A prototype for efficient and secure file sharing and search on encrypted keywords

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Telsy S.p.A.

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Telsy S.p.A.

Telsy is a reliable partner for ICT security solutions and services ever since 1971.

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TELSY is certified by the Italian National Authority for Security as a supplier of devices, systems and solutions for information protection at all security levels.

Dozens of Governments and Corporates have adopted Telsy’s solutions worldwide.

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- ✓ Commercial solutions for cloud encryption and file sharing
- ✓ Attribute-Based Encryption and file sharing
- ✓ Searchable Encryption
- ✓ Telsy prototype

Some notation and terminology...


Secret key


Public key


Encrypted file

Group = set of users sharing some data

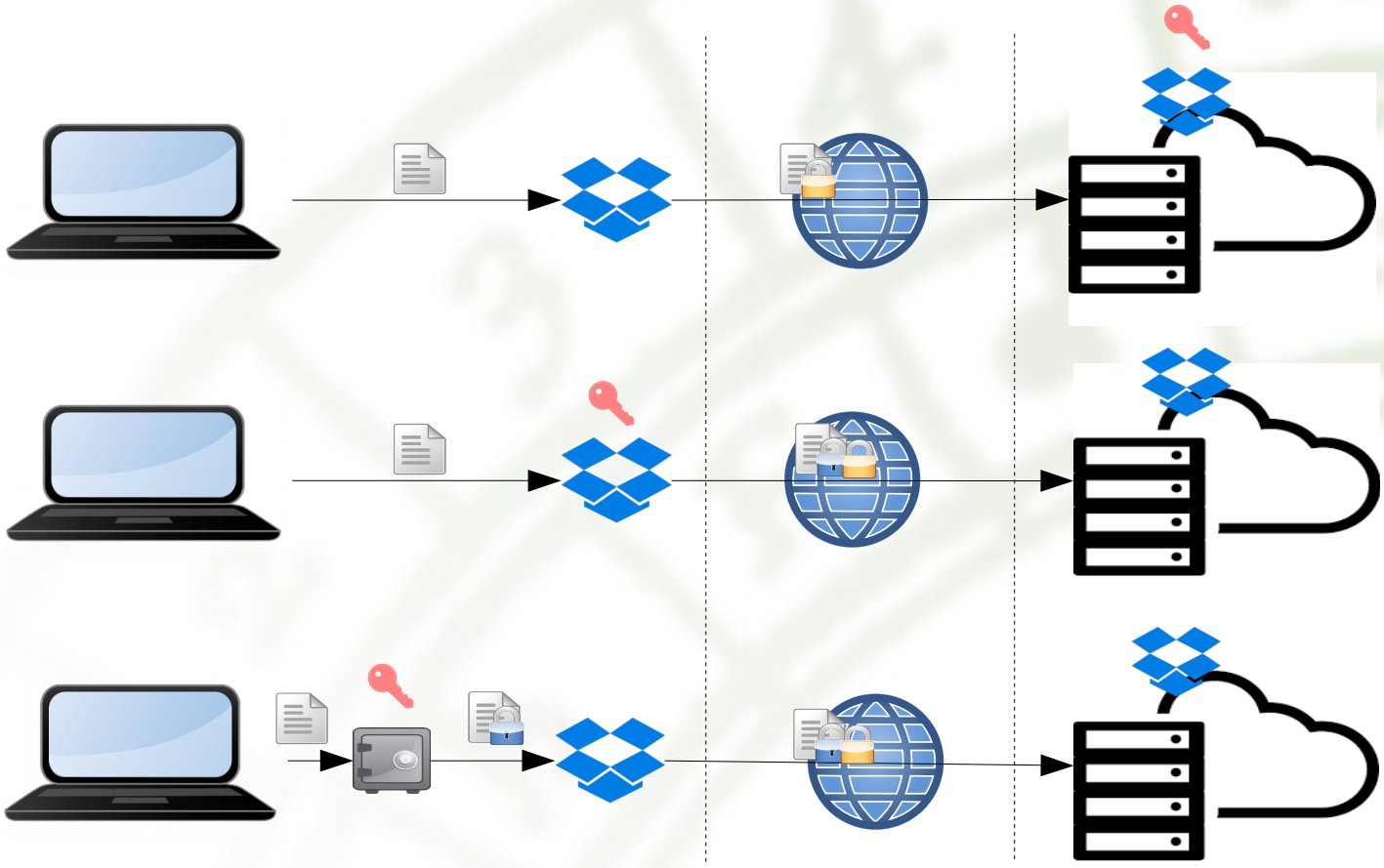
Commercial solutions for cloud encryption and file sharing

Encryption types

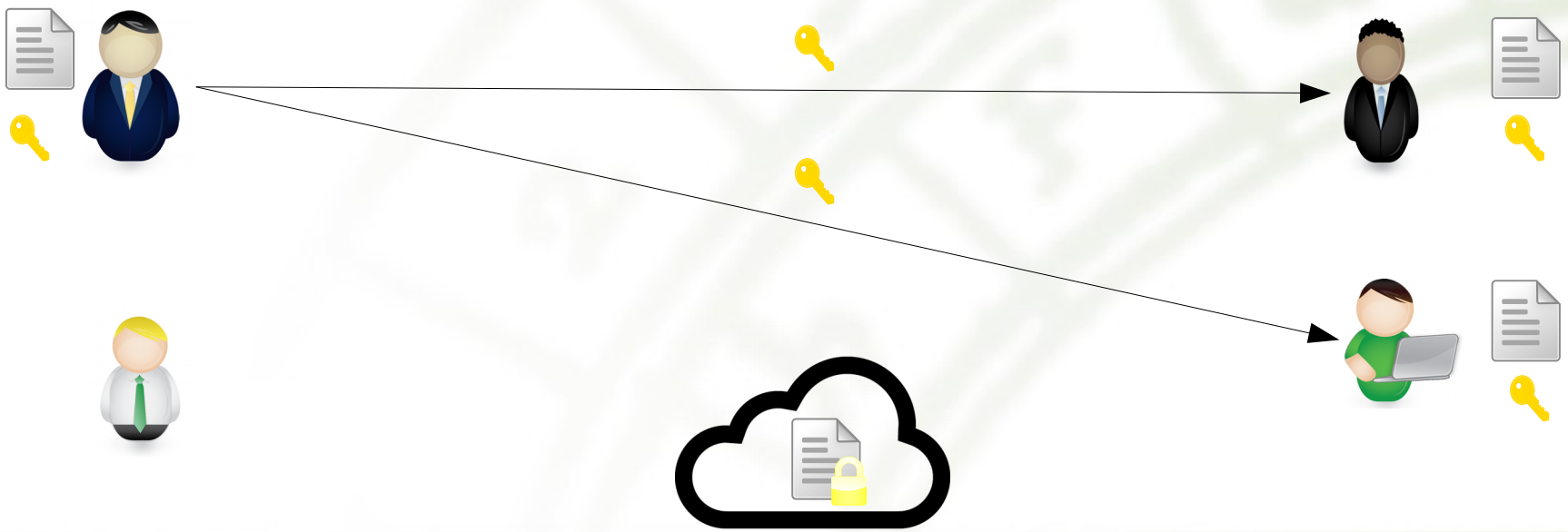
Server Side
Storage, Sharing,
Manipulate data
Ex: Dropbox, Google Drive, OneDrive, ...

Client Side (CS) Native
Storage, Sharing
Ex: Tresorit, Spideroak, ...

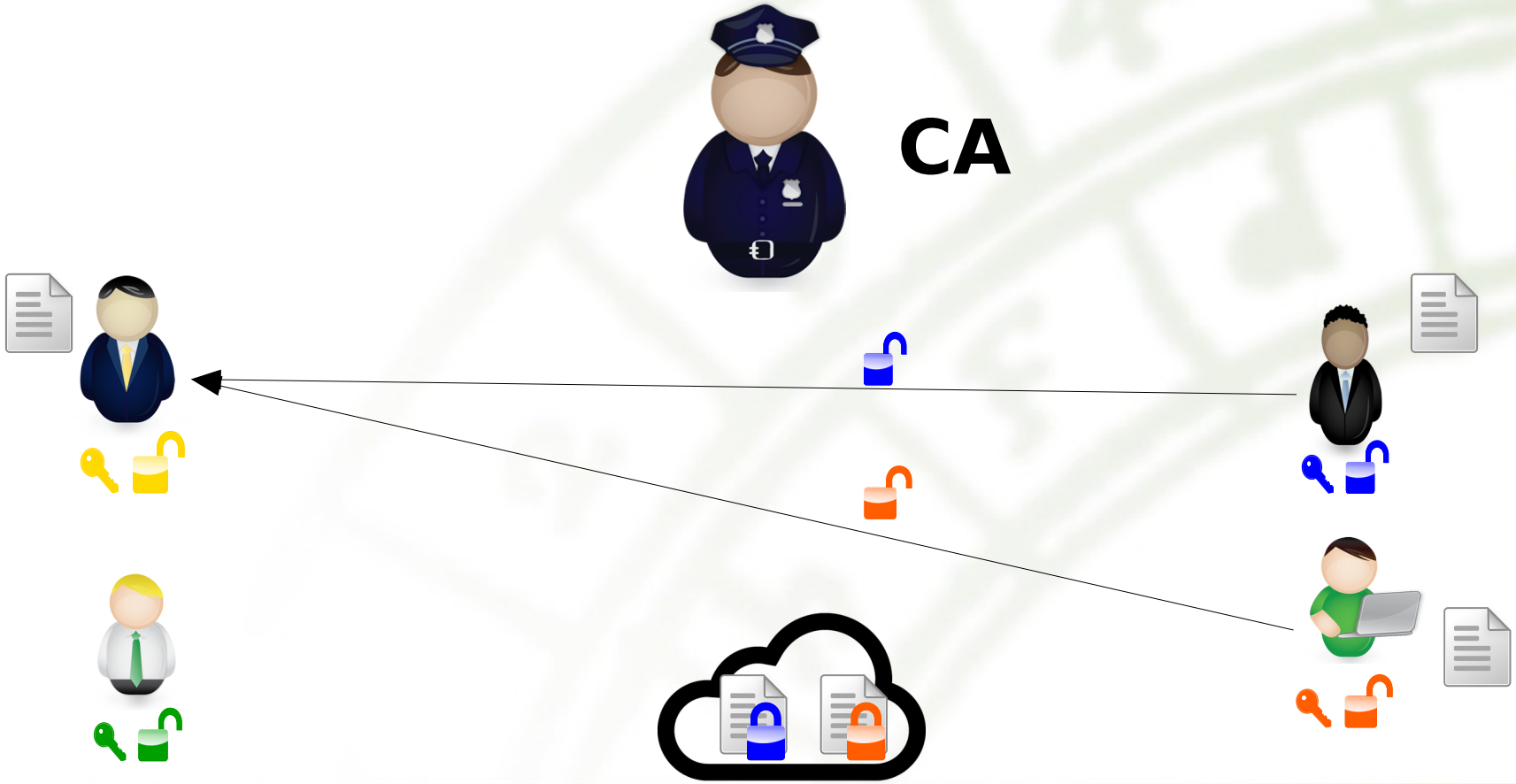
Client Side Third-party
Storage, Sharing,
Ex: Boxcryptor, Cloudfogger, Viivo, ...



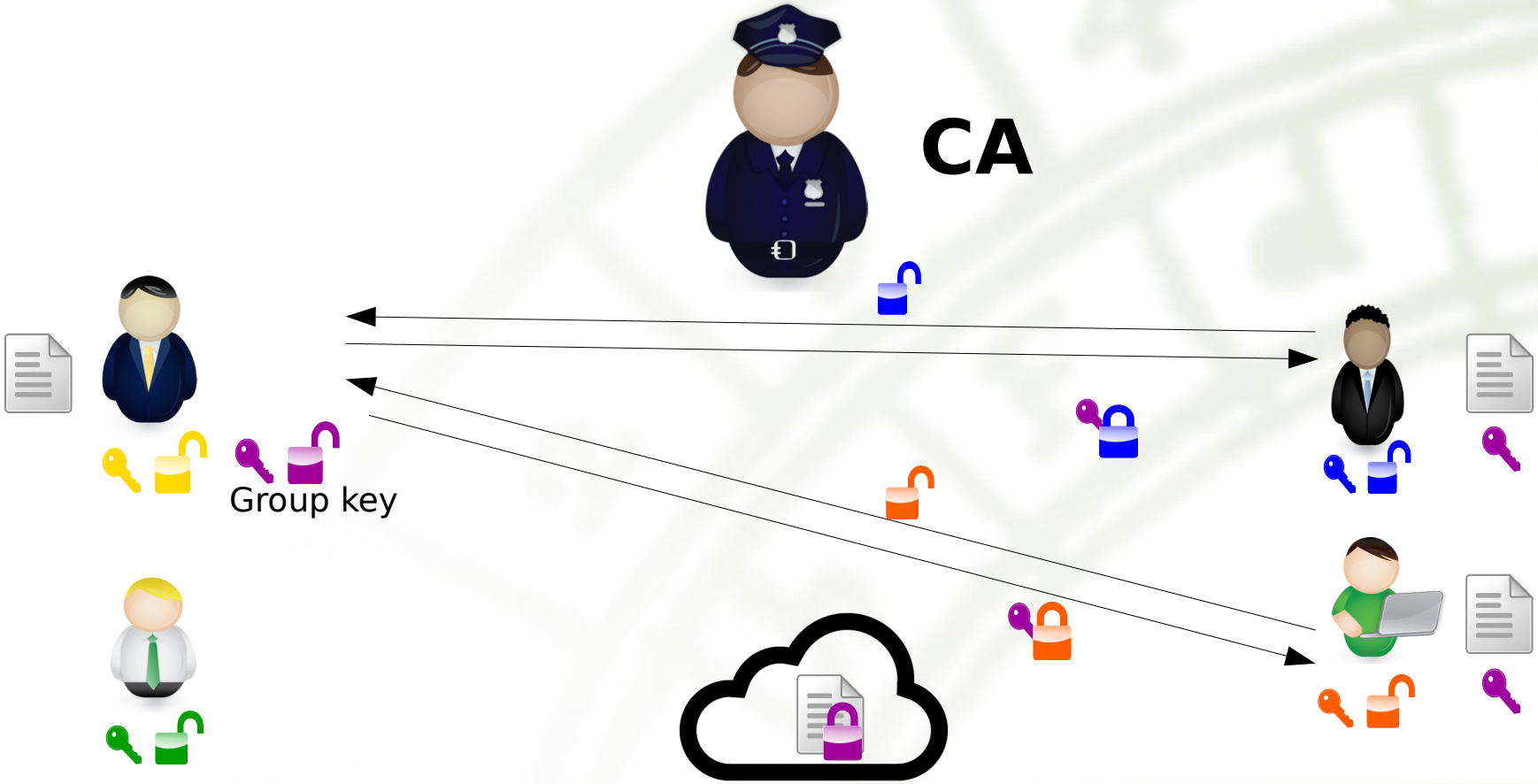
CS file sharing model: solution 0



CS file sharing model: solution 1



CS file sharing model: solution 2



CSE comparison

	Solution 1	Solution 2
Number of personal asymmetric key pairs	1	1
Number of group asymmetric key pairs per user	0	Linear with number of groups a user belongs to*
Ciphertext size	Linear with group size	Constant
Revocation	Delete part of the ciphertext	Re-encryption and key re-destribution
Public-key management	Certification Authority	Certification Authority

* The number of groups can possibly be exponential in the number of users of the system

Attribute-Based Encryption

Attribute-Based Encryption

Attribute-based encryption is a type of public-key encryption in which the secret key of a user and the ciphertext are dependent upon attributes.

In such a system, the decryption of a ciphertext is possible only if the set of attributes of the user key matches (a policy on) the attributes of the ciphertext.

Attribute-Based Encryption

- ✓ 2001 – IBE

  Boneh, Franklin - “Identity-Based Encryption from the Weil Pairing”

- ✓ …
- ✓ 2006 – CP-ABE

  Brent, Sahai, Waters - “Ciphertext-Policy Attribute-Based Encryption”

- ✓ 2006 – KP-ABE

  Goyal, Pandey, Sahai, Waters - “Attribute-Based Encryption for Fine-Grained Access Control of Encrypted Data”

- ✓ …
- ✓ 2009 – FULL SECURE IBE

  Waters - “Dual System Encryption: Realizing Fully Secure IBE and HIBE under Simple Assumptions”

- ✓ 2010 – FULL SECURE ABE

  Lewko, Sahai, Waters, Okamoto, Takashima - “Fully Secure Functional Encryption: ABE and (Hierarchical) Inner Product Encryption”

- ✓ 2011 – Constant ciphertext

  Attrapadung, Libert, de Panafieu - “Expressive Key-Policy ABE with Constant-Size Ciphertexts”

- ✓ …

Attribute-Based Encryption

- ✓ 2011 – Multi-Authority

  Lewko, Waters - “Decentralized Attribute-Based Encryption”

- ✓ 2012 – Dynamic Credential, Ciphertext Delegation

  Sahai, Seyalioglu, Waters - “Dynamic Credentials and Ciphertext Delegation for Attribute-Based Encryption”

- ✓ 2013 – Non-monotonic access structure

  Yang, Wu, Wang, Du - “Fully Secure Attribute-Based Encryption with Non-monotonic Access Structures”

- ✓ 2013 – Fast Decryption

  Hohenberger, Waters - “Attribute-Based Encryption with Fast Decryption”

- ✓ 2013 – Self-Updatable Encryption, Hidden Attributes

  Lee,Choi,Lee,Park,Yung - “Self-Updatable Encryption: Time Constrained Access Control with Hidden Attributes and Better Efficiency”

- ✓ 2014 – Traceble ABE

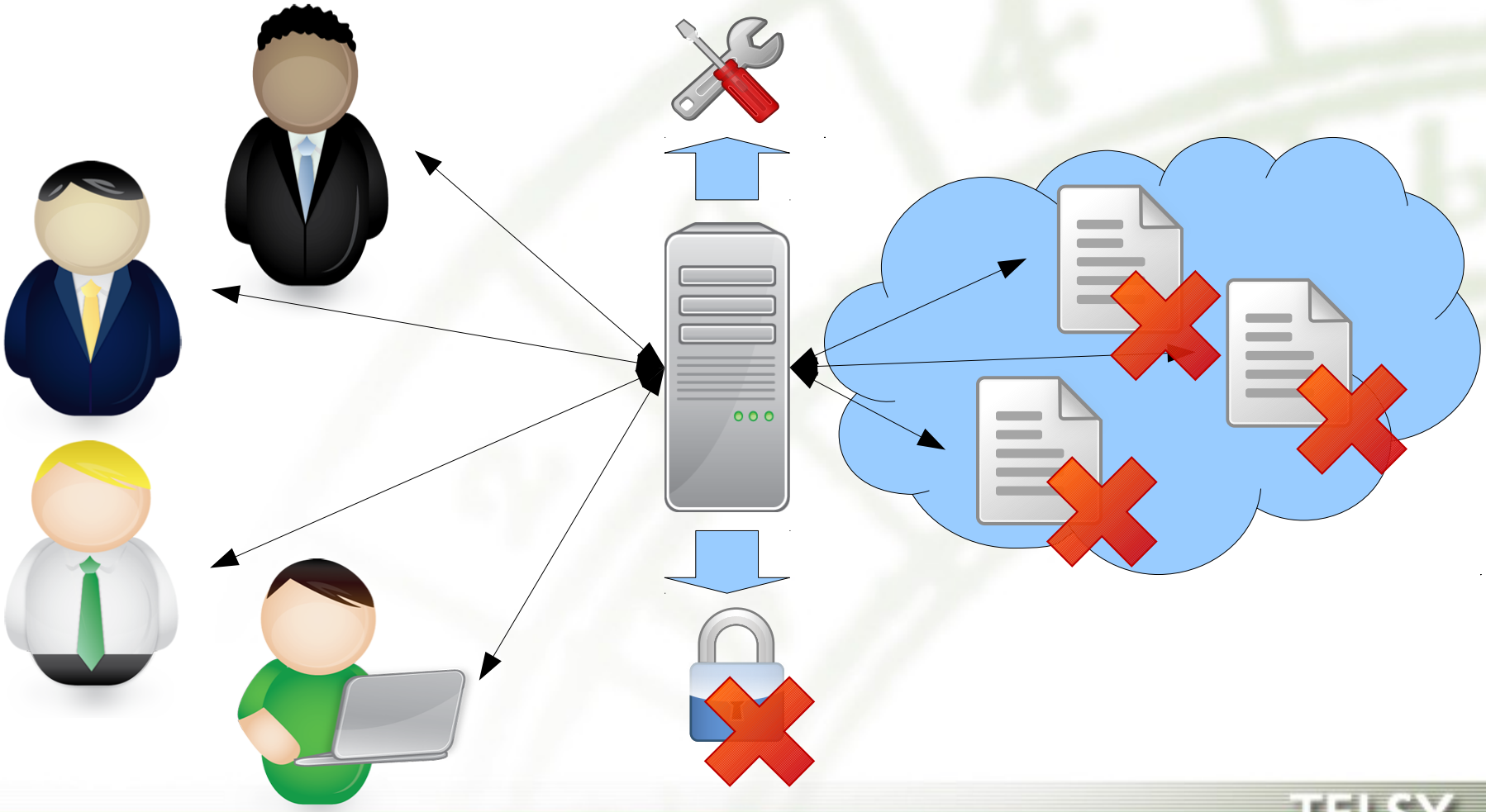
  Liu, Cao, Wong - “Fully Collusion-Resistant Traceable Key-Policy Attribute-Based Encryption with Sub-linear Size Ciphertexts

- ✓ 2015 – Anonymous ABE

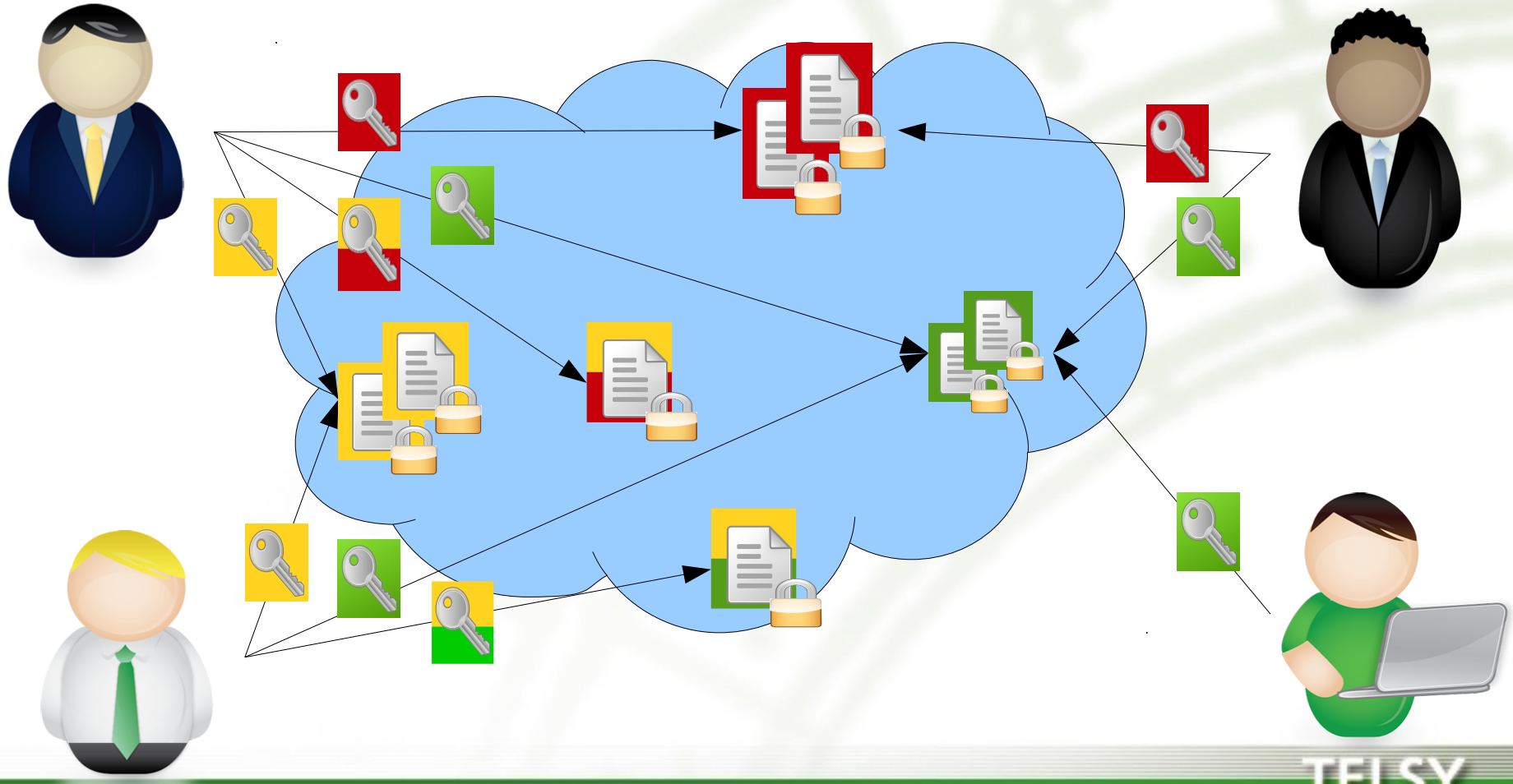
  Taeho, Xiang-Yang, Zhiguo, Meng - “Control Cloud Data Access Privilege and Anonymity With Fully Anonymous ABE”

- ✓ ...

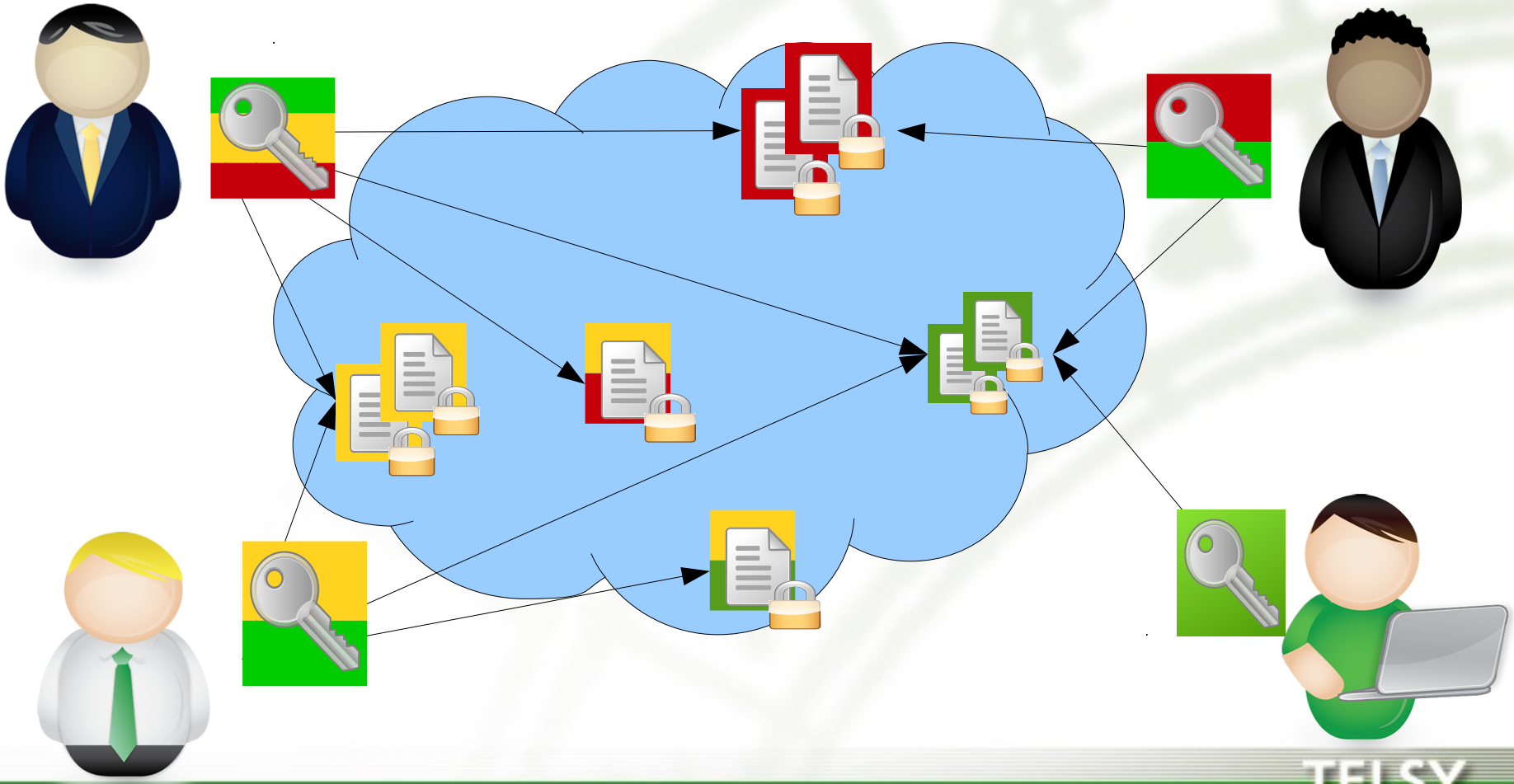
Access Control: Trusted Server



Access Control: Standard Encryption

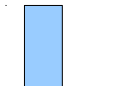


Access Control: Attribute-Based Encryption



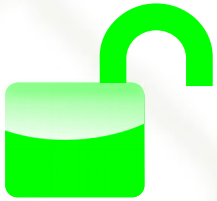
ABE: Characters

AUTHORITY



MASTER KEY

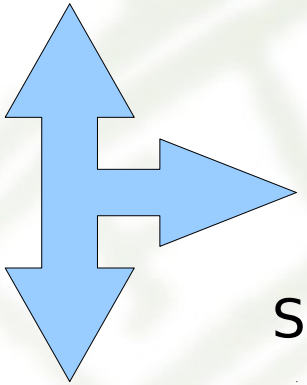
Sender



PUBLIC KEY

Receivers

Group 1
SECRET KEY



Group 2
SECRET KEY

Group 3
SECRET KEY

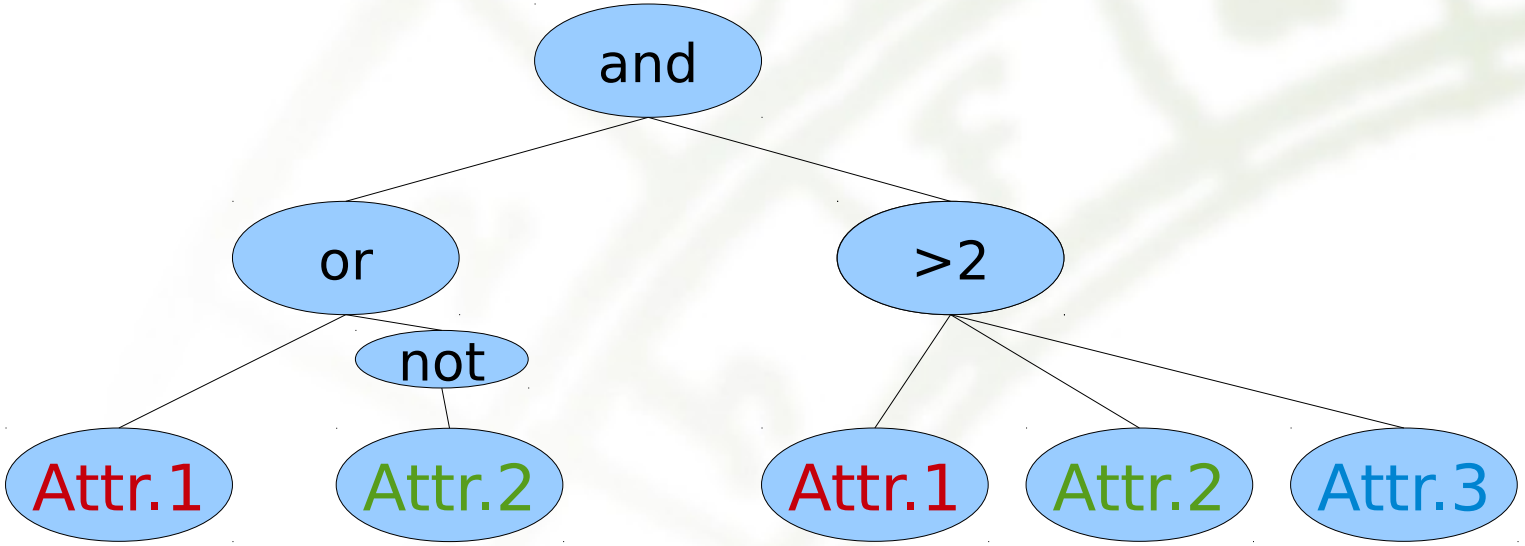
ABE: Attributes

2 Types:

- ✓ Data description (**KEY-POLICY**)
- ✓ User description (**CIPHERTEXT-POLICY**)

ABE: Policy

Can be seen as a tree graph with **and, or, not, threshold** gates



ABE: Performance example

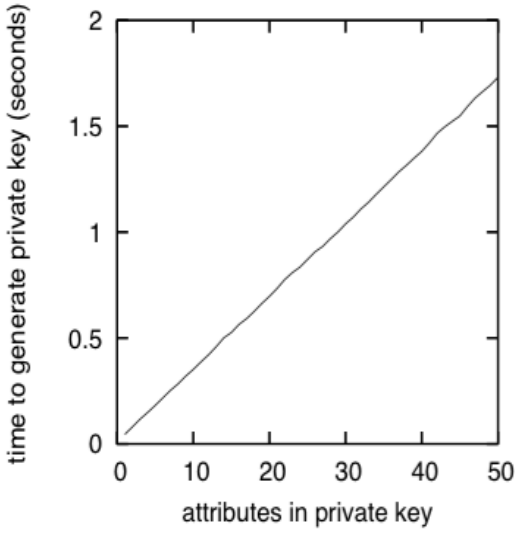
	6 Attributes	20 Attributes
KeyGen	~0.19 ms	~0.50 ms
Encryption	~0.70 ms	~2.10 ms
Decryption	~1.35 ms	~3.76 ms

126-bit Security Level Elliptic Curve, CP-ABE scheme

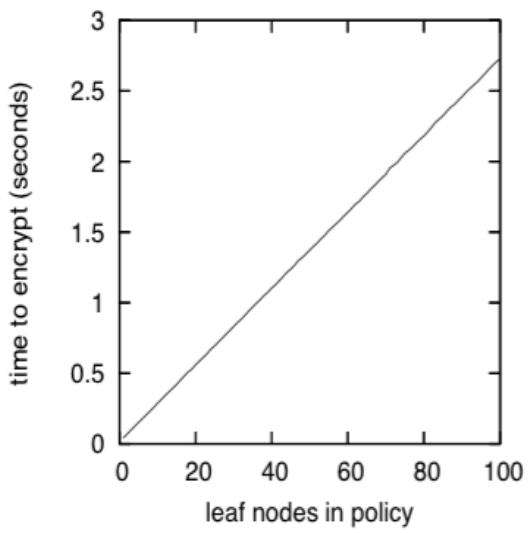
Intel Core i7 4770 @3.4GHz

From: http://sandia.cs.cinvestav.mx/Site/CPABE

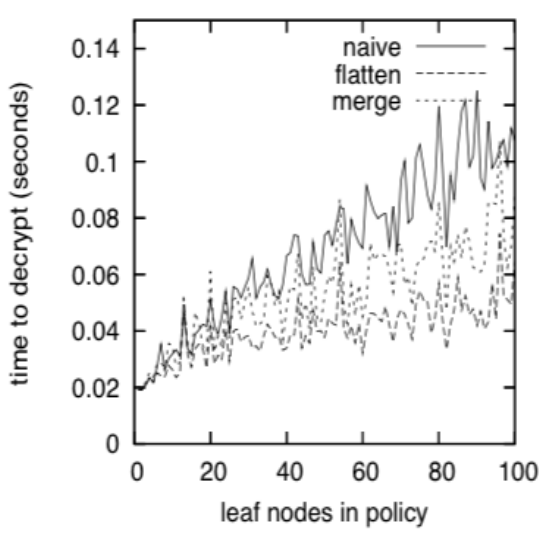
ABE: Performance example



(a) Key generation time.



(b) Encryption time.



(c) Decryption time with various levels of optimization.

Pentium 4 @3.2 GHz

ABE: mathematics

Pairings:

$$e(g^a,g^b) = e(g,g)^{ab}$$

Pairing-Based Cryptography:

- ✓ Elliptic curves (no Diffie-Hellman curves)
- ✓ Lattices
- ✓ Quadratic residues

Searchable Encryption

Searchable encryption

By searchable encryption we do not mean *search over data* (e.g. words inside an email or a file), but we mean an **indexed-based search**.

Searchable encryption

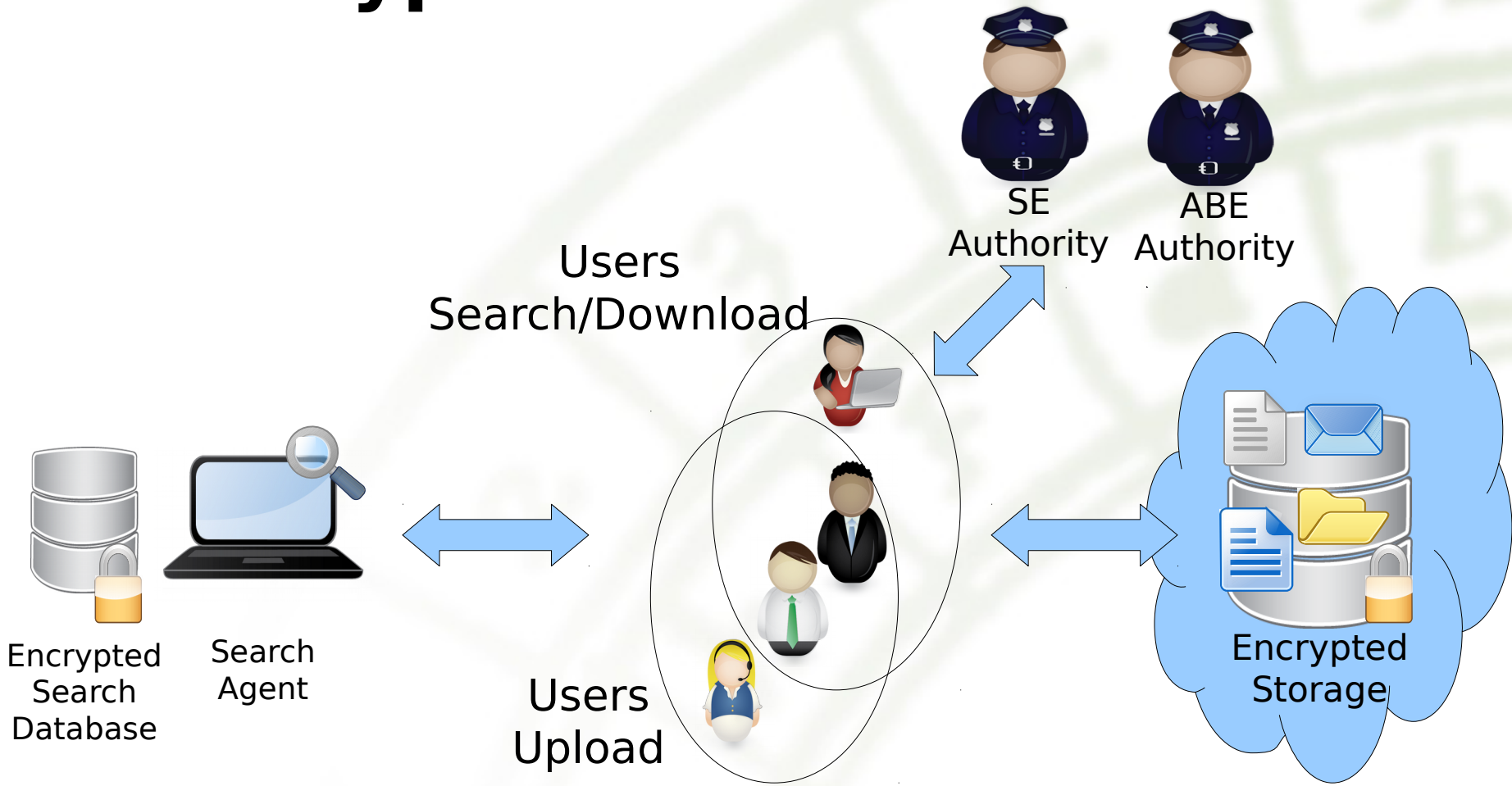
	EXAMPLE	LEAKS	EFFICIENCY	SECURITY	USE
Property-Preserving Encryption	Equality PE (Det.Encr./Token)	EDB and EDB+Token reveals: - access pattern - search pattern	Sublinear in number of docs	- Frequency analisys (FA) - Repeated search (RS) - Dictionary attack (DA), only if public key is used	- high minentropy data - not for mail, text, personal info
	Order PE				
	Orthogonality PE				
Functional Encryption	Anonymous IBE	- access pattern - search pattern	Linear in number of docs	- No FA - RS, DA	Hard to gues search terms
Oblivious RAM	FHE	No leaks	Very inefficient	No FA, RS, DA, ...	Not practical
	Symmetric Encryption Scheme		- Many communications - Reads blocks of memory instead of single encrypted keywords		“Small to medium” dataset
Searchable Symmetric Encryption	- Interactive/ Non-interactive - Response Hiding/Revealing	- search pattern - minimal controlled leakage	Sublinear + Linear Pre-Processing	- No FA	- real dataset

Telsy Prototype

Prototype

The prototype is part of a research project co-funded by the *Italian Ministry of Defence* in the context of the *National Plan for Military Research*

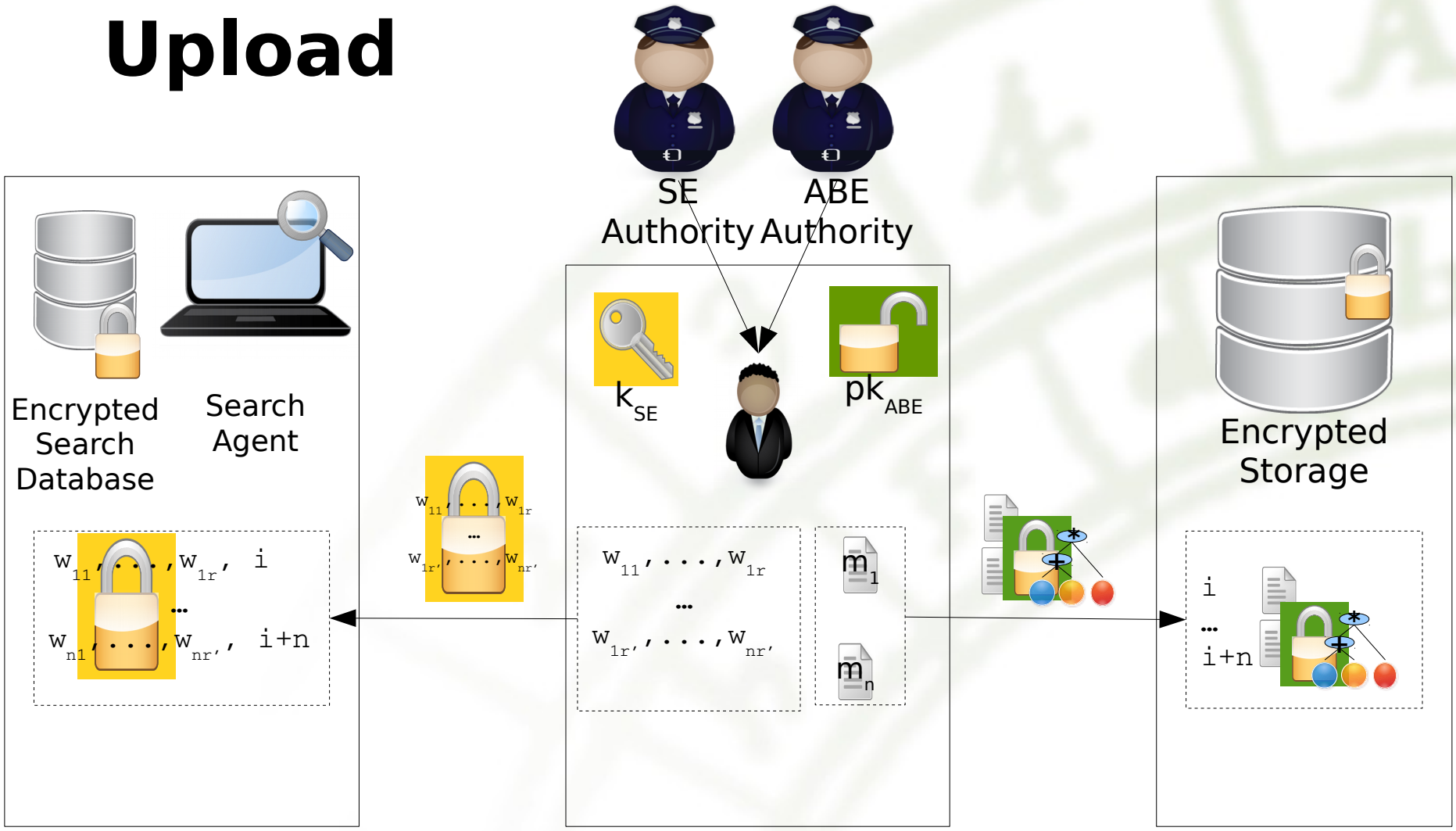
Prototype architecture



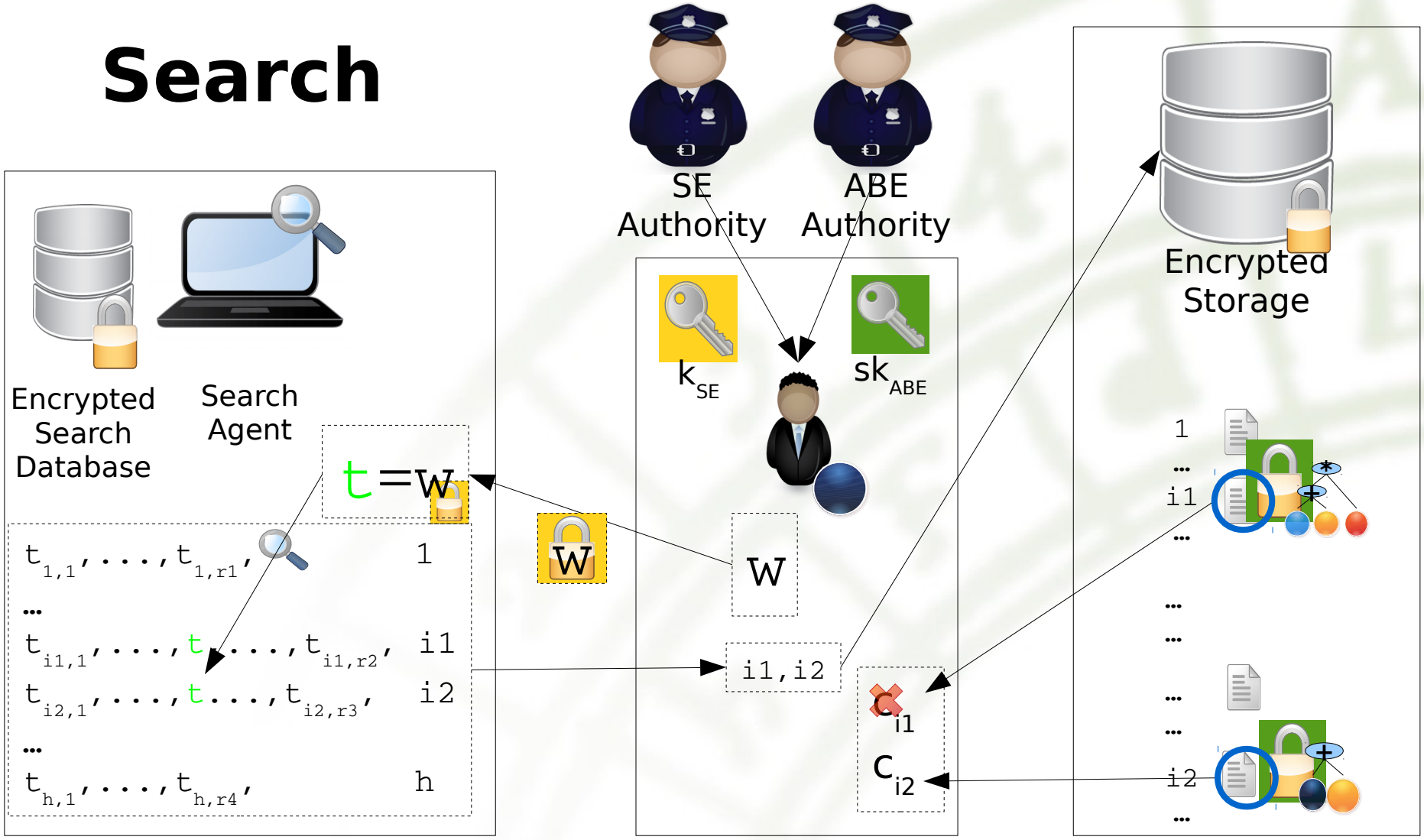
Pre-requisites

- ✓ We want to keep the search and storage servers independent
  - They do not communicate
  - Storage server can be a commercial one and easily replaced
- ✓ It should be possible to manage keys for search and keys for storage separately
- ✓ Access control must be implemented at a cryptographic level in order to have all ciphertext on the same place

Upload


SE Authority
ABE Authority
k_{SE}
pk_{ABE}
Encrypted Search Database
Search Agent
Encrypted Storage
$w_{11}, \ldots, w_{1r}$, i
$w_{n1}, \ldots, w_{nr'}$, i+n
$w_{11}, \ldots, w_{1r}$
$w_{1r'}, \ldots, w_{nr'}$
m_1
m_n
i
i+n

Search


SE Authority
ABE Authority
Encrypted Storage
Encrypted Search Database
Search Agent
t=w
k_SE
sk_ABE
w
w
i1,i2
c_i1
c_i2
1
i1
i2
t_1,1,...,t_1,r1, 1
t_i1,1,...,t...,t_i1,r2, i1
t_i2,1,...,t...,t_i2,r3, i2
t_h,1,...,t_h,r4, h

...thanks for the attention!