The LANE Hash Function

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First SHA-3 Candidate Conference

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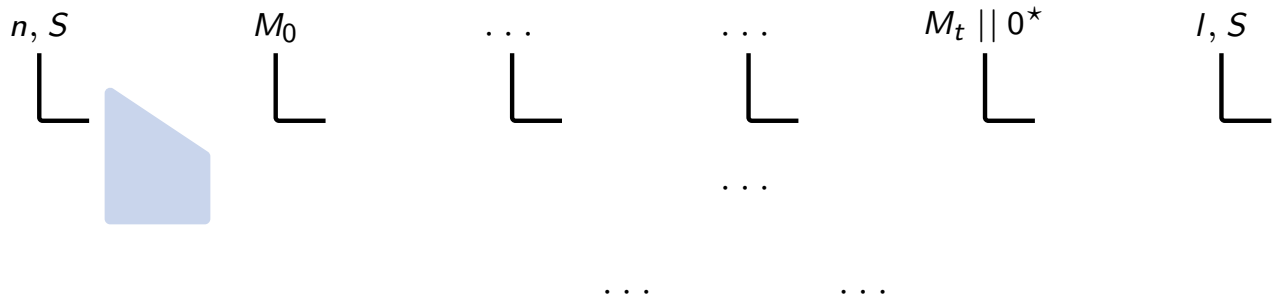
Introduction

LANE

- is **simple**, elegant, easy to understand and analyse.
- has a clear **design rationale**.
- has undergone an extensive **security analysis**.
- is **flexible** in implementation.

Description of LANE



Iteration Mode

- Very **simple** and lightweight
- **Features**: bit counter, output transformation, salt *(opt.)*
- **Security**: No length extension attacks, no long message

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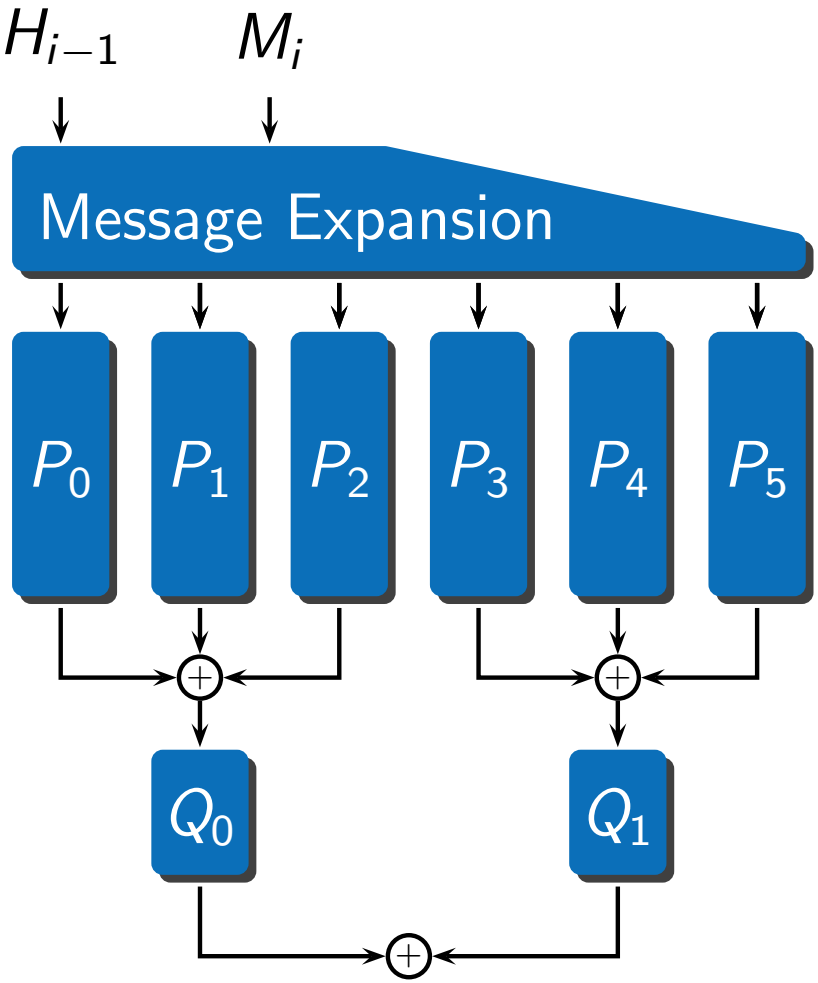
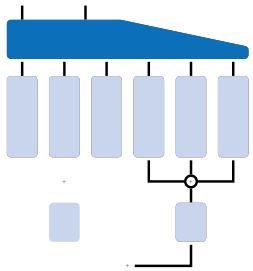
Description of LANE



Compression Function

- **Simple structure**
  - Message expansion
  - 6 **P**-lanes
    (6 resp. 8 rounds)
  - 2 **Q**-lanes
    (3 resp. 4 rounds)
  - XOR combiners
- **Parallelism**
  (but low memory possible)

Description of LANE



$$\ldots \quad = \begin{bmatrix} \quad \end{bmatrix} \cdot \begin{bmatrix} \quad \\ \quad \\ \quad \\ \quad \end{bmatrix}$$

Message Expansion

- **Simple**, lightweight, parallelisable, linear
- Easy and fast to implement *(XOR of large blocks)*
- Ensures **minimum 4 active lanes**

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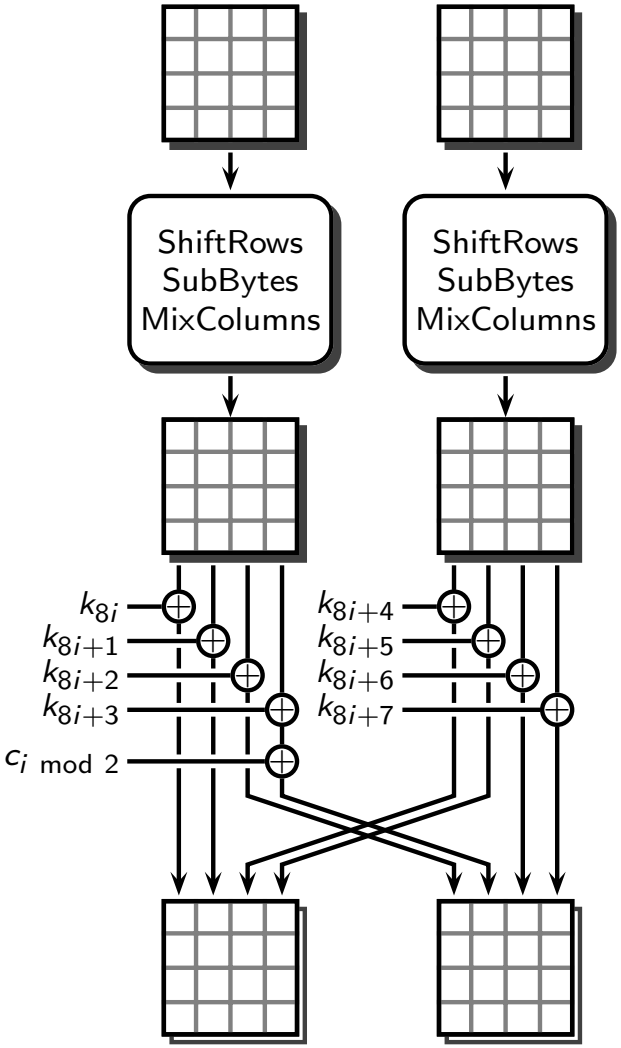
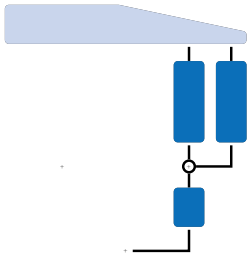
Description of LANE





Permutation 'lanes'

- **From AES:**
  ShiftRows, *SubBytes*, *MixColumns*
- **New:**
  AddConstants, *AddCounter*, *SwapColumns*
-
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Security of LANE

- LANE has undergone an **extensive security analysis**
  - Differential cryptanalysis
  - Truncated differential cryptanalysis
  - Higher order differential cryptanalysis
  - Algebraic attacks
  - Attacks based on reduced query complexity
  - Generalised birthday attack
  - Meet-in-the-middle attacks
  - Long message second-preimage attacks
  - Length-extension attacks
  - Multicollision attacks
  - ...

- Refer to the **supporting documentation**:

  S. Indesteege, E. Andreeva, C. De Cannière, O. Dunkelman, E. Käsper, S. Nikova, B. Preneel, E. Tischhauser

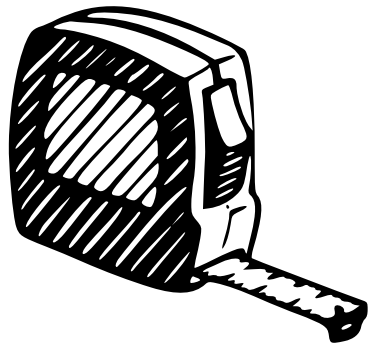
Example: why standard differential cryptanalysis fails

- LANE-256
- Any differential characteristic Q
  - ≥ 4 active P-lanes
  - ≥ 45 active S-boxes per lane
  - $\Pr \leq 2^{-6}$ per active S-box
  - $\Rightarrow \mathbf{Pr(Q) \leq 2^{-1080}}$
- Assume perfect message modification
  - 832 degrees of freedom
  - $\Rightarrow \mathbf{Pr\left(\langle m, m' \rangle \in Q\right) \leq 2^{-248}}$
-

Implementation of LANE

- LANE is **flexible in implementation**
- Reuse techniques for implementing **AES**
- LANE + **AES** = share code/ROM/hardware
- Roughly **half** the speed of AES:
  - AES-128 — 128 bits — 10 AES rounds
    LANE-256 — 512 bits — 84 AES rounds
    ×0.48
  - AES-256 — 128 bits — 14 AES rounds
    LANE-512 — 1024 bits — 224 AES rounds
    ×0.50

Implementation of LANE



Performance results

- **Intel Core2**: 25.7 cpb (LANE-256)
- **Intel AES-NI**: LANE-256 at 5 cpb ?
- **Embedded systems**: 108 bytes of RAM (LANE-256)
- **Hardware** (LANE-256, 0.13 μm CMOS):

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Conclusion

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Designer: Sebastiaan Indesteege

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