Exploring the Interplay of Cryptographic Accumulators and Zero-Knowledge Proofs

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Foundations and Applications of Zero-Knowledge Proofs

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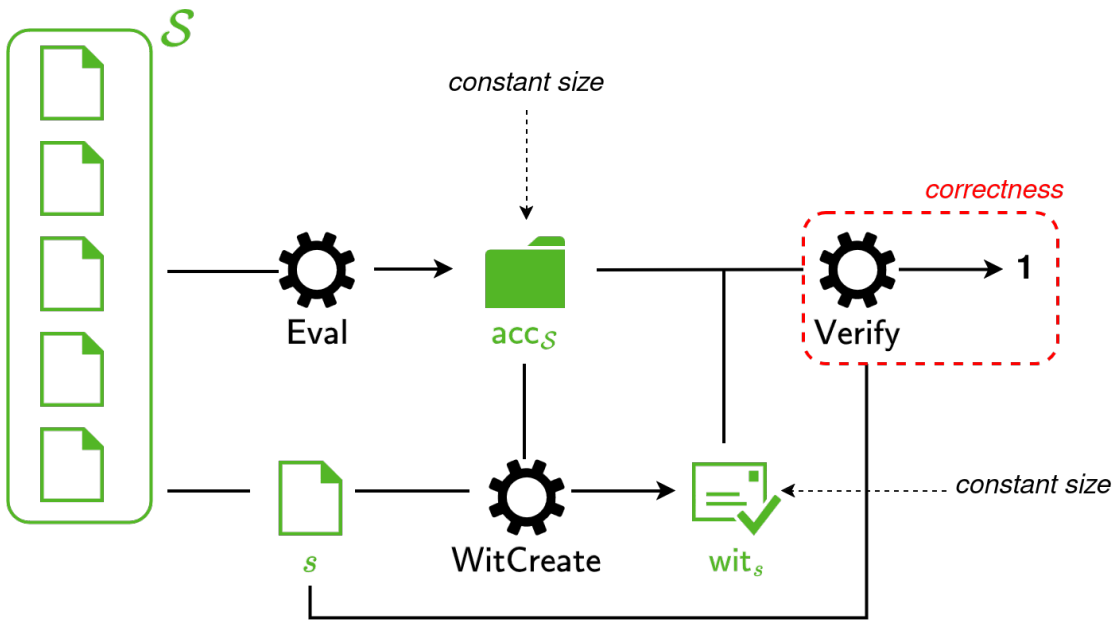
(Asymmetric) Cryptographic Accumulators

Definition (simplified) [1] [2]

- $\mathsf{Setup}(\lambda) \rightarrow \mathsf{pk}, \mathsf{sk}$
- $\mathsf{Eval}(\mathsf{pk}, (\mathsf{sk},)\ \mathcal{S}) \rightarrow \mathsf{acc}_{\mathcal{S}}$
- $\mathsf{WitCreate}(\mathsf{pk}, (\mathsf{sk},)\ \mathsf{acc}_{\mathcal{S}}, \mathcal{S}, s) \rightarrow \mathsf{wit}_s$
- $\mathsf{Verify}(\mathsf{pk}, \mathsf{acc}_{\mathcal{S}}, s, \mathsf{wit}_s) \rightarrow 0/1$



[1] One-way accumulators: A decentralized alternative to digital signatures, Benaloh and de Mare,EUROCRYPT 1993

[2] Revisiting Cryptographic Accumulators, Additional Properties and Relations to other Primitives, Derler, Hanser, and Slamanig CT-RSA 2015

Accumulator Security Properties

In Brief

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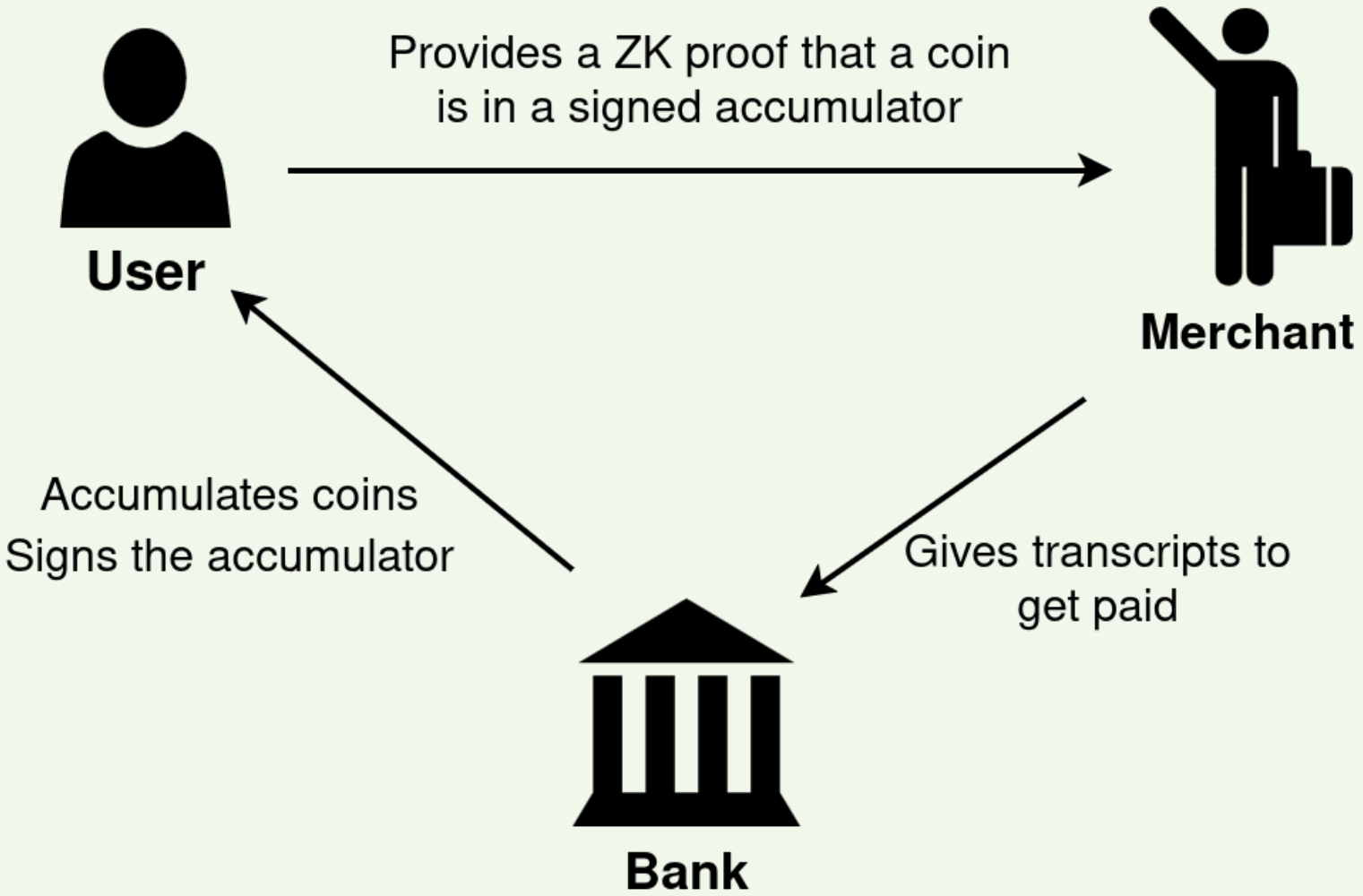
Accumulator with **zero-knowledge proofs of knowledge**

- Prove membership of an element, while keeping the element hidden

Accumulators and ZK Proofs: Example of Application

E-Cash



Other applications: anonymous credentials, ...

Interplay of Accumulators and ZK Proofs

- **Efficiently Provable**: combined with a commitment scheme
  example: RSA-based accumulators and Pedersen commitments[3]

[3] Dynamic Accumulators and Application to Efficient Revocation of Anonymous Credentials, Camenisch and Lysyanskaya, Crypto 2002

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- **SNARK-friendly**: verification done with (zk) SNARKs
  example: Merkle trees, RSA-based accumulators [4]

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[4] Scaling Verifiable Computation Using Efficient Set Accumulators, Ozdemir, Wahby, Whitehat, Boneh, SEC 2020

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- **Determinantal Accumulators**: designed to construct special NIZK proofs [5]

[3] Dynamic Accumulators and Application to Efficient Revocation of Anonymous Credentials, Camenisch and Lysyanskaya, Crypto 2002

[4] Scaling Verifiable Computation Using Efficient Set Accumulators, Ozdemir, Wahby, Whitehat, Boneh, SEC 2020

[5] Set (Non-)Membership NIZKs from Determinantal Accumulators, Lipmaa and Parisella, Latincrypt 2023

Key Takeaways

- **Combining ZK Proofs and Accumulators**
  - Enhances privacy of accumulators
  - Applied in E-Cash, anonymous credentials, and blockchain technologies

Active Research Area