Rethinking Privacy for Extended Sanitizable Signatures

and a Black-Box Construction of Strongly Private Schemes

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Supported by EU H2020 Project prisma cloud

Outline

1. Introduction
2. Revisiting Privacy
3. Generic Construction
4. Conclusions

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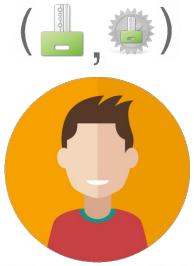
Sanitizable Signature Schemes (SSS) [ACdMT05]

Signer



Sanitizer

Verifier

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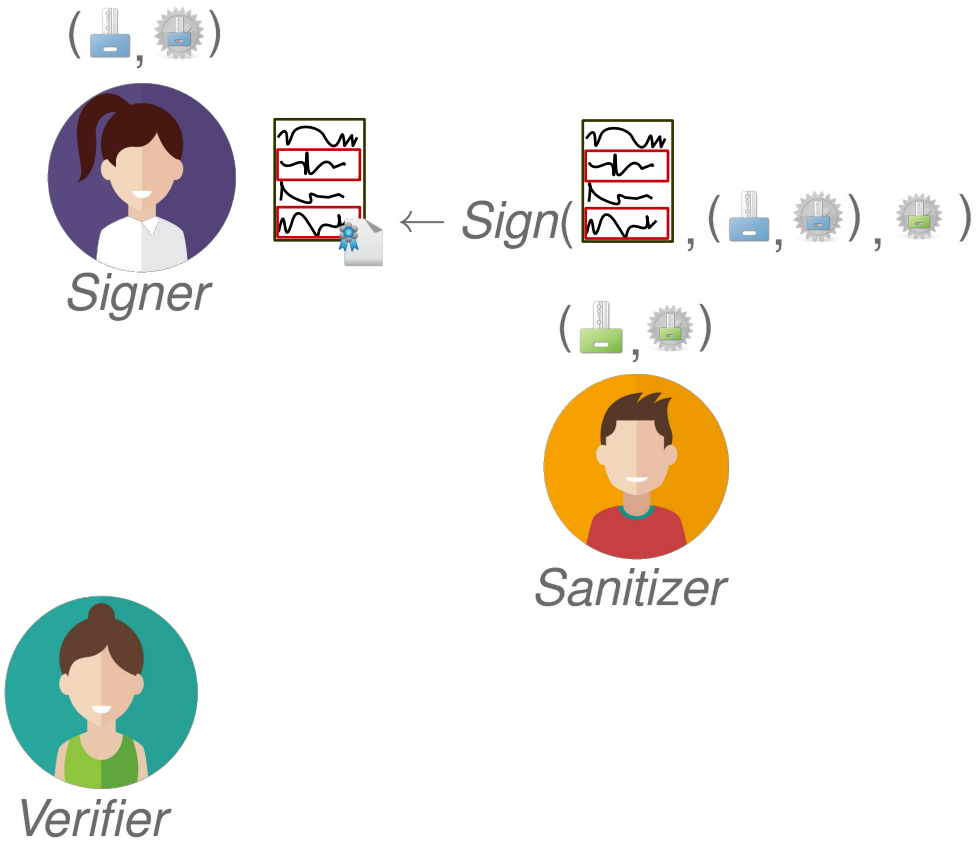

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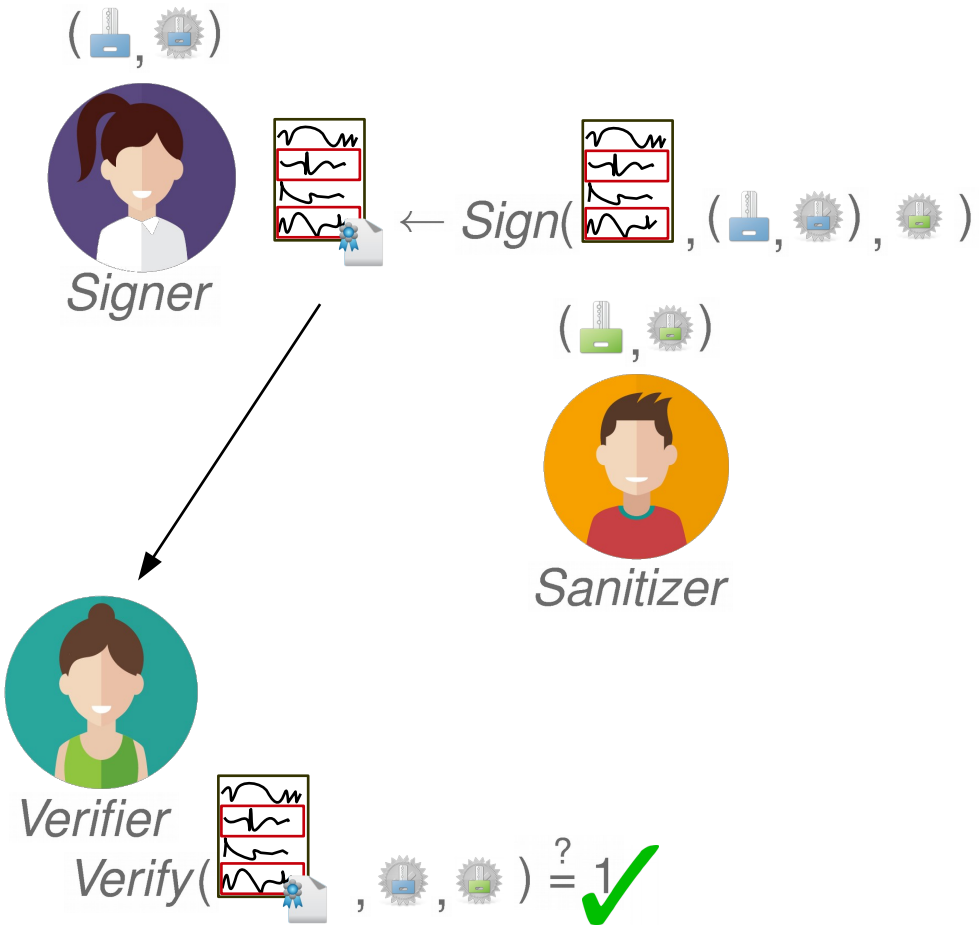

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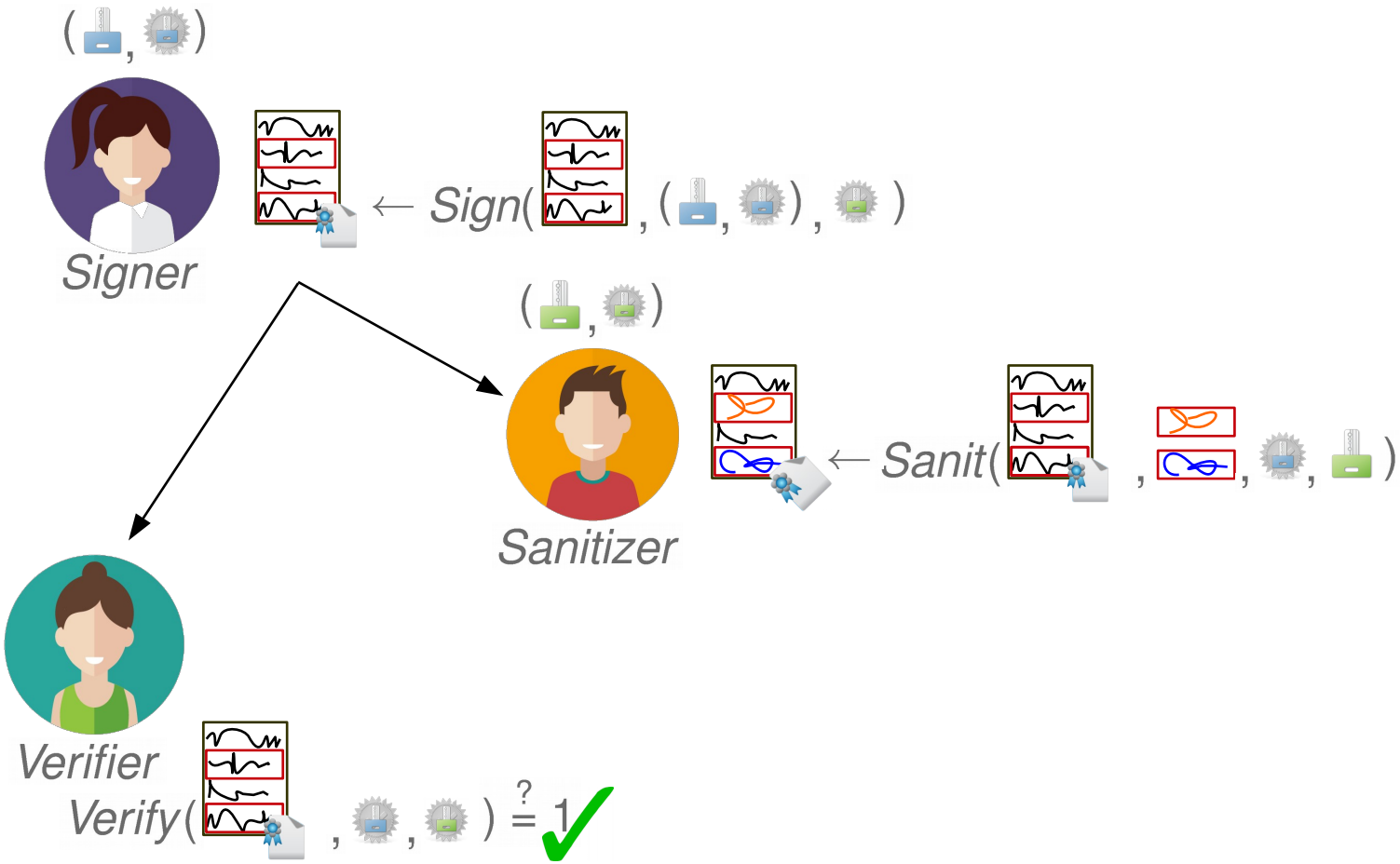

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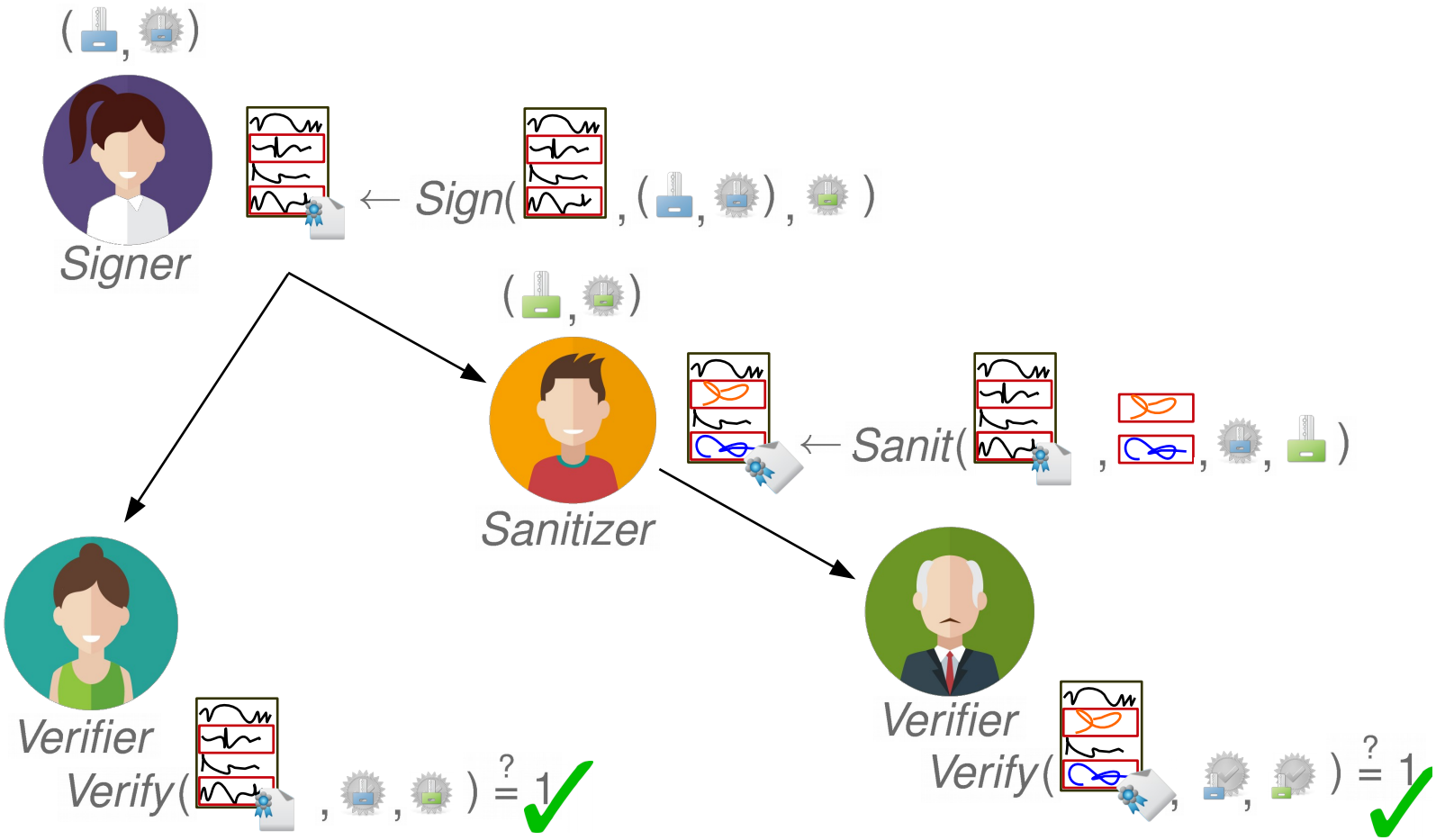

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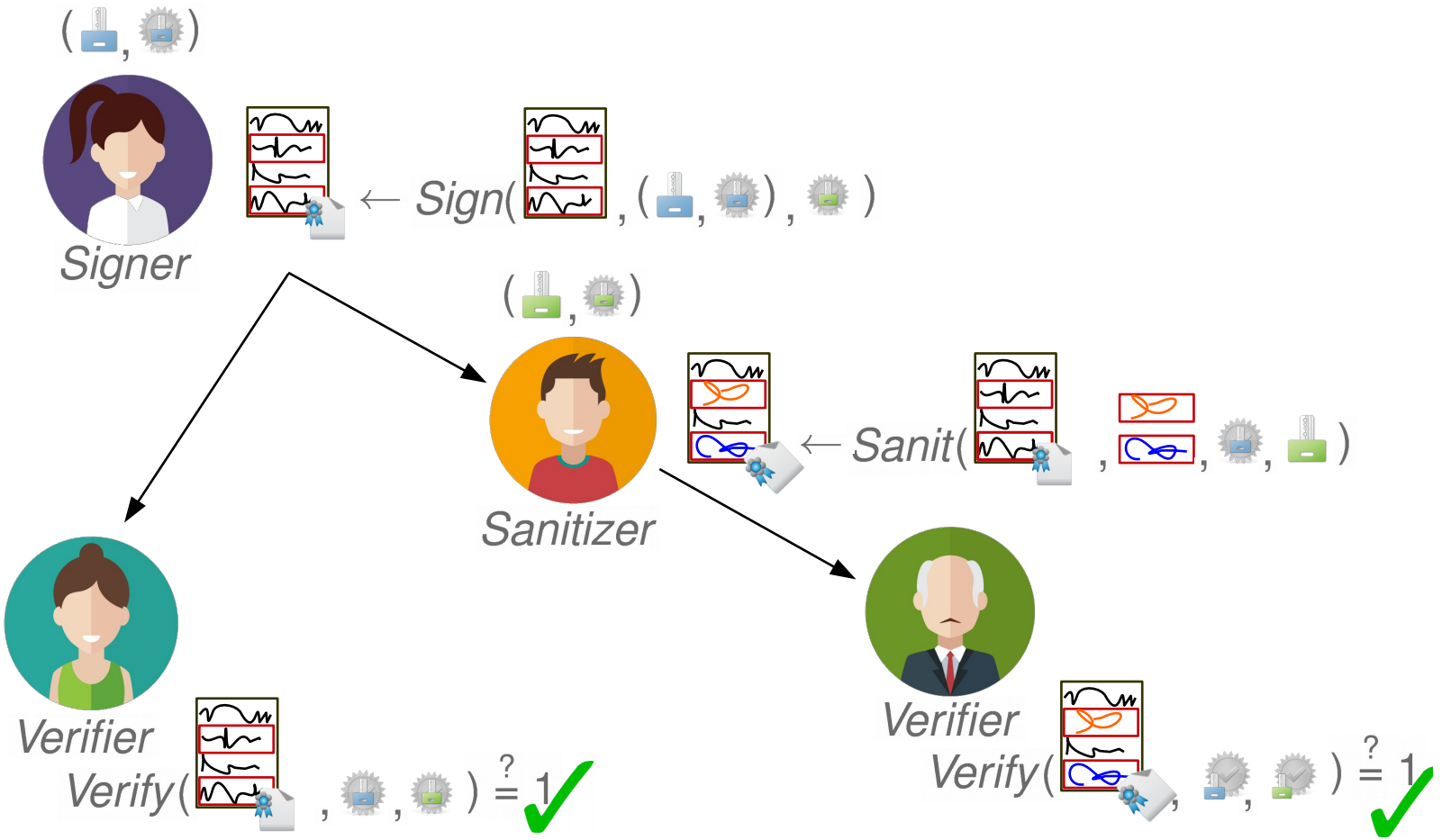

Proof / Judge : original signature of signer or sanitized

Security of SSS [ACdMT05]

Correctness, Unforgeability

- Straight forward

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Formalized in [BFF+09]

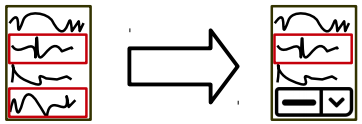
Arbitrary replacements?

- Sanitizer often **too powerful**
- **Limited expressiveness** of signed messages
- **Limited applicability** in several scenarios

Extensions

Several extensions proposed in [KL06]

$\Rightarrow$ `LimitSet` feature



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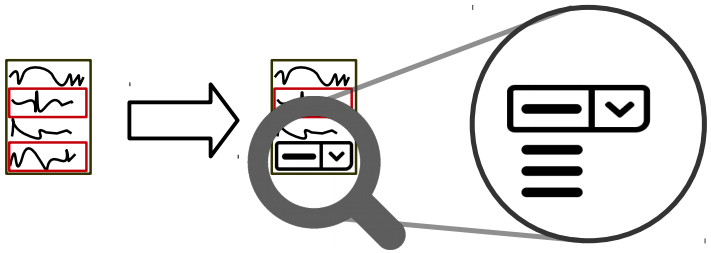

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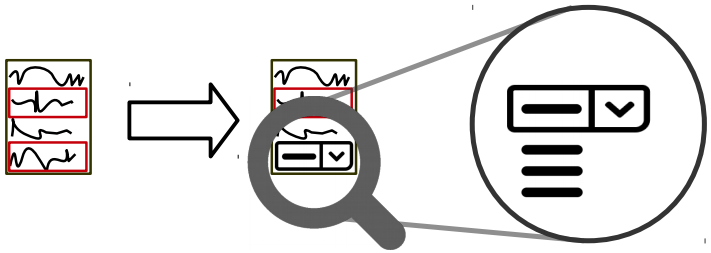

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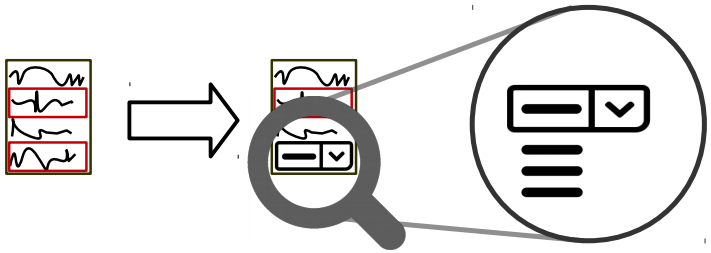

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  - Same changes in linked blocks
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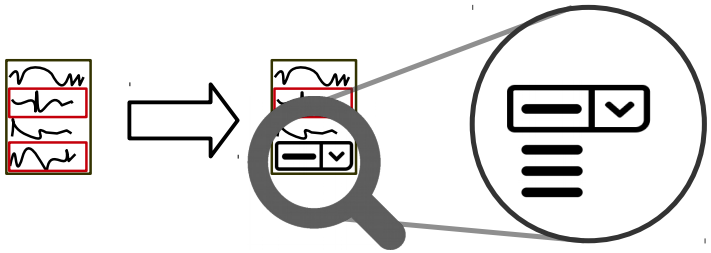

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Unfortunately, no formal definitions.

Motivation

`LimitSet` useful tool in many applications

- Restrict power of sanitizer
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Proper formalization **important**!

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Doctor signs medical records

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Sanitized documents published

$\Rightarrow$ **Verifiers may learn sensitive information!**

Contribution

Stronger privacy notion for ESSS: **strong privacy**

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- From any SSS
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- Strongly private if accu is indistinguishable [DHS15]

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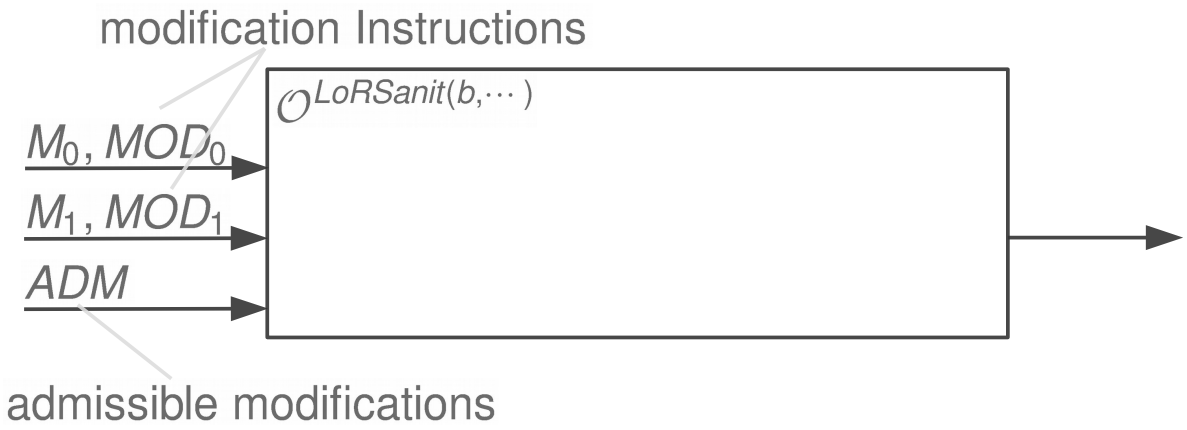

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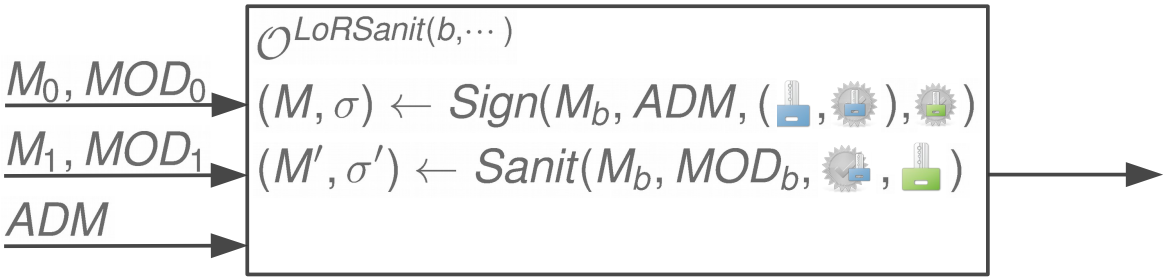

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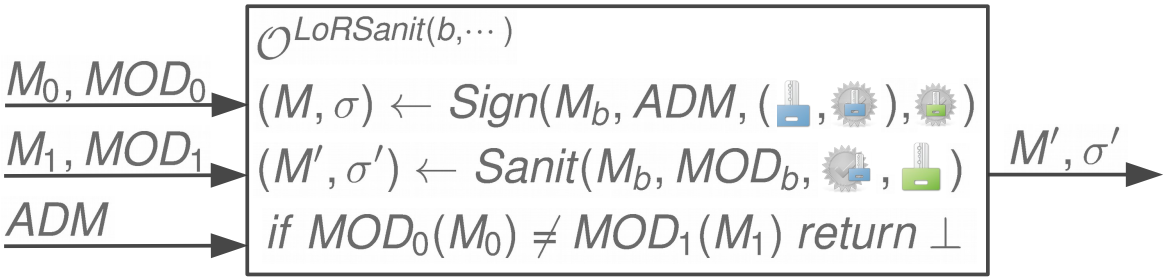

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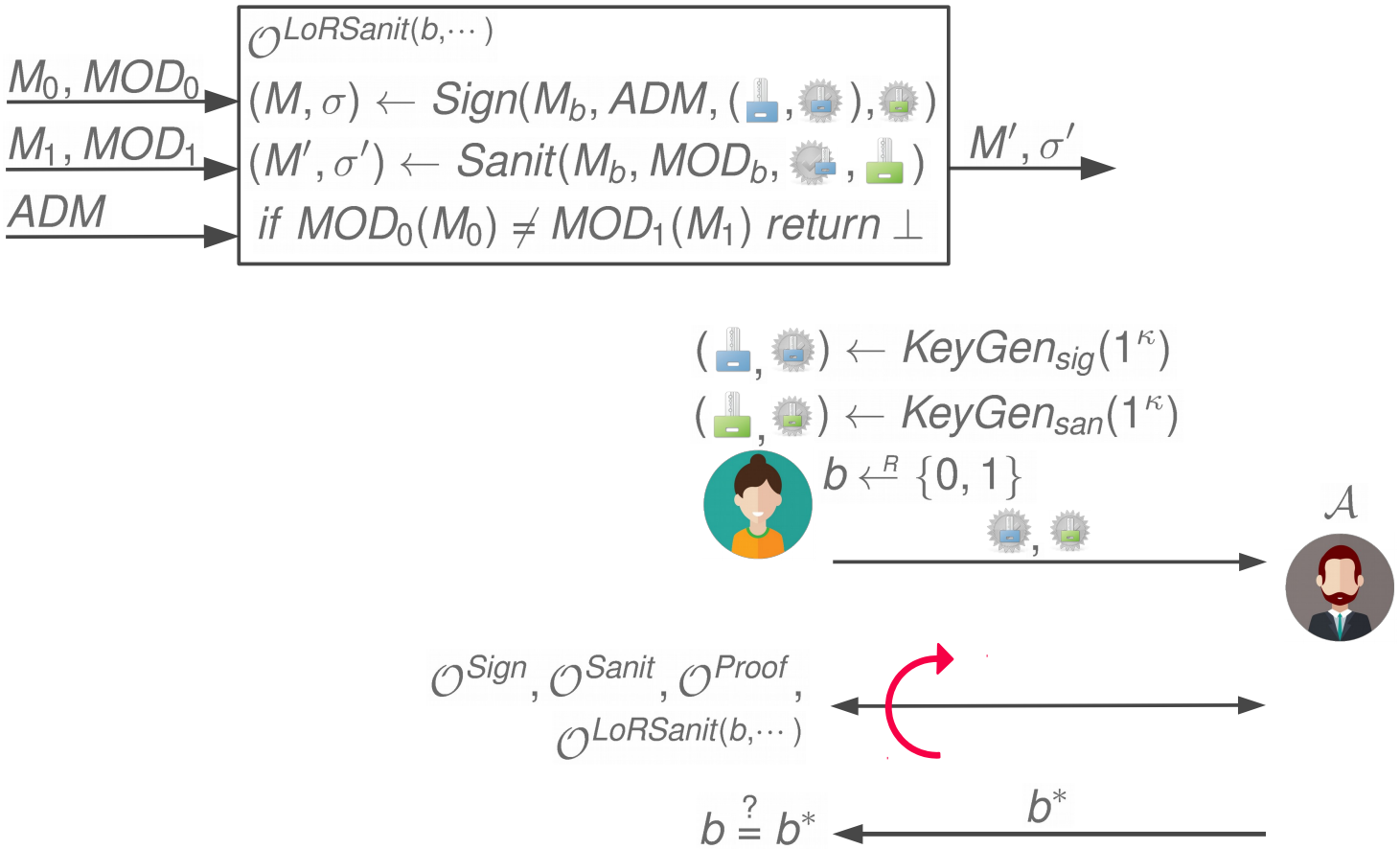

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`LimitSet` $\Rightarrow$ additionally need to specify set limitations

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[CJ10] modified $\mathcal{O}^{LoRSanit}$

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Possible motivation for weak formalization?

- Preserves implication of privacy by transparency [BFF+09]

Adapt Unlinkability to ESSS?

Stronger privacy notion

- Modify $\mathcal{O}^{LoR}$:
  - Submit two message-signature pairs
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We look for notion **between** privacy and unlinkability!

Introducing Strong Privacy

Extension of privacy

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We show that

- Privacy **strictly weaker** than strong privacy
- (Strong) unlinkability **strictly stronger** than strong privacy

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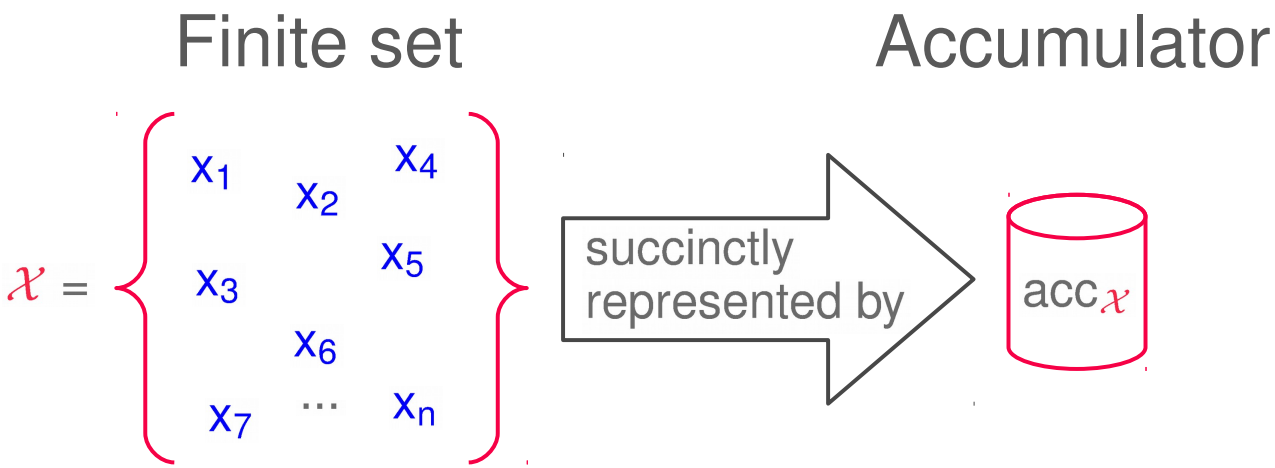
Indistinguishable Accumulators



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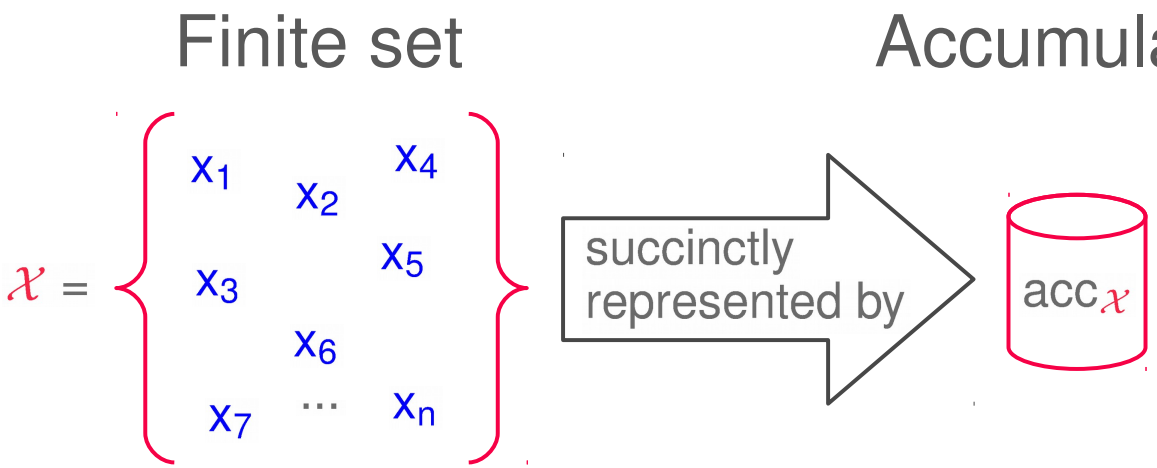

Witnesses wit_x certifying membership of x in $acc_{\mathcal{X}}$

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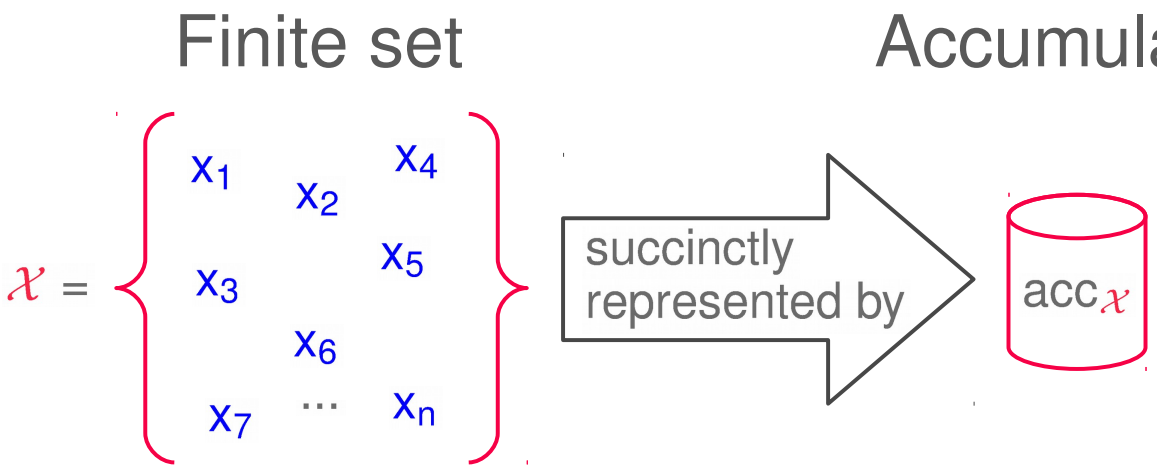

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Indistinguishability

- Neither accu nor witnesses leak information about $\mathcal{X}$

Existing Constructions Supporting `LimitSet`

Problems of existing constructions

- Tailored to specific instantiations
- Meaningful indistinguishability notion very recent [DHS15]
  - Not considered in existing constructions
  - Plain accumulators not required to hide accumulated set

  $\Rightarrow$ **No** strong privacy!

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Existing constructions follow paradigm

- We show that this paradigm is generally applicable

How does the Extension Work?

For each `LimitSet` block

- Include actually chosen message as variable element
- Accumulate sets of admissible changes
- Include accumulators as additional fixed elements
- Include witnesses in the signature

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Verification

- Conventional verification
- \+ Accumulator membership for `LimitSet` blocks
- Unambiguous encoding required!

Security I

Correctness

- Correctness of underlying primitives

Unforgeability

- Unforgeability of underlying SSS

Immutability

- Immutability of underlying SSS
- Collision freeness of accumulator

Security II

Privacy, Transparency

- Privacy, Transparency of underlying SSS

Accountability

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Strong Privacy

Holds if

- `LimitSet` instantiated with indistinguishable accumulator
- Underlying SSS is private

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Generic construction of ESSS

- Providing strong privacy
- Obtain practically efficient implementations with low effort
  - ...by building upon existing schemes

Thank you.

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Full version: http://eprint.iacr.org/2015/843

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References I

[ACdMT05] Giuseppe Ateniese, Daniel H. Chou, Breno de Medeiros, and Gene Tsudik. Sanitizable signatures. In *ESORICS'05*, LNCS, 2005.

[BFF+09] Christina Brzuska, Marc Fischlin, Tobias Freudenreich, Anja Lehmann, Marcus Page, Jakob Schelbert, Dominique Schröder, and Florian Volk. Security of sanitizable signatures revisited. In *PKC'09*, LNCS, 2009.

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