NIST’s Lightweight Crypto Project

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Motivation

- Shift from general-purpose computers to dedicated resource-constrained devices
- New applications e.g. health tracking, self-driving cars, etc.
- Collection of private data
- Security problems
- Lack of cryptographic standards that are suitable for resource-constrained devices

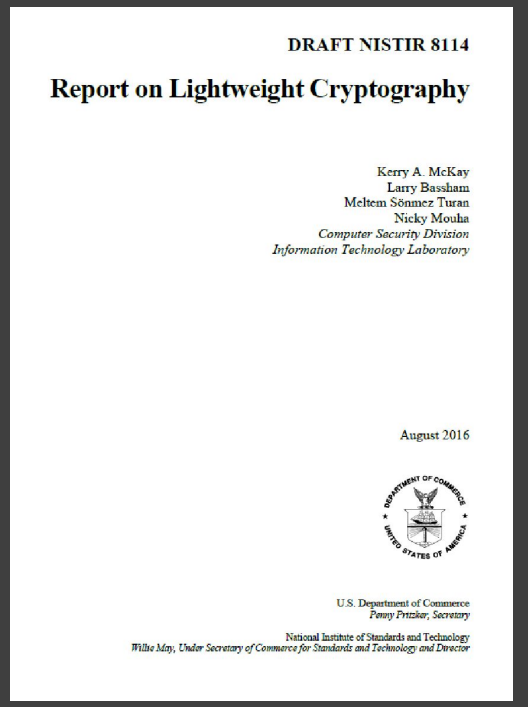
NIST's Lightweight Crypto Project

After receiving some concerns from industry in 2014, NIST initiated the lightweight crypto project

- to understand the need/requirements/characteristics of real-world applications,
- to understand where the NIST-approved algorithms fall short,
- to bring industry/academia/government together,
- to think about future standardization of lightweight primitives.

So far …

- Meetings with industry partners
- The First Lightweight Crypto Workshop at NIST on July 20-21, 2015
- Invited talks at Fast Software Encryption 2015, Lightweight Crypto Day 2015, Lightsec 2015, Cybersecurity Innovation Forum etc.
- Followed the developments in the academic literature (new designs, new efficient implementations of crypto standards etc.)
- Followed the developments in standardization of lightweight crypto
- Draft NISTIR 8114 Report on Lightweight Cryptography, August 2016


DRAFT NISTIR 8114

Report on Lightweight Cryptography

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Initial Questions

???

- What do we mean by lightweight cryptography?
- How do the current NIST-approved crypto standards perform on constrained devices?
- Which constrained devices should we consider? What are the restrictions of the devices/applications?
- Are there solid academic solutions?
- Do we need to add new lightweight algorithms to our cryptographic toolkit? If yes, what should be the process? A competition? An open call?
- What should be the scope of the project?

Lightweight Cryptography

- Subfield of cryptography
- Aims to provide solutions tailored for resource-constrained devices
- It is not weak crypto, but it may be less robust, less misuse resistant, may have fewer features.

“Weight” of a Crypto Primitive

Amount of resources needed to run the primitive.

Depends on the target platform!

For Hardware Applications:
Area, latency, throughput, power/energy consumption etc.

For Software Applications:
Execution time, latency, memory (ROM/RAM) requirements, power/energy consumption etc.

Target Devices

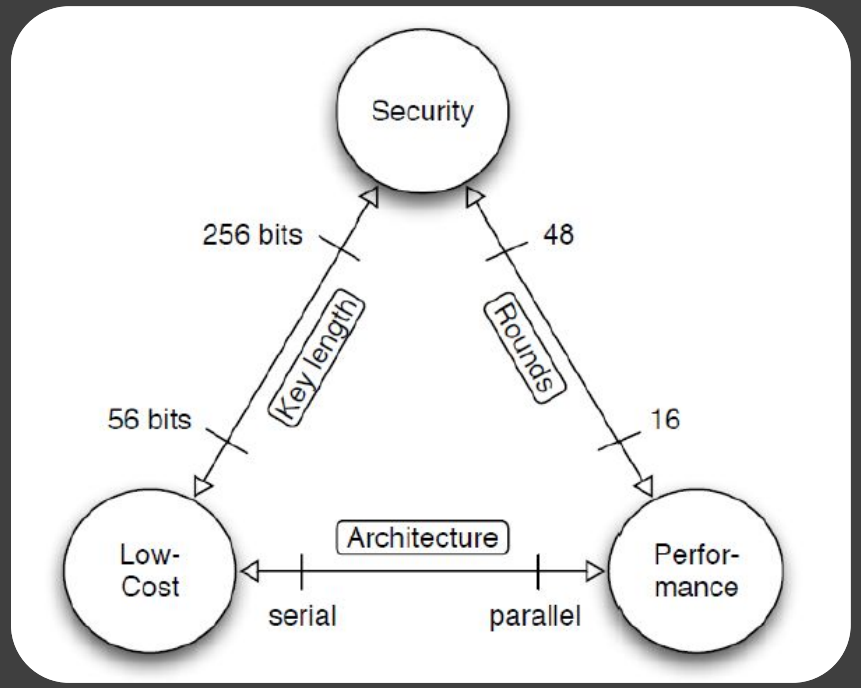
Servers and Desktops	Conventional Cryptography
Tablets and Smartphones	
Embedded Systems	Lightweight Cryptography
RFID and Sensor Networks	

Lightweight Crypto Research

- New lightweight primitives: Modifications of well-analyzed algorithms, old interesting algorithms, new dedicated algorithms
- Cryptanalysis of the new designs
- Benchmarks (e.g. FELICS project), improved implementations of crypto standards

Lightweight Crypto Research

Security-Performance-Cost Tradeoff



- Optimal tradeoff depends on the target technology.
- Small security margin by design
- Different optimizations: size, power, energy, latency, code size, RAM/ROM consumption

Figure: A. Poschmann, *Lightweight Cryptography: Cryptographic engineering for a pervasive world*

Advances in Crypto Design

- Simpler key schedules
- Many iterations of simple rounds
- Simpler operations (e.g. XORs, rotation, 4X4 S-boxes, bit permutations)
- Smaller block/internal/output/message sizes
- New designs with inherent resistance against side channel attacks

Different Attack Models

- Limited number of known plaintexts/ciphertexts imposed by the limitations of the devices (e.g. battery life)
- Less concern about related key attacks (if keys are generated using KDF standards).
- Side channel and fault attacks

Overview of Standardization Efforts

- ISO/IEC SC27 (PRESENT, CLEFIA, PHOTON, SPONGENT, Lesamnta-LW, Enocoro, Trivium)
- CRYPTREC (Target ciphers: AES, Camellia, CLEFIA, PRESENT, LED, Piccolo, TWINE, PRINCE)
- ECRYPT eSTREAM Project – Stream Ciphers for Constrained Environments - 2008 (Mickey, Trivium, Grain)
- Industry-specific standards (Proprietary designs) (A5/1 in GSM, E0 in Bluetooth)

NIST Standards on Constrained Devices

Constrained AES implementations:

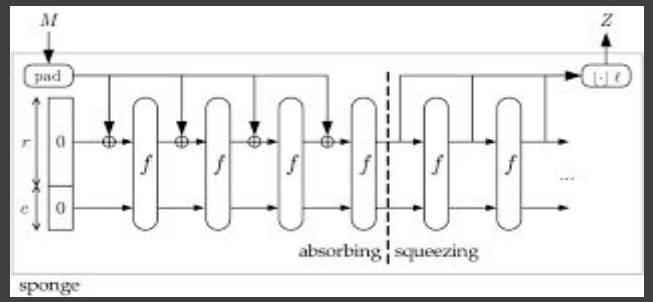
- 1947/2090 GEs (8-bit serial implementation) (Mathew et al., 2015)
- 2400 GEs (Moradi et al., 2011)
- 8-bit AVR microcontrollers 124.6 and 181.3 cpb for encryption/decryption with a code size < 2 Kbyte (Osvik et al., 2010).
- On RL78 16-bit microcontroller, combined enc/dec implementation is not possible within 512 bytes of ROM and 128 bytes of RAM (Moriai, 2016).

Constrained SHA-3 implementations:

- Area requirement of SHA-3 is around 5500GEs, with low, but acceptable, throughput.

SHA-3 and Small Permutations of KECCAK

- Permutation based sponge construction, with widths {25, 50, 100, 200, 400, 800, 1600}.



- Lightweight instance: e.g. 200-bit permutation with r=40, c=160, 12 rounds, 80-bit security.
- Offers tradeoffs
- Reusing permutation for authenticated encryption, hashing, etc.

More research needed for small permutations of Keccak

NIST's Lightweight Crypto Project - The Scope

All cryptographic primitives and modes that are needed in constrained environment!

Initial focus :

Symmetric Cryptography (Block Ciphers, Hash Functions, MACs, Stream Ciphers, Authenticated Encryption Schemes)

NIST's Lightweight Crypto Project - The Approach

How do we develop standards?

- *International competitions* (*e.g., AES, SHA-3)*
- *Adoption of existing standards: (e.g., RSA, HMAC)*
- *Open call for proposals:* (e.g. modes of operations)
- *Development of new algorithms* if no suitable standard exists (e.g., DRBGs)

For Lightweight Crypto

- *Open call for proposals*
- *Portfolio of algorithms with limited use*

NIST's Lightweight Crypto Project - The Profiles

- Evaluate and recommend algorithms based on ***Profiles***.
- Profiles include set of design goals, physical characteristics of target devices, performance characteristics imposed by the applications, and security characteristics.
- Profiles will be determined by NIST, based on the feedback we receive from the industry.

Next Steps

- Get feedback to develop profiles
- Announce the profiles - 2017
- Call for submissions for the profiles (submission requirements, guidelines, and set of evaluation criteria will be published on our project webpage).
- Third Lightweight Crypto Workshop in 2018 to discuss proposals

Feedback

- The proposed approach
- The questions listed in NISTIR 8114
- Evaluation process
- Timeline

Contact info

Send your feedbacks to: lightweight-crypto@nist.gov

Lightweight Crypto Email Forum : lwc-forum@nist.gov

Project website: http://www.nist.gov/itl/csd/ct/lwc-project.cfm

THANKS!