr{E}(pp,x,\pi) \end{array}\right] \leq negl(\lambda)$$

Take aways:

SNARK: Succinct Non-interactive Argument of Knowledge

SNARG: Succinct Non-interactive Argument

Efficiency: Prover time, verifier time, proof-size, pp-size

Security: setup (trusted/transparent), model (ROM) and assumptions (discrete log)

Most of it depends on the commitment scheme!

¡¡¡Gracias!!!

Obrigado!!

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@criptolatinoOrg