UNIVERSITY OF TWENTE.

Private Sharing of IOCs and Sightings

(short paper)

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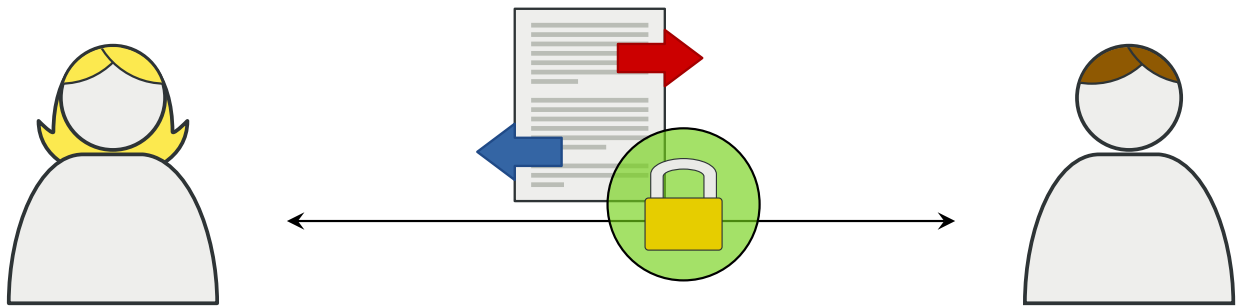
Workshop on Information Sharing and Collaborative Security, 2016

What This Talk Is About: Private Information Sharing

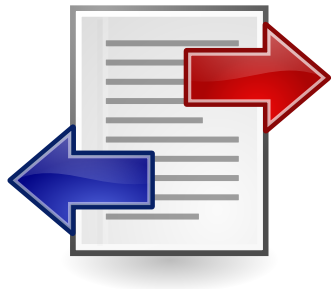


- Privacy-enhanced information sharing
- Simple & existing cryptographic techniques
- Proof-of-concept implementations

Information Sharing in Practice

Clear benefits

- Quicker detection
- Better protection
- Improved situational awareness



Challenge: Sensitive Data

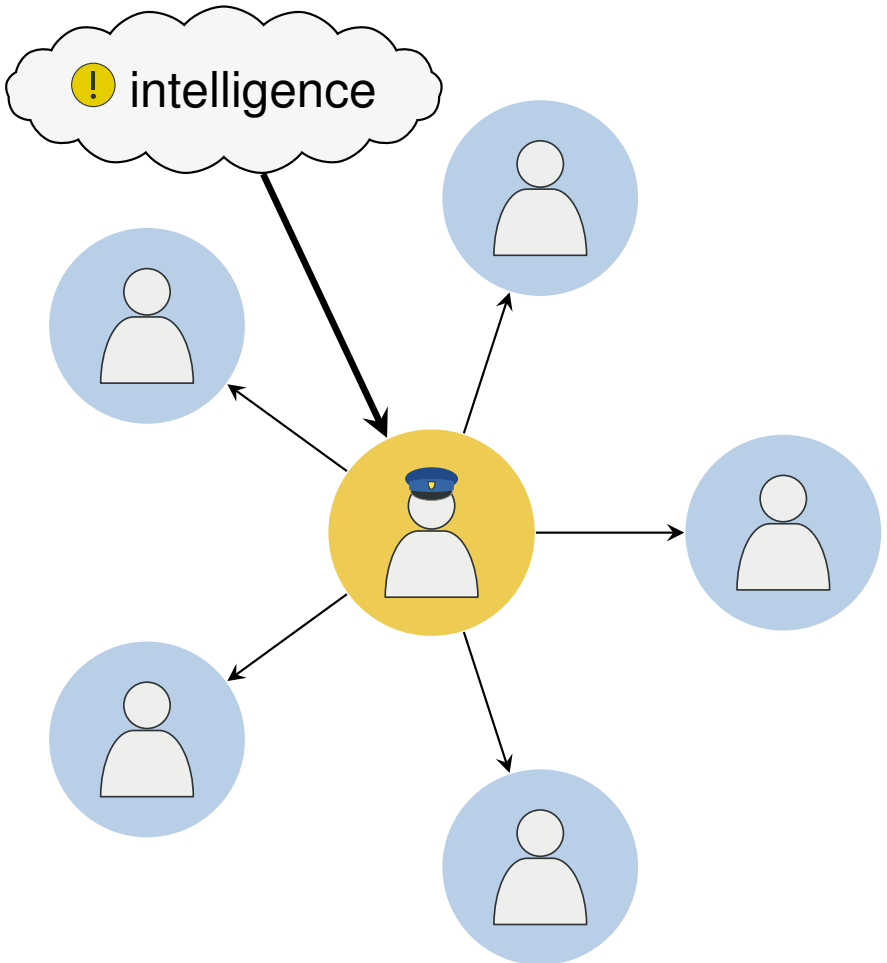
Information leakage due to

- information shared with a compromised party
- freedom of information laws

Leads to

- reputation damage
- notifying and informing attackers

Information Sharing via the Source–Subscriber Model



Source
CERT or
anti-virus company

Subscriber
critical infrastructure
or other company

Type of Security Information Shared by a Source

Source (e.g., CERT or anti-virus company)

Indicators of Compromise (IOCs)
Description of potentially malicious observables using features (IP address, hash of a malicious file, . . .).

Examples (Indicator of Compromise)

- `fileHash = bbd758d9b26404d9b28957af865d1234`
- `(destIP = 198.51.100.43) ∧ (destPort = 80 ∨ destPort = 443)`

Course of Action (COA)
Measures to be taken to address a specific threat.

Example (Course of Action)

If IOC #2043 is matched, kill process *x* and remove files *y* and *z*.

Type of Security Information Shared by a Subscriber

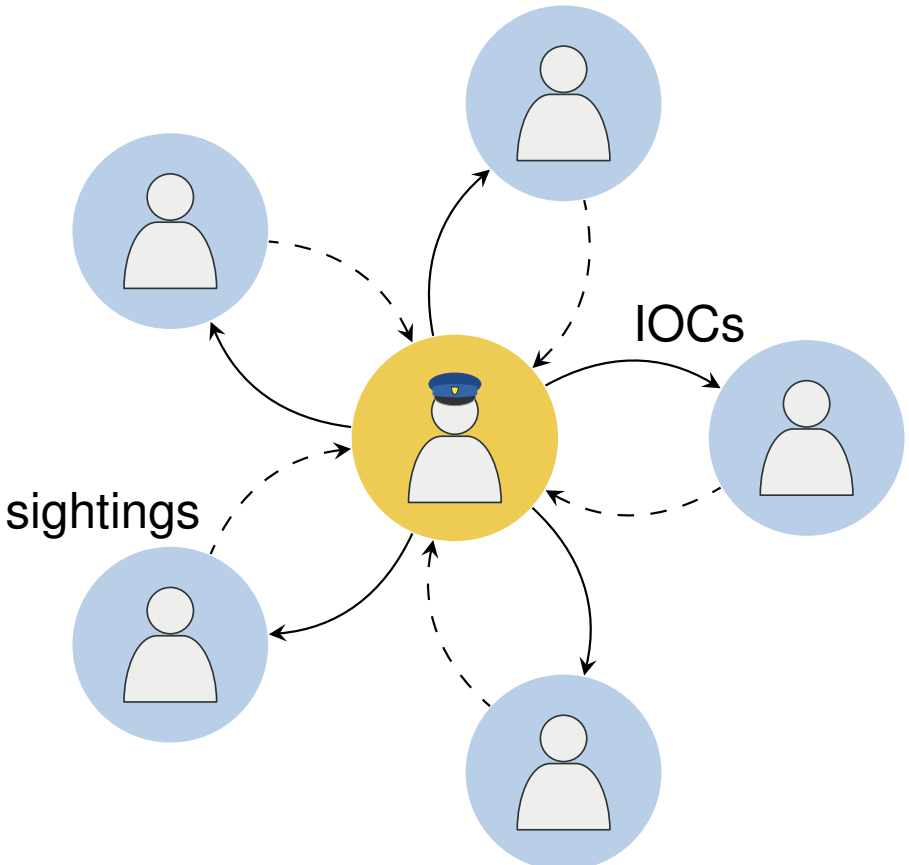
Subscribers (e.g., critical infrastructures or other companies)

Sightings
Report of a matched IOC: The observables match the pattern described in the IOC.

Example (Sighting)

In the previous hour, IOC #175 matched 2 times against our network traffic.

Information Sharing via the Source–Subscriber Model



Source
CERT or
anti-virus company

Subscriber
critical infrastructure
or other company

Indicator of Compromise

- IP address
- malicious software hash
- . . .

Sighting
Report of a matched IOC

Why Do We Need Private Information Sharing?

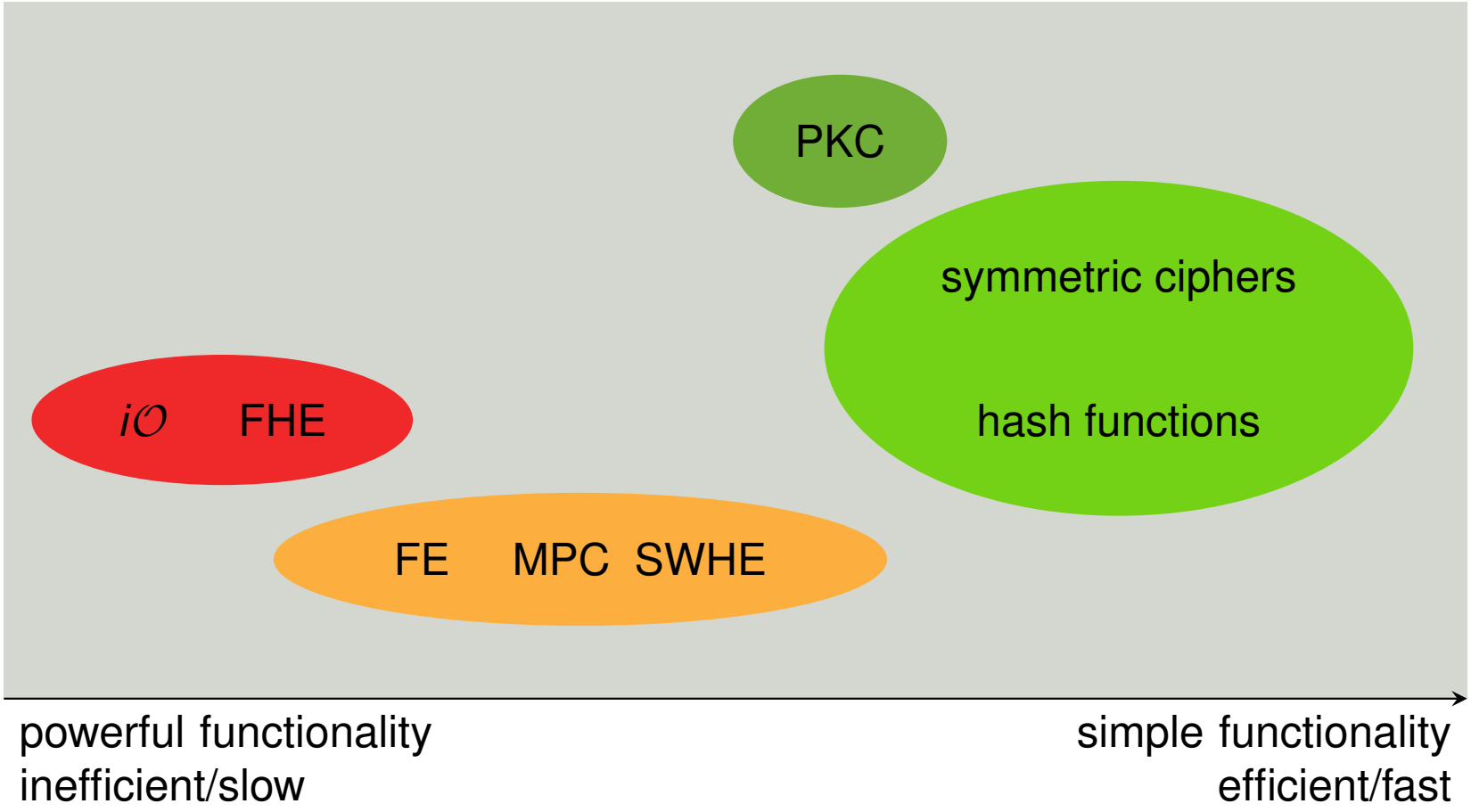
Source (e.g., CERT or anti-virus company)
shares IOCs and COAs

- Prevent attackers from learning the detection technique
- Protect the intellectual property of an anti-virus company

Subscribers (e.g., critical infrastructures or other companies)
share sightings

- Prevent attackers from learning they are detected
- Avoid reputation damage

Private Information Sharing through Cryptography



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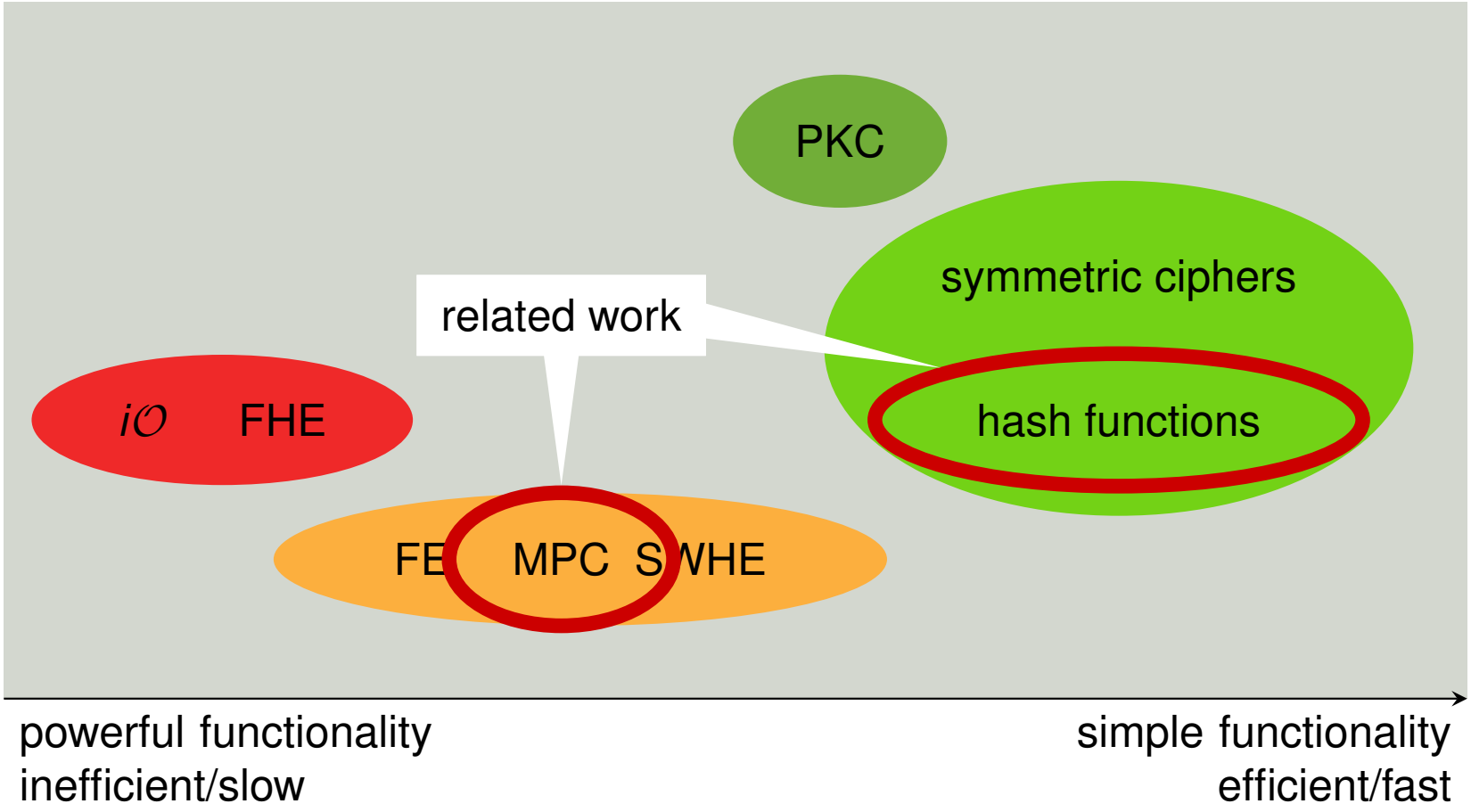
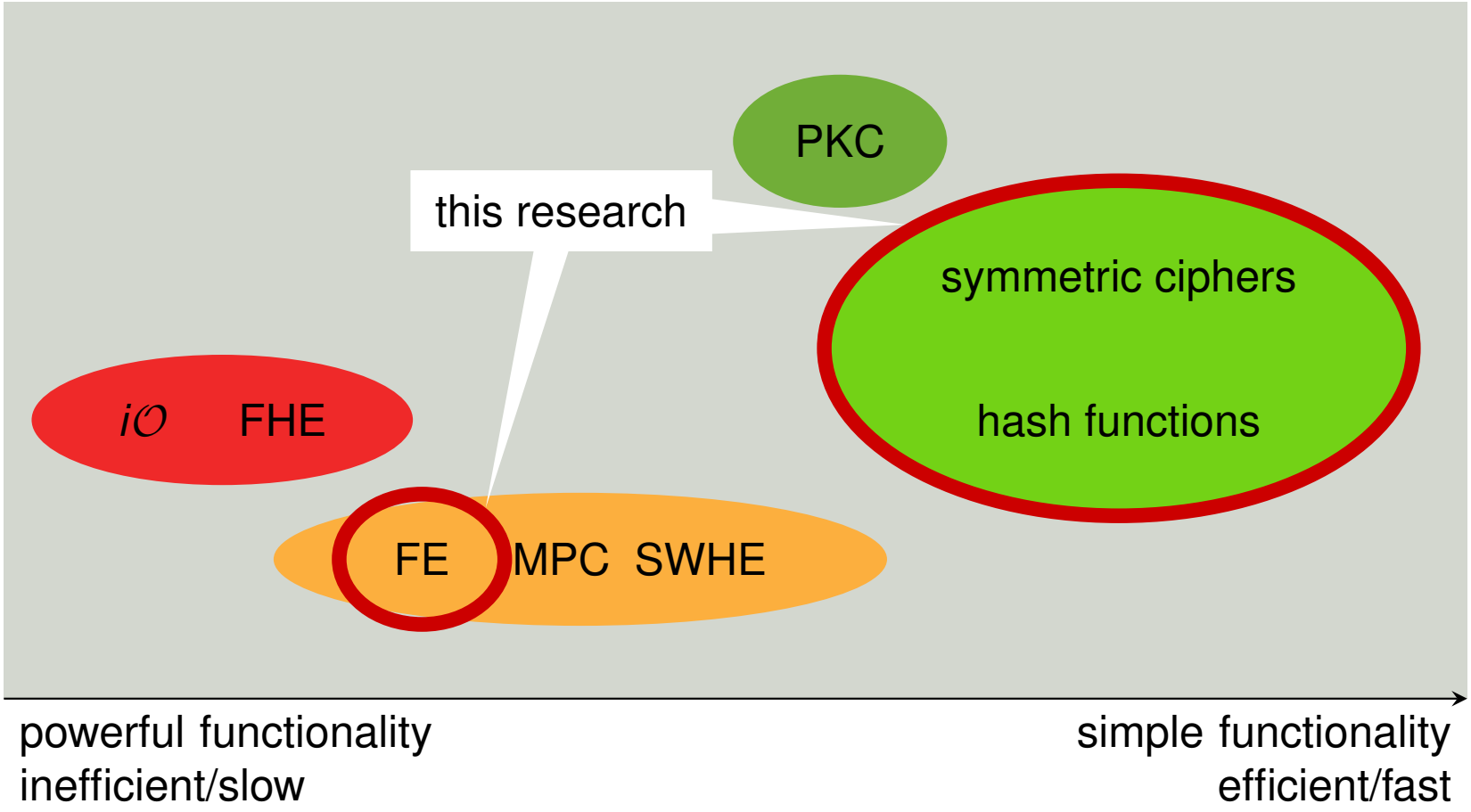
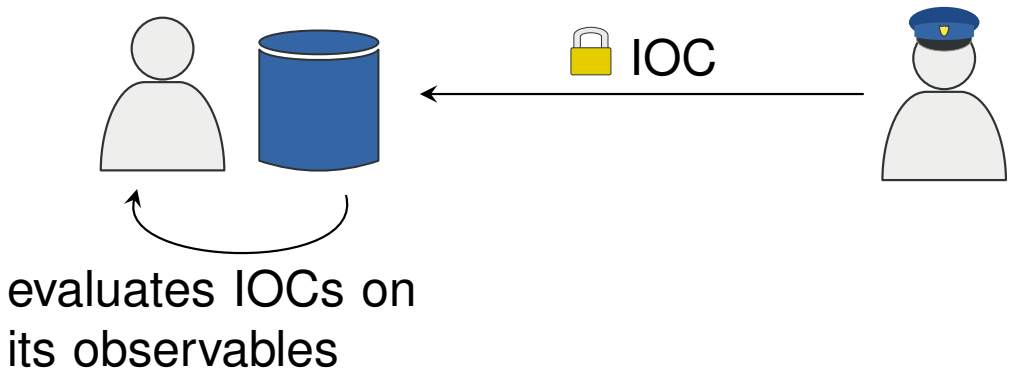


Private Information Sharing through Cryptography



Scenario for Private IOC Sharing



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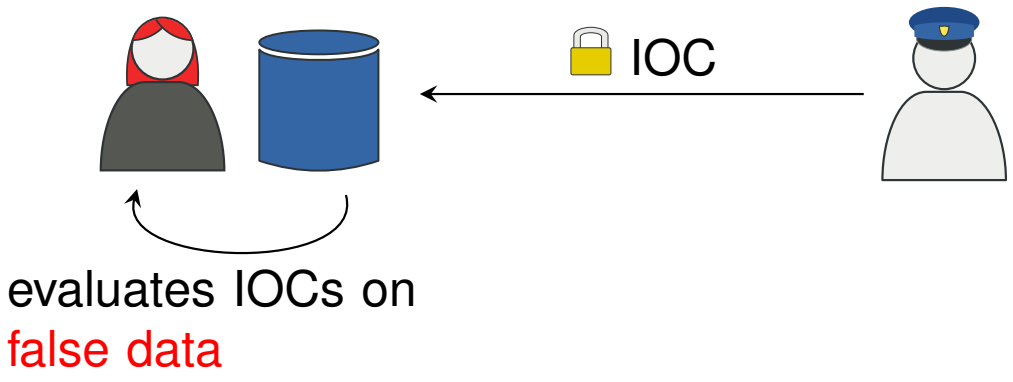

Inherent to the Scenario

Subscriber can evaluate an IOC with false data.

Our Approach to Private IOC Sharing

1. Write the IOC in disjunctive normal form.

$$(\texttt{destIP} = 198.51.100.43 \land \texttt{destPort} = 80) \lor (\texttt{destIP} = 198.51.100.43 \land \texttt{destPort} = 443)$$

2. Split the IOC rule into subrules at every `OR` gate.

$$\text{IOC}_1\colon \texttt{destIP} = 198.51.100.43 \land \texttt{destPort} = 80$$
$$\text{IOC}_2\colon \texttt{destIP} = 198.51.100.43 \land \texttt{destPort} = 443$$

3. Concatenate the feature values, choose a salt and the number of iterations, and derive a symmetric encryption key

$$k = \text{KDF}(198.51.100.43 \,\|\, 80, \texttt{salt}, \texttt{iterations})$$

Example (Cryptographic IOC)

$(\text{AES}_k(\text{COA}), \text{“}\texttt{destIP,destPort}\text{”}, \texttt{salt}, \texttt{iterations})$

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1. Write the IOC in disjunctive normal form.

$$(\texttt{destIP} = 198.51.100.43 \land \texttt{destPort} = 80) \lor (\texttt{destIP} = 198.51.100.43 \land \texttt{destPort} = 443)$$

2. Split the IOC rule into subrules at every `OR` gate.

IOC_1: $\texttt{destIP} = 198.51.100.43 \land \texttt{destPort} = 80$
IOC_2: $\texttt{destIP} = 198.51.100.$

prevents precomputation attacks

3. Concatenate the feature values, choose a salt and the number of iterations, and derive a symmetric encryption key

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Our Approach to Private IOC Sharing

1. Write the IOC in disjunctive normal form.

```
(destIP = 198.51.100.43 ∧ destPort = 80) ∨
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```

2. Split the IOC rule into subrules at every `OR` gate.

IOC_1: `destIP = 198.51.100.43 ∧ destPort = 80`
IOC_2: `3 ∧ destPort = 443`

influences evaluation time

3. Concatenate the feature values, choose a salt and the number of iterations, and derive a symmetric encryption key

$$k = \mathrm{KDF}(\texttt{198.51.100.43} \,\|\, \texttt{80}, \texttt{salt}, \texttt{iterations})$$

Example (Cryptographic IOC)

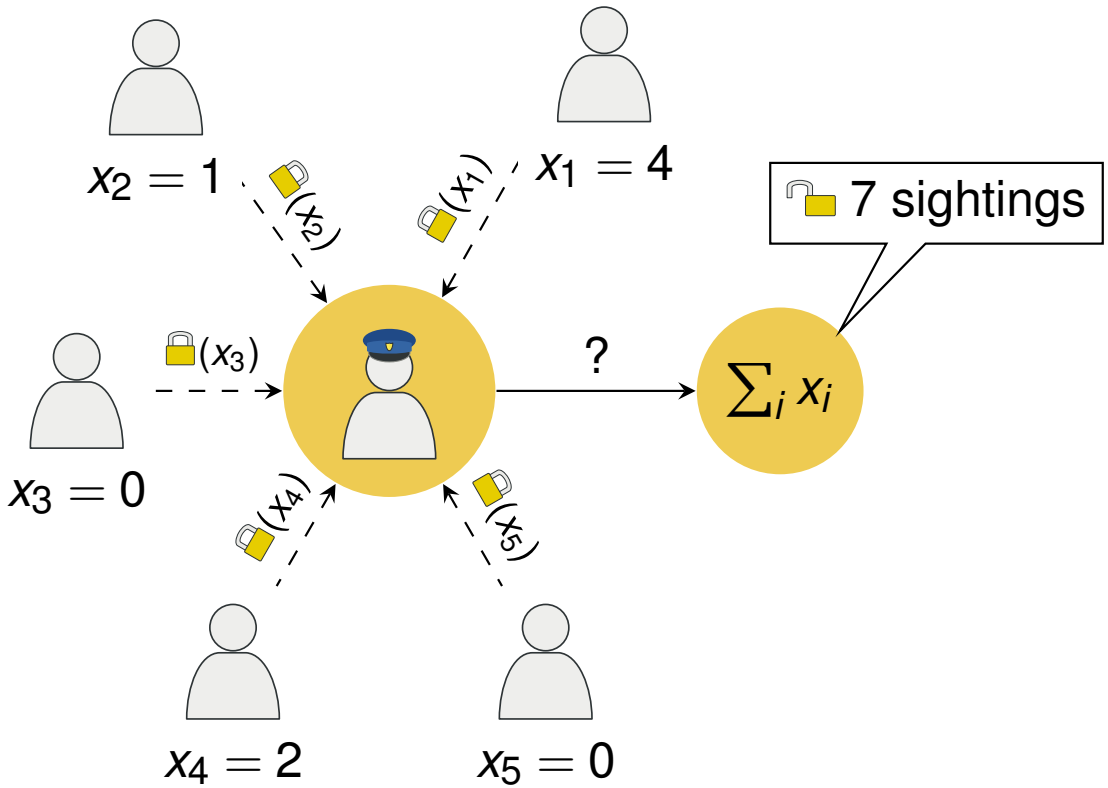
$(\mathrm{AES}_k(\mathrm{COA}), \text{“}\texttt{destIP,destPort}\text{”}, \texttt{salt}, \texttt{iterations})$

Private IOC Sharing: Proof-of-Concept Implementation

- Python wrapper for Bro [CRIPTIM]
- Key derivation functions: HKDF and PBKDF2 using SHA-256
- Encryption using AES

- Cryptographic overhead: depends on number of iterations
  - Minimal overhead per evaluation (e.g., per network flow): $\pm 40\,\mu s$ per IOC

Scenario for Private Reporting of Sightings



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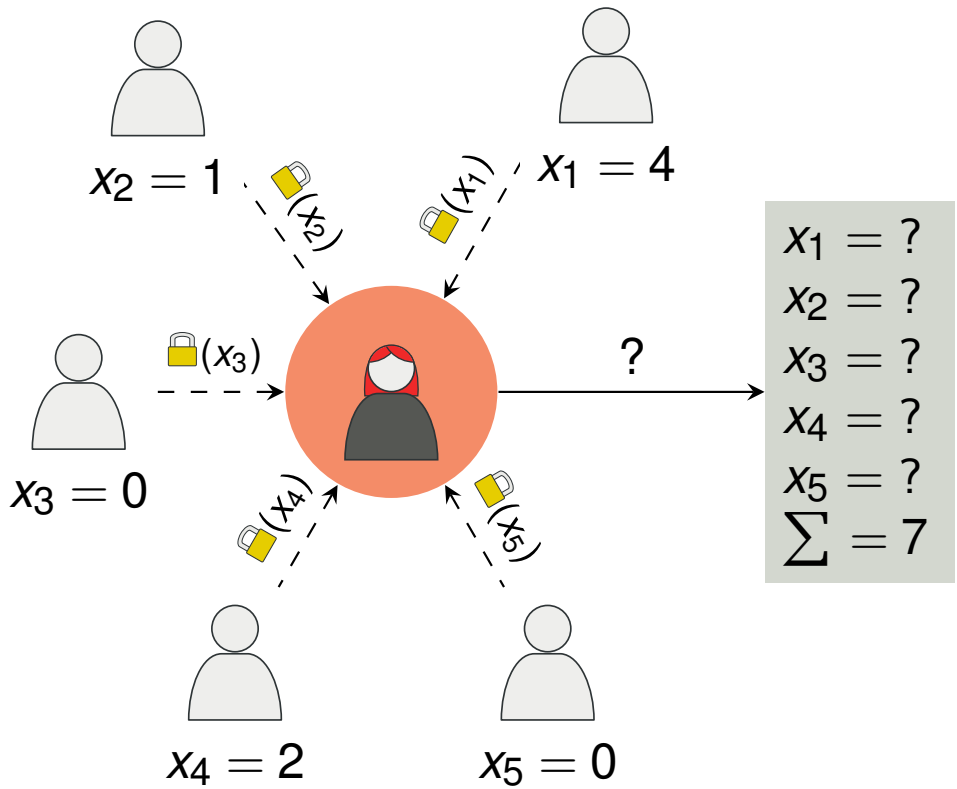

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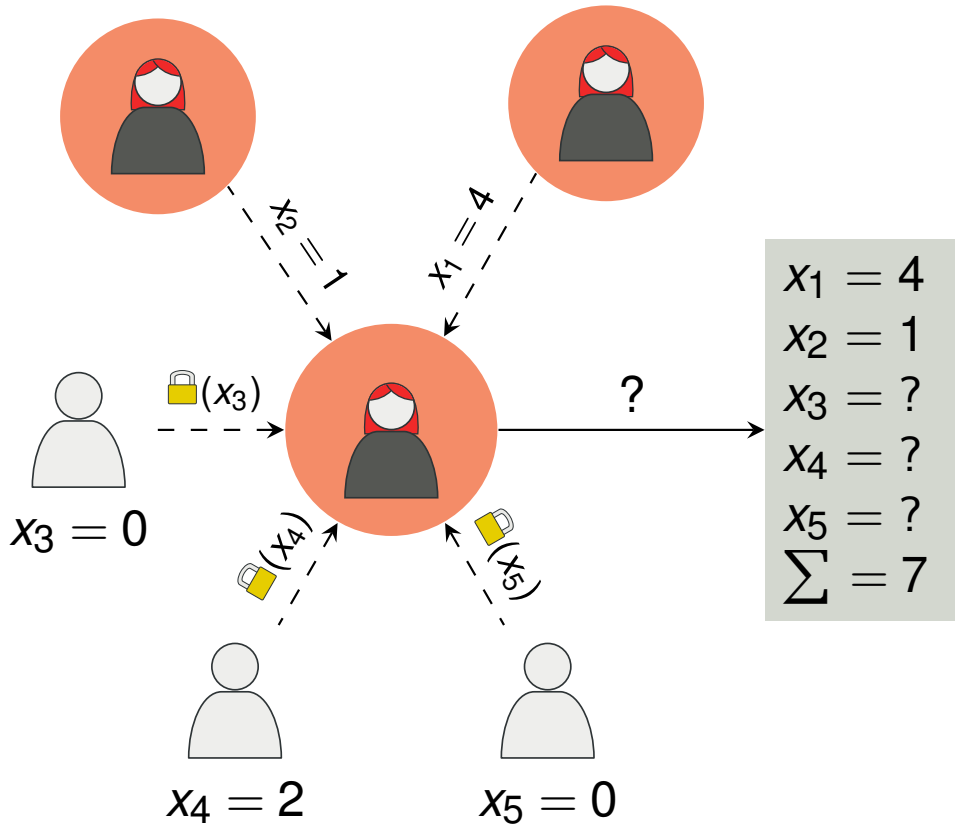


Properties of Our Approach

- Source only learns the sum, *not the individual values* of the subscribers.
- All subscribers need to contribute to the computation, otherwise the source can learn the individual values

$$x_j = \sum_i x_i - \sum_{i \in [n] \setminus j} x_i$$

- Can be used for more specific counts

  e.g., number of matches being false positive

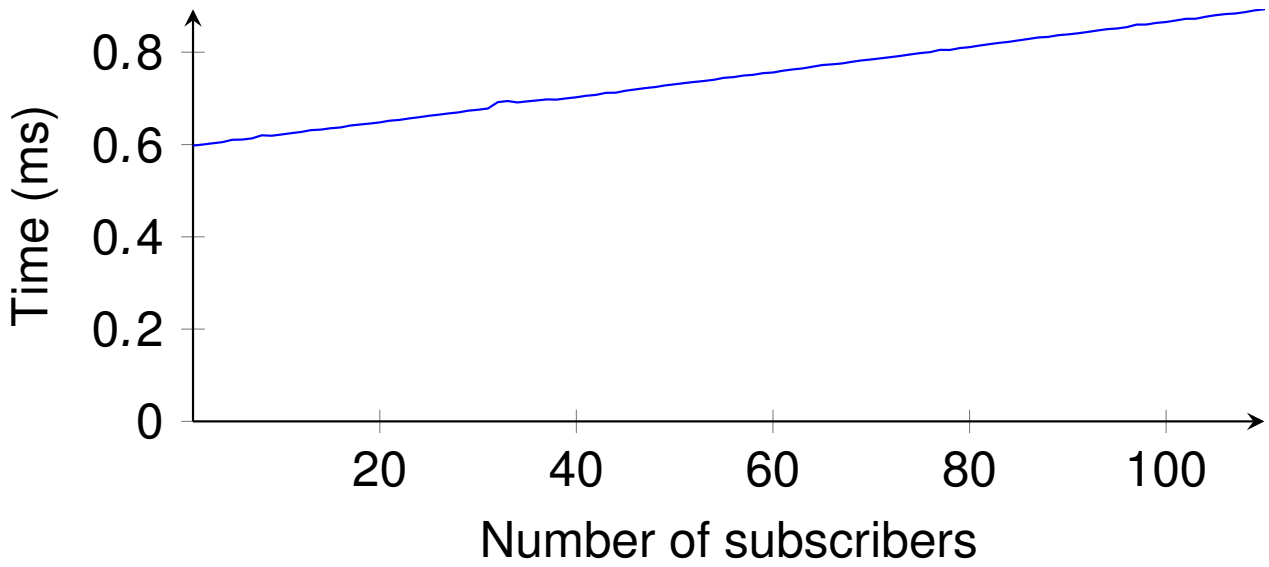
Proof-of-Concept Implementation of Private Reporting of Sightings

Privacy-preserving aggregation scheme [Shi et al. 2011]

- Python implementation [CRIPTIM]
- P-256 elliptic curve (≈ 128 bit security)

Results

- Encryption time (for a single subscriber): 0.58 ms
- Aggregate ciphertexts and decrypt



Summary

- Efficient, existing cryptography for private information sharing
- Cryptographic constructions for practical use
  - IOCs: speed–privacy trade-off (minimal overhead: < 0.05 ms)
  - Sightings: encryption and decryption in < 1 ms

- Outlook
  - Evaluation using real sensitive data, in real systems
  - Other types of information sharing using cryptographic techniques

Questions?

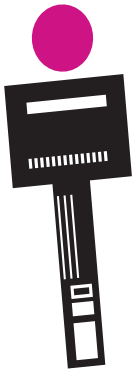
Contact: t.r.vandekamp@utwente.nl

NWO TNO National Cyber Security Centre *Ministry of Security and Justice* Ministry of the Interior and Kingdom Relations

References

[CRIPTIM] *Implementations of Private Information Sharing Schemes*. CRIPTIM consortium. URL: https://github.com/CRIPTIM/.

[Shi et al. 2011] E. Shi, T. H. Chan, E. G. Rieffel, R. Chow, and D. Song. "Privacy-Preserving Aggregation of Time-Series Data." In: *Proceedings of the Network and Distributed System Security Symposium (NDSS)*. 2011.



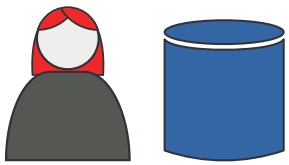
Appendix

1. Questions
   - Details about Using a Salt
   - Details about Substring Matching
   - Details about Traitor Tracing
   - Privacy-Preserving Aggregation [Shi et al. 2011]

Details about Using a Salt

Definition (Salt)

A salt is a large, public, random number.
Due to the randomness, it is unpredictable.



1 precomputes many potential IOCs

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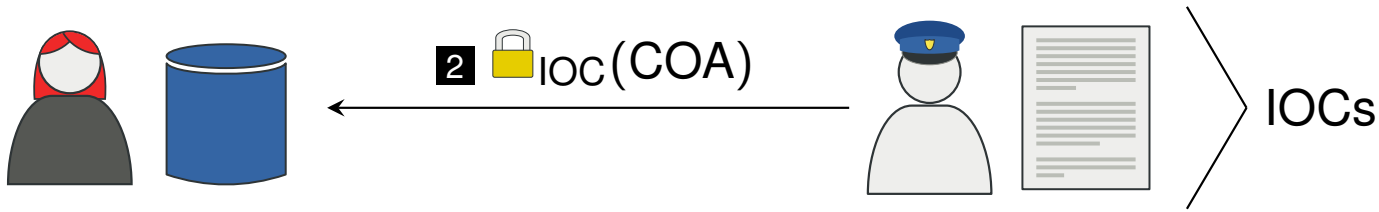

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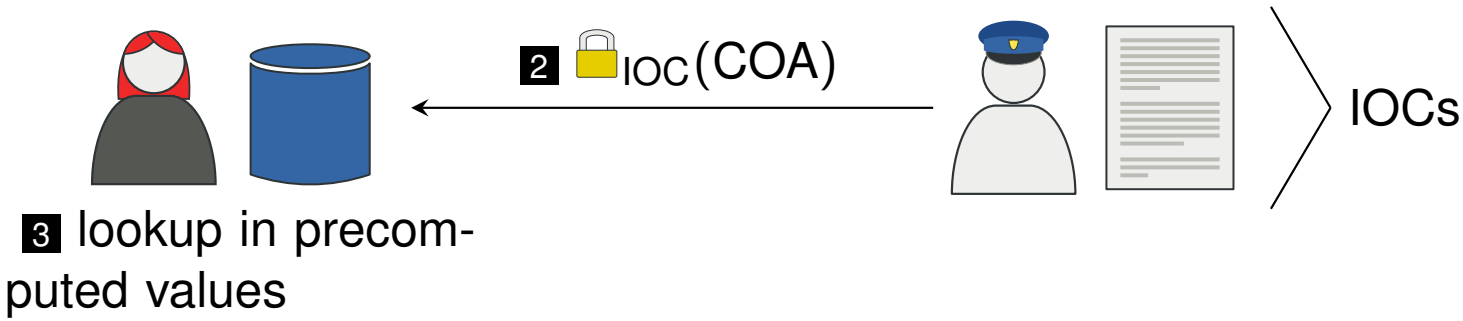

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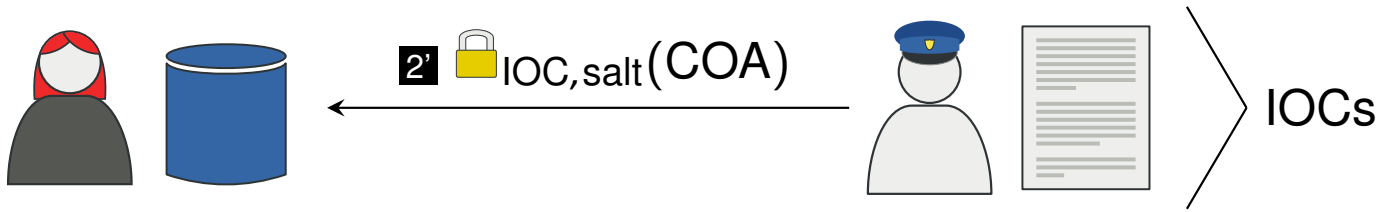

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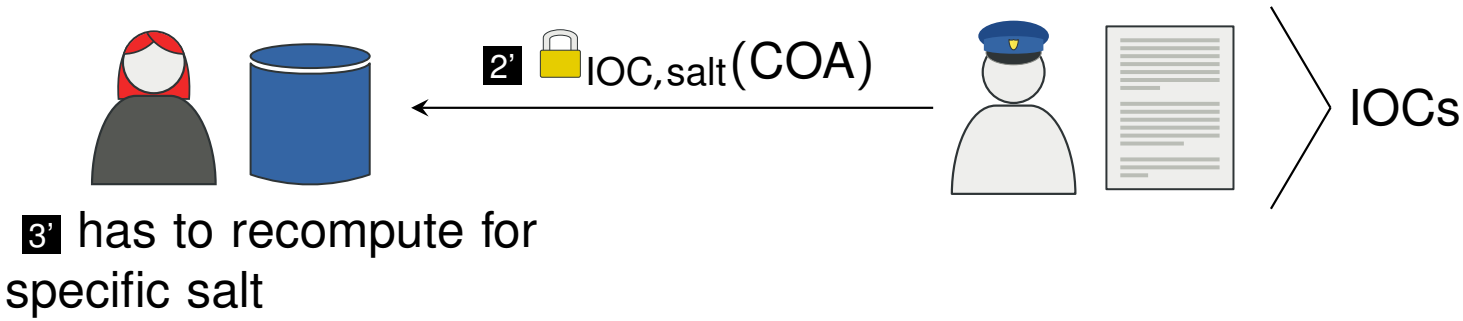

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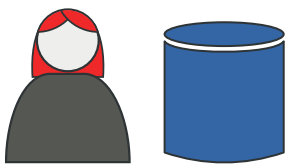

If using a randomized block cipher modes of operation, no salt is needed.

question overview

Details about Substring Matching

Example (Substring matching)

IOC: `content=abc ∧ offset=4 ∧ depth=6`

	≤ 3	4	5	6	7	8	9	≥ 10	match?
IOC_1	...	a	b	c	...				✗
IOC_2	...		a	b	c	...			✗
IOC_3	...			a	b	c	...		✓
IOC_4	...				a	b	c	...	✗
Observable	...			a	b	c	...		

◂ question overview

Details about Traitor Tracing

Example (Traitor Tracing)

Include an identifier of the subscriber in the cryptographic IOCs:

$(\text{AES}_{k_{\text{ID}}}(\text{COA}), \text{“}\texttt{ID},\texttt{destIP},\texttt{destPort}\text{”}, \texttt{salt}, \texttt{iterations})$

◂ question overview

Privacy-Preserving Aggregation [Shi et al. 2011]

Setup $g \in \mathbb{G}, \quad \mathrm{SK}_i \in_R \mathbb{Z}_p, \quad \mathrm{AK} = -\sum_i \mathrm{SK}_i$

Encryption $\mathrm{CT}_{i,\mathrm{ID}} = g^{x_{i,\mathrm{ID}}} H(\mathrm{ID})^{\mathrm{SK}_i}$

Aggregation $V = H(\mathrm{ID})^{\mathrm{AK}} \prod_i \mathrm{CT}_{i,\mathrm{ID}} = \prod_i g^{x_{i,\mathrm{ID}}}$

Decryption $\mathrm{dlog}_g V = \sum_i x_{i,\mathrm{ID}}$

◂ question overview

Privacy-Preserving Aggregation Setup Using MPC

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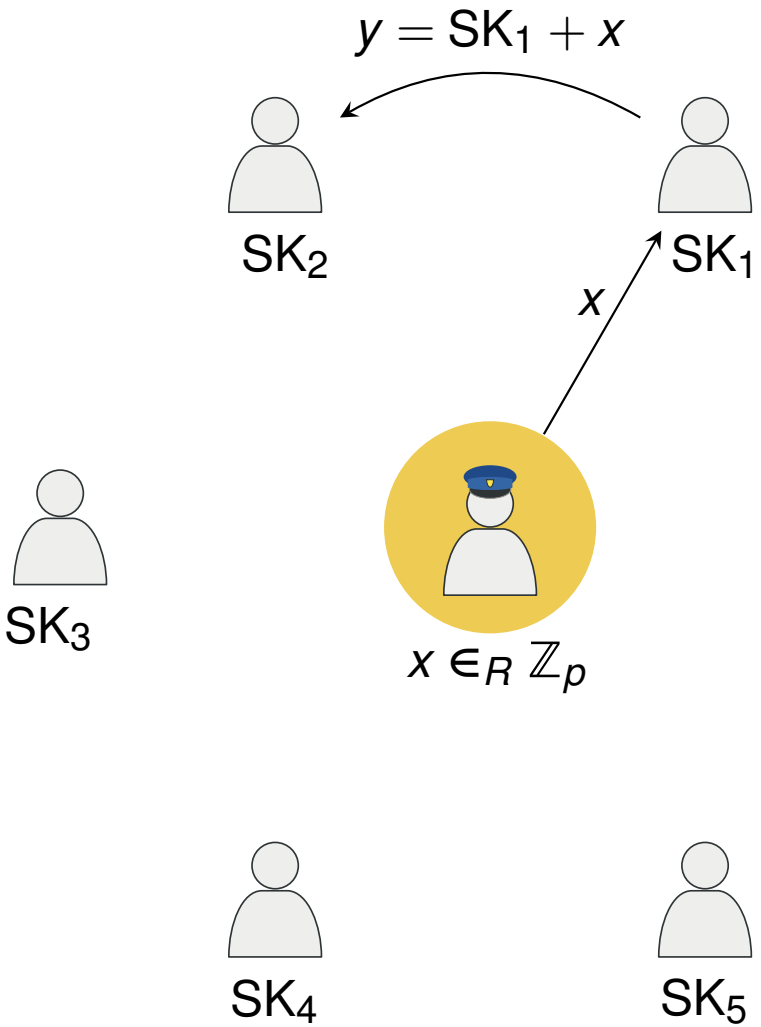

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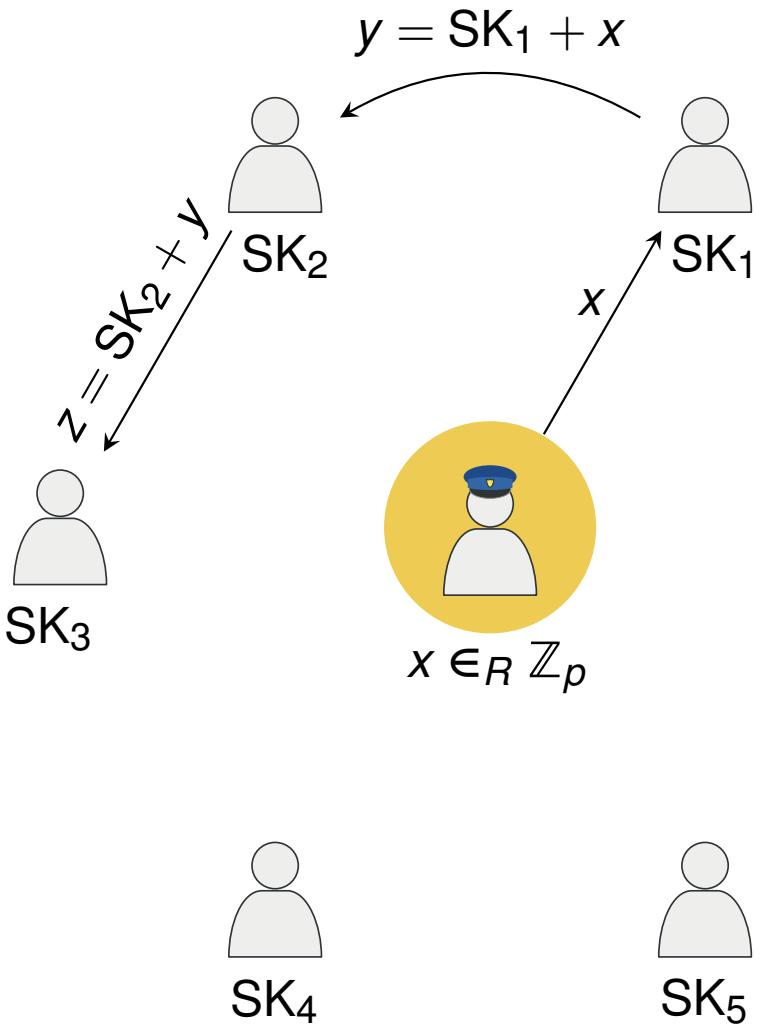

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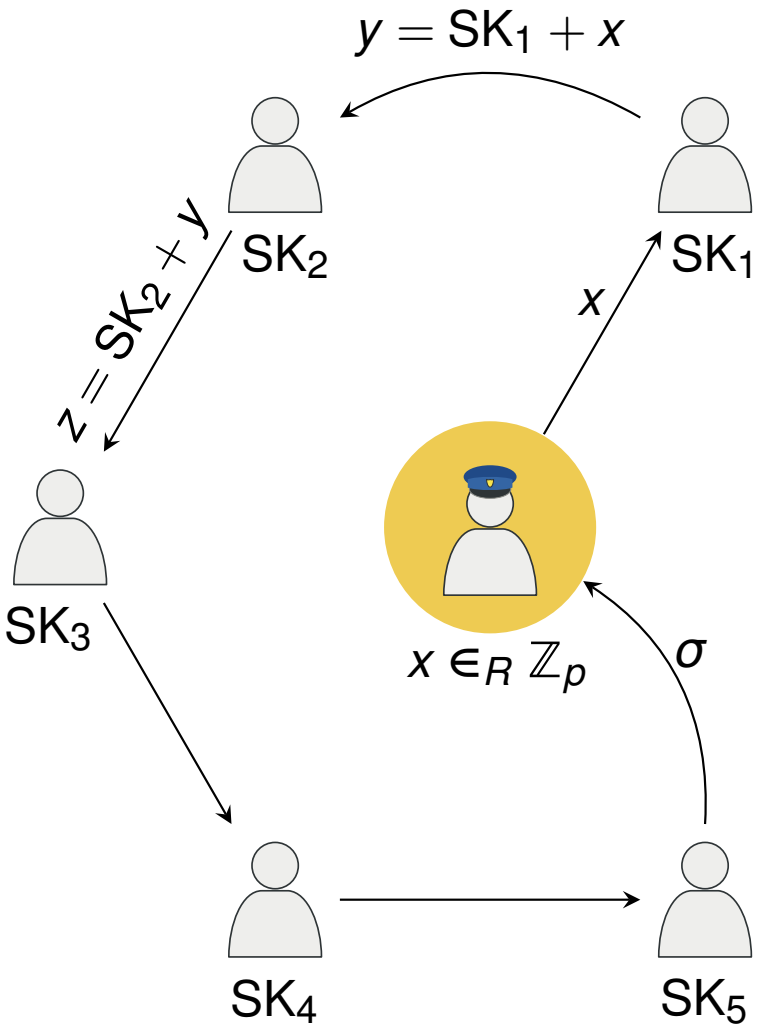

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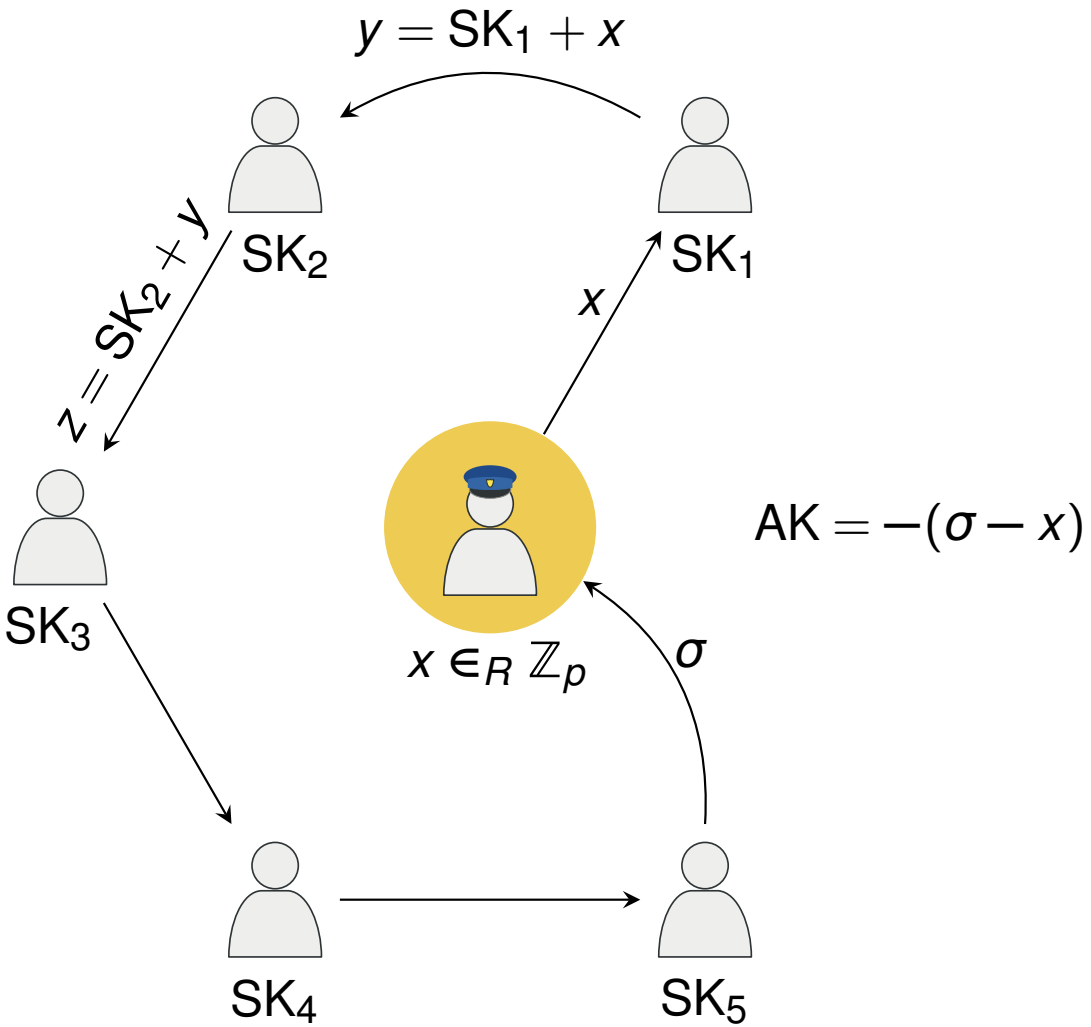

◂ question overview