Radboud University

Block-Cipher-Based Tree Hashing

Aldo Gunsing

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- Stronger notion states that every output should be uniformly random and independent
- Formalized as indifferentiability by Maurer et al. [MRH04] and specified for hashing by Coron et al. [CDMP05]

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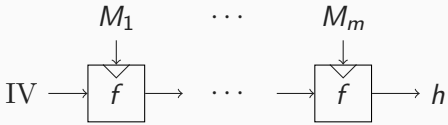
  - For an indifferentiable hash function H, the MAC $S(K, M) = H(K \parallel M)$ is secure with a security level of $\min(k, n/2)$

Length Extension

- Merkle-Damgård hashes based on a fixed-sized compression function f



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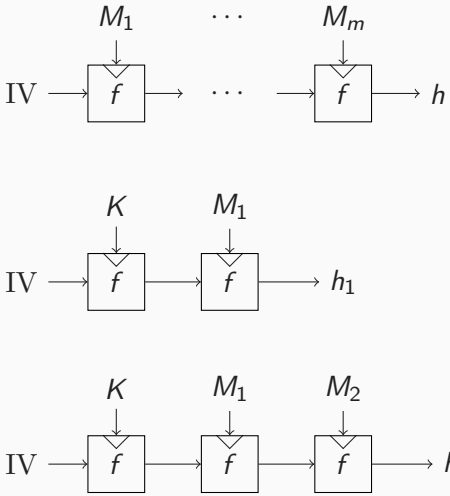

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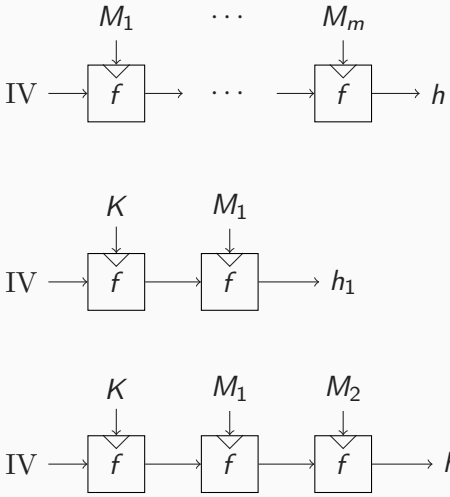

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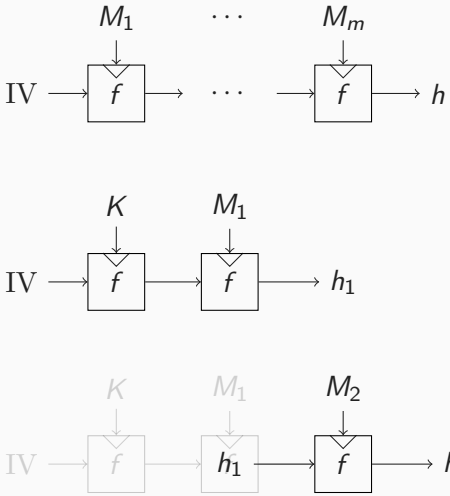

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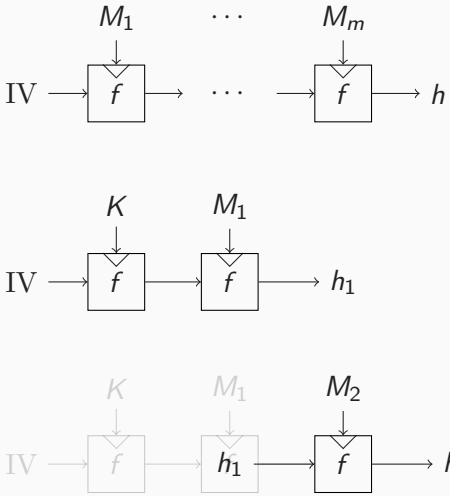
- This means that $H(K \parallel M)$ is not a secure MAC, hence H is not indifferentiable



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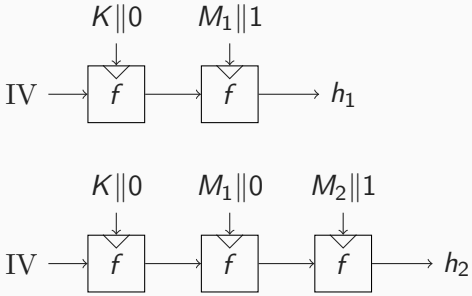

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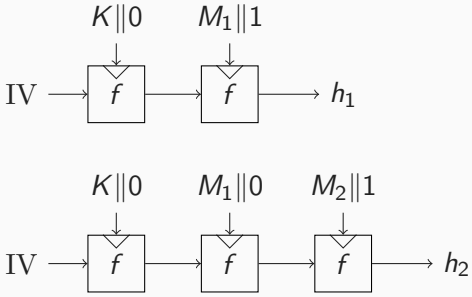
- This construction is shown indifferentiable using an ideal compression function f by Coron et al. [CDMP05]



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- Finding sufficient conditions for such constructions, among others, was investigated by Daemen et al. [DMA18]

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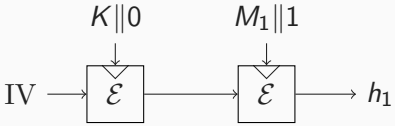

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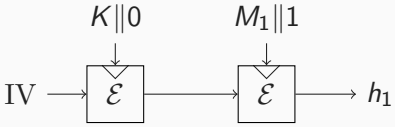

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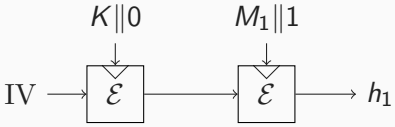

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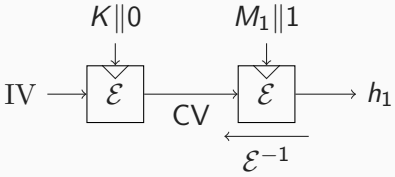

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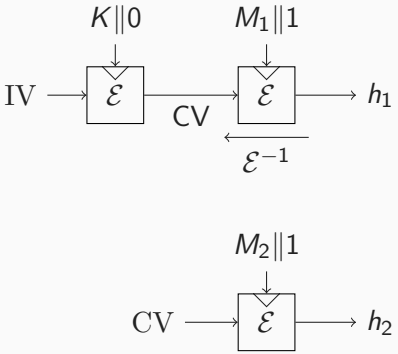

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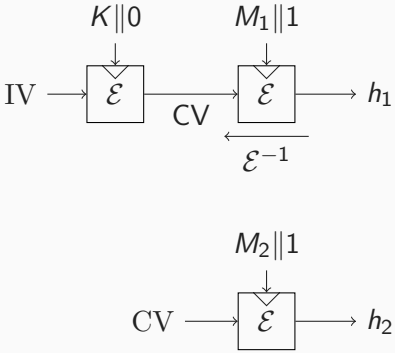
- Hence this construction is not secure, but it does satisfy the conditions



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- A more thorough look reveals that the error is more fundamental about the ideal world in the indifferentiability setting

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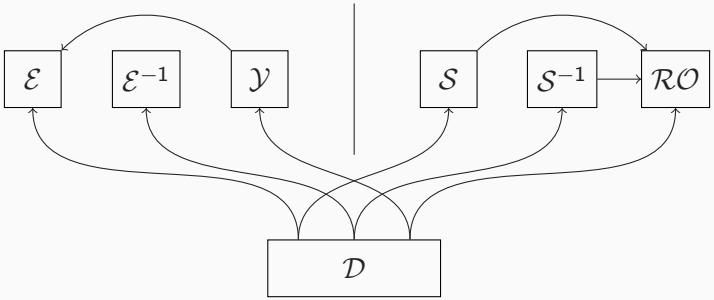

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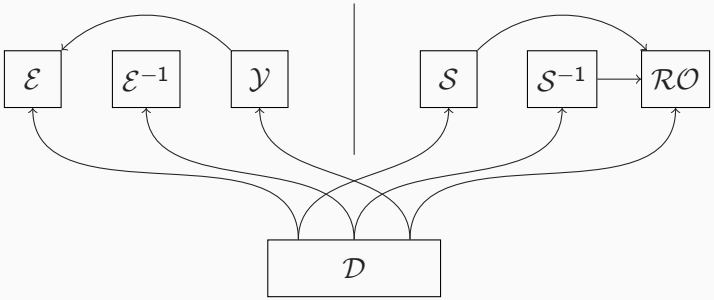

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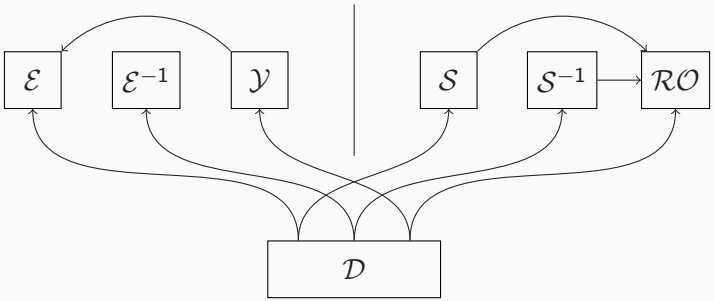

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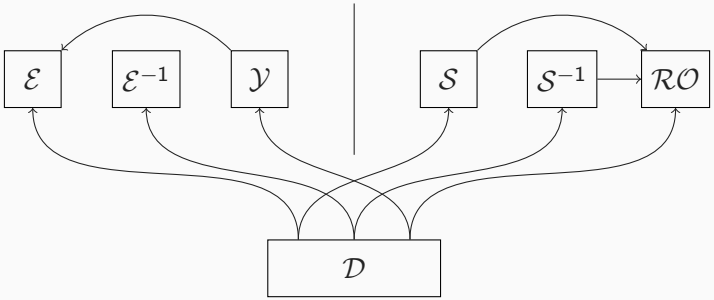

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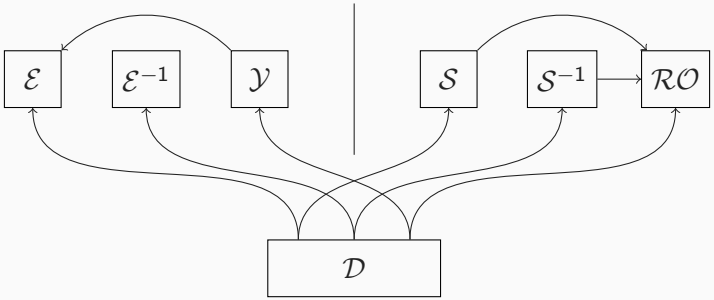

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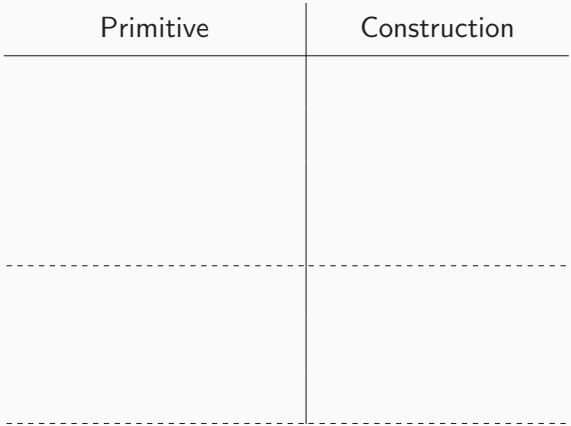

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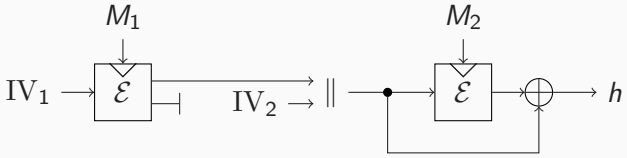

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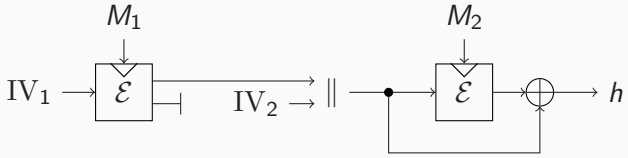

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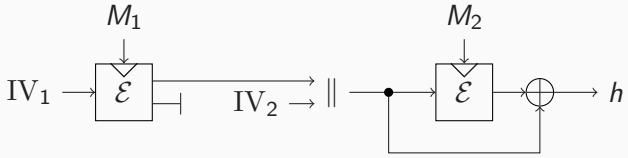

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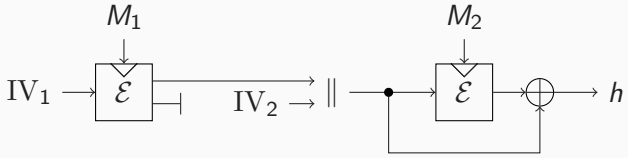

Feed-Forward Finalization

- A common construction is to use a feed-forward on top of the block cipher
- Only required for the final compression call
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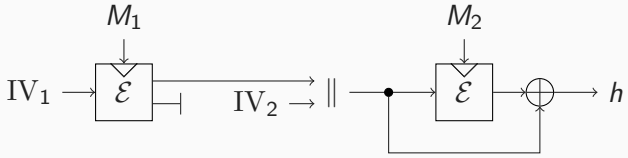
- The simulator has to loop over all possible IV_2 and query the random oracle
- Does not influence the advantage of $\mathcal{D}$, but does increase the query complexity of the simulator $\mathcal{S}$, which should be limited



BLAKE3

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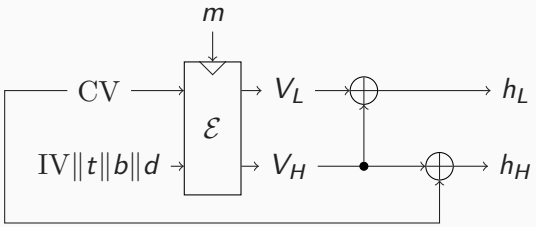

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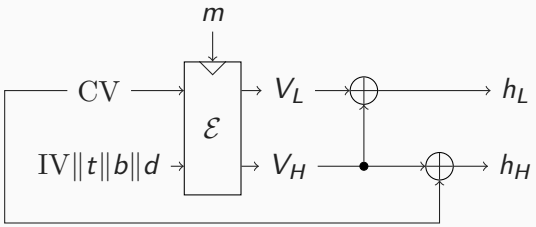

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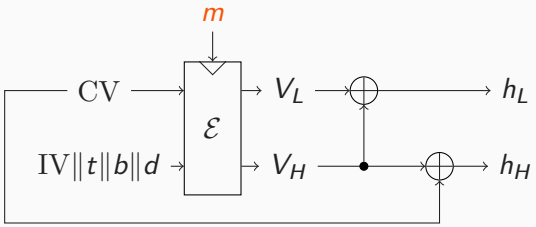

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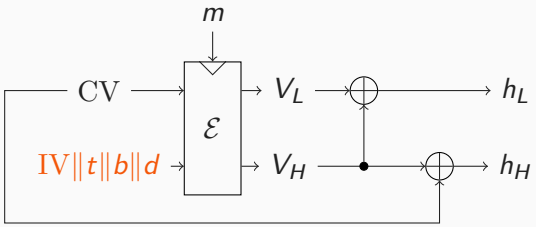

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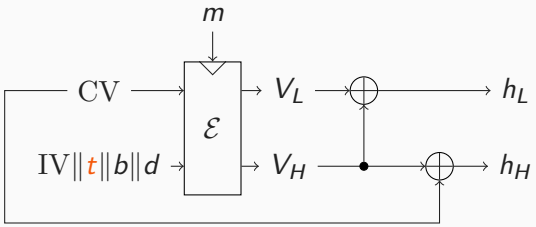

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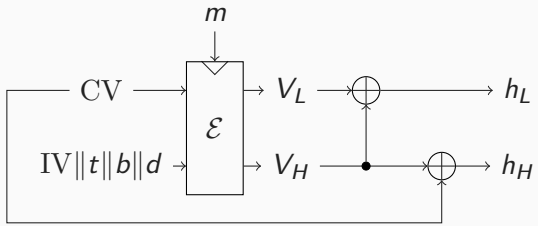
- Let $h_t = H(M, t)$ denote the output of the hash with counter t
- Then the full output is equal to $h_0 \parallel h_1 \parallel h_2 \parallel \cdots$

BLAKE3: Security Analysis

- BLAKE3 uses feed-forward finalization



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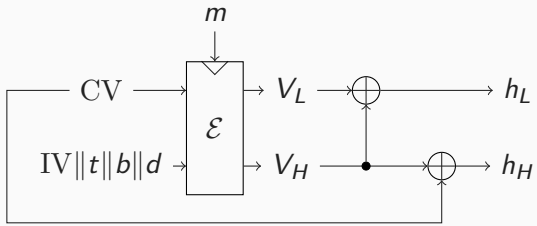

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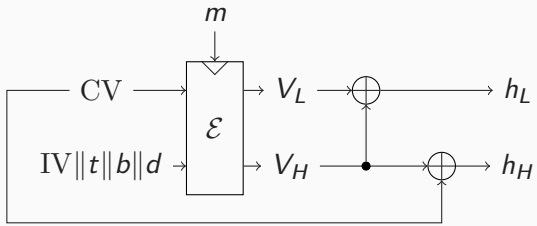

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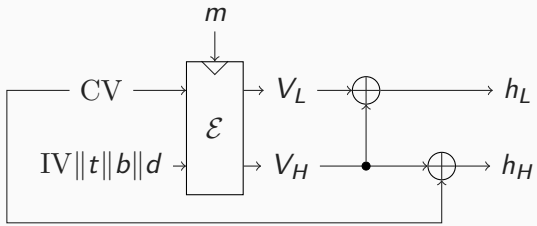

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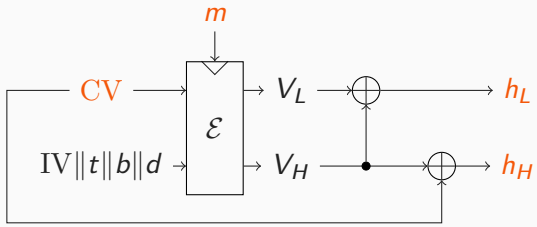

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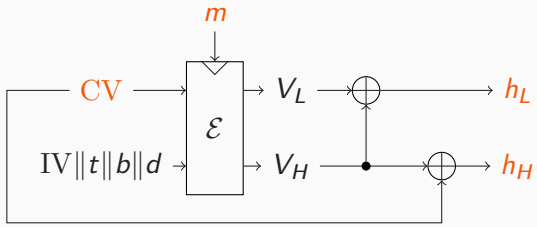

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  - The offset, equal to the remaining key, $t = K_2' \in \{0,1\}^{58}$, can be computed directly

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Thank you for your attention!

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