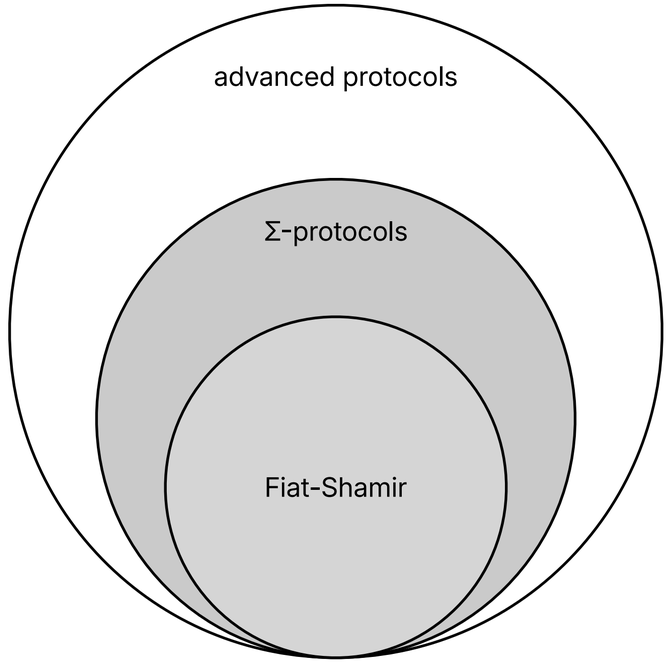
Σ-Protocols and Fiat-Shamir

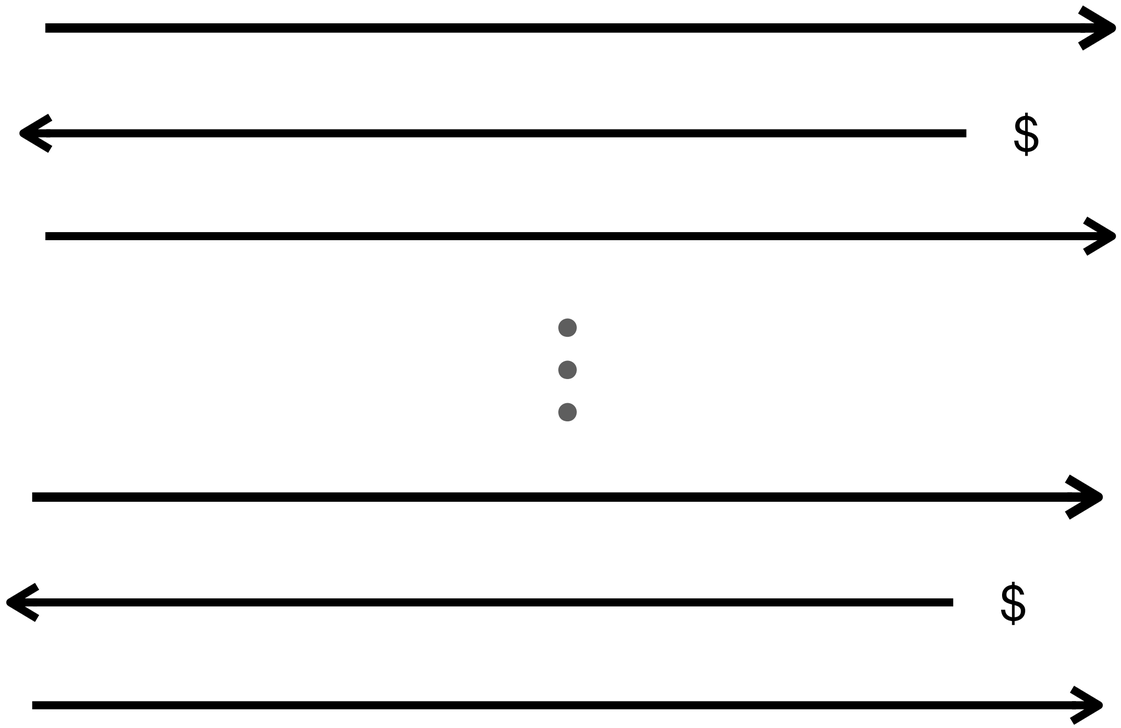
Michele Orrù, Alessandro Chiesa, Cathie Yun



Zero-knowledge proofs

Prover convinces a verifier that some secrets satisfy a statement.

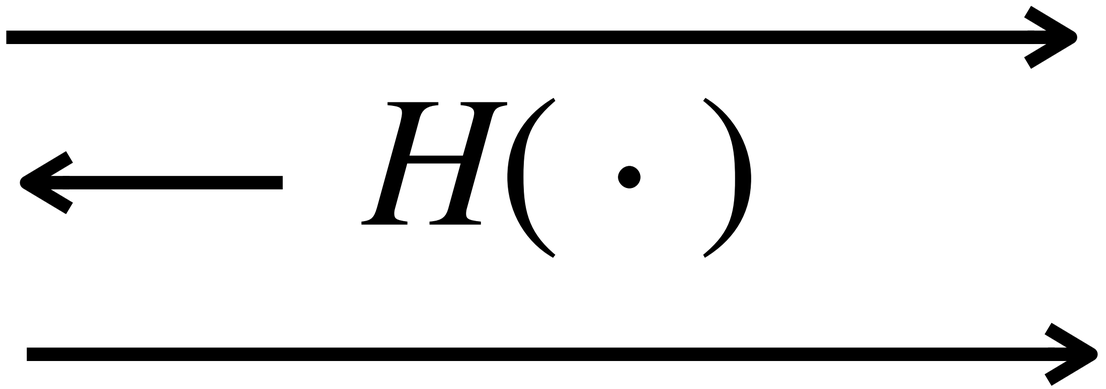
```
prove(statement, secrets)
```




```
verify(statement, messages)
```

Fiat-Shamir spec

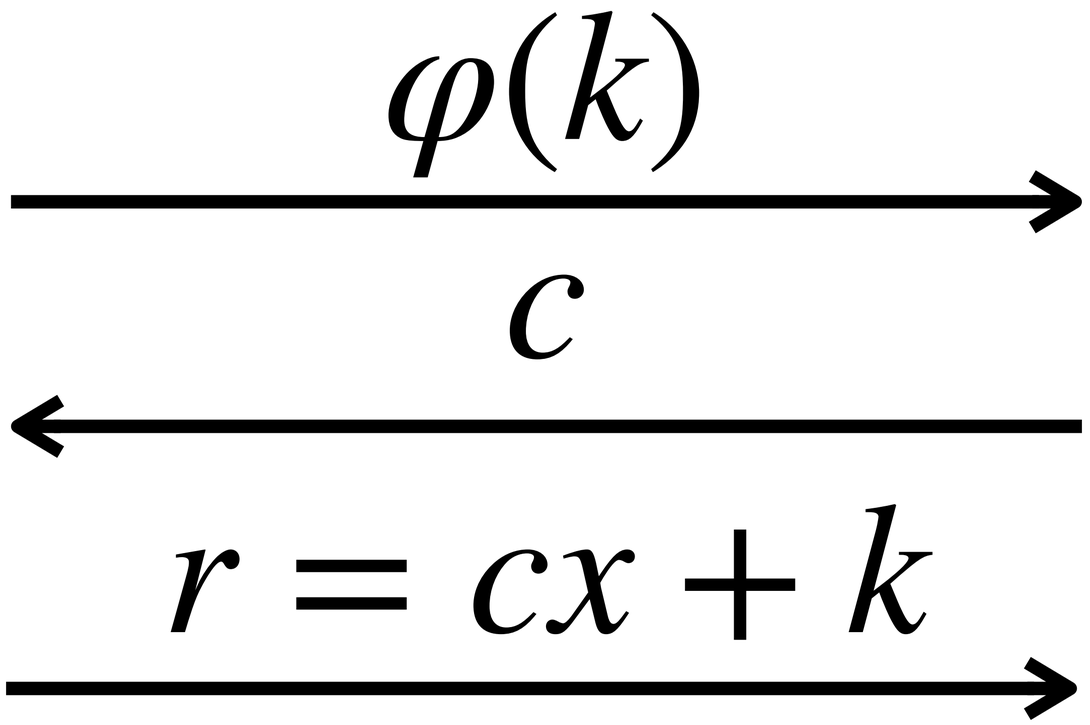
Objective: transform interactive proofs into non-interactive.



Approach: rely on well-established foundations, with provable security.

Sigma Protocol spec

Objective: specify Maurer proofs.



Prove knowledge of x such that $\varphi(x) = X$.

They are out there

Σ-protocols + Fiat-Shamir in standards and in the wild.

IETF RFCs

-2017. rfc8235 (Schnorr)
-2023. rfc9497 (VOPRF)

Other standards

-NIST MPTC, C2.7
-W3C DID

IETF drafts

-2023. draft-irtf-cfrg-bbs-signatures
-2024. draft-kalos-bbs-blind-signatures
-2024. draft-kalos-bbs-per-verifier-linkability
-2024. draft-ladd-privacypass-bbs
-2025. draft-yun-cfrg-arc
-2025. draft-google-cfrg-libzk

Deployments

$$\varphi = [G]$$

$$\varphi = \begin{bmatrix} G \\ H \end{bmatrix}$$

$$\varphi = \begin{bmatrix} G_1 & G_2 & \dots & G_n & \bar{A} \end{bmatrix}$$

Why

Goals

Interoperability
Security
Quality

Risks

Redundancy
Reuse attacks

Opportunities

prepare for SNARKs
PQ agenda

https://sigma.zkproof.org