The Hash Function Hamsi

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Outline

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General Design

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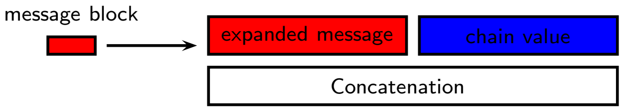

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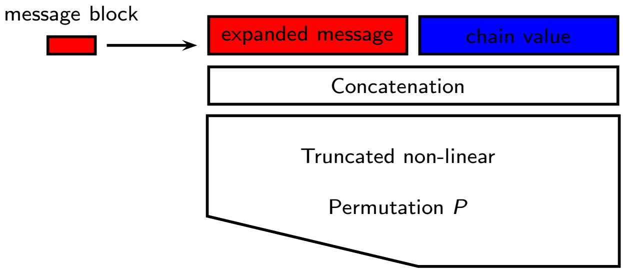

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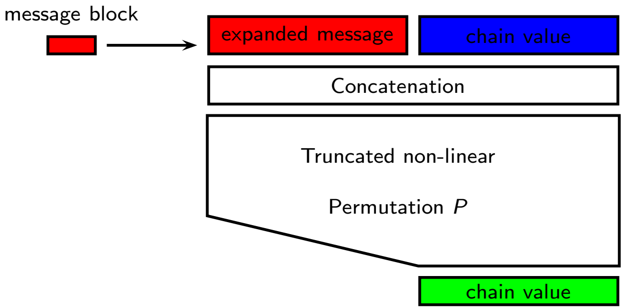

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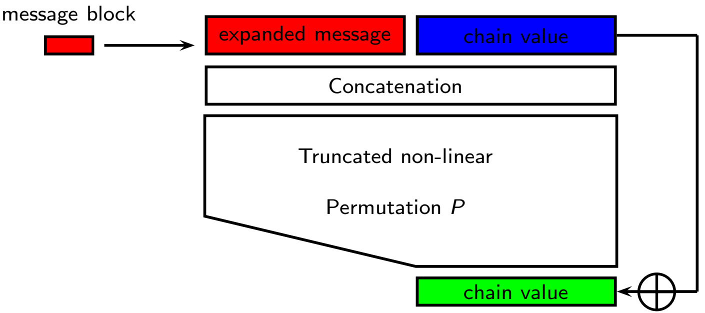

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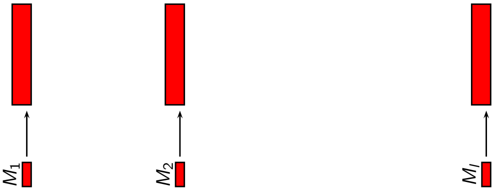

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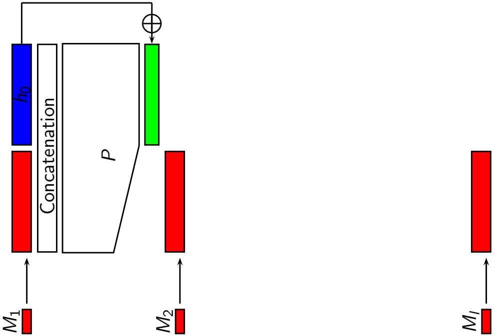

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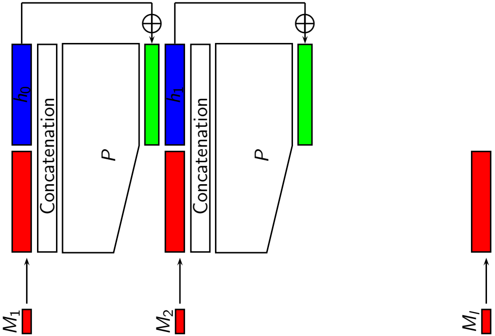

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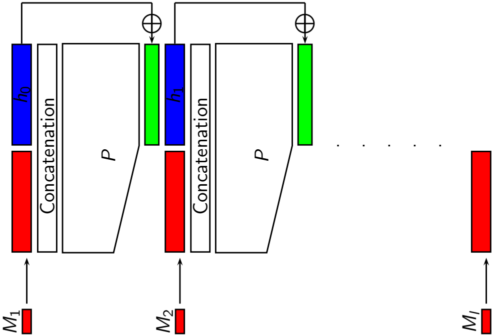

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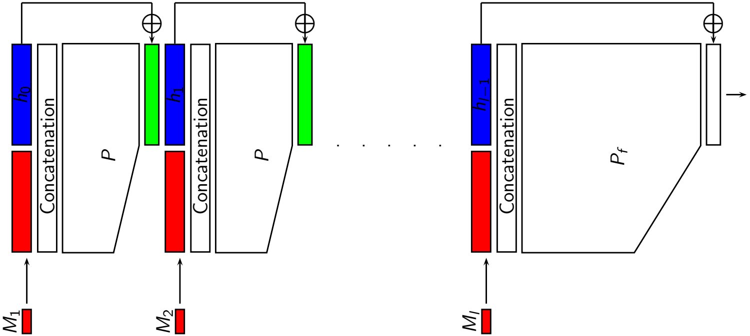

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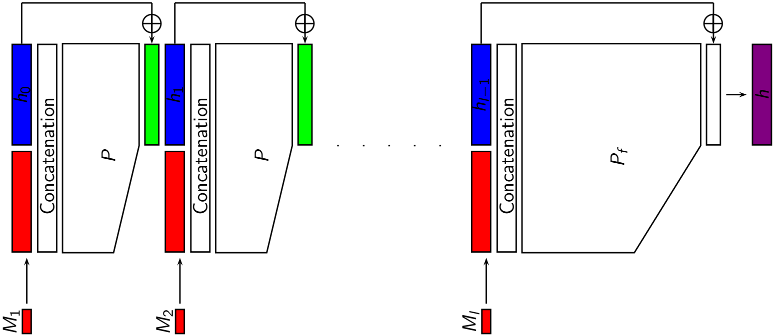

General Design

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  - 2 different non-linear permutations; P, P_f

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  - Message expansion
  - Feedforward of the previous chaining value
  - 2 different non-linear permutations; P, P_f
- Hamsi iteration operates over small message blocks
  - 32-bit $\longrightarrow$ Hamsi-256
  - 64-bit $\longrightarrow$ Hamsi-512

  - Hamsi-256 $\longrightarrow$ 512-bit internal state size
  - Hamsi-512 $\longrightarrow$ 1024-bit internal state size

Outline

Message Expansion

Hamsi-256

Hamsi-512

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32-bit

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Linear code [128,16,70] over F_4

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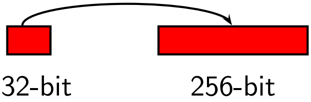
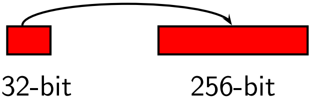


Hamsi-512

Message Expansion

Hamsi-256

Linear code [128,16,70] over F_4



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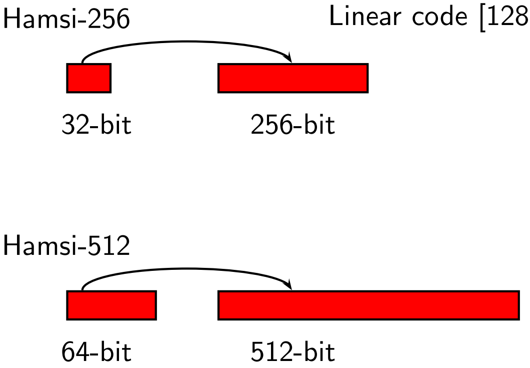

Message Expansion

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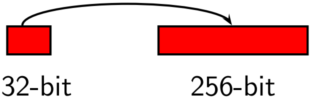
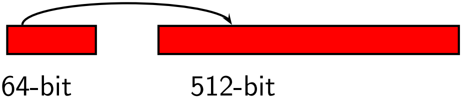


Hamsi-512

Linear code [256,32,131] over F_4



Message Expansion

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- Best Known Linear Codes; optimal choice for given parameters
- Minimum distance → active Sboxes for one round
  - 70 for Hamsi-256
  - 131 for Hamsi-512
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- Provides strong diffusion against differential type attacks
- Can be computed in parallel
- Can be implemented efficiently in software and hardware

Outline

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- XOR of constants and a counter
- Substitution is by 4×4-bit Sboxes
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- Substitution is by 4×4-bit Sboxes
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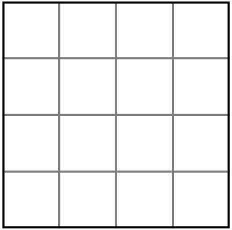
- Sbox and L are from the block cipher Serpent
- P and P_f only differ in the number of rounds and constants
  - P has 3 rounds, P_f has 6 rounds
  - P_f is only applied at the finalization

Concatenation

$$(m_0, m_1, \ldots, m_7, c_0, c_1, \ldots, c_7)$$

Hamsi-256 state



Concatenation

$$(m_0, m_1, \ldots, m_7, c_0, c_1, \ldots, c_7) \xrightarrow{C}$$

Hamsi-256 state

m_0	m_1	c_0	c_1
c_2	c_3	m_2	m_3
m_4	m_5	c_4	c_5
c_6	c_7	m_6	m_7

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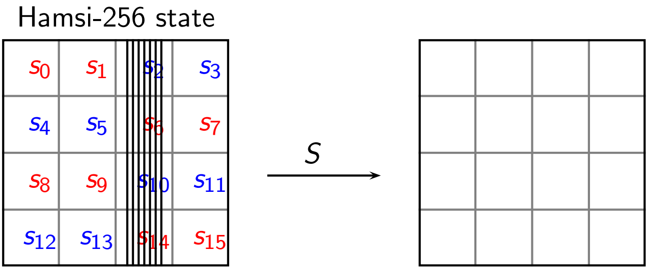
- Each Sbox inputs 2-bits from the chain value and the expanded message.
- Chaining value and expanded message words appear in all bit positions of the Sboxes.

Substitution

Hamsi-256 state

s_0	s_1	s_2	s_3
s_4	s_5	s_6	s_7
s_8	s_9	s_{10}	s_{11}
s_{12}	s_{13}	s_{14}	s_{15}

Substitution



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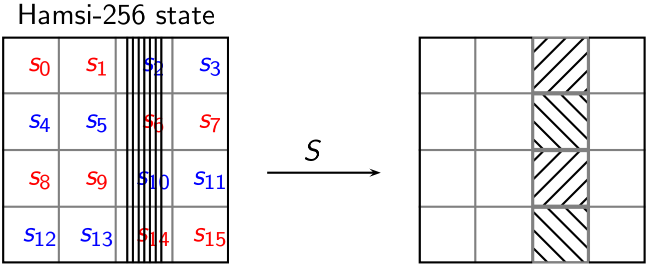

- 4×4 *Serpent* Sbox
- Confusion/diffusion across the rows
- Can be processed in parallel, word size up to 128-bits
- Suitable for bitsliced implementation

Diffusion

Hamsi-256 state

A_0	B_0	C_0	D_0
D_1	A_1	B_1	C_1
C_2	D_2	A_2	B_2
B_3	C_3	D_3	A_3

$$\xrightarrow{L}$$

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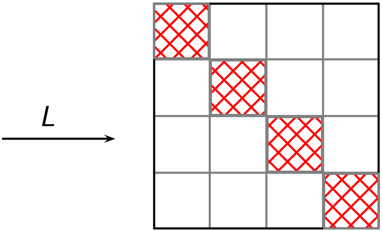
Diffusion by L



Diffusion

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A_0	B_0	C_0	D_0
D_1	A_1	B_1	C_1
C_2	D_2	A_2	B_2
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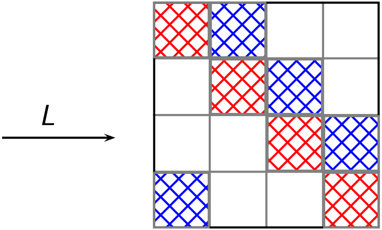

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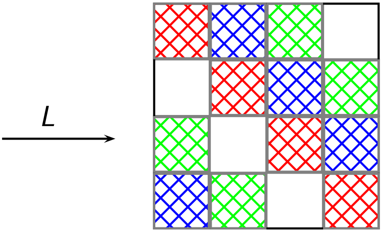

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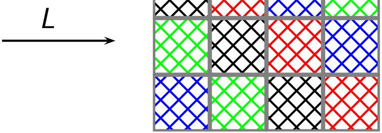
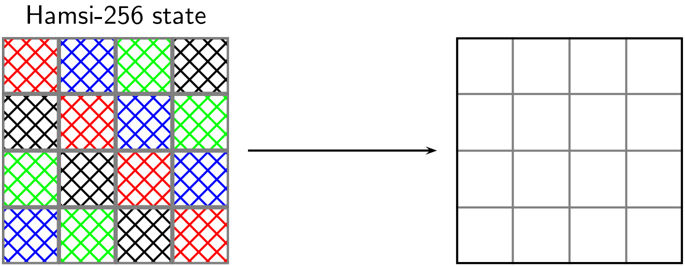


- L consists of XOR, rotation and shift operations
- L operates on 32-bit words; inputs and outputs 4 words
- Any single bit difference amplified by L affects a different Sbox

Truncation



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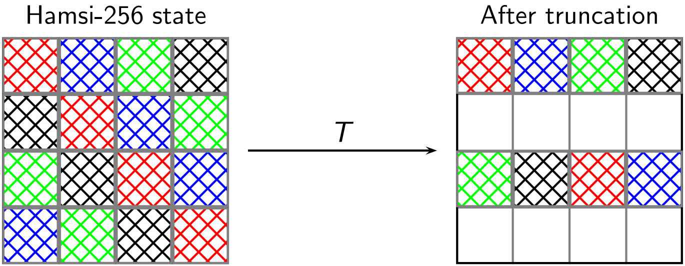

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  - Sboxes have good differential/linear and avalanche properties
    - Algebraic degree of all but one output bit is 3; we are not aware of any attacks based on this.
  - Feedforward is added against generic preimage attacks
  - L is applied in such a way to destroy symmetry
  - P_f is to prevent against length extension and slide attacks

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  - Any difference on the message very quickly activates many Sboxes (thanks to message expansion. . .)
  - Message modification can not help to cancel difference propagation (message block is concatenated to the chain value)
- External collision seems much harder to find. . . (P_f has 6 rounds)

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- Use your imagination!

Outline

Software-Hardware

- Hamsi is a software and hardware friendly algorithm
- Hamsi-256 runs at 25cpb on Intel Core2 (in C using SSE2 instructions)
  - Further improvements are in progress
- Hardware results for Hamsi-256:
  - Area: 14.5KGate, UMC 130 nm library, typical case
  - Timing: 3.2ns as critical path delay, 310MHz
  - Throughput: 3.3Gbps

Conclusion

- Hamsi is a secure and fast hash function
- Feel free to analyze it
- Feel free to make it faster

- `http://homes.esat.kuleuven.be/~okucuk/hamsi/`