An Efficient CDH-based Signature Scheme With a Tight Security Reduction

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— Crypto '05 —

Contents

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The attacker model

Goal of the adversary for a Signature Scheme

- Total break of the scheme (recovering the private key) – BK

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Then, the strongest model is EUF-CMA.

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An attacker that breaks the signature scheme with probability ε and within time τ is transformed into a solver of one hard problem, with probability ε' and within time τ'.

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GEMPLUS

The *EDL* signature scheme

It is independently proposed in [CP92],[JS99] and proved in [GJ03] is defined as follows.

Key generation: The private key is a random number $x \in \mathbb{Z}_q$. The corresponding public key is $y = g^x$.

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Correctness: So $c = \mathcal{G}(g, h', y, z, u', v')$

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- The reduction is tight, in the *random oracle model*

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- No online possibility (or [ST01] technique, that makes signature longer and cost more time to sign and verify)

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- Katz-Wang scheme ([KW03]), based on the Decisional Diffie-Hellman (DDH)
- Katz-Wang scheme ([KW03]), based on the CDH, with shorter signatures

Our Scheme

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Step 1 of our construction is defined as follows (Appendix B):

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Exact Security of Our Scheme

We have the following theorem:

Theorem

Let $\mathcal{A}$ be an adversary which can produce, with success probability ε, an existential forgery under a chosen-message attack within time τ, after q_h queries to the hash oracles and q_s queries to the signing oracle, in the random oracle model. Then the computational Diffie-Hellman problem can be solved with success probability ε' within time τ', with

$$\varepsilon' \geq \varepsilon - 2q_s \left(\frac{q_s + q_h}{q} \right)$$

and

$$\tau' \lesssim \tau + (6q_s + q_h)\tau_0$$

where τ_0 is the time for an exponentiation in $G_{g,q}$.

Intuition of the Proof of Security

Imagine a forger returns a forge $(\hat{z}, \hat{s}, \hat{c})$, we compute corresponding $\hat{u}$, $\hat{v}$. As in *EDL*, we write $\hat{u} = g^k$, $\hat{v} = \hat{h}^{k'}$ and $\hat{z} = \hat{h}^{x'}$ (we do not know k, k', x, x').

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As the signature is valid,

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So, in the exponent world,

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- the forger is able to find a new h and its corresponding h^x
- or the forger is able to reuse an h that was given by the simulator/actual signer

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In case 2, the proof shows that the attacker can be used to solve a DL (or collision on $\mathcal{H}$ or $\mathcal{G}$ hash functions). As $h = \mathcal{H}(u) = \hat{h} = \mathcal{H}(\hat{u})$, $u = \hat{u}$. So $u = g^s\, y^{-c} = \hat{u} = g^{\hat{s}}\, y^{-\hat{c}}$. If $c \neq \hat{c}$, we recover the DL as $x = \frac{s-\hat{s}}{c-\hat{c}} \bmod q$.

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