Enabling Anonymous Credentials for Digital Identity Wallets

EIC Conference 2026

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European Digital Identity Wallet (EUDI)

- All EU member states must provide EUDI Wallets to their citizens by the end of 2026 according to eIDAS (Regulation 2024/1183)

Example Visualization

eIDAS

- ..aims at ensuring **user data protection, non-discriminatory** access to wallets, and **interoperability** among wallets across the EU.
- ..standardizes the Feature Set and Security Requirements of Wallets
- ..is a **blueprint** for the rollout of the overall ecosystem.

EUDI | Privacy & Security Requirements in eIDAS

Privacy: *The technical framework of the European Digital Identity Wallet shall*

(a) *not allow providers of electronic attestations of attributes or any other party […] to obtain data that allows transactions or* ***user behaviour to be tracked, linked or correlated*** *[…]*

(b) *enable privacy preserving techniques which* ***ensure unlinkability****, where the attestation of attributes does not require the identification of the user.*

https://eur-lex.europa.eu/eli/reg/2024/1183/oj

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Security:

- **Level of Assurance High** (for PID), but not for all credentials
- **Accepted schemes** → ENISA Agreed Cryptographic Mechanisms
- **Hardware certification** requirements
- Secure cryptographic **device binding**

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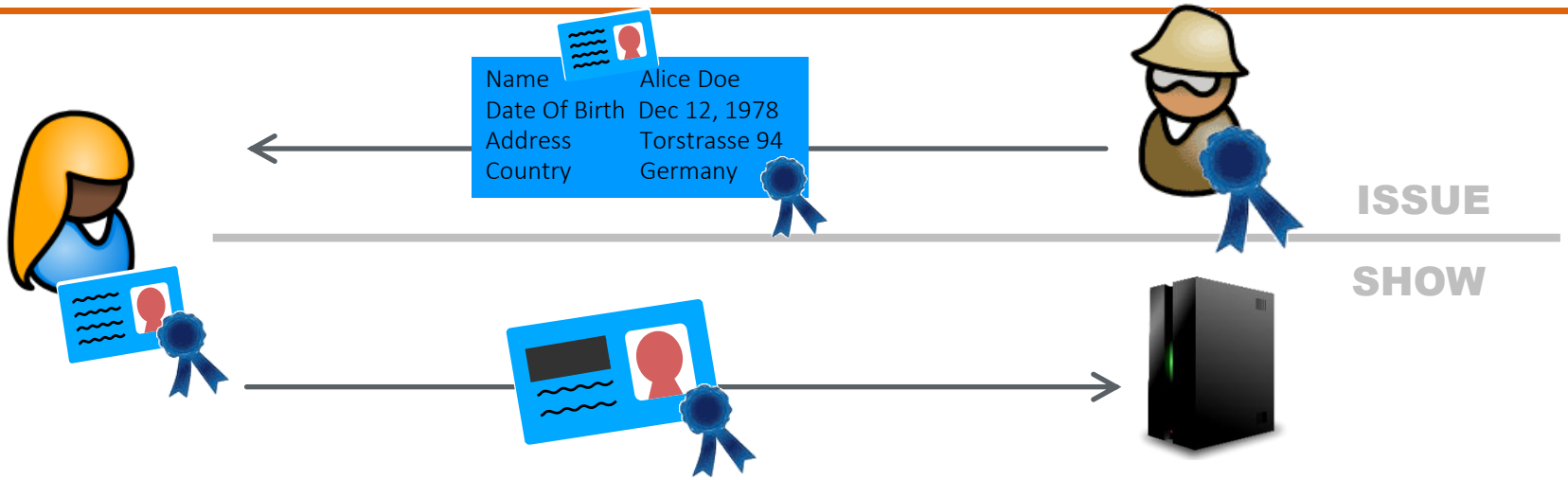
EUDI | Solution with Classical Signatures



- Digital identity credentials based on cryptographic signatures

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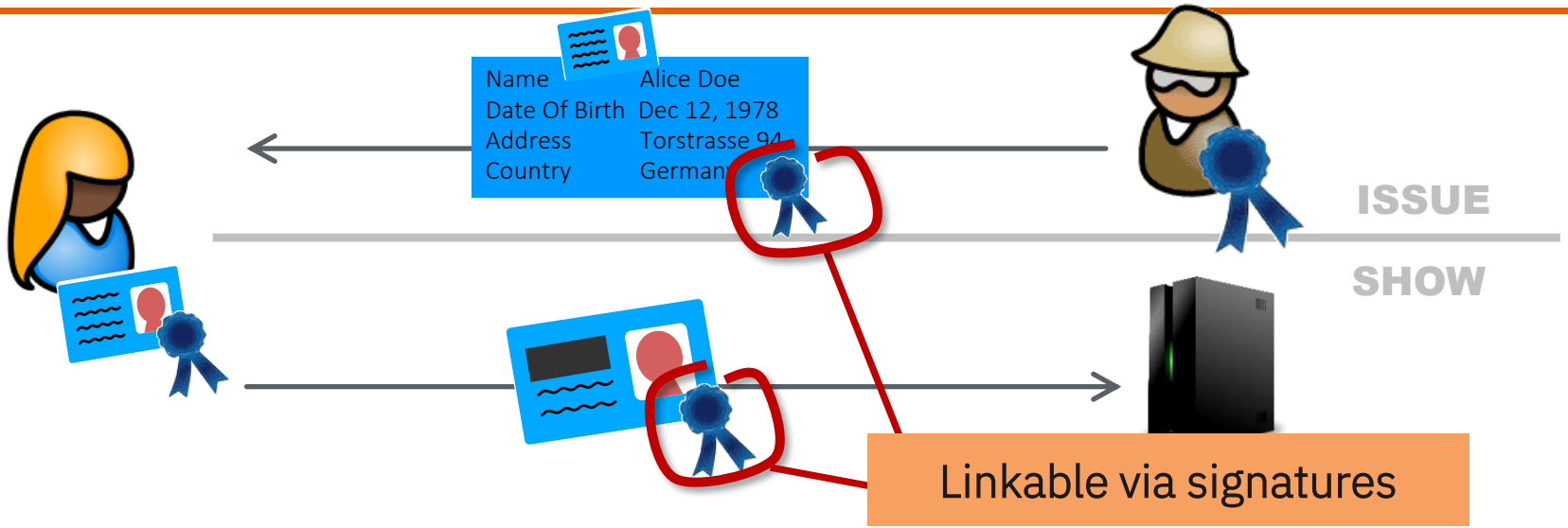

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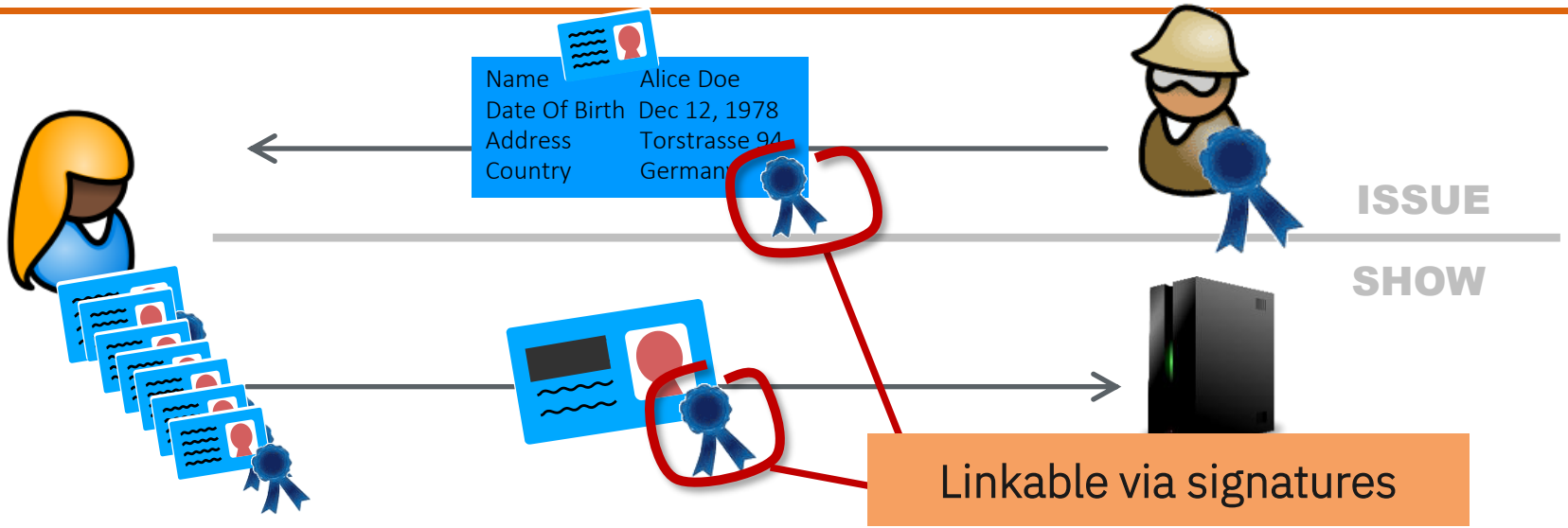

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- Digital Signatures are great for security, especially for a highly distributed system but bad for privacy → unique identifier
- Current solution: **batch issuance** of one-time use credentials & holder keys

EUDI | Batch Issuance

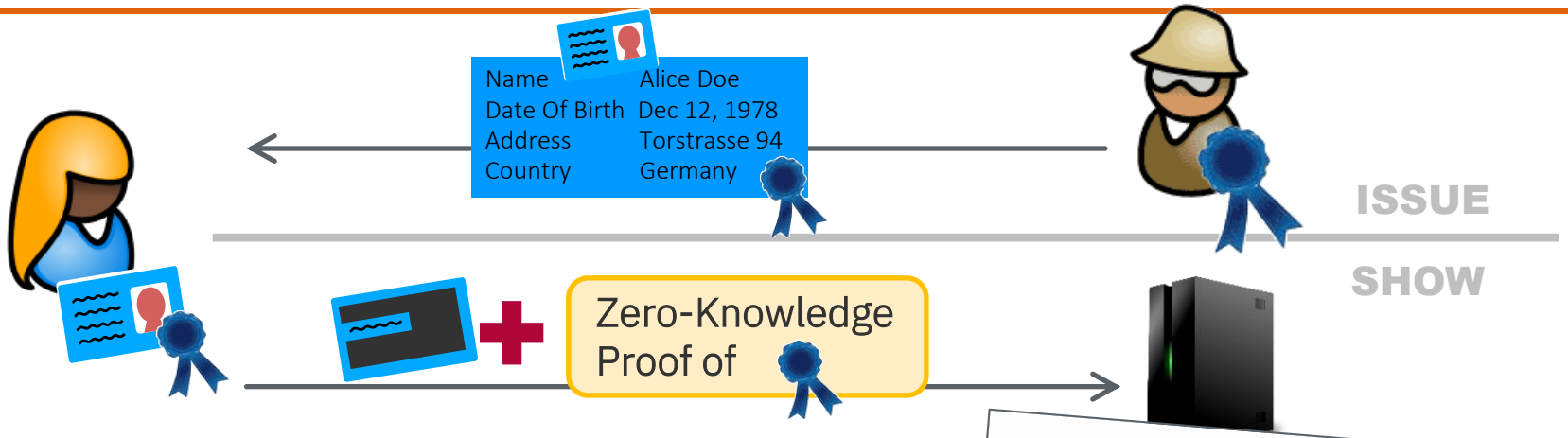
- Batch Issuance needed for **every statement with a signature** that might be used for correlation
  - Credentials (PID, EAAs)
  - Wallet Attestations (used towards issuers)

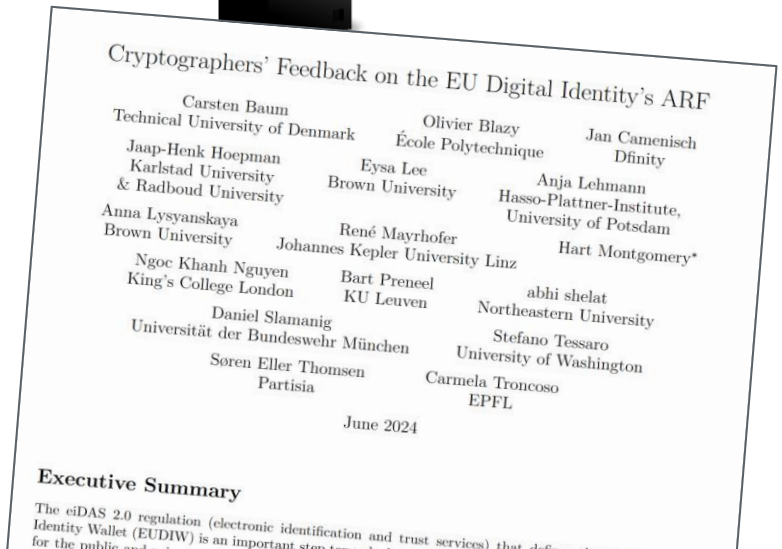
- Creates **complexity & burden** in the overall system & infrastructure:
  - Issuers need to issue and manage batches of credentials
  - Wallets need to generate and manage a lot of keys (which is costly if we are talking about server-based HSMs)

- A **malicious issuer** would still be able to link those one-time use signatures & keys

Can we get to even stronger **privacy guarantees** & make the **overall system simpler**?

Anonymous Credentials & Zero-Knowledge Proofs





Cryptographers' Feedback on the EU Digital Identity's ARF

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Anja Lehmann, Hasso-Plattner-Institute, University of Potsdam
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June 2024

Executive Summary

The eIDAS 2.0 regulation (electronic identification and trust services) that defines Identity Wallet (EUDIW) is an important step for the public and

https://github.com/eu-digital-identity-wallet/eudi-doc-architecture-and-reference-framework/issues/200

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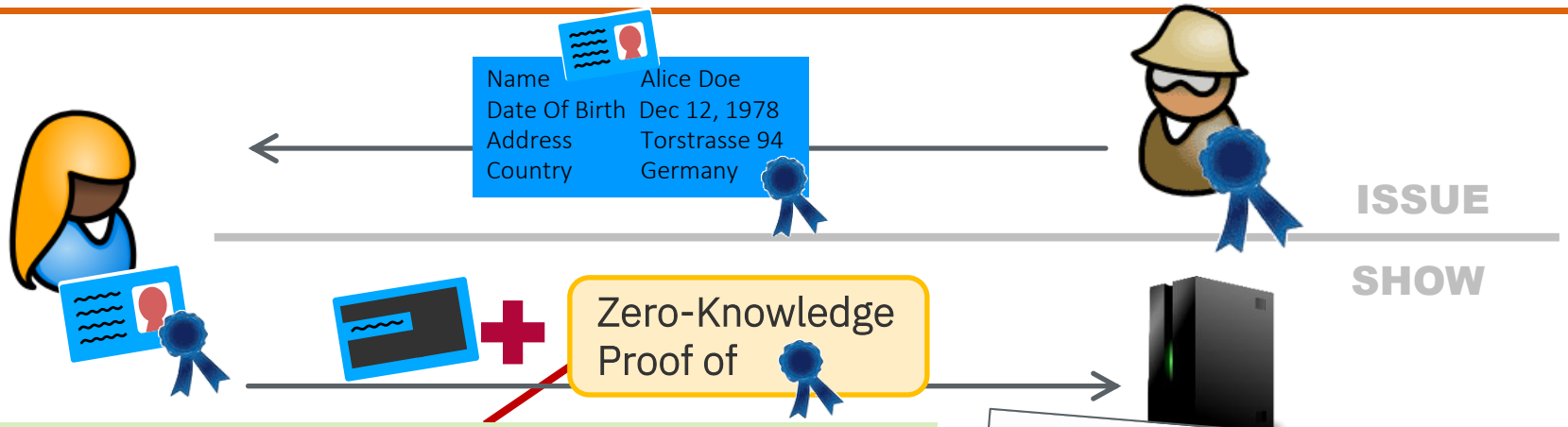
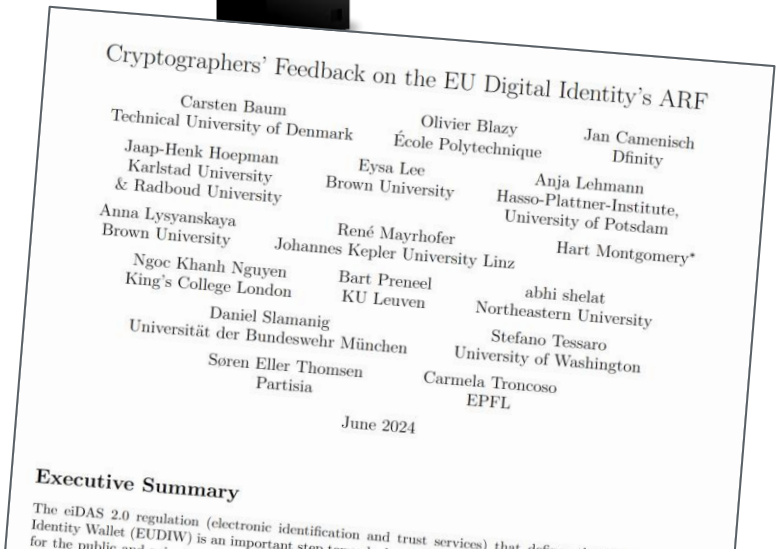


Zero-Knowledge Proof (ZKP)

Proof that reveals nothing beyond validity

→ multi-show unlinkability & untraceability

Practical ZKP-based solutions exist since 25 years



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Why does EUDI not use Anonymous Credentials (yet) ?

1 | All protocols and schemes must be **standardized** → interoperability (& sign of maturity)

Regulated use cases (e.g. eID): all crypto must be in "Agreed Cryptographic Mechanisms" by ENISA (previously SOG-IS catalogue)

Primitive	Scheme	R/L	Notes
RSA	PSS (PKCS#1v2.1) [RFC8017, PKCS1, ISO9796-2]	R	
FF-DLOG	KCDSA [ISO14888-3]	R	
	Schnorr [ISO14888-3]	R	41-DSARandom
	DSA [FIPS186-4, ISO14888-3]	R	
EC-DLOG	EC-KCDSA [ISO14888-3]	R	
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	EC-GDSA [TR-03111]	R	
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RSA	PKCS#1v1.5 [RFC8017, PKCS1, ISO9796-2]	L	40-PKCSFormatCheck

List of „approved" crypto when EUDI ARF was designed (now it also includes PQC)

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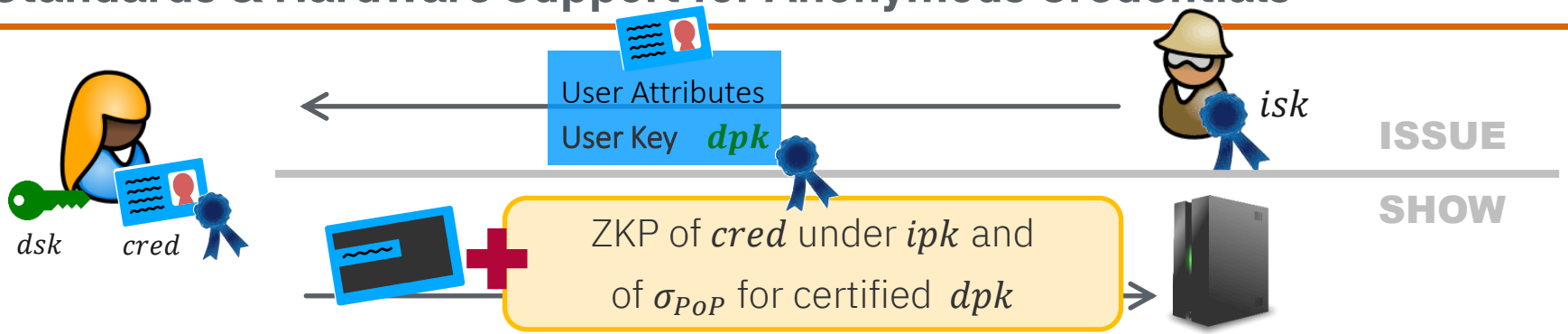
2 | Credential must be bound to **hardware**-protected device key

EUDI Wallet requires Level-of-Assurance (LoA) High

Secure Elements support only ECDSA (and curve P256)

Standards & Hardware Support for Anonymous Credentials



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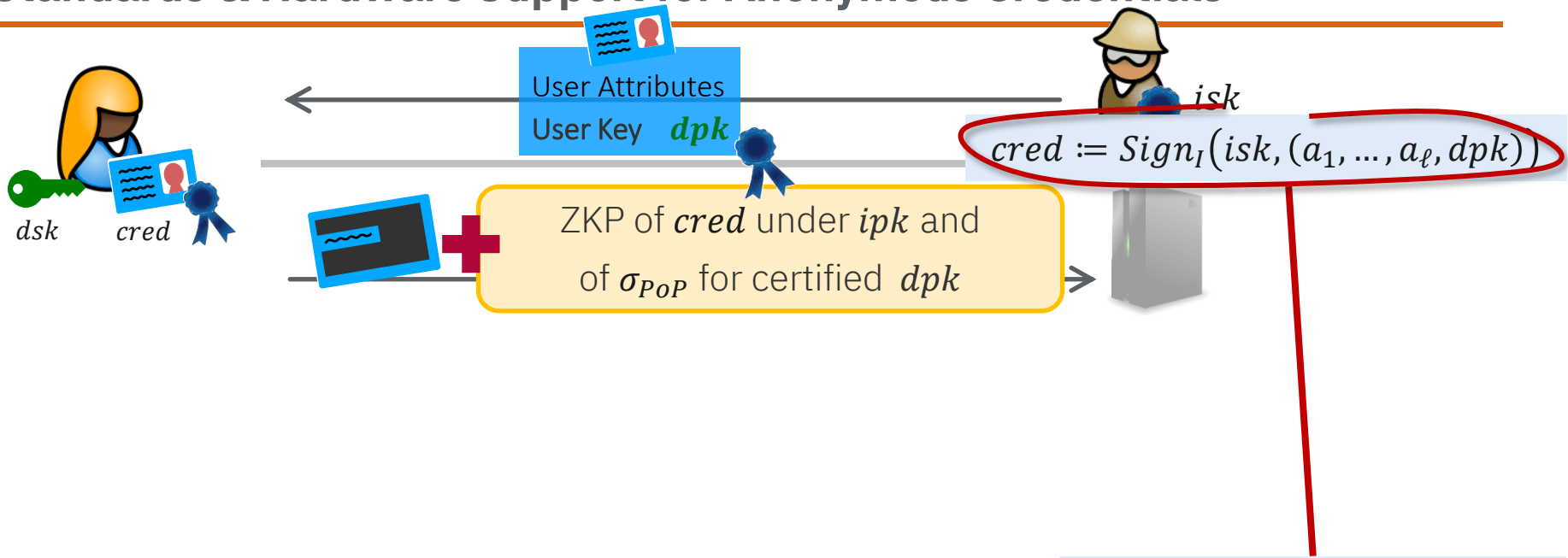

Issuer signature scheme:

- ZKP-friendly
- Hardware support for LoA high credentials

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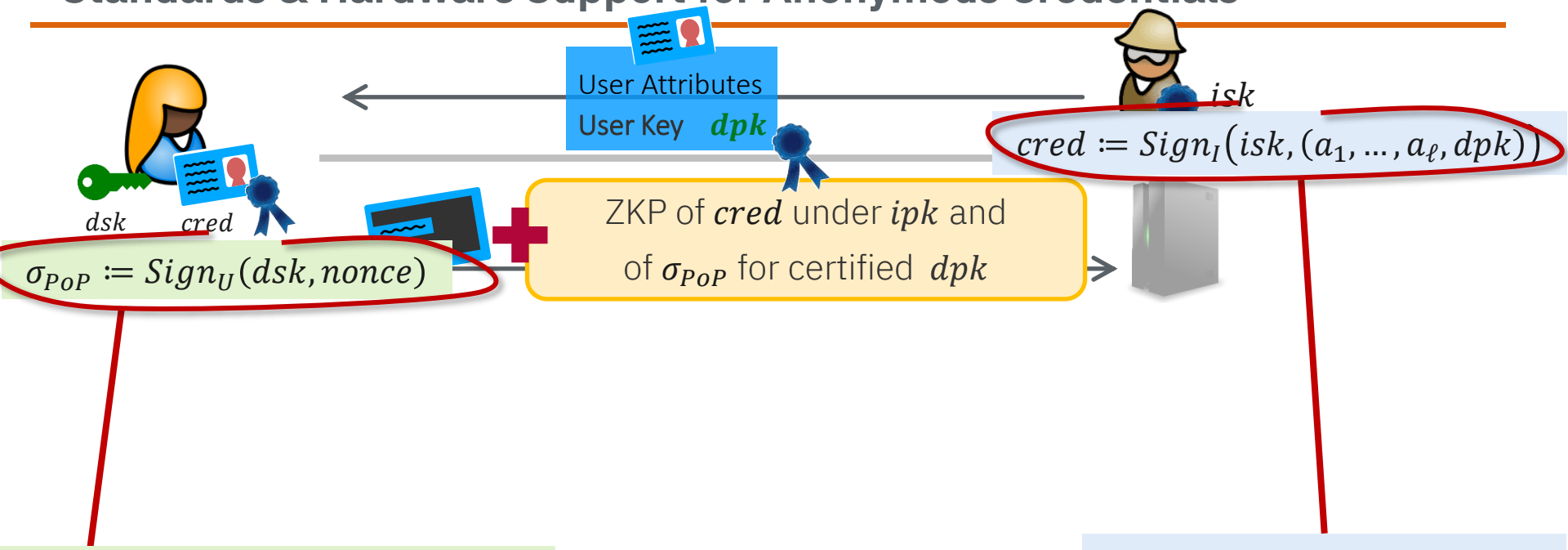

Device signature scheme

- (somewhat) ZKP-friendly
- Hardware support essential for non-transferability

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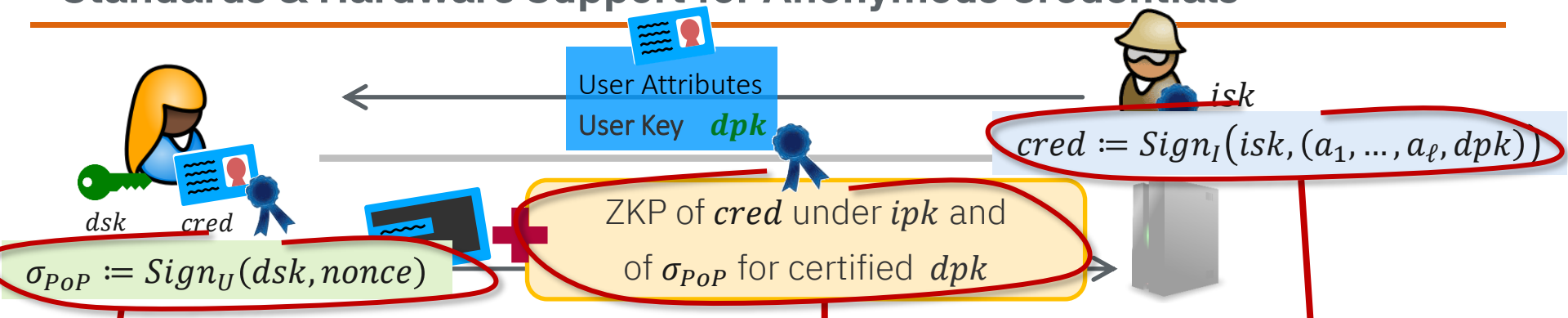

ZKP scheme

- ZKP runs entirely on "public" values

→ ZKP not needed in secure hardware, only standardized
(and "approved" for LoA high)

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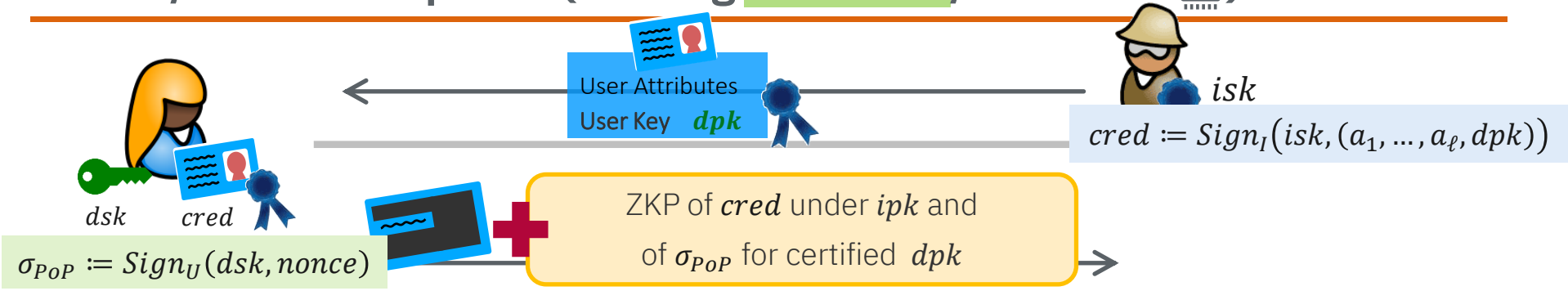
Short/Mid-Term Options (Existing Standards/Hardware)



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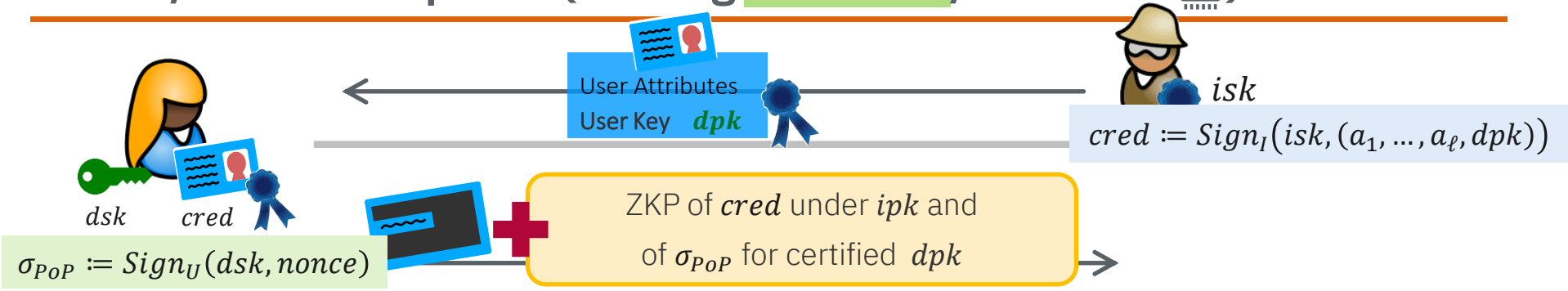

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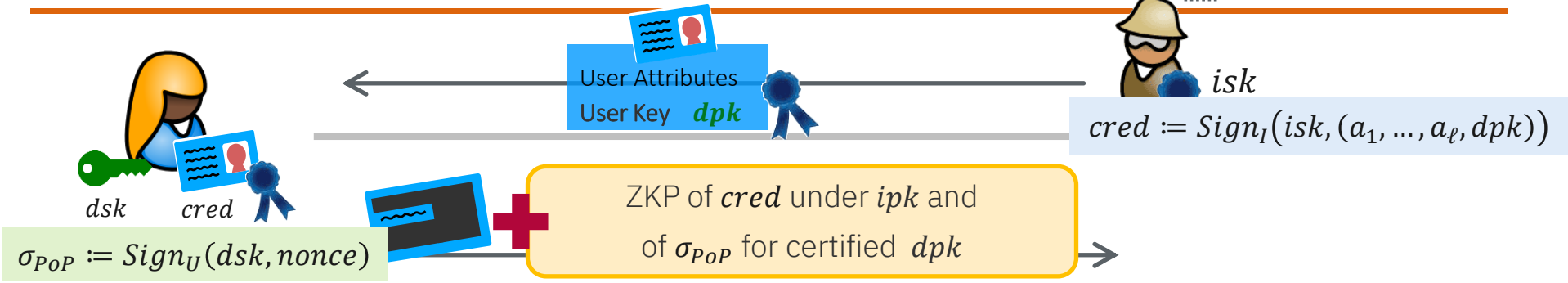

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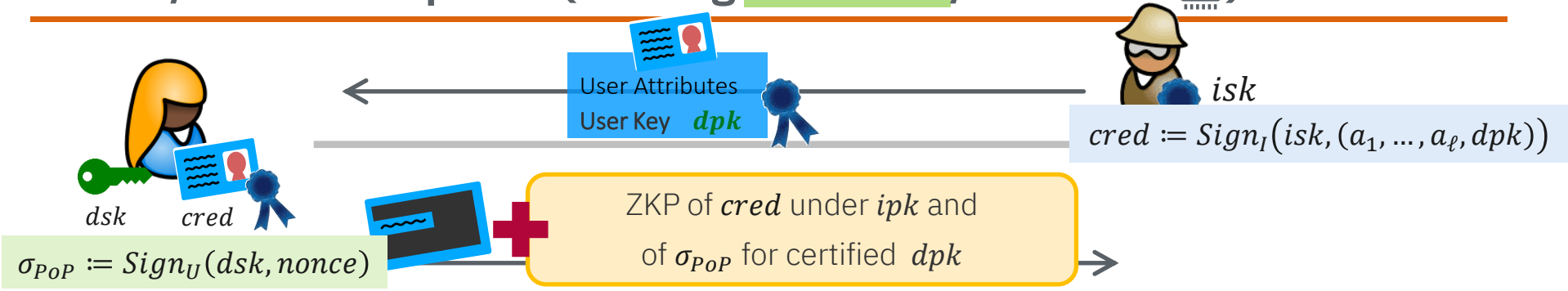

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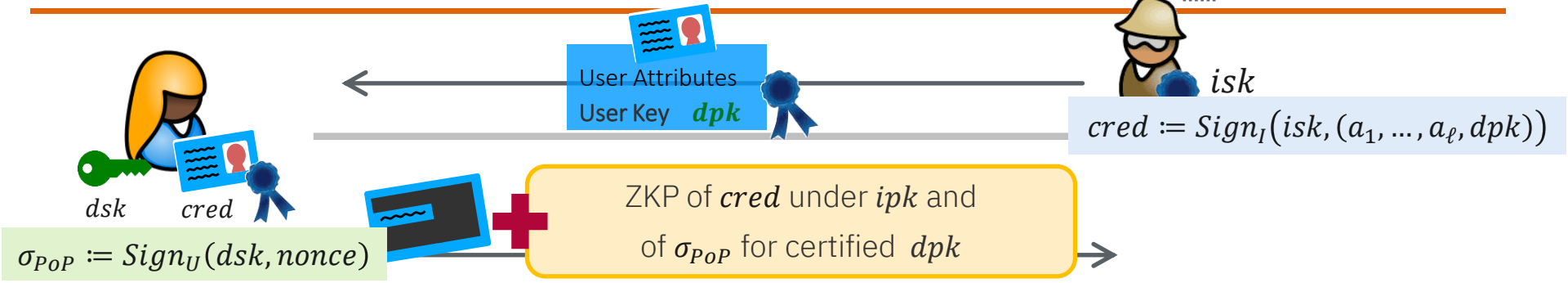

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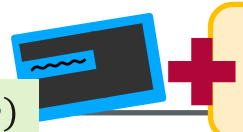
Short/Mid-Term Options (Existing Standards/Hardware)

$cred := Sign_I(isk, (a_1, \dots, a_\ell, dpk))$

$\sigma_{PoP} := Sign_U(dsk, nonce)$



ZKP of $cred$ under ipk and of σ_{PoP} for certified dpk

BBS/ECDSA and ECDSA/Circuit considered for EUDI Wallet „v2“ [TS13& TS14]
Currently undergoing standardization in ETSI

Issue

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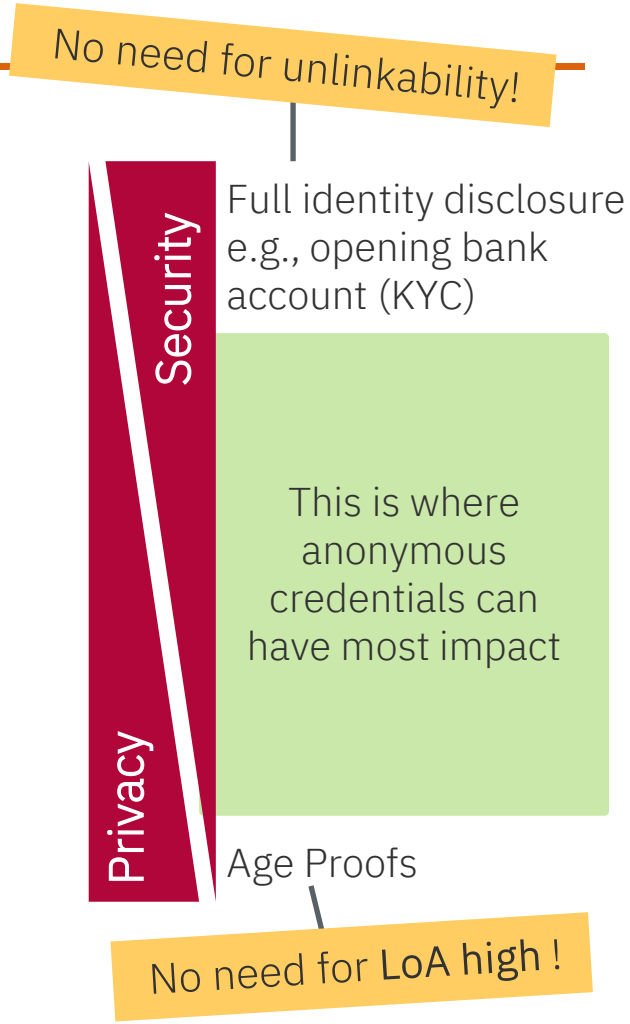
- ZKP-compatible protocols (OID4VC) & data formats



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Longterm: full post-quantum security

- Current solutions have PQC-privacy, but classic soundness
- PQC solutions need (a bit) more research & time to analyse
  - Current work provides concrete target for PQC research
    Insights from pre-PQC serve as blueprint
  - Shape PQC base standards & hardware APIs now(ish)

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- Core challenges have been addressed: device binding, standards (ongoing)
  Different options with complementary legacy/complexity tradeoffs
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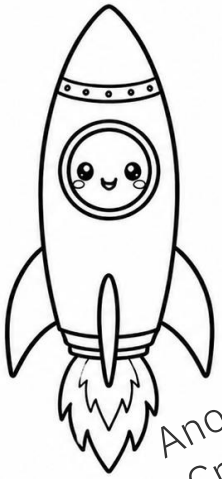

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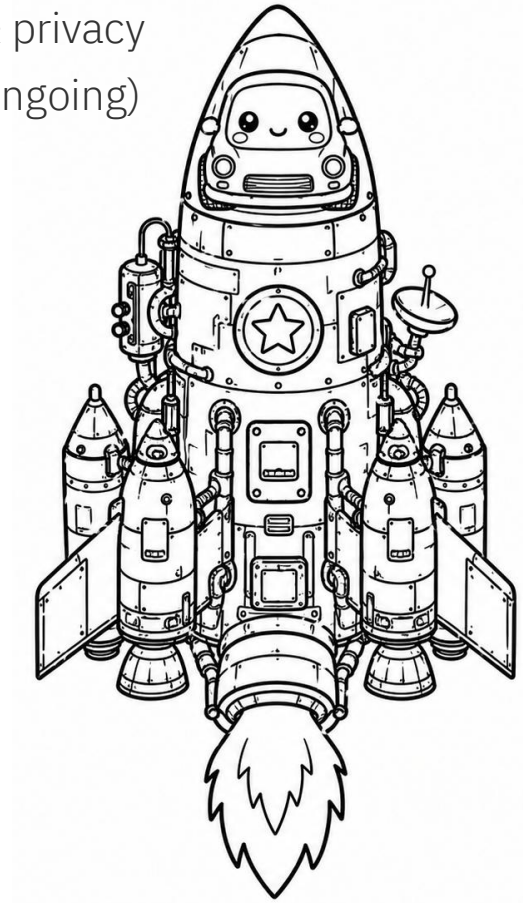

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More information: https://ia.cr/2026/330 & https://ia.cr/2025/1981

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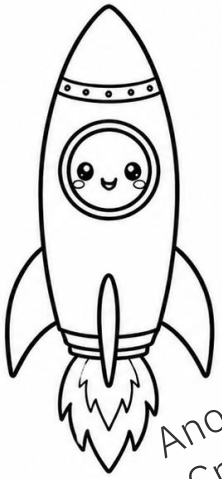

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