Leakage-Resilient Cryptography from Puncturable Primitives and Obfuscation

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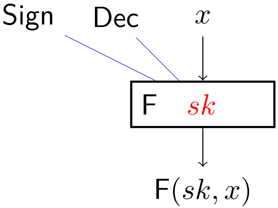
1. Background
2. Motivation
3. Primitives
4. Our Framework Towards Leakage-Resilience
   - Leakage-Resilient PKE
   - Leakage-Resilient SKE
   - Leakage-Resilient Signature
5. Achieving Optimal Leakage Rate

Outline

Leakage-Resilient Cryptography



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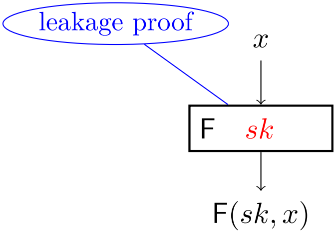

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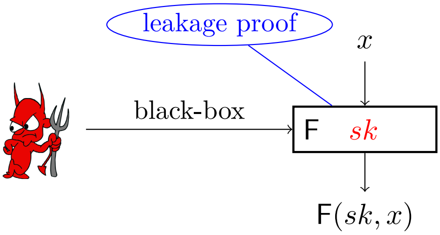

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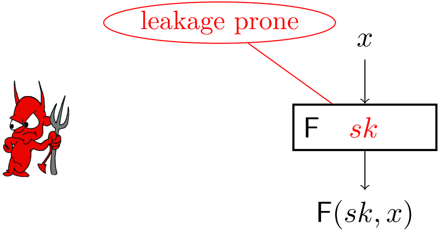
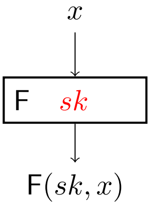


Leakage-Resilient Cryptography

leakage attacks (since 1996) invalidate this idealized assumption



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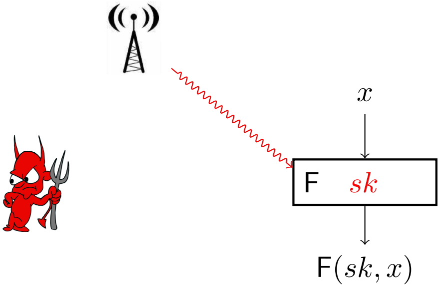

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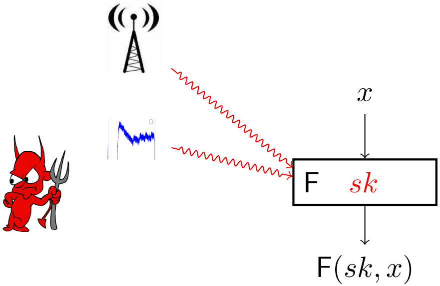

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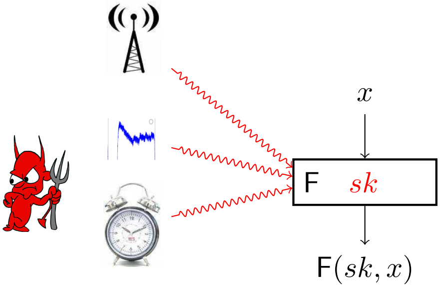

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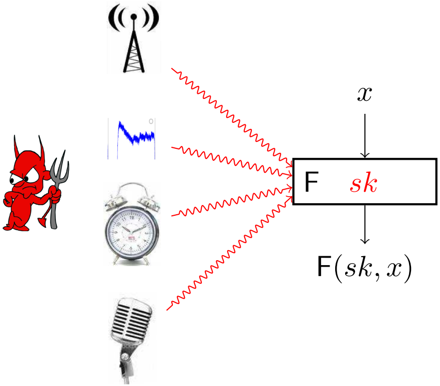

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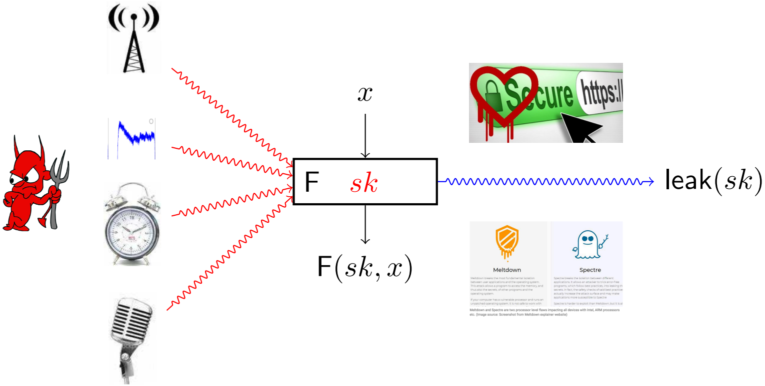

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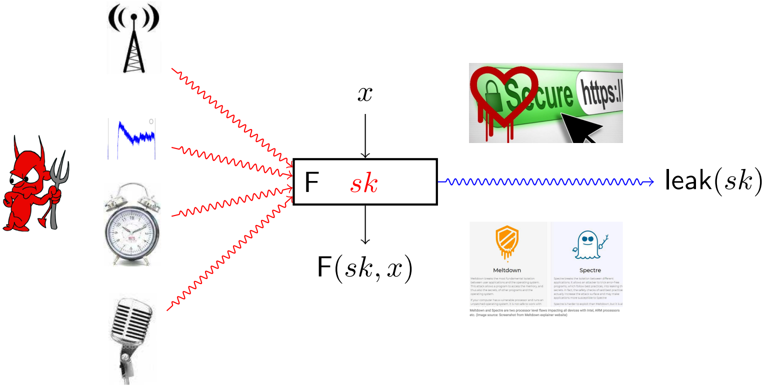
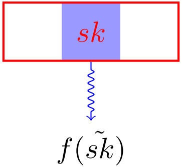


- Leakage-Resilient Cryptography: provably secure against *all* leakage attacks captured by leakage model.

Leakage Models

Various leakage models in the literature, differing in their specifications of leakage source/functions/behaviors:



- Only computation leaks model: [MR04]...
- Bounded leakage model: [AGV09, KV09, NS09, ADW09, ADN+10, QL13, CQX18]...
- Auxiliary input model: [DKL09, DGK+10]...
- Continual leakage model: [BKKV10, DHLW10]...

Bounded Leakage Model

In this work, we focus on the most basic bounded leakage model

- conceptually simple yet general enough
- results in BLM used as building blocks for leakage-resilient schemes in more complex leakage models

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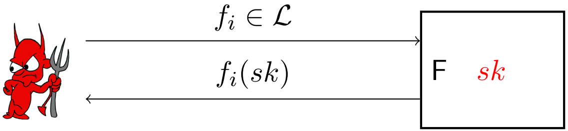
A template of BLM



$$\sum |f_i(sk)| < \ell \leq |sk|$$

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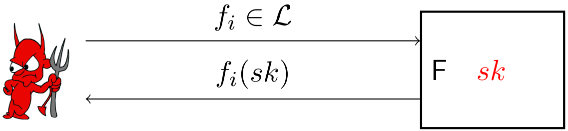


$$\sum |f_i(sk)| < \ell \leq |sk|$$

- leakage ratio $\rho = \ell/|sk| \rightsquigarrow 1 - o(1)$ is optimal

Outline

Leakage-Resilient Workhorse Primitives

In the last two decades, a broad range of LR cryptographic schemes have been proposed.

But, several interesting problems are still open around *lower-level, workhorse* primitives, such as SKE, PKE and Signature

Leakage-Resilient SKE

LR SKE can be reduced to constructing LR wPRF

- Pietrzak [Pie09], Dodis and Yu [DY13]: any PRF is already leakage-resilient against $\ell = O(\log \lambda)$-bit leakage
- Hazay et al. [HLWW13]: OWF $\Rightarrow$ LR wPRF with leakage rate $O(\log \lambda)/|sk|$

Is there a generic construction of LR wPRF with optimal leakage rate?

Leakage-Resilient PKE

Existing LR PKE are based on either specific assumptions such as LWE [AGV09] and QR [BG10], or more generally the hash proof system [NS09]

Whether the classic construction of PKE based on TDF/TDR can be made LR? Is there a generic construction of LR PKE?

CCA security vs. leakage-resilience (dual)

- CCA: $\mathcal{A}$ learns sk via a specific family of functions (tie to $\mathsf{Dec}(sk, \cdot)$) with unbounded output length
- LR: $\mathcal{A}$ learns sk via arbitrary functions with bounded output length

Is there a connection between CCA security and LR?

Leakage-Resilient Signature

Challenging problem: fully leakage-resilience – EUF-CMA remains in the presence of both secret key and random coins leakage

- when Sign is deterministic or public-coin: standard LR $\Rightarrow$ FLR

All the known FLR Sigs [BSW11, MTVY11, LLW11, GJS11] are randomized and secret-coin.

Boyle et al. [BSW11] left the open problem

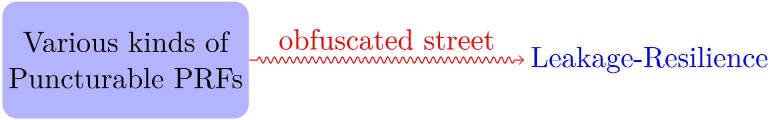
Do there exist deterministic or public-coin LR signatures?

Bonus: such kind of Sig remain secure even all the random coins are revealed

This Work

Our goal: Generic constructions of LR encryption and signature with optimal leakage rate (in the bounded leakage model)

Our major insight



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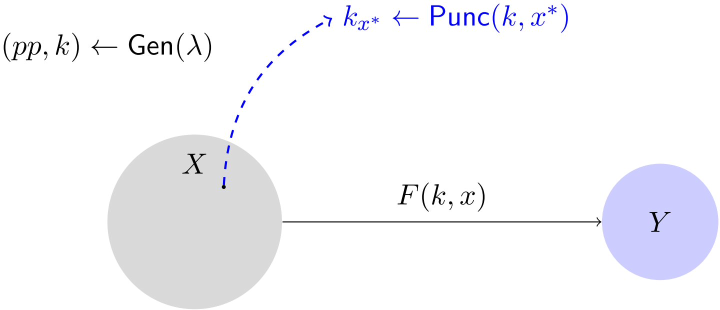
Puncturable PRF [SW14]



$$\mathsf{Eval}(k_{x^*}, x) = F(k, x) \text{ for } x \neq x^*$$

Selective Puncturable PRF

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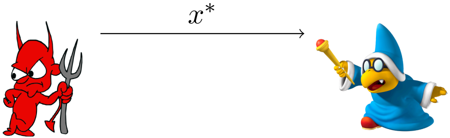

Selective Puncturable PRF

x^* $\longrightarrow$

$$(pp, k) \leftarrow \mathsf{Gen}(\lambda)$$
$$k_{x^*} \leftarrow \mathsf{Punc}(k, x^*)$$
$$y_0^* \leftarrow F(k, x^*)$$
$$y_1^* \xleftarrow{\text{R}} Y$$

Selective Puncturable PRF

$\beta \xleftarrow{R} \{0,1\}$

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x^*, k_{x^*}, y^*_β $\longleftarrow$

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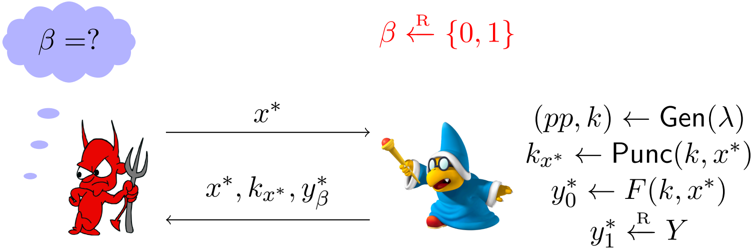

- directly implied by GGM-PRF $\Leftarrow$ OWF

Weak Puncturable PRF

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$$(pp, k) \leftarrow \mathsf{Gen}(\lambda)$$
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Weak Puncturable PRF

$$\beta \xleftarrow{R} \{0,1\}$$

$$\xleftarrow{\quad pp,\, x^*,\, k_{x^*},\, y^*_\beta \quad}$$

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Weak Puncturable PRF

$\beta =?$

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$\longleftarrow$

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Theorem: $sPPRF \Leftrightarrow wPPRF$

Indistinguishability Obfuscation [BGI+12]

A uniform PPT machine $i\mathcal{O}$ is called an indistinguishability obfuscator if:

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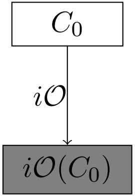
- Preserving Functionality: $\forall C \in \mathcal{C}_\lambda$, $\forall x \in \{0,1\}^*$

$$\Pr[C'(x) = C(x) : C' \leftarrow i\mathcal{O}(C)] = 1$$



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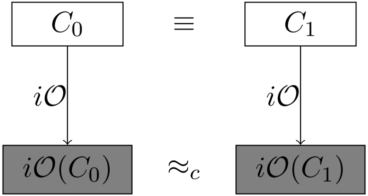
$$\Pr[C'(x) = C(x) : C' \leftarrow i\mathcal{O}(C)] = 1$$
- Indistinguishability of Obfuscation
$\forall$ PPT adversaries $(\mathcal{S}, \mathcal{D})$, $\exists$ a negl. function α:
$\Pr[\forall x, C_0(x) = C_1(x) : (C_0, C_1, aux) \leftarrow \mathcal{S}(\lambda)] \geq 1 - \alpha(\lambda) \Rightarrow$
$$|\Pr[\mathcal{D}(aux, i\mathcal{O}(C_0)) = 1] - \Pr[\mathcal{D}(aux, i\mathcal{O}(C_1)) = 1]| \leq \alpha(\lambda)$$



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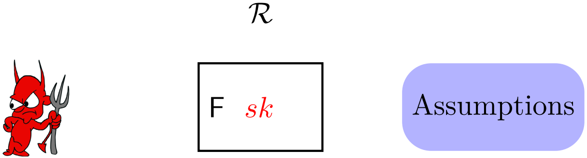
Approaches towards Leakage Resilience



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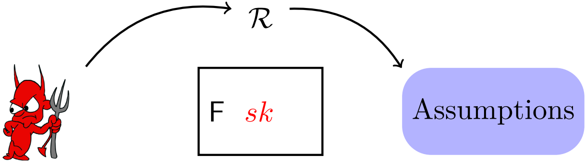

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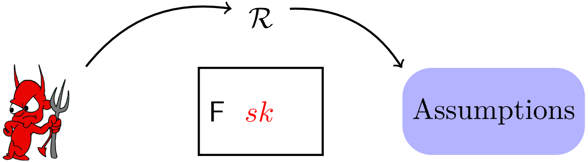

Technical hurdle: a seemingly paradox

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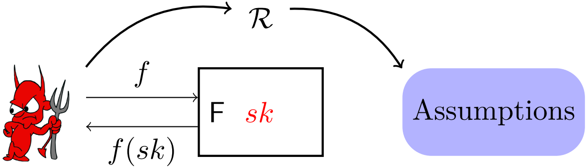

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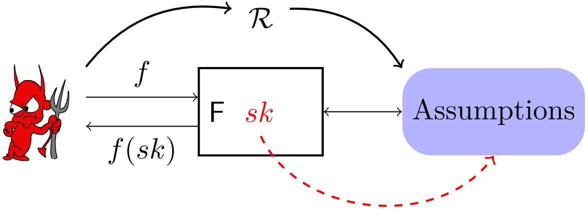
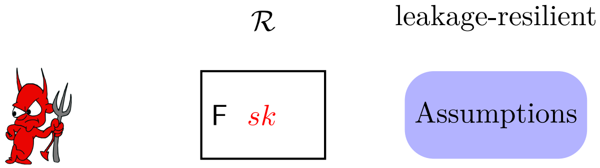


Technical hurdle: a seemingly paradox

- In order to answer *arbitrary* leakage queries, it seems $\mathcal{R}$ must know sk
- Typically $\mathcal{R}$ does not know sk since the challenge instance is embedded in it

Approach I

Rely on leakage-resilient assumptions, i.e., the assumption still holds even in the presence of partial leakage of secret



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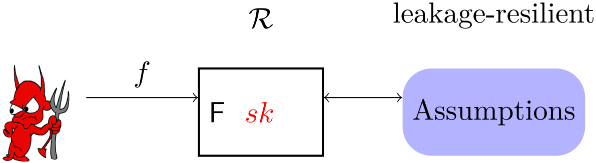

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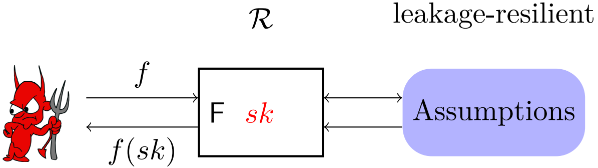

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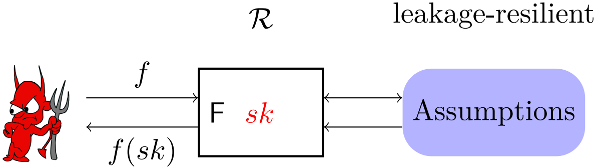

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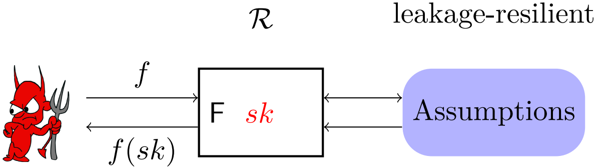
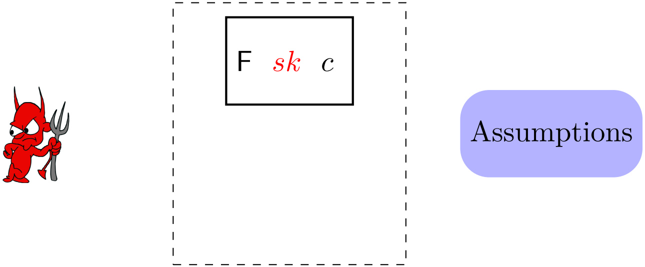


- Katz and Vaikuntanathan [KV09]: UOWHF is LR-OW + ss-NIZK $\Rightarrow$ LR SIG
- Akavia et al. [AGV09]: normal pk $\approx_c$ lossy pk even in the presence of sk leakage $\Rightarrow$ Regev PKE is LR

Approach II

detached strategy + leakage-resilient assumptions/facts



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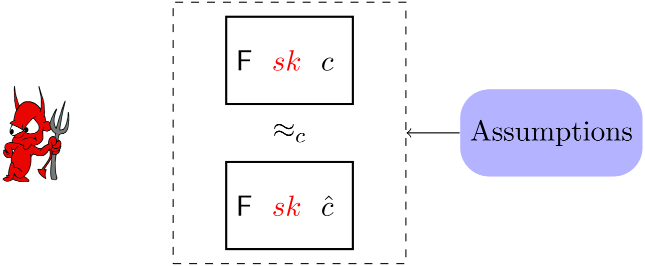

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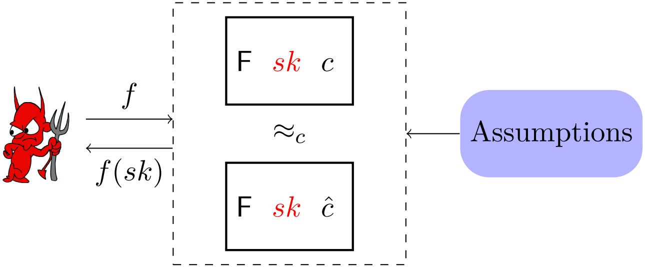

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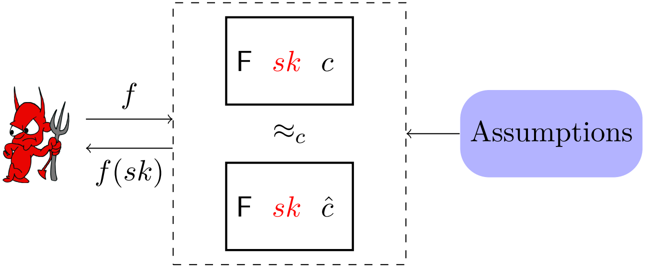

- Naor and Segev [NS09]: SMP $\Rightarrow c \approx_c \hat{c}$; $k \leftarrow \mathsf{Ext}(sk, \hat{c})$

  leftover hash lemma (leakage-resilient fact)

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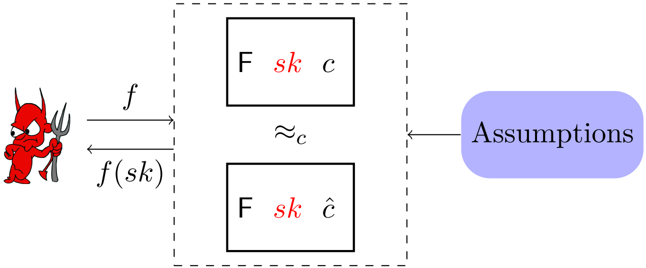

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- Dodis et al. [DGK+10]: DDH $\Rightarrow c \approx_c \hat{c}$; $k \leftarrow \mathsf{hc}_{\hat{c}}(sk)$ w.r.t. f (auxliary-input model)

  Goldreich-Levin theorem (leakage-resilient assumption)

A common theme of the two above main approaches

- $\mathcal{R}$ always try to simulate leakage oracle *perfectly*, i.e., answering leakage queries with *real* secret key.

To do so, we have to either rely on LR assumptions or resort to sophisticated design with specific structure.

It is interesting to investigate the possibility of

> simulate leakage oracle *computationally*, i.e., answering leakage queries with simulated leakage

This might lend new techniques to address the unsolved problems in LRC.

Dachman-Soled et al. [DGL+16] discovered powerful applications of $i\mathcal{O}$ to LRC

- Sahai-Waters PKE $\leadsto$ leakage resilient

Background: Sahai-Waters KEM

Ingredients: $i\mathcal{O}$, PRG $\mathsf{G} : \{0,1\}^\lambda \to \{0,1\}^{2\lambda}$, weak puncturable PRF $F : SK \times \{0,1\}^{2\lambda} \to Y$

- $\mathsf{Gen}(\lambda)$: pick $sk \xleftarrow{R} SK$, $pk \leftarrow i\mathcal{O}(\text{Encaps})$
- $\mathsf{Encaps}(pk; r)$: $(c, k) \leftarrow pk(r)$
- $\mathsf{Decaps}(sk, c)$: $k \leftarrow F(sk, c)$

Encaps
Constants: PPRF key sk
Input: randomness $r \in \{0,1\}^\lambda$
1. compute $x \leftarrow \mathsf{G}(r)$; output $c = x$, $k \leftarrow F(sk, x)$

Why Sahai-Waters is not Leakage-Resilient?

The proof uses "punctured programs" technique and security is reduced to the weak pseudorandomness of punctured PRF

$$pk \leftarrow i\mathcal{O}(\text{Encaps}(sk)) \rightsquigarrow pk \leftarrow i\mathcal{O}(\text{Encaps}^*(sk_{x^*}))$$
$$\text{session key } k^* \leftarrow y^* \leftarrow F(sk, x^*), \text{ where } x^* \xleftarrow{\text{R}} \{0,1\}^{2\lambda}$$

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The sources for non-leakage-resilient

- Construction perspective: the information of y^* could be leaked via leakage queries on sk, and thus may not be random anymore in $\mathcal{A}$'s view.
- Proof perspective: in some hybrid game, $\mathcal{R}$ only knows sk_{x^*}, and thus unable to handle arbitrary leakage queries.

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Dachman-Soled et al. [DGL+16] made Sahai-Waters KEM leakage-resilient by using $i\mathcal{O}$ twice.

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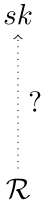
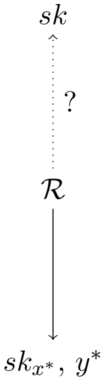
Abstract and Generalize the Core Idea



Abstract and Generalize the Core Idea



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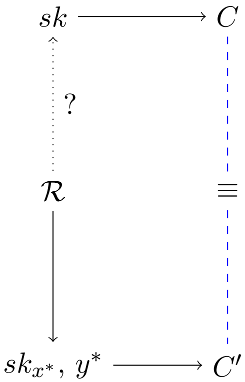

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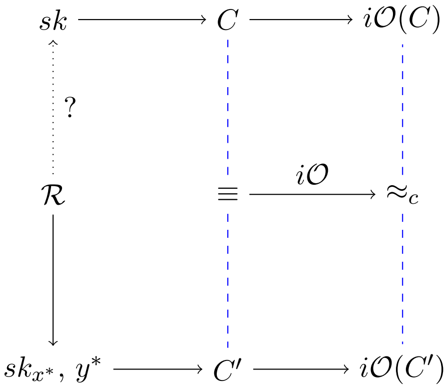

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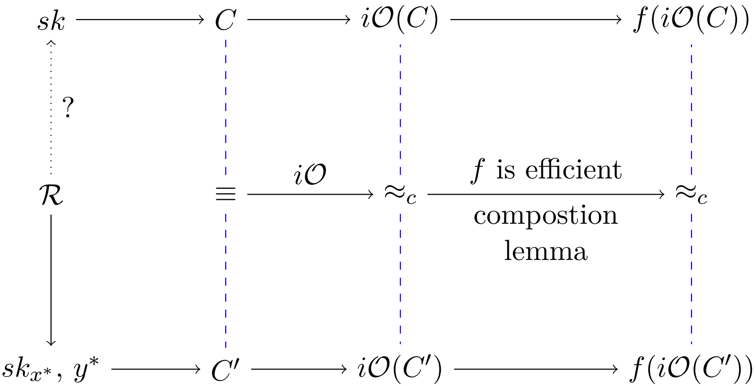

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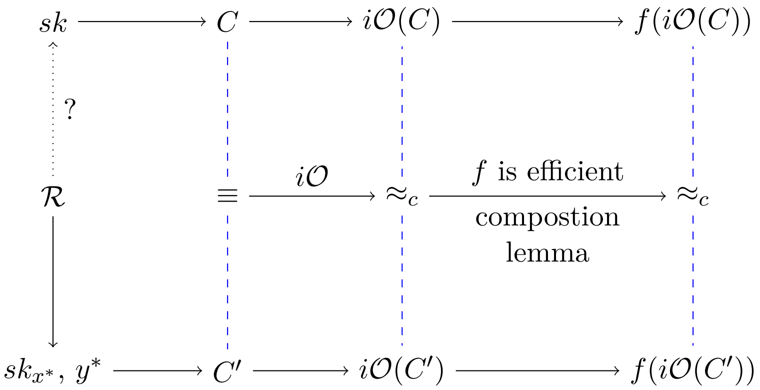


simulate leakage in a computationally indistinguishable manner

Key Observation

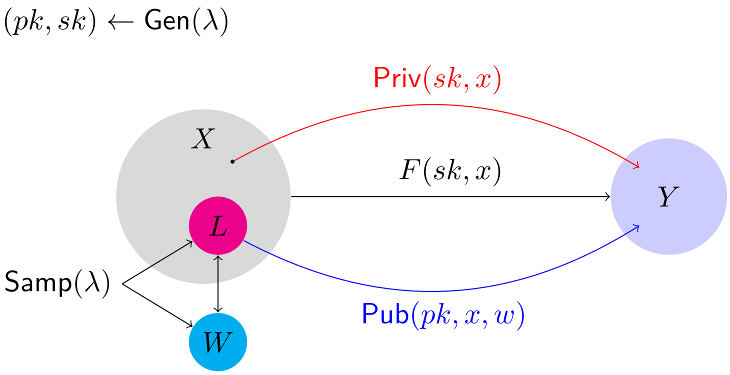
Can we push the idea to extreme?

- Dachman-Soled et al. [DGL+16]: Sahai-Waters KEM can be made LR by setting sk as an obfuscated program
- Chen et al. [CZ14]: the essence of Sahai-Waters KEM – $i\mathcal{O}$ bootstraps Punc-PRF into Punc-"publicly evaluable" PRF

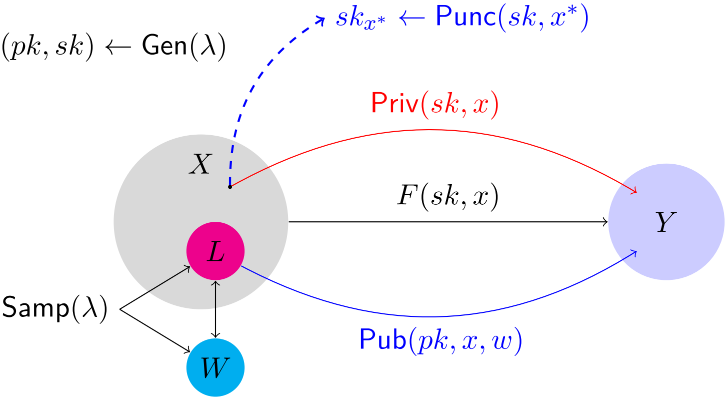
These two results suggest:

$$i\mathcal{O}(\text{Punc-PEPRF}) \rightsquigarrow \text{LR PEPRF}$$

(Puncturable) Publicly Evaluable PRF



(Puncturable) Publicly Evaluable PRF



Security of (Puncturable) Publicly Evaluable PRF

Security of (Puncturable) Publicly Evaluable PRF

$\xleftarrow{\quad pk \quad}$

$(pk, sk) \leftarrow \mathsf{Gen}(\lambda)$

Security of (Puncturable) Publicly Evaluable PRF

$\beta \xleftarrow{R} \{0,1\}$

$\xleftarrow{\quad pk \quad}$

$$(pk, sk) \leftarrow \mathsf{Gen}(\lambda)$$
$$(x^*, w^*) \leftarrow \mathsf{Samp}(\lambda)$$
$$sk_{x^*} \leftarrow \mathsf{Punc}(sk, x^*)$$
$$y_0^* \leftarrow F(sk, x^*)$$
$$y_1^* \xleftarrow{R} Y$$

$\xleftarrow{\quad x^*,\ y_\beta^*,\ sk_{x^*} \quad}$

Security of (Puncturable) Publicly Evaluable PRF

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$\xleftarrow{\quad pk \quad}$

$\xleftarrow{\quad x^*,\ y_\beta^*,\ sk_{x^*} \quad}$

$\xrightarrow{\quad \beta' \quad}$

Security of (Puncturable) Publicly Evaluable PRF

$\beta =?$

$\beta \xleftarrow{R} \{0,1\}$

$$(pk, sk) \leftarrow \mathsf{Gen}(\lambda)$$
$$(x^*, w^*) \leftarrow \mathsf{Samp}(\lambda)$$
$$sk_{x^*} \leftarrow \mathsf{Punc}(sk, x^*)$$
$$y_0^* \leftarrow F(sk, x^*)$$
$$y_1^* \xleftarrow{R} Y$$

pk ←

$x^*,\ y_\beta^*,\ sk_{x^*}$ ←

β' →

$$|\Pr[\beta = \beta'] - 1/2| \leq \mathsf{negl}(\lambda)$$

Security of (Puncturable) Publicly Evaluable PRF

$\beta \xleftarrow{R} \{0,1\}$

$(pk, sk) \leftarrow \mathsf{Gen}(\lambda)$

$(x^*, w^*) \leftarrow \mathsf{Samp}(\lambda)$

$sk_{x^*} \leftarrow \mathsf{Punc}(sk, x^*)$

$y_0^* \leftarrow F(sk, x^*)$

$y_1^* \xleftarrow{R} Y$

$\xleftarrow{\quad pk \quad}$

$\xrightarrow{\quad f_i \quad}$

$\xleftarrow{\quad f_i(sk) \quad}$

$\xleftarrow{\quad x^*,\ y_\beta^*,\ sk_{x^*} \quad}$

$\xrightarrow{\quad \beta' \quad}$

$|\Pr[\beta = \beta'] - 1/2| \leq \mathsf{negl}(\lambda)$

LR-PEPRF from Punc-PEPRF

Idea: Obfuscate-and-Extract

LR-PEPRF from Punc-PEPRF

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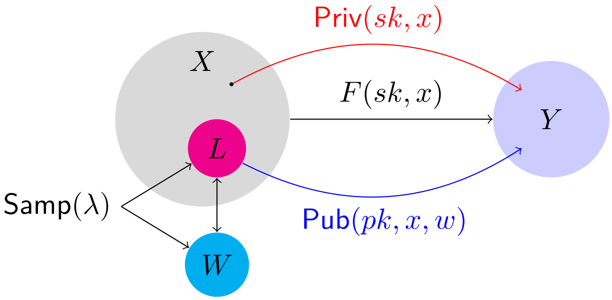

LR-PEPRF from Punc-PEPRF

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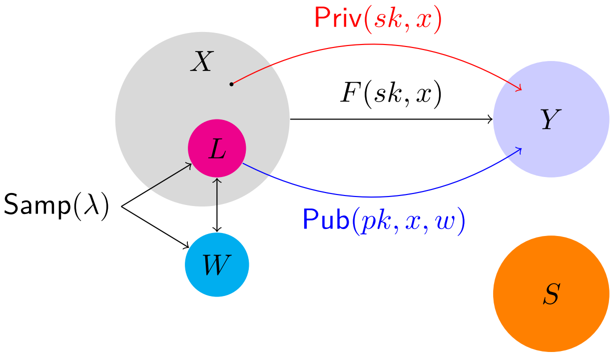

LR-PEPRF from Punc-PEPRF

Idea: Obfuscate-and-Extract

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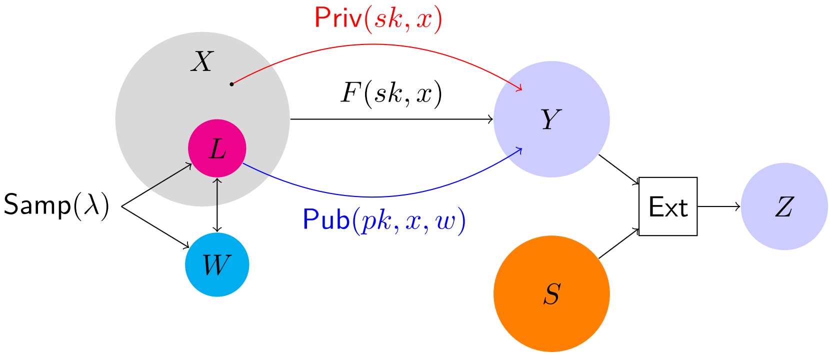
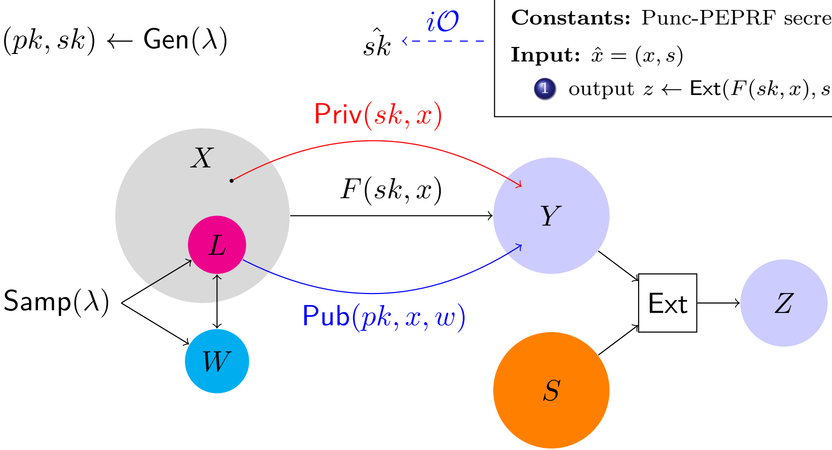


LR PEPRF $\hat{F}$ from $X \times S$ to Z: $\mathsf{Ext}(F(sk, x), s)$

LR-PEPRF from Punc-PEPRF

Idea: Obfuscate-and-Extract

Priv
Constants: Punc-PEPRF secret key sk
Input: $\hat{x} = (x, s)$
1. output $z \leftarrow \mathsf{Ext}(F(sk, x), s)$



LR PEPRF $\hat{F}$ from $X \times S$ to Z: $\mathsf{Ext}(F(sk, x), s)$

Theorem: *The above PEPRF $\hat{F}$ is leakage-resilient under appropriate parameter setting.*

Game 0. (the original game) $\hat{sk} \leftarrow i\mathcal{O}(\mathrm{Priv})$

Game 1. $\hat{sk} \leftarrow i\mathcal{O}(\mathrm{Priv}^*)$, where $y^* \leftarrow F(sk, x^*)$

Priv^*
Constants: Punc-PEPRF punctured key sk_{x^*}, x^* and y^*
Input: $\hat{x} = (x, s)$
1. If $x = x^*$, output $\mathsf{Ext}(y^*, s)$. Else, output $\mathsf{Ext}(F(sk_{x^*}, x), s)$.

Game 2. $y^* \xleftarrow{R} Y$

- $\mathrm{Priv} \equiv \mathrm{Priv}^* + i\mathcal{O} \Rightarrow$ **Game 0** $\approx_c$ **Game 1**
- punc-PEPRF $\Rightarrow$ **Game 1** $\approx_c$ **Game 2**
- randomness extractor $\Rightarrow z^* \leftarrow \mathsf{Ext}(y^*, s^*) \approx_s U_Z$

Constructions of Punc-PEPRF

$i\mathcal{O}$(Punc-PEPRF) $\rightsquigarrow$ LR-PEPRF $\Rightarrow$ LR-KEM

How to construct Punc-PEPRF?

wPPRF+PRG+$i\mathcal{O}$ (a slight modification of SW KEM)

- clarify and encompass Dachman-Soled et al's construction

Punc-TDF $\Leftarrow$ correlated-product TDF [RS09]

- PTDF can be viewed as a special type of adaptive TDF – $\mathcal{O}_{\text{inv}}$ can be instantiated succinctly

Punc-EHPS $\Leftarrow$ derivable EHPS

- "derivable" is a mild property that satisfied by all the known realizations of EHPS [Wee10]

Significance

Matsuda and Hanaoka [MH15]: Punc-KEM – capture a common pattern towards CCA security

- Punc-PEPRF $\Rightarrow$ Punc-KEM with perfect punctured decapsulation soundness

CCA security obtained via punctured road can be converted to Leakage-Resilience in a *non-black-box* manner via $i\mathcal{O}$

- PKE via CP-TDF
- PKE via EHPS

Outline

1. Background
2. Motivation
3. Primitives
4. Our Framework Towards Leakage-Resilience
   - Leakage-Resilient PKE
   - Leakage-Resilient SKE
   - Leakage-Resilient Signature
5. Achieving Optimal Leakage Rate

Extension to the Symmetric Setting

$i\mathcal{O}(\text{weak-Punc-PRF}) \rightsquigarrow \text{LR-weak-PRF} \Rightarrow \text{LR-SKE}$

$(pp, sk) \leftarrow \mathsf{Gen}(\lambda)$

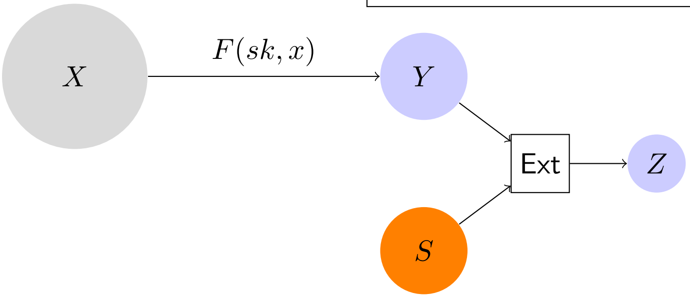
$\hat{sk} \xleftarrow{i\mathcal{O}}$

Priv

Constants: wPPRF secret key sk

Input: $\hat{x} = (x, s)$

1. output $z \leftarrow \mathsf{Ext}(F(sk, x), s)$



LR wPRF $\hat{F}$ from $X \times S$ to Z: $\mathsf{Ext}(F(sk, x), s)$

Outline

Review of Sahai-Waters Signature

Essence of Sahai-Waters Signature: $i\mathcal{O}$ makes PRF-based MAC publicly verifiable

- $\mathsf{Gen}(\lambda)$: pick $k \xleftarrow{R} K$ for sPPRF $F : K \times M \to Y$, pick a OWF $g : Y \to Z$; set $sk \leftarrow k$, $vk \leftarrow i\mathcal{O}(\text{Verify})$.
- $\mathsf{Sign}(sk, m)$: output $\sigma \leftarrow F(k, m)$.
- $\mathsf{Verify}(vk, m, \sigma)$: output $vk(m, \sigma)$.

Verify

Constants: sPPRF key k

Input: message m and signature σ

1. output $g(\sigma) =? g(F(k, m))$.

Proof of Selective Security

Theorem: *Sahai-Waters signature is selectively secure.*

Game 0. (original game) $vk \leftarrow i\mathcal{O}(\text{Verify})$.

Game 1. $vk \leftarrow i\mathcal{O}(\text{Verify}^*)$, here $z^* \leftarrow g(\sigma^*)$, $\sigma^* \leftarrow F(k, m^*)$.

Verify^*
Constants: punctured sPPRF key k_{m^*} and z^*
Input: message m and signature σ
1. If $m = m^*$, output $g(\sigma) =? z^*$.
2. Else, output $g(\sigma) =? g(F(k_{m^*}, m))$.

Game 2. $\sigma^* \leftarrow Y$.

- $\text{Verify} \equiv \text{Verify}^*$ + $i\mathcal{O}$ $\Rightarrow$ **Game 0** $\approx_c$ **Game 1**
- sPPRF $\Rightarrow$ **Game 1** $\approx_c$ **Game 2**
- OWF $\Rightarrow$ σ^* is unpredictable in **Game 2**

How to make Sahai-Waters's signature Leakage-Resilient?

Technical hurdle: how to handle leakage queries?

1. express signing algorithm as a program and obfuscate the program as sk
2. simulate leakage queries with function-equivalent key – an obfuscation of a program build from k_{m^*} and σ^*

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Problems

- Construction perspective: leakage queries leak the information of σ^* (the preimage of z^*) $\Rightarrow$ unable to reduce unforgeability to one-wayness of g
- Proof perspective: $\mathcal{R}$ does not know σ^*

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- Proof perspective: $\mathcal{R}$ does not know σ^*

Our solution: using LR OWF instead of standard OWF

- In the final security game, $\mathcal{R}$ can translate leakage queries on secret key to those on σ^*.

LR OWF + sPPRF + $i\mathcal{O} \Rightarrow$ deterministic LR SIG (selective)

How to achieve adaptive security?

- Using Extremely Lossy Function [Zha16] hash the message before signing: deterministic but relying on exponential hardness assumption
- Applying "prefix-guessing technique" [RW14]: randomized but public-coin

So far the best solution to the open problem posed by Boyle et al. [BSW11] (Eurocrypt' 11)

Outline

How to achieve optimal leakage rate?

The leakage rate of our basic constructions is low

- secret key is an obfuscated program $\rightsquigarrow$ large size
- the maximum leakage amount $\leq \log_2 |Y|$

Can we achieve optimal leakage rate?

Dachman-Soled et al.'s Approach

Secret key – a secret obfuscated program (like a gun that must be kept secretly)

Dachman-Soled et al.'s Approach

Secret key – a secret obfuscated program (like a gun that must be kept secretly)

Decompose the secret obfuscated program

- make the logic part public
- set a trigger device inside the public program and use trigger as the secret key

The Case of LR-PEPRF from Punc-PEPRF

Priv

Constants: Punc-PEPRF secret key sk

Input: $\hat{x} = (x, s)$

1. Output $z \leftarrow \mathsf{Ext}(F(sk, x), s)$

Modification: $ct^* \leftarrow \mathsf{Enc}(k_e, 0^n)$, $n = \log |Y|$; pick a CRHF h, set $h(ct^*) = t^*$

ct^* is set as secret key, obfuscated program is made public.

Priv

Constants: Punc-PEPRF secret key sk, t^*

Input: ct, $\hat{x} = (x, s)$

1. If $h(ct) \neq t^*$, output $\perp$. Else, output $z \leftarrow \mathsf{Ext}(F(sk, x), s)$.

greatly shrink the size of secret key: an obfuscated program $\rightsquigarrow$ a ciphertext

Security Proof

Game 0. $C_{\text{eval}} \leftarrow i\mathcal{O}(\text{Priv})$ as part of pk, $ct^* \leftarrow \text{SKE}.\mathsf{Enc}(k_e, 0^n)$ as sk.

Game 1. $ct^* \leftarrow \text{SKE}.\mathsf{Enc}(k_e, y^*)$, where $y^* \leftarrow F(sk, x^*)$

Game 2. $C_{\text{eval}} \leftarrow i\mathcal{O}(\text{Priv}^*)$

Game 3. $y^* \xleftarrow{\text{R}} Y$

Priv*
Constants: Punc-PEPRF punctured secret key sk_{x^*}, k_e, t^*
Input: ct, $\hat{x} = (x, s)$
1. If $h(ct) \neq t^*$, output $\perp$.
2. Else if $x = x^*$, set $y^* \leftarrow \text{SKE}.\mathsf{Dec}(k_e, ct)$, output $z \leftarrow \mathsf{Ext}(y^*, s)$.
3. Otherwise, output $z \leftarrow \mathsf{Ext}(F(sk, x), s)$.

$$|t^*| + \ell \leq |Y|,\ |Y| \leq |ct^*| \text{ and } \rho = \ell / |ct^*|$$

Analysis

To achieve optimal leakage rate

- h must be compressing to decrease $|t^*|$, otherwise t^* (hardwired in public program) will reveal too much information of $y^* \leftarrow F(sk, x^*)$
- The choice may make the programs in **Game 1** and **Game 2** have differing-inputs

a collision: $ct' \neq ct^*$ but $h(ct') = t^* = h(ct^*)$ where ct' decrypts to $y' \neq y^*$

$\rightsquigarrow$ one have to resort to differing-input obfuscation, which is highly suspicious.

Our Technique

Idea: replace CRHF with lossy function

- Injective mode: ensure Priv and Priv* are equivalent $\rightsquigarrow$ safely use $i\mathcal{O}$
- Lossy mode: switch to lossy mode to greatly reduce $|t^*|$ $\rightsquigarrow$ t^* only leaks very little information of y^*,

By appropriate parameter choice, $\rho = 1 - o(1)$

This settles the open problem posed by Dachman-Soled et al. [DGL$^+$16]: achieving optimal leakage ratio without resorting to $di\mathcal{O}$

This trick might be instructive elsewhere for avoiding differing-input obfuscation

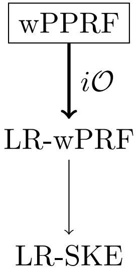
Conclusion

We develop a framework for building leakage-resilient cryptography in BLM from punc-primitives and $i\mathcal{O}$.

Major insight: various punc-PRFs can achieve LR on an obfuscated street

1. wPPRF+$i\mathcal{O}$ $\rightsquigarrow$ LR wPRF $\Rightarrow$ LR-SKE
2. punc-PEPRF+$i\mathcal{O}$ $\rightsquigarrow$ LR PEPRF $\Rightarrow$ LR-PKE
    - as a building block of independent interest, we realize punc-PEPRF from newly introduced punc-objects such as PTDFs and PEHPS.
3. sPPRF+ LR-OWF + $i\mathcal{O}$ $\Rightarrow$ the first LR-public-coin Sig
    - solve the open problem posed by Boyle et al. (Eurocrypt 2011)
4. By further assuming lossy functions, all the above constructions achieve optimal leakage rate – not known to be achievable for wPRF, PEPRF and public-coin Sig before.
    - solve the open problem posed by Dachman-Soled et al. (PKC 2016, JOC 2018)

Conclusion



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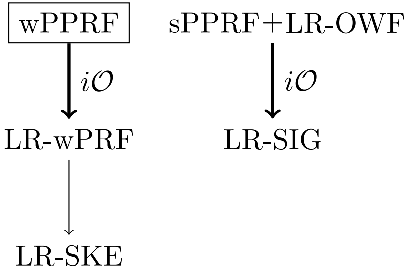

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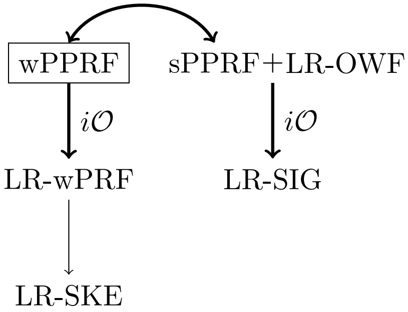

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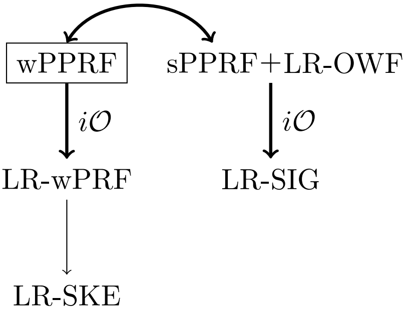
wPPRF
sPPRF+LR-OWF
PPEPRF
$i\mathcal{O}$
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LR-wPRF
LR-SIG
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LR-SKE
LR-PKE

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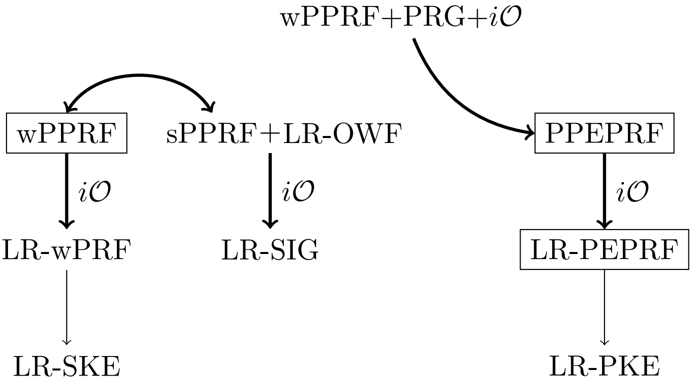
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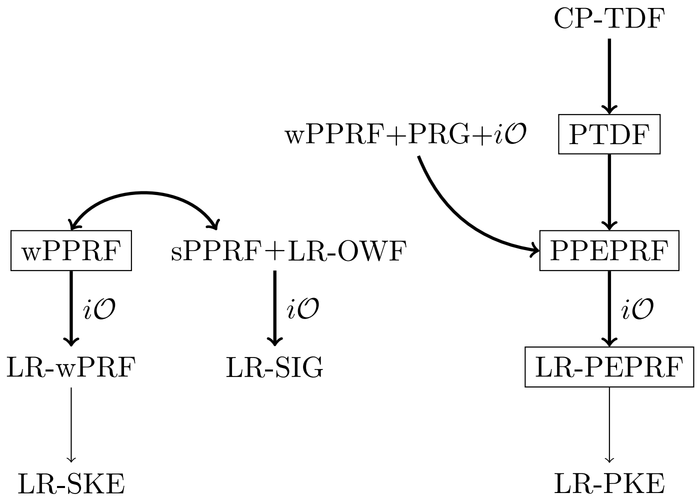

CP-TDF
wPPRF+PRG+$i\mathcal{O}$
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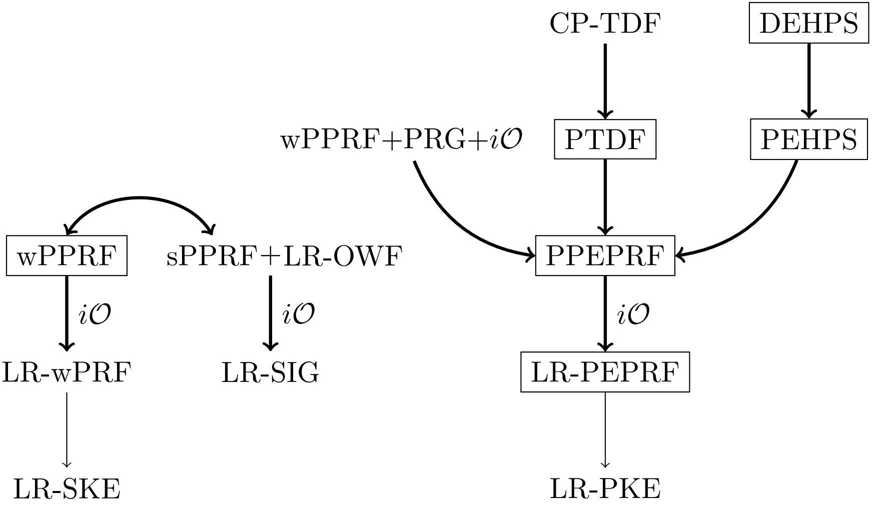
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Thanks for Your Attention!

Any Questions?

https://eprint.iacr.org/2018/781

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