Efficient Public-Key Cryptography with Bounded Leakage and Tamper Resilience

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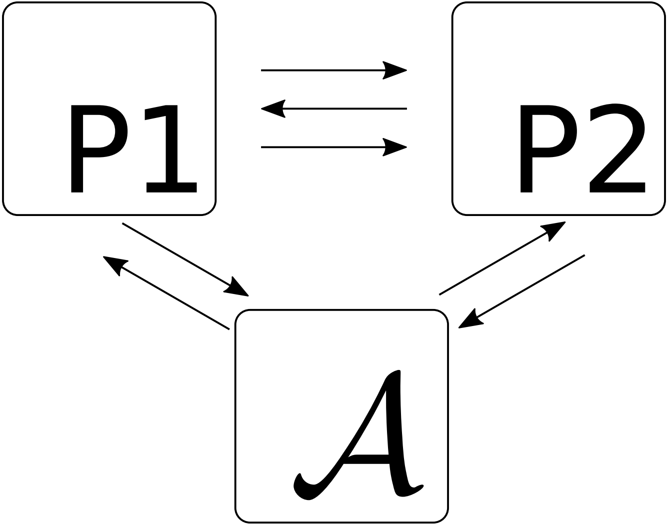
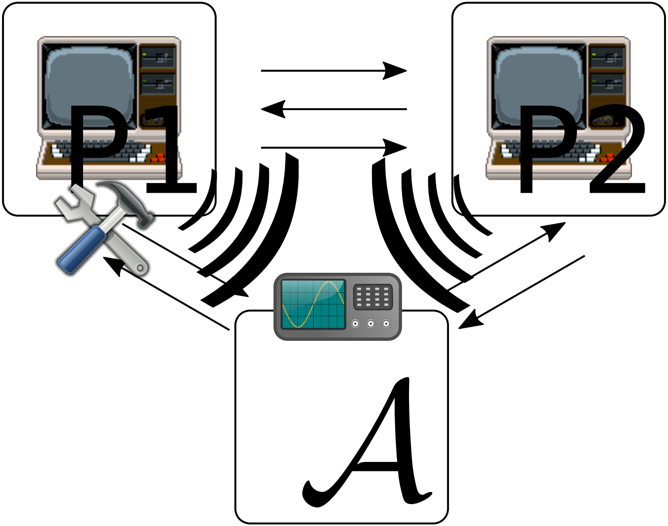
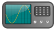
(Provable Secure) Crypto before Physical Attacks



Crypto with Physical Attacks



 Leak Attacks [Koc96],

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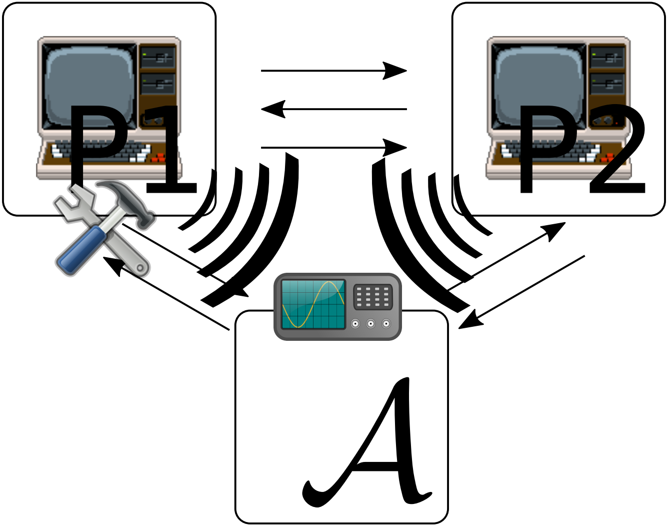
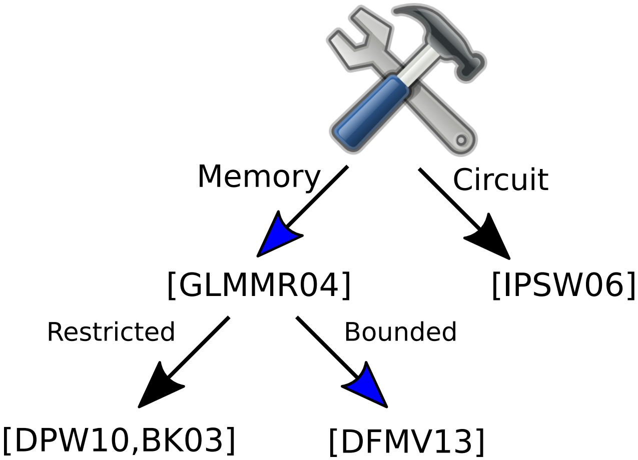


Leak Attacks [Koc96], Tampering Attacks [BDL97]

(Minimal) Related Works



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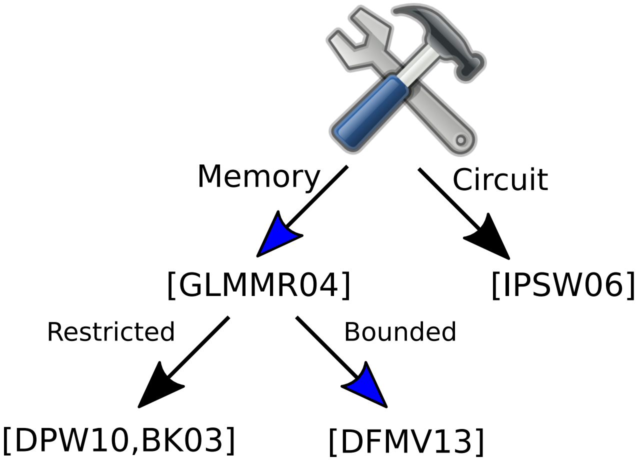

- Definitions of Bounded-Tamper (and Leakage) Resilience,
- Identification Scheme and Signatures (ROM),
- CCA-Secure PKE.

Our Contributions

- BTL Signature Scheme.

  Example. The Imp. result of [GLMMR03] does not hold.

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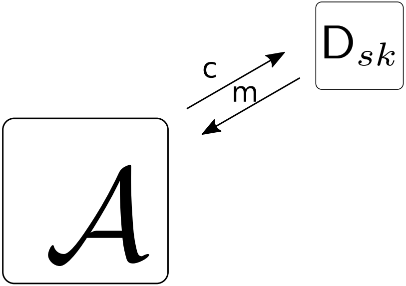
- BLT CCA Public Key Encryption.
  Naor-Yung paradigm, what about Cramer-Shoup?

Section 2

BLT-CCA PKE

(t, ℓ)-BLT IND-CCA PKE:



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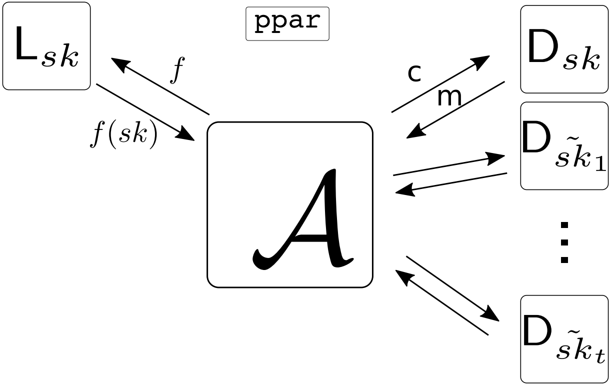

- $\mathcal{A}$ leaks before challenge ℓ bits;
- $\mathcal{A}$ instantiates before challenge t oracles

(for $\ell + t \leqslant |sk| - \omega(\log k)$)

The Scheme of [QL13]: Building Blocks

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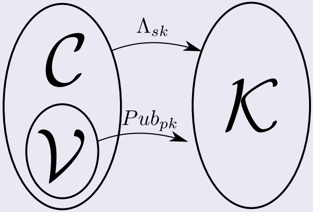
ϵ-Hash Proof System



- Complete: For $c \in \mathcal{V}$, $Pub_{pk}(c, w) = \Lambda_{sk}(c)$.
- Sound: For $c \in \mathcal{C} \setminus \mathcal{V}$,any $pk = \mu(sk)$: $\widetilde{\mathbb{H}}_\infty(K := \Lambda_{sk}(c)|pk) \geqslant -\log \epsilon$
- Set Membership Problem.

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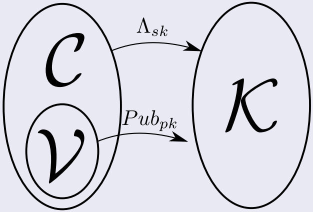

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δ-extractor

$\widetilde{\mathbb{H}}_\infty(\mathbf{X}|\mathbf{Z}) \geqslant \delta$, we have $(\mathbf{Z}, \mathbf{S}, \mathrm{Ext}(\mathbf{X}, \mathbf{S})) \approx (\mathbf{Z}, \mathbf{S}, \mathbf{U})$

The Scheme of [QL13]: Building Blocks, Pt.2

ℓ-(OT-)Lossy Filter

$$\mathsf{LF}_\phi : \mathcal{T} \times \mathcal{X} \to \mathcal{Y}$$

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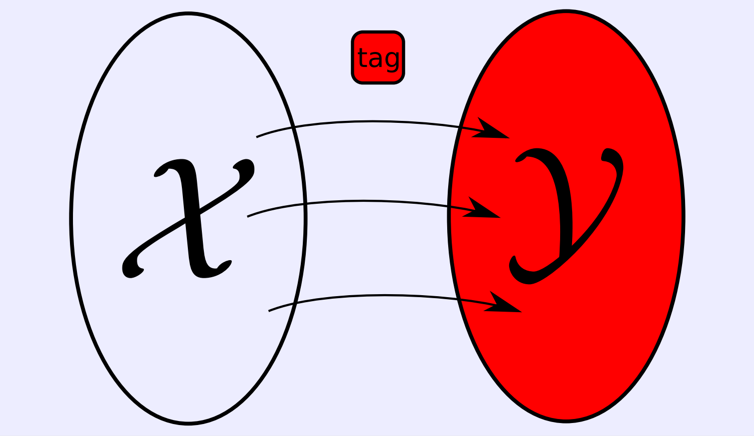

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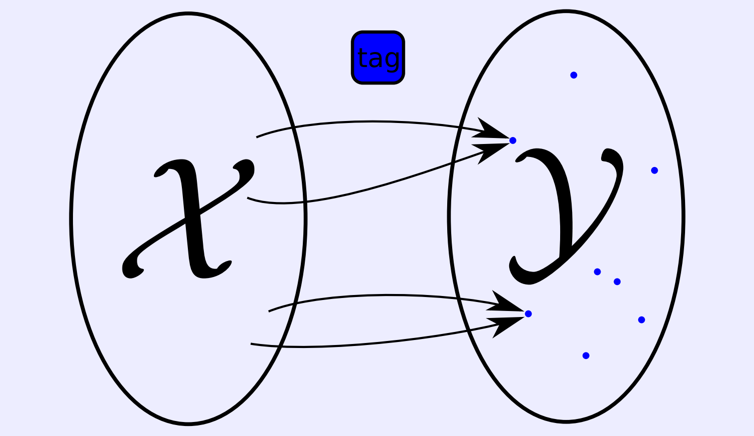

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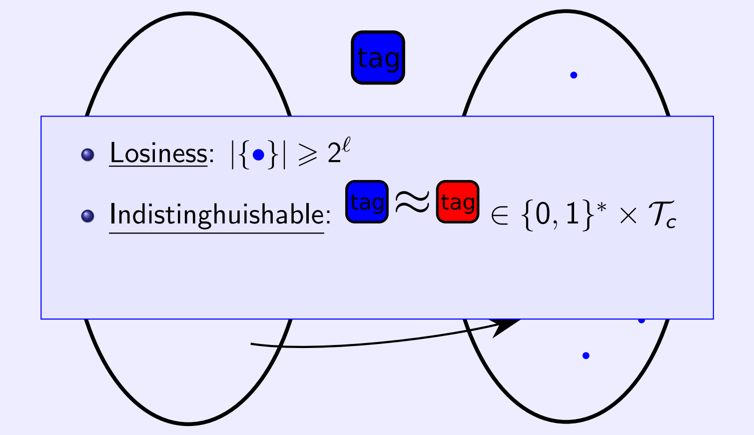

- Losiness: $|\{\bullet\}| \geqslant 2^{\ell}$
- Indistinghuishable: $\boxed{\text{tag}} \approx \boxed{\text{tag}} \in \{0,1\}^* \times \mathcal{T}_c$

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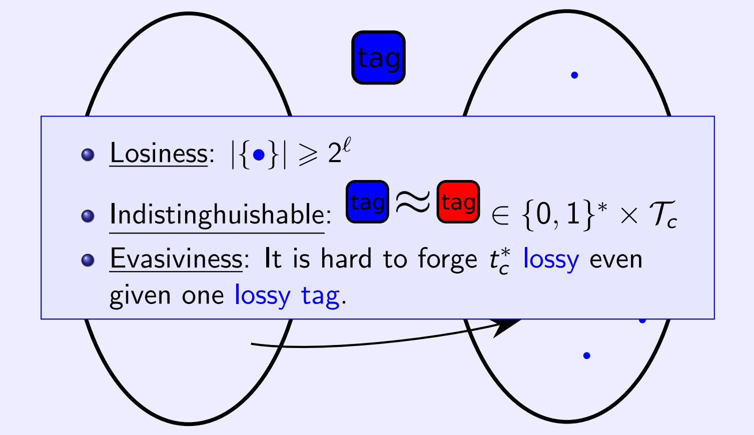

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- Evasiviness: It is hard to forge t_c^* lossy even given one lossy tag.

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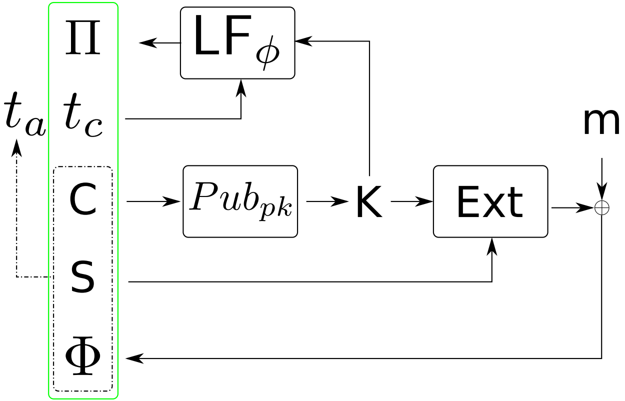

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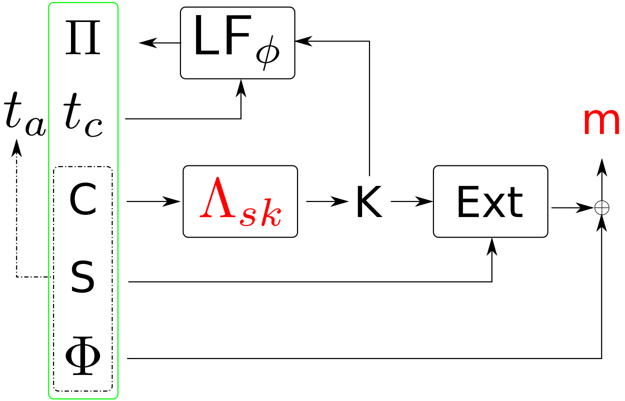

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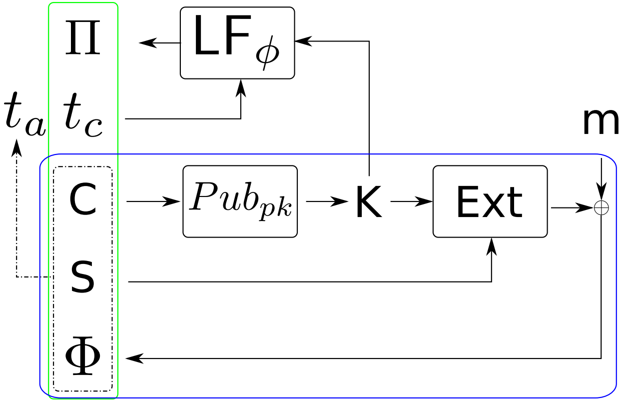

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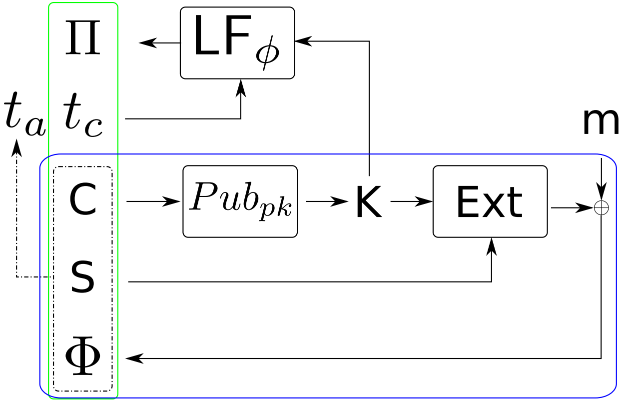

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Reduce Tampering to Leakage

$$\boxed{\mathsf{Dec}_{T(sk)}} \approx \boxed{\mathcal{O}_{\boxed{\mathsf{aux}}}}$$

- $aux = L(sk)$
- Interact **unbounded** with $\mathsf{Dec}_{T(sk)}$, while *aux* small and **bounded**.

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$$((C, S, \Phi),\ t_c, \Pi)$$

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$(C, \mu(\tilde{sk}))$ fully define K. Execute Decryption.

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$C \notin \mathcal{V}$

Depend on $\mathbb{H}_\infty(\Lambda_{\tilde{sk}}(C)|\textbf{View} = v)$.

- If big then output $\perp$;
- If small then <u>leak</u> $\tilde{sk}$ and run $\mathrm{Dec}_{\tilde{sk}}$.

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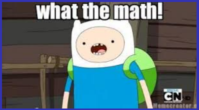
Mathemagical!!



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$$t = \frac{s}{\alpha + \beta}$$

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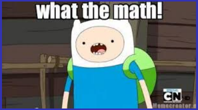

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We can instantiate the HPS using RSI.

Open Problems

- Is the tampering rate $O(1/k)$ inherent?
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Thank You!