Advanced cryptography for privacy protection

Cases from the government field

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PhD, Smals Research

20 dec. 2019

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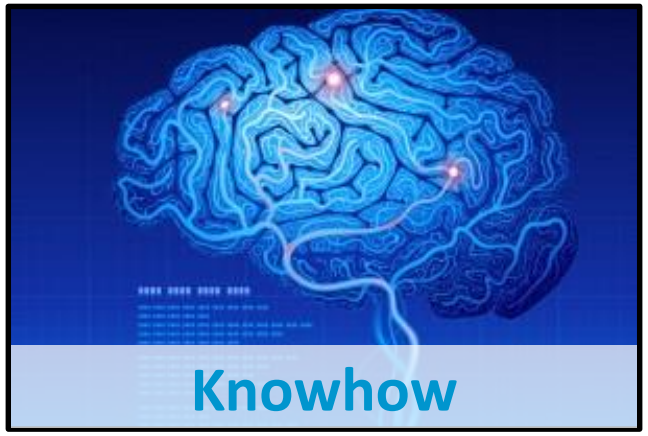
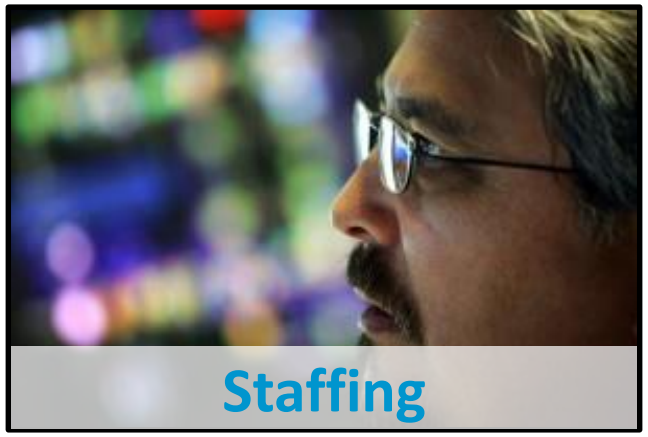
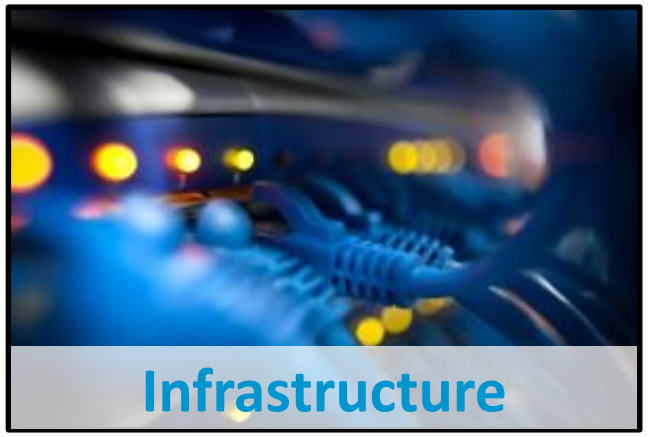
SUPPORT FOR E-GOVERNMENT







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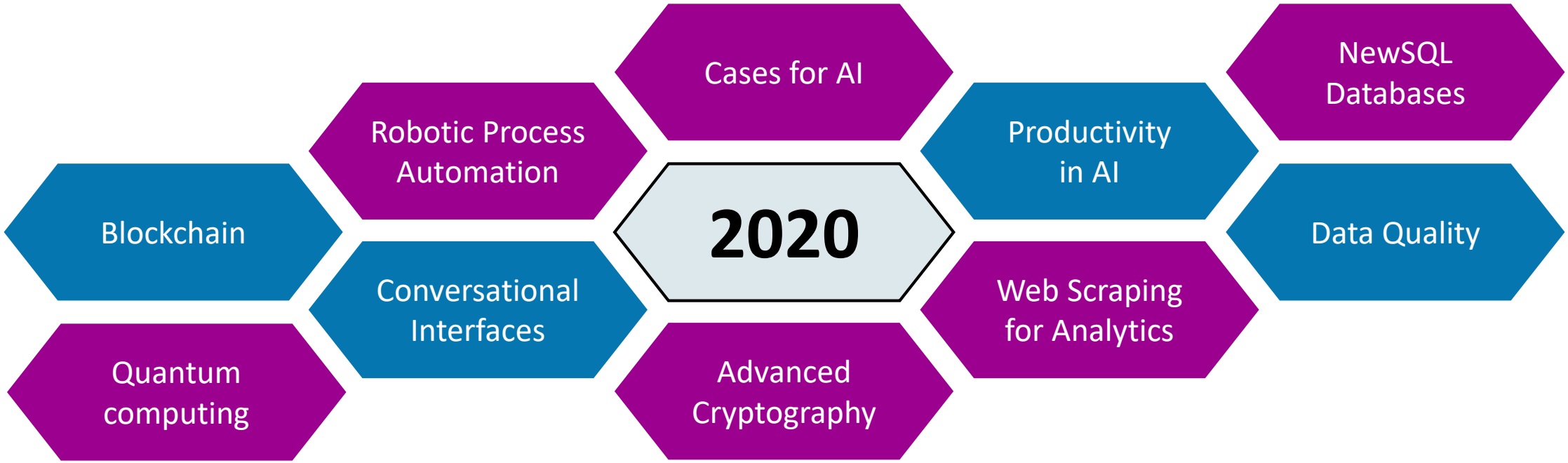
Innovation with new technologies

Consultancy & expertise

Internal & external knowledge transfer

Support for going live



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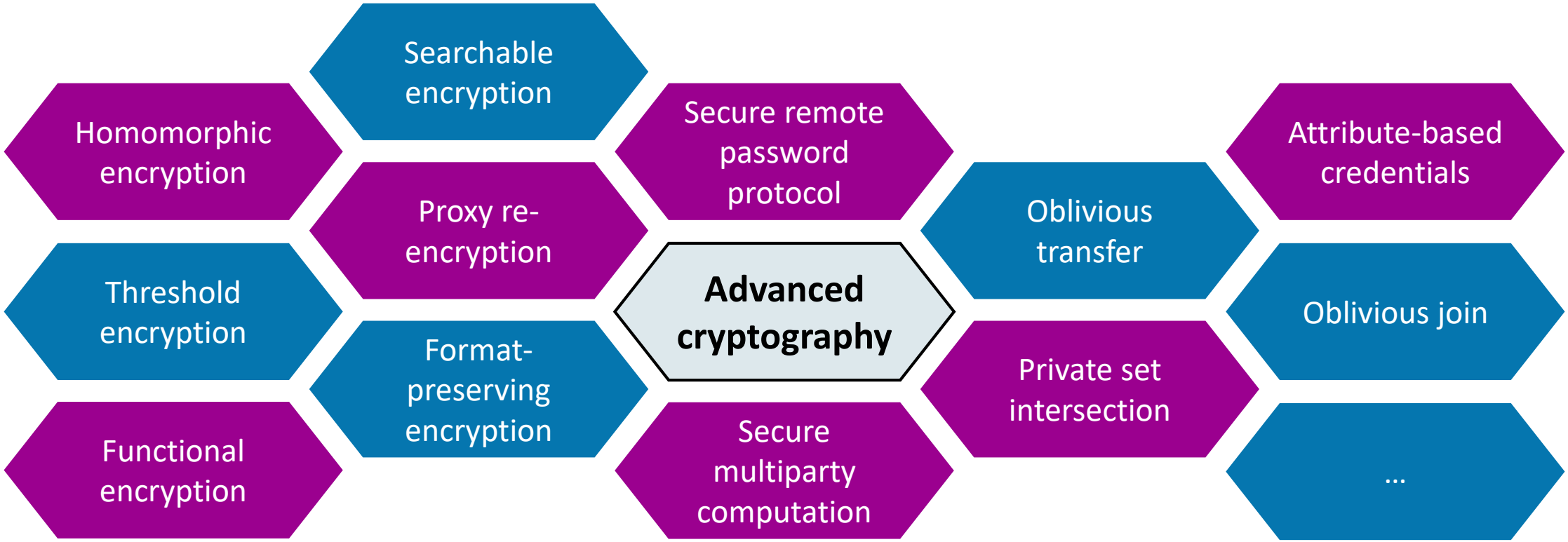
Much more is possible with cryptography

CRYPTO WORK HORSES

- Symmetric encryption
- Digital signatures
- Public key cryptography
- Hashing
- Authentication
- …

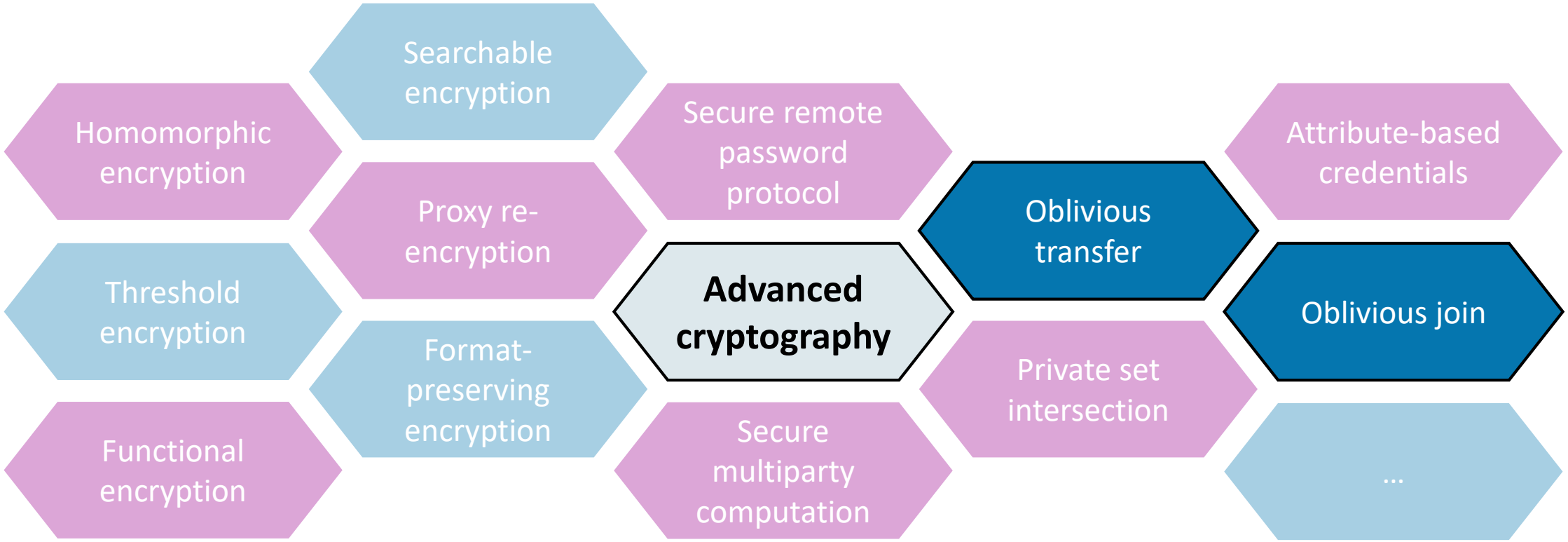
Known & widely applied in government context

Advanced cryptography



Potential within government context

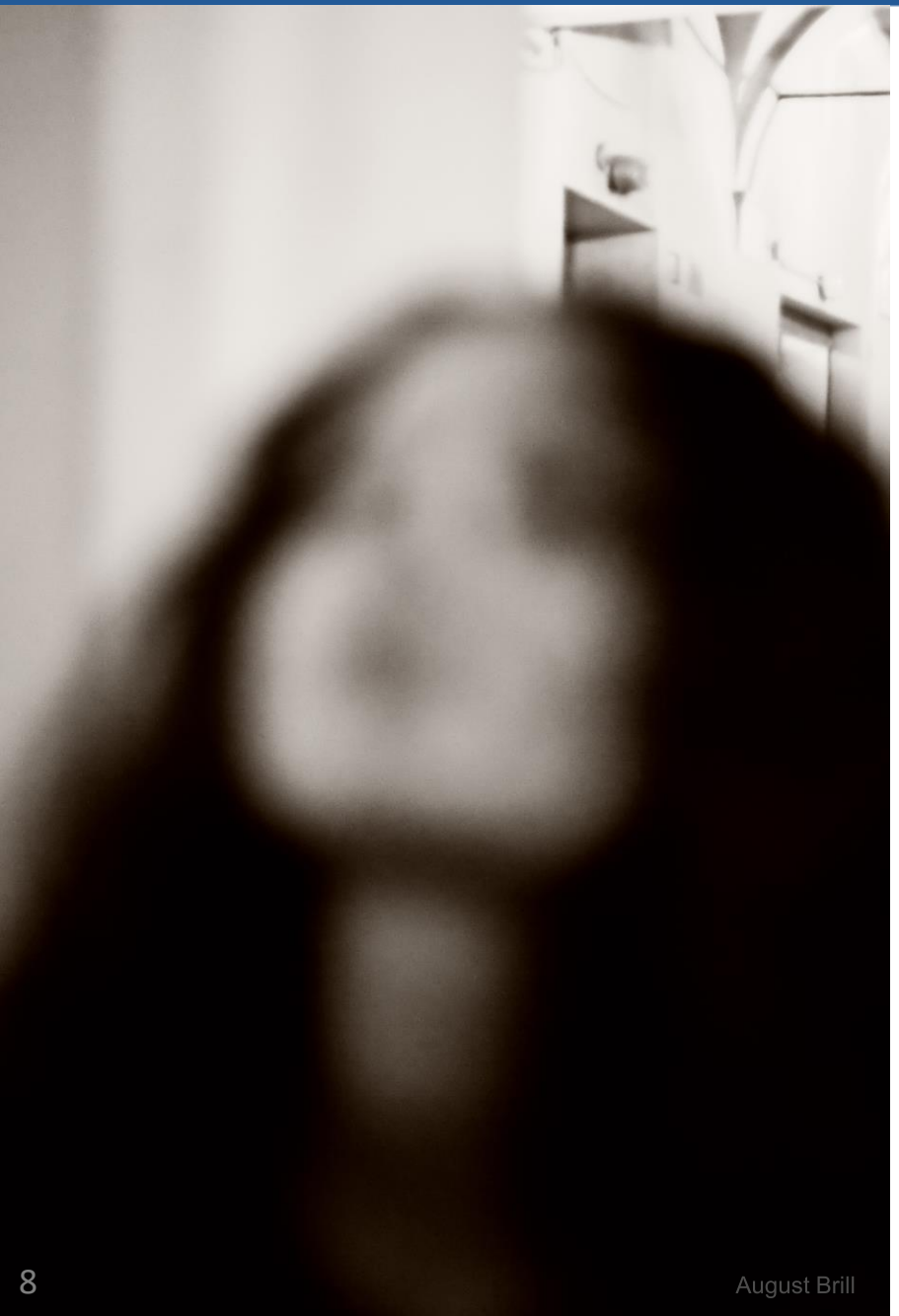
Advanced cryptography



Potential within government context

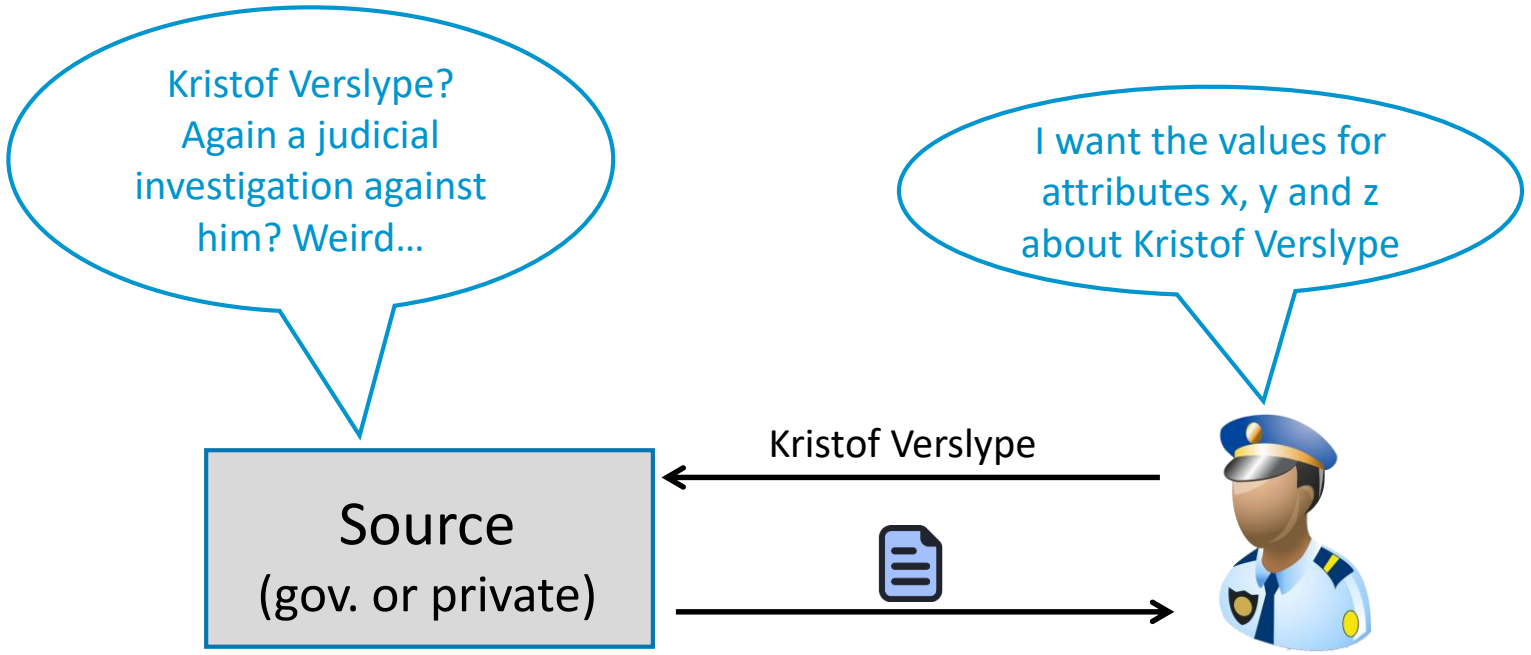
Oblivious transfer

Oblivious transfer – Problem statement



Scenario

Investigation by Ministery of Justice of into specific citizen
Ministery needs information provided by multiple sources



Proportionality
Privacy subject towards source
Confidentiality of investigation

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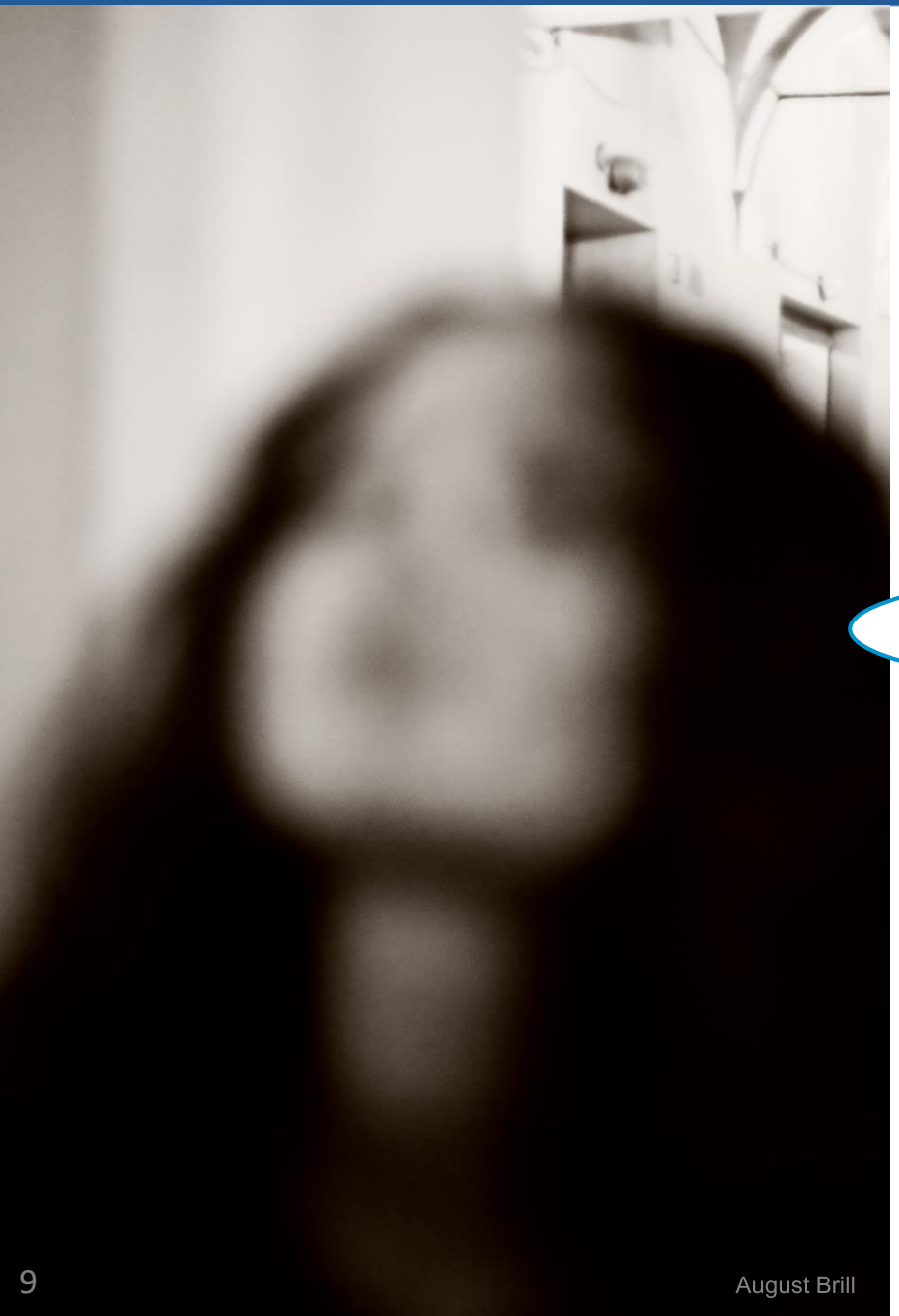
August Brill

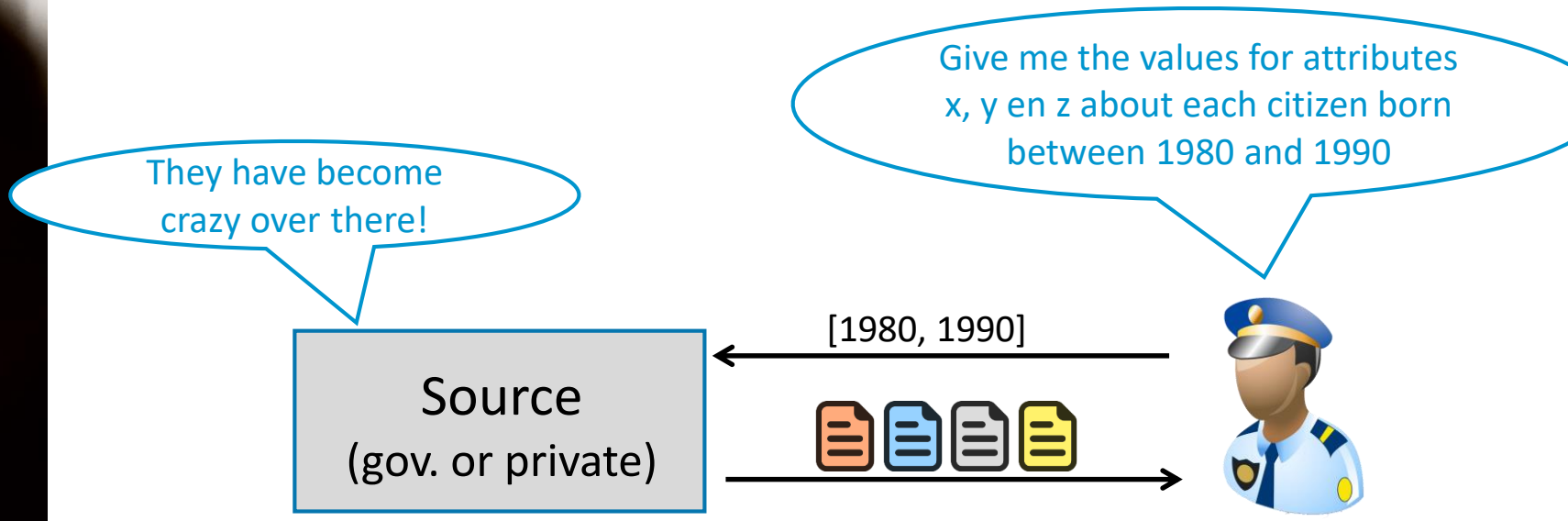
Oblivious transfer – Problem statement



Scenario

Investigation by Ministery of Justice against a specific citizen

Ministery needs information provided by multiple sources



Proportionality

Privacy subject towards source

Confidentiality of investigation

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Oblivious transfer - Tension

Privacy of citizen & confidentiality investigation towards sources

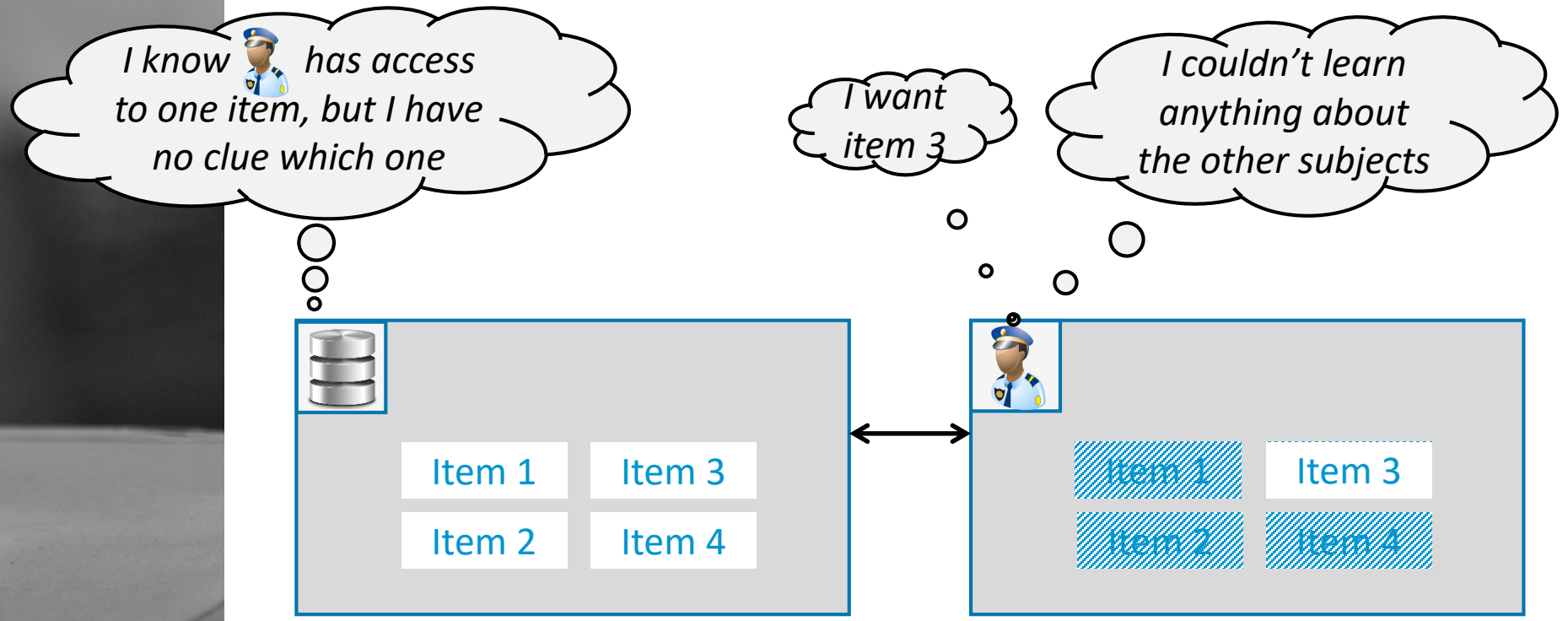
Tension

Proportional processing of personal data by ministery of justice

Jobeca (Jarr1520) @ Flickr

Oblivious transfer - Concept

Te sender provides to a receiver access to one item out of a bigger set of items. De sender does not learn which item.



Sologenesis (Leo) @ Flickr

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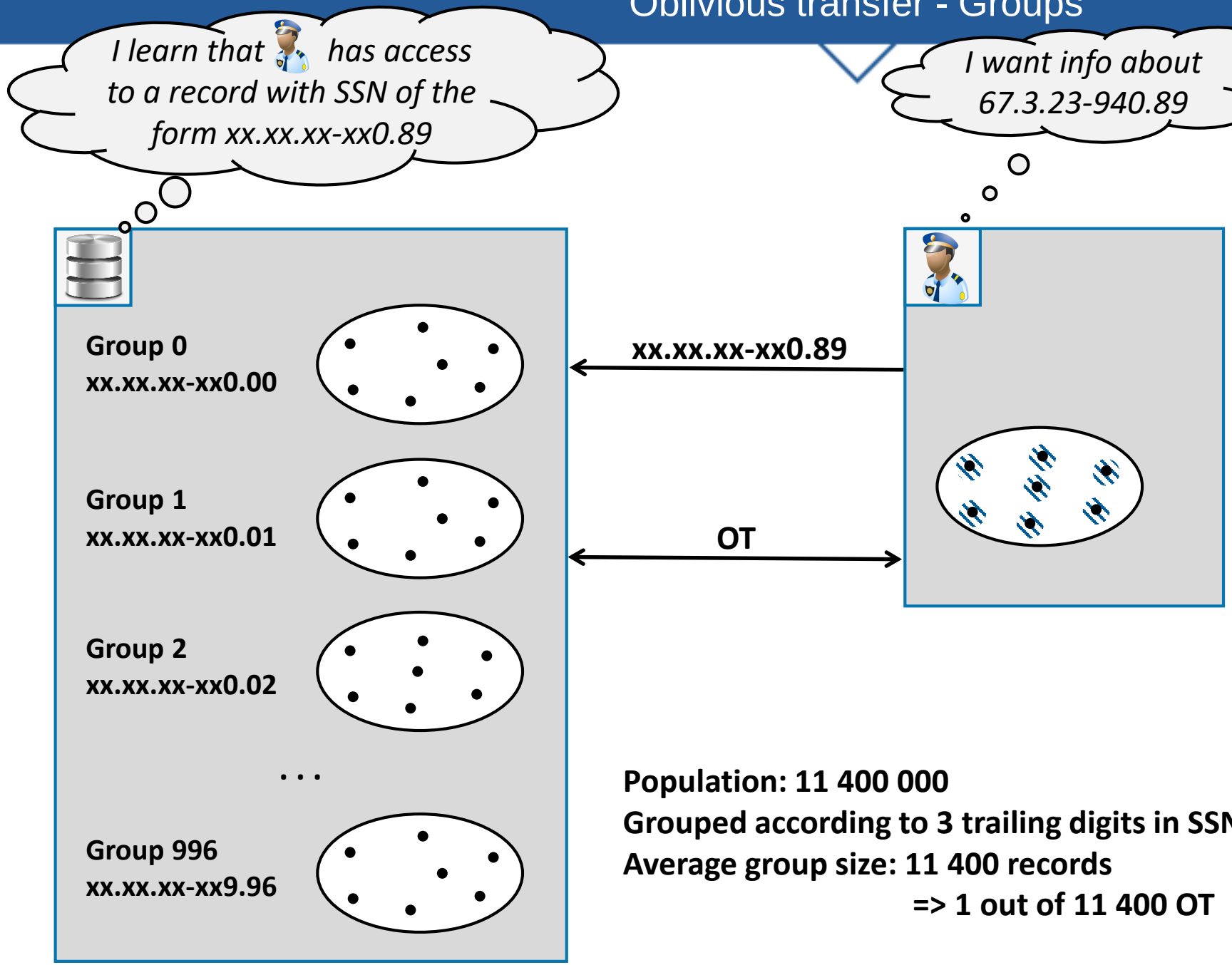
Oblivious transfer - Groups

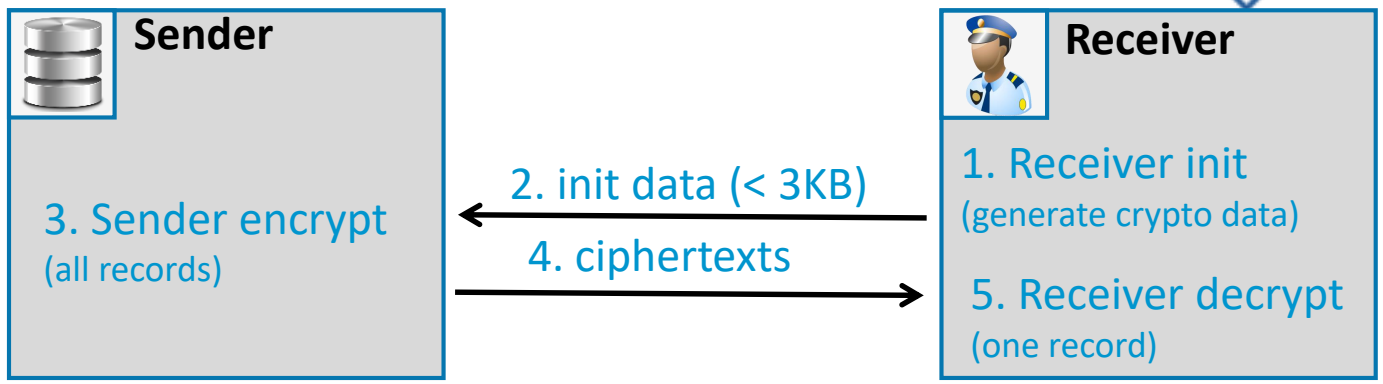


Population: 11 400 000
Grouped according to 3 trailing digits in SSN
Average group size: 11 400 records
=> 1 out of 11 400 OT

In reality

- Millions of records, but grouped. OT applied on one group
- Legal obligation to remove irrelevant ciphertexts asap

Oblivious transfer – Implementation & performance



Computational load at sender

256 bit security, standard laptop

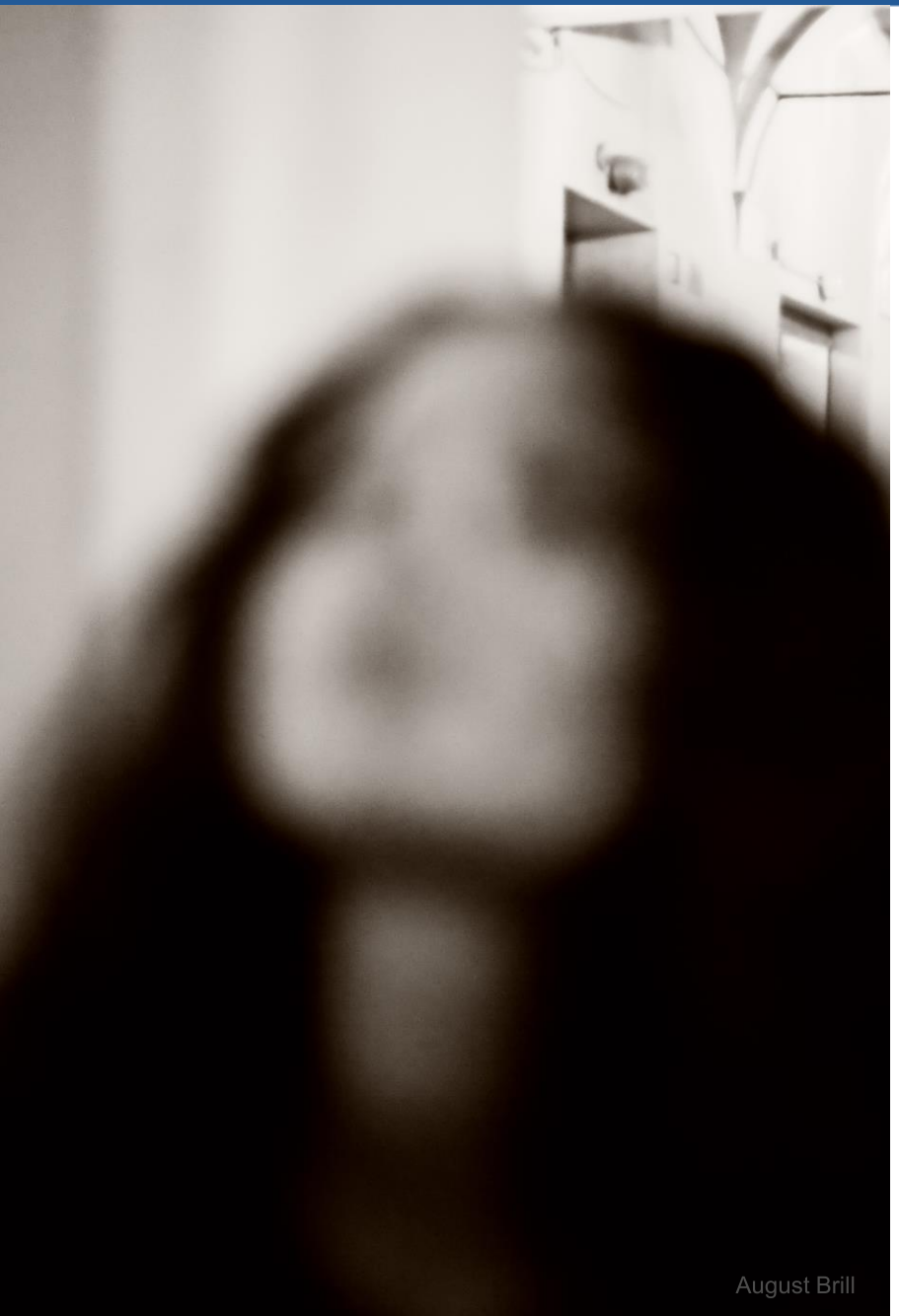
	1 out of 1000 records			1 out of 10 000 records			1 out of 25 000 records		
	Receiver init O(log n)	Sender encrypt O(log n*s)	Receiver decrypt O(s + log n)	Receiver init O(log n)	Sender encrypt O(log n*s)	Receiver decrypt O(s + log n)	Receiver init O(log n)	Sender encrypt O(log n*s)	Receiver decrypt O(s + log n)
20,7KB/rec.	213ms	925ms	30ms	299ms	4896ms	27ms	289ms	11544ms	37ms
103,4KB/rec	214ms	2604ms	33ms	270ms	22 146ms	36ms	282ms	54586ms	40ms

Setup
Data in-memory / Lenovo Thinkpad L570, Windows 10, Intel Core i5-6300 CPU @ 2,40Ghz, 16GB, P-521 curve, no multithreading.
Only of crypto calculations, not of storage I/O or communication
Average of 10 runs is taken

Smals Research Java implementation

- M Byali, A Patra, D Ravi, P Sarkar. *Fast and Universally-Composable Oblivious Transfer and Commitment Scheme with Adaptive Security*. IACR Cryptology ePrint Archive, **2017**
- C. Peikert, V. Vaikuntanathan, B. Waters. *A Framework for Efficient and Composable Oblivious Transfer.* CRYPTO 2008: Advances in Cryptology – **CRYPTO 2008** pp 554-571

Oblivious transfer



Concept

- Active research domain with advanced protocols
- High efficiency
- Own Java implementation

Applicability

- Answer to a concrete need
- New technology for our sector
- Will take while to get it in production

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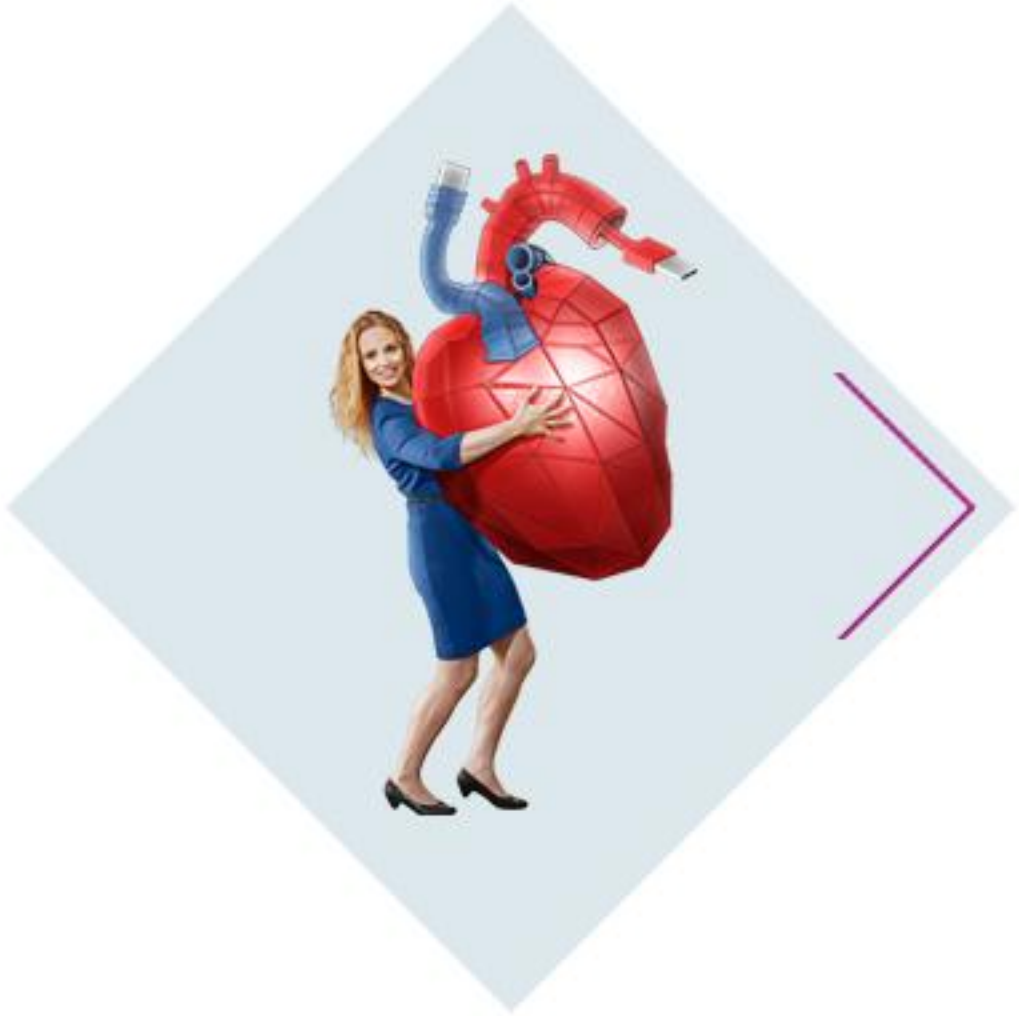


Oblivious join

Concept by Smals Research

Fictional example

Citizen selection

- All persons self-employed as secondary activity
- With a wage above € 50 000 / year as employee

Required data

- Specific medical data &
- Data about insurance as independent

Cooperation by multiple organisations required

RSZ - ONSS - LSS

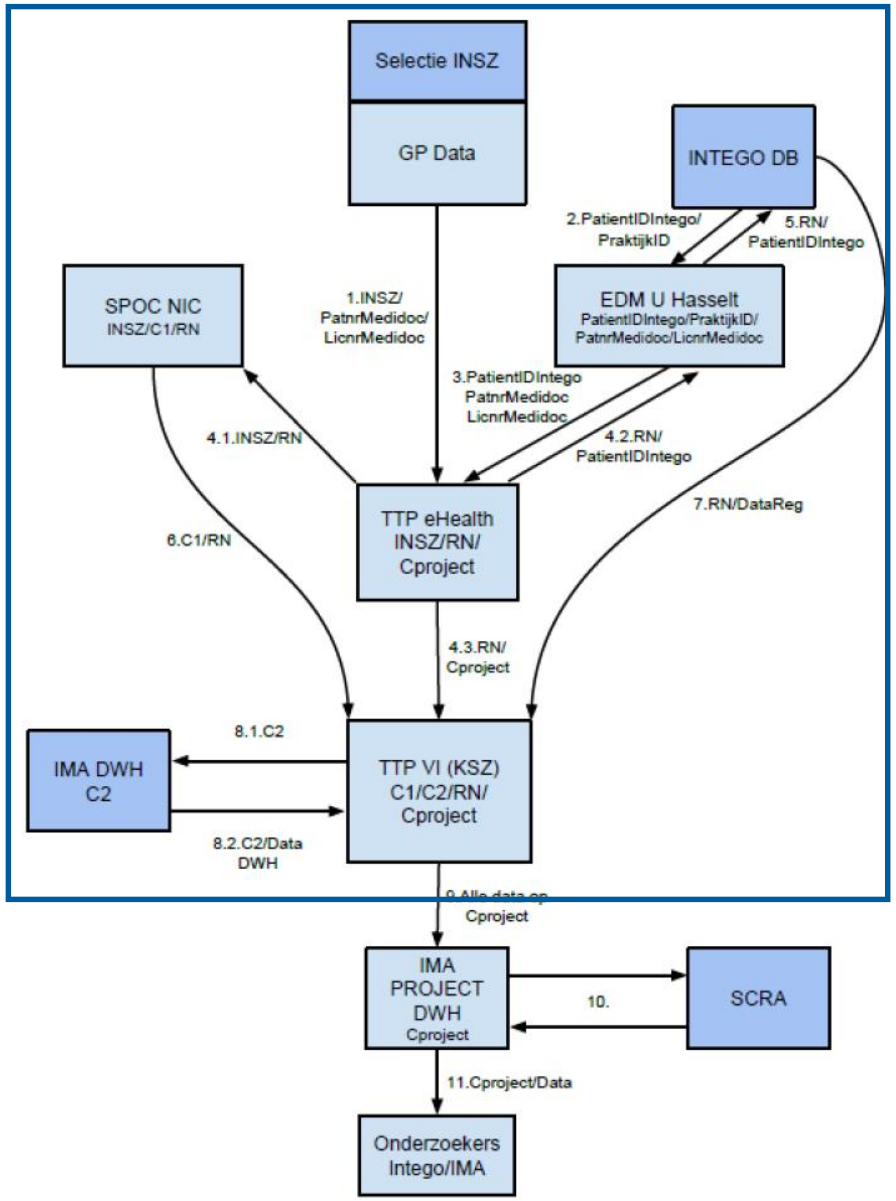
RSVZ

Belgian Cancer Registry

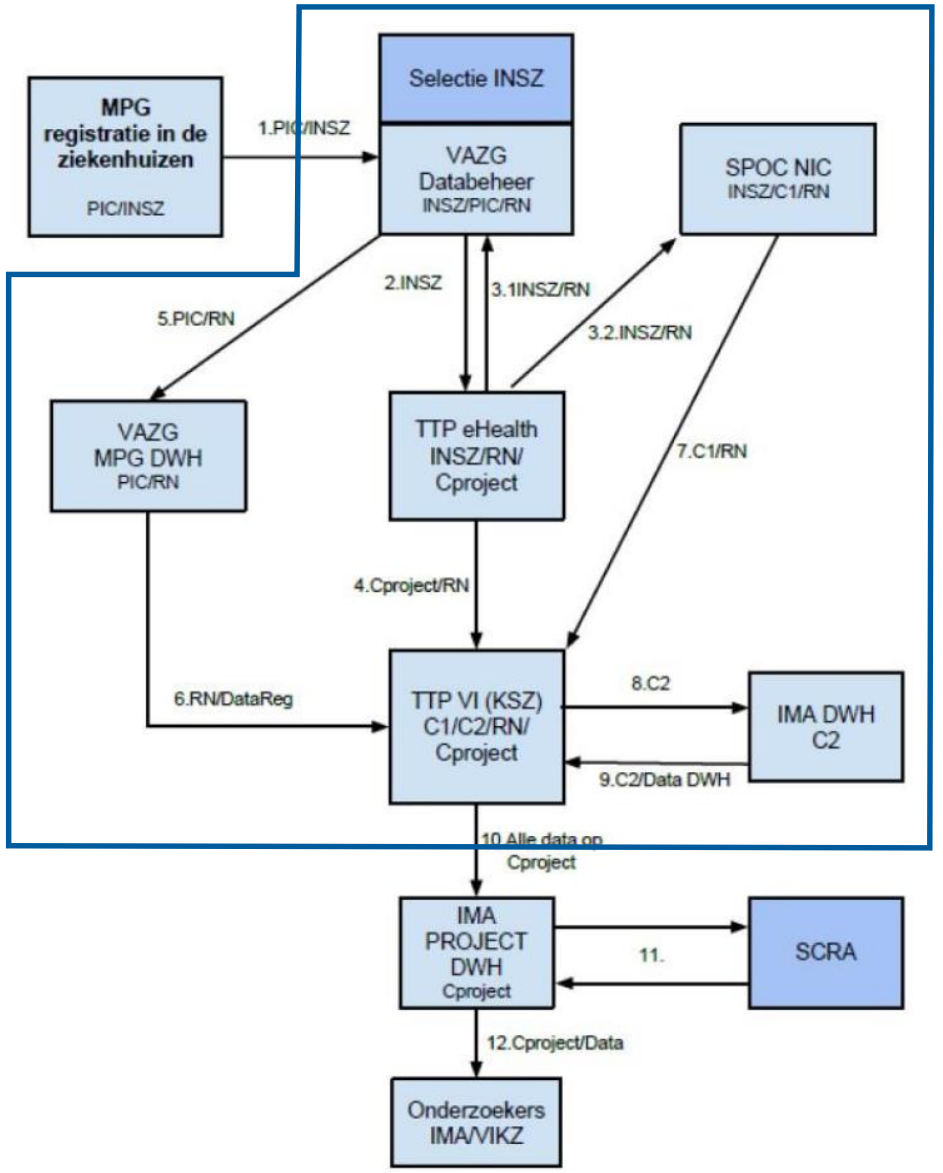
Joining and pseudonymizing personal data from multiple sources for research purposes

Joining personal data – Current practice

Example 1



Example 2



KSZ BCSS

Deliberation nb. 17/071 from 19/9/17 (left)

Deliberation nb. 19/062 from 2/4/19 (right)

- Complex flow
- Bespoke
- Slow
- Security risks
- Data leakage

Oblivious join – Data leakage

Context

Joining and pseudonymizing personal data from multiple sources for research purposes

Scenario

Citizen selection

- All persons self-employed as secondary activity
- With a wage above € 50 000 / year as employee

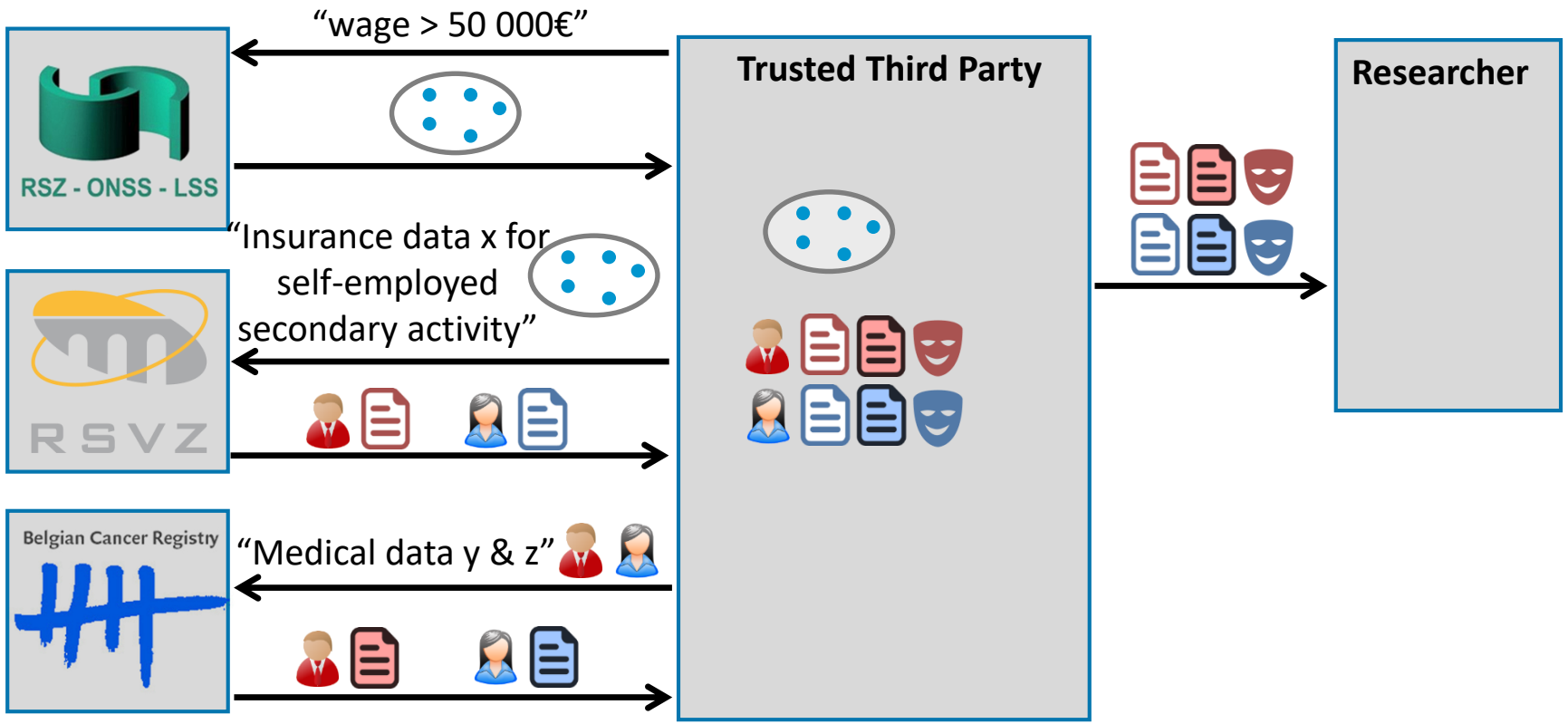
Required data

- Specific medical data
- Data about insurance as independent

Issues

- Data leakage towards senders and/or TTP
- Extra intermediaries increase complexity

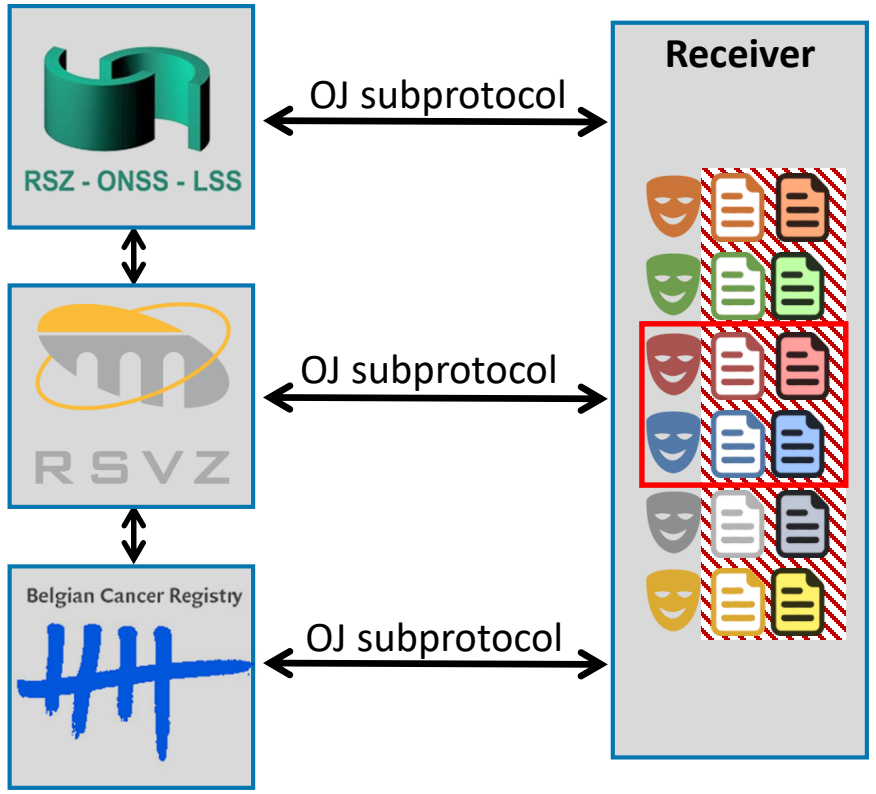
Potential traditional approach



Oblivious join

Idea

- Each sender sends all potentially relevant data to the receiver, but encrypted and pseudonymized
- Receiver can decrypt iff something received about the same citizen from each sender



Senders don't learn (statistical or personal) data.

Receiver learns only required pseudonymized **personal** data.

Minimal leakage of **statistical data** leaks to the receiver

in example:

- #citizens with wage > € 50 000
- #independents as secondary activity

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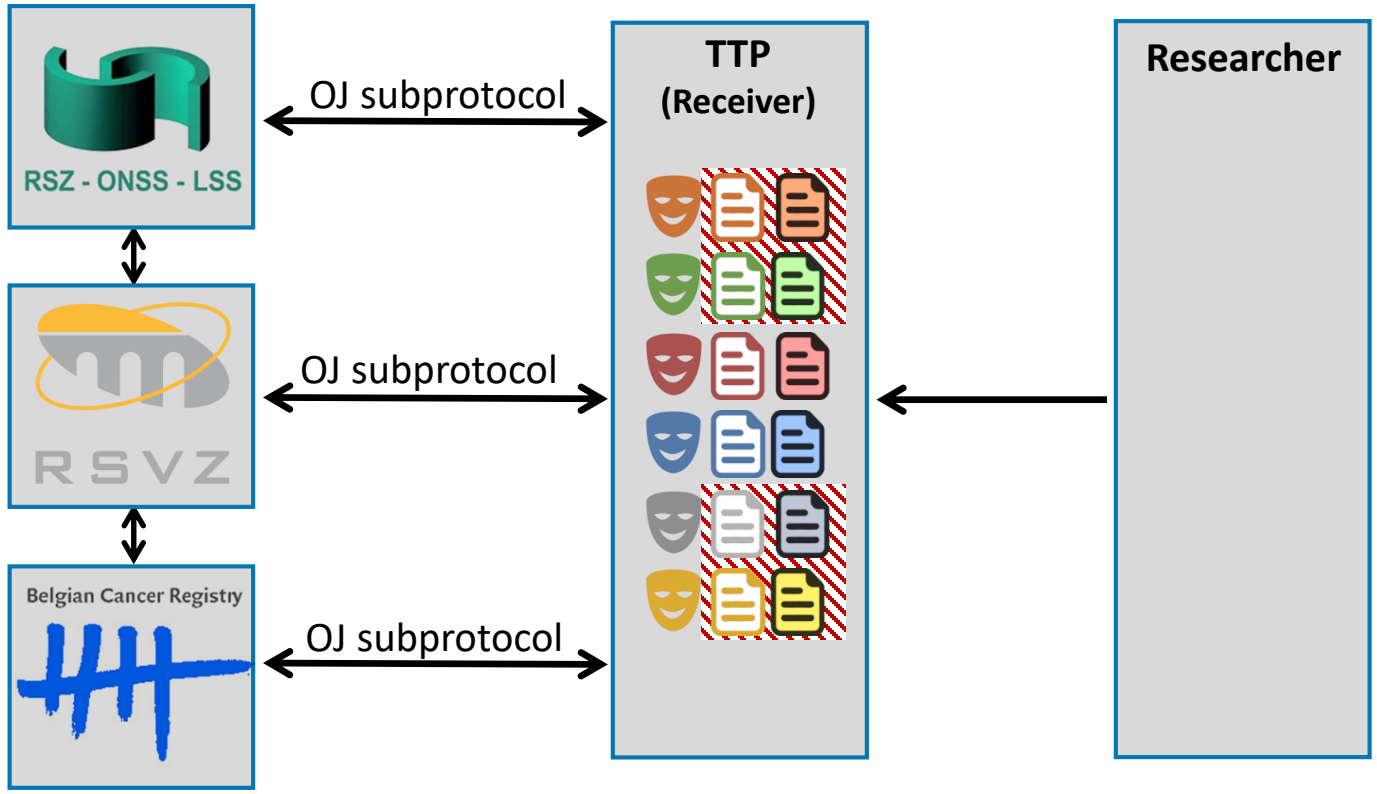
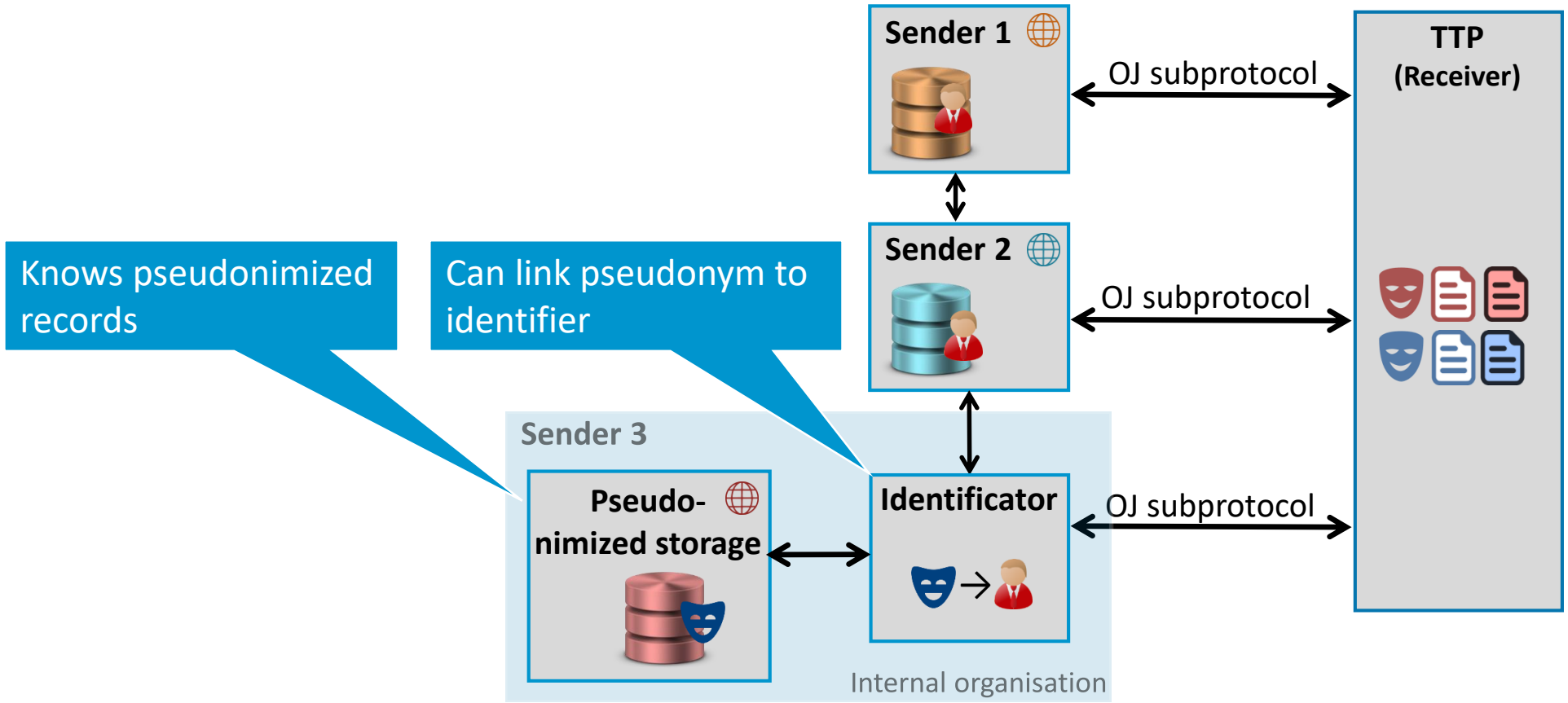
Oblivious join

TTP (Trusted third party)

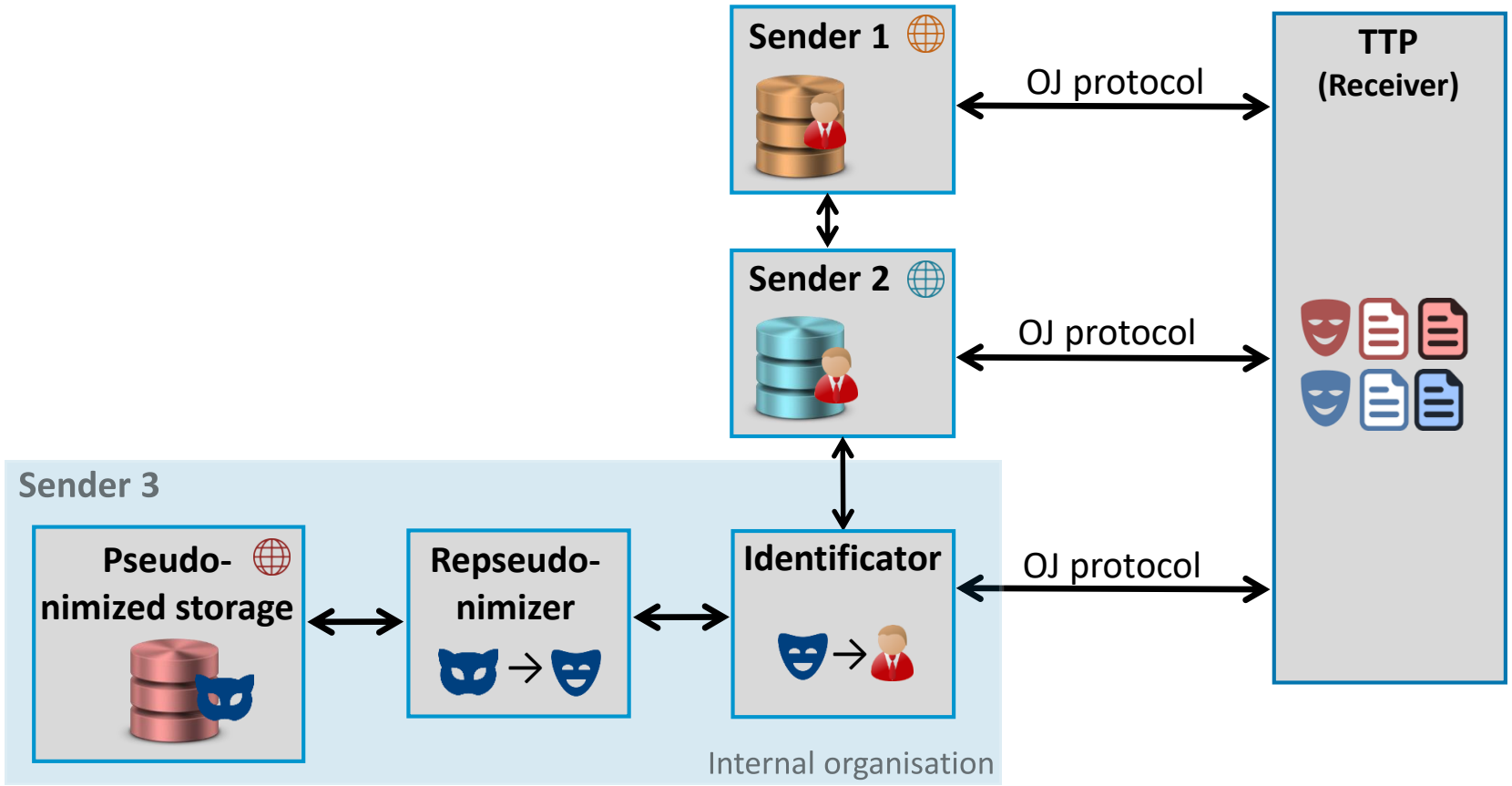
- Removes asap irrelevant ciphertexts
- Potentially does additional operations (e.g. checks)
- Access control w.r.t. researcher
- ‘Trust’ very limited



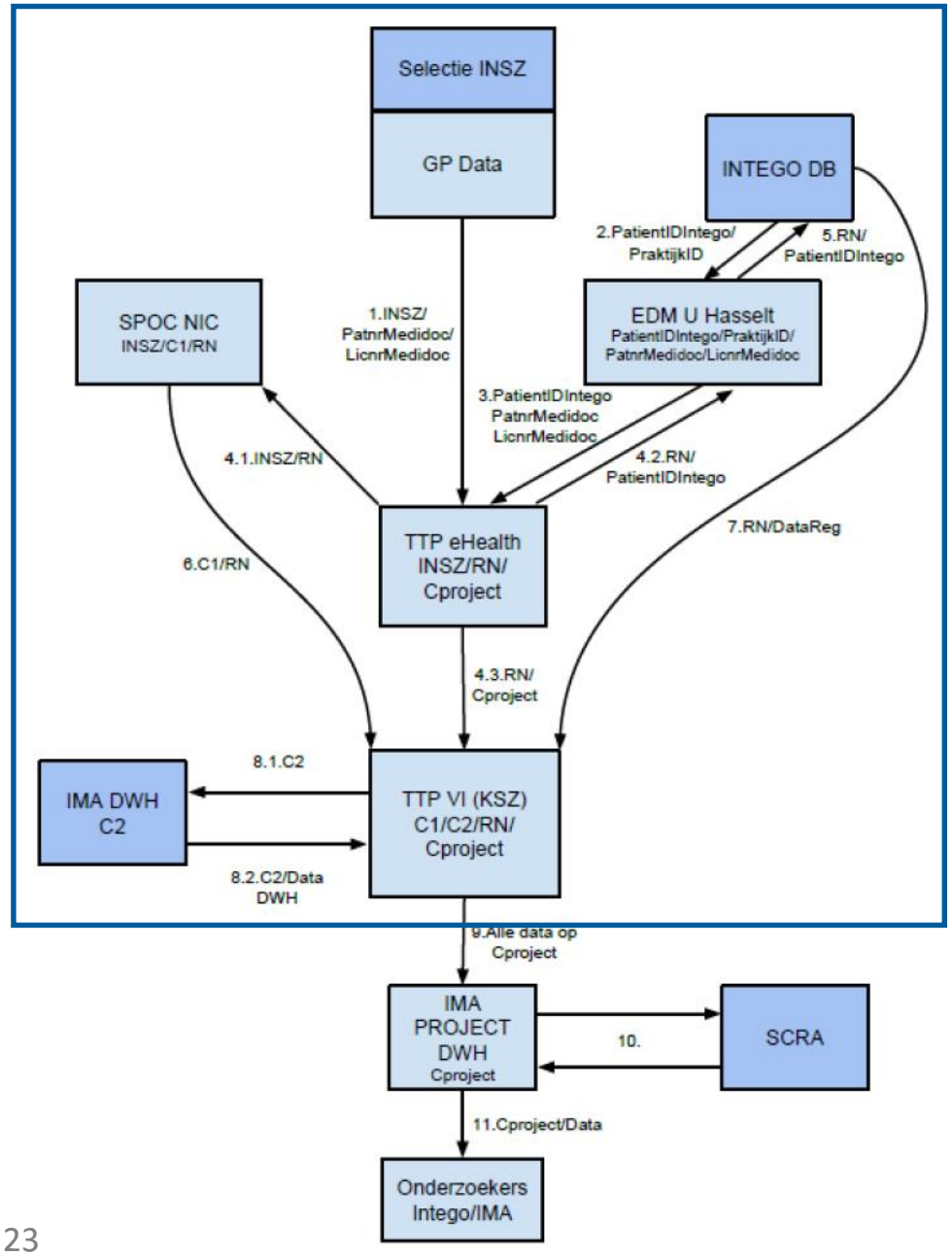
Oblivious join

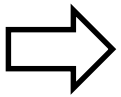


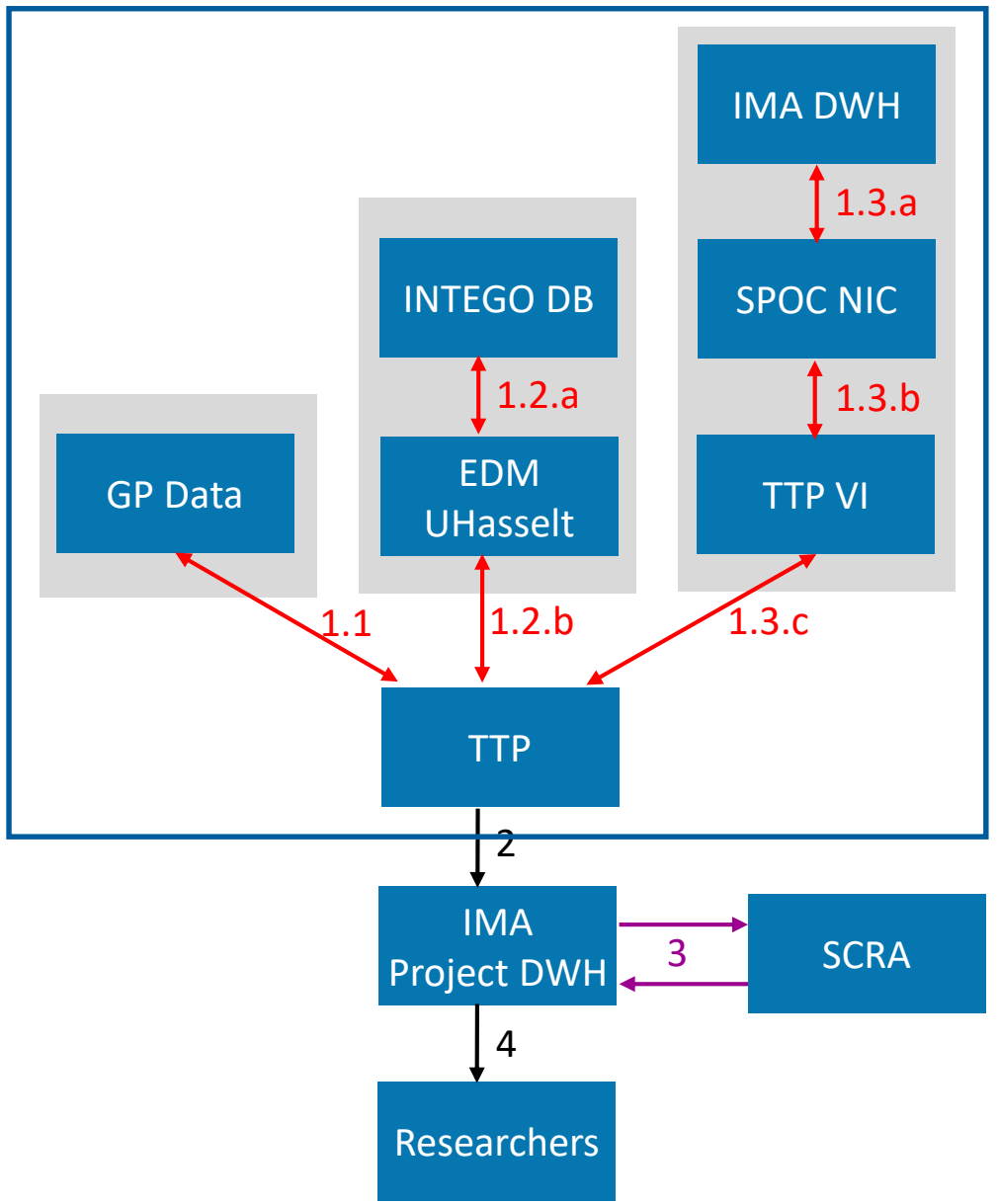
Oblivious join



Current practice Vs. Oblivious join







Deliberation nb. 17/071 from 19 September 2017

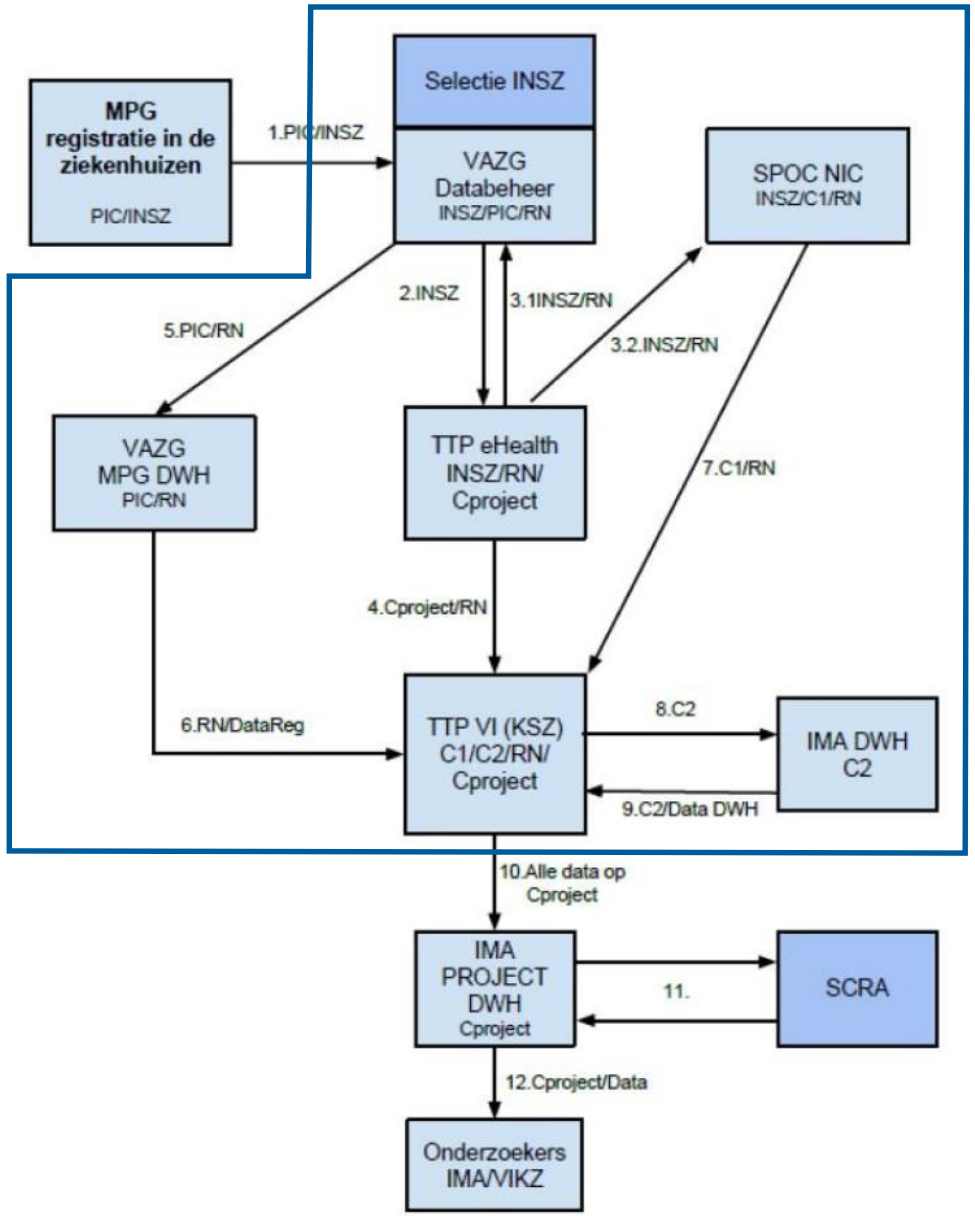
Oblivious join automated

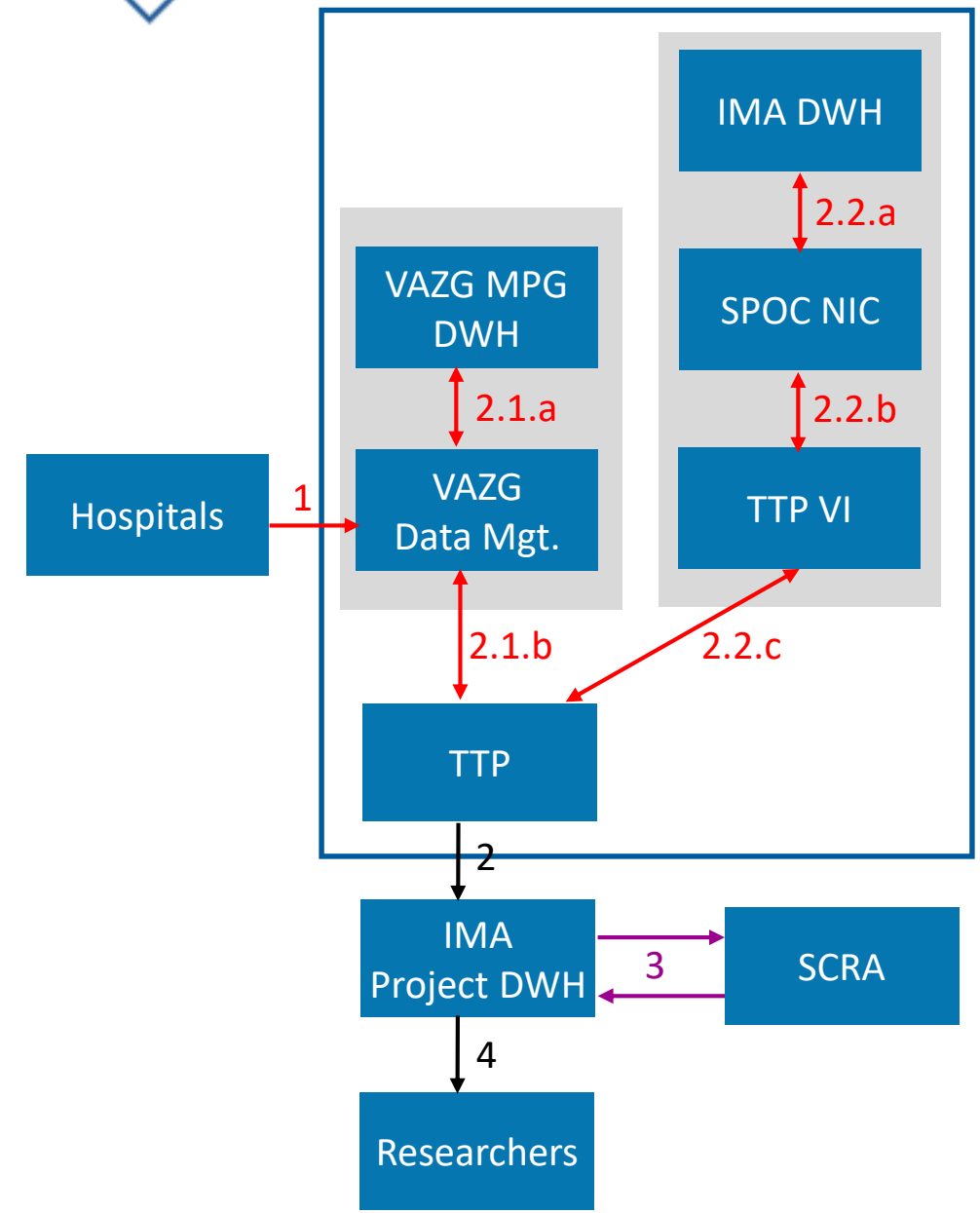
Analysis

Data transfer

Standard flow in parallel
No data leakage

Current practice Vs. Oblivious join





Deliberation nr. 19/062 from 2 April 2019

Oblivious join automated

Analysis

Data transfer

Standard flow in parallel
No data leakage

Oblivious join

Status

- **First library for test and demo purposes**
  with core functionality
- Efficiency for 256 bit security: “A few hours” [1]
- Technical description in progress
- Collaboration with legal and security services

[1] Preliminary tests on Ubuntu 18.04, Intel Core i5-8250 CPU @ 1,60Ghz, 4 cores, 6GB

Joining & pseudonymizing personal data

- In a standardized way
- Without data leakage

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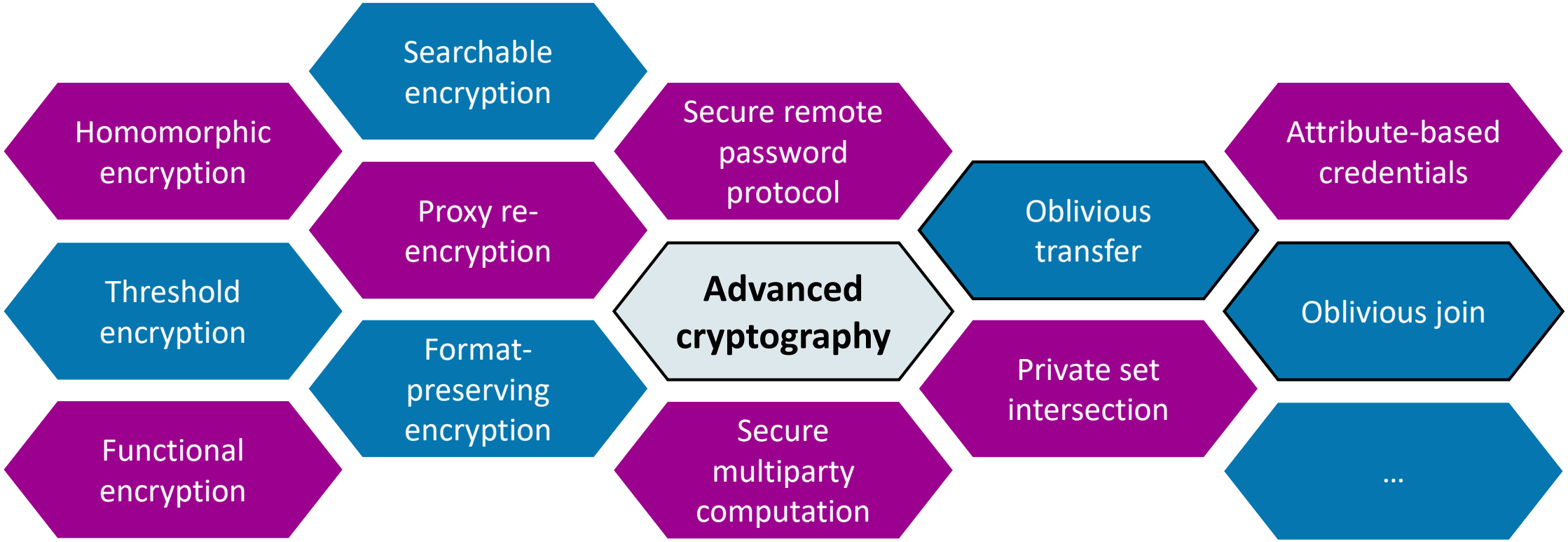
Advanced cryptography



Potential within government context

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Cryptographer, PhD
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Smals research sees opportunities within government context

Complex or hard to attain goals in a traditional way?

Functional requirements

Security & privacy (GDPR) requirements

Ongoing research

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