Trust and Privacy in a Heterogeneous World

PhD Defense

Stefan More

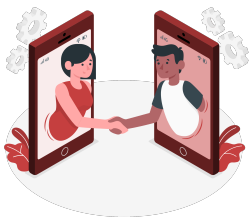
30. November 2023

Graz University of Technology

Trust and Privacy

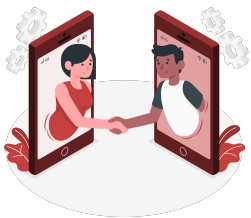
Trust and Privacy

Trust



Trust (noun); to **trust** (verb):

Trust



Trust (noun); to **trust** (verb):

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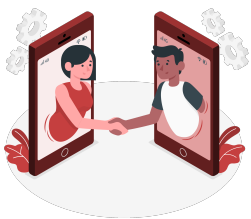
- *assured* reliance on the truth of someone or something

Trust



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- *assured* reliance on the truth of someone or something

Trust is an enabler!

Trust as Enabler

Without trust:

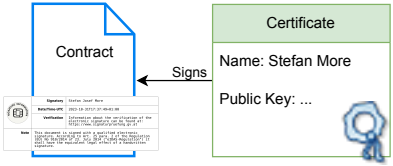
Trust as Enabler

Without trust:

- no reliance on person/document possible
  - need for (manual) verification
  - assessment of reputation, insurance, ...

Computational Trust?

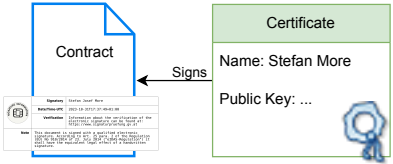
Computational Trust?



Certificate

- contains identity and public key
- used to sign other data

Computational Trust?



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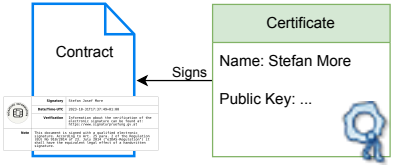

Certificate

- contains identity and public key
- used to sign other data

Credential

- contains attributes

Cryptography

Cryptographic signatures can provide:

- Integrity

Cryptography

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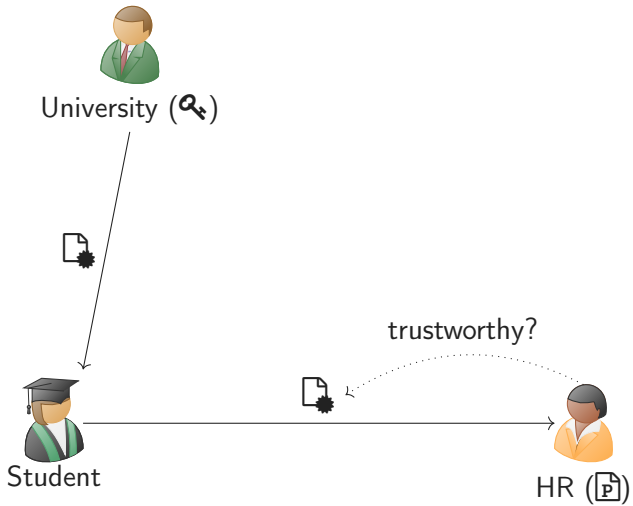
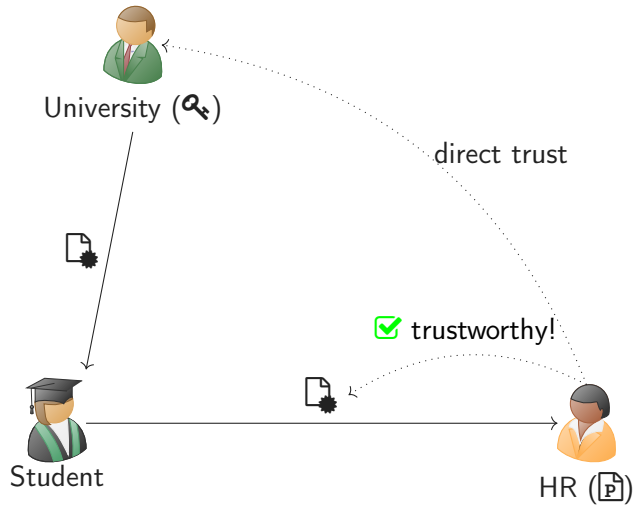
Cryptography

Cryptographic signatures can provide:

- Integrity
- Authenticity?
  - Data was signed by specific cryptographic key. But ...
    - is this key really the issuer's key?
    - is this issuer qualified to issue that information?


University (🔑)
trustworthy?
Student
HR (P)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direct trust
trustworthy!
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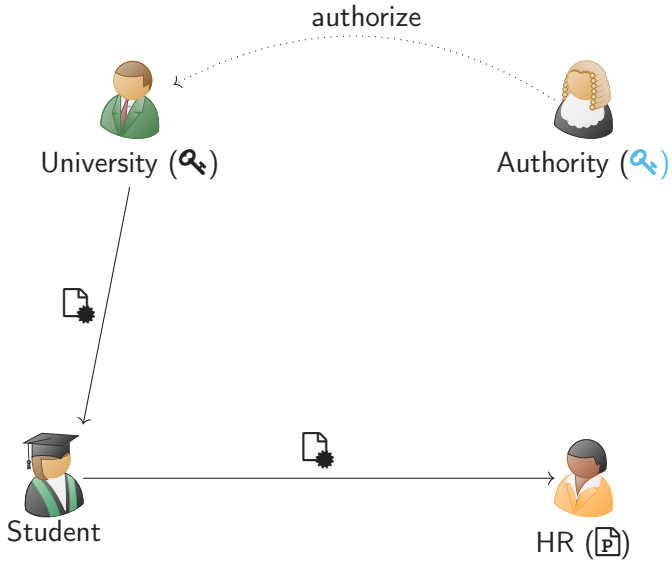
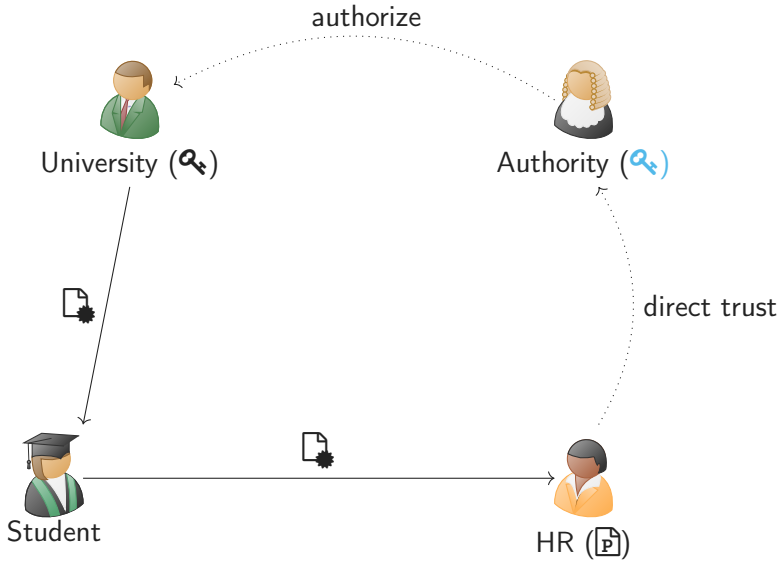

authorize
University ( )
Authority ( )
Student
HR ( )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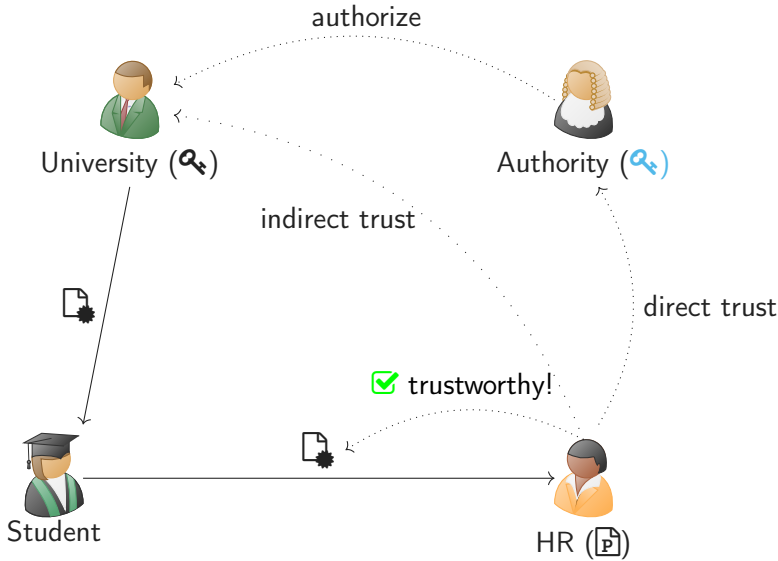
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University ( )
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Trust Scheme

- Legal regulations, technical standards, infrastructure, and organizations

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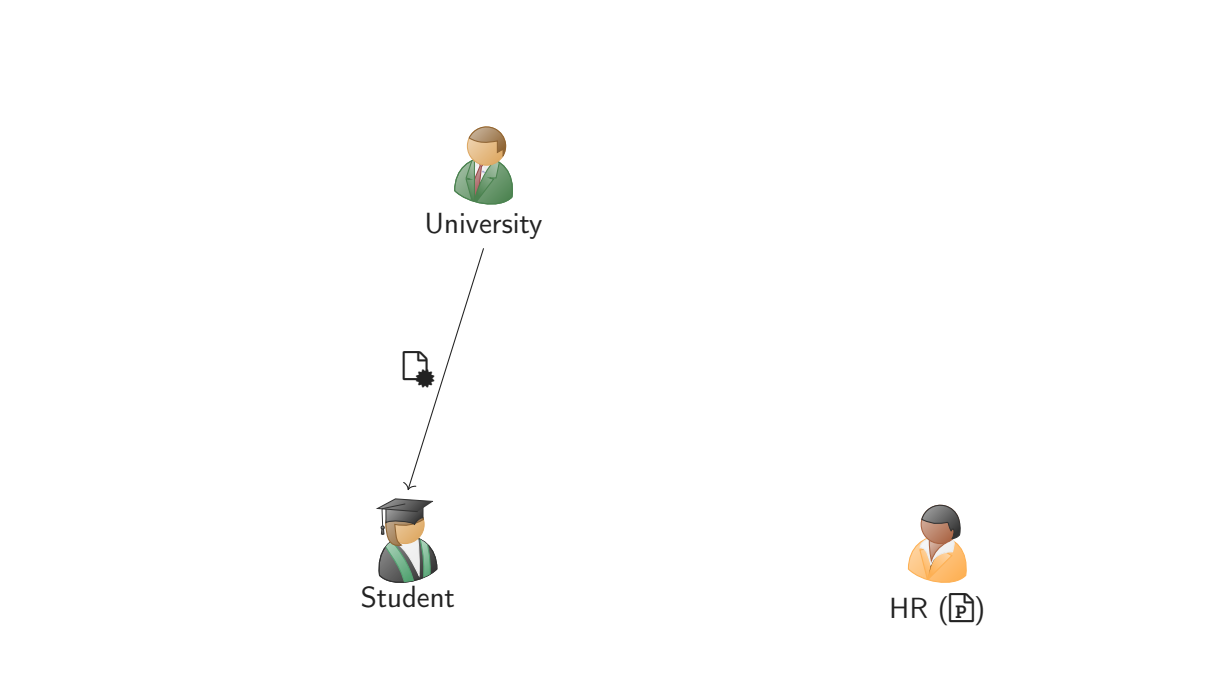
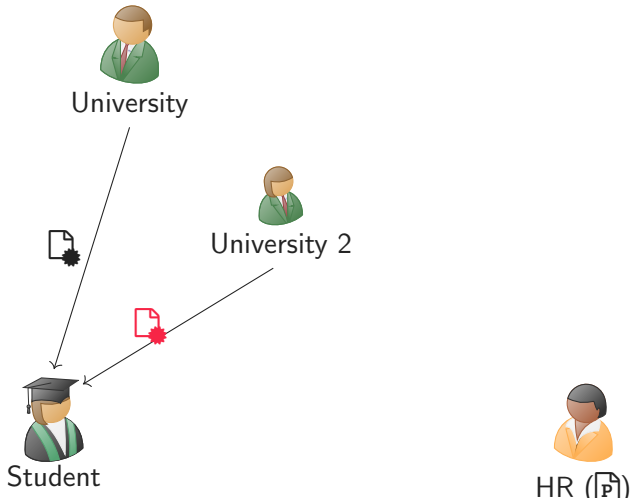
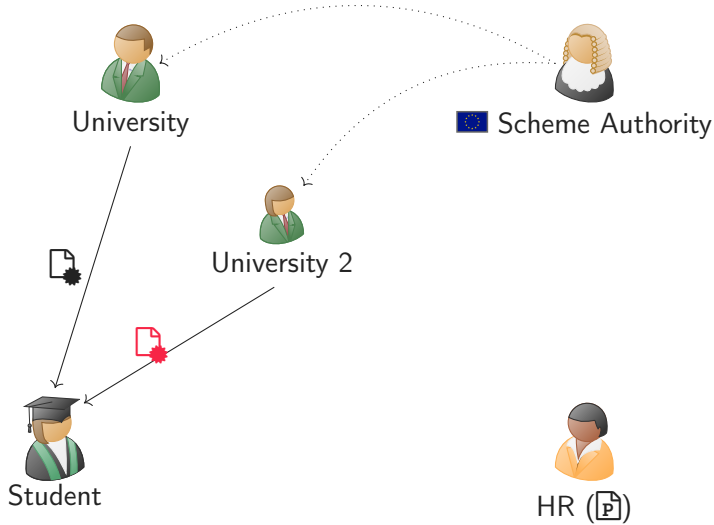
- Authorize qualified issuers
- Verifier trusts the Trust Scheme
  (direct trust in scheme, indirect trust in issuer)

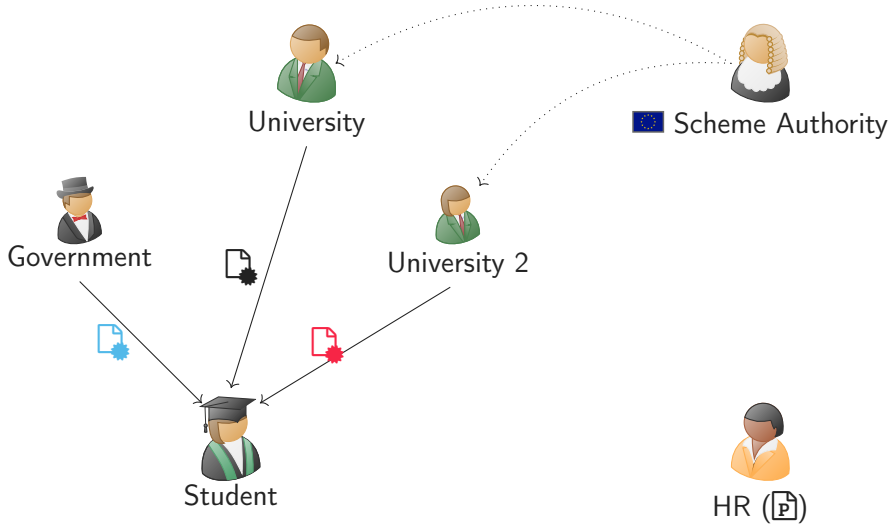
Examples:

- Web PKI: CA/Browser Forum, list of trusted root CAs
- EU: eIDAS regulation, EU Trusted List


University
Student
HR (P)


University
University 2
Student
HR (P)


University
Scheme Authority
University 2
Student
HR (P)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Scheme Authority
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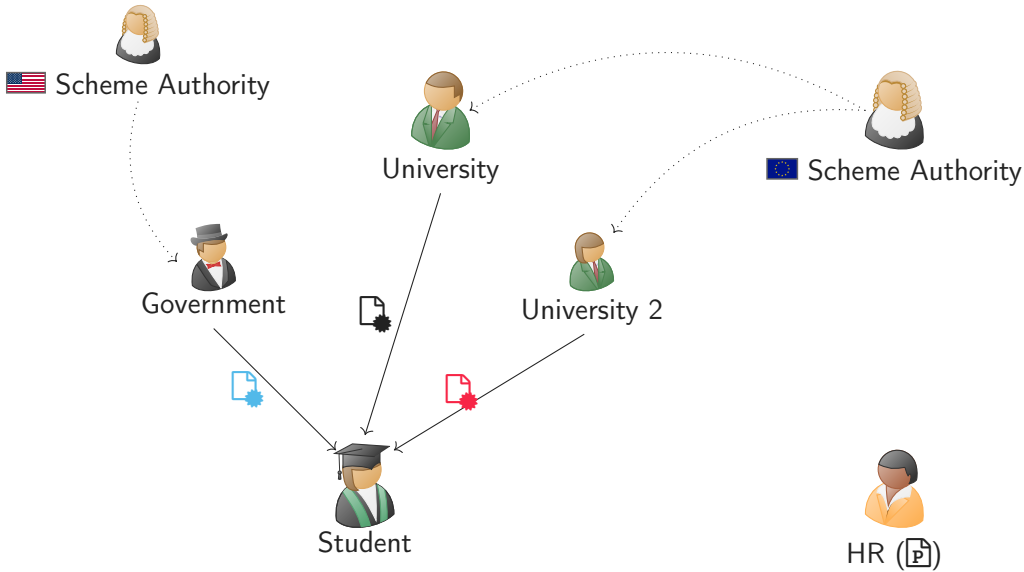
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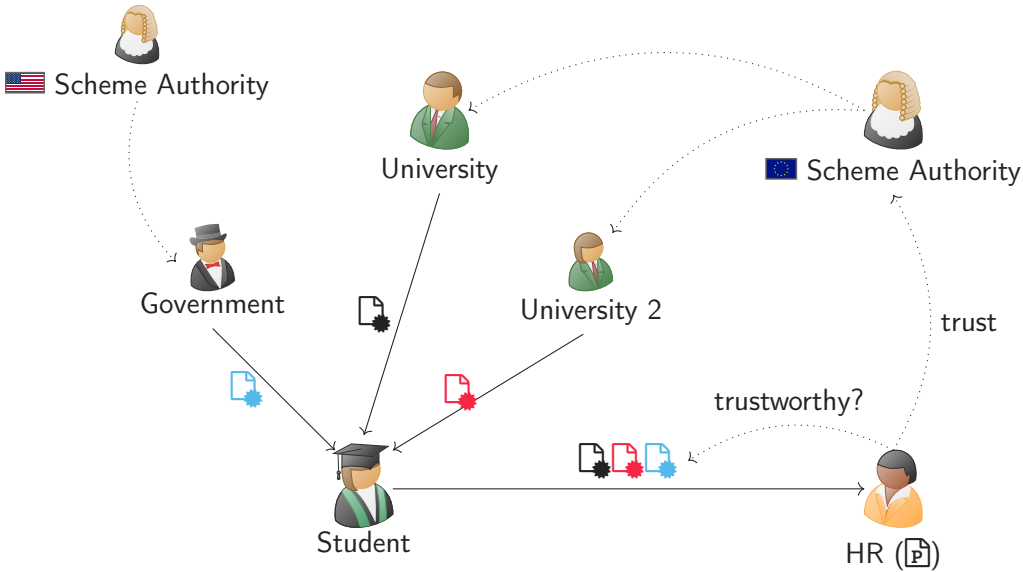
Scheme Authority
University
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trust
trustworthy?
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Challenges of *going global in a heterogeneous world:*

- Complex transactions: many credentials

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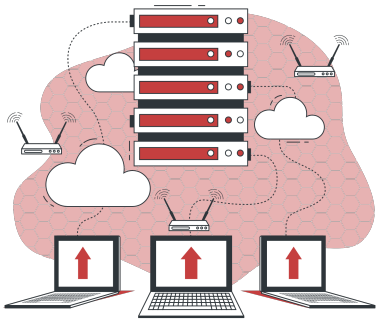
- Need to setup cryptographic material for each scheme
- Different encoding of trust





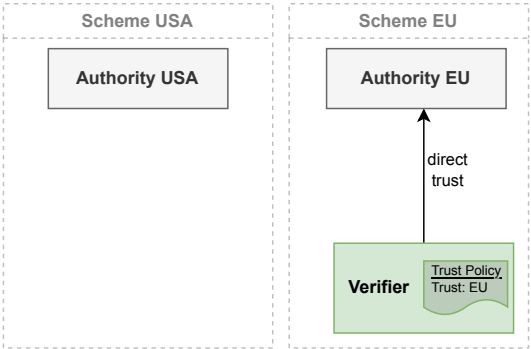


Global Trust Infrastructure

Trust Scheme Recognition

Many different schemes

- Verifier only trusts few directly



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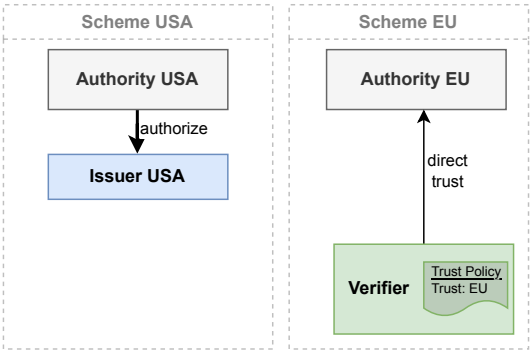

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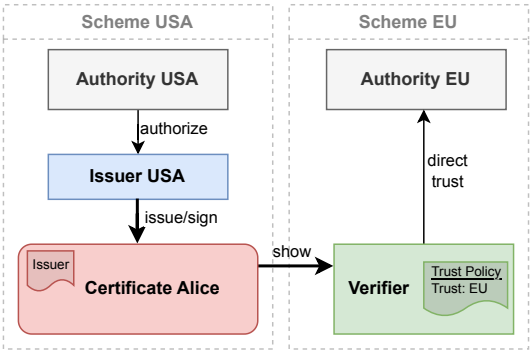

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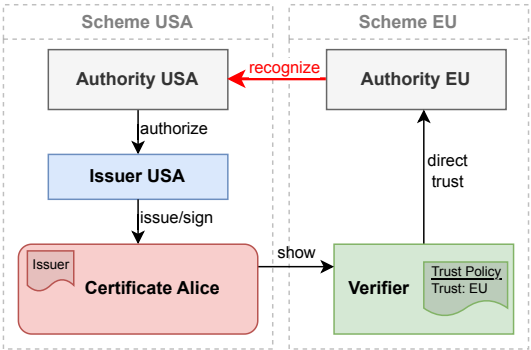
Trust Scheme Recognition:

- Trust Schemes identified by human-readable name
- Recognition:
  list of names of other schemes



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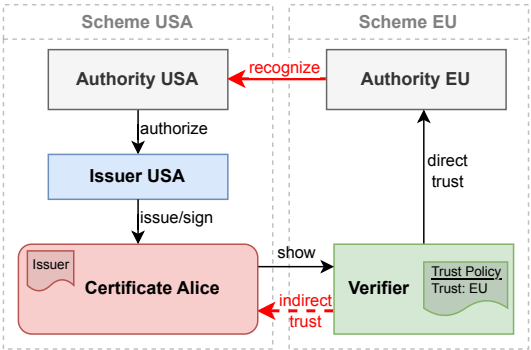
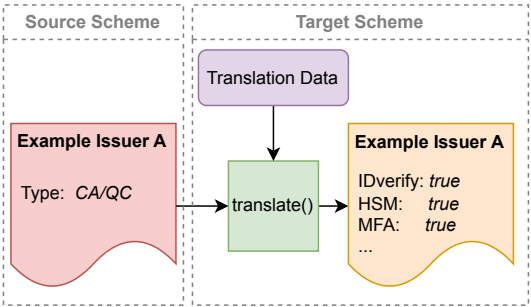
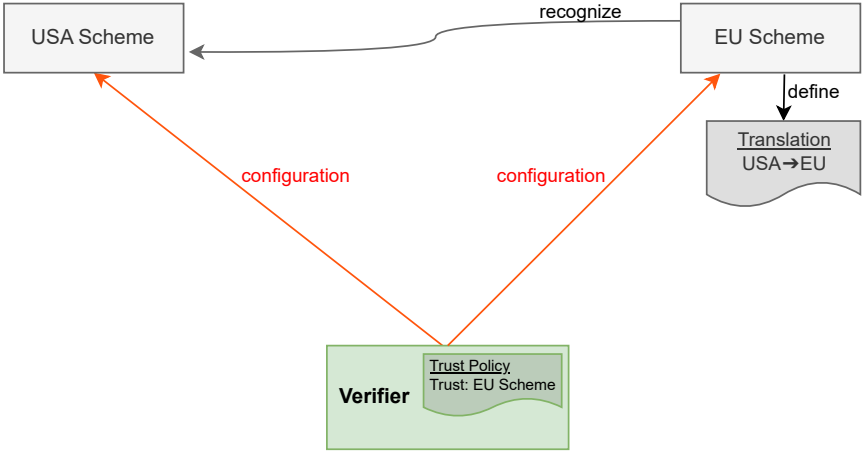


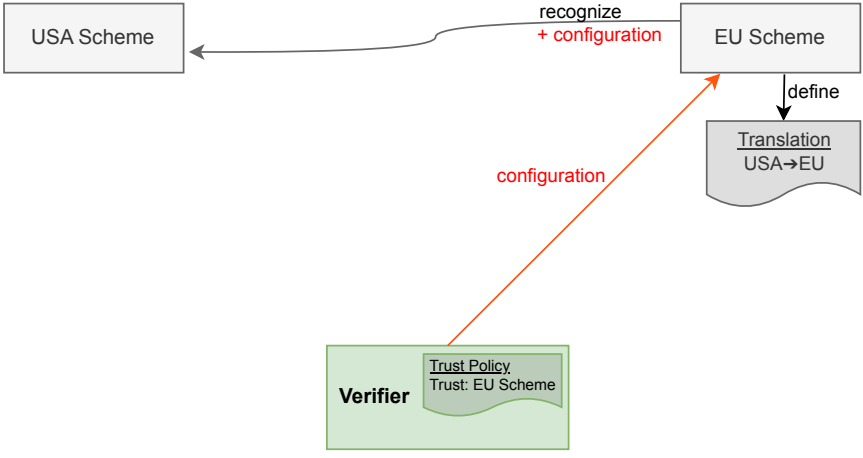
Trust Translation

Varying understanding of trust

- Trust character of a credential
- Boolean, Ordinal, Tuple-based




USA Scheme
recognize
EU Scheme
define
Translation
USA➔EU
configuration
configuration
Verifier
Trust Policy
Trust: EU Scheme


USA Scheme
recognize
+ configuration
EU Scheme
define
Translation
USA→EU
configuration
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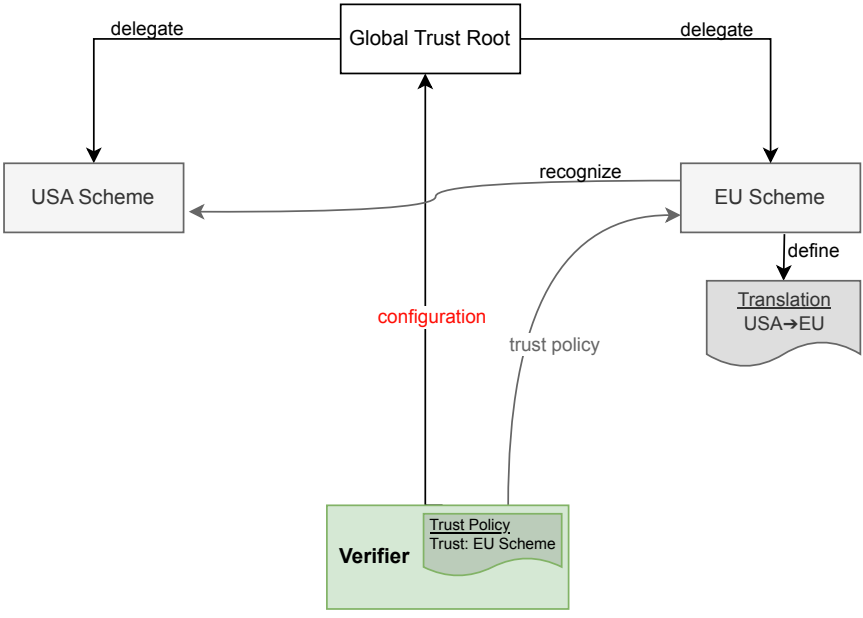
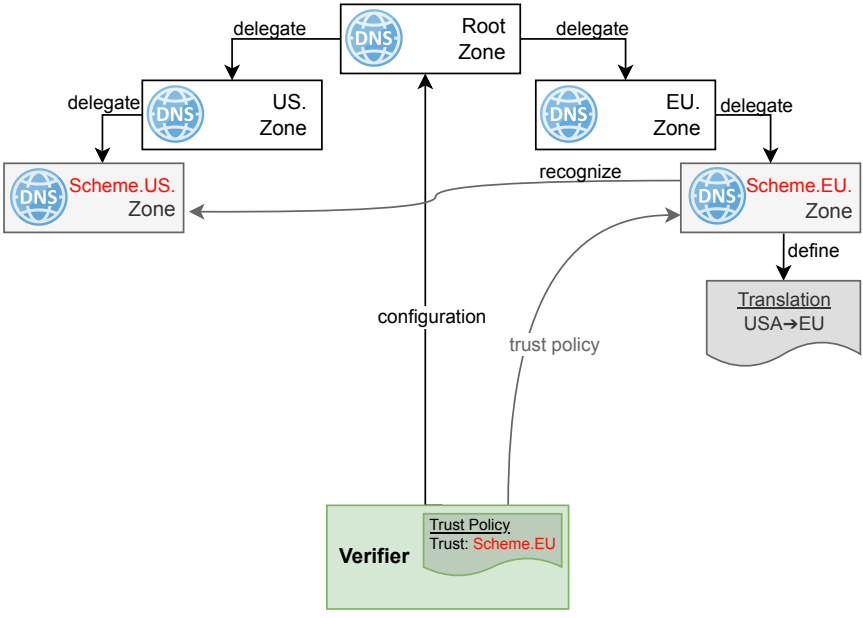
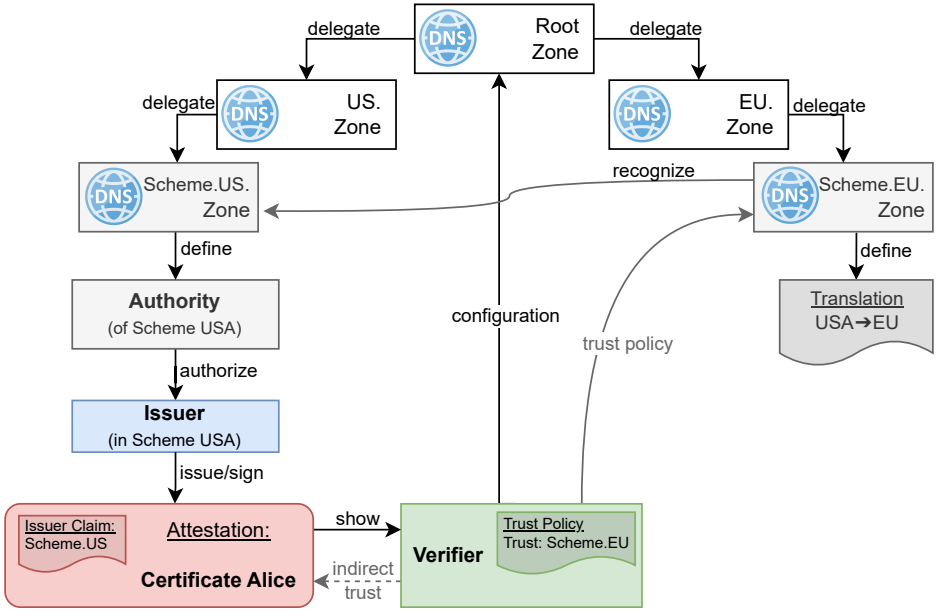
Trust Policy
Trust: EU Scheme


delegate
Global Trust Root
delegate
USA Scheme
recognize
EU Scheme
define
Translation
USA→EU
configuration
trust policy
Verifier
Trust Policy
Trust: EU Scheme


delegate
Root Zone
delegate
delegate
US. Zone
delegate
EU. Zone
delegate
Scheme.US. Zone
recognize
Scheme.EU. Zone
define
Translation USA→EU
configuration
trust policy
Verifier
Trust Policy
Trust: Scheme.EU


delegate
Root Zone
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delegate
US. Zone
delegate
EU. Zone
delegate
recognize
Scheme.US. Zone
Scheme.EU. Zone
define
define
Authority
(of Scheme USA)
Translation
USA➔EU
configuration
trust policy
authorize
Issuer
(in Scheme USA)
issue/sign
Issuer Claim:
Scheme.US
Attestation:
Certificate Alice
show
indirect
trust
Verifier
Trust Policy
Trust: Scheme.EU

Discussion

- Governance
  - eIDAS Article 14
  - DNS / DNSSEC (ICANN/IANA)
  - LIGHTest provides legal framework: [GJ19]

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  - DNS / DNSSEC (ICANN/IANA)
  - LIGHTest provides legal framework: [GJ19]

- Requirements Evaluation
  - 🔨 DNS governance for legal *liability*
  - ☑ Support for different scheme types
  - ☑ Single cryptographic root

Publications

DNS-based Trust Scheme Publication
+ Trust Recognition + Trust Translation

Wagner, G., Wagner, S., **More, S.**, Hoffmann, M., "DNS-based Trust Scheme Publication and Discovery". In: *Open Identity Summit*. 2019

More, S. "Trust Scheme Interoperability: Connecting Heterogeneous Trust Schemes". In: *ARES*. 2023

Going global in a heterogeneous world:

- ☑ Complex transactions: many credentials
- ☑ Multiple issuers, qualified in different schemes

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  - Need to enable verifiers to define their own trust rules

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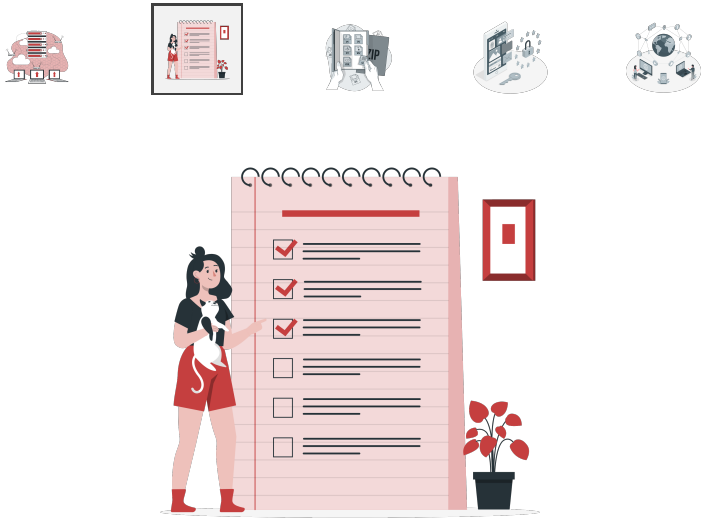

TPL: Trust- & Access-Policies

Example rule:

Accept any application
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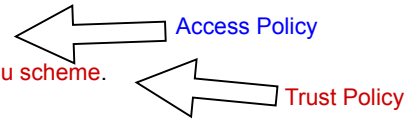
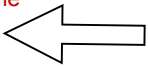


Motivation / Goals

Example rule:

Accept any application
from CS master-level graduates
with a diploma qualified in EU-Edu scheme
or any scheme recognized by EU-Edu.



Trust Recognition/Translation

Example rule:

Accept any application
  from CS master-level graduates
  with a diploma qualified in EU-Edu scheme
  or any scheme recognized by EU-Edu
and a recommendation letter
  issued to the same student
  by a person qualified in the EU-Sci scheme.

} Second Credential
with Inter-credential constraint

The *TPL* System

The ***TPL* Trust- and Access-Policy System**:

Enable Service Providers to encode their own rules

The *TPL* System

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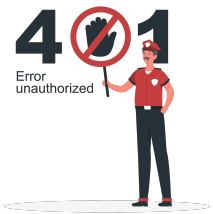

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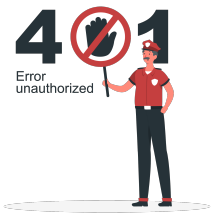

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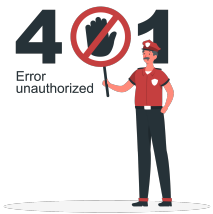
  - Predicates (use-case: integration with SSI)

The *TPL* System



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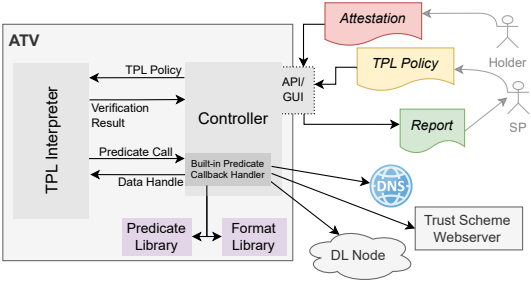
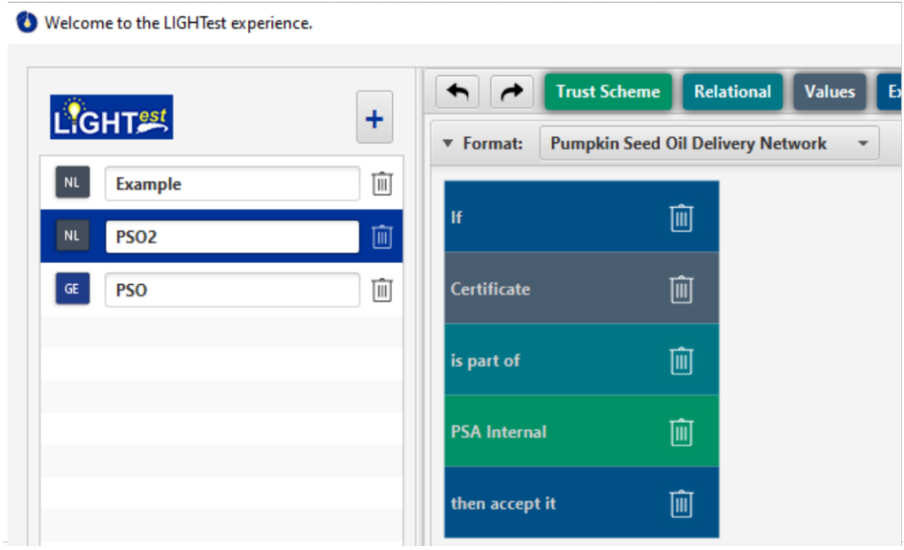
TPL Components

- TPL Policy Language
- TPL Interpreter
- Automated Trust Verifier (ATV)



Bonus: graphical *TPL* editor



Publications

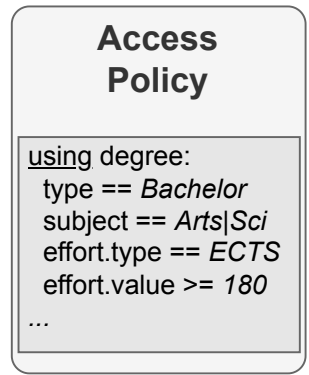
Mödersheim, S., Schlichtkrull, A., Wagner, G., **More, S.**, Alber, L., "TPL: A Trust Policy Language". In: *IFIPTM*. 2019

Alber, L., **More, S.**, Mödersheim, S., Schlichtkrull, A., "Adapting the TPL Trust Policy Language for a Self-Sovereign Identity World". In: *Open Identity Summit*. 2021

More, S., Alber, L., "YOU SHALL NOT COMPUTE on my Data: Access Policies for Privacy-Preserving Data Marketplaces and an Implementation for a Distributed Market using MPC". In: *ARES*. 2022

Going global in a heterogeneous world

Problem: Different Credential Schemata



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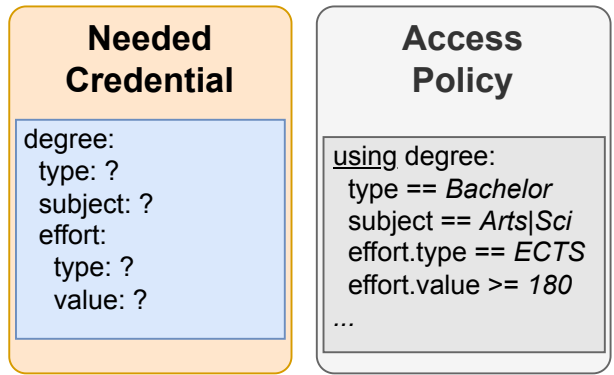

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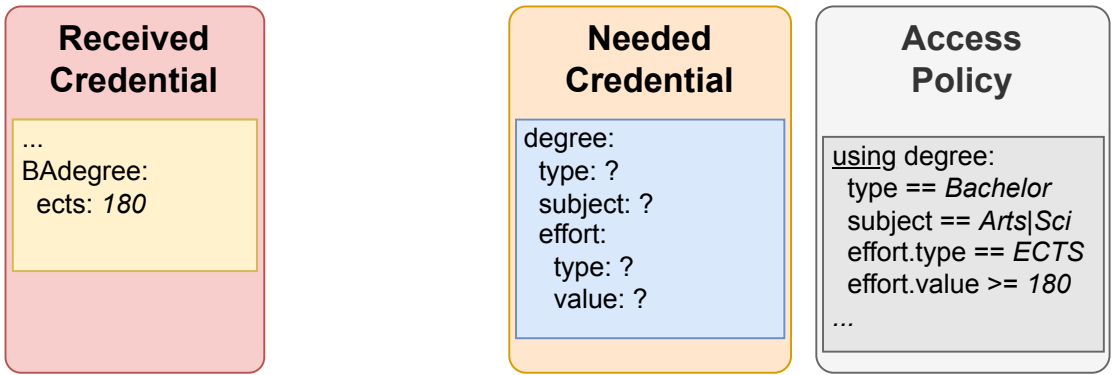
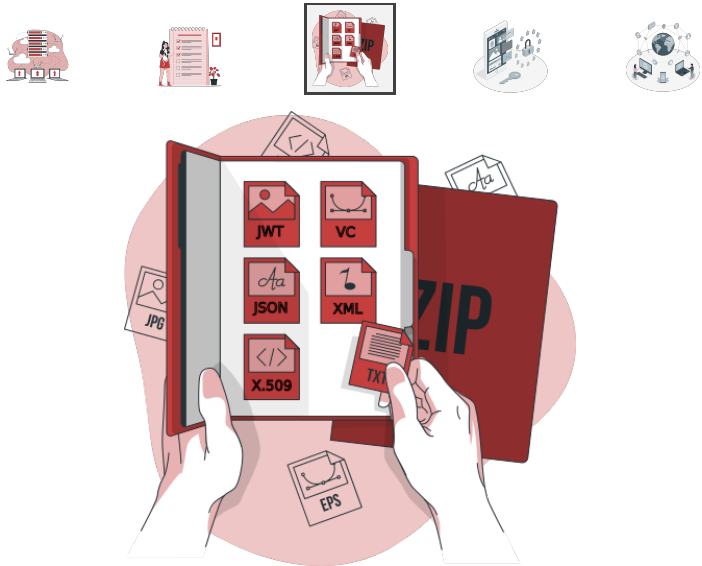
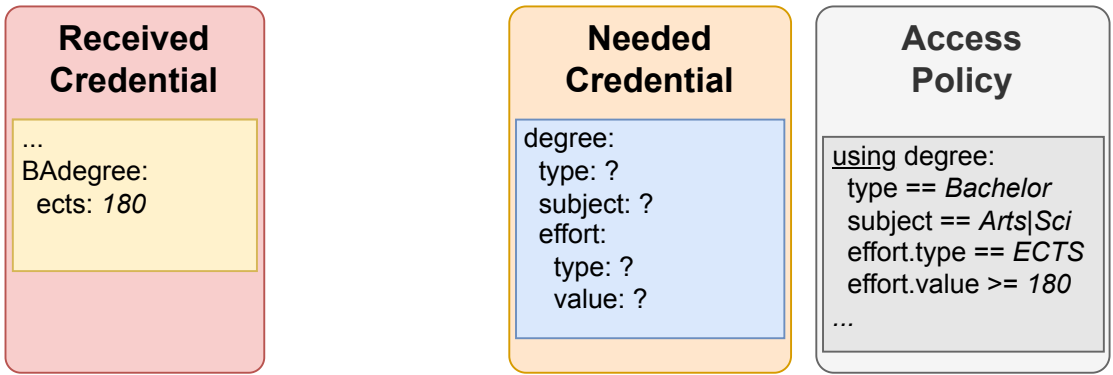




Credential Format Interoperability

Going global in a heterogeneous world

Problem: Different Credential Schemata



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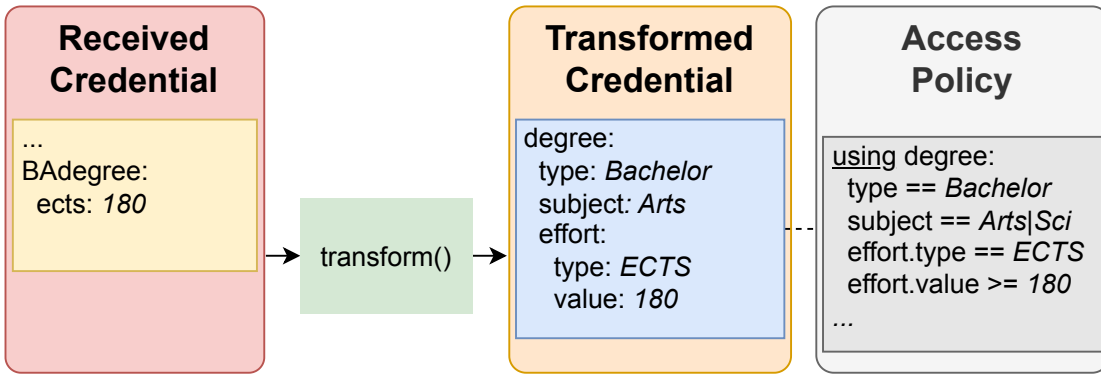

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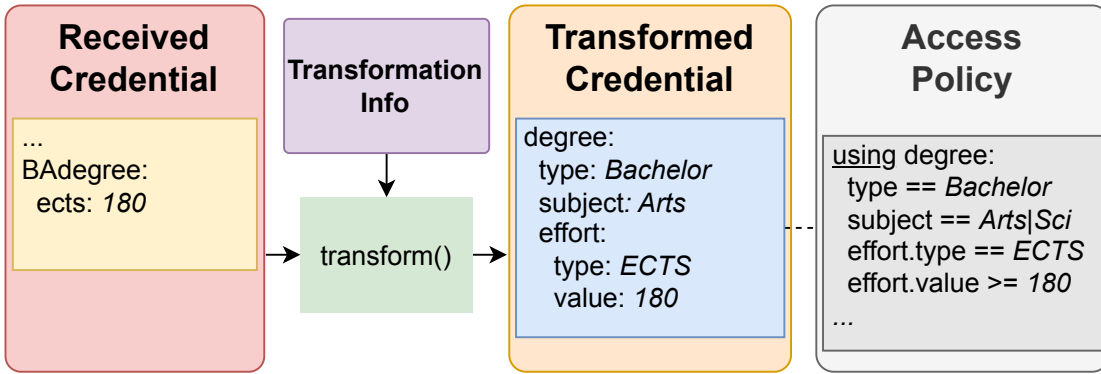
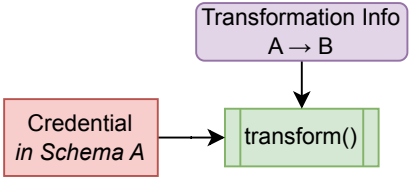


Trusted Credential Transformation



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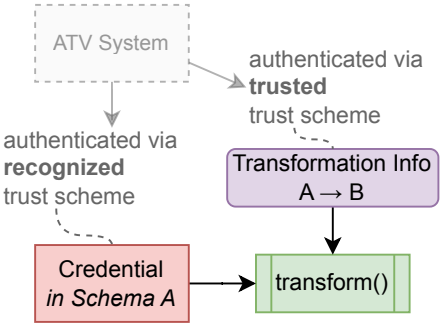

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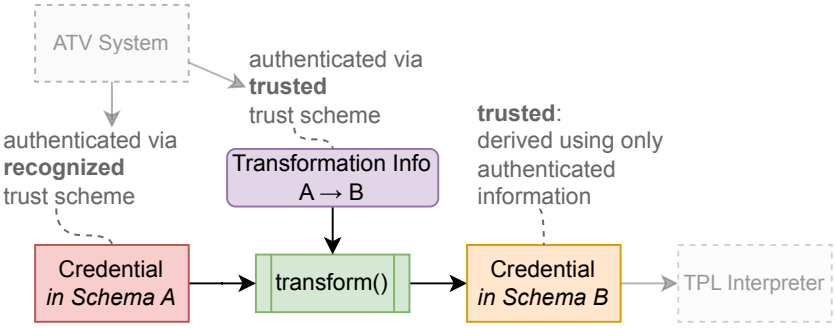
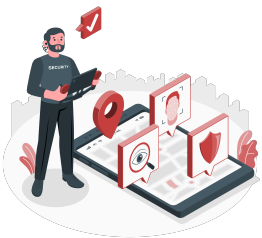


Publication

More, S., Grassberger, P., Hörandner, F., Abraham, A., Klausner, L. D., "Trust Me If You Can: Trusted Transformation Between (JSON) Schemas to Support Global Authentication of Education Credentials". In: *SEC*. 2021



Going global in a heterogeneous world:

- Service Provider is happy about trustworthy information
- What about the User?

Trust and Privacy

Computers

- Computers are omnipresent and interconnected
  - $\Rightarrow$ A lot of sensitive data
  - Behavior, medical, political preferences, personality profiles, ...

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Various actors (mis-)use these data, e.g.

- Targeted advertising
- Surveillance capitalism
- Disinformation campaigns

Privacy

Privacy (noun):

- from Latin *Privatus*: what is private

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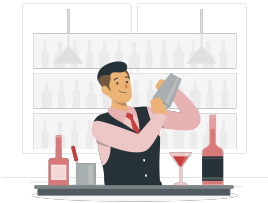
Privacy is a right!

European Convention on Human Rights (Article 8):
Everyone has the right to respect for his private and family life, his home and his correspondence.



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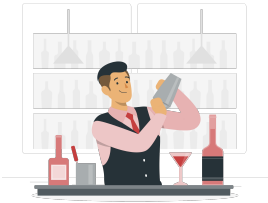

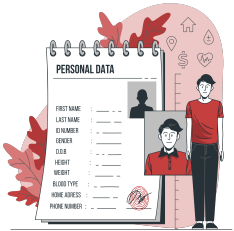

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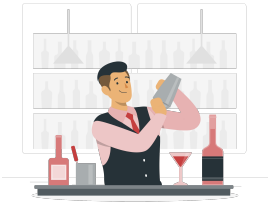

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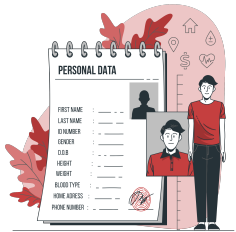


A lot of data revealed

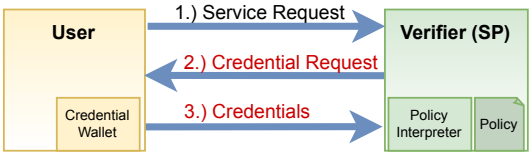
Privacy !?

Privacy-enhanced Access Policies

Privacy in Access Control: Challenges

Privacy:

- To prove they fulfill a policy, users need to send full credentials and reveal all attributes



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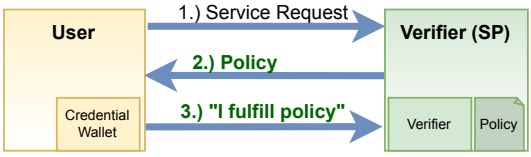

Background: Zero-knowledge Proofs

(Non-interactive) Zero-knowledge Proof:

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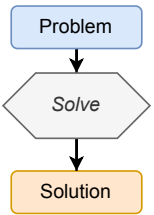

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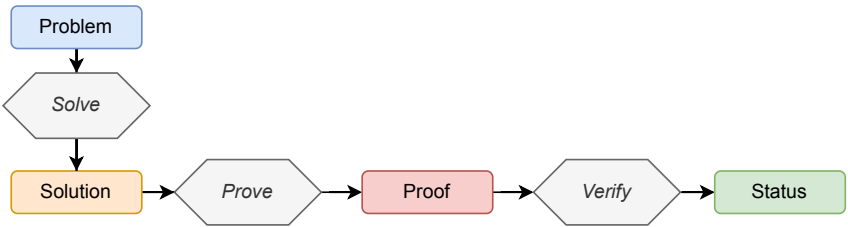

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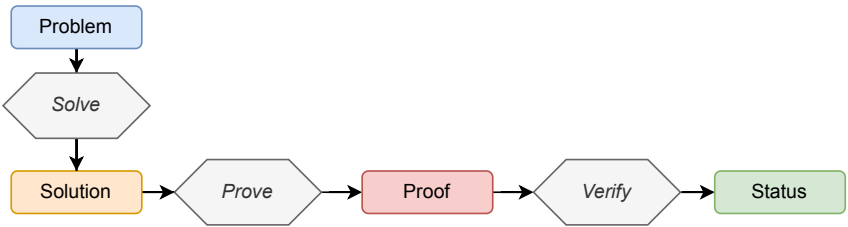
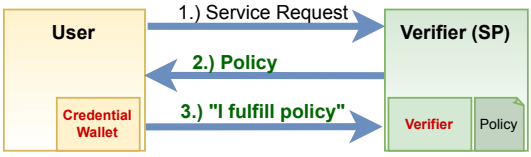


We extend policy language systems
with privacy features using zero-knowledge proofs.

Privacy in Access Control: Challenges

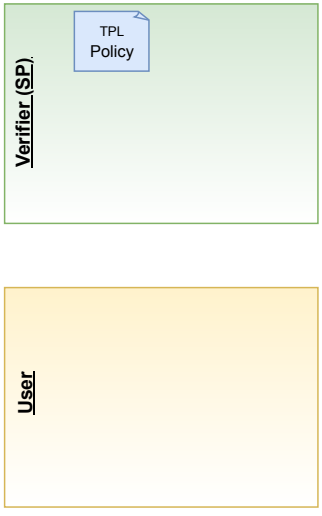


Integration Gap:

- Use of privacy features with existing technologies

Privacy-preserving Policy System:

1. Policy author defines which attributes need to be revealed (and for which proof of statement is enough)



Contribution

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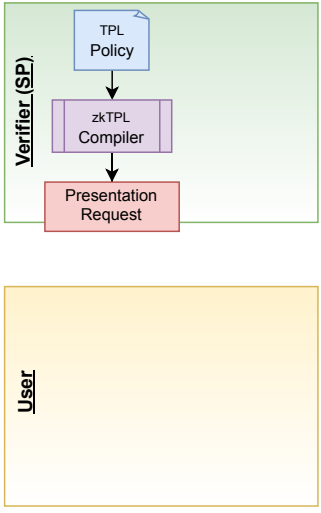

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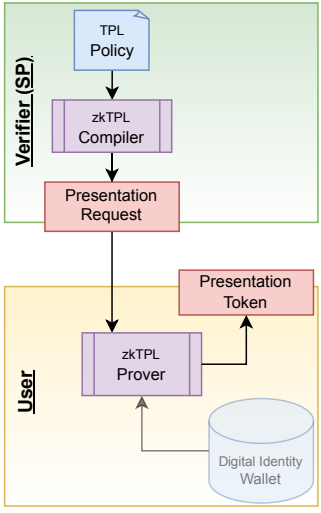

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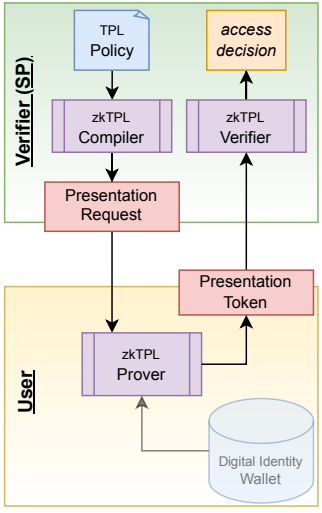

Evaluation

- Performance
  - 2 curves, 2 commitments
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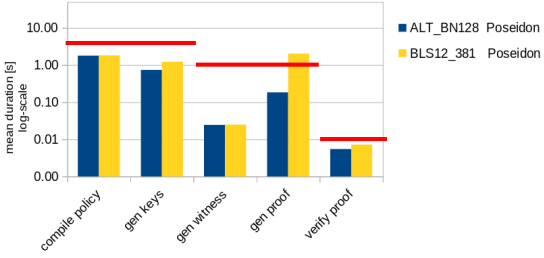

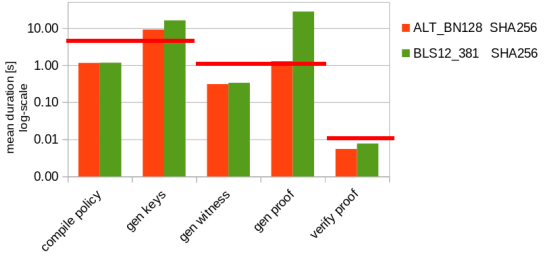

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Evaluation

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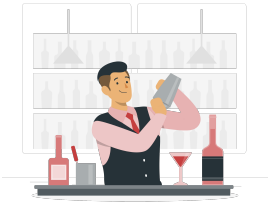
- Future Work
  - Linkability
  - ZKP Setup & NIZK Toolchains
  - Policy Authoring Tools & UX

Publication

More, S., Ramacher, S., Alber, L., Herzl, M., "Extending Expressive Access Policies with Privacy Features". In: *TrustCom*. 2022



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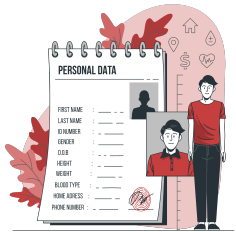
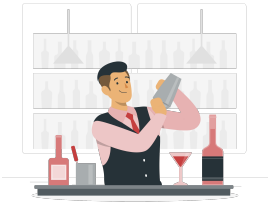


A lot of data revealed

☑ zkTPL



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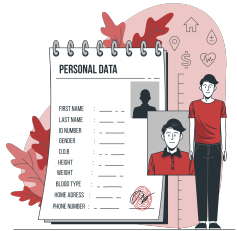

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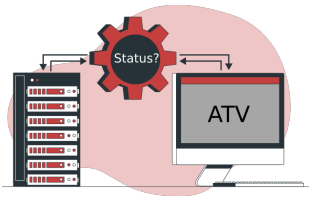

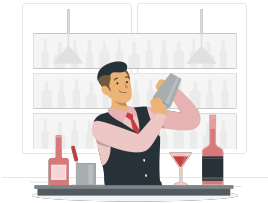

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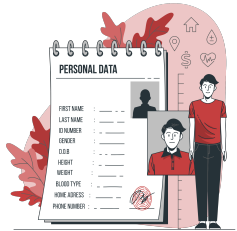

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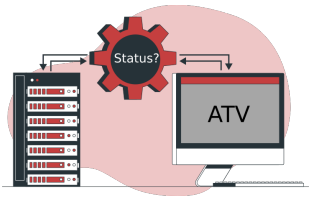

State learns about visit

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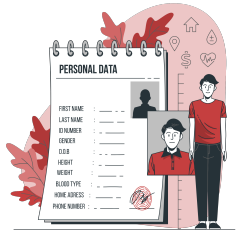

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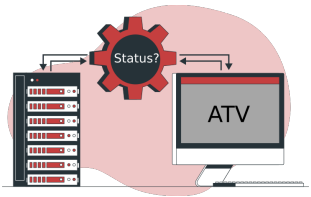

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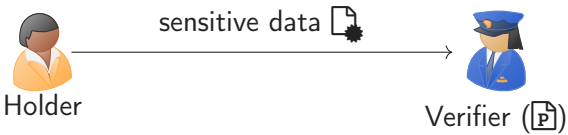
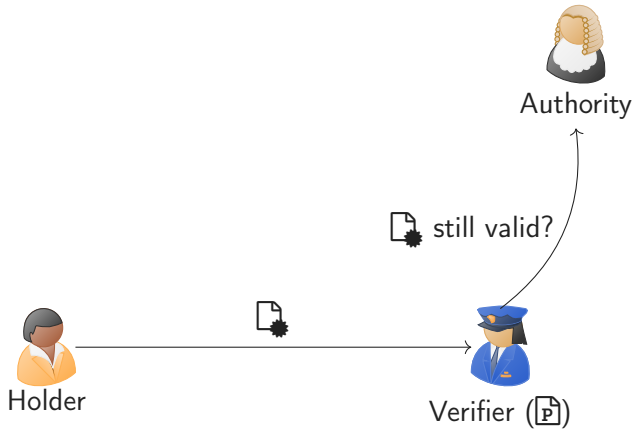
Privacy !?

Ledger State Attestations

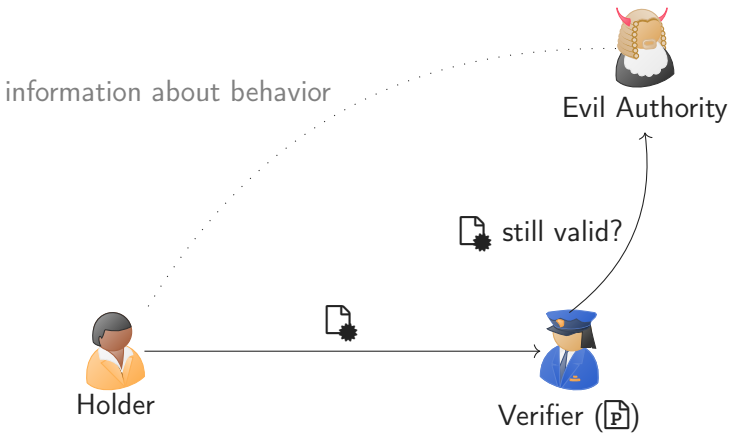
Challenges:





Challenges:

- Verification leaks information about the user's behavior to registry



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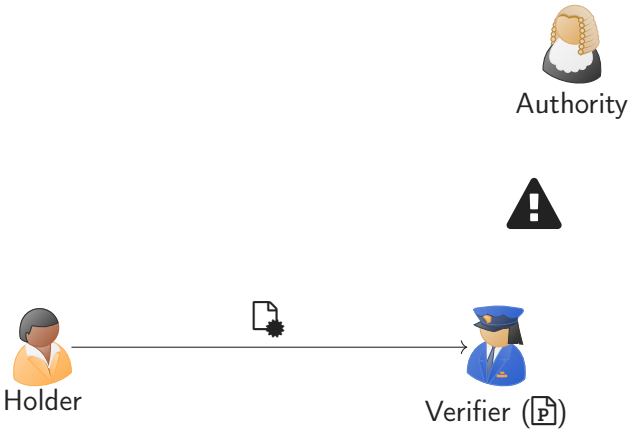

Challenges:

- Verification leaks information about the user's behavior to registry
- Registry might be unavailable
- Verifier needs to be online

Challenge

Status Registry involved in Status checks

Challenge

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Solution: Remove communication between Verifier and DL

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Context: Distributed Ledger-based Registries

Challenge

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Solution: Remove communication between Verifier and DL

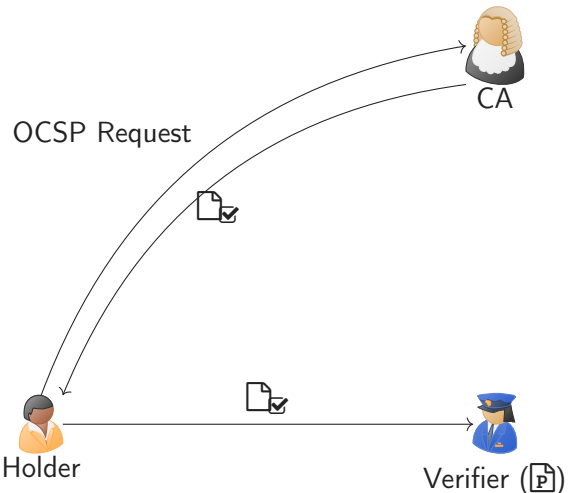
Context: Distributed Ledger-based Registries

Challenges:

- Many DL nodes: Who signs a response/attestation?
- Not just revocation: Need for generic query system

Ledger State Attestations: Concept

Contribution: *We augment DL data to be trustable by an offline verifier.*



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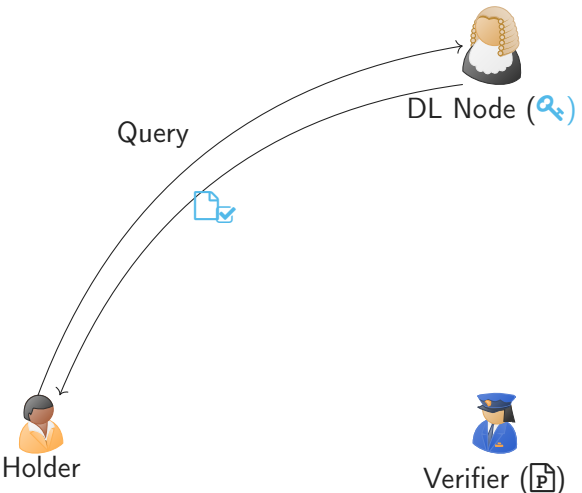

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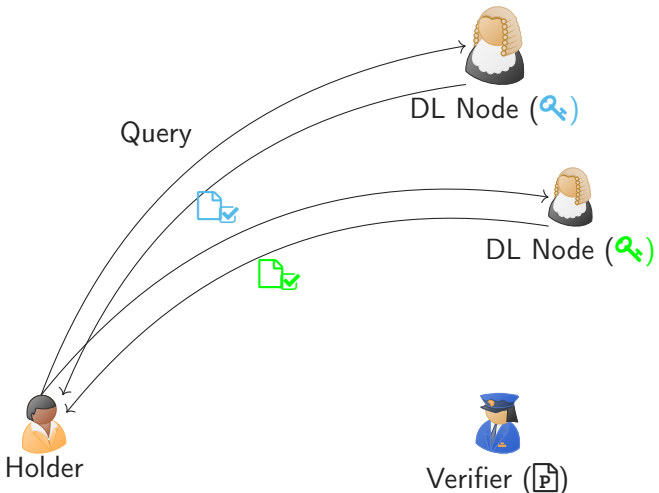

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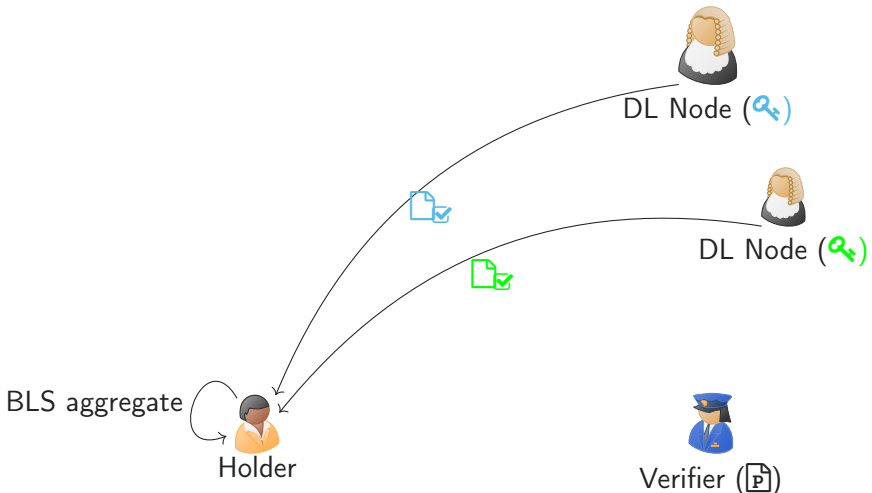

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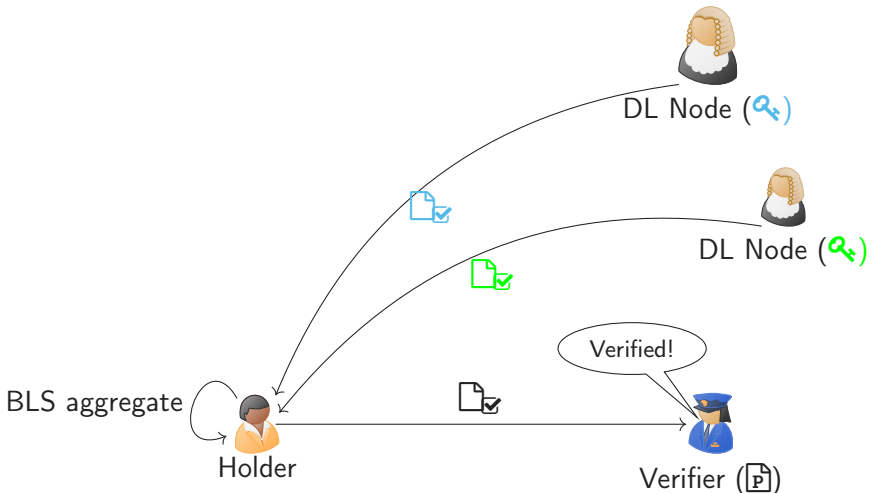

Publication

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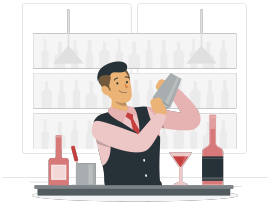

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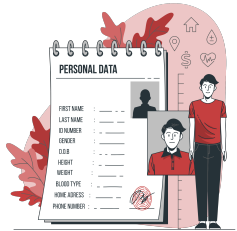

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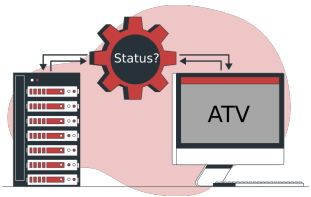

State learns about visit

☑ LSA

Overall Summary

Global
Trust Infrastructure

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TPL Trust- &
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Credential Format
Interoperability

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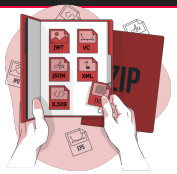

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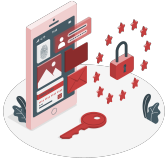

Privacy-enhanced
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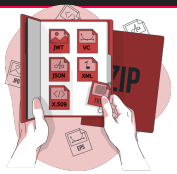
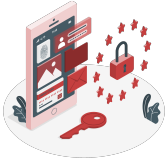
TPL Trust- &
Access-Policies



Credential Format
Interoperability



Privacy-enhanced
Access Policies

Ledger State
Attestations

Contribution Summary

18 Publications

+1 under submission

8 First Author

Contribution Summary

18 Publications

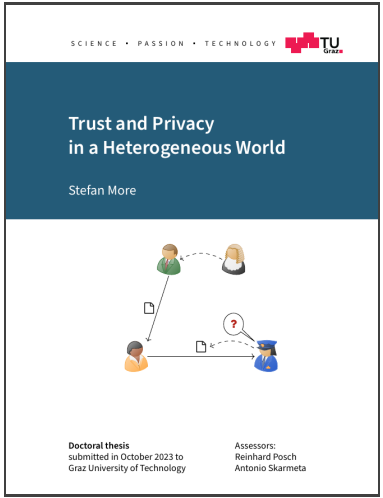
+1 under submission

8 First Author

Service & Community

- PC (OID, ARES SECPID)
- Session Chairing

- 3 Horizon 2020 Projects
- CTF Team Coordinator
- CryptoParty Founder



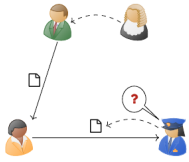
Thank you for your attention!

And your support!

SCIENCE • PASSION • TECHNOLOGY

Trust and Privacy in a Heterogeneous World

Stefan More



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