Dynamic Credentials and Ciphertext Delegation for ABE

Amit Sahai, Hakan Seyalioglu, Brent Waters

Attribute-Based Encryption
[S-Waters 2005, GPSW'06, BSW'07]

Different users will have credentials (attributes).

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`Forensics`

$$\mathsf{KeyGen}(MSK, S) \rightarrow K_S$$

Attribute set =
`Top Secret,`
`Forensics`

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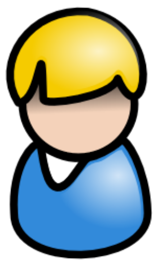

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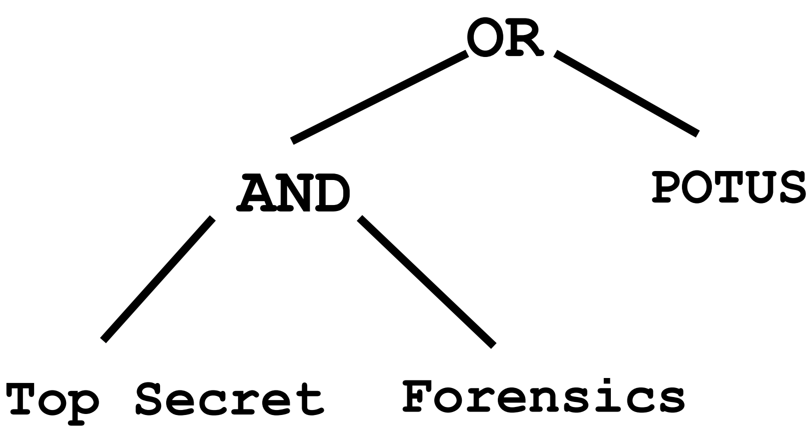
Encryption takes as input a policy.

$$\mathsf{Encrypt}(PK, M, P) \rightarrow C_P$$



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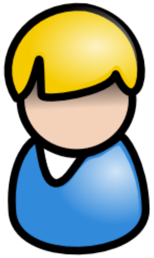

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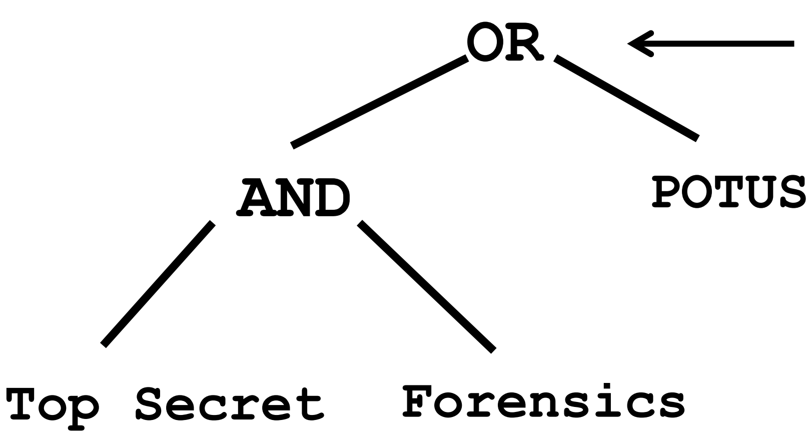

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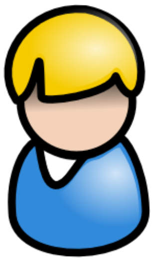

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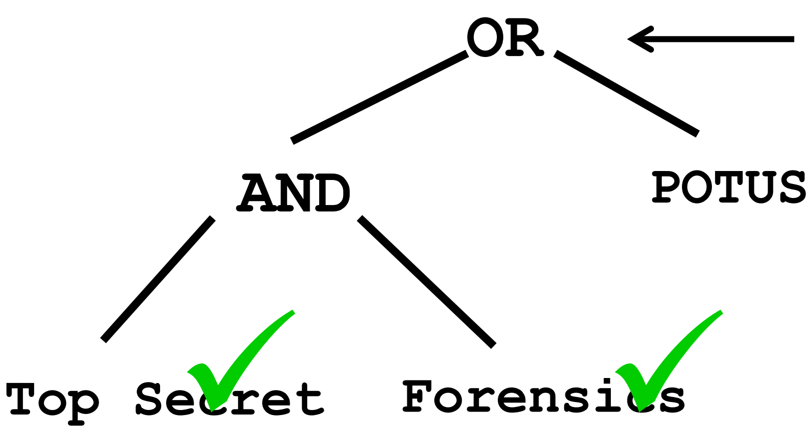

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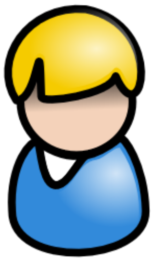

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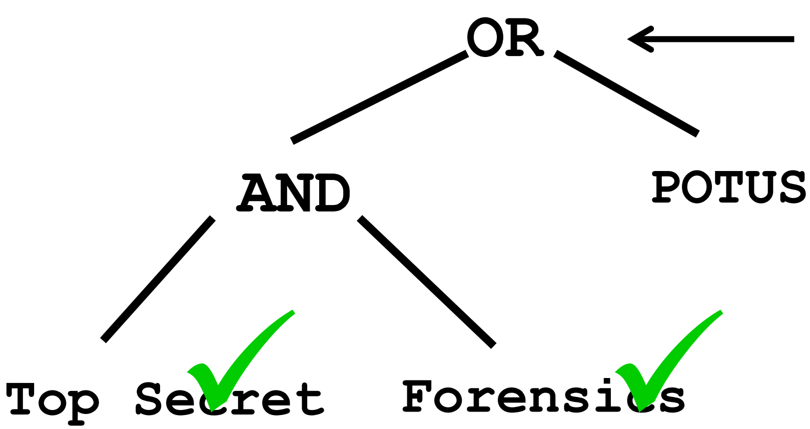

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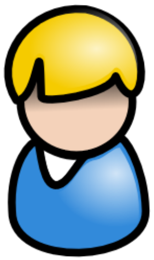

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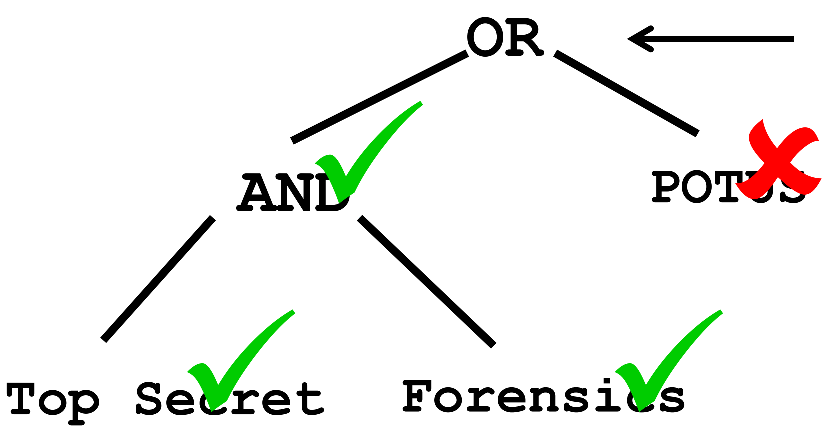

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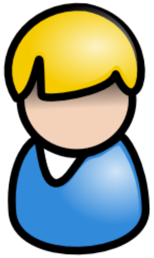

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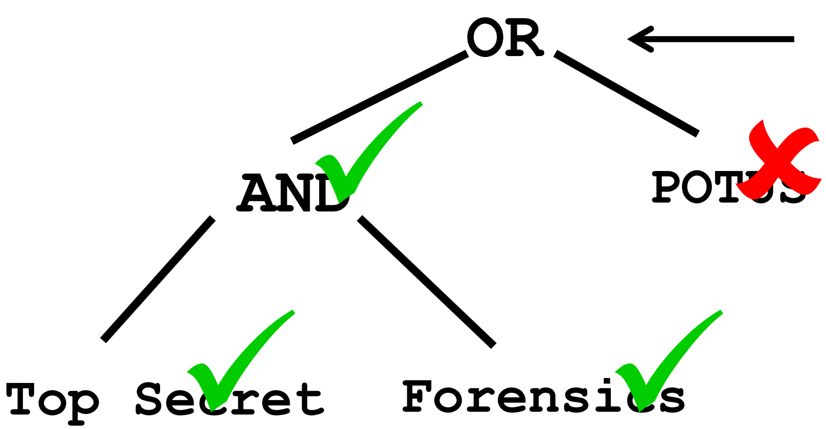

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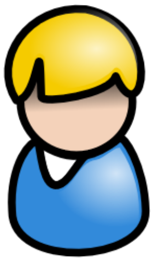

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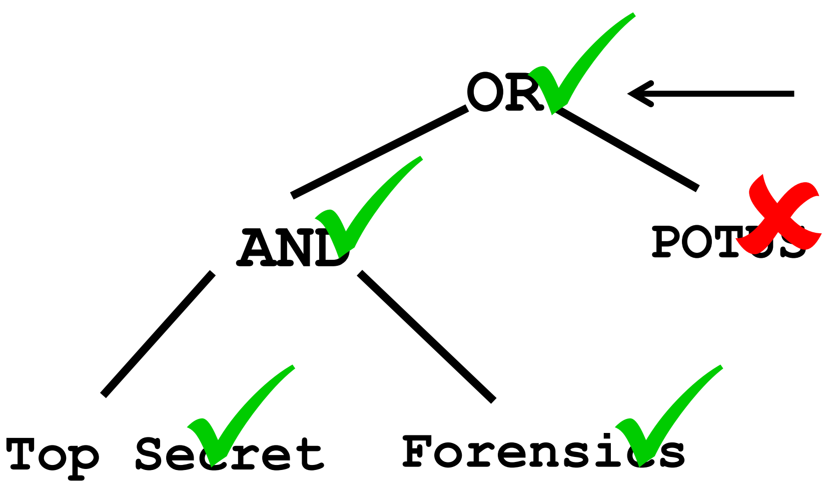

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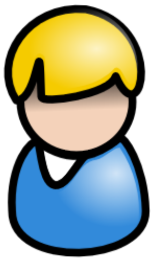

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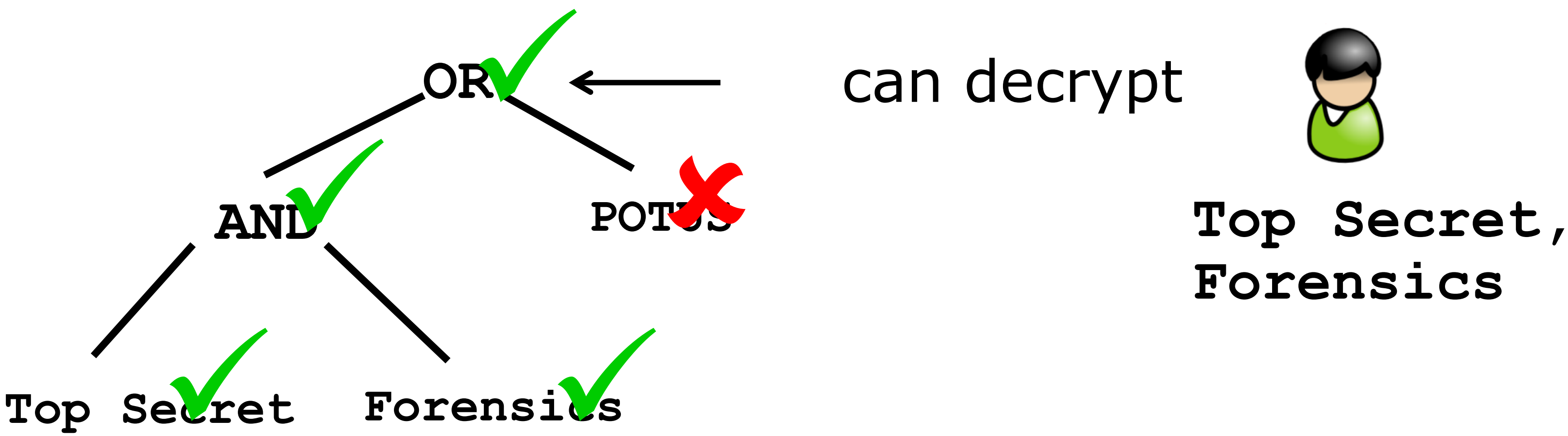

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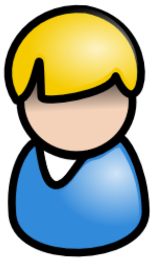

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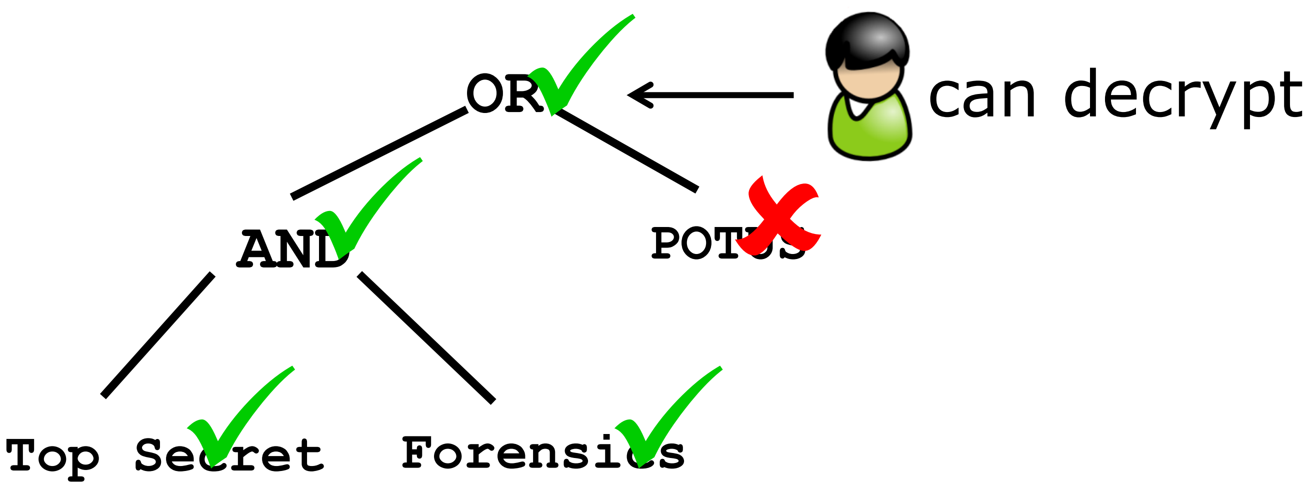

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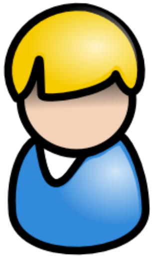

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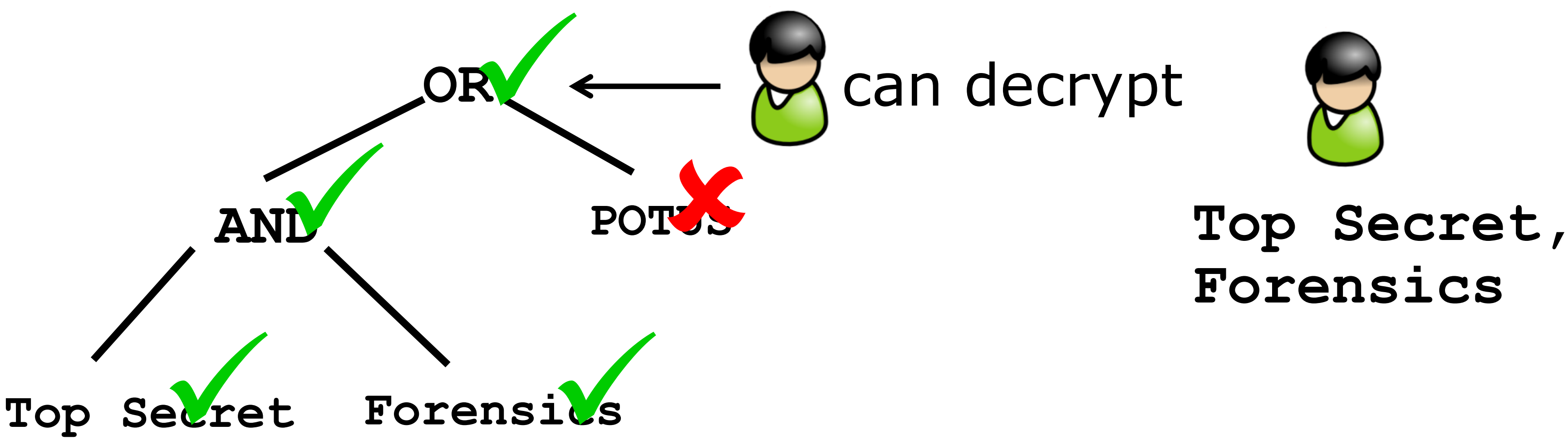

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This work: Dynamic Credentials

Are the security concerns the same as standard revocation?

No: standard revocation is for *broadcast*: you only care about protecting the future

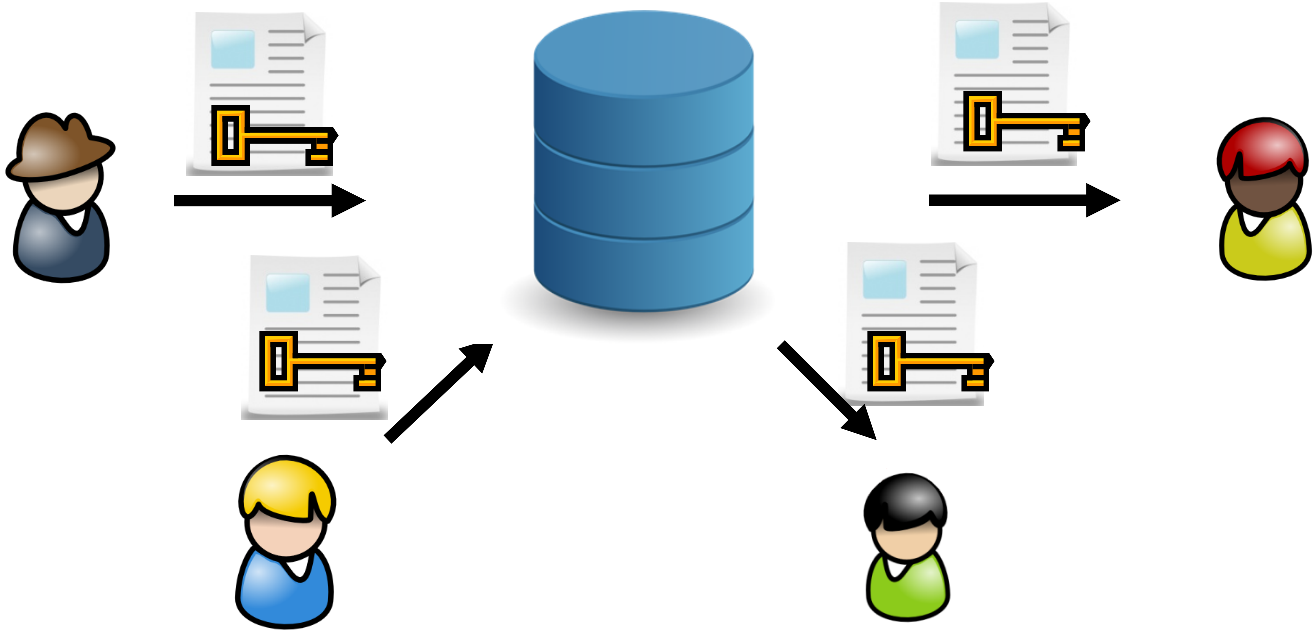
We illustrate with a motivating example:

Inspired by a wonderful conversation with Thomas King and Daniel Manchala (Xerox LA) Our thanks to them for inspiring this work!

Motivation

Setting:
Company with ABE based access control

Normally, employee only accesses files he needs (enforced by access logs).



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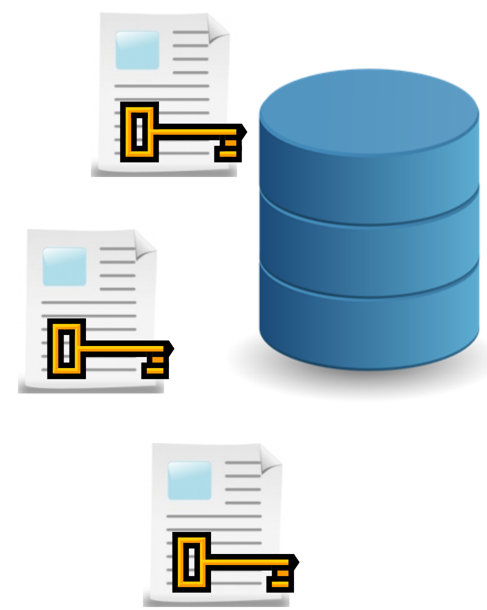
Employee Termination:
Employee’s key is revoked. Standard guarantee: he can’t access files added in the future.



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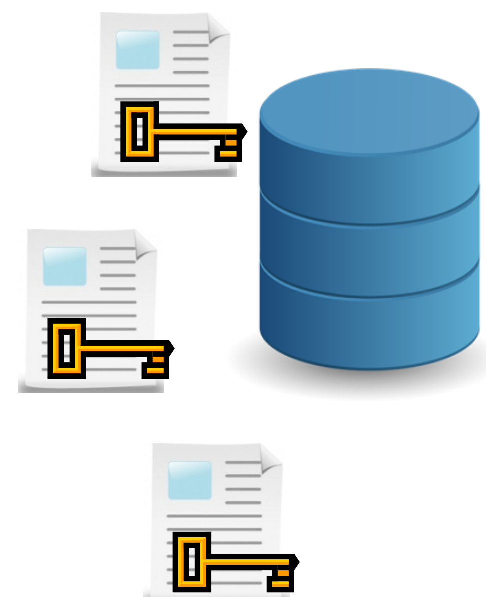

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Serious problem: balance between strict security and ease of use:
Necessitates broader access policies,
with countermeasures against misuse of privilege.

Preventing access to old files, even if they match old access policy, is important security concern.

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This breaks down into two guarantees.

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Main Result: First ABE scheme to address both of these problems simultaneously.

Two Security Guarantees

- Assume we have security for new files:

  $\text{Encrypt}(PK, M, P, t)$ can only be decrypted by users with secret key for time $\geq t$.

  (e.g., user with credential for time t+2 can decrypt)

- How can we get security for old files?

Solution ideas

Decrypting and Re-encrypting:
Every night, re-encrypt all files on server

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We ask:
Can we allow server to “refresh” the encryption
without needing any secret keys,
and without growing the ciphertext?

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Our Approach

Directly Refreshing Ciphertext:
Increment the time component using public data

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More generally, for standard ABE:

$$\mathsf{Encrypt}(PK, M, P) = C$$

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Delegation

An example of **ciphertext delegation** in ABE [BSW07]:

Key Generation.

$$MSK = \alpha, \beta \leftarrow \mathbb{Z}_p$$

$$PK = g^{\beta}, g^{1/\beta}, e(g,g)^{\alpha}$$

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(Only used in decryption)

Delegation

Encryption.

Take the ciphertext policy:
"Has `top secret (ts.)' and `accounting (ac.)' attributes"

$$s \leftarrow \mathbb{Z}_p$$

$$s = q_{ts.} + q_{ac.}$$

$$C = (Me(g,g)^{\alpha s} \quad ,$$

$$C_{ts.} = g^{q_{ts.}} \quad , \quad C'_{ts.} = H(ts.)^{q_{ts.}} \quad ,$$

$$C_{ac.} = g^{q_{ac.}} \quad , \quad C'_{ac.} = H(ac.)^{q_{ac.}})$$

Delegation

Can we delegate this to the policy:
"Has attributes `top secret (ts.)' and `accounting (ac.)' and `director (dir.)' "

We are given the ciphertext:

$$Me(g,g)^{\alpha s}$$

$$C_{ts.} = g^{q_{ts.}} \quad , \quad C'_{ts.} = H(ts.)^{q_{ts.}} \quad ,$$

$$C_{ac.} = g^{q_{ac.}} \quad , \quad C'_{ac.} = H(ac.)^{q_{ac.}}$$

where: $s = q_{ts.} + q_{ac.}$

and the public key: $g^{\beta}, g^{1/\beta}, e(g,g)^{\alpha}$

Delegation

Generate: $q_{dir.} \leftarrow \mathbb{Z}_p$

$$C = (Me(g,g)^{\alpha s} e(g,g)^{\alpha q_{dir.}} = Me(g,g)^{\alpha(s+q_{dir.})}$$

$$C_{ts.} = g^{q_{ts.}} \quad , \quad C'_{ts.} = H(ts.)^{q_{ts.}} \quad ,$$
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Why is this a good ciphertext? $s' = s + q_{dir.}$

Plus: Use re-randomization to prevent subtle attacks.

Types of Delegation

We show most current ABE schemes support a variety of efficient ciphertext delegation ops:

- Increasing node thresholds
- Increasing node thresholds and adding nodes
- Deleting subtrees

We also conduct survey of delegation operations on LSSS matrix based schemes [GPSW06, Waters11, LOSTW10].

Conclusion

1. We define ciphertext delegation and give a number of efficient methods for ciphertext delegation.
2. We use ciphertext delegation to solve the problem of revocable storage.
3. We also construct fully secure ABE schemes that achieve revocation security vs. future encryptions.
4. We show how to combine these elements to achieve the first fully secure ABE schemes for dynamic credentials.