Towards the Selection of the Finalists

NIST Lightweight Cryptography Standardization Process

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INFORMATION TECHNOLOGY LABORATORY

Outline

- NIST lightweight cryptography standardization process
- Comparisons of the round 2 candidates
- Evaluation criteria and next steps

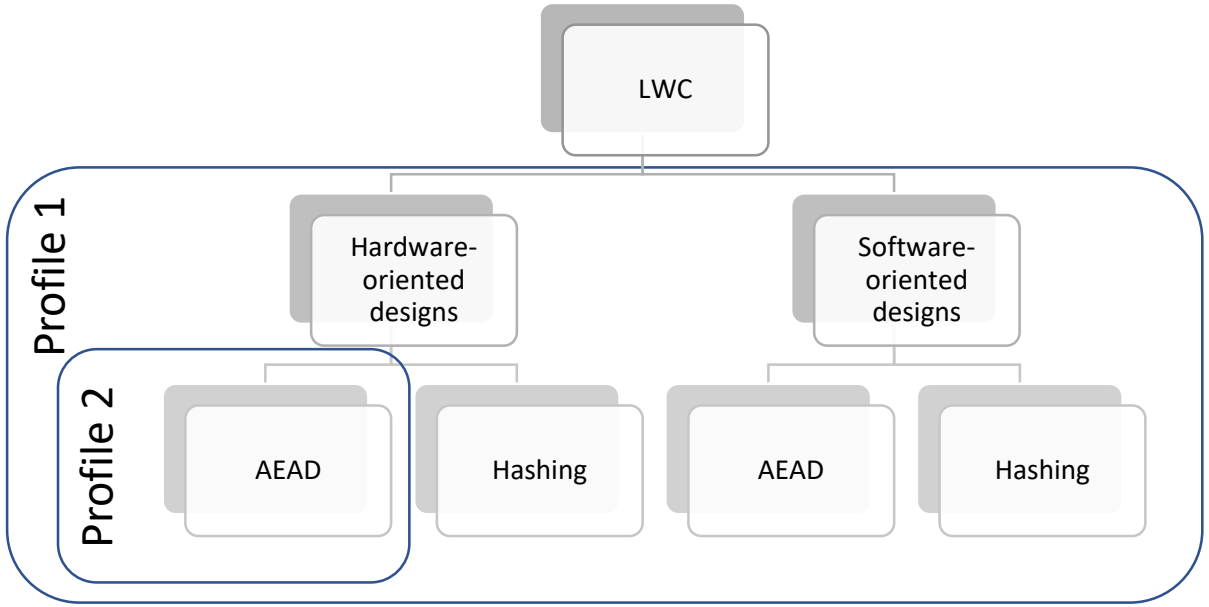
Welcome – 4th NIST LWC Workshop

- Three-day virtual workshop
- Six sessions to discuss
  - Status updates
  - Security analysis and performance of second round candidates
  - Selection of the finalists
- 2 NIST talks, 23 accepted talks, open discussion

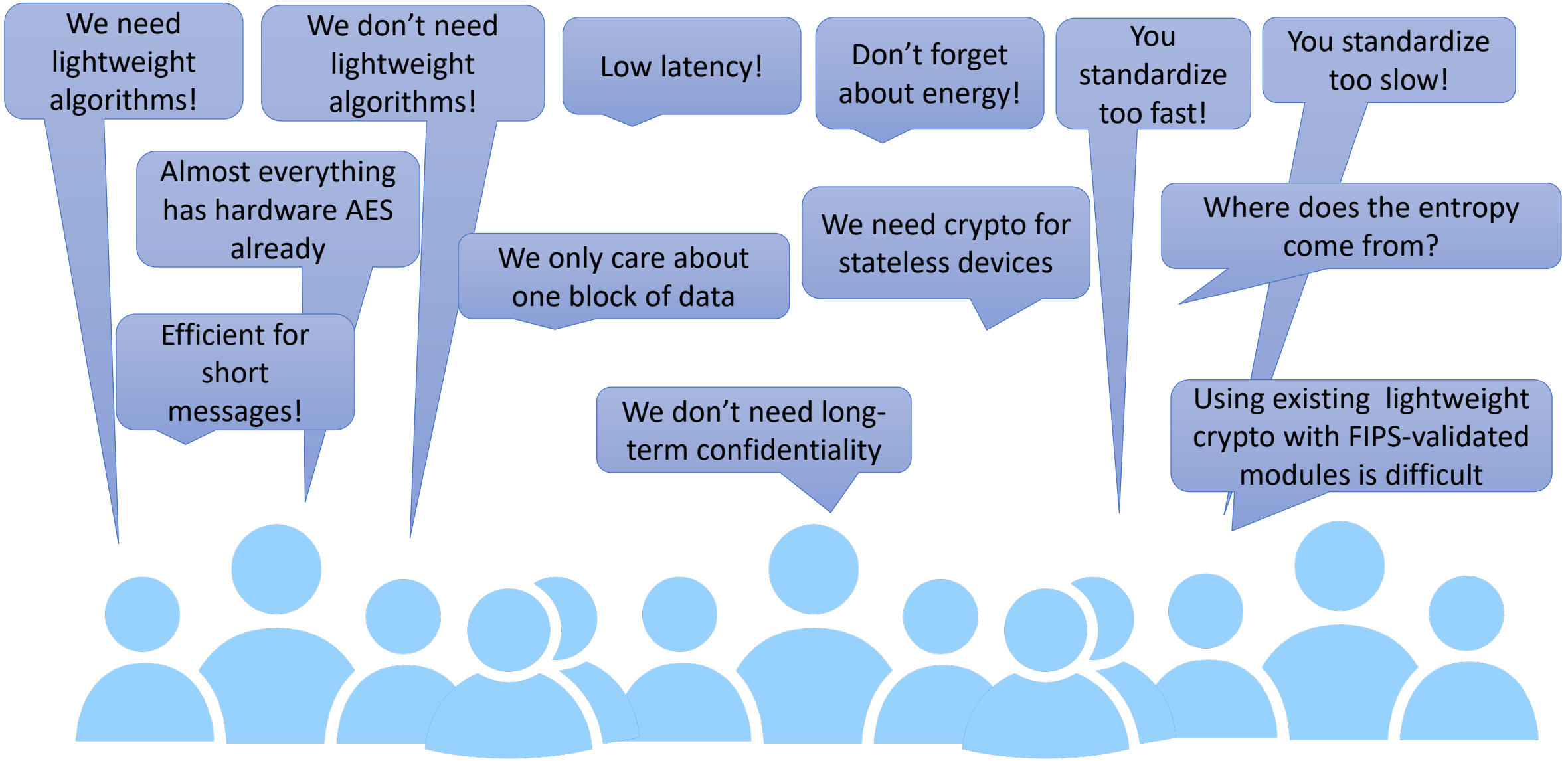
Where We Began

- Need for cryptographic standards for applications in constrained environment that are not well-served by existing NIST standards
  - Needs vary by application
  - Tailoring to target devices and applications could lead to many standards
- The big question was “where do we start?”
  - Decided to begin with symmetric cryptography in constrained environments

- Two profiles in withdrawn draft whitepaper
  - Profile 1 for AEAD + hashing in SW and HW
  - Profile 2 for AEAD in hardware
- Feedback shaped the submission requirements
- Instead of two profiles, asked for AEAD with optional hashing functionality

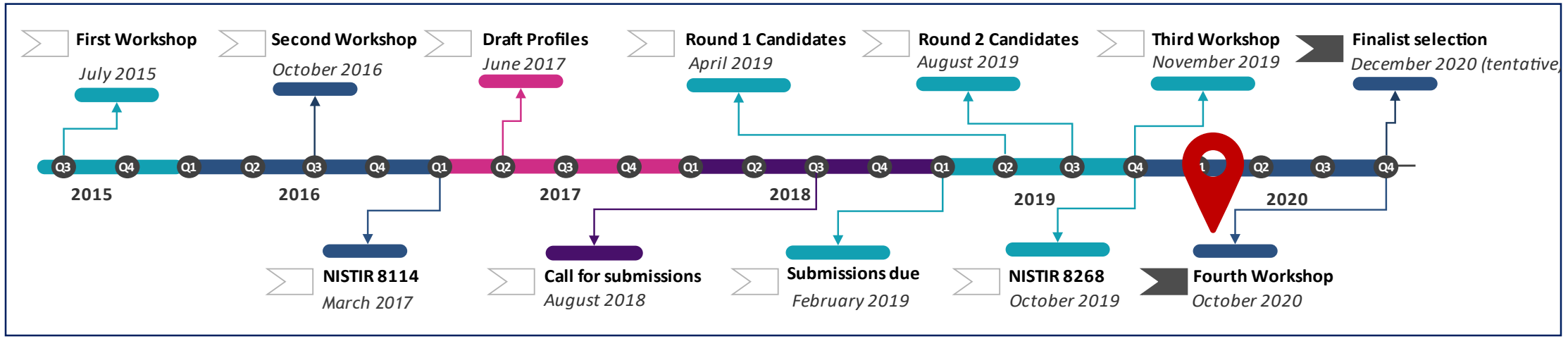


Feedback (paraphrased)



NIST LWC Standardization Process

- Competition-like process
- **Scope:** AEAD with optional hashing functionality
- In April 2019, announced 56 Round 1 candidates (out of 57 submissions)
- In August 2019, announced 32 Round 2 candidates
  - Selection based on cryptographic maturity of the designs
- Extended the finalist selection by 3 months, expected in December 2020

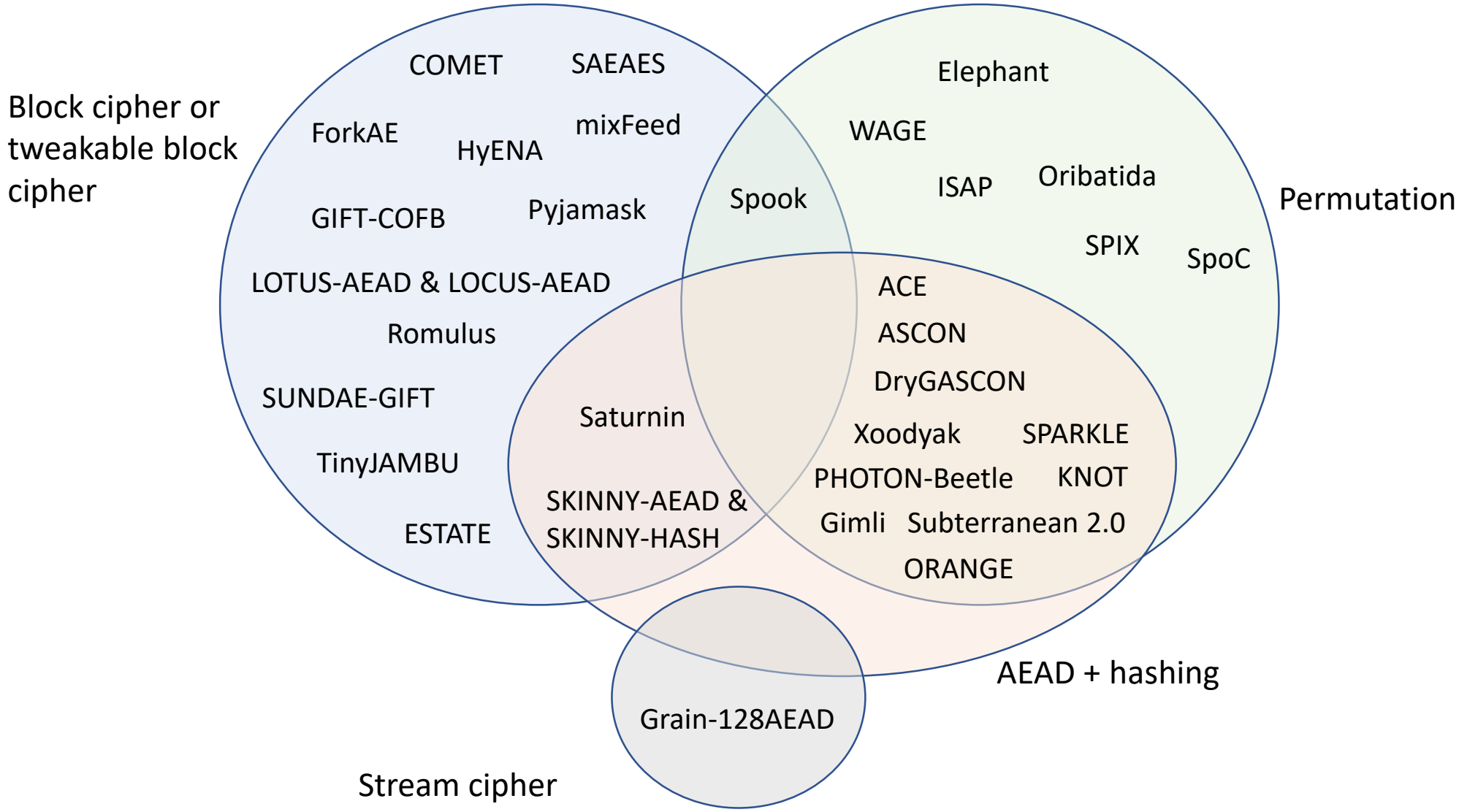


Considerations

- Security
  - Claims by the submitters
  - Maturity of analysis by the submitters and third parties
- Implementation flexibility to achieve cost/performance tradeoff best for application
- Performance
  - Benchmarking results in constrained software and hardware environments
  - Comparison to current NIST standards
- Additional Features
  - Nonce misuse security, RUP security, post-quantum security, side channel resistance, etc.
- Design diversity
- Standardization
  - Public confidence
  - Ease of standardization and adoption

Second Round Candidates

Design (Primitive Level) & Functionality



Design (Mode Level)*

Sequential

Classical sponge with public permutation

ACE, ASCON, DryGASCON, Gimli, KNOT, SPIX, Spook, Subterranean 2.0, WAGE, Xoodyak

Modified sponge with public permutation

ORANGE, Oribatida, PHOTON-Beetle, SPARKLE, SpoC

(T)BC-based feedback with rate 1

COMET, GIFT-COFB, HyENA, mixFeed, Romulus

Classical sponge with secret permutation

SAEAES, TinyJAMBU

Enc-then-Mac

ISAP, Saturnin

Mac-then-Enc

ESTATE, SUNDAE-GIFT

Stream cipher based

Grain-128AEAD

Parallel

ForkAE

LOTUS-AEAD & LOCUS-AEAD

ΘCB3-based

SKINNY-AEAD

OCB3-based

Pyjamask

Enc-then-Mac

Elephant

* Primary variant only

Candidates Using Crypto Standards

AES (FIPS 197)	KECCAK (FIPS 202)	PHOTON (ISO/IEC 29192-5)	SKINNY** (ISO/IEC 18033-7)	SPONGENT (ISO/IEC 29192-5)
Comet	Elephant*	ORANGE	ForkAE*	Elephant
ESTATE*	ISAP*	PHOTON-Beetle	Romulus	
mixFeed*			SKINNY-AEAD/HASH	
SAEAES				

* with modification

** in progress

Additional Features

Many candidates claim additional features, such as

- Various levels of nonce misuse resistance
- RUP-security
- Related-key security
- Lending themselves to side-channel resistant implementations
  - Leakage-resilience, threshold implementations, etc.
- Post-quantum security
- Additional variants supporting various key/tag sizes, or optimization for short messages

Software Benchmarking

Microcontroller benchmarking by Renner, Pozzobon, and Mottok
• ATmega328P • ARM Cortex-M3 • ARM Cortex-M7 with FPU • Kendryte K210 • Xtensa LX6

Microcontroller benchmarking by Weatherley
• ARM Cortex-M3 • Xtensa LX6 • ATmega2560

Microcontroller benchmarking by NIST LWC Team
• ATmega328P • ARM Cortex-M0+ • ARM Cortex-M4 with FPU

eBACS (ECRYPT Benchmarking of Cryptographic Systems)
• Many systems covering ARM, AMD, Intel, PPC, RISC-V, and MIPS architectures

RISC-V benchmarking by Campos et al.
• SiFive E31 • VexRiscv simulator • riscvOVPsim simulator

Hardware Benchmarking

FPGA benchmarking by Mohajerani et al.	**ASIC benchmarking by Khairallah, Peyrin, and Chattopadhyay**
• Artix-7 • Cyclone 10 LP • ECP5	• Synopsys VCS simulator • Xilinx ISim simulator

Status Updates

In August 2020, NIST requested *optional* status updates from the submission teams on

- New proofs/arguments supporting the security claims
- New software and hardware implementations
- New third-party analysis and its implications
- Platforms and metrics in which the candidate performs better than current NIST standards
- Target applications and use cases for which the candidate is optimized
- Planned tweak proposals, if submission accepted as a finalist
- Any other relevant information

NIST received 27 status updates

- Available on the project website at https://csrc.nist.gov/Projects/lightweight-cryptography/round-2-candidates

Tweaks

- Finalists will have the opportunity to update submission packages and propose tweaks to submissions.
- 15 teams are considering tweaking their submissions, according to status updates
  - Increasing/decreasing number of rounds
  - Adding new functionality (e.g., XOF, hash, new modes) and new variants
  - Swapping ordering of nonce/ad/message processing
  - Updating primary variants, input sizes (nonce size)
  - Dropping family members
  - Modifying the internal details of the underlying primitive
- Tweaks are expected to be small changes to the design
  - 'big' changes to the **primary variant** may signal that the submission is not mature enough for standardization
- Tweak submission guidelines will be provided

Finalist Selection

- After the 15-month evaluation of the second-round candidates, NIST plans to select the finalists in December
- Target around 8
- Selection criteria
  - Security analysis (third-party and submitter)
  - Software and hardware benchmarking
  - Diversity of the finalists
  - Additional features

Timeline and Next Steps

- Selection of the finalists
- Publication of the report on 2nd round
- Provide guidelines for the tweaks
- Deadline for updated submission packages
- Publication of the updated submissions in the project webpage

- Final round around one year

Thanks!

https://csrc.nist.gov/Projects/lightweight-cryptography

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