The Skein Hash Function

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Niels Ferguson
Stefan Lucks
Bruce Schneier
Doug Whiting
Mihir Bellare
Tadayoshi Kohno
Jon Callas
Jesse Walker

Overview

- Fast
  - 6.1 cycles/byte on reference platform
  - More than 500 MB/s (4 Gb/s) per core.
- Secure
  - Uses block cipher (we know how to analyze those)
  - Conservative choice in # rounds
  - Formal security arguments for the mode
- Flexible
  - Lots of extra features

Design Philosophy

- Simplicity
- Optimize security per clock cycle
- Implementability on a variety of platforms
- Many simple rounds
- Maximum diffusion
- Simple CPU operations
- Flexibility

Critical Design Decisions

- A block cipher
  - There are many tools to analyze block ciphers
  - Streaming modes are not as well understood
- A tweakable block cipher
  - Message block offset in tweak replaces MD-strengthening
  - Considerable flexibility at no additional cost
- Matyas-Meyer-Oseas mode
  - Attacker controls plaintext input, not key input
- No table lookups (avoids side channel attacks)
- Three different internal state size, arbitrary output size

Skein Building Blocks

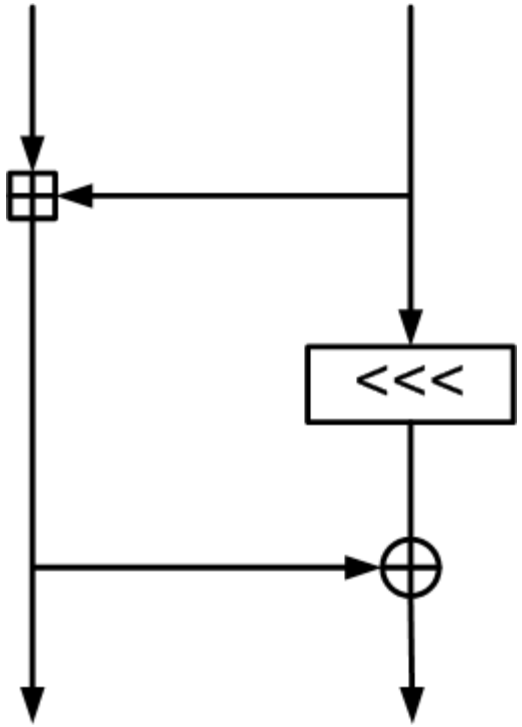
- Threefish large-block tweakable block cipher
- Unique Block Iteration(UBI)
- Optional Argument System

The Threefish Block Cipher

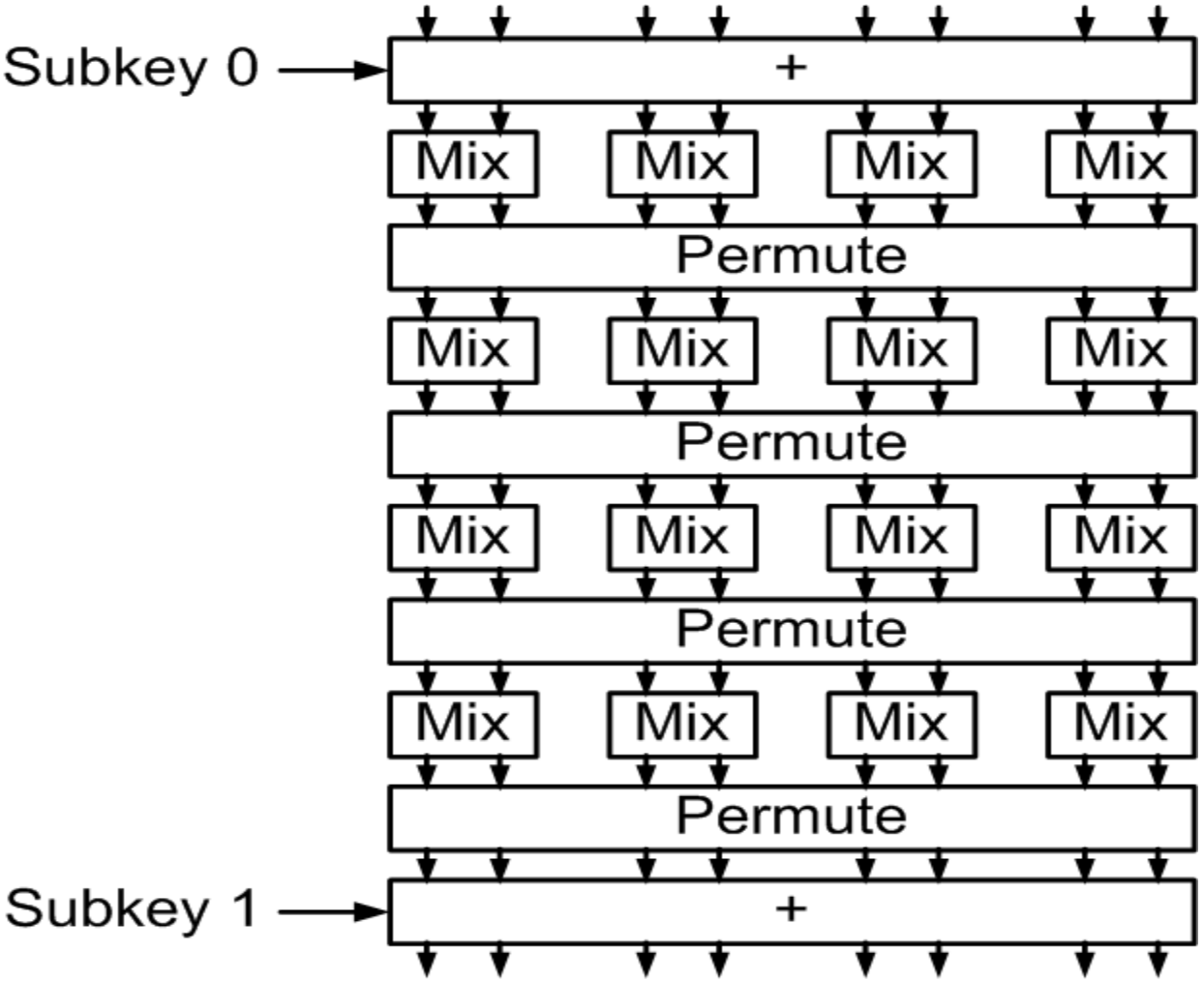
- Three versions
  - 256-bit block size
  - 512-bit block size
  - 1024-bit block size
- SP-network
- Based on very simple Mix function
- Simple key schedule

MIX Function

- Operates on two 64-bit words
- Uses only three primitive operations
- Takes 1 clock cycle (amortized) on reference platform



Four Rounds of Threefish-512



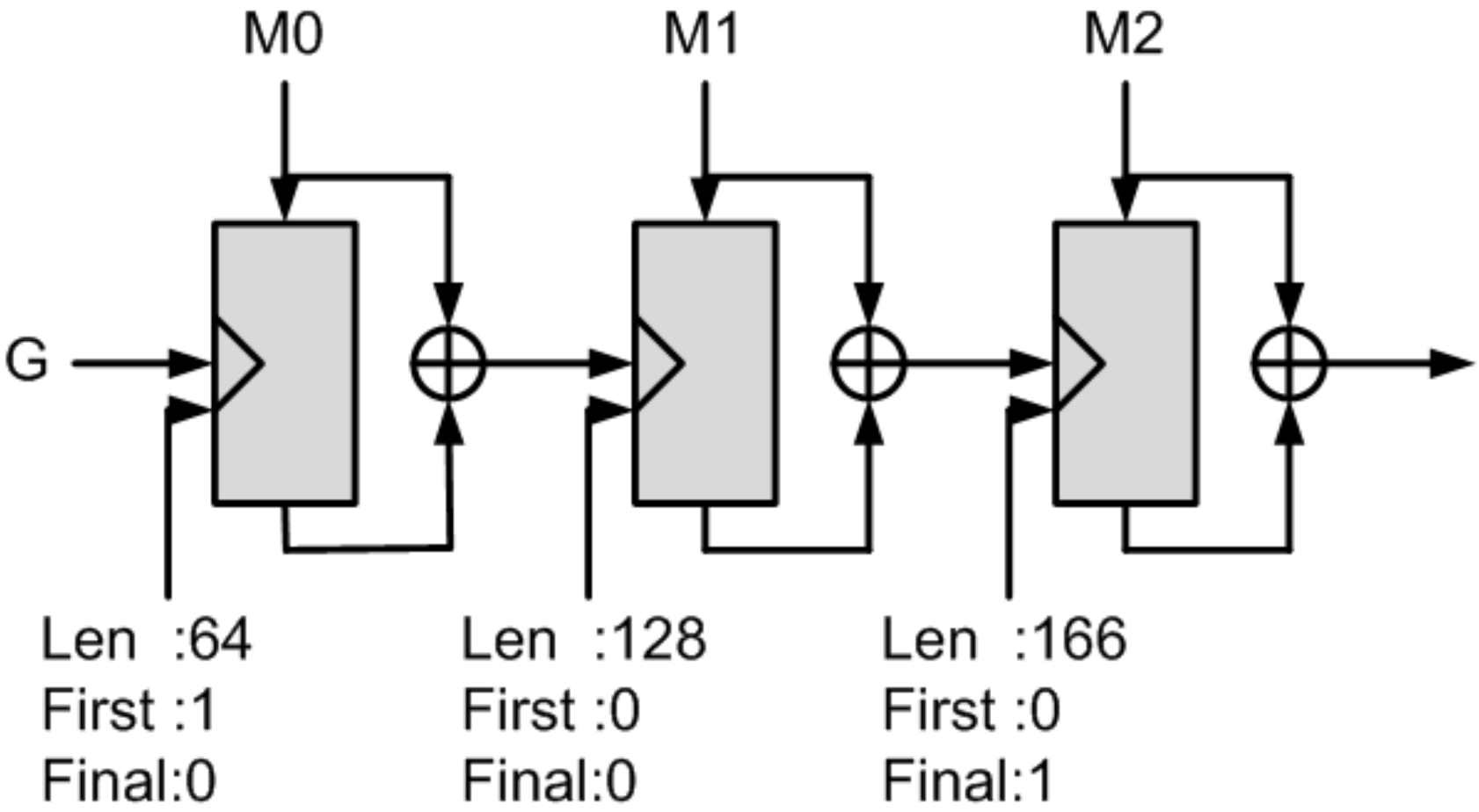
Threefish Key Schedule

- Inspired by Skipjack key schedule
- Key is the same size as the plaintext
- 128-bit Tweak value
- Each subkey is computed using three additions
- Counter to avoid slide attacks

Many Rounds

- Threefish has many rounds
  - Threefish-256 has 72
  - Threefish-512 has 72
  - Threefish-1024 has 80
- Each round is very simple, easy to analyze
  - But there are so many of them
- Full diffusion takes 9-11 rounds
- 7-8 full diffusions in the cipher
  - Compare with 5-7 for AES

UBI Compression Mode



Other Features

- Variable hash output size
- Tree hashing (with flexible leaf & node size)
- Large-block block cipher

- Through Optional Argument System:
  - Personalization
  - Zero-overhead MAC
  - Key Derivation Function
  - Password-based key derivation (PBKDF)
  - PRNG
  - Stream cipher (with nonce)

Security Proofs

- If the compression function is collision-resistant, then so is Skein.
- If Treefish is a tweakable PRP, then Skein is:
  - A PRF
  - A secure KDF
  - A secure MAC
  - A stream cipher
  - A PRNG
  - Secure when used in HMAC
- If Threefish is an ideal tweakable cipher, then Skein is indifferentiable from a random oracle.

Speed (in cycles/byte)

	Skein-256	Skein-512	Skein-1024
x64	7.6	6.1	6.5
x86 no SSE	32.8	32.5	37.5
x86 + SSE	21.6	20.1	25.5
Atmel AVR (8-bit CPU)	600 (C) 300 (asm)	600 (C)	625 (C)
FPGA (Xilinx Virtex-5)		>1 Gb/s	

~1000 cycles to hash a one-block message (Skein-512).

Memory Usage

- ~100 bytes RAM for Skein-256
  - SHA-256 needs > 128 bytes
- ~200 bytes RAM for Skein-512
  - SHA-512 needs > 256 bytes
- Many speed/code-size tradeoffs

Questions?

For more information: http://www.skein-hash.info