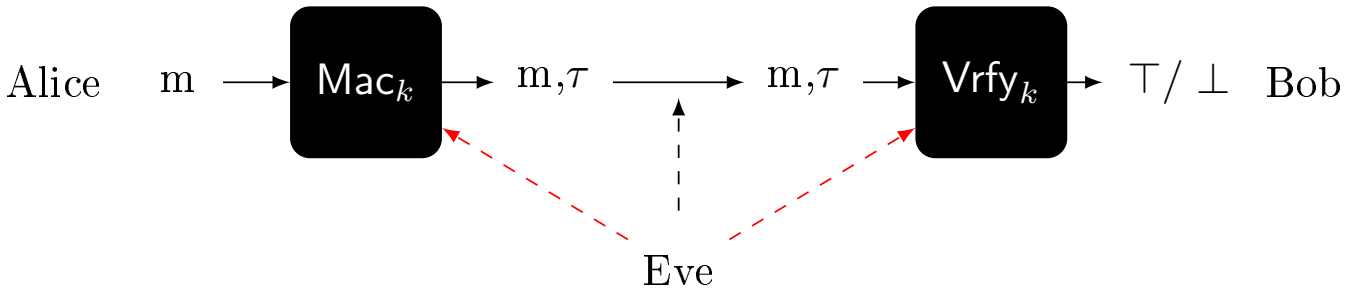
Efficient Leakage-Resilient MACs Without Idealized Assumptions

Francesco Berti, Chun Guo, Thomas Peters, François-Xavier Standaert

07-12-2021

Integrity and Leakage



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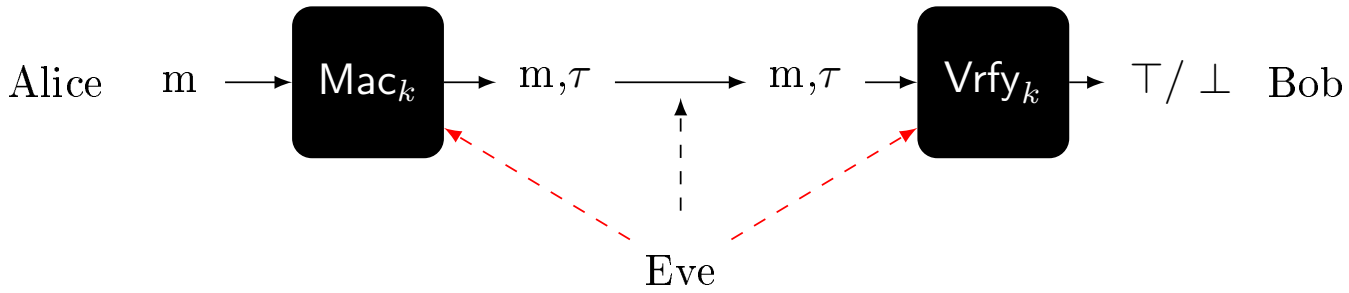
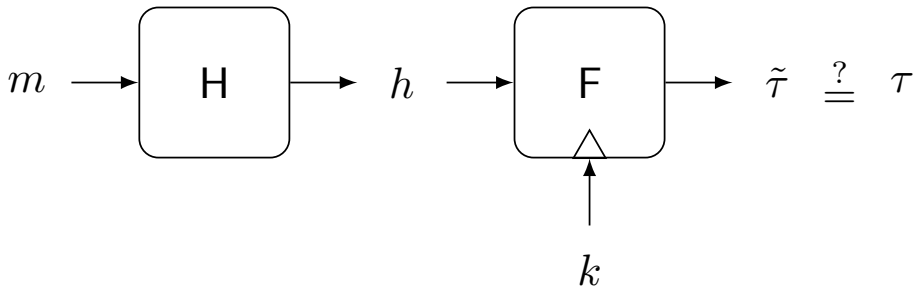


With access to the physical devices, measure

- power consumption, time, EM radiation [side-channels]

These physical observations *leak* critical information (even the full key).

Side-channel vs integrity - ex: Hash-then-BC



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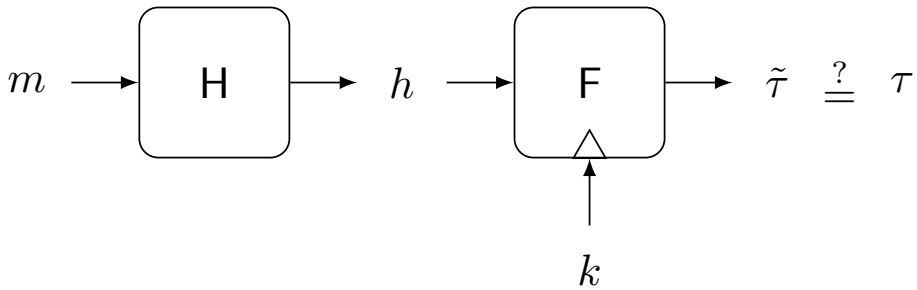

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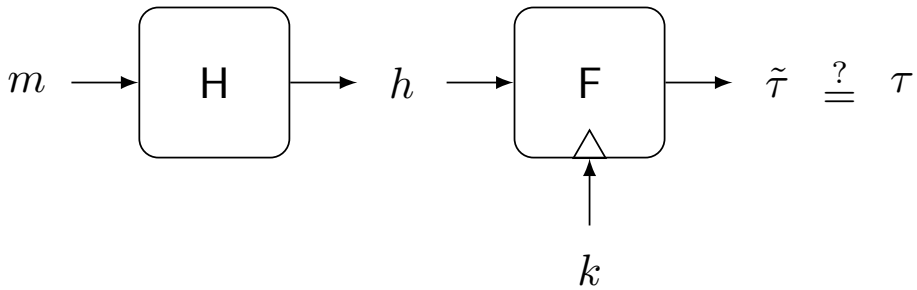

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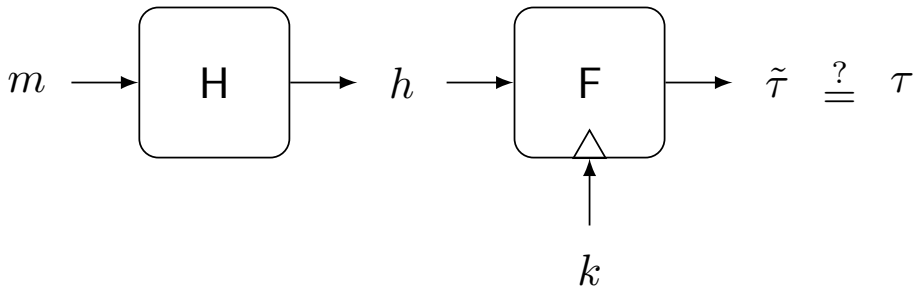

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Cryptographic device *are not* blackbox oracles.

Leakage-resilient Cryptography - Tradeoffs

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- verifiability
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Anyway, it gives : what to protect + efficient constructions.
Thus, we use *strong unpredictability with leakage* (sUL)

Results: integrity with leakage

- LR–MAC1
  - 1 TBC call and a collision-resistant hash
    - Beyond birthday secure (BBB) only with long tweaks (2n)
- LR–MAC2
  - 2 TBC calls and a collision-resistant hash
    - BBB with half collision resistant hash function
- HTBC
  - 1 TBC call and a collision-resistant hash
    - security with a stronger (not idealized) assumption for the hash

Summary

1. Background
   1. Unforgeability for MAC in presence of leakage
   2. Modeling leakage - unbounded leakage model
   3. sUL - Security definition for TBC in presence of leakage
   4. HTBC - [BGPPS19]
2. LR–MAC1
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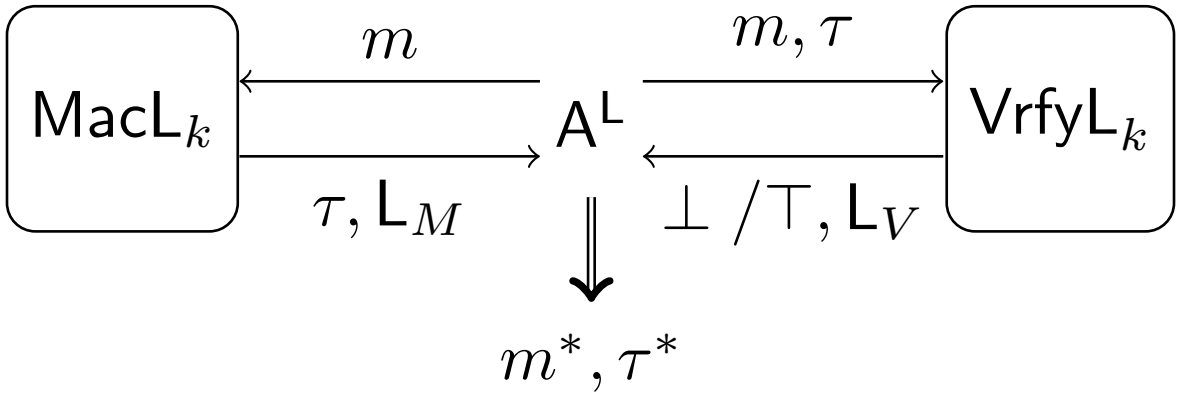
suf–L2 - Security for MACs with leakage [BGPPS19]

Strong unforgeability with Leakage



Hard to forge even if A

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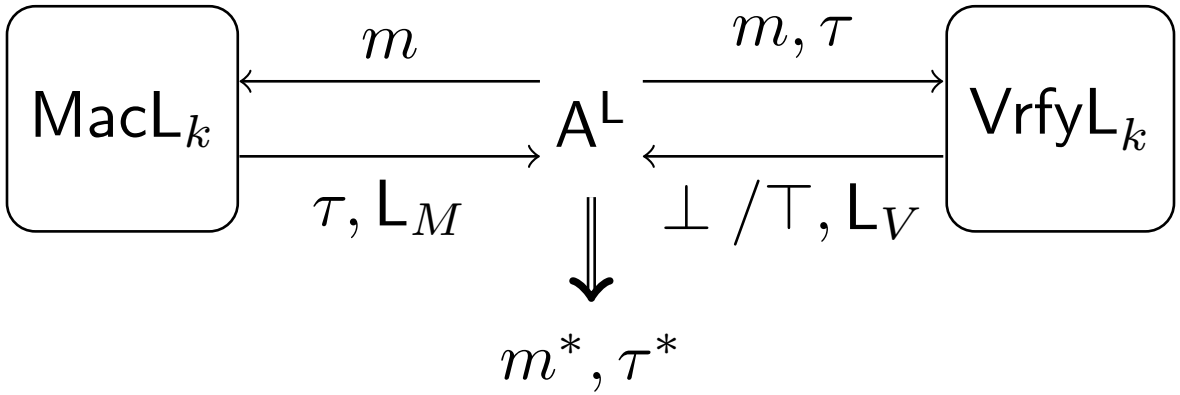

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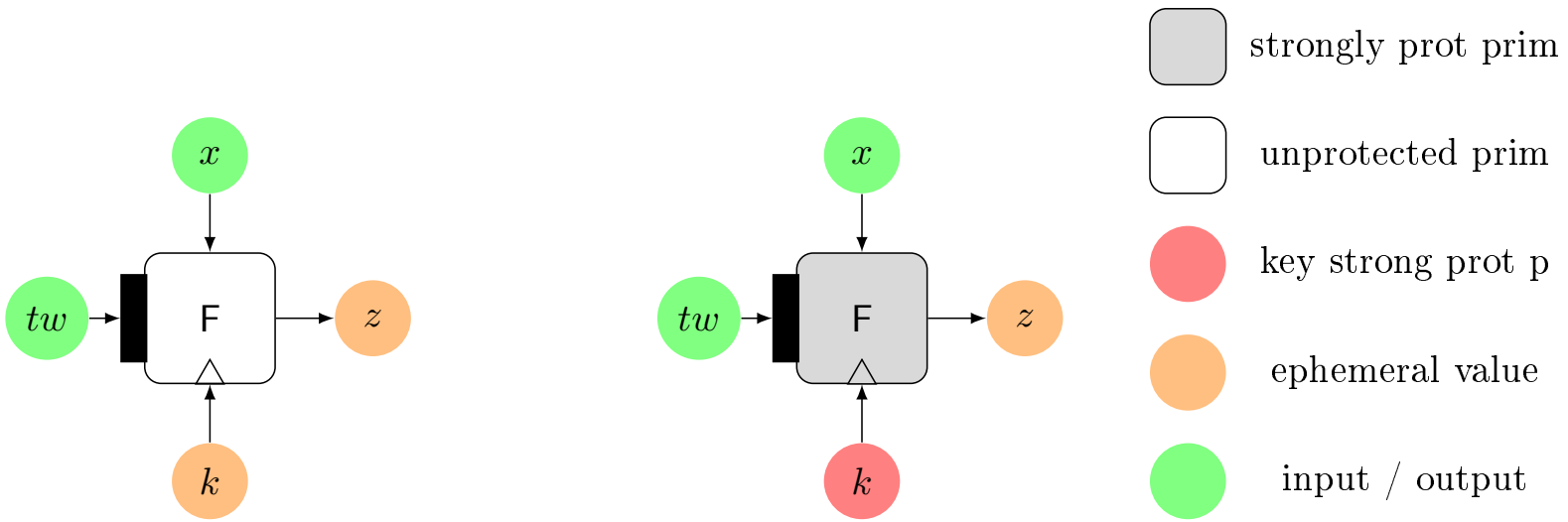
Problem: Model the leakage (L)?

Modeling leakage - Unbounded leakage model [BPPS17]



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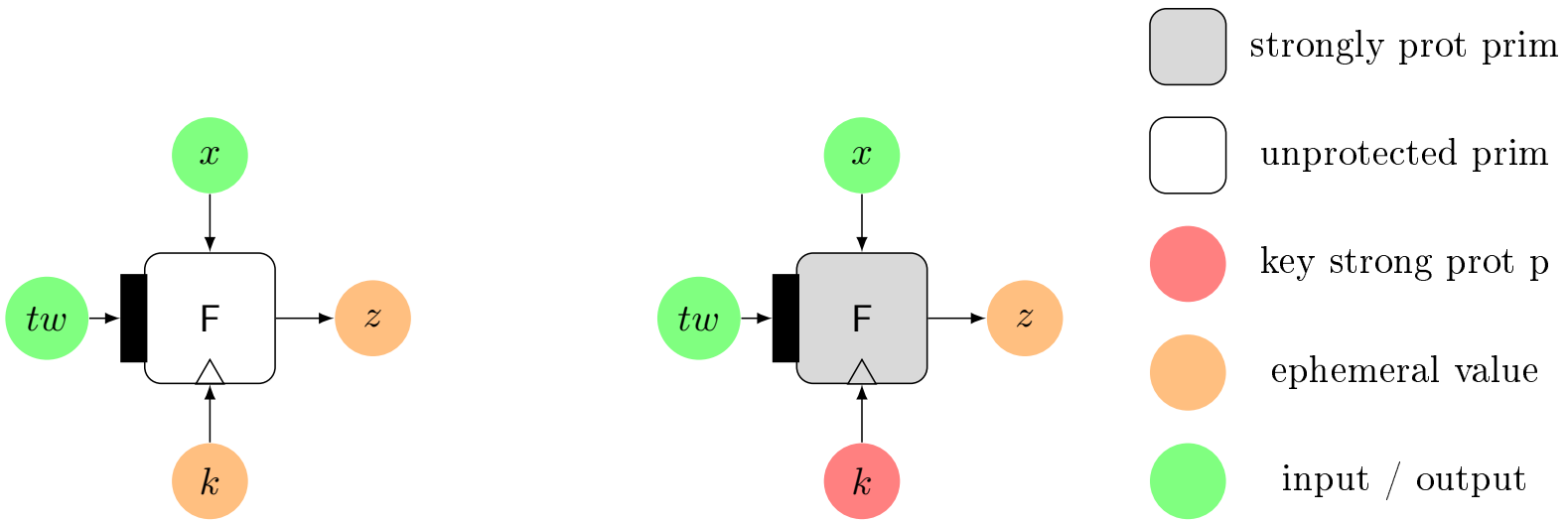

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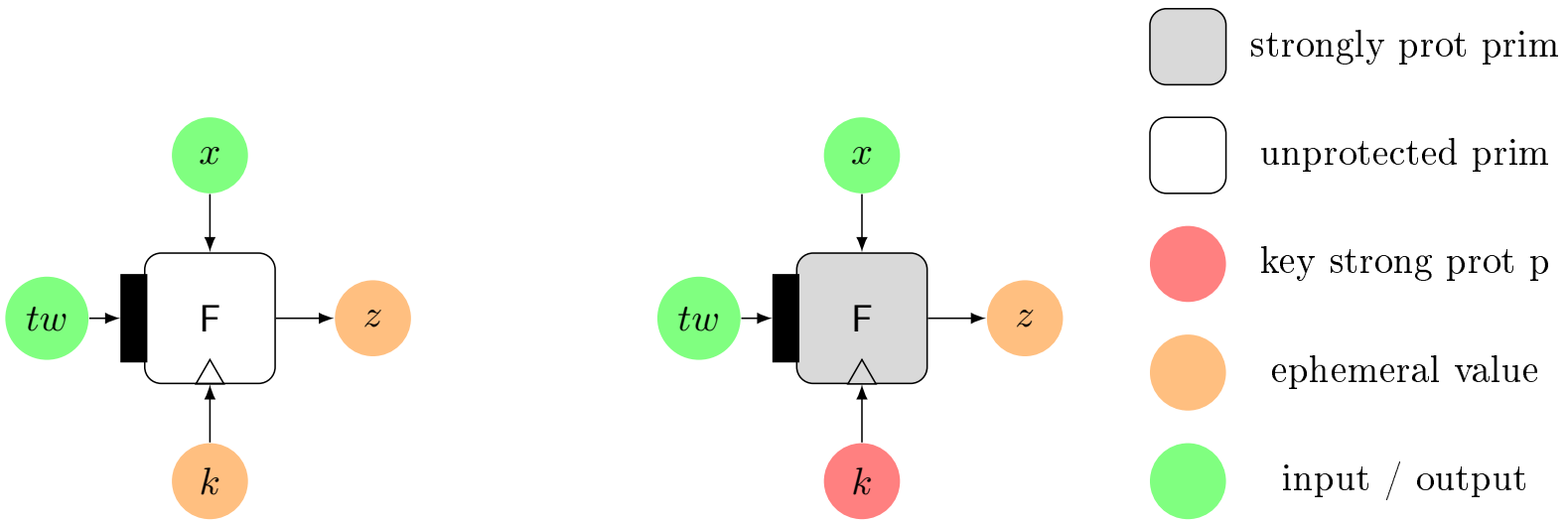

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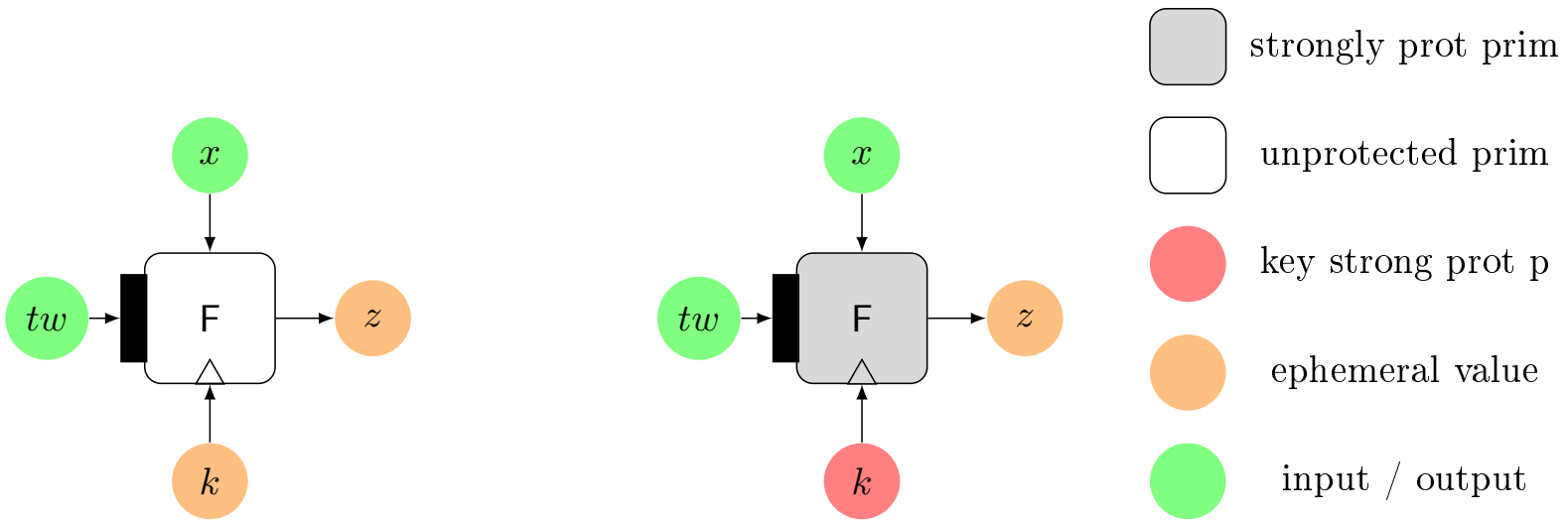

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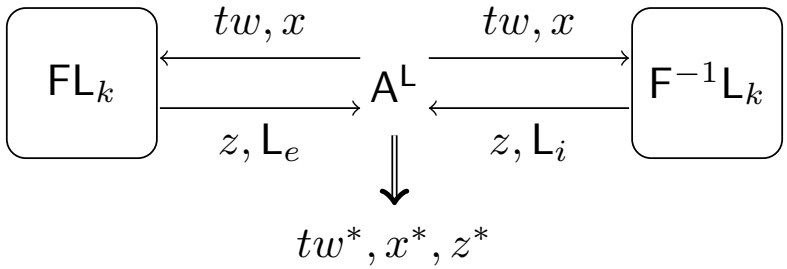
Problem: Verifiable security of the grey TBC.

sUL - Security in presence of leakage for strongly protected TBC [BGPPS19]

Strong Unpredictability with Leakage



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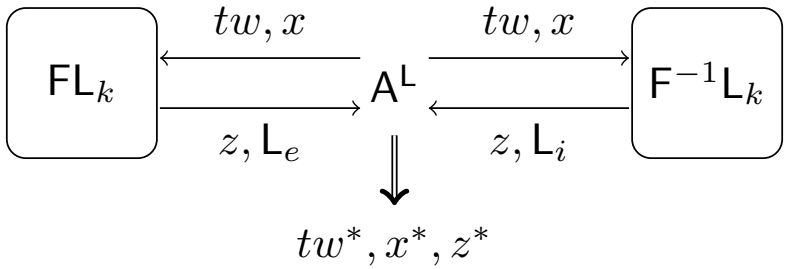

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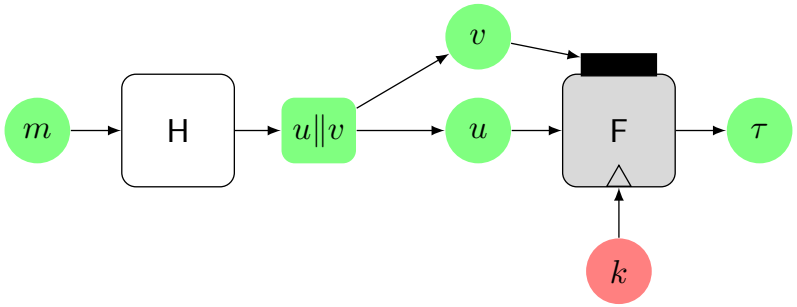
Verifiabile by a laboratory.

HTBC - F sUL + H Random Oracle [BGPPS19]



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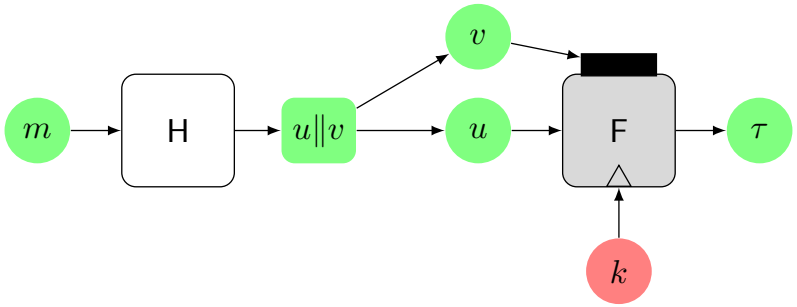

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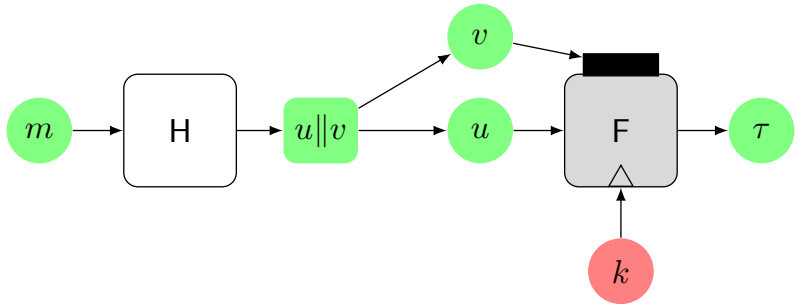

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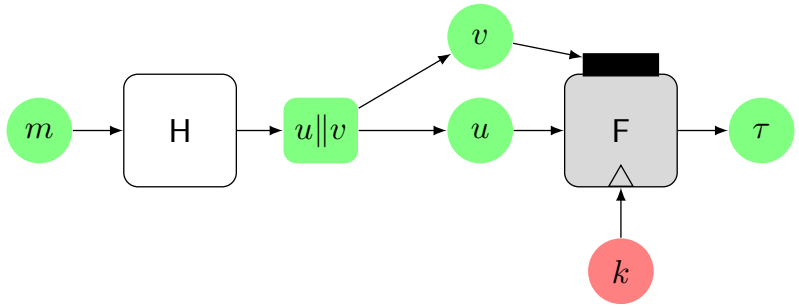

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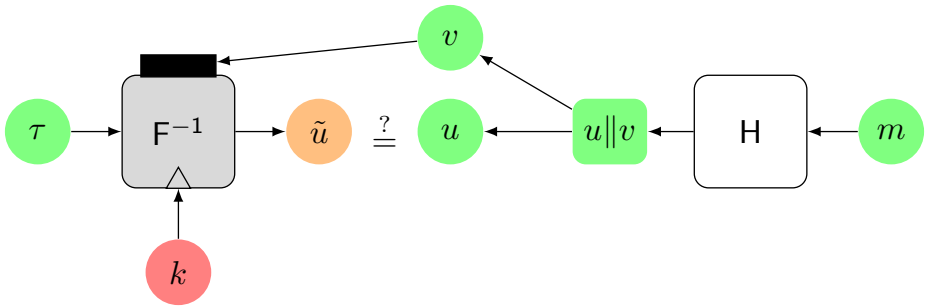

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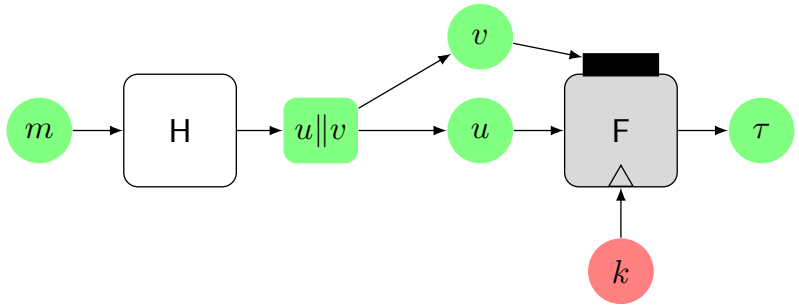

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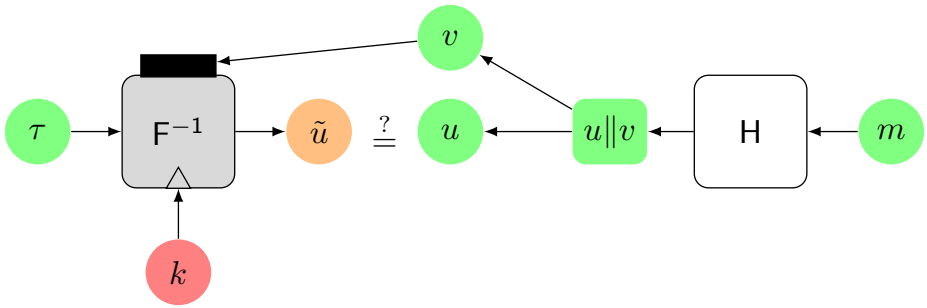

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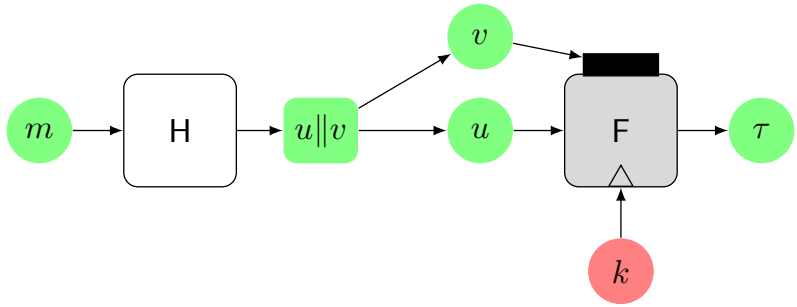

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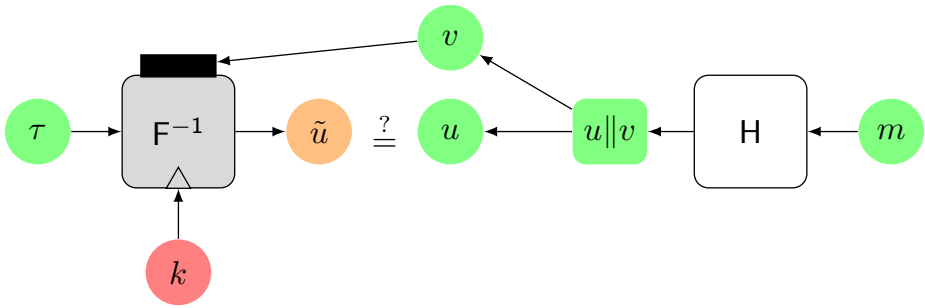

[BGPPS19] If F is sUL, problematic interactions between F and H.

- They used the random oracle to bound the probability that the adversary computes $u\|v = \mathsf{H}(m)$ and then obtains $u = \mathsf{F}_k^{-1,v}(\tau)$.

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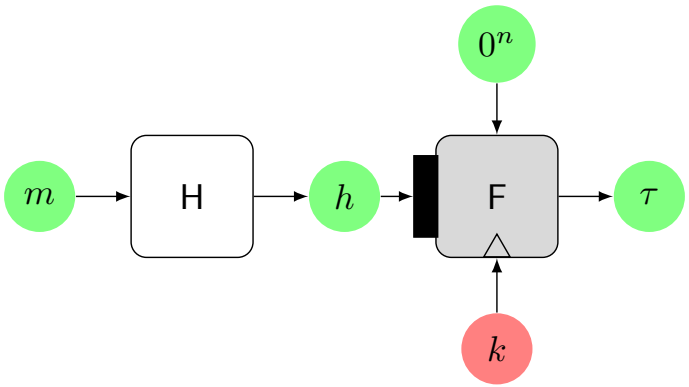

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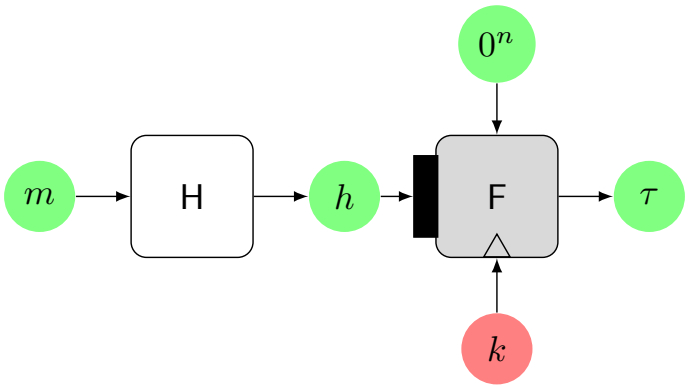

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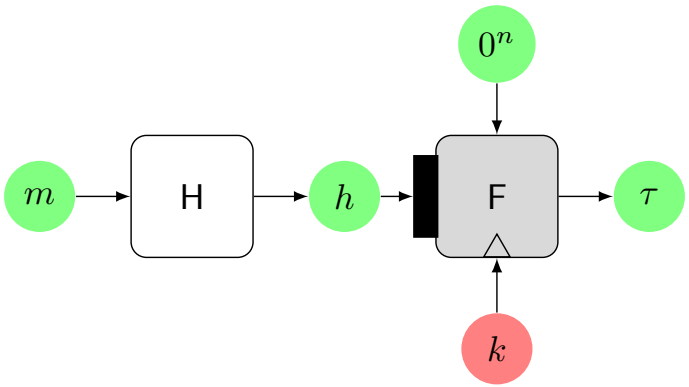

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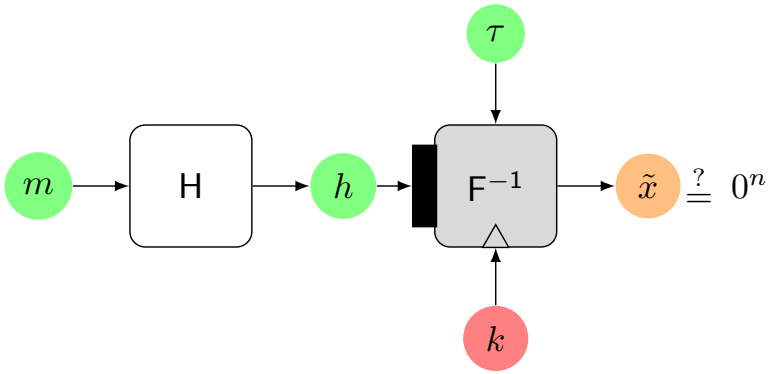

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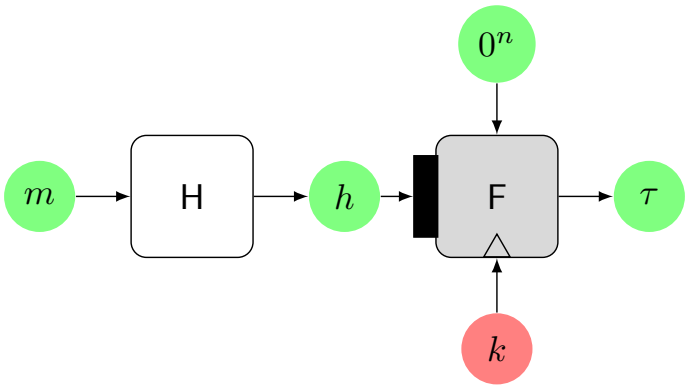

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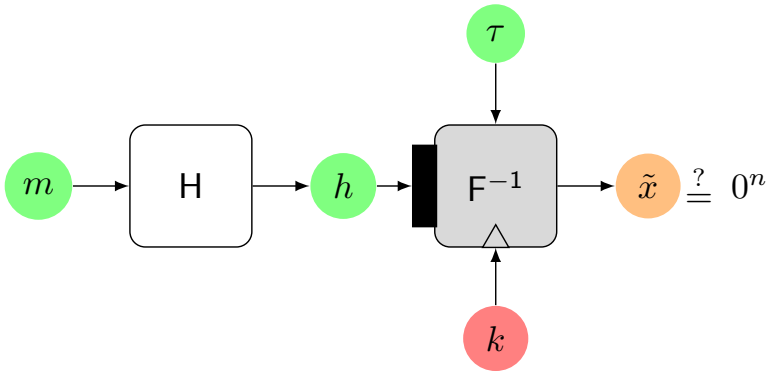

$\tilde{x}$ (if $\neq 0^n$) is useless

LR–MAC1 - suf–L2-security

LR–MAC1 is (q_M, q_V, ϵ)-suf–L2 secure with

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Proposal implementation: F = Deoxys–384 and H is SHA256.

- Deoxys [128-bit block and 256-bit tweak]

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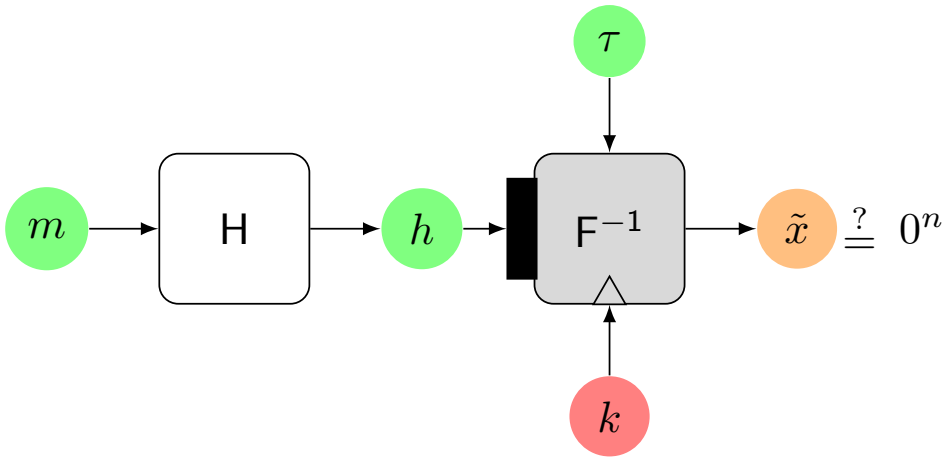

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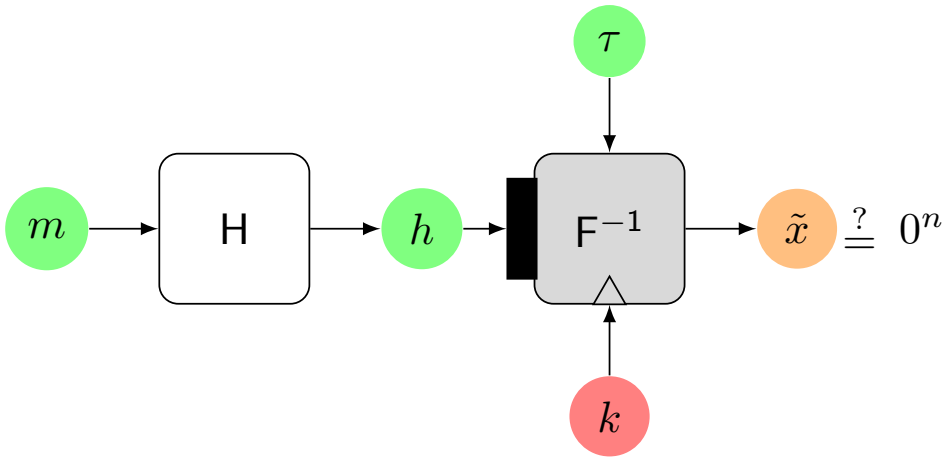

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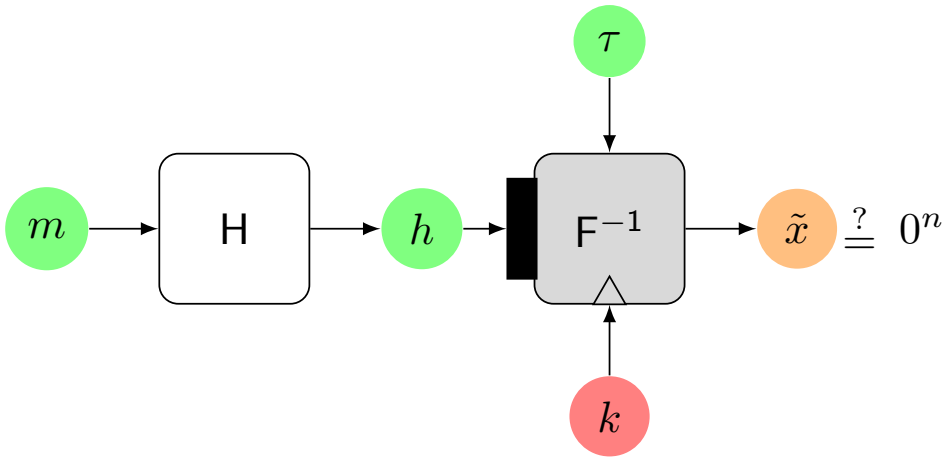

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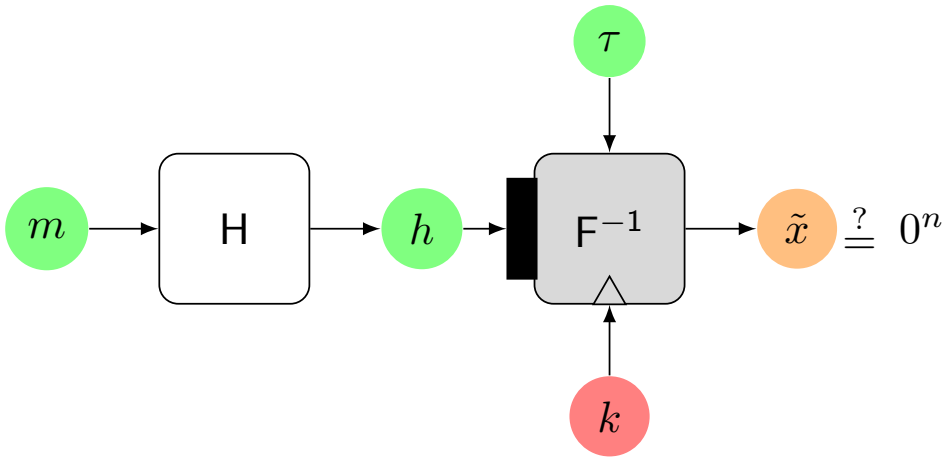

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Now, we obtain easily the security result

F_1: We have found a collision for the hash function.

F_2: $(0^n, h^i, \tau^i)$ is a valid triple for F_k which has never been computed before. Thus, we are able to predict the output of F_k.

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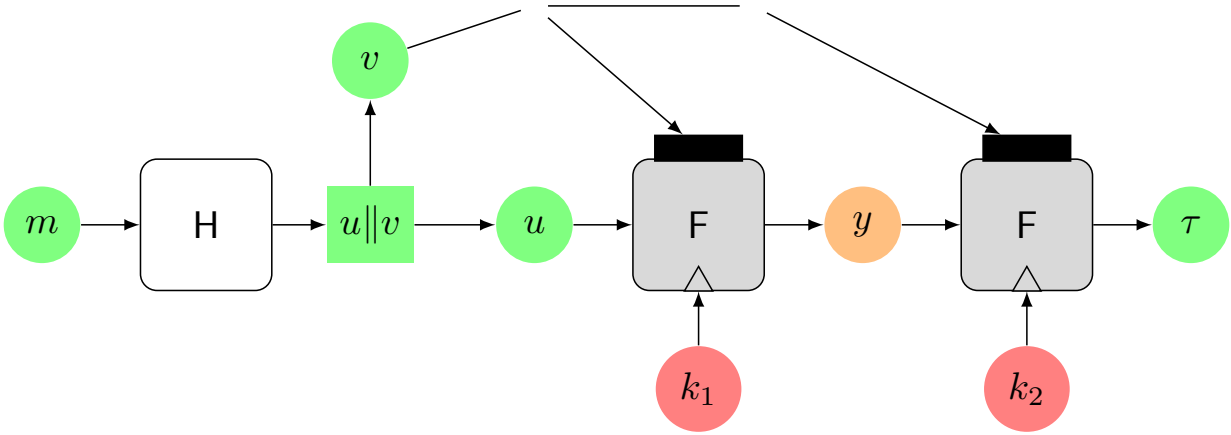

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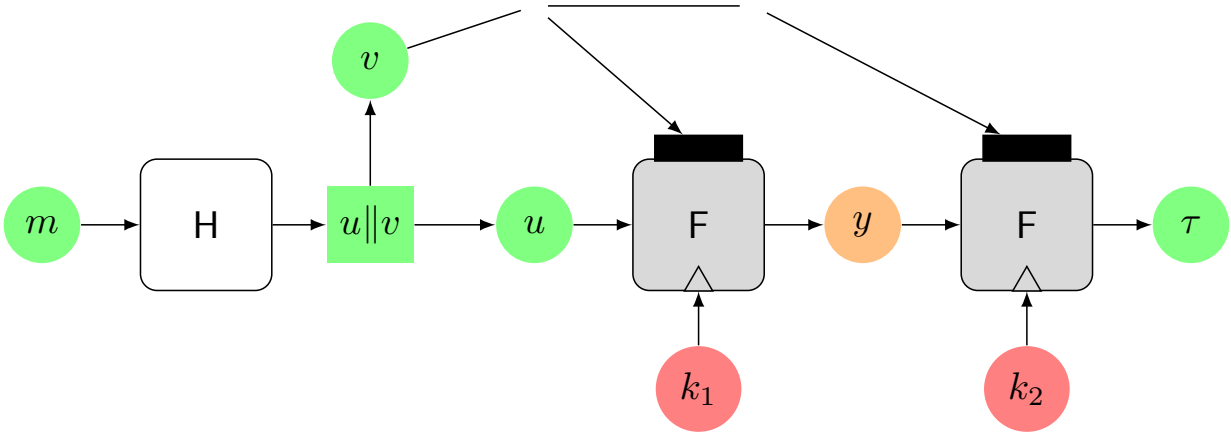

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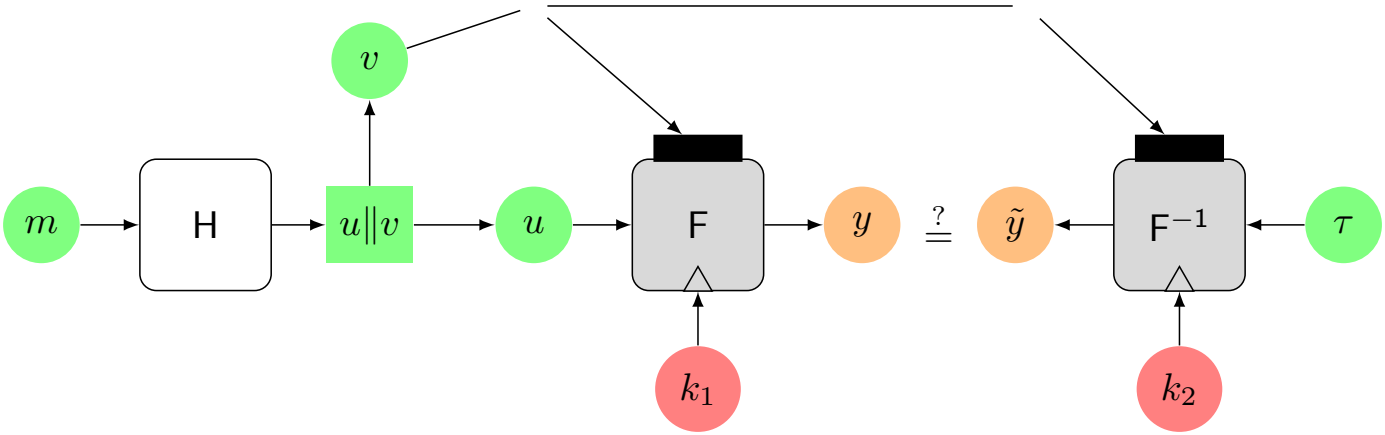

Verify if $y = \tilde{y}$. Use F^{-1}.

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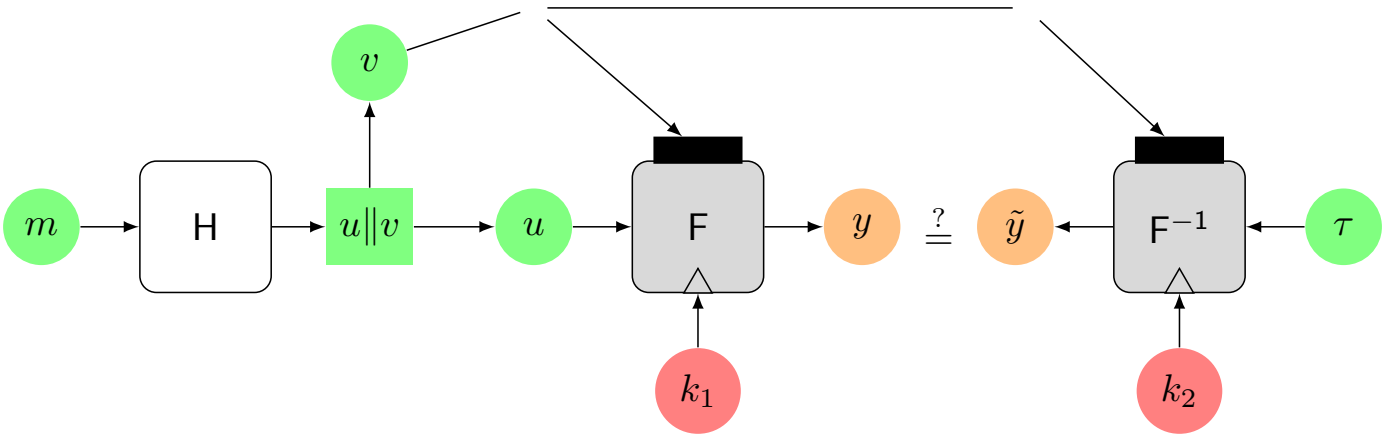

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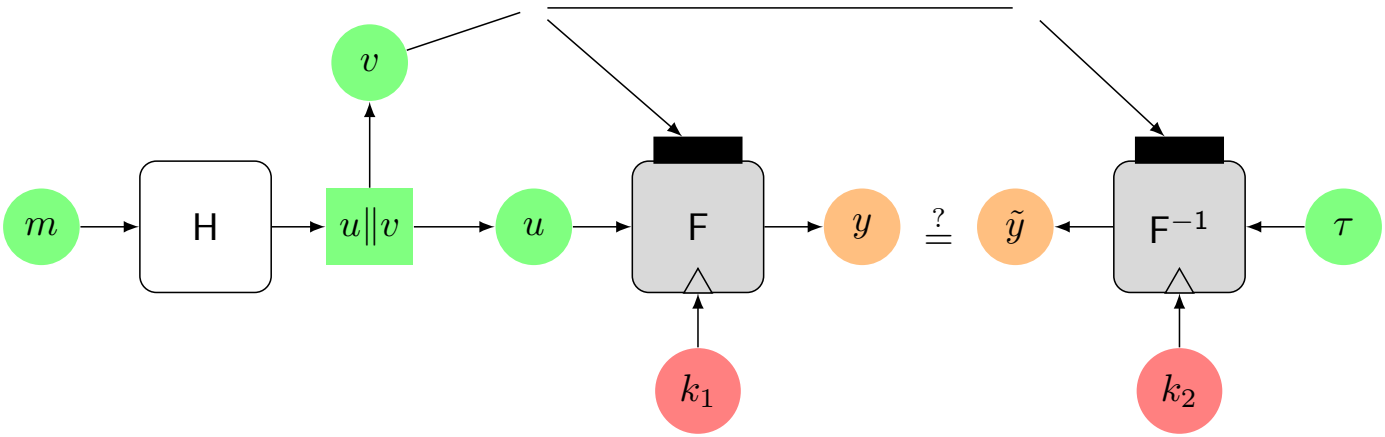
LR–MAC2 - suf–L2-security



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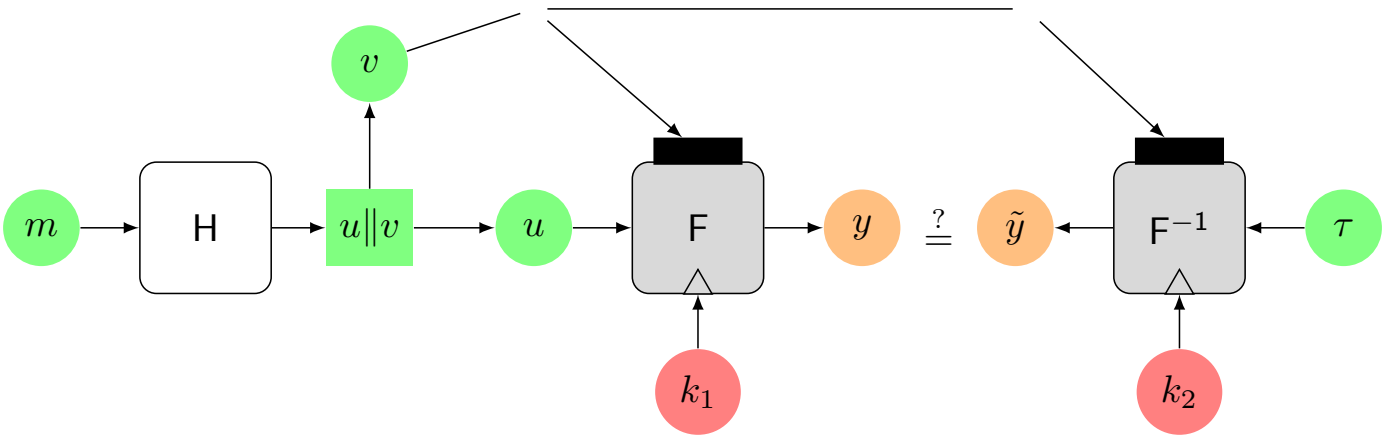

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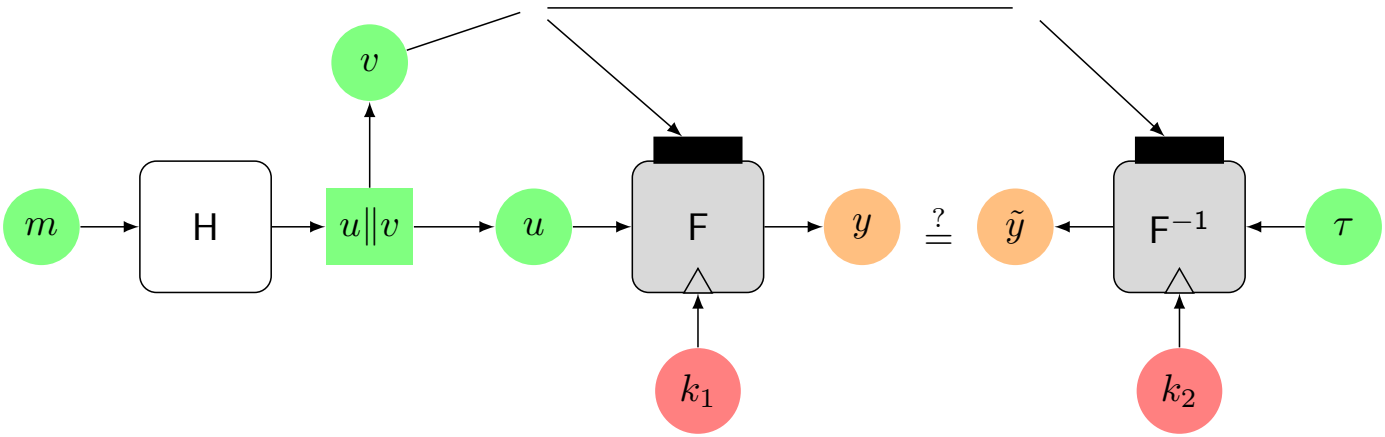

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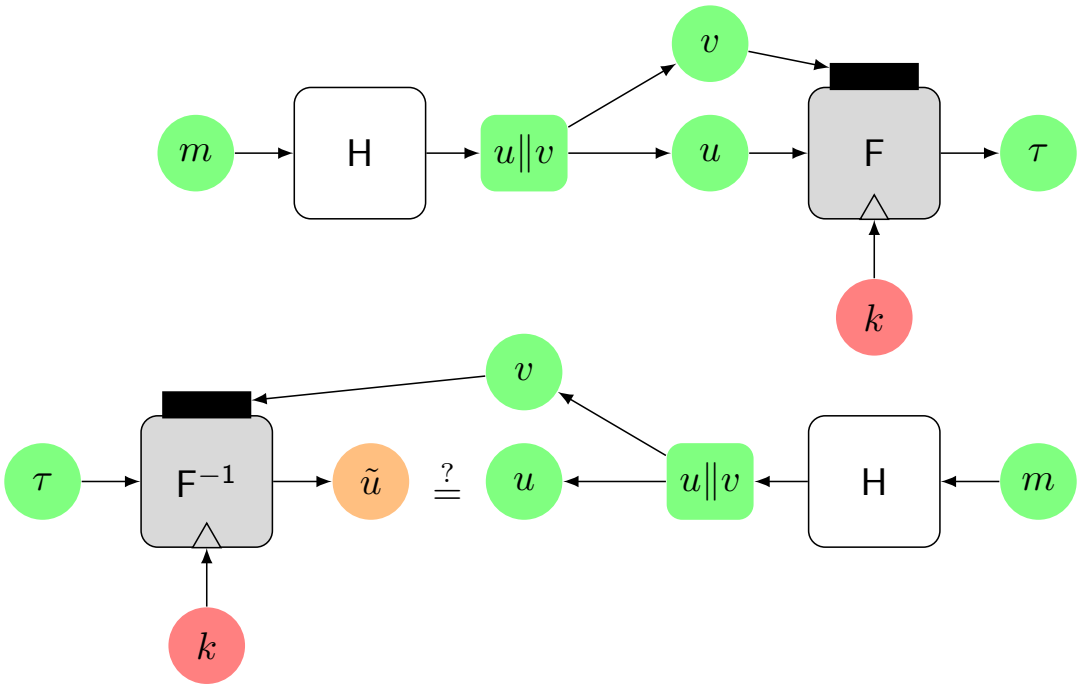
Lower-half-collision resistance: Find $m_1, ..., m_\mu$ s.t. $\mathsf{H}_s(m_i) = ...\|h_2$.

HTBC - New security results

Strong hypothesis for H.



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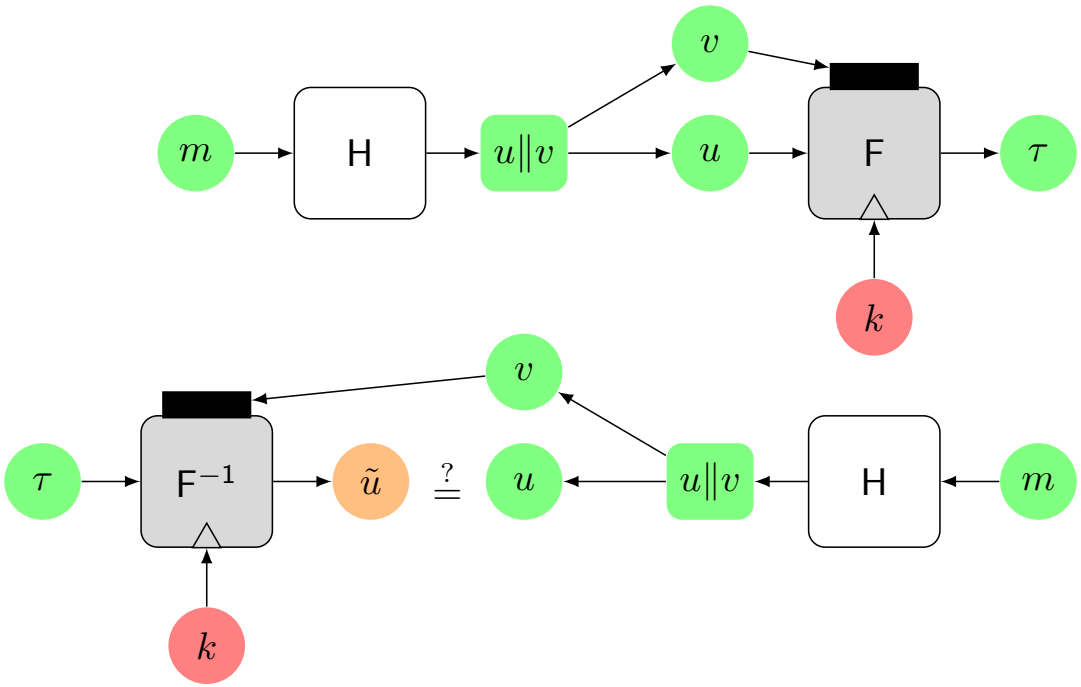

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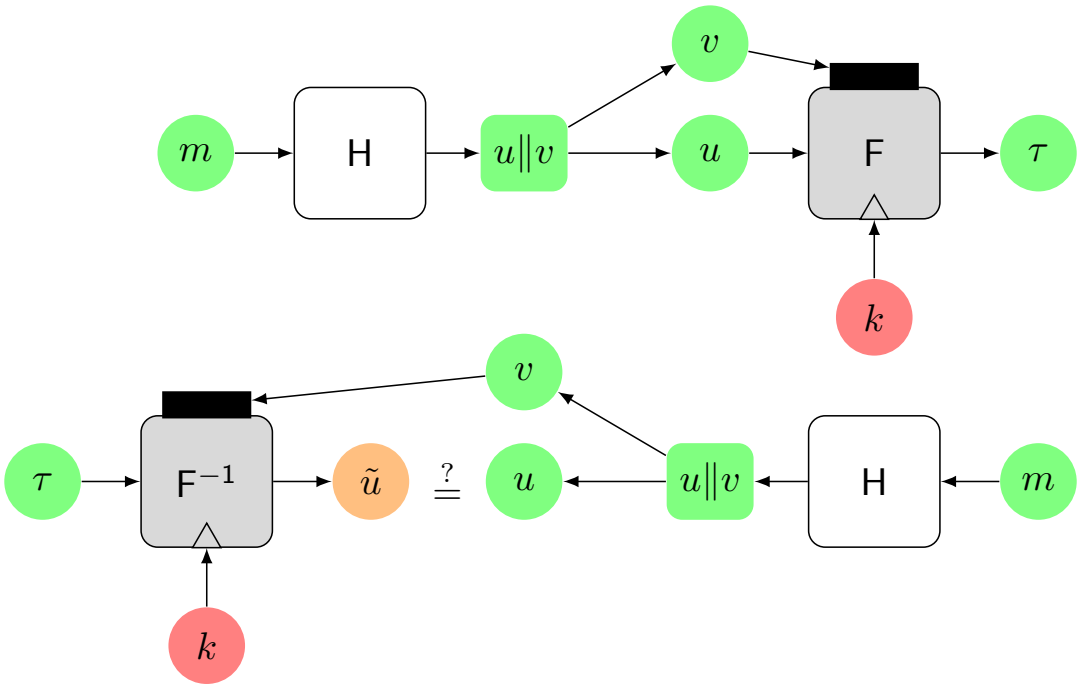

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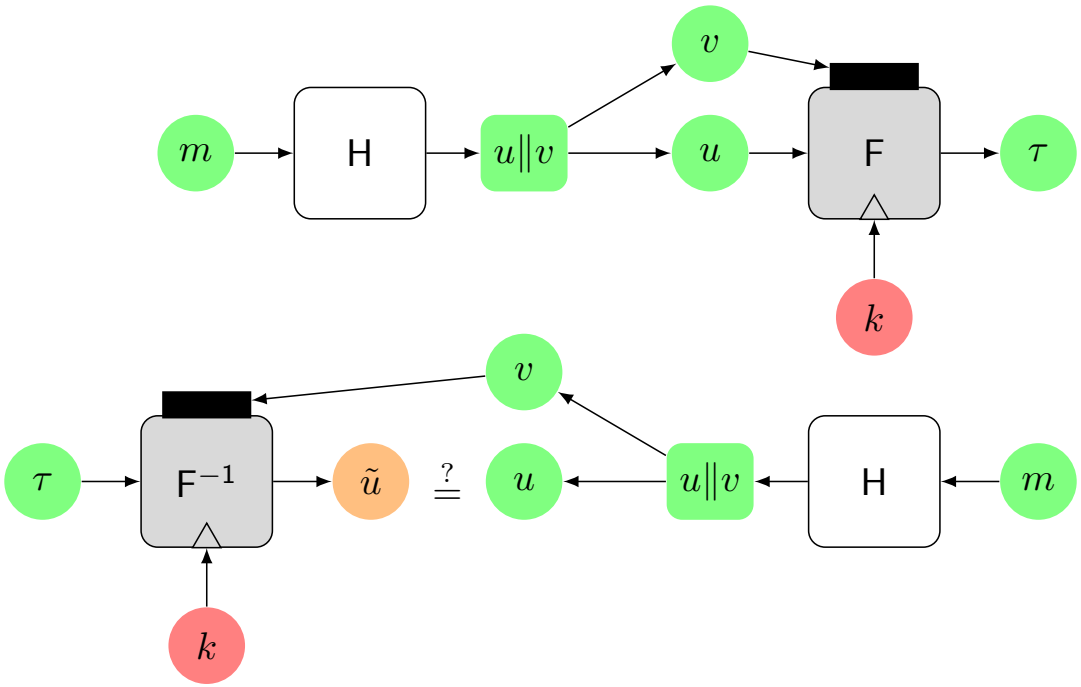

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- Future works
  - Instantiation + comparing performances
  - Extension to authenticated encryption (AE)

Thank you

- francesco.berti@tu-darmstadt.de
- chun.guo.sc@gmail.com
- thomas.peters@uclouvain.be
- fstandae@uclouvain.be