JH

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- Design
- Security
- Performance

Innovative Design

- New compression function structure
- Proposed the generalized AES design method
- Combining the best of AES and Serpent

Design: New compression function structure

$M^{(i)}$: m bits

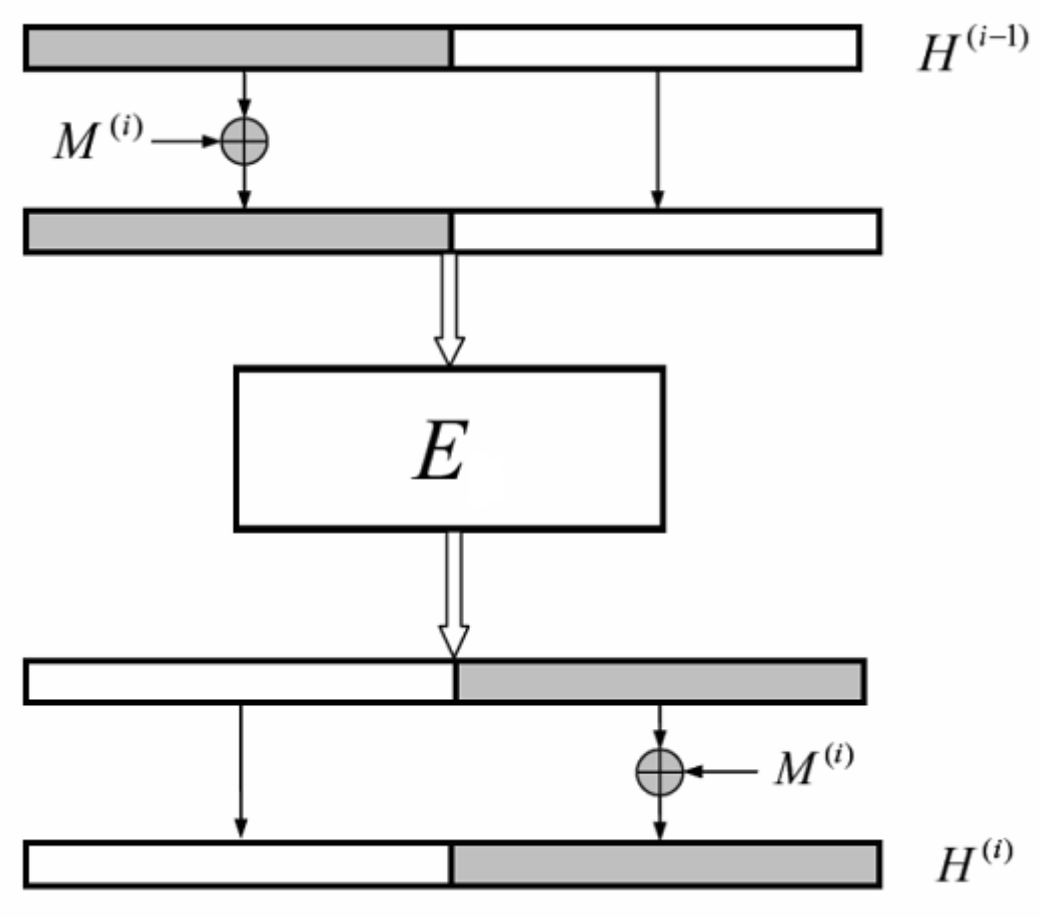
$H^{(i)}$: $2m$ bits

New, simple

efficient

=> does not discard

part of the output of ***E***



Design: Proposed the generalized AES design method

SPN + MDS code (to a multi-dimensional array)

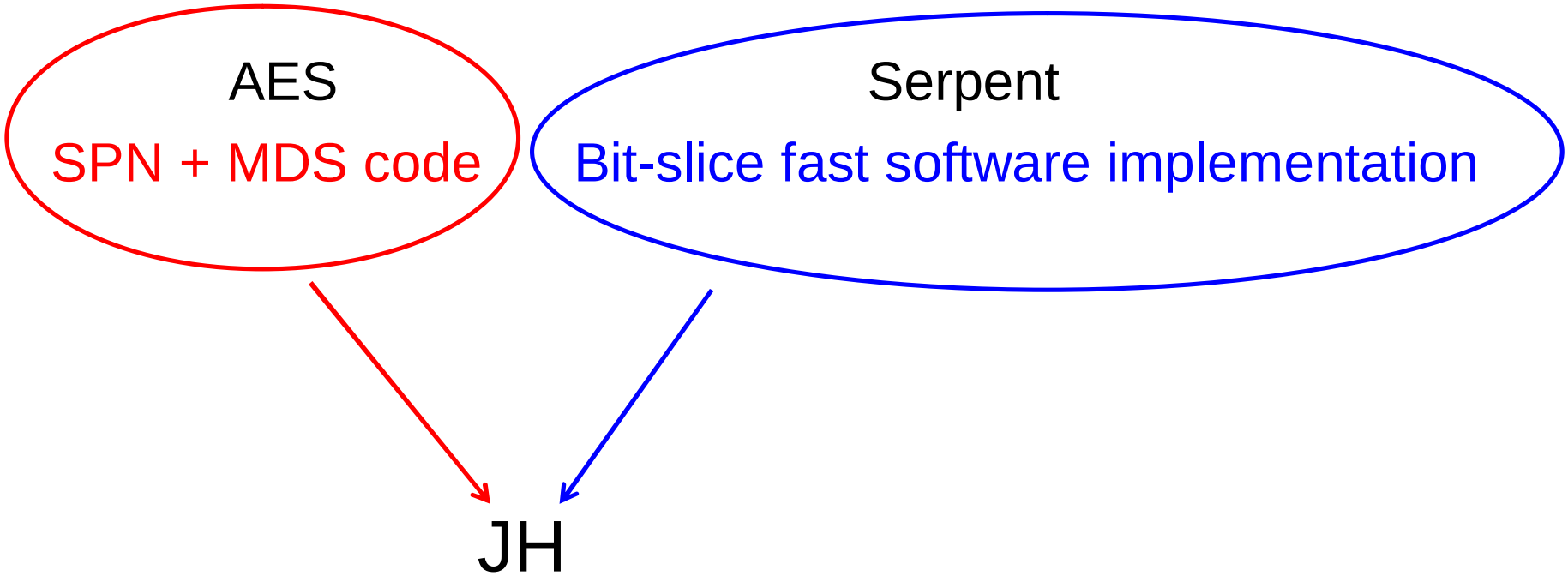
=> A simple, efficient and flexible approach to design a large permutation (block cipher) from small components by increasing dimension

Examples:

AES (2D, 128 bits) => 3D (512 bits) => 4D (2048 bits);

JH (8D, 1024 bits) → bit-slice

Design: Combining the best of AES and Serpent



Security

The generalized AES design:

SPN + MDS (to a multi-dimensional array)

- Advantages
  - Analyze a small function to find the best attack
  - Verify the attack on a small function

Security: Differential attack

a compression function in JH involves:

512 message bits, 9216 Sboxes

a differential path in JH involves more than 600 active Sboxes => strong against differential attack

Security: Other attacks

- Preimage attack on the mode
  - meet-in-the-middle collision search
  - 2^{507} computations + 2^{507} memory + 2^{526} memory accesses (Bhattacharyya et al, FSE 2010)
  - more expensive than brute force

Security: Other attacks (contd.)

- Rebound attacks on JH (Rijmen et al. FSE 2010)
  - Semi-free-start collision
    - 16 out of 35.5 rounds (2^{178} computations + 2^{101} memory)
  - Semi-free-start near collision
    - 22 out of 35.5 rounds (2^{156} computations + 2^{143} memory)
- My opinions on rebound attacks
  - Rebound attack is not a threat to JH
    - As stated in the original JH submission, JH compression function is strong against the attack from the middle
  - Rebound attack is only useful for Matyas–Meyer–Oseas-like structure

Security: Other attacks (contd.)

- 820/1024-bit near collision for 10 out of 35.5 rounds

  (2^{23} computations, Turan et al., the 2nd SHA-3 conference)

Security: Proof

- JH
  - Indifferentiable with less than $2^{n/3}$ queries (n = 512)

    Low bound (Bhattacharyya et al, FSE 2010)

Performance

- Hardware or resource constrained platform
  - Identical round functions
  - Small components
  - Compute round constants on-the-fly
- Fast software
  - Bit-slice with seven different round functions
- Easy to implement for software and hardware
  - The difficult part is to derive the bit-slice description
    => I did it already (two years ago in the submission)

Performance: Fast software

Bit-slice; suitable for the 128-bit SIMD instruction set (available on many platforms):

compute 128 Sboxes in parallel
compute 128 MDS codes in parallel

ebash results:
about 17 cycles/byte on the common Intel & AMD processors;
very close to that of SHA-256

Performance: Fast software (contd.)

- More efficient on the incoming microprocessors with 256-bit AVX instruction set
  - Intel (Sandy Bridge Q4 2010)
  - AMD (Bulldozer 2011)

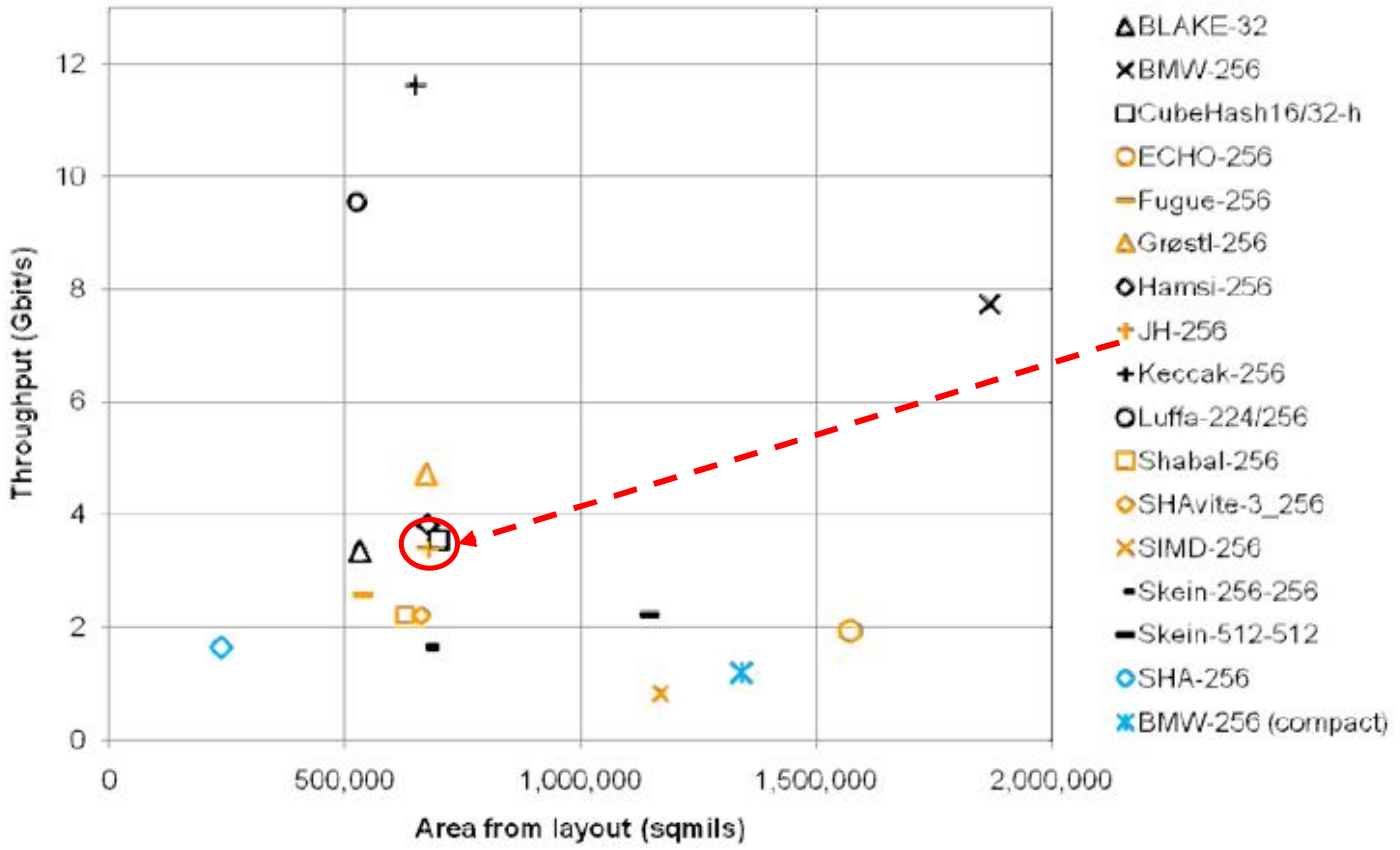
  Compute 256 Sboxes in parallel

- The size of data register has been gradually increasing

  8 bits → 16 bits → 32 bits → 64 bits → 128 bits → 256 bits →

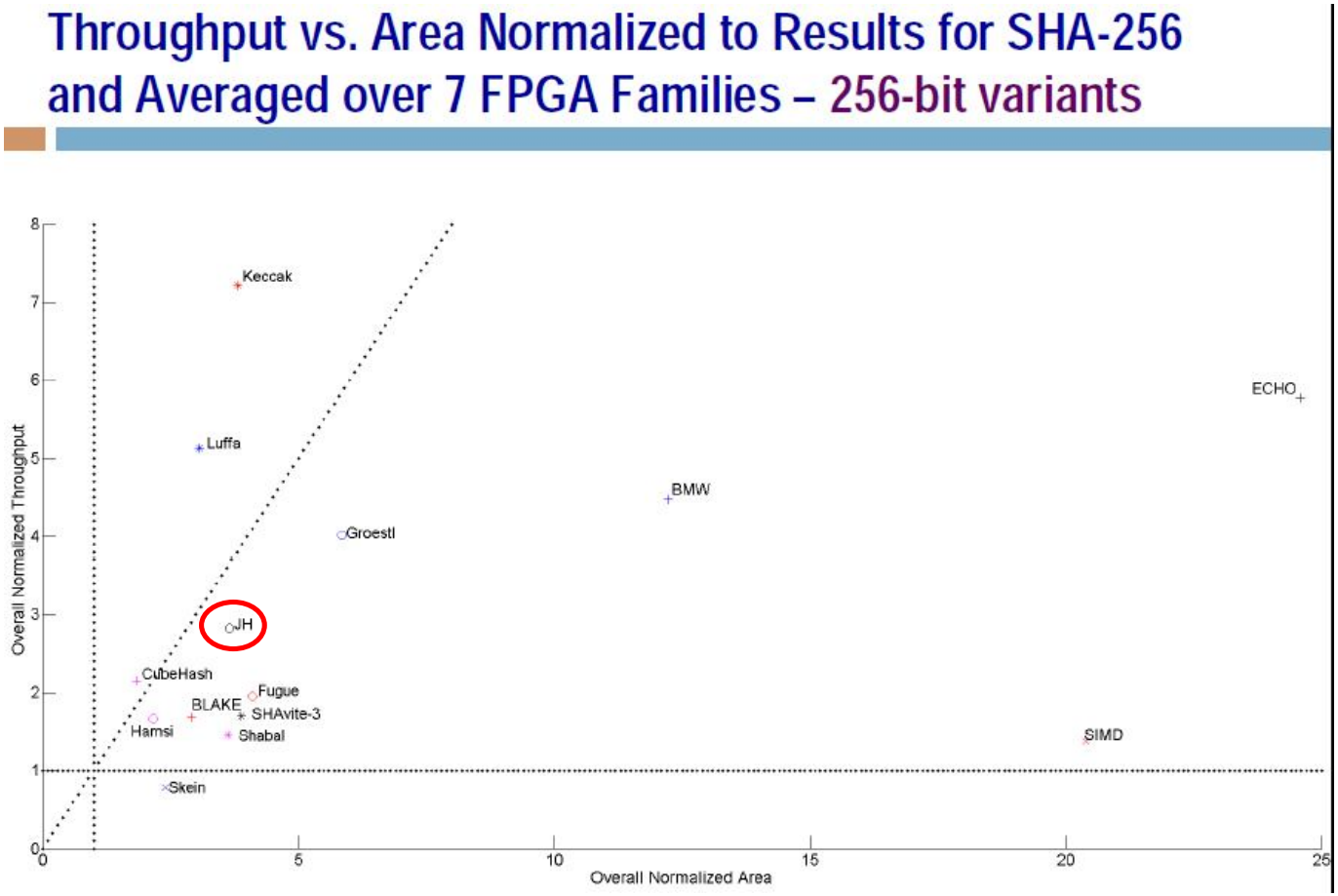
Performance: Hardware

- ASIC: Tillich et al (the 2nd SHA-3 conference)



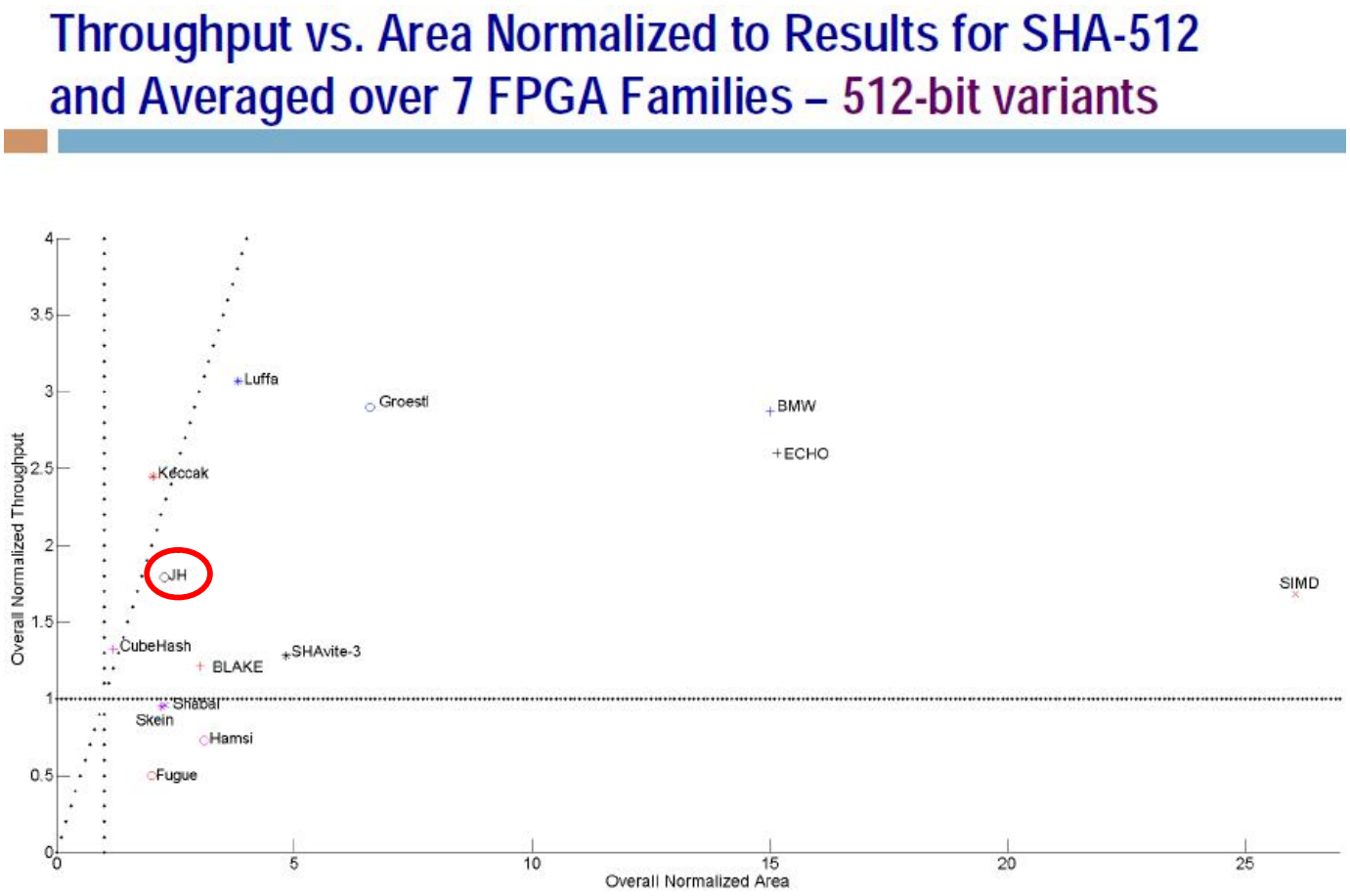
Performance: Hardware (contd.)

- Gaj et al (the 2nd SHA-3 conference)



Performance: Hardware (contd.)

- Gaj et al. (the 2nd SHA-3 conference)



Performance: Hardware (contd.)

- Baldwin et al. (the 2nd SHA-3 conference)
  - JH is one of the top three candidates in FPGA implementation

Conclusion

- Design
  - New compression function structure
  - The generalized AES design method
  - Combining the best of AES and Serpent
- Strong
- Efficient for software and hardware