Selected Areas in Cryptology

Monika Trimoska

Selected Areas in Cryptology - Part 1
Spring, 2024

TU/e

General info

- Lecturers:
  - Bart Mennink, Radboud University <b.mennink@cs.ru.nl>
  - Monika Trimoska, Eindhoven University of Technology <m.trimoska@tue.nl>

- Every **Thursday, 10:00 - 12:45** (Week 6-21)

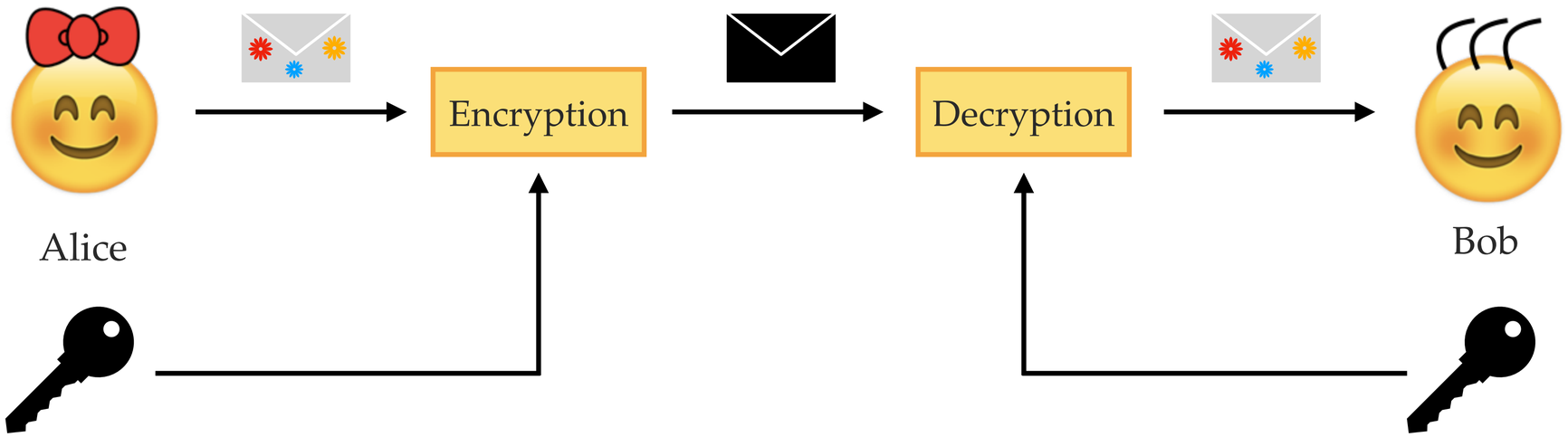
- Location: Utrecht, room **BBG 005**

- Evaluation
  - Exam (written or oral): **June 13**, 2024.
  - Retake: **July 4**, 2024.
  - The assignments are **not** included in the grade, but feedback will be given if submitted.

- Recordings: https://vimeo.com/showcase/10950327 ; Password: t7i8

Cryptology 101

(Secret-key) Cryptography



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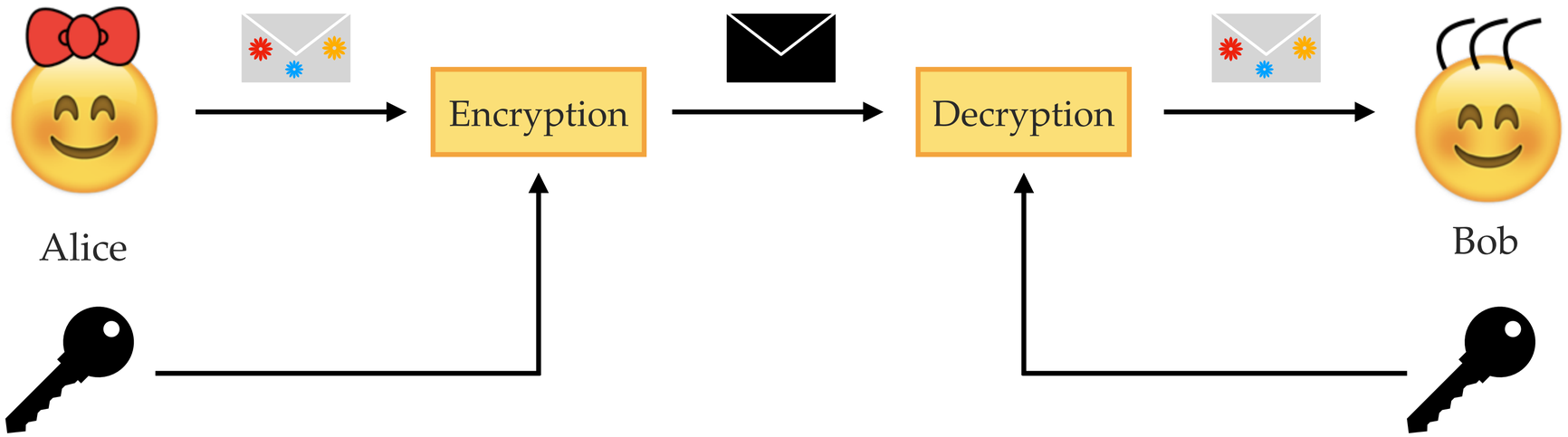

Example. (Caesar cipher) Shift all letters in the message by $s = 4$ positions down the alphabet.

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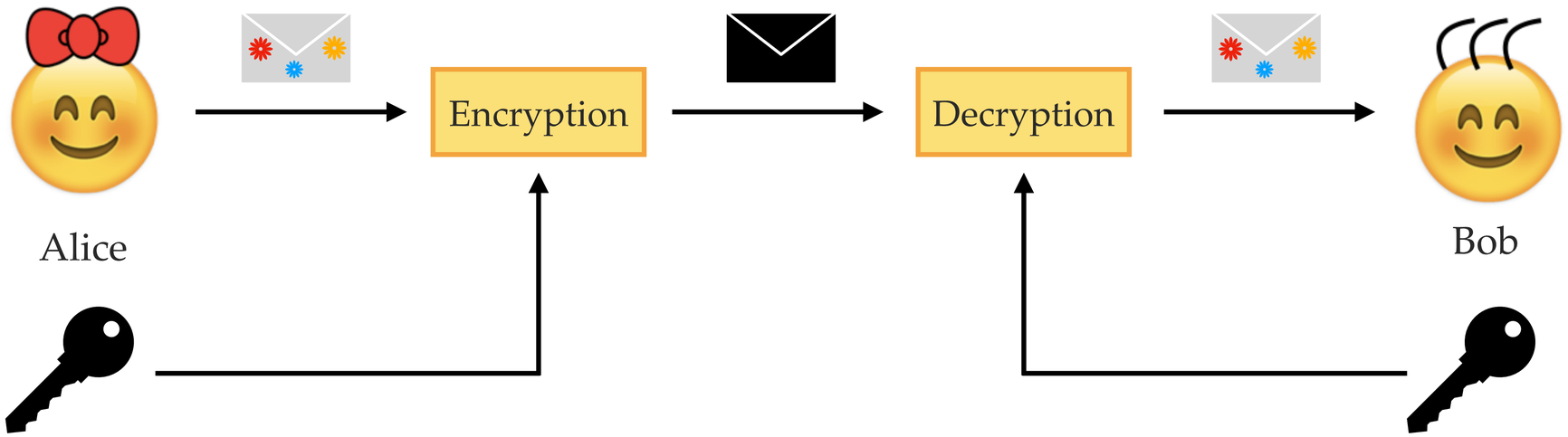
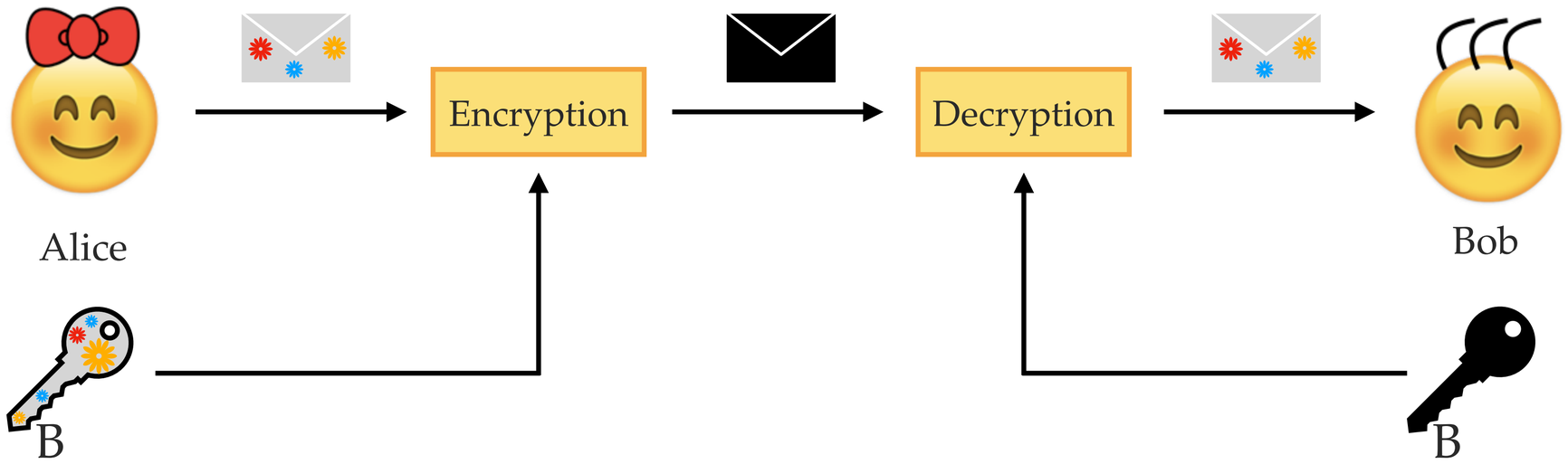


Example. (Caesar cipher) Shift all letters in the message by $s = 4$ positions down the alphabet.

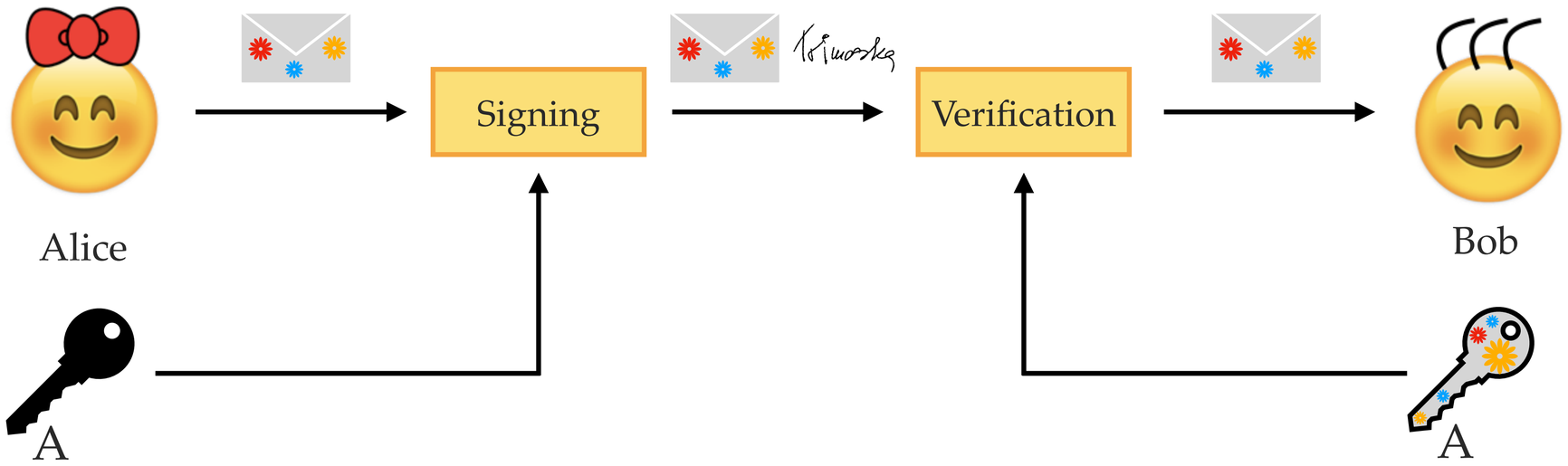
↳ Everything is public information, except for the secret key!

Public-key cryptography



Public-key encryption

Public-key cryptography

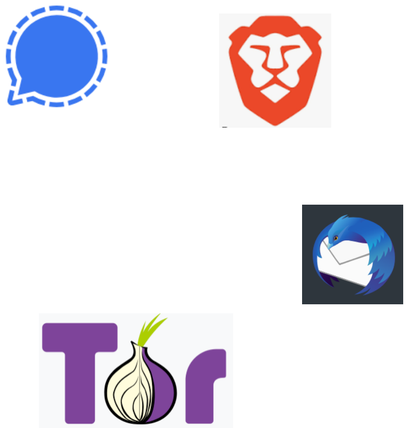


Digital signature scheme

Security and privacy tools

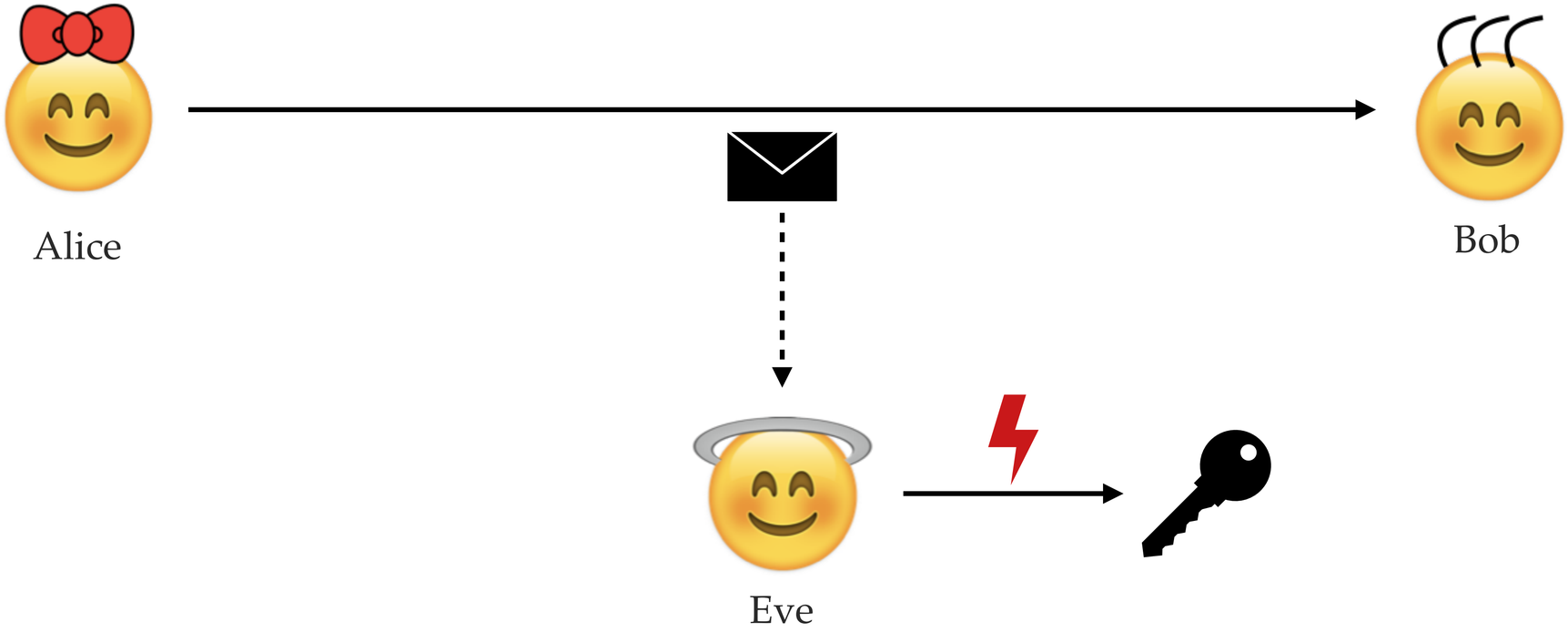
https://prism-break.org/en/

https://www.privacytools.io/

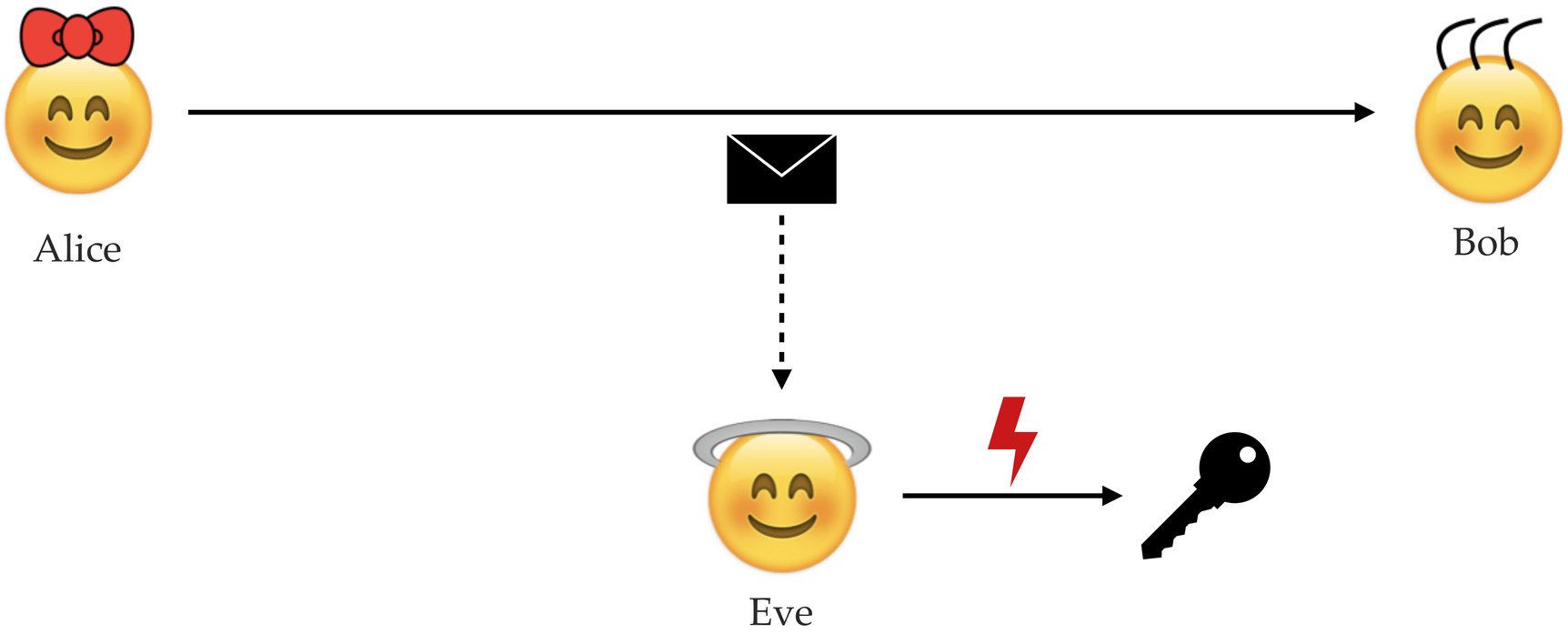


Privacy as a right

Cryptanalysis



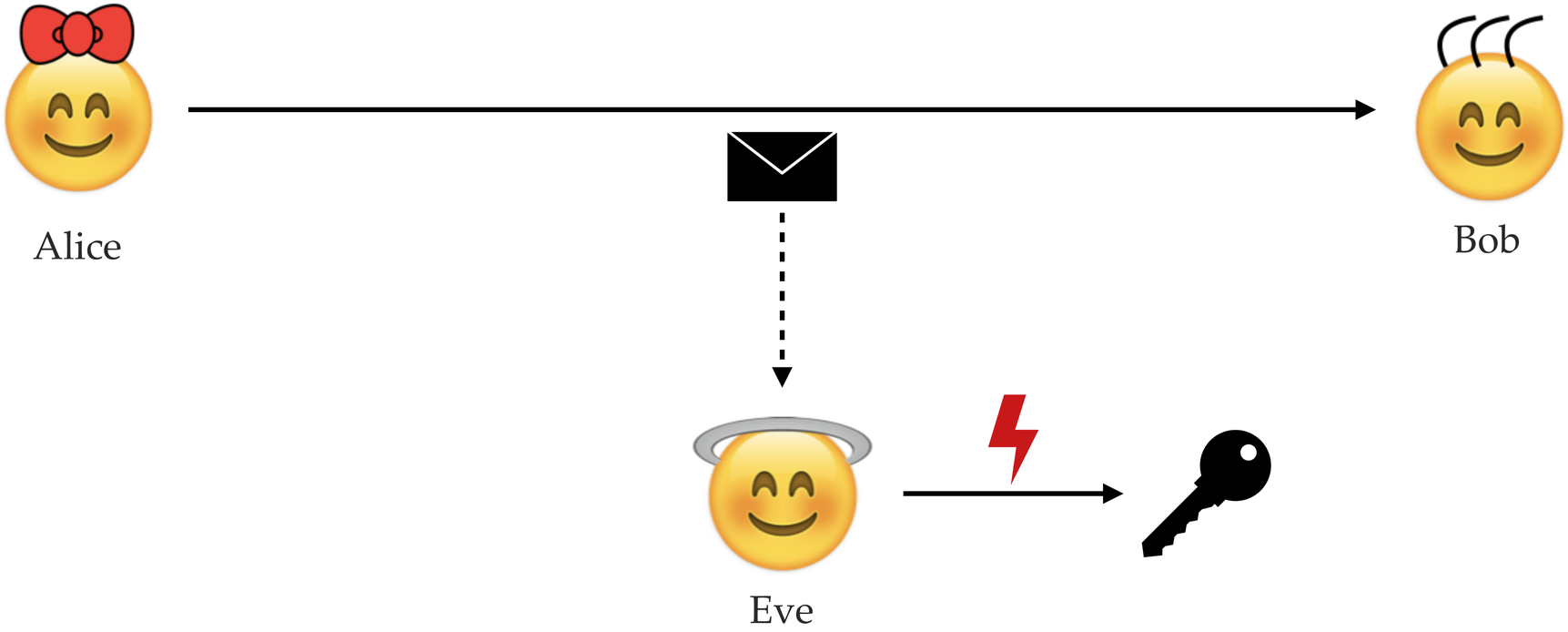
Cryptanalysis



Goal of cryptanalysis in academia

- Ensure that the cryptosystems are secure, before the deployment in real-world applications.
- Determine minimum key length requirements.

Cryptanalysis



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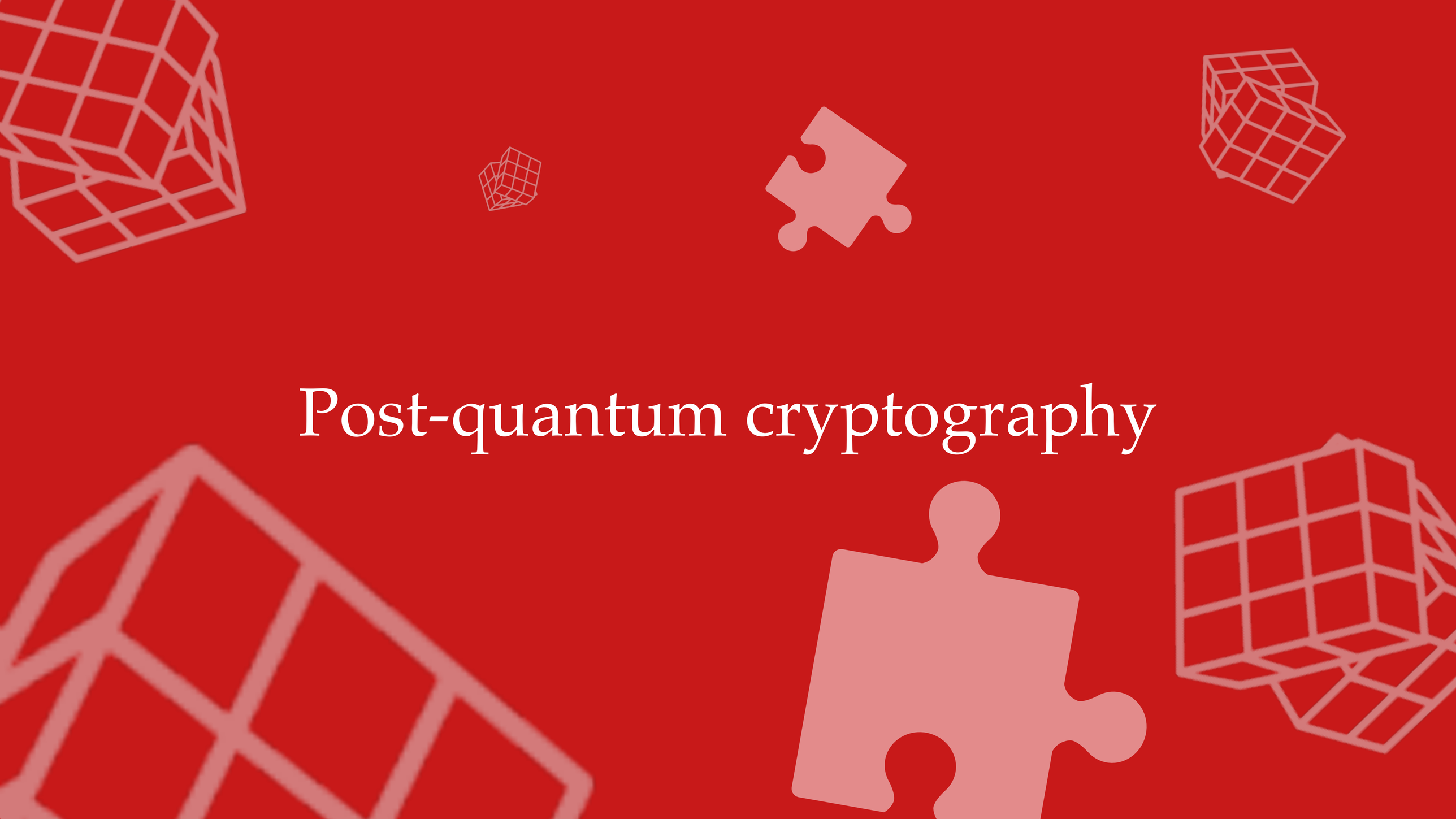
Example: NIST security levels	
I	2^{128}
III	2^{192}
V	2^{256}

Post-quantum cryptography



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- Shor's quantum algorithm: solves integer factorisation and discrete logarithms in abelian groups in polynomial time.
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  - Impact on symmetric cryptography (as a rule of thumb): double the key sizes.

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  - All* currently deployed public-key cryptosystems would be broken by an adversary in possession of a large quantum computer.
  - All public-key cryptosystems need to be replaced.
  - If the public-key cryptography component is broken, the entire infrastructure is broken because the handshake is compromised.
- Grover's quantum algorithm: quadratic speedup of exhaustive search.
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Computationally hard problems

Discrete log problem

Travelling salesman problem

MQ (multivariate quadratic) problem

Isomorphism of polynomials problem

Boolean satisfiability problem

Code equivalence problem

Integer factorisation problem

Graph colouring problem

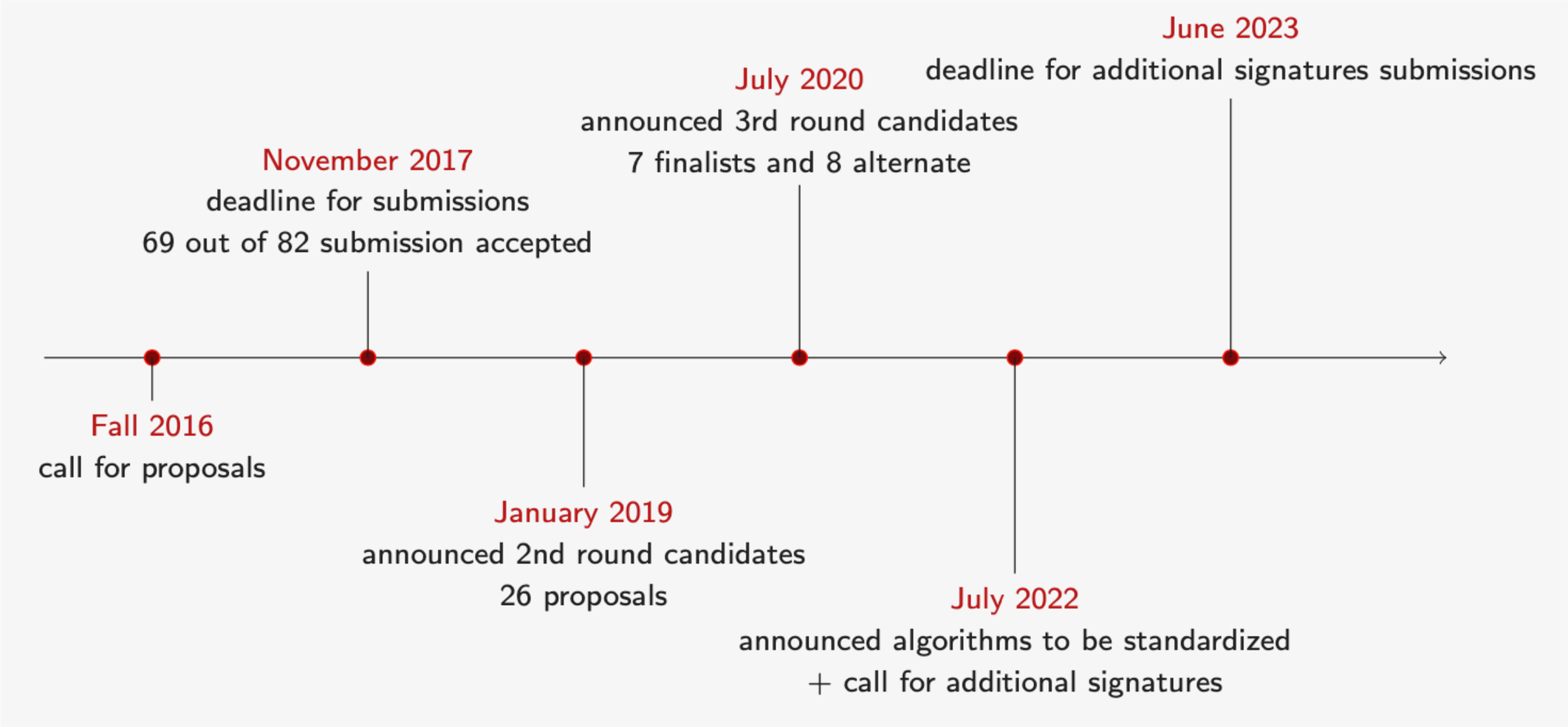
Isogeny path problem

Syndrome decoding problem

Standardisation efforts

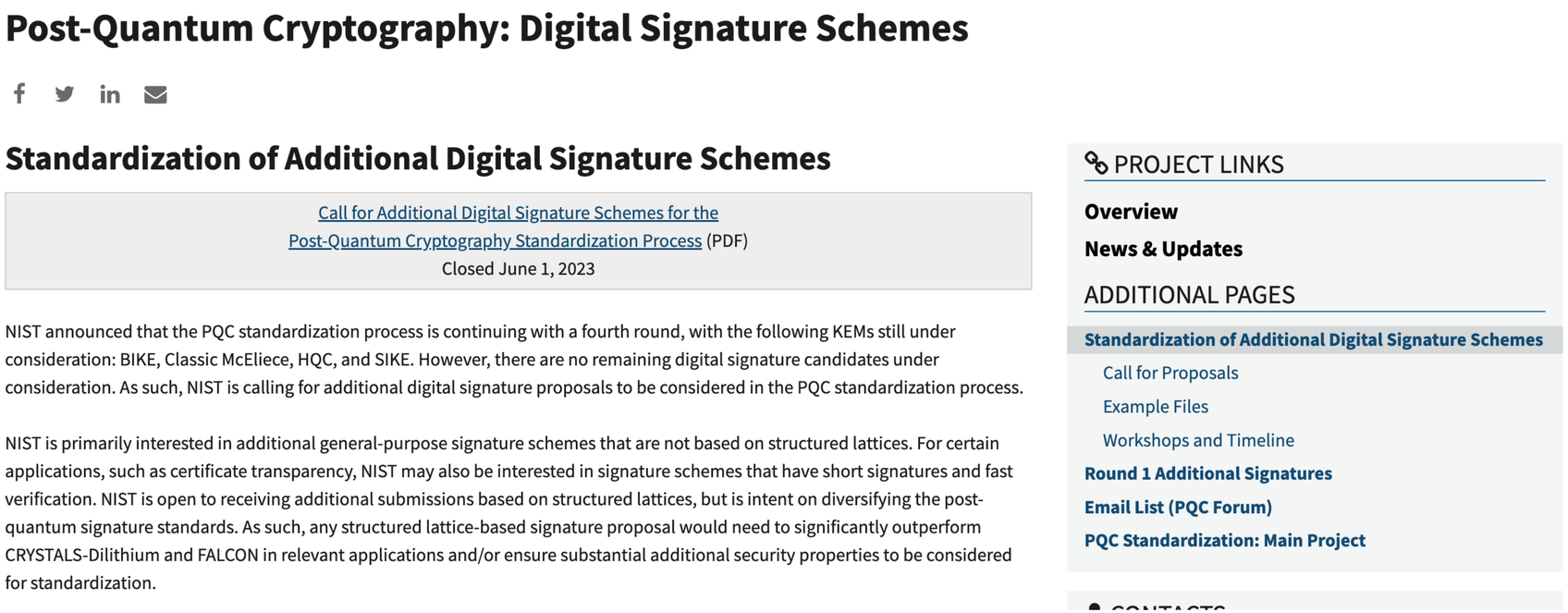
- National Institute of Standards and Technology (NIST), United States
- Information security, cybersecurity and privacy protection: ISO/IEC WD
- Internet Research Task Force (IRTF): RFC 8391
- Chinese Association for Cryptologic Research (CACR), China
- Korean Post-Quantum Cryptography Competition (KpqC), South Korea
- …

NIST standardisation timeline



More signatures

Standardization of Additional Digital Signature Schemes



Post-Quantum Cryptography: Digital Signature Schemes

Standardization of Additional Digital Signature Schemes

Call for Additional Digital Signature Schemes for the
Post-Quantum Cryptography Standardization Process (PDF)
Closed June 1, 2023

NIST announced that the PQC standardization process is continuing with a fourth round, with the following KEMs still under consideration: BIKE, Classic McEliece, HQC, and SIKE. However, there are no remaining digital signature candidates under consideration. As such, NIST is calling for additional digital signature proposals to be considered in the PQC standardization process.

NIST is primarily interested in additional general-purpose signature schemes that are not based on structured lattices. For certain applications, such as certificate transparency, NIST may also be interested in signature schemes that have short signatures and fast verification. NIST is open to receiving additional submissions based on structured lattices, but is intent on diversifying the post-quantum signature standards. As such, any structured lattice-based signature proposal would need to significantly outperform CRYSTALS-Dilithium and FALCON in relevant applications and/or ensure substantial additional security properties to be considered for standardization.

PROJECT LINKS

Overview

News & Updates

ADDITIONAL PAGES

Standardization of Additional Digital Signature Schemes

Call for Proposals

Example Files

Workshops and Timeline

Round 1 Additional Signatures

Email List (PQC Forum)

PQC Standardization: Main Project

NIST announced 40 valid submissions divided in 7 categories:

- Code-based
- Isogeny-based
- Lattice-based
- MPC-in-the-Head
- Multivariate
- Symmetric-based
- Other

Course plan : part 1

- Algebraic cryptanalysis: MQ solving
- Multivariate cryptography: trapdoor constructions; UOV
- Code-based cryptography I: equivalence problems; the Fiat-Shamir construction
- Code-based cryptography II: information set decoding; the MPC-in-the-Head construction
- Lattice-based cryptography: Dilithium (subject to change)
- Isogeny-based cryptography: SQISign (subject to change)
- Hash-based cryptography: stateless signatures; SPHINCS$^+$

Tutorials

- The tutorial session in week i is dedicated to answering your questions from assignment $(i-1)$.
- Some of the exercises are about experimenting with the mathematical objects that are studied via a computer algebra system. You can submit those for feedback in either SageMath or Magma, according to your preference.