Mediated Signatures - Towards Undeniability of Digital Data in Technical and Legal Framework

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Outline

1. Advanced Digital Signatures
   - Qualified Signatures
   - Validity of the Signature
   - Standard Implementation
   - Risk Issues
   - Reasons of Failure

2. Mediated Signatures
   - Cryptographic Description
   - Mediated RSA Example
   - Application Scenario
   - Legal Framework
1 Advanced Digital Signatures
   ■ Qualified Signatures
   ■ Validity of the Signature
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   ■ Risk Issues
   ■ Reasons of Failure

2 Mediated Signatures
   ■ Cryptographic Description
   ■ Mediated RSA Example
   ■ Application Scenario
   ■ Legal Framework
The Concept of Qualified Signatures

- Signature creation data (secret key)
- Signature verification data (public key)
The Concept of Qualified Signatures

Qualified Certificate

1. certificate issuer
2. date of issue and expiration
3. ID of the certificate holder:
   - family name: Kutyłowski
   - given name: Mirosław
   - personal number (PESEL): ...
4. 2048 RSA public key: 0x00308187028181 ...
5. signature of the issuer ...

signature creation data (secret key)

signature verification data (public key)
The Concept of Qualified Signatures

signature creation data (secret key) + digital document $\rightarrow$ signature

signature verification data (public key) + signature + document $\rightarrow$ validation output
Checking the Signature

1. **Verification of the signature**
   (using the public key from the certificate)

2. **Verification of the identity of the key holder**
   – checking the certificate
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**Cryptographic Point of View**

If signature verifies correctly then:
- it was created with the proper signing key, or
- the signing scheme has been broken
Checking the Signature

1. **Verification of the signature**
   (using the public key from the certificate)

2. **Verification of the identity of the key holder**
   – checking the certificate
   - **problem:** the signing key can be: stolen (with a smart card), retained by the certification provider, leaked (trapdoor), smart card can be misused, ...

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- the signing scheme has been broken

**Additional Mechanisms**

Each certificate:
- has limited validity period
- can be revoked by issuer / signer
Standard Implementation – Properties

A secret (signing) key:
- stored on a cryptographic smart card
- access secured with a PIN number

Status of the certificate can be checked with:
- OCSP (Online Certificate Status Protocol)
- recent CRL (Certificate Revocation List) – risky for the verifier
Key idea:
- enable signing offline

Reality:
- verification must be performed online
- signing time unknown
Risk Issues

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3. kleptography (⇐ malicious manufacturer)

Many of these problems can be eliminated by adopting Mediated Signature Architecture.
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Many of above problems can be eliminated by adopting: Mediated Signature Architecture
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Mediated Signature Architecture
Reasons of Failure of Qualified Signatures

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single technical point of failure: secure signature creation device
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## Reasons of Failure of Qualified Signatures

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Some Critical Issues

- **Single technical point of failure**: Secure signature creation device
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Some Critical Issues

**single technical point of failure:** secure signature creation device

**based on trust and not technical measures:** use of randomness, key generation services

**signing time unclear:** after creating the signed data, **before**
- requires additional mechanisms

**no way to block temporarily:** impossible to disable signing possibility temporarily (like a credit card) or apply a signing policy

**legal problems:** Poland: impossible to check legal status of a signature at the time of verification, it is possible to check validity for the past
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Background

1. there are at least two parties of the protocol:
   - user
   - security mediator

2. creation of a single signature is possible if all the necessary parties are involved (by using the appropriate cryptographic material)
User

(1) creates a pre-signature $S_1$, using his private key $K_1$:

$$S_1 = \text{SIG}(K_1, \text{Hash}(M))$$

Mediator

(2) finalizes the signature, using the appropriate keying material $K_2$:

$$S = \text{FIN}(K_2, S_1)$$
Mediated Signature Architecture

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Mediator:
(2) finalizes the signature, using the appropriate keying material $K_2$:

$$S = \text{FIN}(K_2, S_1)$$

- there is one public key $K$ related to the secret key pair $(K_1, K_2)$
- $S$ is the signature of $M$
RSA Based Mediated Signature

Keys

- $n = pq$, $d \cdot e = 1 \mod \varphi(n)$
- splitting the key $d$:
  - for mediator: $d_1 := \text{HSM}(K, ID_{signer})$
  - for the signer: $d_2 := d - d_1$
RSA Based Mediated Signature

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**Signature Creation**
- signer: \( s_1 := (\text{hash+padding}(M))^d_1 \)
- mediator: \( s_2 := (\text{hash+padding}(M))^d_2 \)
- signature: \( s := s_1 \cdot s_2 \mod n \)

**Signature Verification**
as usual
RSA Based Mediated Signature

Extended Scenario
- one key on a smart card
- the second key on the laptop
- the third key on a server

Attack
Creating a signature by the adversary requires
- stealing the smart card, and
- stealing the laptop, and
- breaking into the server
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For Paranoids
split the key into even more pieces and put them on independent devices
Main Features

Revocation

The signer can block signing possibility for any time, any reason, ... :

- block the card used in his office for vacation time and holidays
- block the card during a stay in a hospital
- block the card for the time 23:00-6:00 every day
- ...

in this case the signature WILL NOT BE CREATED

Monitoring

Mediator can monitor the signing activities and refuse to finalize if something suspicious is going on
Main Features II

**Signing Time**
Mediator can implement hash chaining and provide undeniable and verifiable evidence of the signing time

**Verification**
- no adjusting the software necessary - no special time stamps, ... that need to be interpreted well
- in fact, Mediator performs pre-validation of a signature, making it easier for the recipient of the document

**Risks**
- we do not depend solely on security of smart cards!
- two weaker but independent mechanisms are better than a single strong one
Public Administration Case Study

Signing documents exchanged between citizens and public authorities:

- single point of contact as a favorable solution: it can be integrated with Mediator
- privacy: the public bodies know anyway these documents
- signature can be created by ID cards even if thousands of them are stolen or lost (security does not depend solely on ID cards) the smart cards do not require the best possible protection and can serve for a longer time
- automatic and provable date of signing - elimination of frauds and legal disputes
Use in Corporations

- full control over signing activities, disabling a single user immediate
- excellent tool for controlling document flow in a heterogeneous IT environment
Mediator runs security mechanism that are fully compatible with the Directive, the Directive does not prohibit to use further cryptographic keys to improve security, the whole system really satisfies the security requirements from Annex III, affordable smart cards do not fulfill these requirements, if we take them seriously.

1. Signature creation data are still in hands of the signer.
Compatibility with EU Directive

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Compatibility with EU Directive

1. **signature creation data are still in hands of the signer**

2. **Mediator runs security mechanism that are fully compatible with the Directive,**
   
   the Directive does not prohibit to use further cryptographic keys to improve security

3. **the whole systems really satisfies the security requirements from Annex III,**

   **affordable smart cards do not fulfill these requirements, if we take them seriously**
Foresight

Future

- the concept of qualified electronic signatures based on classical X.509 architecture is technically obsolete
- the future belongs to distributed security mechanism supported by online mechanisms
Thank you for attention!