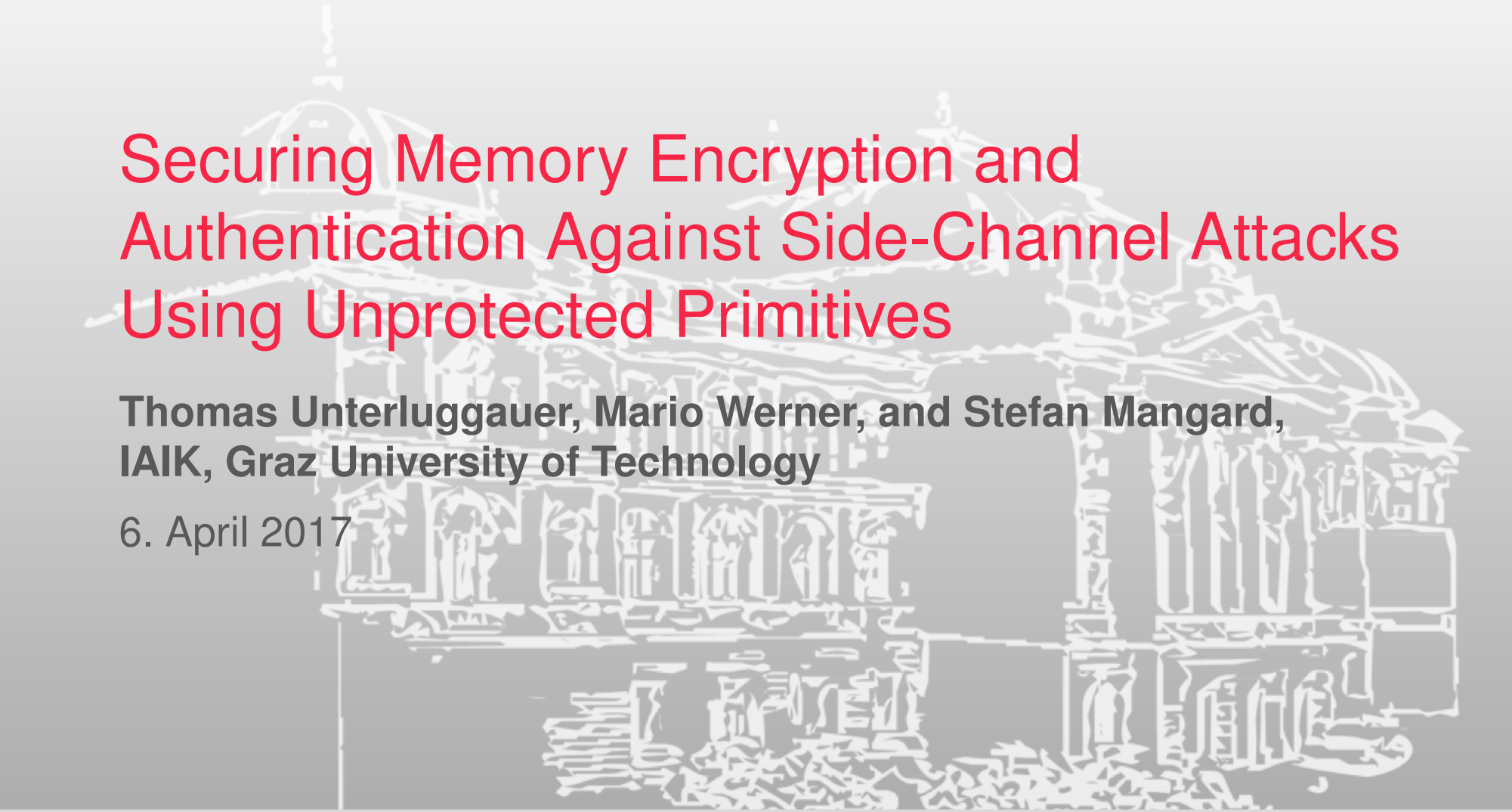

Securing Memory Encryption and Authentication Against Side-Channel Attacks Using Unprotected Primitives

Thomas Unterluggauer, Mario Werner, and Stefan Mangard,
IAIK, Graz University of Technology

6. April 2017

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- Differential power analysis (DPA) practically feasible

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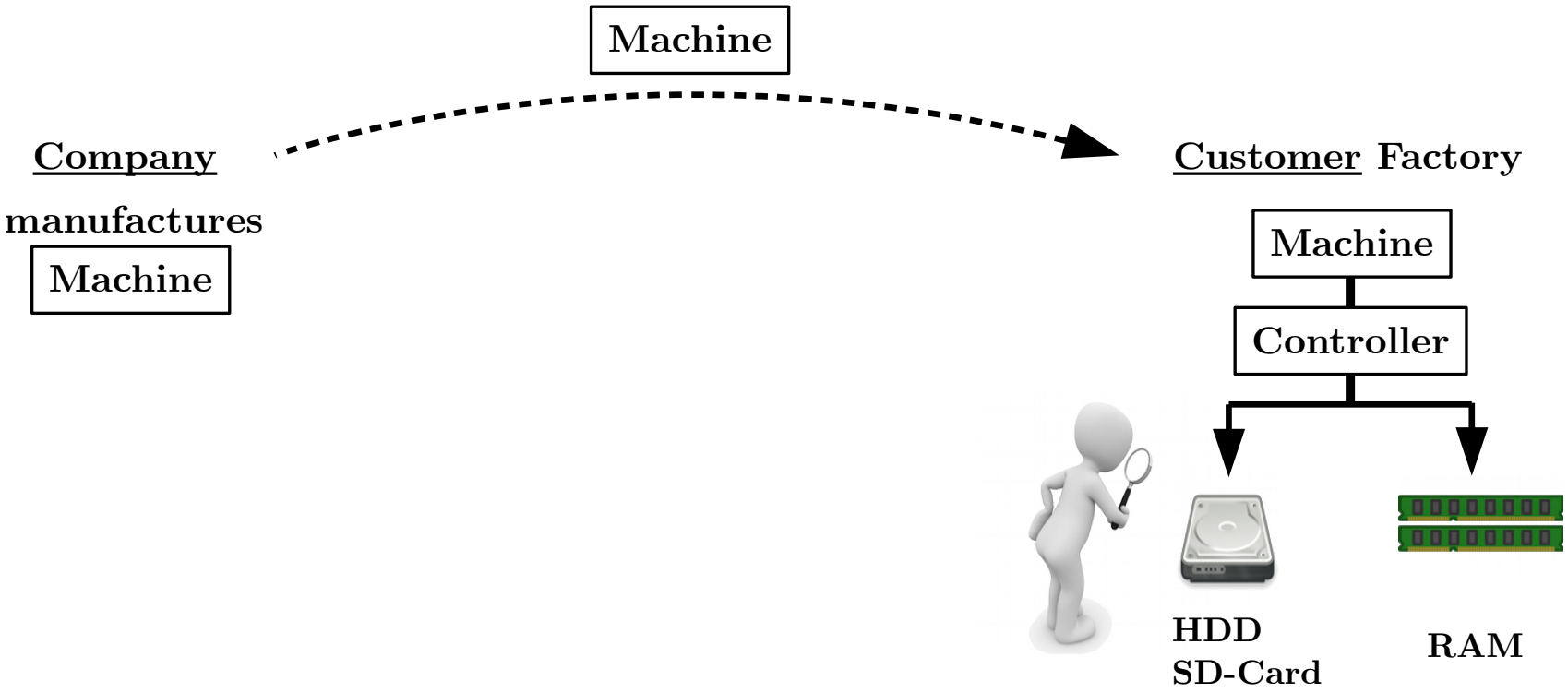
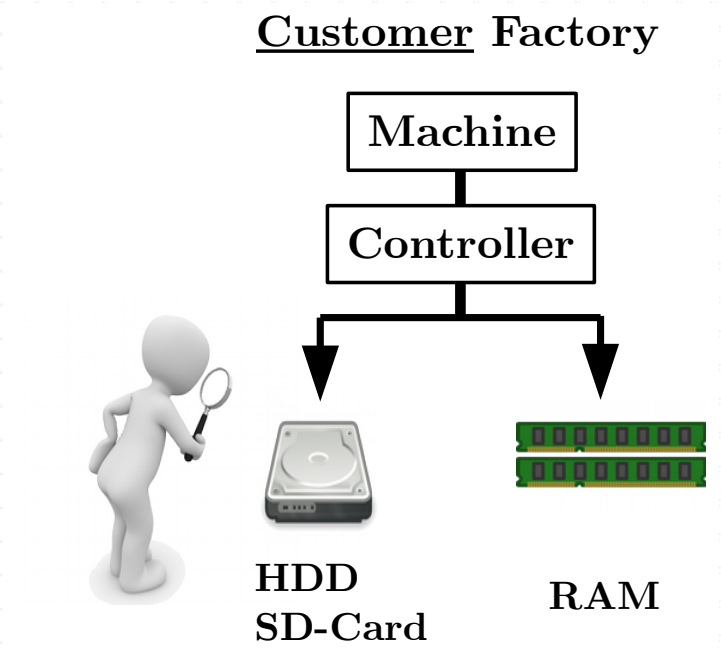
    - Limit inputs processed under one key by two
  - Higher-order protection: masking of plaintexts
  - No need for DPA-protected implementations
  - Suitable for both RAM and NVM
  - Memory overhead: 7.3% for 512-byte disk sectors

Motivation


Machine
Company
manufactures
Machine
Customer Factory
Machine
Controller
HDD
SD-Card
RAM

Motivation

- Memory contains high-value assets
- Customer interested in:
  - Intellectual property
    - Source code
    - Control parameters
  - Billing data
    - Pay per use



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- Countermeasure:
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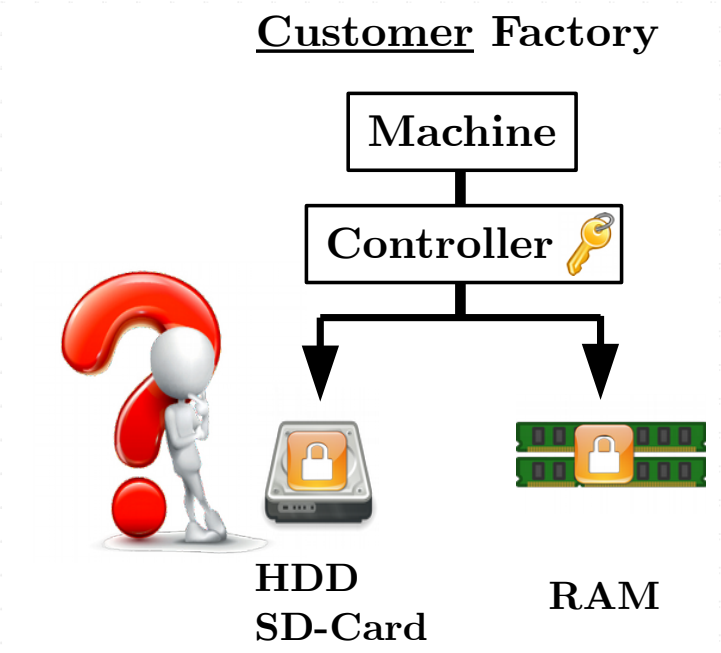
  - Store key securely



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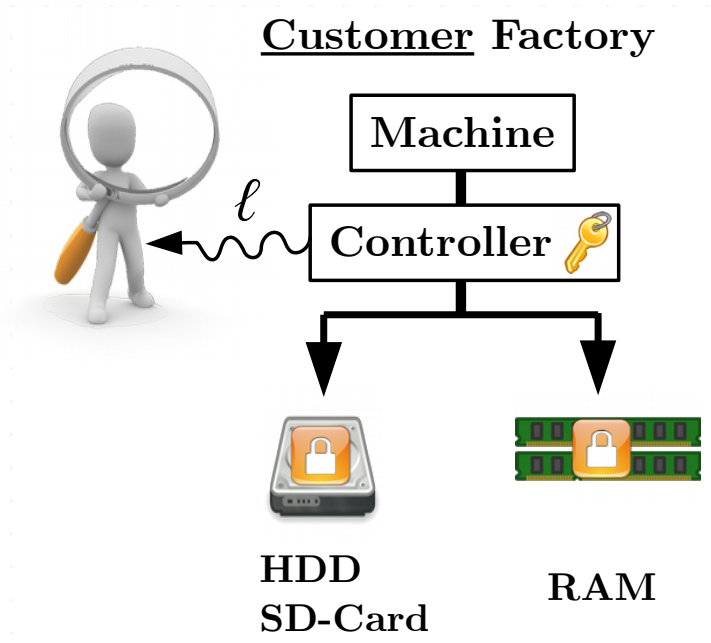
  - Power, EM, timing,...



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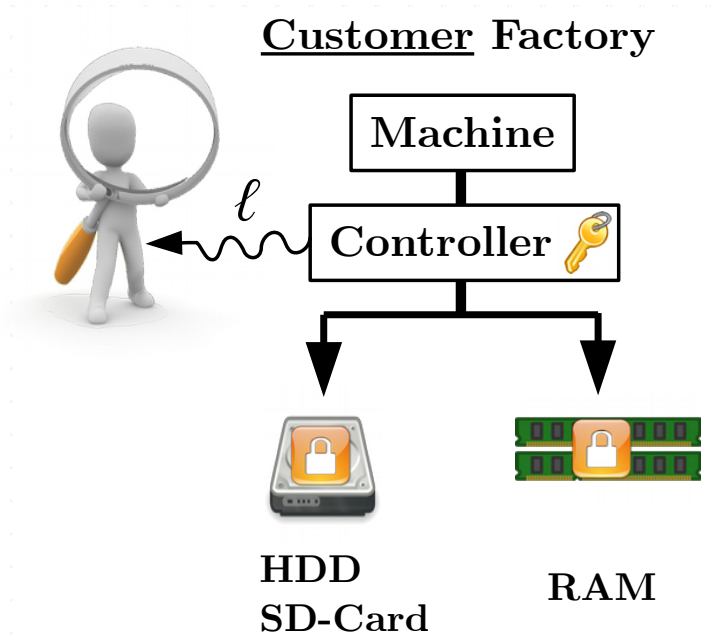
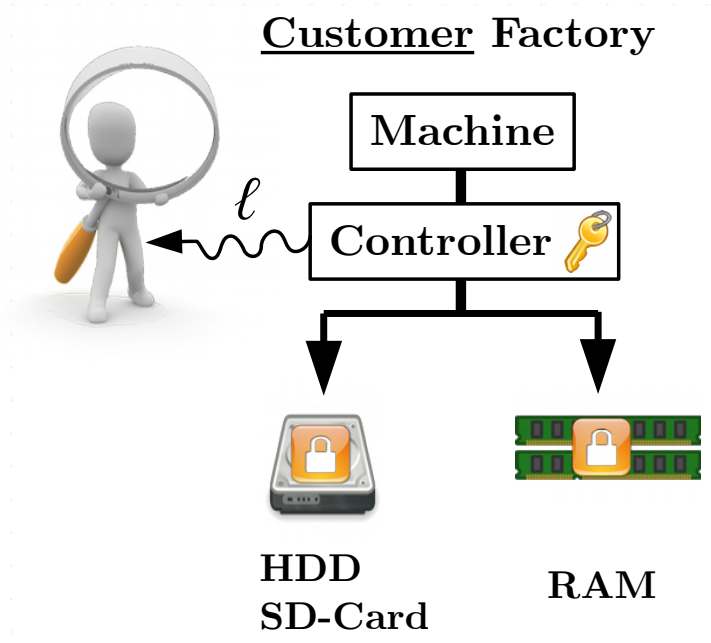


$\Rightarrow$ Side-channel attacks possible

Attack Setting

- Computing device running in hostile environment
- Memory contains sensitive information



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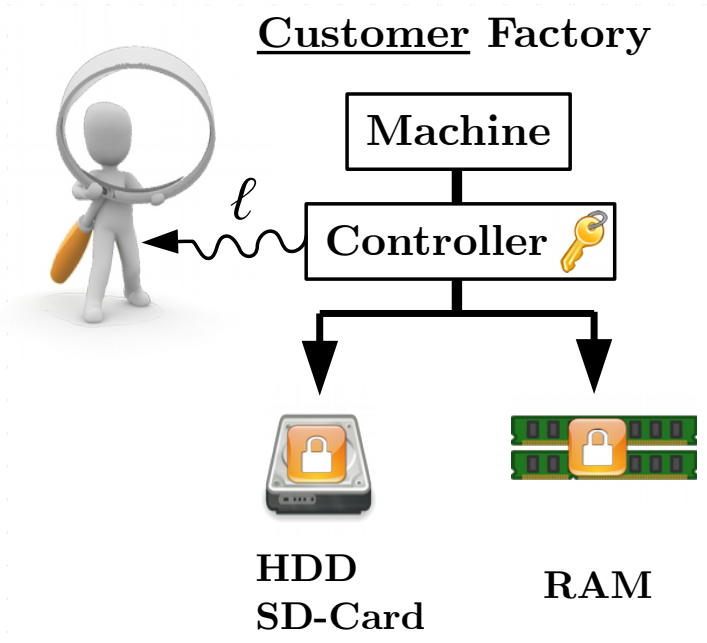
- Attacker can access device and (encrypted) memory
- Side-channel information available to the attacker



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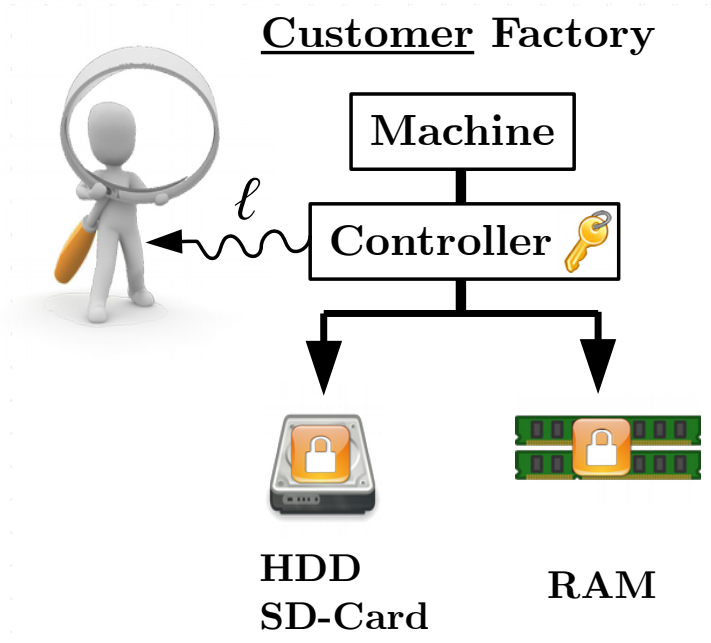
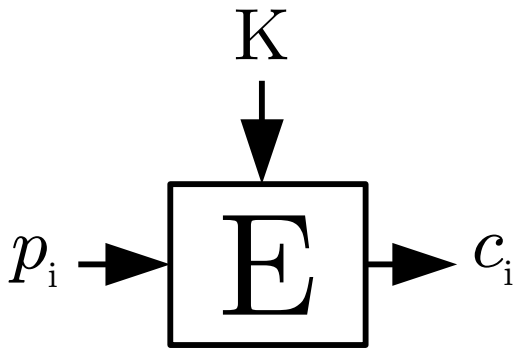


$\Rightarrow$ Simple memory encryption is insufficient

Differential Power Analysis

- Key K used for multiple p_i, c_i
  - n encryptions: $E_K(p_i)$



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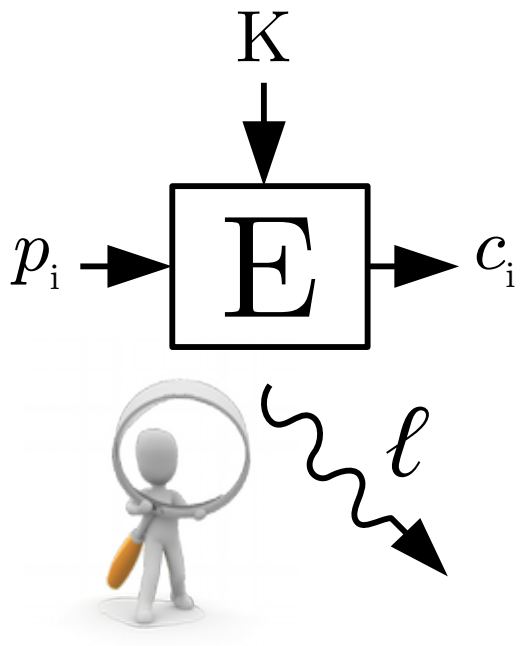

Differential Power Analysis

- Key K used for multiple p_i, c_i
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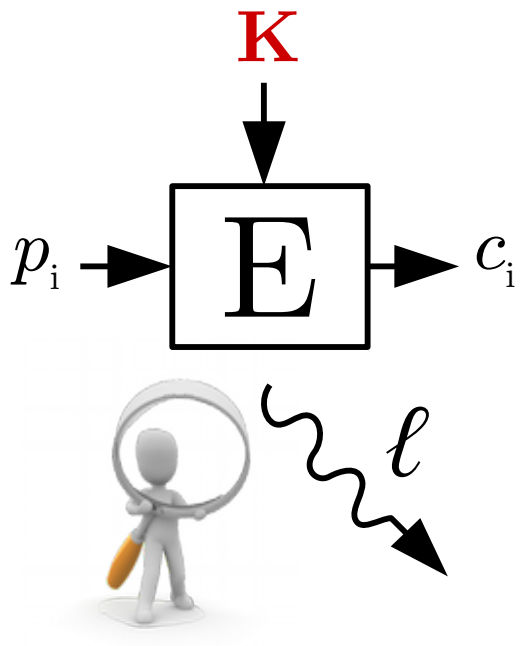
- Observe power consumption
- Power model for $E_K(p_i) \; \forall \; K$
  - Divide-and-conquer approach
- Statistical analysis reveals K
  - E.g. correlation



DPA Countermeasures

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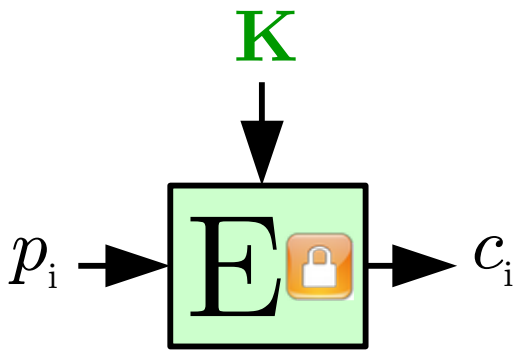

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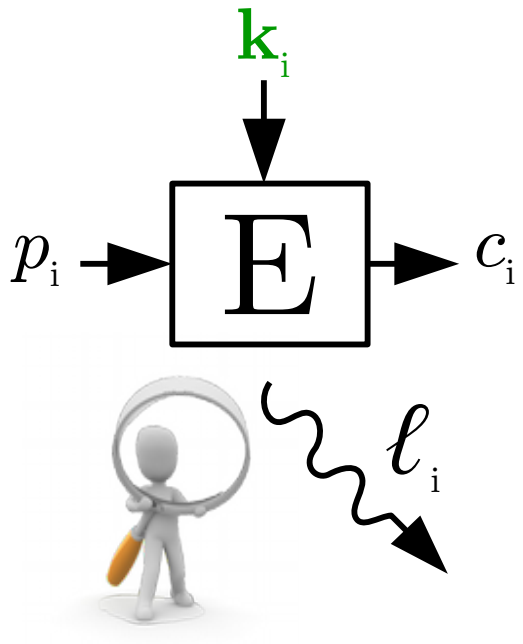

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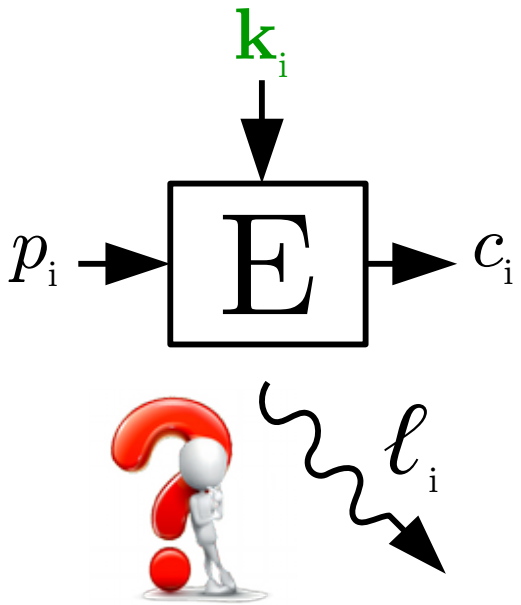
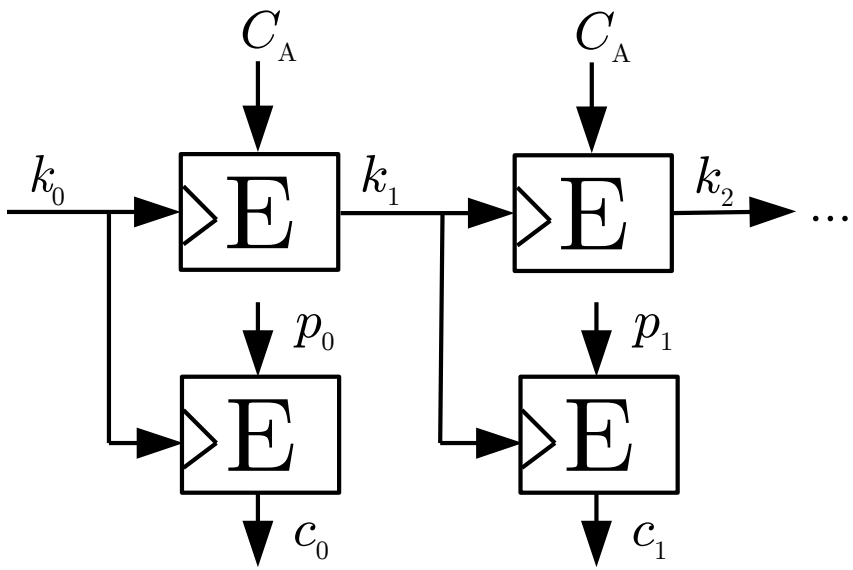
  - Leakage-resilient encryption
  - Application to memory encryption?



Re-Keying for Memory Encryption

- Leakage-resilient schemes for arbitrary length



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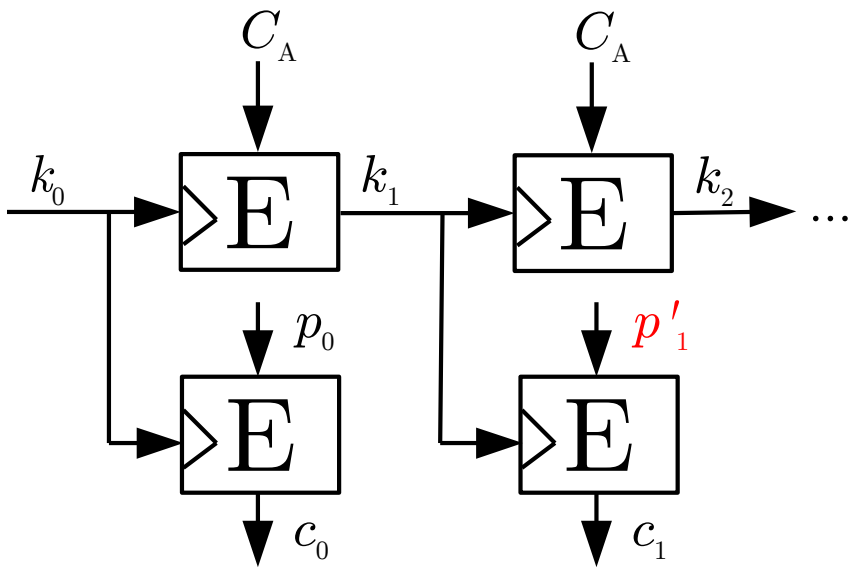

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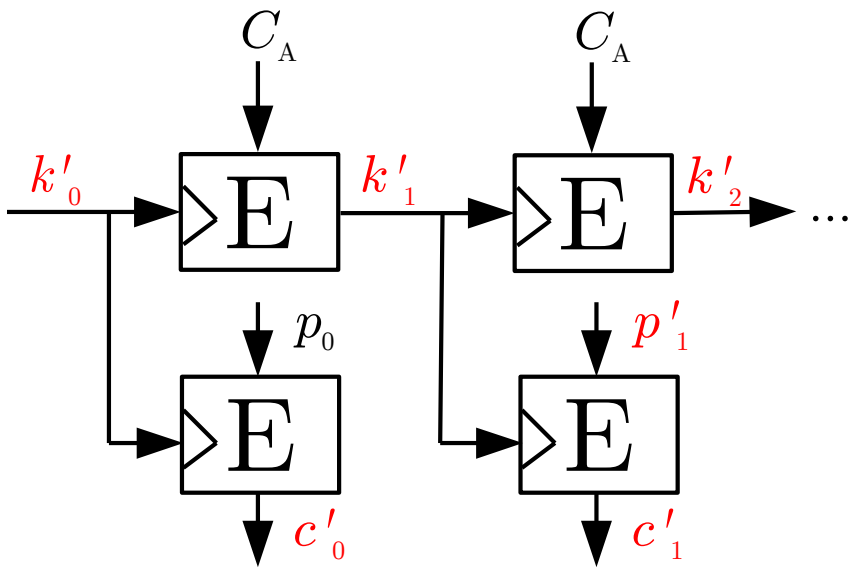

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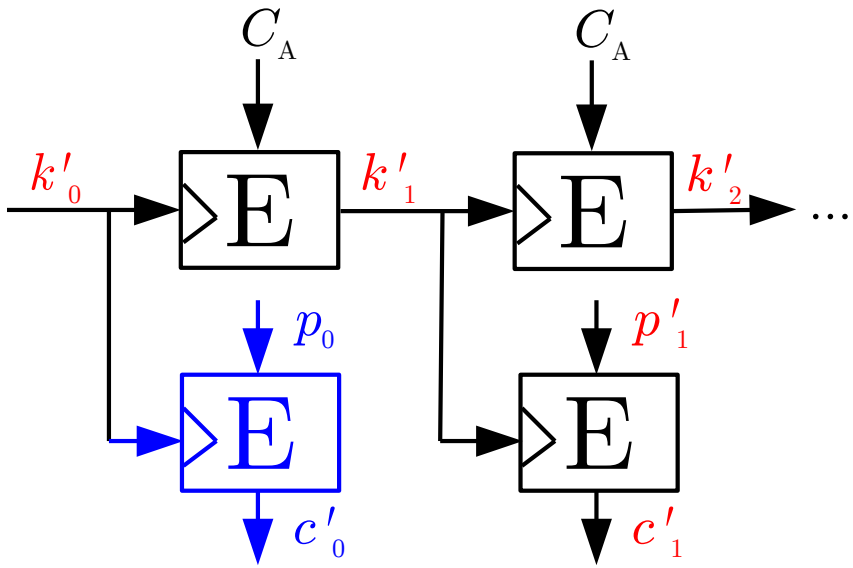
- 2nd-order DPA to learn constant plaintexts



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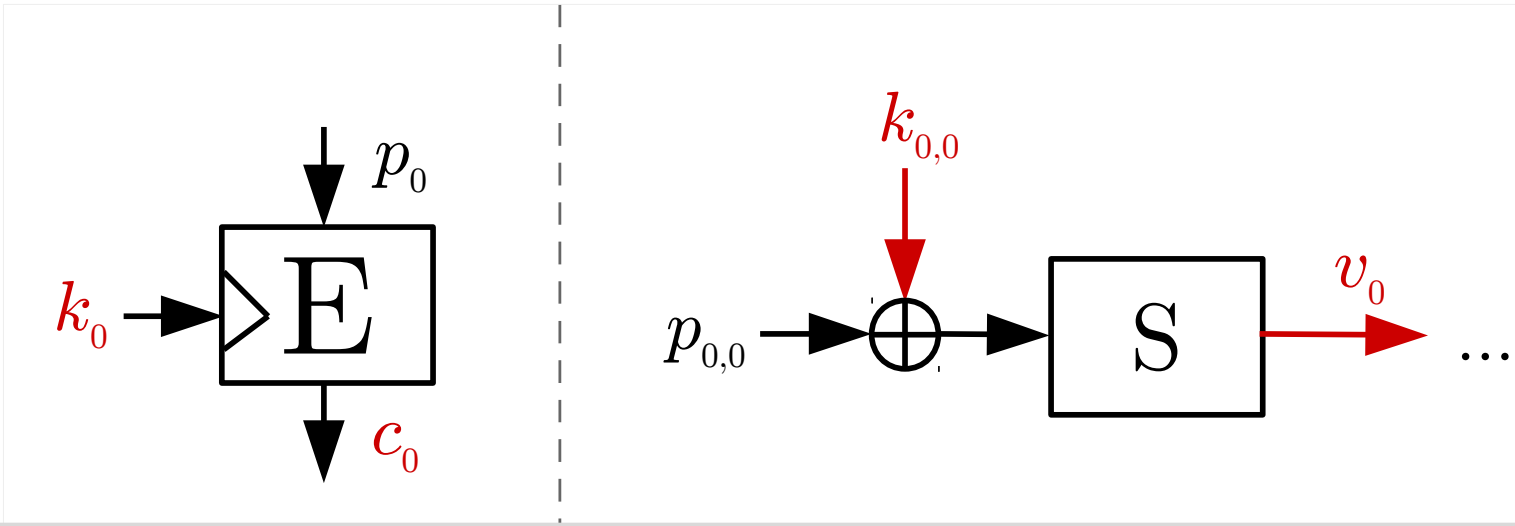

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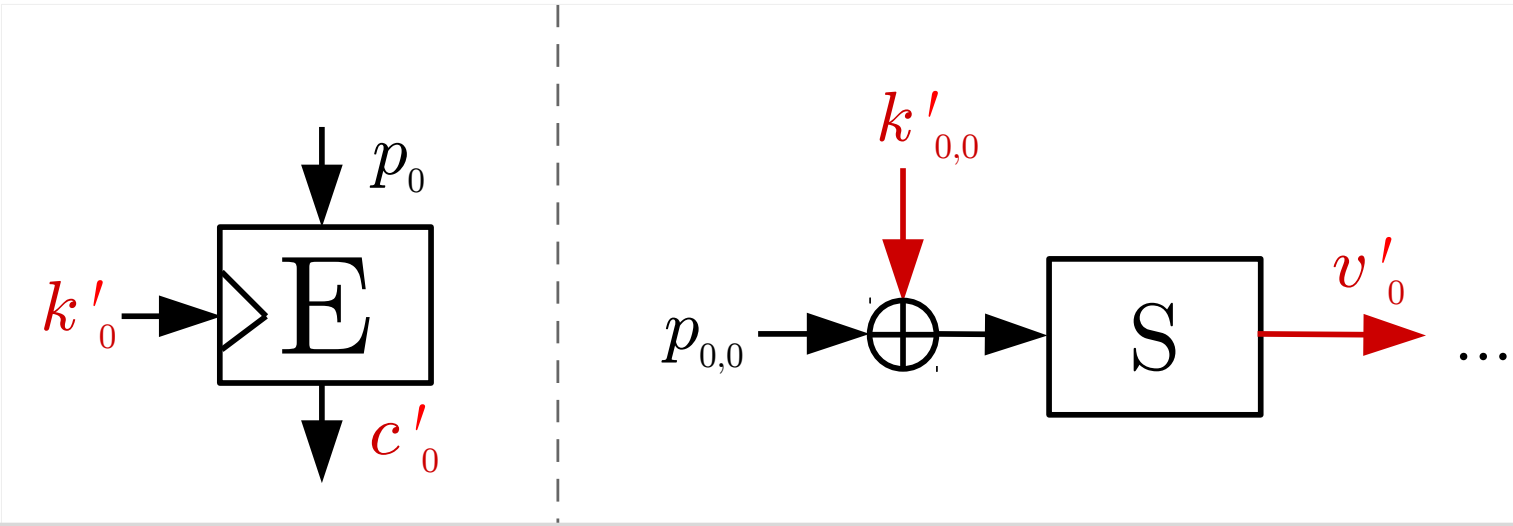

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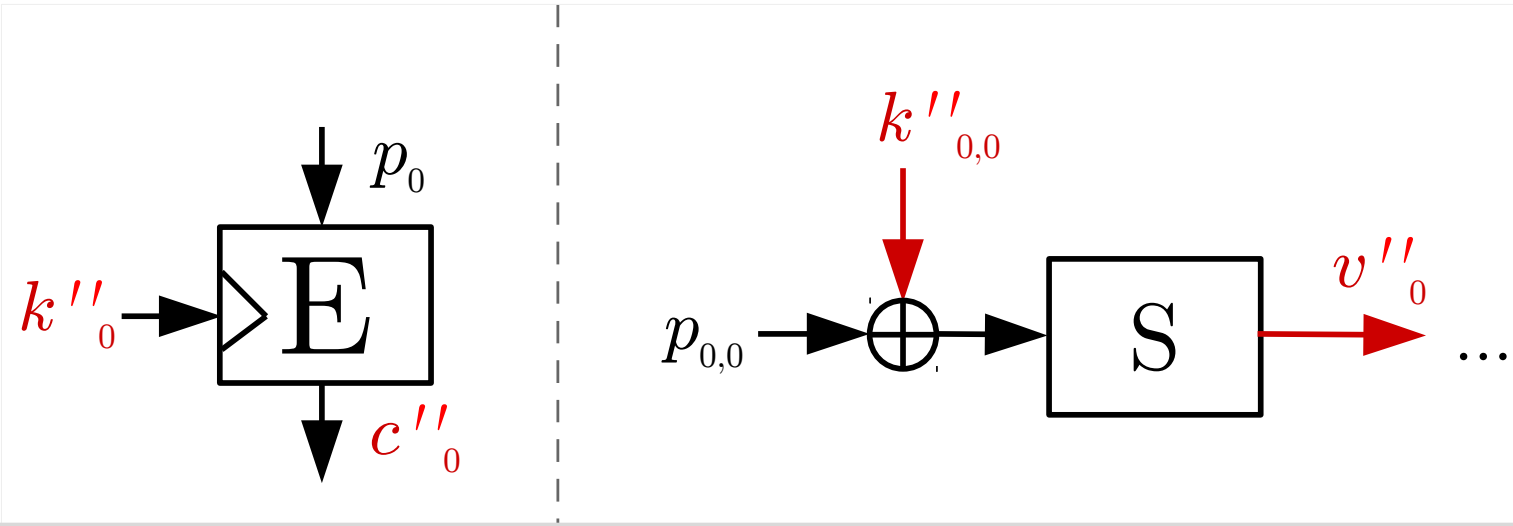

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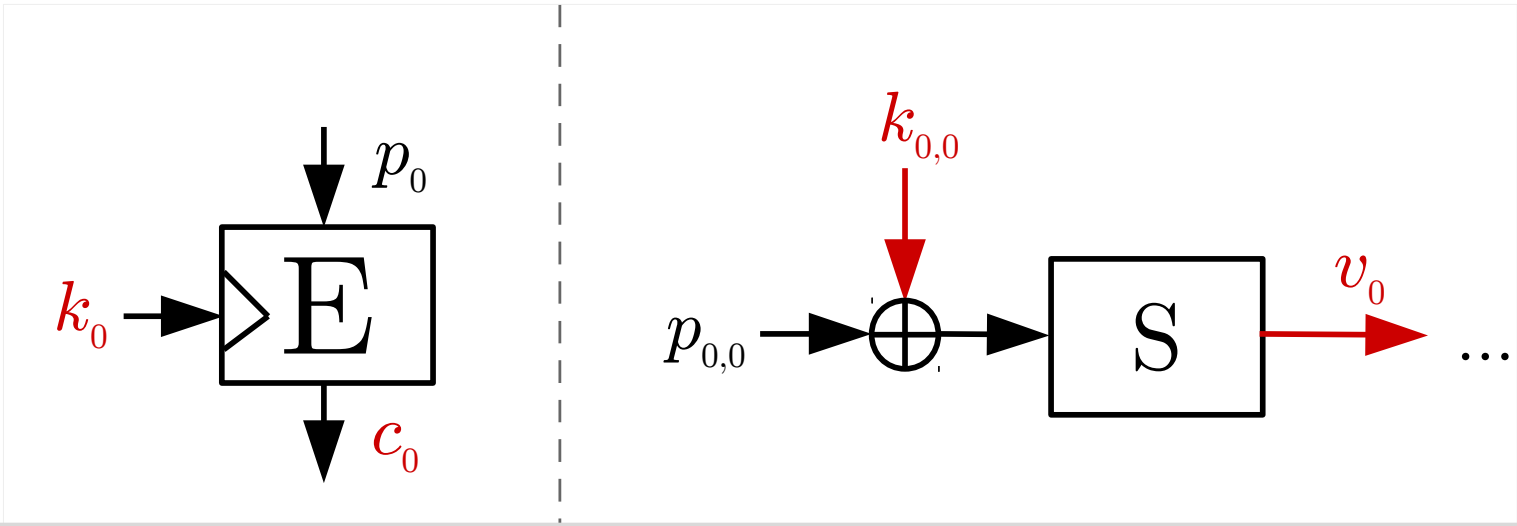

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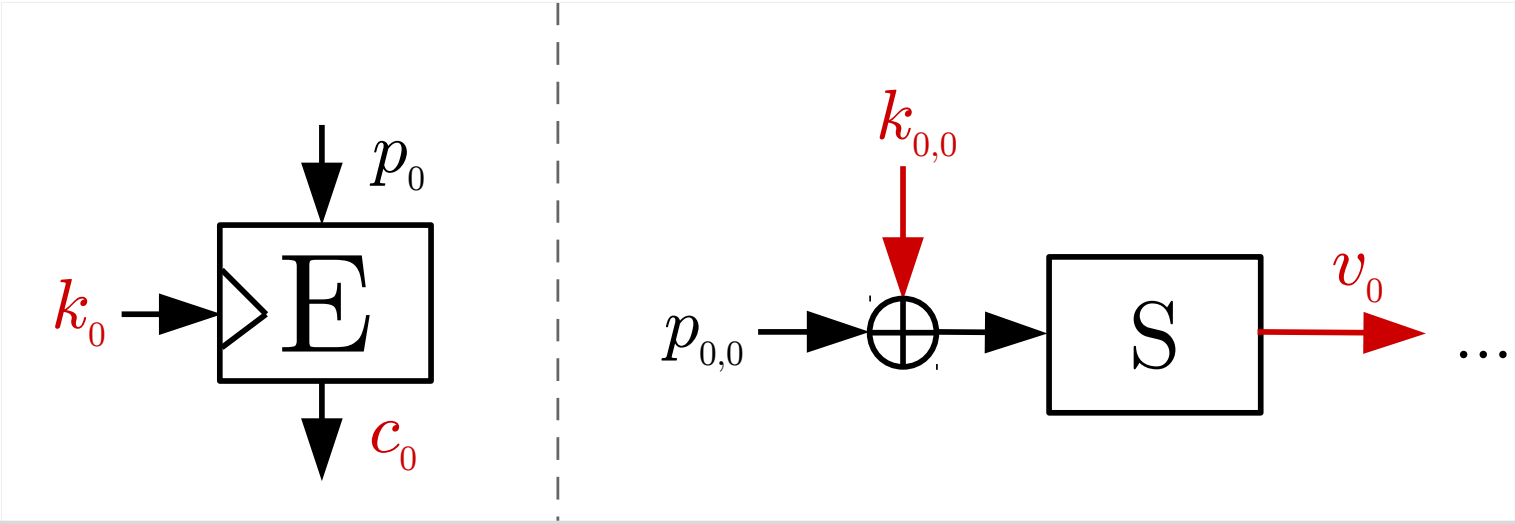

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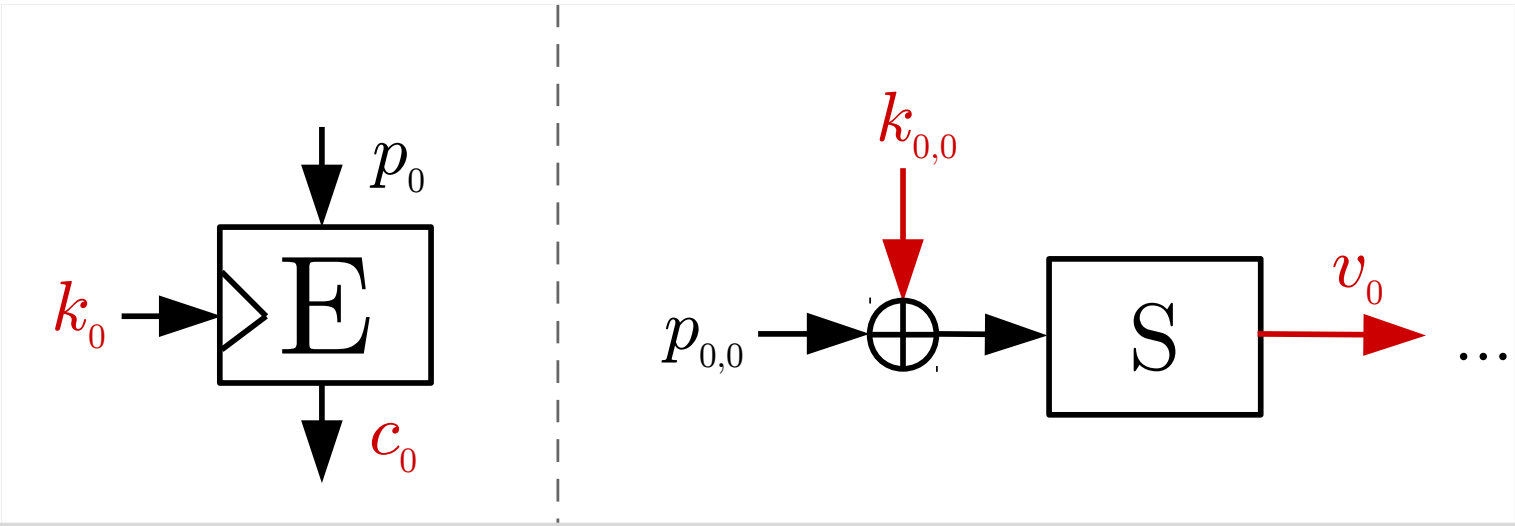

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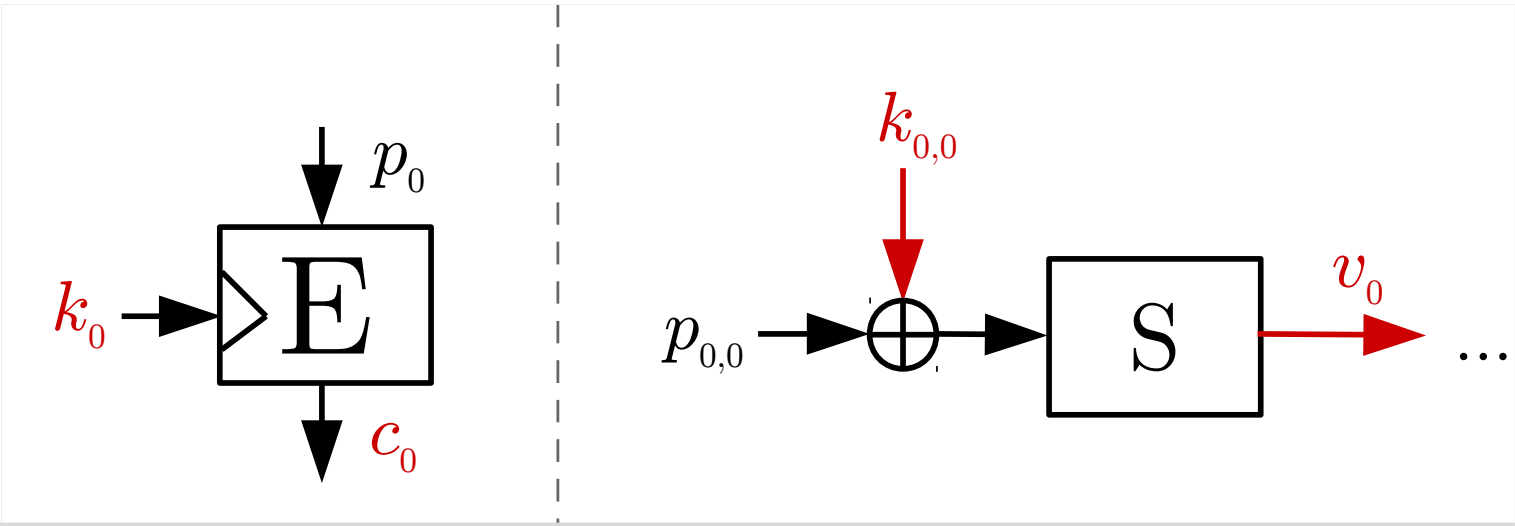

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- Streaming mode vs. random access
  - Split memory in blocks with different keys
  - Secure key storage on trusted chip
  - Minimal storage: tree approach
    - C.f., Merkle tree

MEAS

- Memory split into m blocks $p_0, p_1, \ldots, p_{m-1}$

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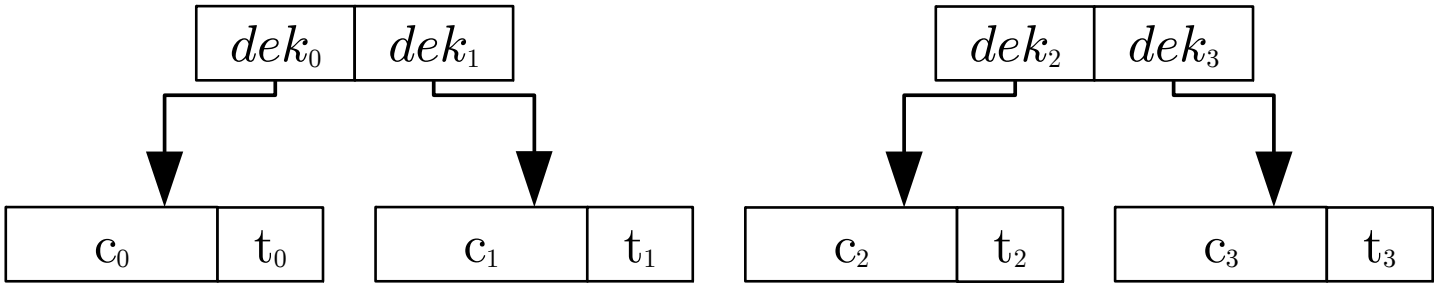

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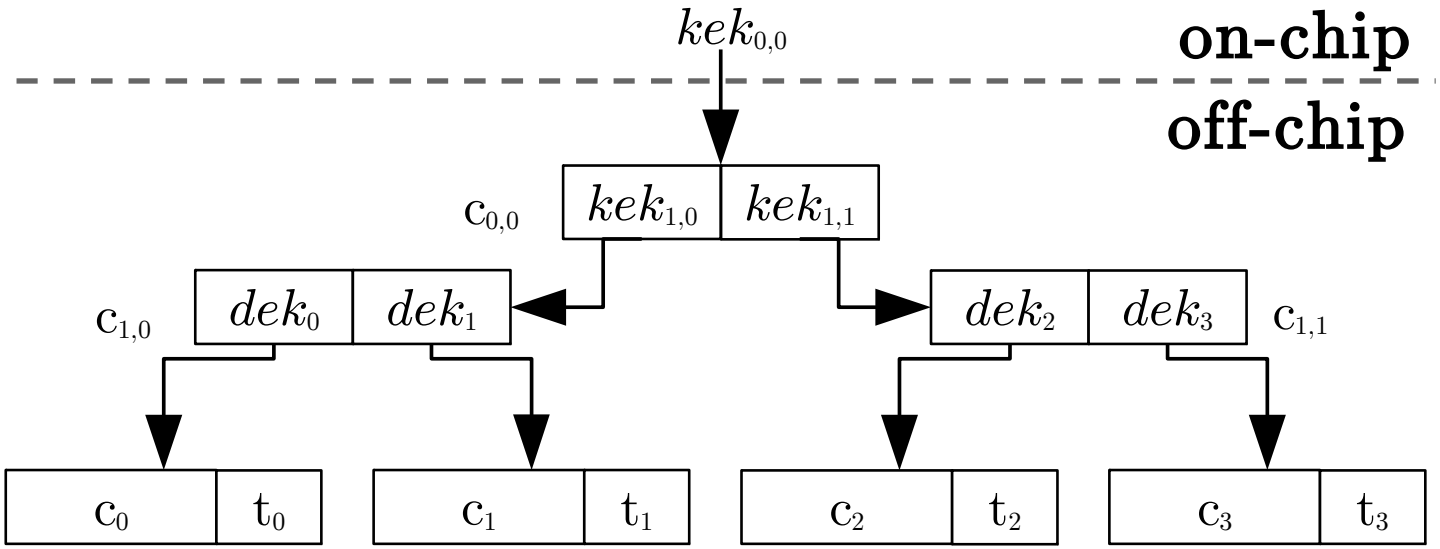

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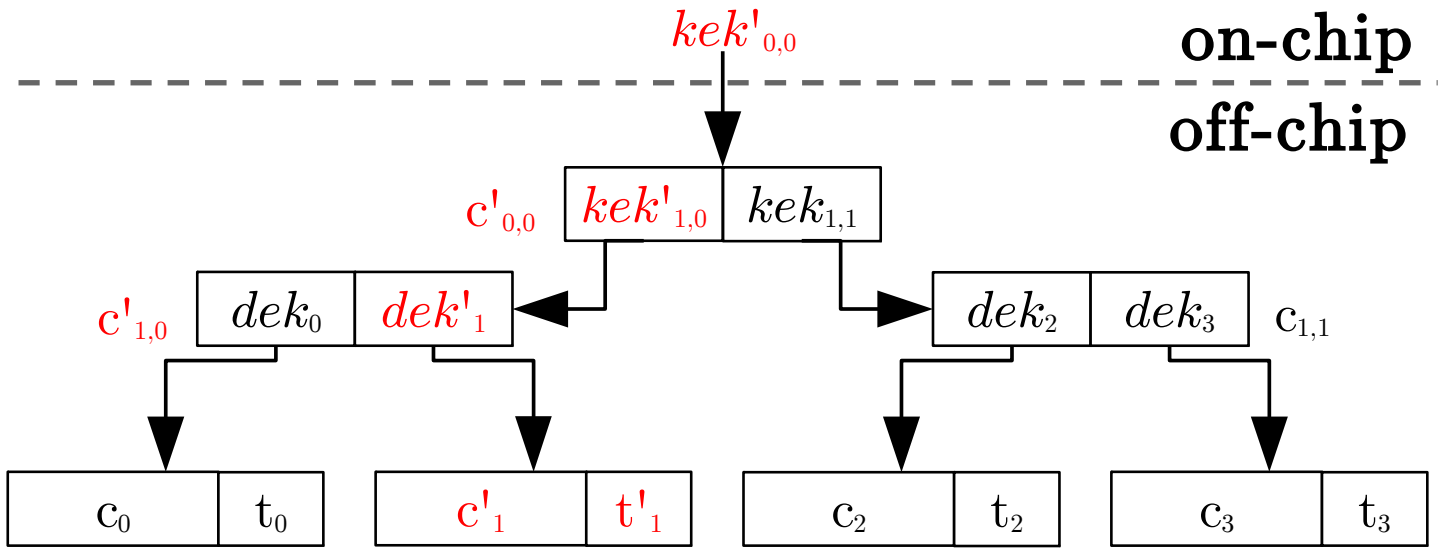

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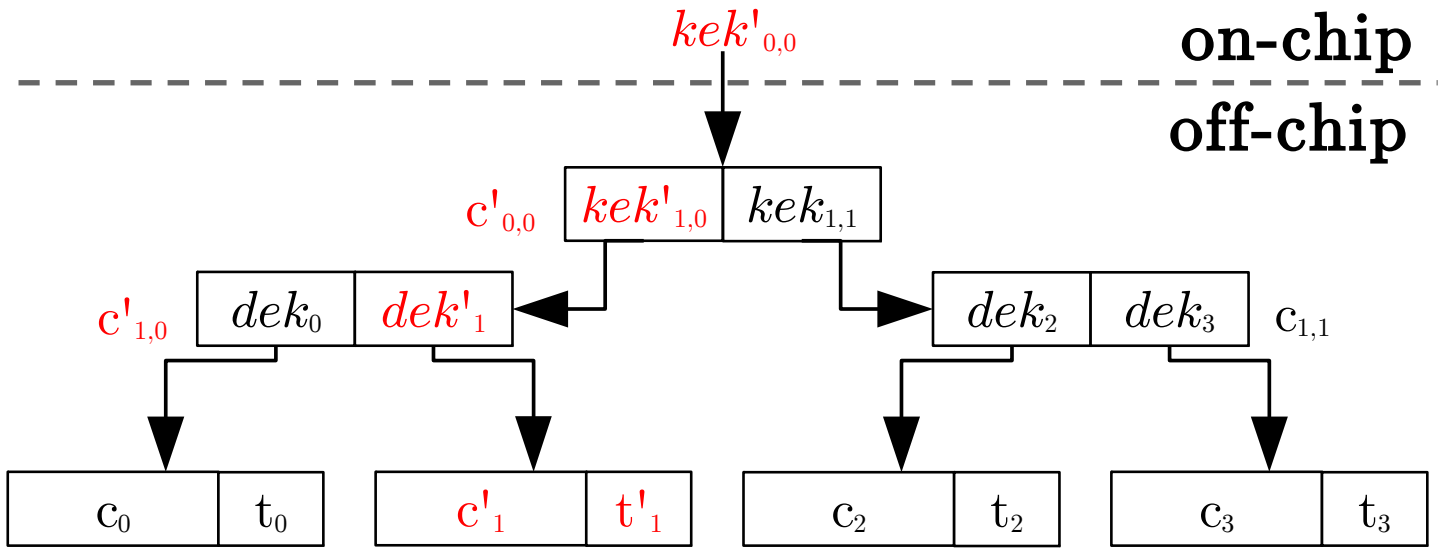

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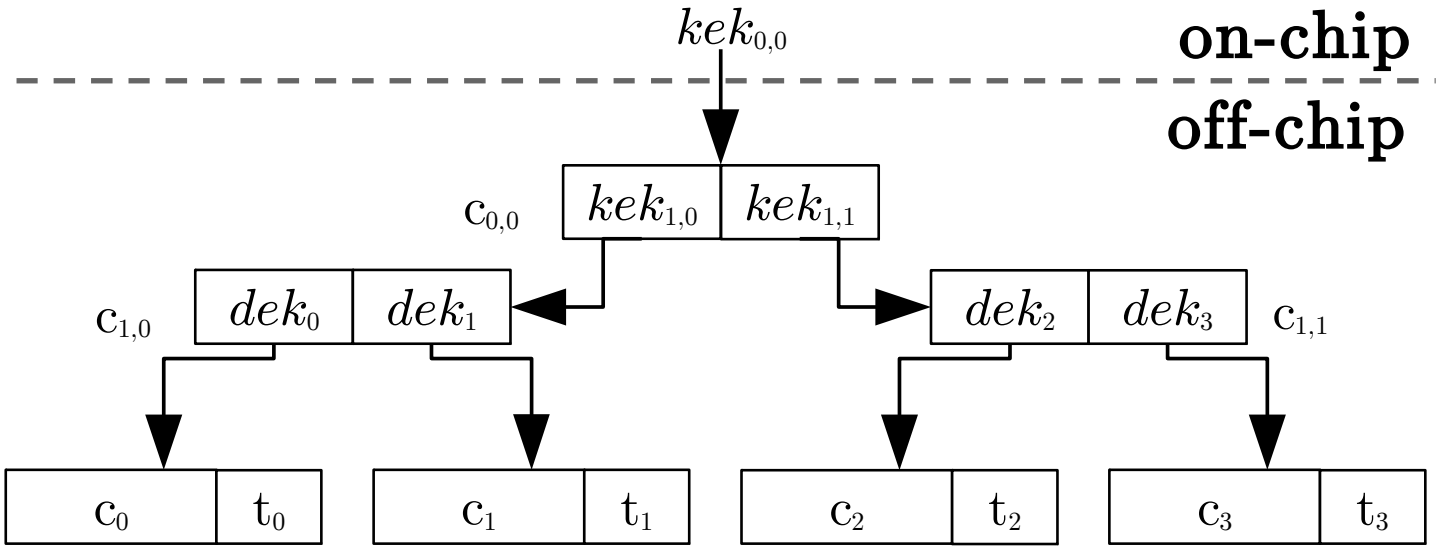

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- Various trade-offs possible

Comparison

	Auth.	Conf.	DPA Security	
MEAS	✓	✓	✓	
PAT	✓			
TEC Tree	✓	✓		
Merkle Tree	✓		✓	
XTS / XEX		✓		

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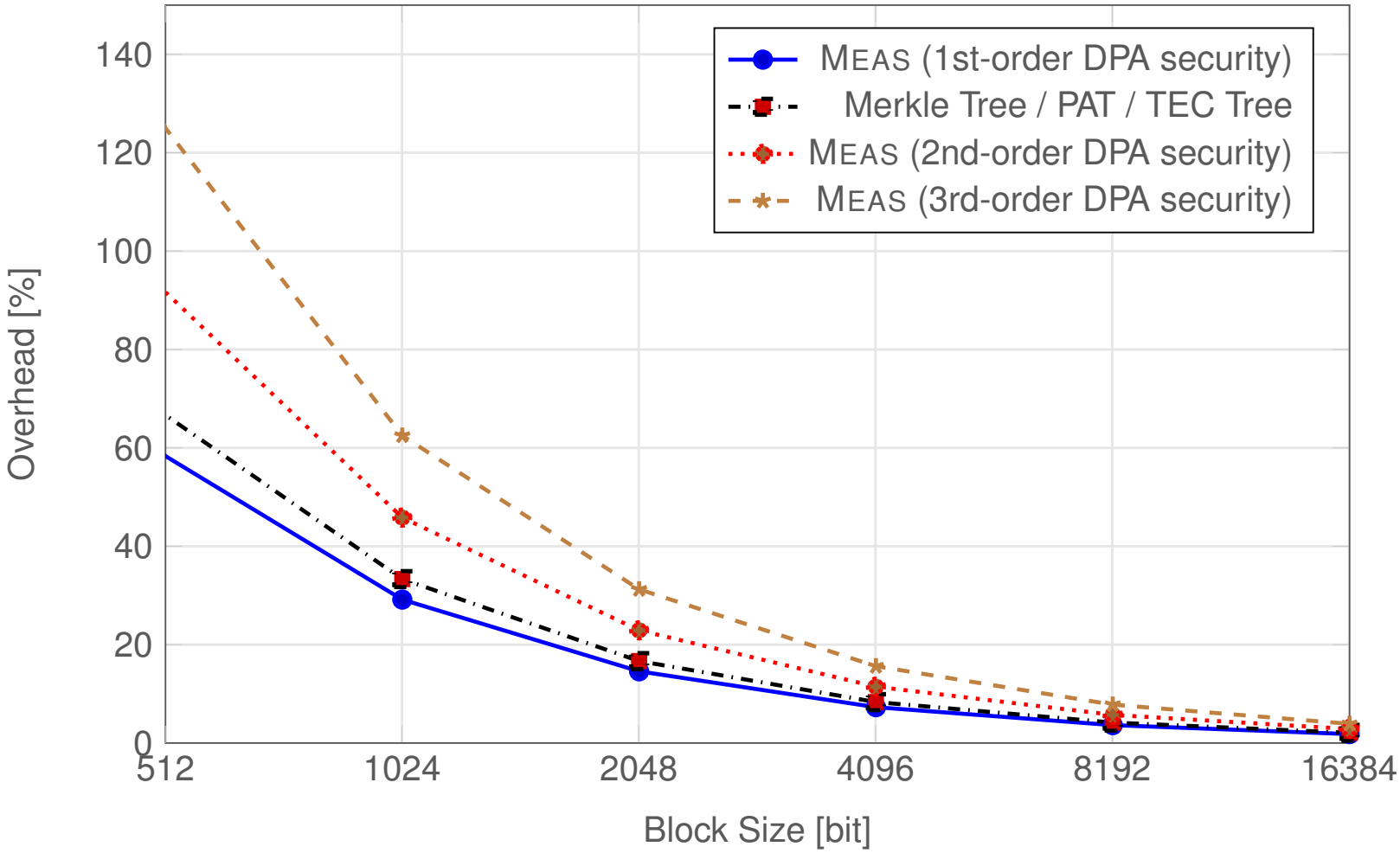
Memory Overhead



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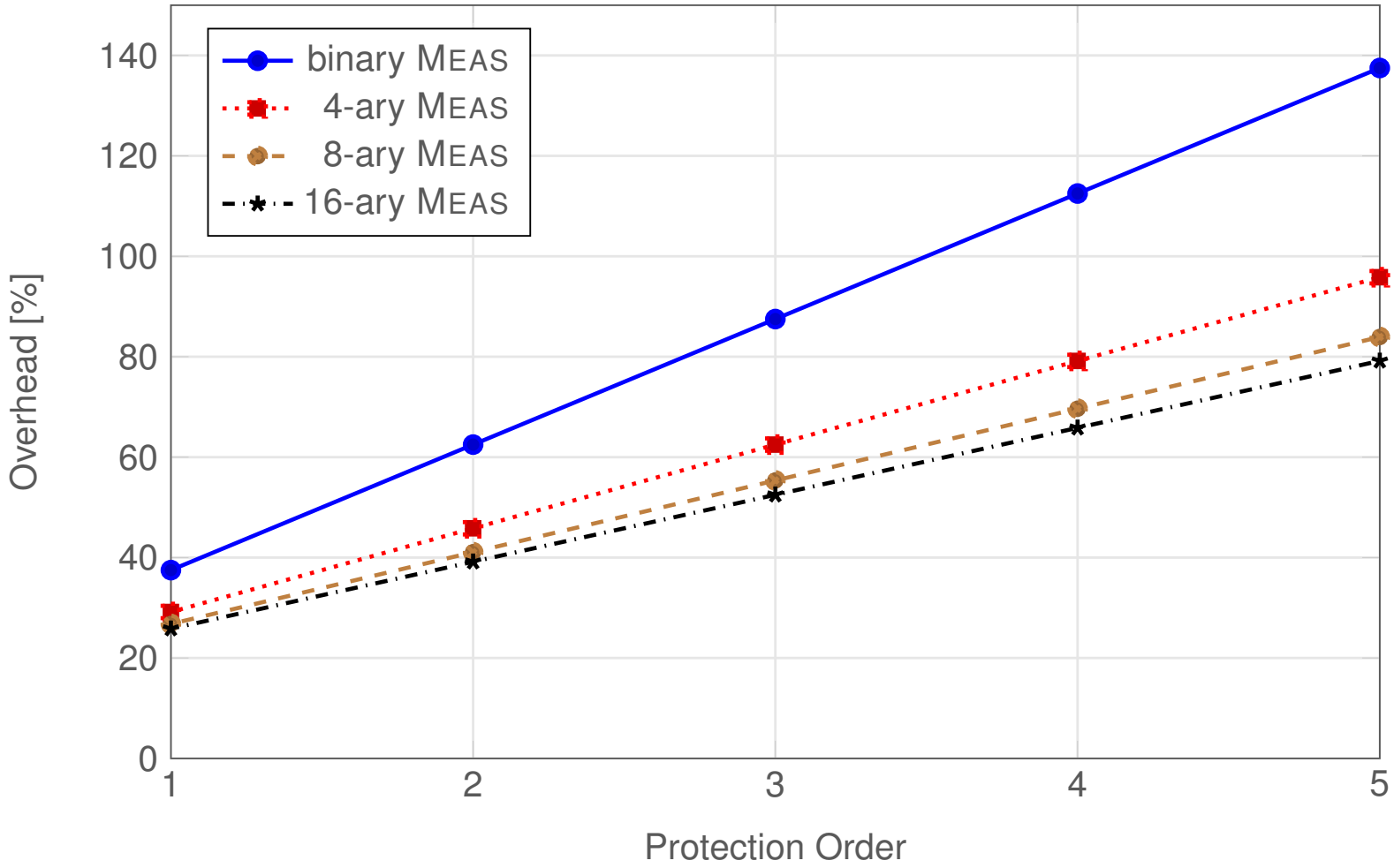

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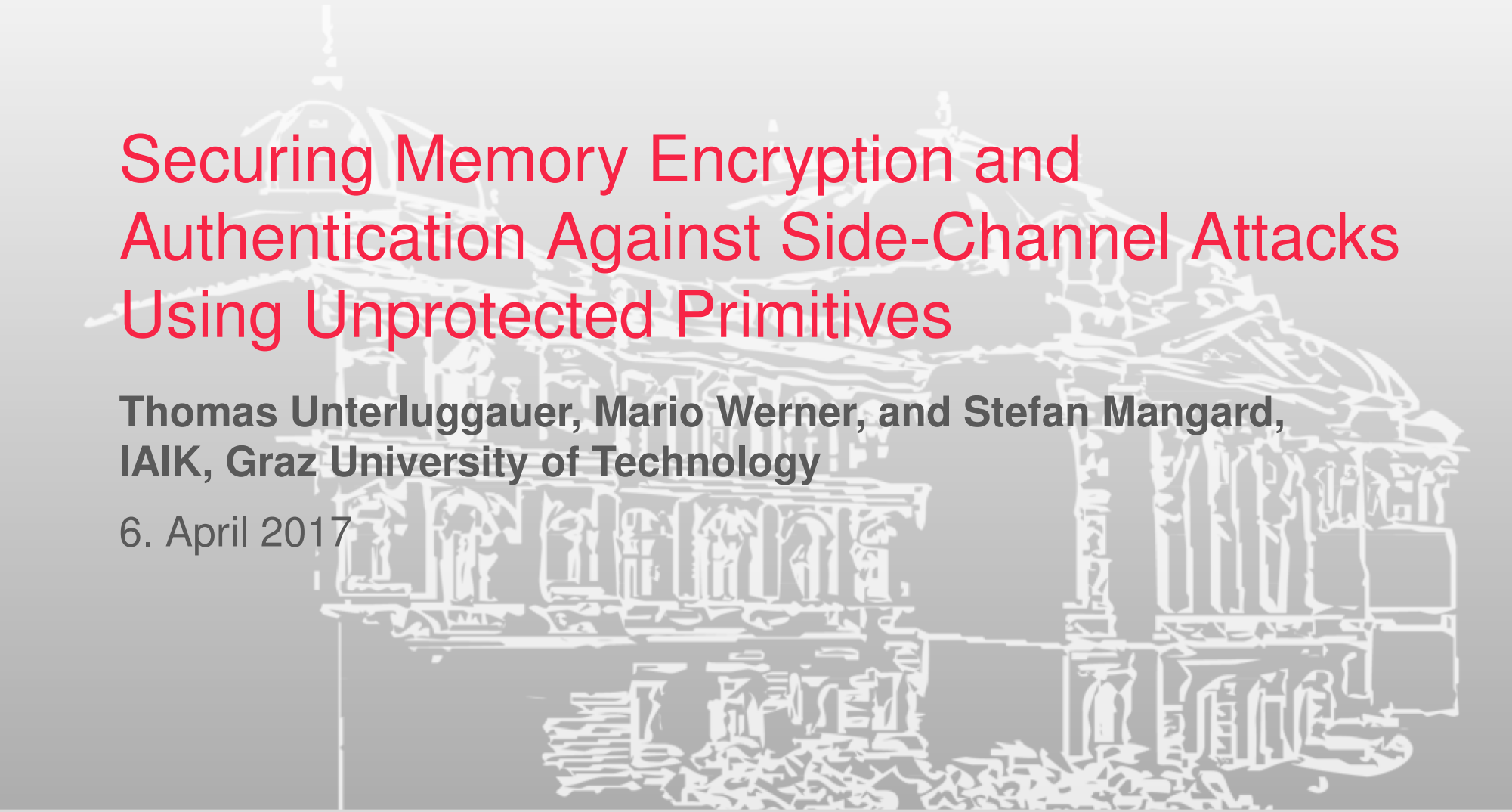

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