A New Approach To Efficient Revocable Attribute-Based Anonymous Credentials

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Outline

1. Introduction
2. Novel ABC Paradigm [HS14]
3. Novel Revocation Approach
   - Security Model
   - Constructions
4. Conclusion

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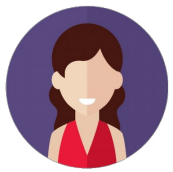
Attribute-Based Anonymous Credentials (ABCs)

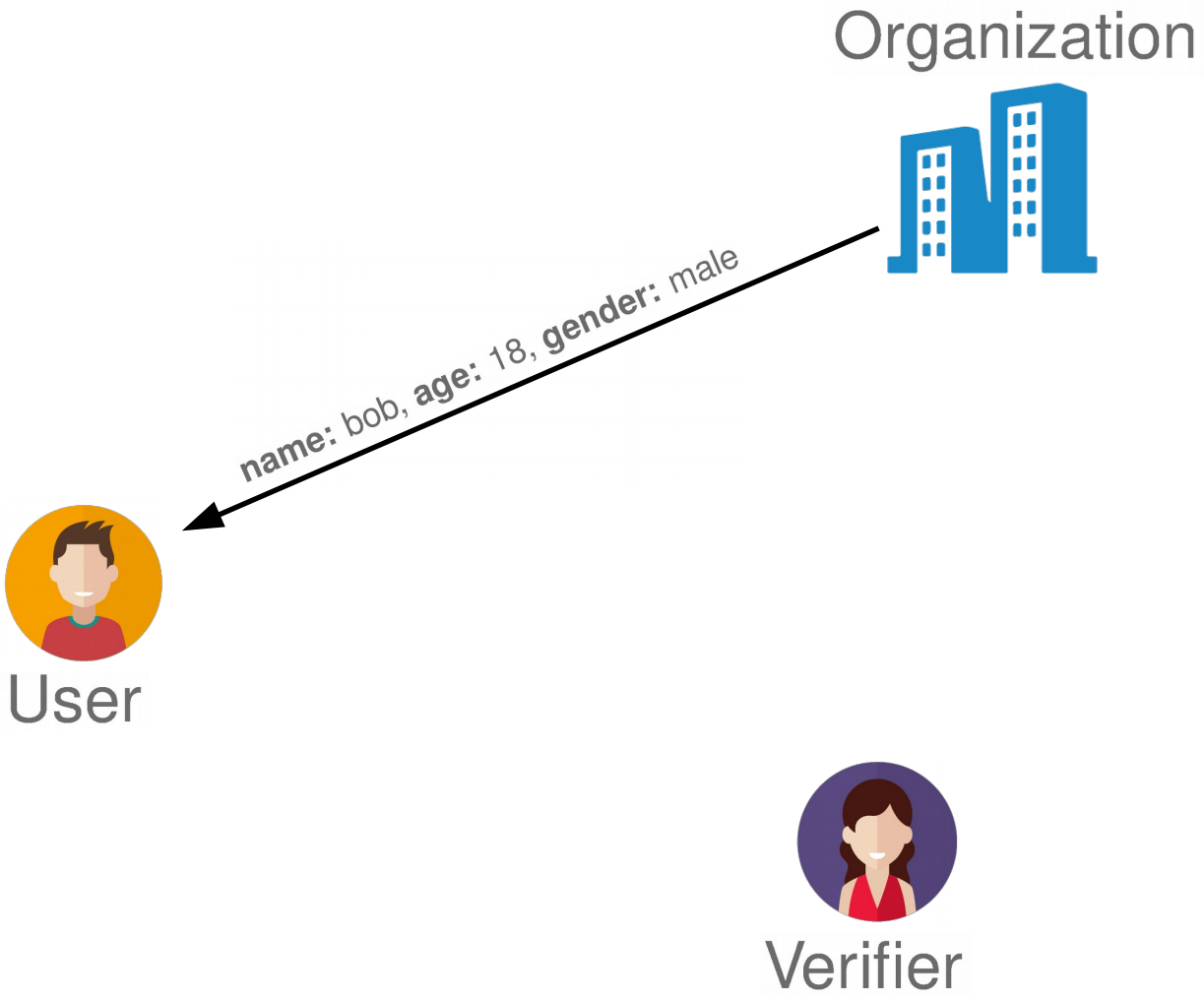
Organization

User



Verifier

Attribute-Based Anonymous Credentials (ABCs)



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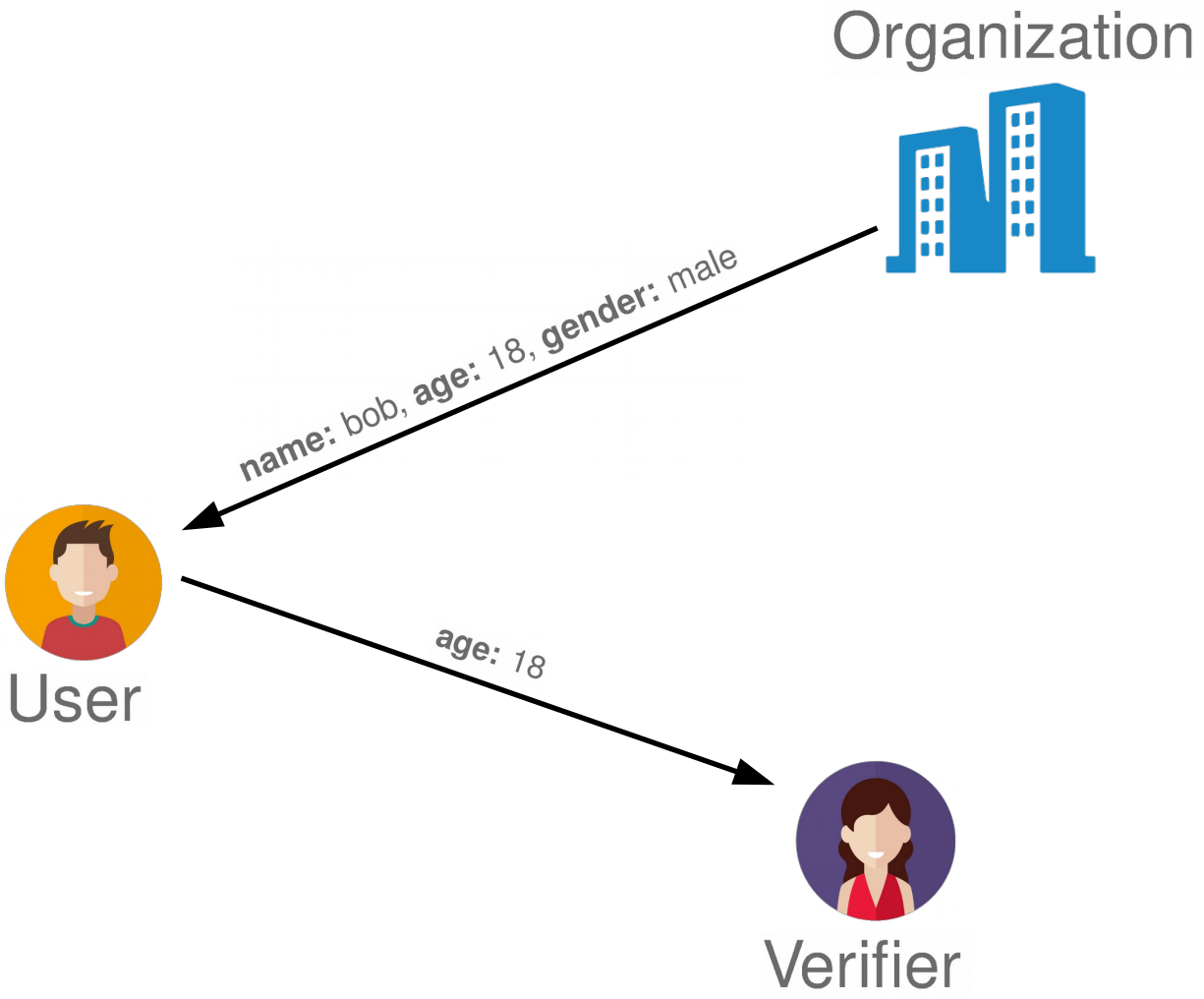

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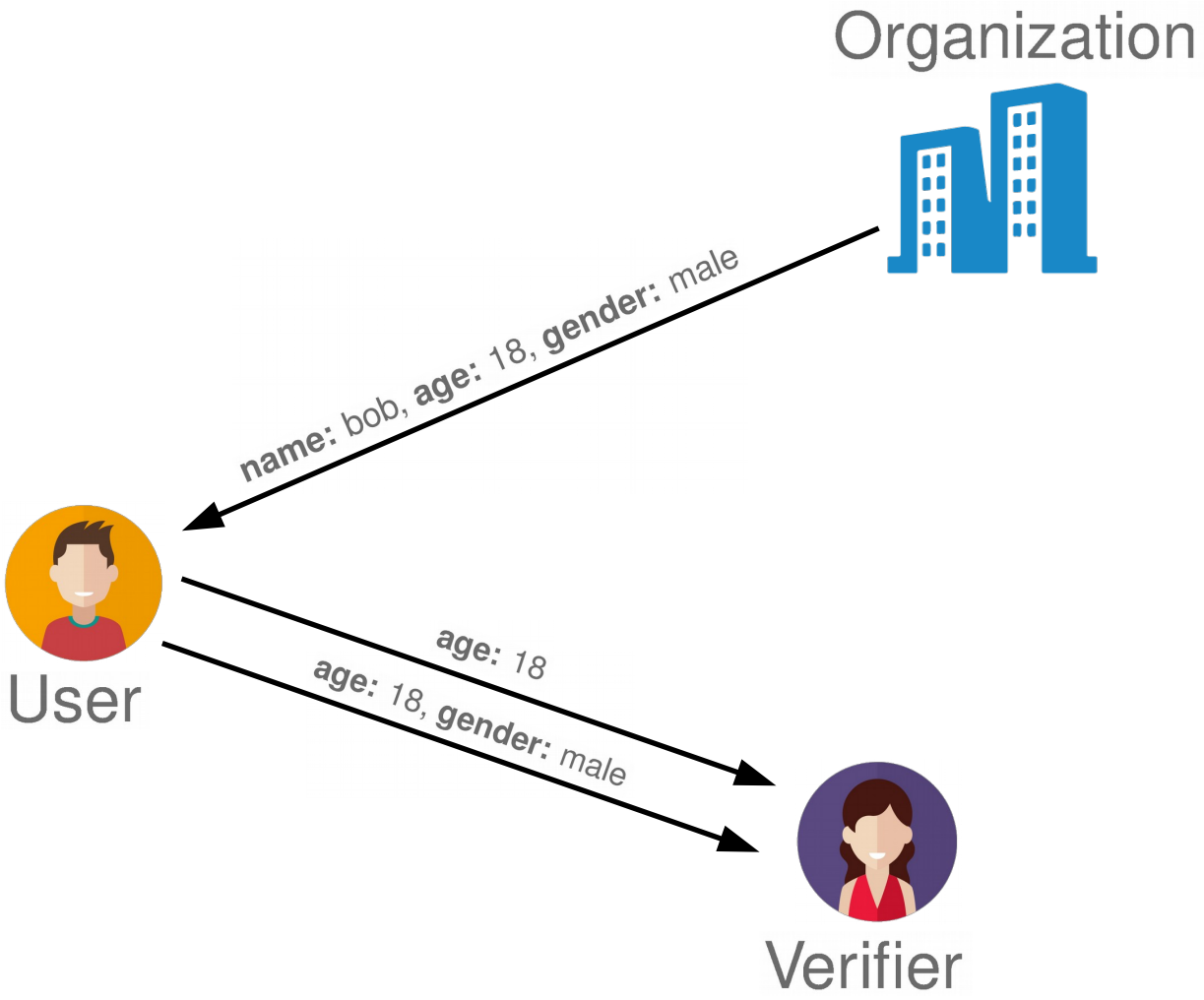

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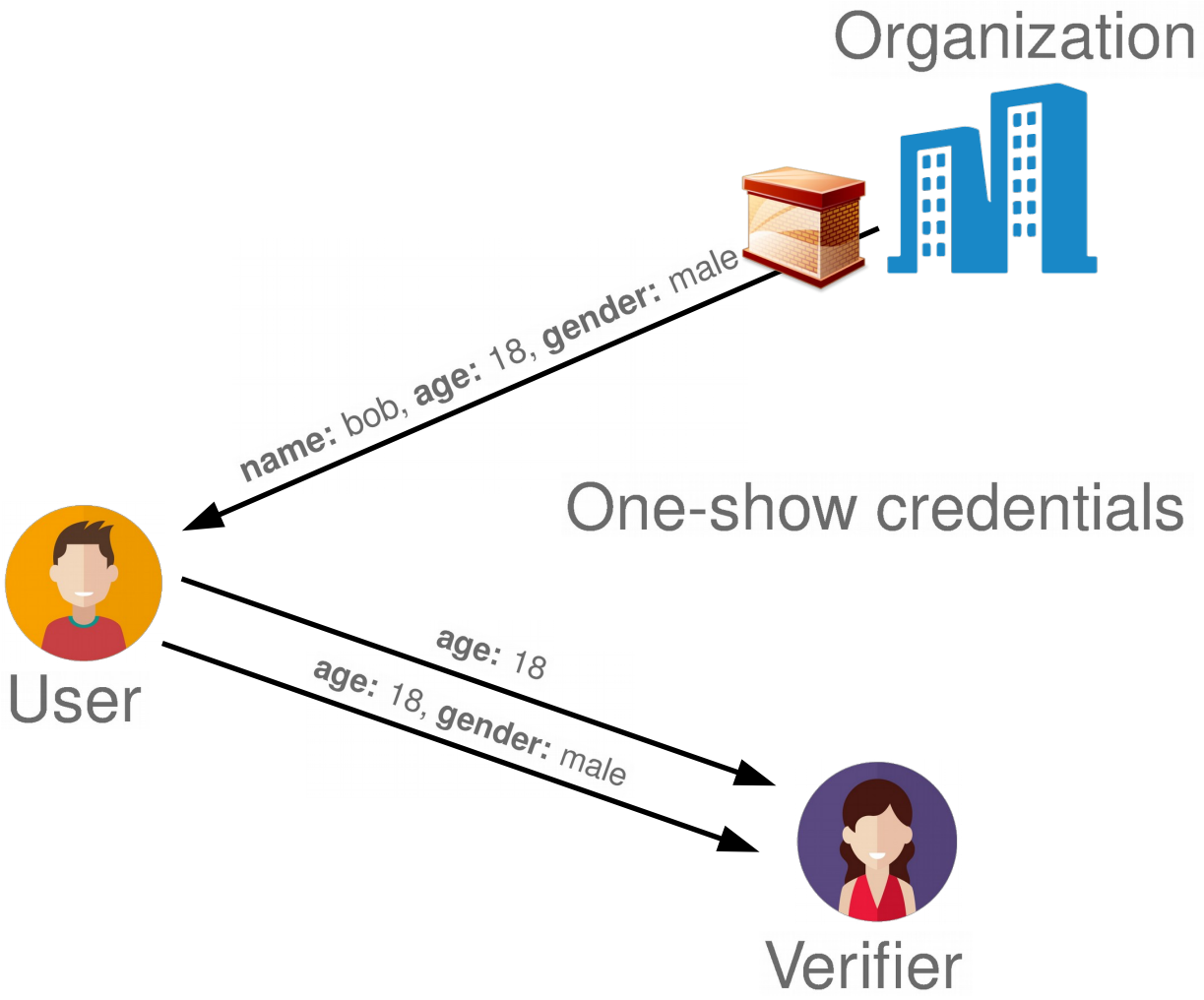

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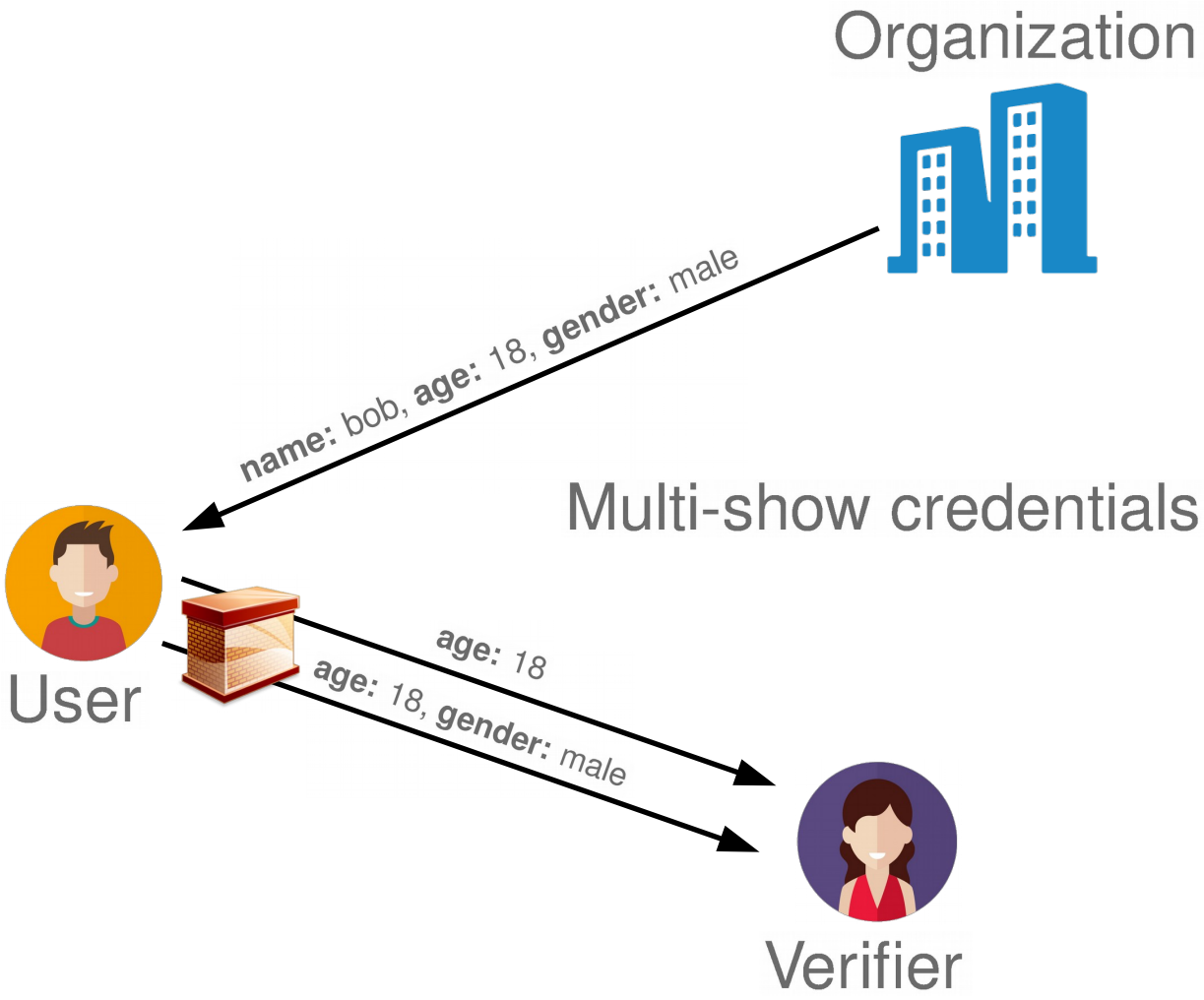

Attribute-Based Anonymous Credentials (ABCs)

Work in the field is wide

- Most prominent: IBM's Idemix, Microsoft's U-Prove

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Novel approach to multi-show ABCs [HS14]

- **S**tructure **P**reserving **S**ignatures on **E**quivalence **C**lasses
  - (**SPS-EQ**)
- Interesting properties
  - $O(1)$ size of creds and $O(1)$ communication
  - No PoK for unrevealed attributes
  - Only single $O(1)$ PoK for freshness

Motivation

Revocation: important feature in practice

Question

Revocation mechanism

- Following similar principles
- Preserving the nice asymptotic properties

Contribution

Accumulator-based blacklist revocation for [HS14]

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Revocation typically considered as an add-on

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Comparison of both approaches

Preliminaries

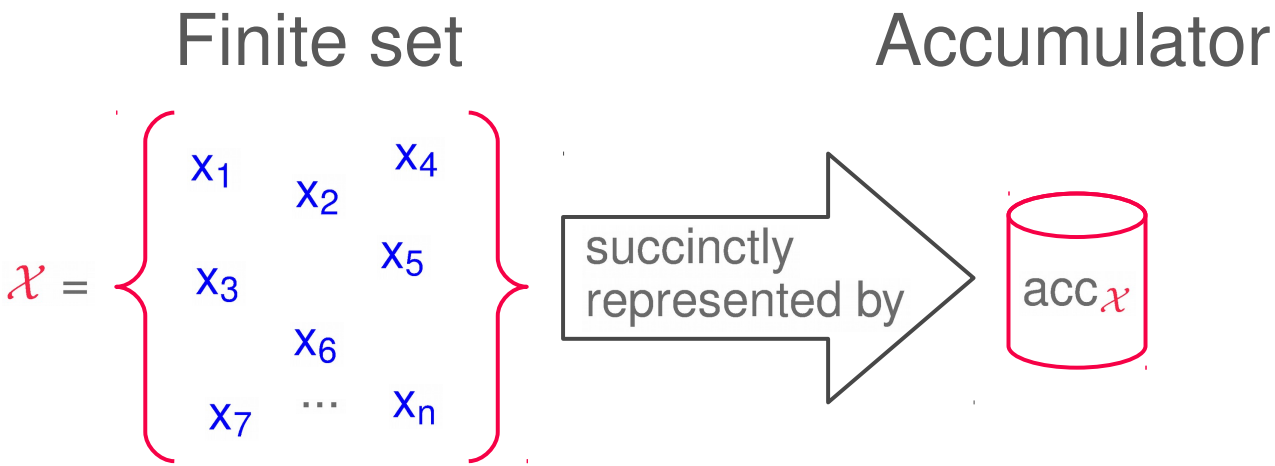
Asymmetric bilinear map (pairing)

- $e : \mathbb{G}_1 \times \mathbb{G}_2 \rightarrow \mathbb{G}_T$, where $|\mathbb{G}_1| = |\mathbb{G}_2| = |\mathbb{G}_T| = p$
- $e(aP, b\hat{P}) = e(P, \hat{P})^{ab}$ (Bilinearity)
- $e(P, \hat{P}) \neq 1_{\mathbb{G}_T}$ (Non-degeneracy)
- $e(\cdot, \cdot)$ efficiently computable (Efficiency)

SXDH setting

$\Rightarrow$ DDH assumed to hold in $\mathbb{G}_1$ and $\mathbb{G}_2$

Cryptographic Accumulators



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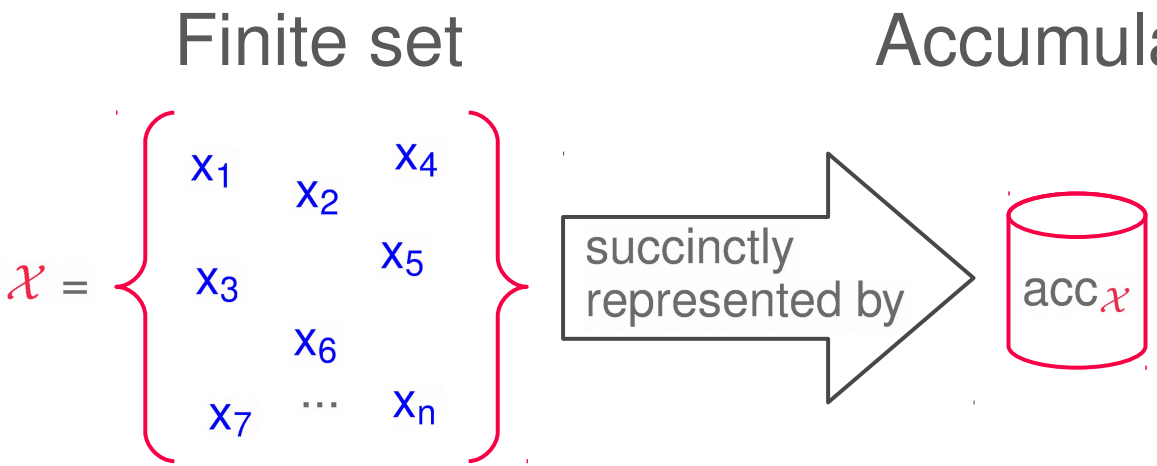

Witnesses wit$_x$ certifying membership of x in acc$_{\mathcal{X}}$

- Efficiently computable $\forall\ x \in \mathcal{X}$
- Intractable $\forall\ x \notin \mathcal{X}$

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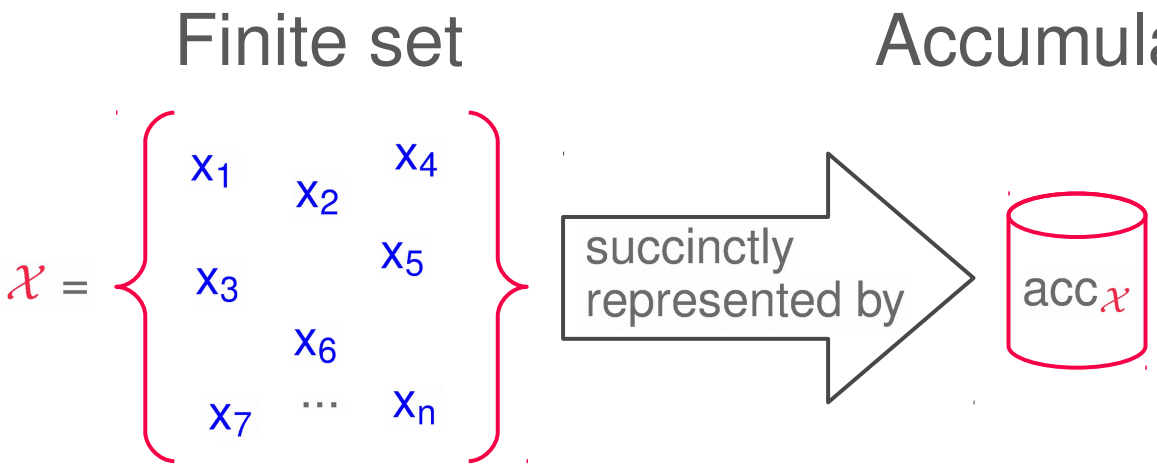

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$\Rightarrow$ **Collision freeness**

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Structure Preserving Signatures [AFG+10]

Sign group element vectors

$\Rightarrow$ Sigs and PKs only consist of group elements

Verification solely via

- Pairing-product equations
- Group membership tests

Signing Equivalence Classes [HS14]

Partition $\mathbb{G}_i^\ell$ into projective equivalence classes

$$M \in \mathbb{G}_i^\ell \sim_{\mathcal{R}} N \in \mathbb{G}_i^\ell \Leftrightarrow \exists k \in \mathbb{Z}_p^* : N = k \cdot M$$

SPS-EQ

- Given σ on M
- Publicly derive σ' on $M' \in [M]_{\mathcal{R}}$

$\Rightarrow$ IND of classes under DDH in $\mathbb{G}_i$

Signing Equivalence Classes [HS14] II

Security properties

- Correctness
- EUF-CMA security (w.r.t. equivalence classes)
- Perfect adaption of signatures
  - (M', σ') obtained by re-randomizing (M, σ)
  - Indistinguishable from fresh signature on M'

Novel ABC Paradigm [HS14]

Credential

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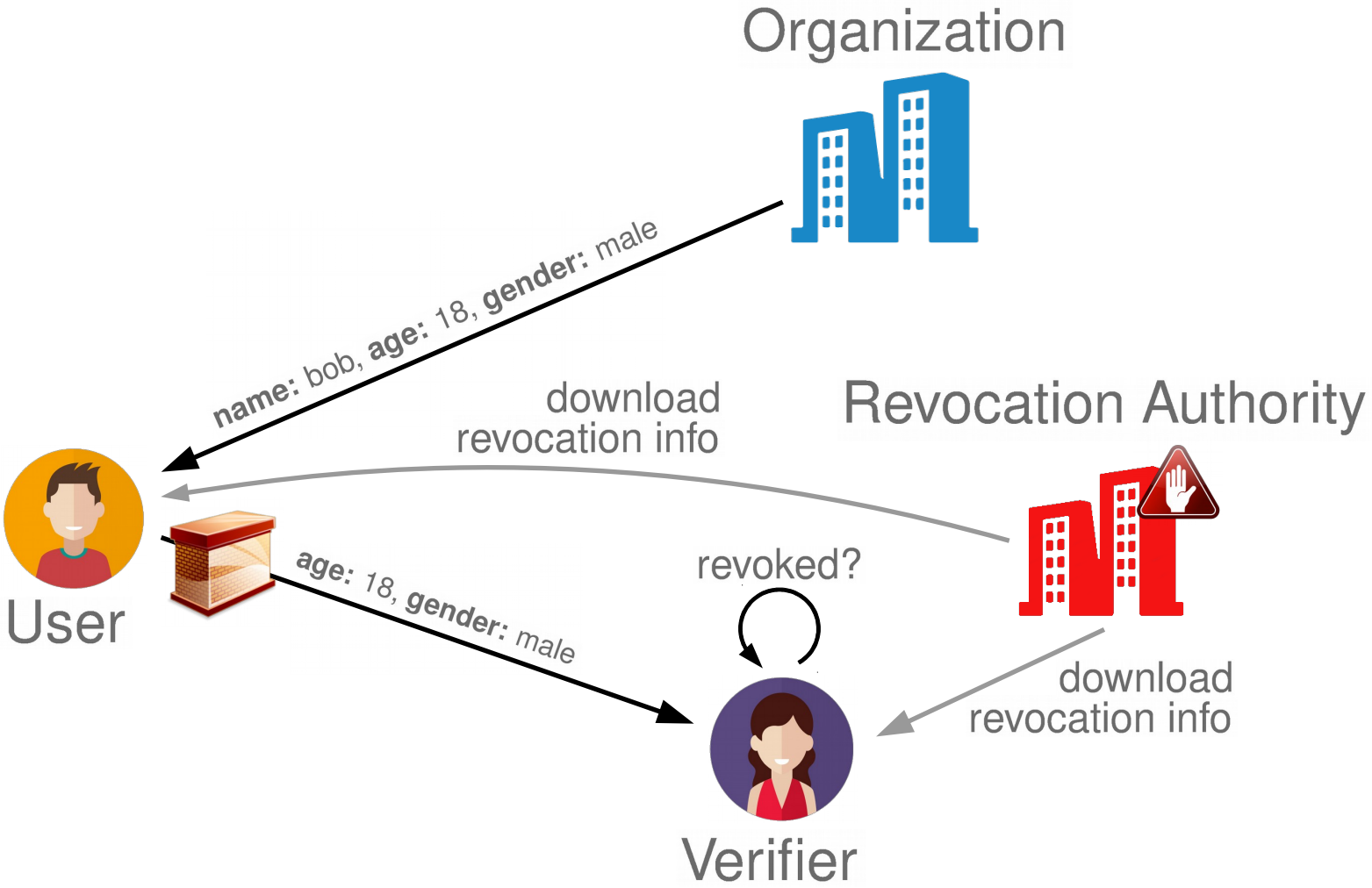

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Correctness: everything works if honestly computed

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$\Rightarrow$ Adversary:

  - Can corrupt users, obtain secret keys of users, revoke users
  - Acts as dishonest user

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Anonymity:

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Novel Revocation Approach

Idea:

- Choose accumulator s.t. compatible with re-randomization

Construction (sketch):

- Incorporate **nym** as credential component
- Accumulator contains all revoked *nym*s

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  - \+ Simple $O(1)$ PoK for technical reasons

Security

Unforgeability

- ≈ Unforgeability of underlying ABC
- \+ Case for collision freeness of accu
- \+ Some technicalities regarding extraction
  - 3 additional DLOG proofs

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  - Indistinguishable from random

Security II

Anonymity contd'

- Indistinguishability shown under
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DDH-like assumptions

- 1 holds in GGM
- 1 follows from (R, S, T, f)-DDH [Boy08]

U-Prove Based Revocation Approach

Follow classical revocation approach

- Adapt U-Prove revocation [ACN13, NP14]

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Follow classical revocation approach

- Adapt U-Prove revocation [ACN13, NP14]

Construction (sketch):

- Incorporate **nym** in credentials
- Accumulator contains revoked *nyms*
- PoK of non-membership witness and **nym**
- PoK that **nym** coincides with **nym** in credential

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Anonymity

- Components depending on the challenge bit
  - Indistinguishable from random
  - Shown under DDH in $\mathbb{G}_1$
  - ... and perfect adaption of signatures

Comparison

Comparison based on [UW14]

- BN implementation on ARM-Cortex-M0+

Obtain:

- Novel Approach: +15 $\mathbb{G}_1$ equivalents
- Classic Approach: +14 $\mathbb{G}_1$ equivalents

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Obtain:

- Novel Approach: +15 $\mathbb{G}_1$ equivalents
- Classic Approach: +14 $\mathbb{G}_1$ equivalents

Show:

- Novel Approach: +20 $\mathbb{G}_1$ equivalents
- Classic Approach: +33 $\mathbb{G}_1$ equivalents

$\Rightarrow$ worst case (best case: even 2 $\times$ faster)

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New conceptually simple approach

- Easy to comprehend
- Easy to implement

$\Rightarrow$ New direction in revocation for ABC systems

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Performance

- Both approaches practically efficient
- Novel approach yields more efficient showings

Thank you.

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