Threshold Cryptography for Multiple Operators

INFORMATION TECHNOLOGY LABORATORY

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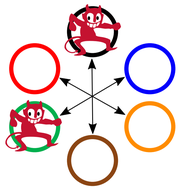
NIST National Institute of Standards and Technology U.S. Department of Commerce

The threshold paradigm

Distribute trust over a secret key, via *secret-sharing*. Then, a key-based operation goes through without the key being in any one place.



Threshold: Secure even if f parties are malicious.

Focuses: signatures and encryption schemes.

Good news:

- Strong feasibility results (MPC)
- Well understood framework
- Expert stakeholders interested in standards

Challenges: many tradeoffs (e.g., various building blocks; crypto assumptions vs. efficiency) to consider; enable composability.

Webpage: https://csrc.nist.gov/projects/threshold-cryptography

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Poster produced by Luís T. A. N. Brandão (at NIST as a contractor from Strativia) for the NIST-ITL Science Day 2021 (October 28)

Towards guidelines

PAST (2019–2020)
- 2 reports
- 2 workshops

PRESENT **Call 2021a** for feedback **till Sep. 13**

UPCOMING **IR 8214B** Specify criteria

Call for feedback (2021a) on criteria:

Gadgets	**Interchangeability**	**Threshold profiles**
System model	**Games and UC**	**Adaptive security**

Looking forward:

- One "supplement" per primitive
- Public consultation with experts
- NISTIR on criteria
- Future guidance and recommendations

Acronyms. **AES**: Advanced Encryption Standard. **AHE**: Additively Homomorphic Encryption. **DSA**: Digital Signature Algorithm. **ECDSA**: Elliptic-curve DSA. **EdDSA**: Edwards-curve DSA. **MPC**: Secure Multiparty Computation. **RSA**: Rivest Shamir Adleman. **UC**: Universal Composability.

"Thresholdizations" in consideration

Legend: secret-shared (secret-key d, nonce k, primes p, q); clear view (message m, plaintext p, signature [component] s, modulus N).

Threshold EdDSA/Schnorr.
- $s = k + c \cdot d \pmod q$
- Linear in d and k: easy if k is random.

Threshold ECDSA.
- $s = k^{-1} \cdot (m + r \cdot d) \pmod q$
- Non-linear relation: MPC or AHE based.

Threshold RSA sign/decrypt.
- $s = m^d \pmod N$
- Easy to thresholdize using RSA.

Threshold AES.
- $c = \mathrm{Enc}_d(p)$. MPC for Boolean circuit.

Distributed RSA keygen.
- $p, q \leftarrow^{\$} \mathrm{Primes}[\lambda], N = p \cdot q$
- Pre-sieving, biprimality test (multi trials).