RSAConference2019
San Francisco | March 4–8 | Moscone Center

BETTER.

SESSION ID: IDY-W02

Zero-knowledge proofs (ZKP): Privacy Preserving Authentication

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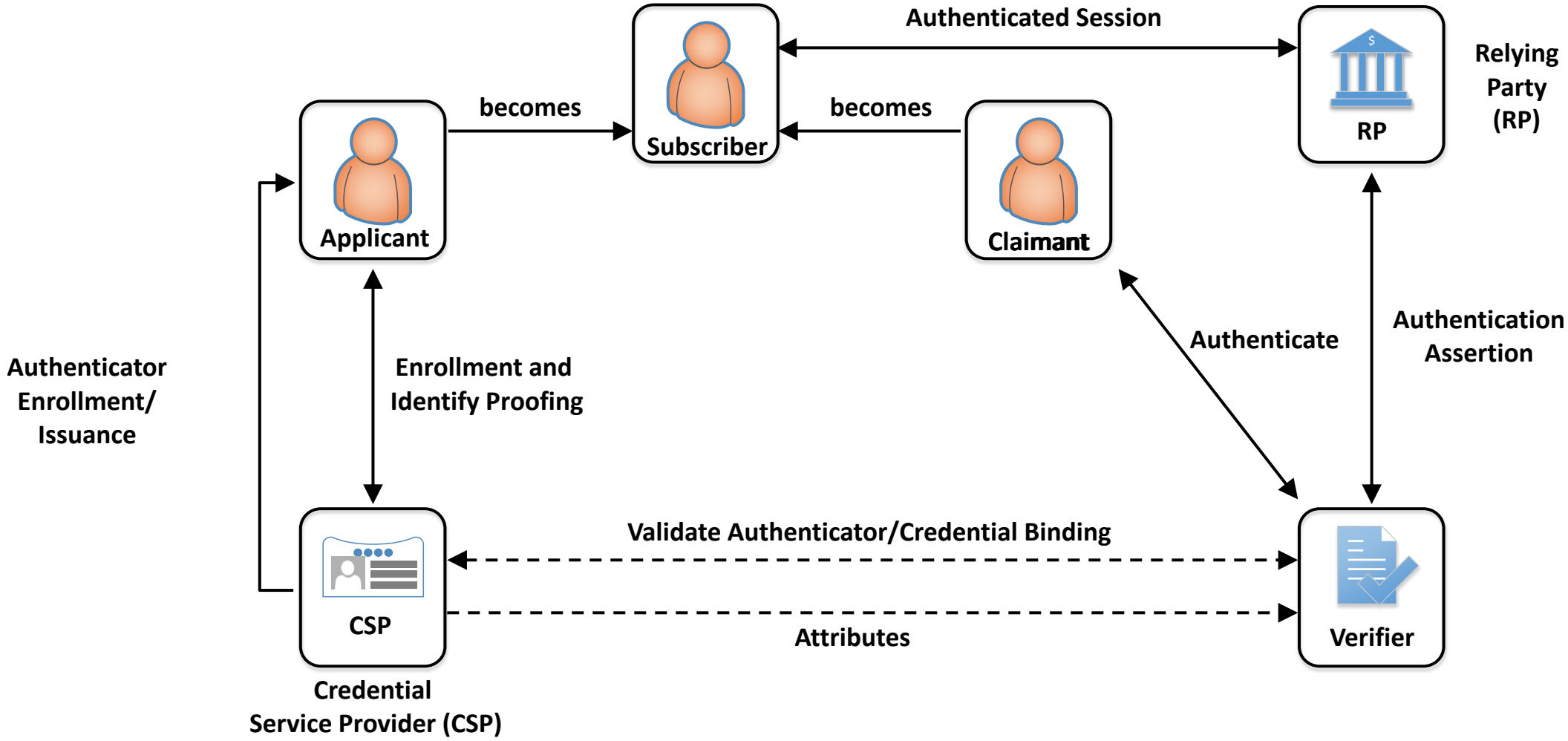
Privacy Preserving Digital Identity

Balancing Personal Privacy with Institutional Integrity

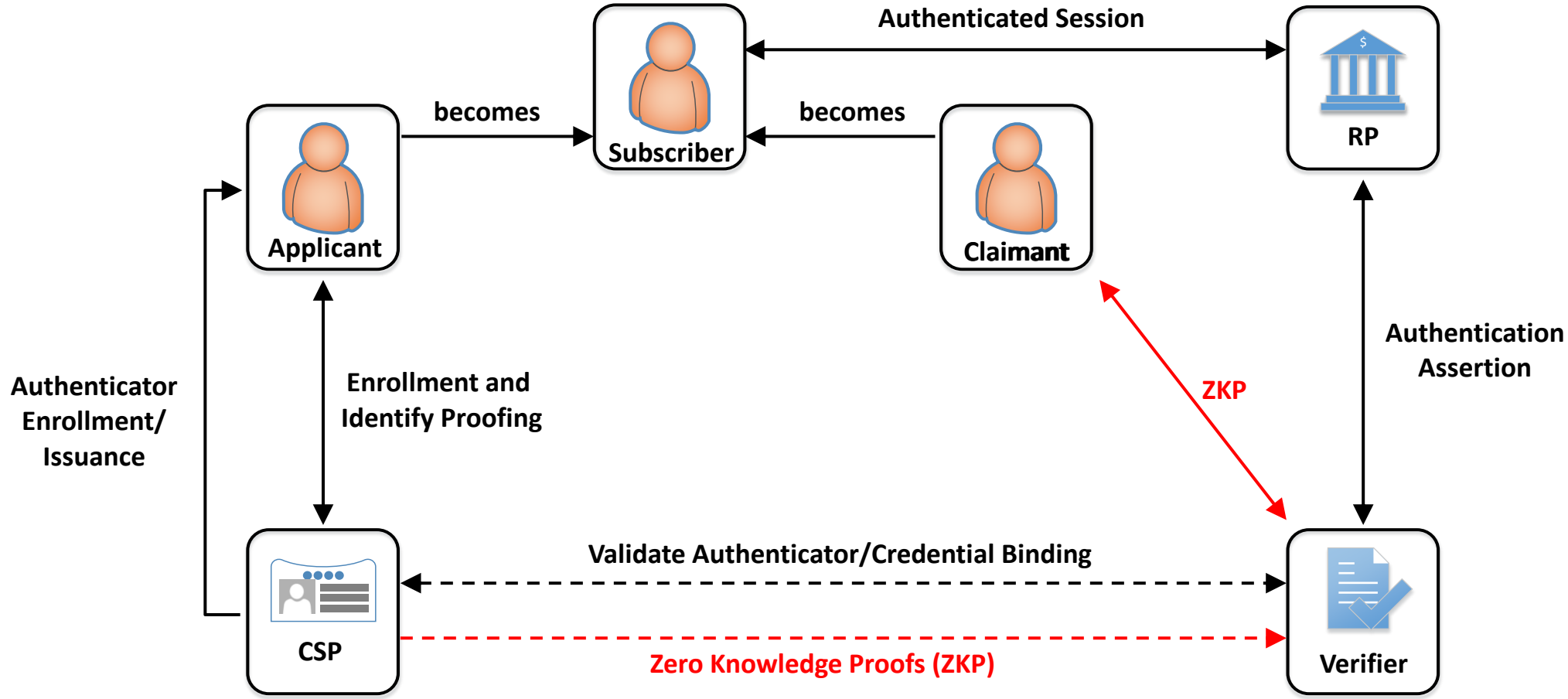
Risks

- Loss of privacy
- Data breaches
- Identity theft
- Surveillance

Digital Identity Model



Privacy Preserving Digital Identity Model



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Zero-Knowledge Proofs

Definition

What is Zero-Knowledge Proof?

- Zero-knowledge proofs are an elegant technique to limit the amount of information transferred from a prover ‘A’ to a verifier ‘B’ in a cryptographic protocol.
  - The idea is to replace "knowledge" by "knowledge about knowledge"

- The name "zero-knowledge proofs" is slightly misleading, since the prover A reveals one bit of knowledge to the verifier B (is input I a member of language L?).
  - *L = interactive proof for the language L*

Zero-Knowledge Proof Properties

ZKP enables:

Completeness

- If statement is true, verifier will be convinced by prover.

Soundness

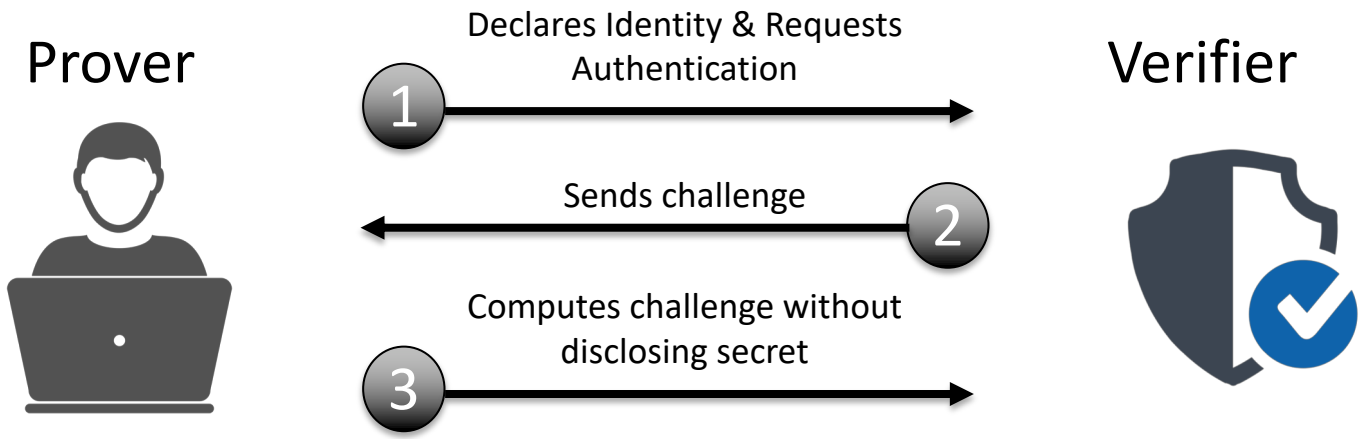
- If statement is false, a cheating prover cannot convince verifier it is true.

Zero-Knowledge

- Verifier learns nothing beyond the statement's validity.

ZKP Usage with Authentication

- Performing authentication without exchanging passwords
- Enterprises can protect proprietary information by sharing proofs about the data without sharing the actual data



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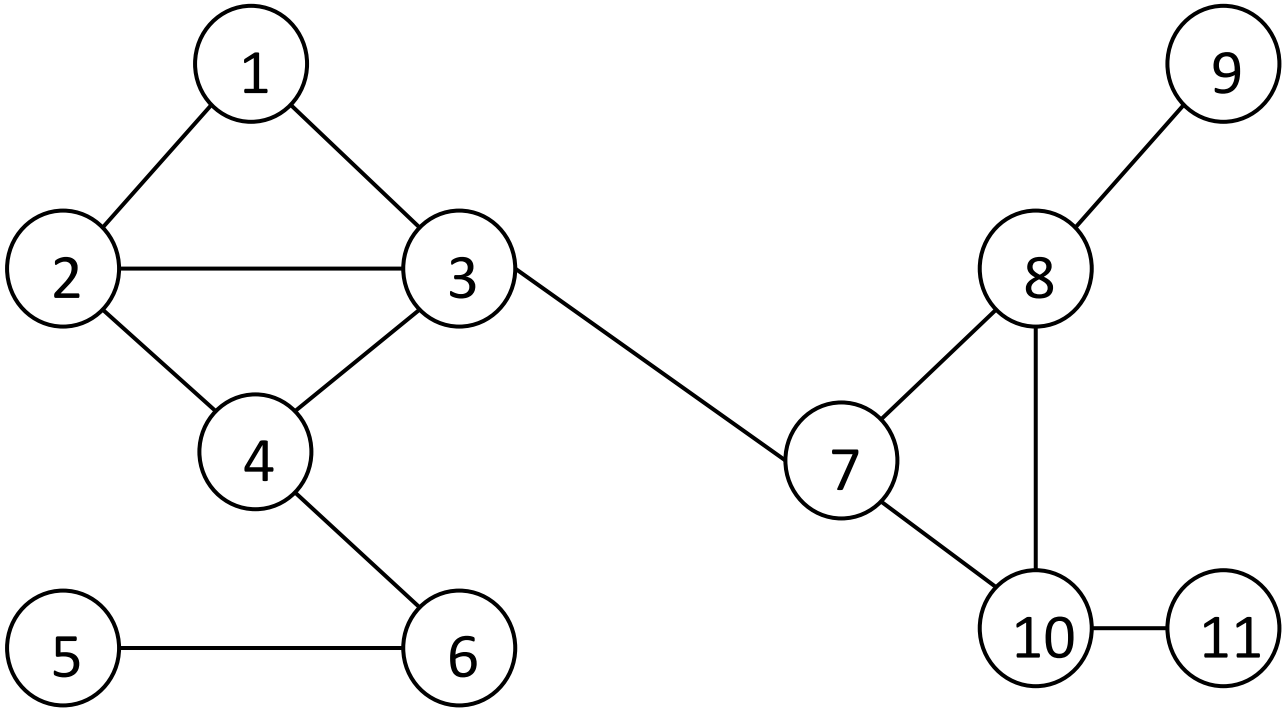
Zero-Knowledge Proof Illustration

Quick Activity!

Zero-Knowledge Proof Illustration

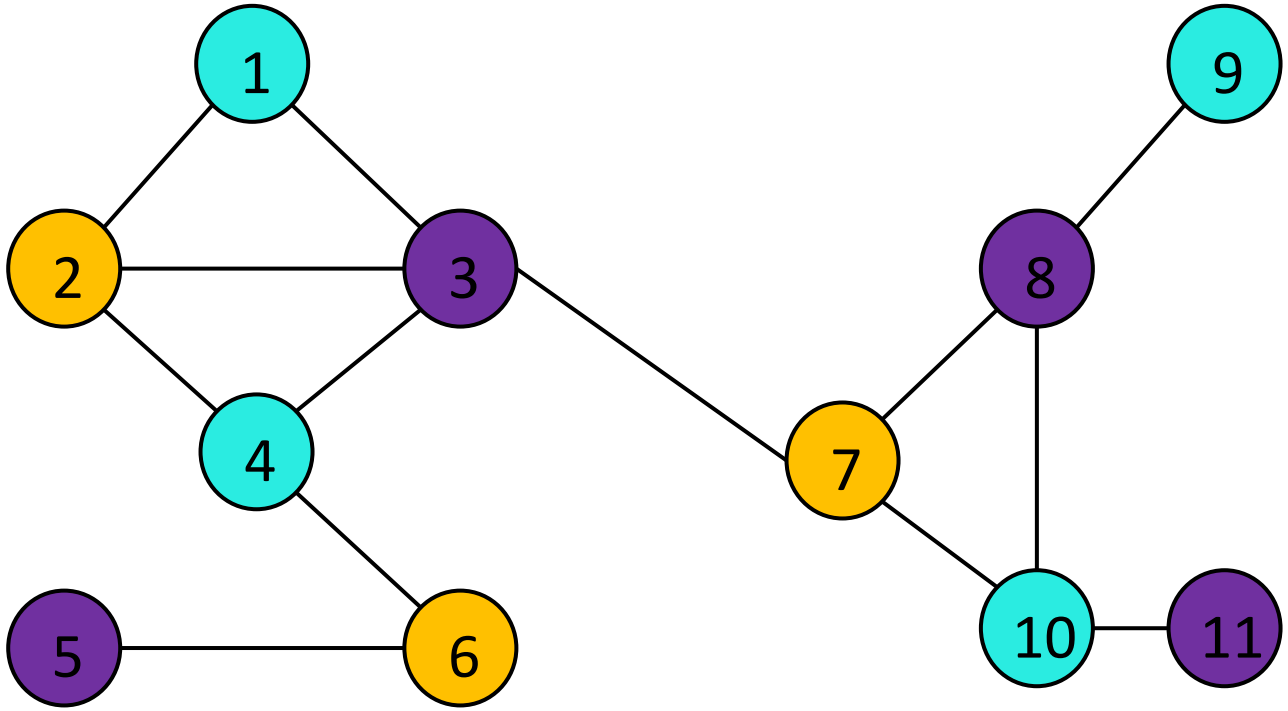
The Challenge:

Mathew Green



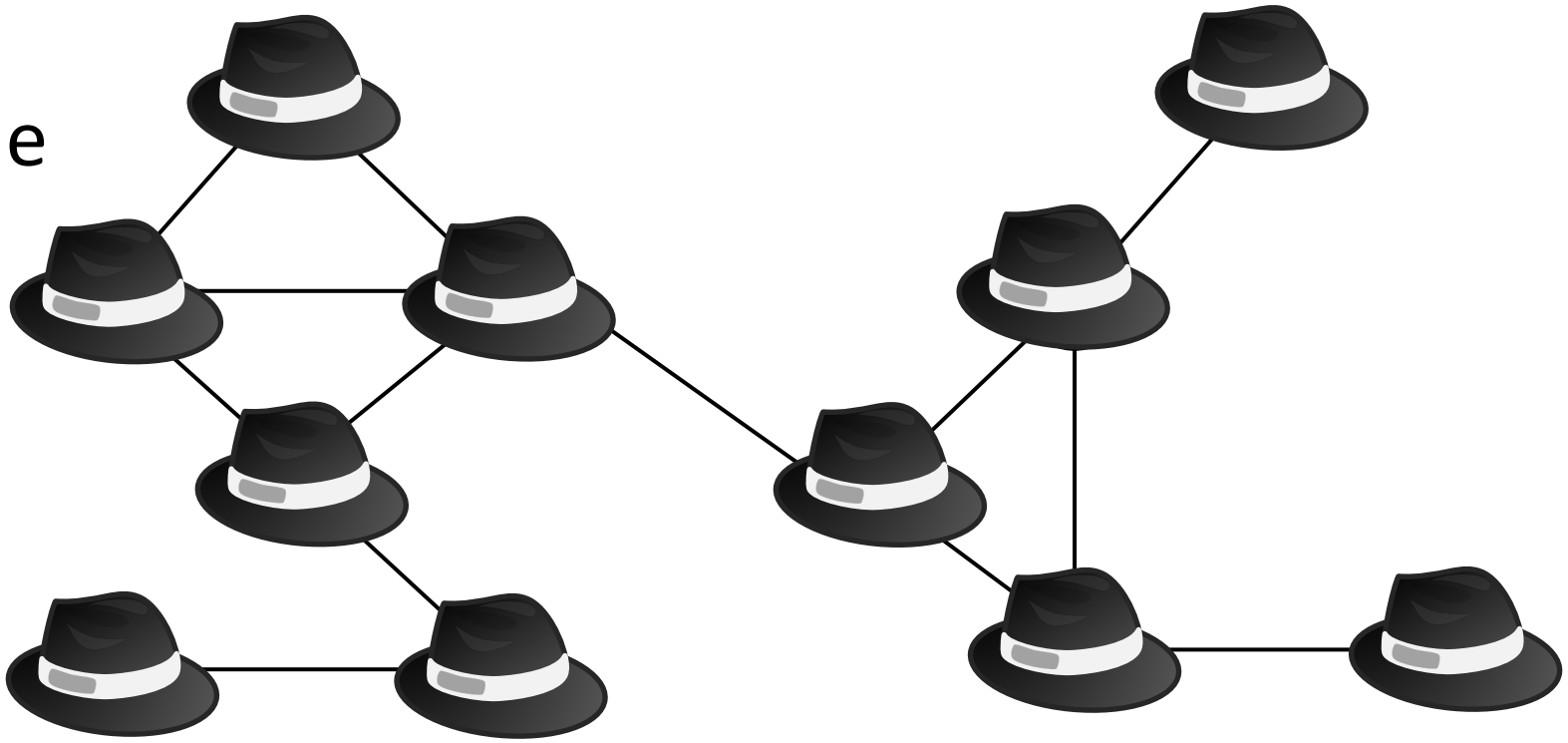
Zero-Knowledge Proof Illustration

The Solution:



Zero-Knowledge Proof Illustration

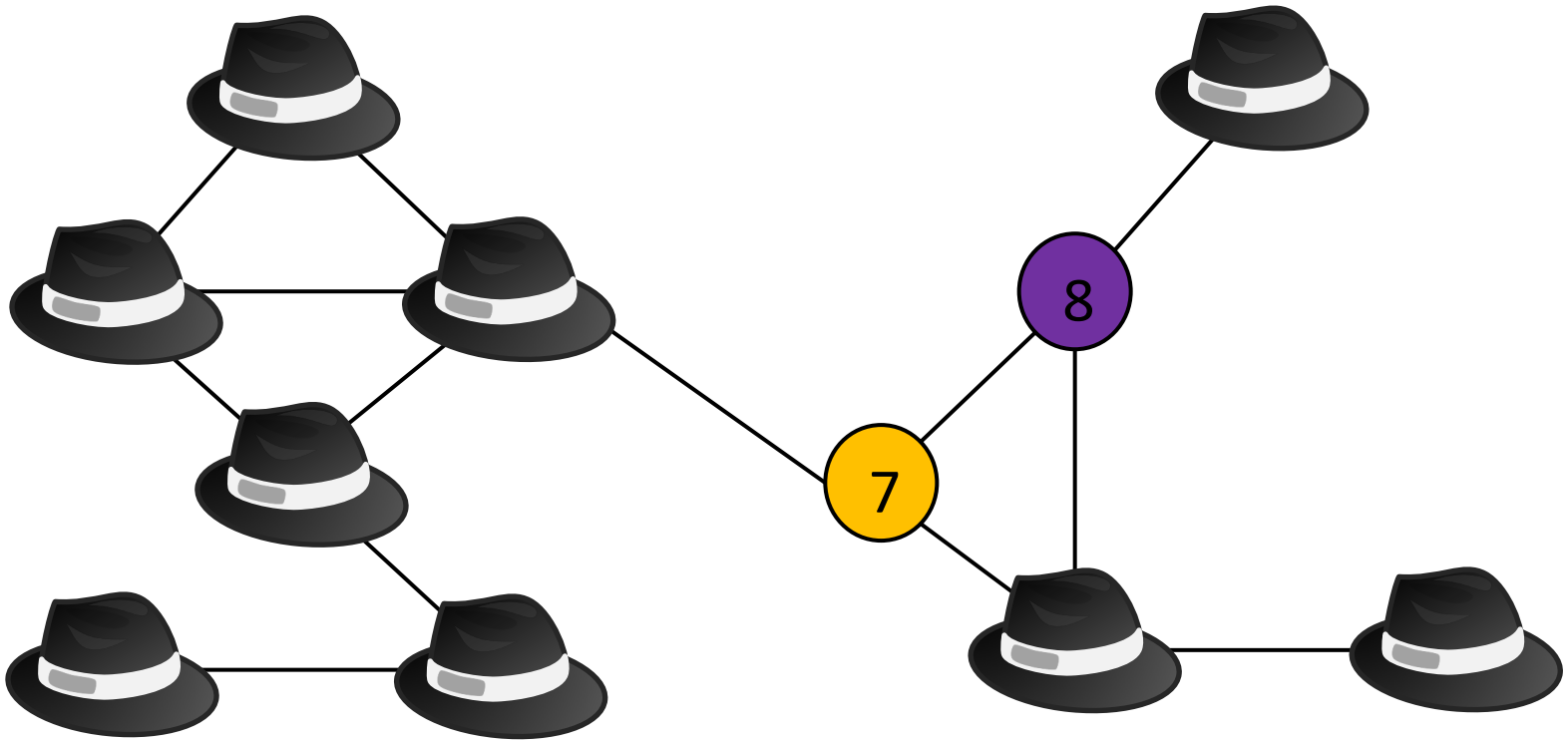
- The hats perfectly covered ‘protects’ the solution



Zero-Knowledge Proof Illustration

Proof of Solution:

- Remove any two hats
- See vertices are different colors



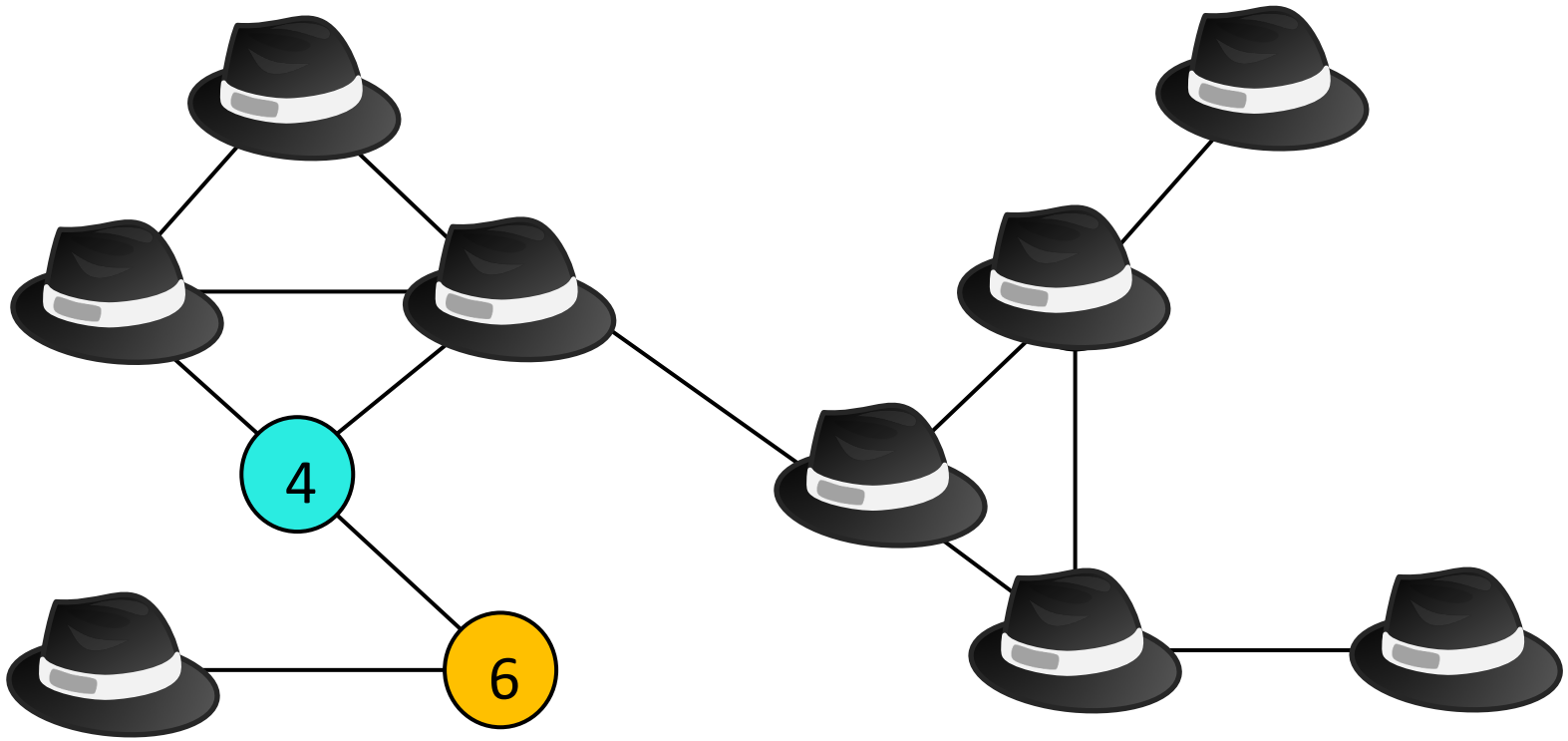
Zero-Knowledge Proof Illustration

Repeat this process:

- Clear previous solution
- Add randomness
- Solve again

Accept or reject:

- Complete for preset number of rounds
- Telecom accepts or rejects



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Zero-Knowledge Proof Variants

Practical Application

Zero-Knowledge Proof Variants

ZKP	Interactive, multiple messages, need stable communication channel
NIZKP	Not interactive, one message
Graph Isomorphism	Interactive, compare graphs, efficient computation
zk-SNARK	Need one-time, trusted setup to generate key at launch
zk-STIK	Scalable Transparent Interactive Oracle of Proof (IOP) of Knowledge
zk-STARK	No setup, working on memory issues, I or NI, post-quantum secure
Designated Verifier	DVNIZK, not just any entity can be verifier, verifier must know secret
Bulletproof	No setup, 188 bytes, 10 ms in some cases, not post-quantum secure
Laticce-Based	Lattice-based cryptography, post-quantum secure, research

Zero-Knowledge Proof Practical Application

Where to apply ZPK:

- Authentication
- Messaging
- Secure Sensitive Information (PCI Data)
- Data Sharing
- File System Control
- Storage Protection

Zero-Knowledge Proof : Use Cases

- ING is a Netherlands based bank
- Experian
- UK citizens using the GOV.UK

Zero-Knowledge Proof : Technology Landscape

MIRACL

KRIPTAN

Microsoft UProve

Velix.ID

NUGGETS

SEDICCII

SOVRIN

STRATUMN

IBM

Val:ID

NuID

QEDit

PEER MOUNTAIN

CIVIC

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Considerations

Potential Challenges

Zero-Knowledge Proof Considerations

- Transparent
- Universal
- Compliant with upcoming ZKP Standards
- Interactive, non-interactive
- Secure (threat model)
- Post-quantum secure

Zero-Knowledge Proof Challenges

- Low usability
- Expensive
- Requires high compute power

Zero-Knowledge Proof Application

- Assess use cases for privacy preserving authentication and authorization
- Evaluate and perform a POC with a ZKP Identity landscape solution
- Protect identities using ZKP

Questions

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References

Stand on the Shoulders of Giants

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