Thursday

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Sources

- "Divertible protocols and atomic proxy cryptography" by M. Blaze, G. Bleumer, and M. Strauss. EUROCRYPT '98.
- "Improved Proxy Re-Encryption Schemes with Applications to Secure Distributed Storage" by G. Ateniese, K. Fu, M. Green, and S. Hohenberger
- "Identity-Based Proxy Re-encryption" by M. Green and G. Ateniese

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Credits

- Kevin Fu (~~MIT~~ UMass)
- Matt Green (JHU)
- Susan Hohenberger (~~MIT~~ JHU)



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First Translations

Susan => Alice
Kevin => Bob
Matt => Charles

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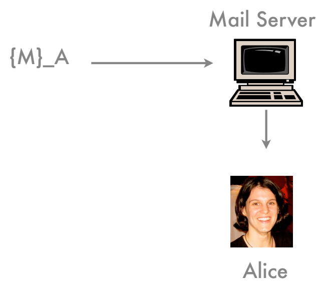
PRE: An Example



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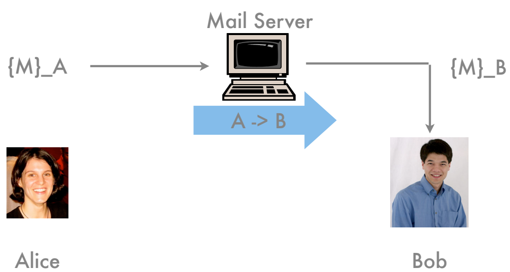

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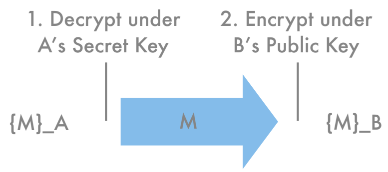

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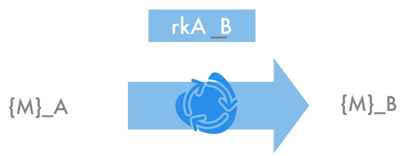

1. Plaintext NOT revealed
2. rk_A->B does not reveal secrets

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PRE and RFIDs

- The RFID stores encrypted data
- Encryption can be read by A
- The reader transforms the encryption for A into one for Bob
- This effectively addresses the revocation problem in RFIDs

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Blaze, Bleumer and Strauss

Alice: $SK = a, PK = g^a$	Bob: $SK = b, PK = g^b$

$$\{M\}_A = Mg^r, g^{ra}$$

$b/a \bmod q$

$$\{M\}_B = Mg^r, g^{rb}$$

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- Bidirectional
- Requires interactive proxy-key generation (both Alice and Bob must provide their secrets)
- Secret key leaked by colluding with the proxy
- Transitivity (from A->B, B->C the proxy can compute A->C)

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A Simple PRE Scheme (1)

Alice: $SK = a, PK = g^a$	Bob: $SK = b, PK = g^b$	
$e() : G_1 x G_1 \rightarrow G_2$	$Z = e(g, g)$	$M \in G_2$

$$\{M\}_A^1 = MZ^k, Z^{ka}$$

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A Simple PRE Scheme (2)

$$\{M\}_A^2 = MZ^k, g^{ka}$$

$$g^{b/a} \in G_1$$

$$\{M\}_B^2 = MZ^k, Z^{kb} = e(g^{ka}, g^{b/a})$$

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VPNs

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Old Key <> New Key

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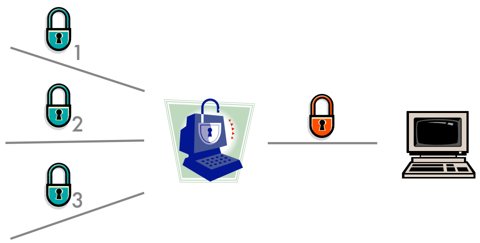
Key Management



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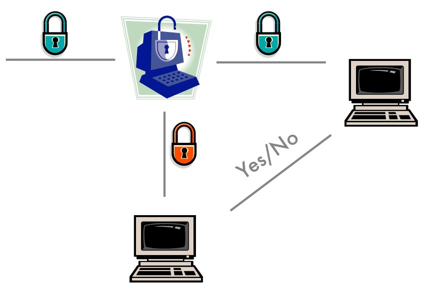
Spam of Encrypted Data



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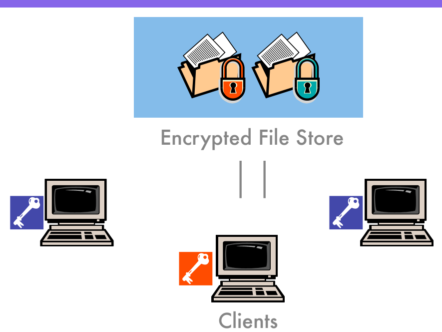
Encrypted File Storage



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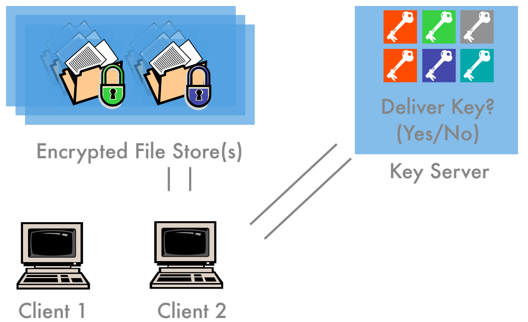
Using a Key Server



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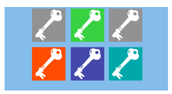
Disadvantages



- Online server is vulnerable
- Content owner must trust Key Server
- Server operator has complete access to keys

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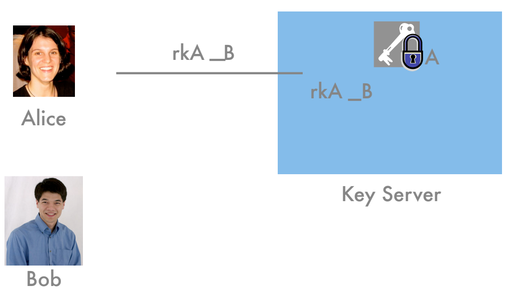
Sharing with New Users



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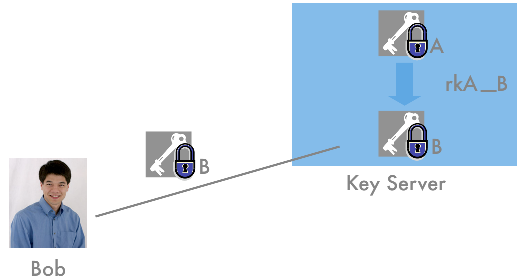
Proxy Key Distribution



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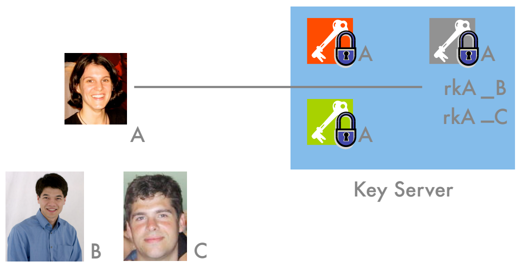
Alice as Group Manager



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Performance

- Computed on a 2.8Ghz Pentium IV
- 512-bit super-singular curve
- Miracl Library

Encryption	Re-encryption	Final Decryption
7.7ms	21.7ms	3.4ms

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Implementation

- Built on Chefs Networked file system
  - Confidential version of SFSRO
  - 128-bit AES encryption
- Dual-purposed file and key server
- Tested performance while compiling EMACS

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ID-based Schemes

- Encrypt under "alice@company.com"
- Specify attributes, like "Alice | | Security Clearance | | Oct 2011"
- Trusted party

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ID-based PRE

$$(C_1, C_2) = (g^r, e(g^s, H_1(\text{"A"})^r) \cdot M)$$

$$rk_1 = h / H_1(\text{"A"})^s$$
$$rk_2 = \text{Encrypt}(\text{"B"}, h)$$

Proxy

Re-encryption:

$$C_1' = C_1 = g^r$$
$$C_2' = C_2 \cdot e(C_1, rk_1) = e(g^r, h) \cdot M$$
$$C_3' = rk_2 = \text{Encrypt}(\text{"B"}, h)$$

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Re-encrypting multiple times

$C'_1 = C_1 = g^r$

$C'_2 = C_2 \cdot e(C_1, rk_1) = e(g^r, h) \cdot M$

$C'_3 = rk_2 =$ Encrypt(“B”, h)

Given another re-encryption key $rk_{B\text{->}C}$, we can encrypt this last ciphertext again

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Re-encrypting multiple times

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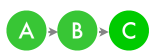
$C'_2 = C_2 \cdot e(C_1, rk_1) = e(g^r, h) \cdot M$

$C'_3 = rk_2 =$ Encrypt(“B”, h)

$\bar{C}_1 \ \bar{C}_2 \ \bar{C}_3$



Given another re-encryption key $rk_{B\text{->}C}$, we can encrypt this last ciphertext again

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Open Problems

- New applications and more efficient schemes
- Remove random oracles for id-based schemes and unidirectional ones
- Multi-use unidirectional schemes with no expansion
- Generalize the concept

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