Chair for Security in Information Technology
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The Performance and (Hidden) Communication Cost of Hardware Accelerators for Hash Primitives Used in Post-Quantum-Cryptography

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Motivation

- Post-Quantum Cryptography (PQC) uses computationally intensive subroutines
  - Huge percentage for hashing and PRNG (mostly SHA-3)
  - Other examples NTT-based polynomial multiplication (mostly for lattice schemes)

→ HW acceleration obviously makes sense

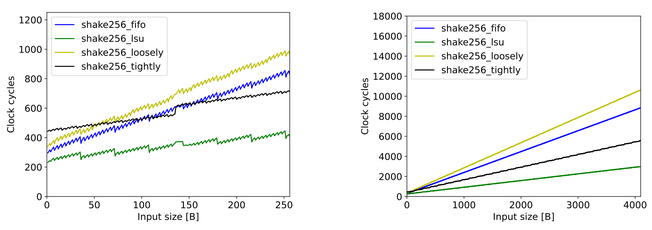
✗ BUT accelerators often under-utilized!

Contribution

- Benchmarks of architectures for **Hash** (variable input, fixed output length) and **CSPRNG** scenario (fixed input, variable output length)
- Case-Study of **SPHINCS+**, **Kyber**, **Dilithium** and **Falcon**

Benchmark Results - SHAKE256

Hash Scenario

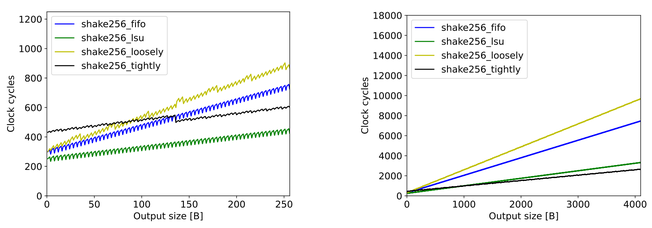


(a) Hash scenario up to 256 Bytes input

(b) Hash scenario up to 4096 Bytes input

- Tightly-coupled efficient for small inputs, suffers from “software absorption”
- LSU-coupled version efficient due to parallel absorption/data transfer

CSPRNG Scenario



(a) CSPRNG scenario up to 256 Bytes output

(b) CSPRNG scenario up to 4096 Bytes output

- LSU-coupled version still efficient in general

Hardware Acceleration[a]

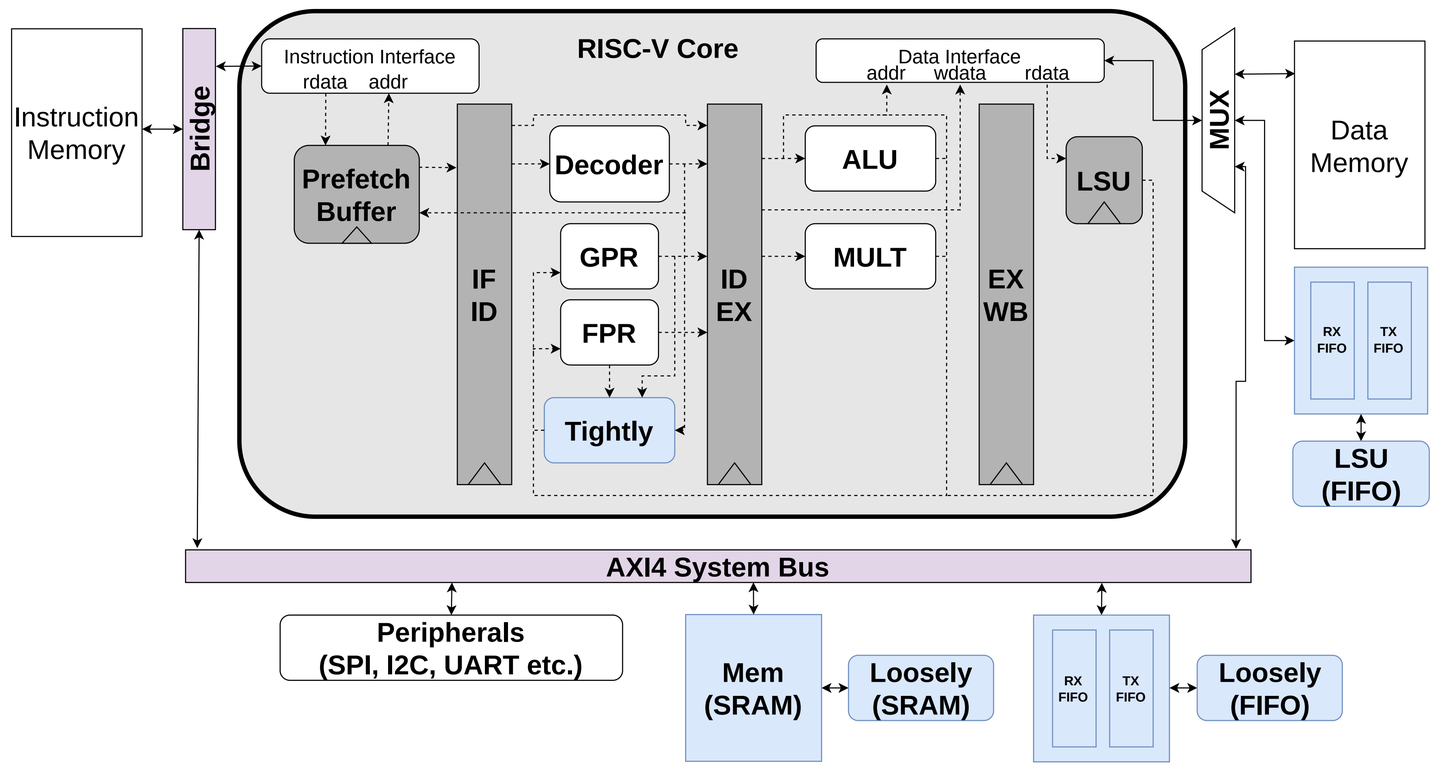
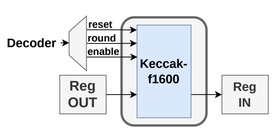
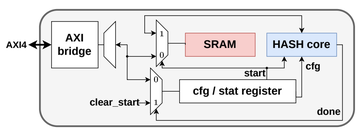


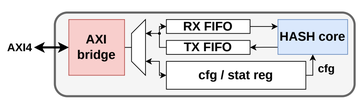
Figure 1 Overview of the platform and the different coupling options



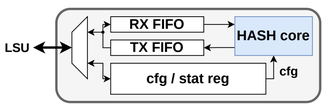
(a) Tightly Coupled Architecture



(b) Loosely (SRAM) Coupled Architecture



(c) Loosely (FIFO) Coupled Architecture



(d) LSU (FIFO) Coupled Architecture

Case-Study: SPHINCS+

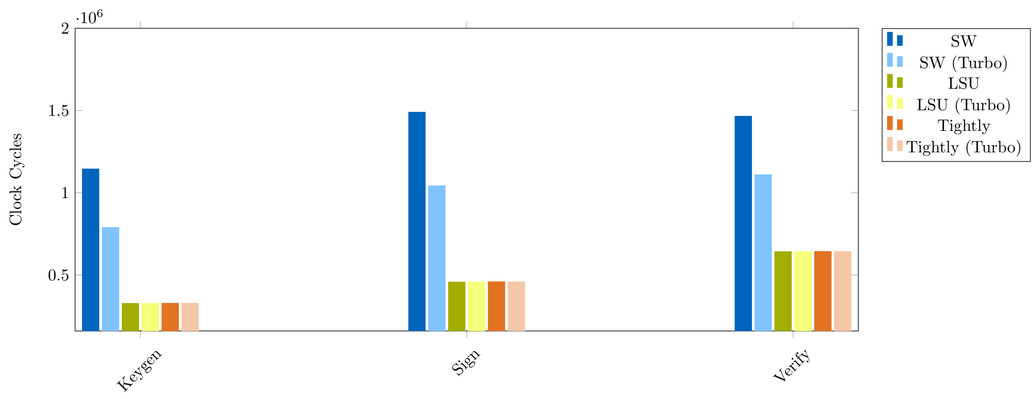
Architecture	Keygen	Sign	Verify
shake256_sw	145 119	3 602 835	201 209
shake256_lsu	1 725	42 598	2 458
shake256_tightly	2 902	71 921	4 091

Table 1 Kilo cycles for SPHINCS+ 128f-simple.

Architecture	Keygen	Sign	Verify
shake256_sw	9 288 740	70 607 335	69 400
shake256_lsu	109 770	837 742	852
shake256_tightly	184 914	1 410 992	1 419

Table 2 Kilo cycles for SPHINCS+ 128s-simple.

Case-Study: Kyber



- Round-reduction directly visible in SW
  - ✓ About 25 % to 30 % speed-up for turbo-shake256
- Limited gain for accelerators
  - Less than 1 % for turbo-shake256

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[a]Patrick Karl, Jonas Schupp, and Georg Sigl. “The Impact of Hash Primitives and Communication Overhead for Hardware-Accelerated SPHINCS+”. In: Constructive Side-Channel Analysis and Secure Design. Ed. by Romain Wacquez and Naofumi Homma. Cham: Springer Nature Switzerland, 2024, pp. 221–239.