Avalanche effect in improperly initialized CAESAR candidates

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icons from The Noun Project

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Cryptoprimitives abuse: OpenSSL example

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void RAND_seed(const void *buf, int num);
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... this lead to a flood of error reports.

Initi[illegible]pose: [illegible]SSL example

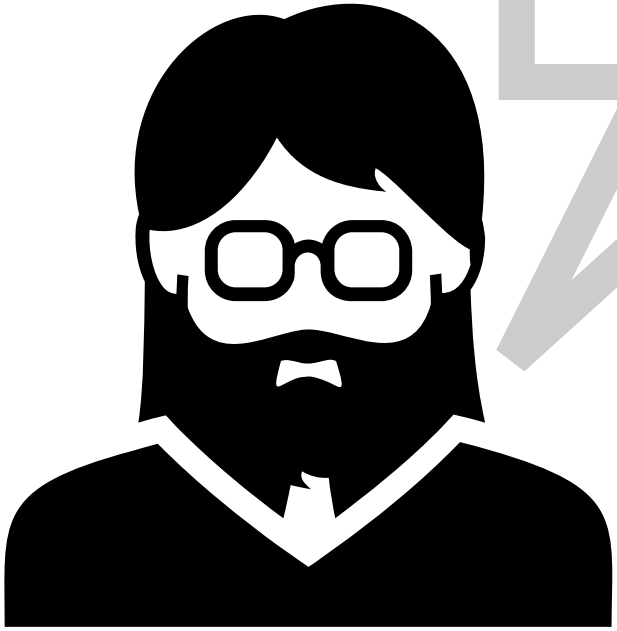
- [illegible]SL init[illegible]5)
- Add[illegible]
  if at le[illegible]
  (pro[illegible]
- [illegible]r re[illegible]

example courtesy of Peter Gutmann
Lessons learned in implementing
and deploying crypto software
USENIX 2002

- constant string
- public key components
- rand() calls
- /etc/passwd, /var/log/syslog
- downgrading
- seeding by the unseeded generator
- “patching” to disable entropy checks
- ...

A call for ...

Developer-resistant cryptography!*



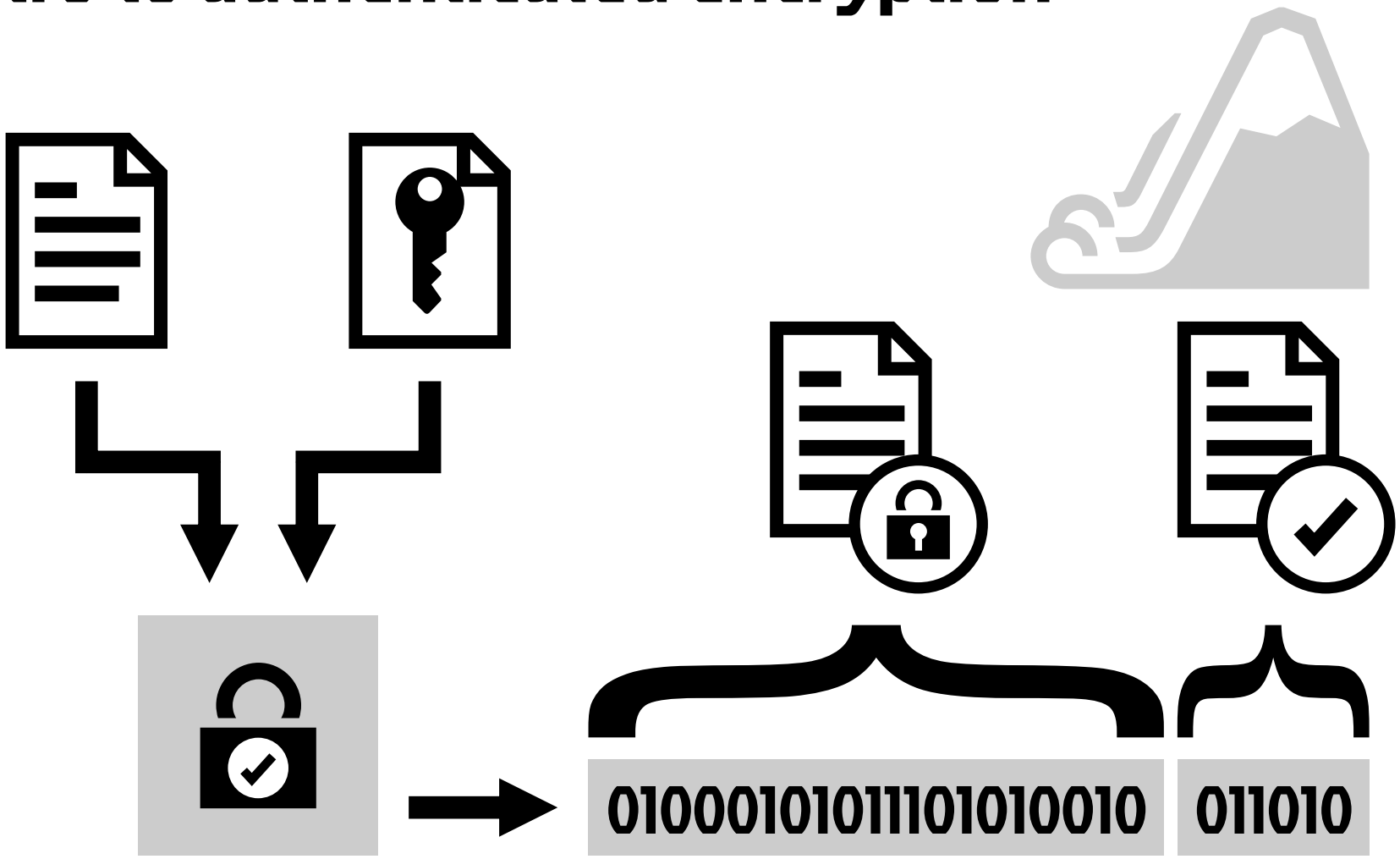
*Kelsey Cairns, Graham Steel

W3C/IAB Workshop on Strengthening the Internet Against Pervasive Monitoring (STRINT), London, UK, February 28-March 1, 2014.

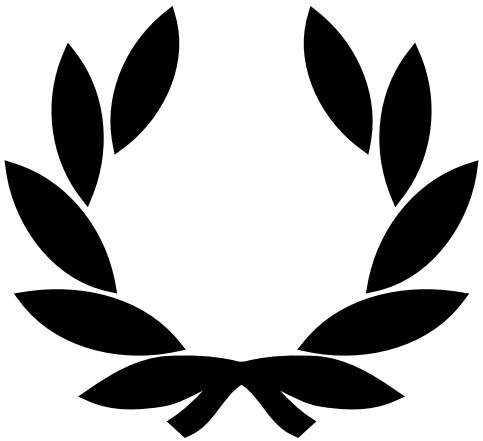
Authenticated encryption?

```
int crypto_aead_encrypt(
    unsigned char *c, unsigned long long *clen,
    const unsigned char *m, unsigned long long mlen,
    const unsigned char *ad, unsigned long long adlen,
    const unsigned char *nsec,
    const unsigned char *npub,
    const unsigned char *key
);
```

Intro to authenticated encryption



Tested AE schemes



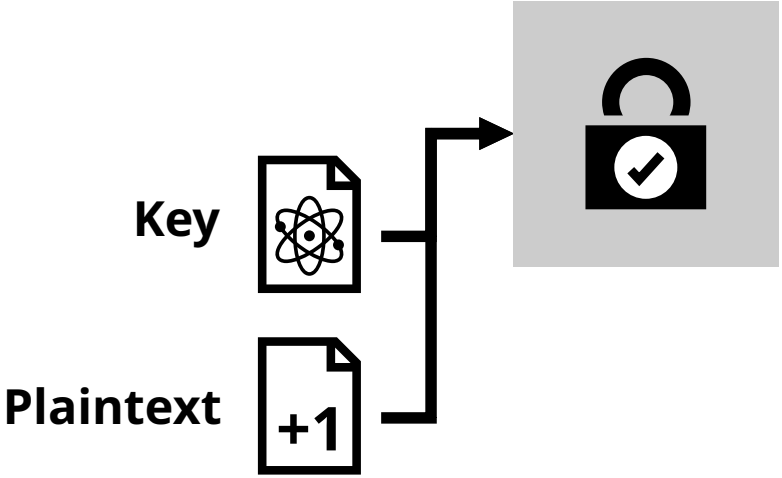
CAESAR

Competition for Authenticated Encryption: Security, Applicability and Robustness

(EPFL, KU Leuven, Inria, Uni. of California, Vodafone, STMicroelectronics, ...)

56 designs (172 shemes) in 1st round

Generating stream of data



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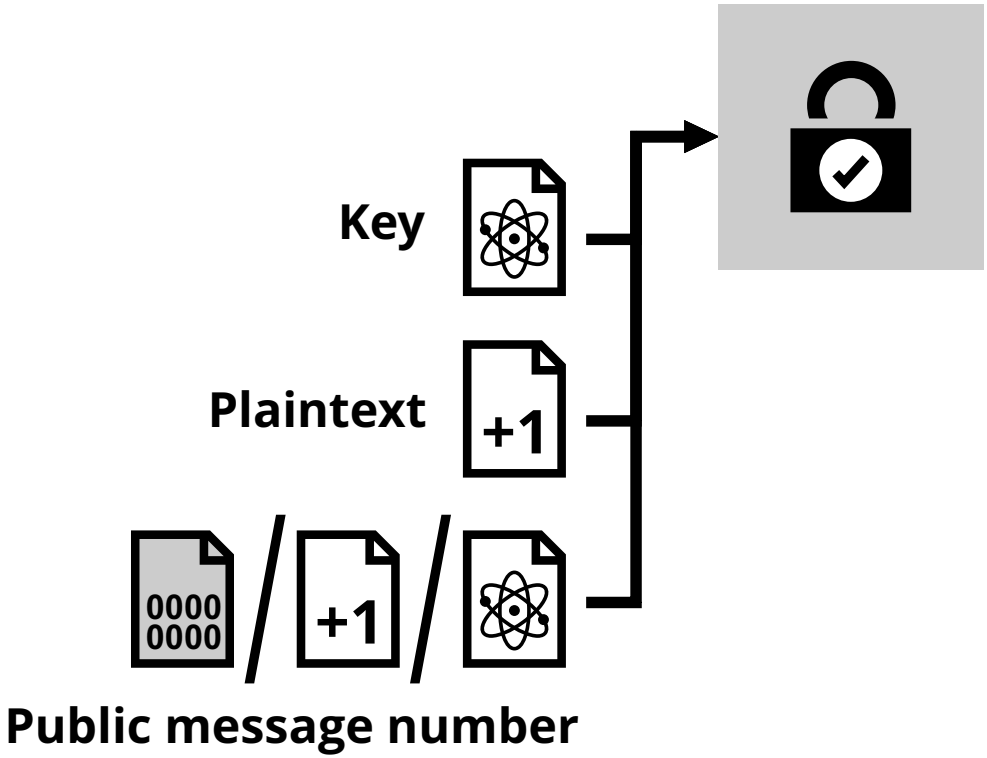

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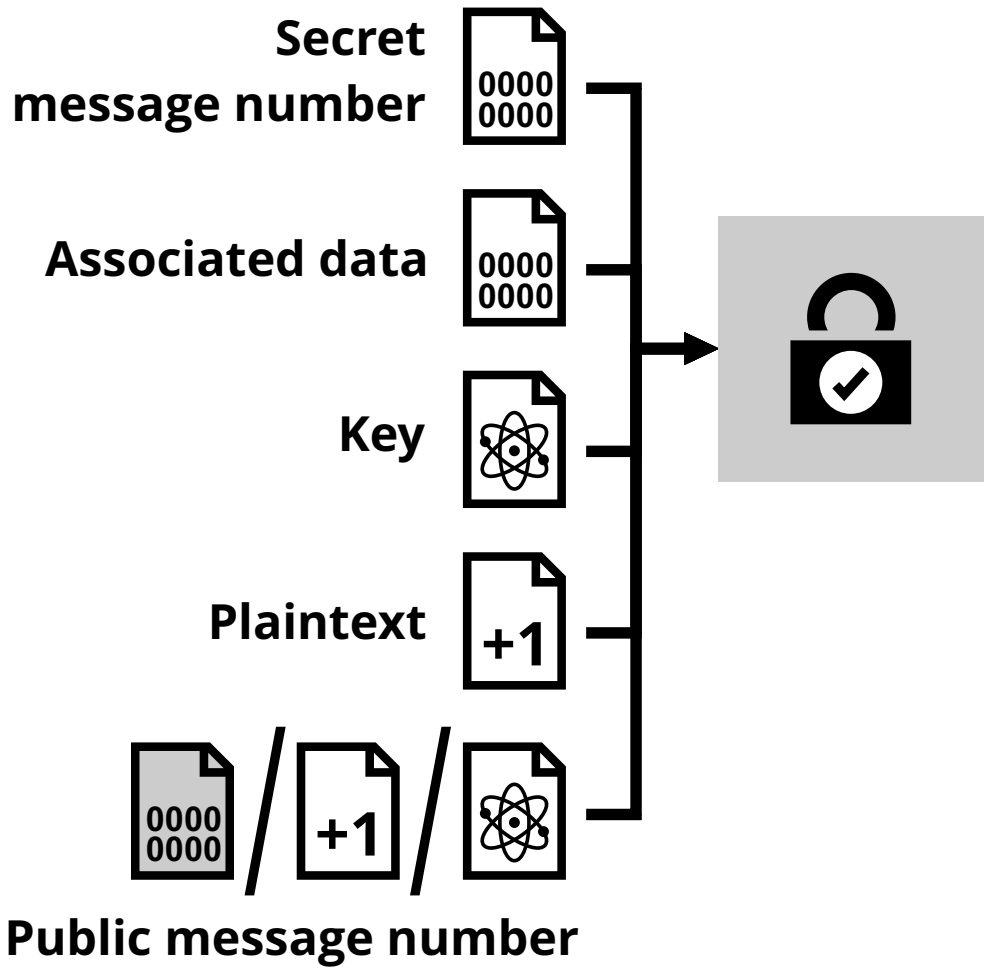

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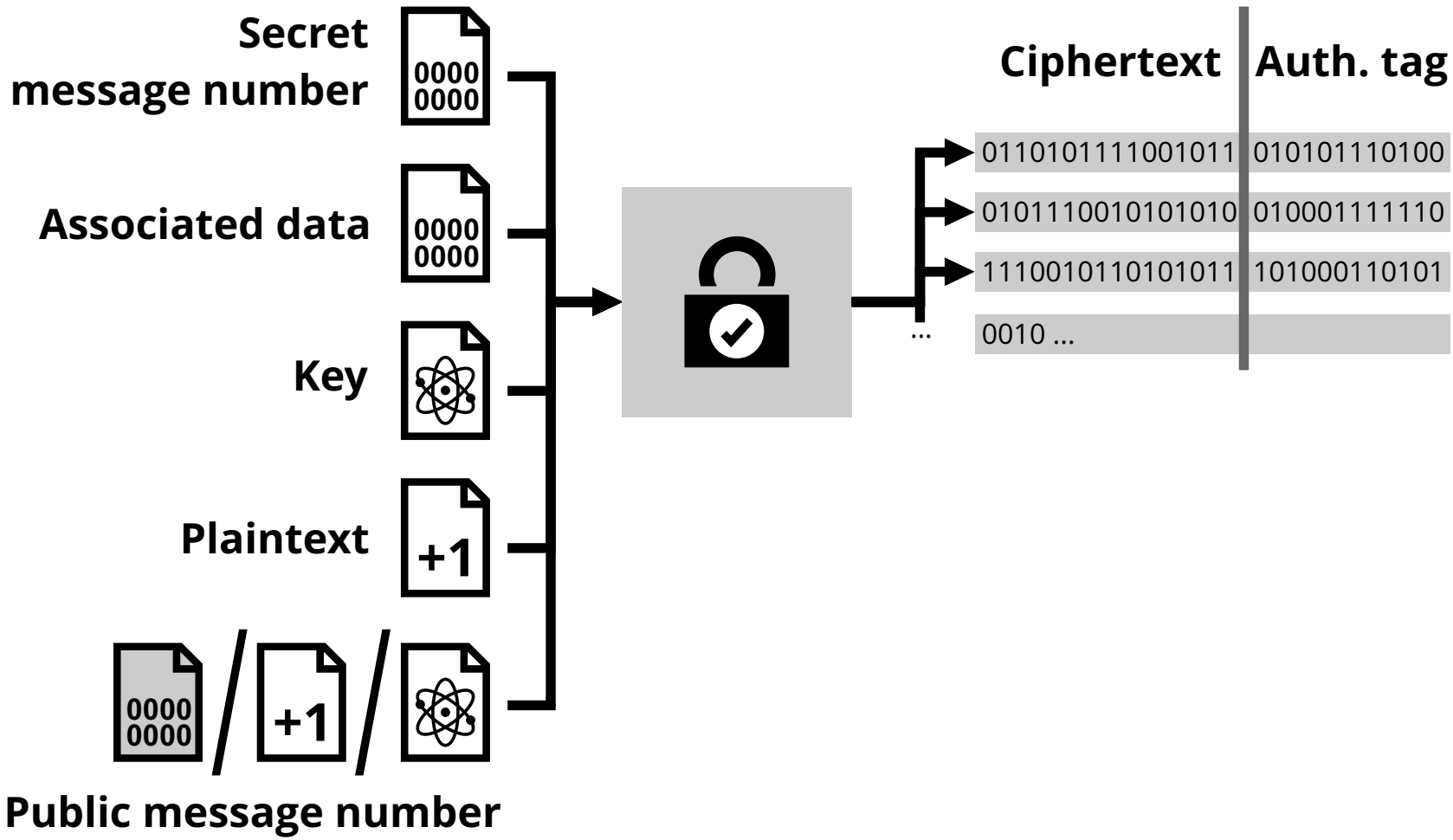

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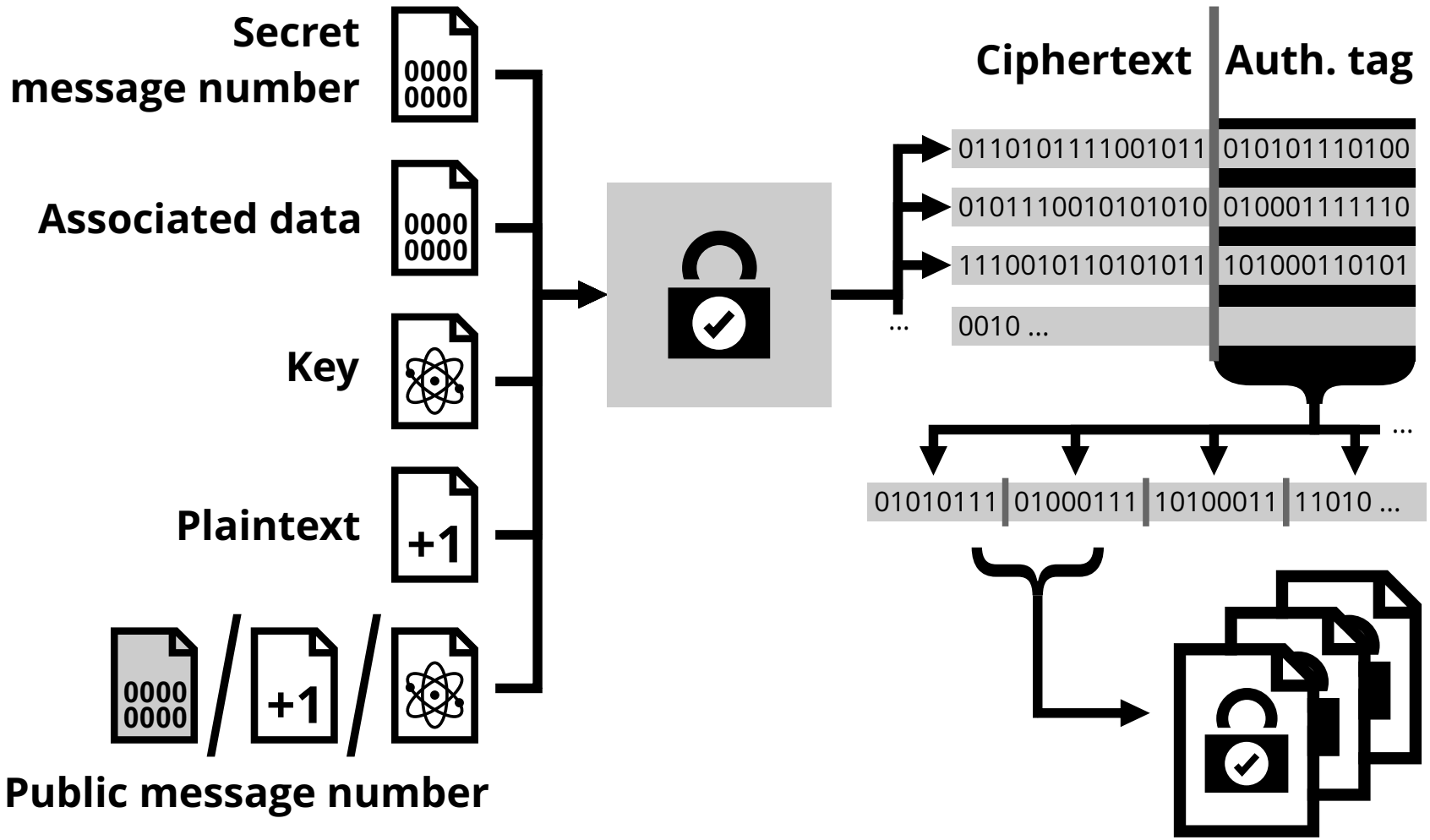
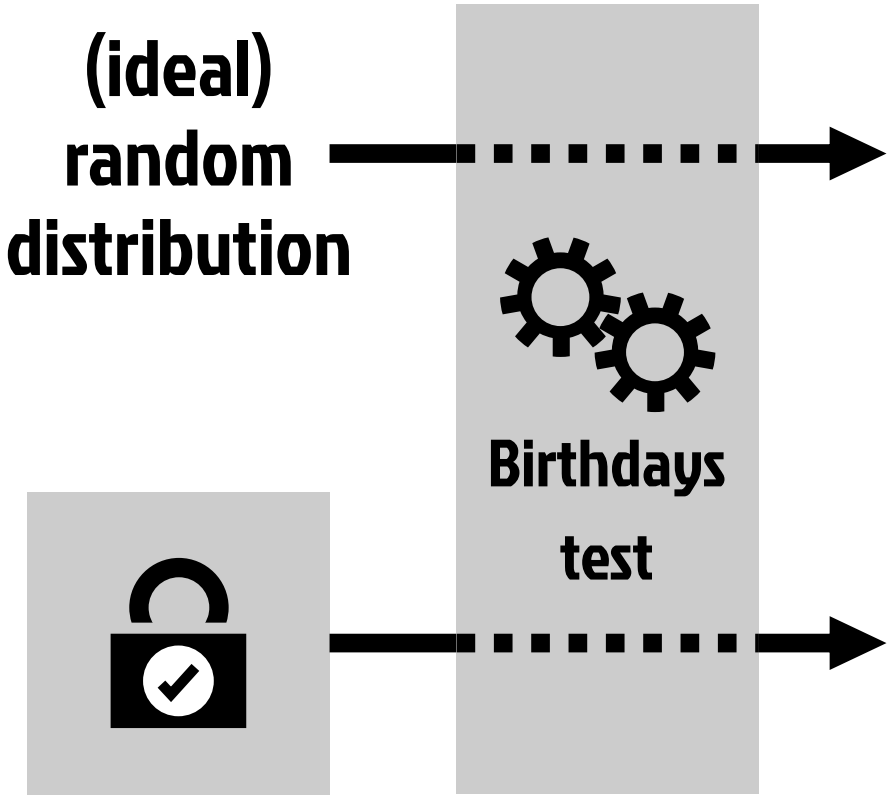


Statistical testing of randomness



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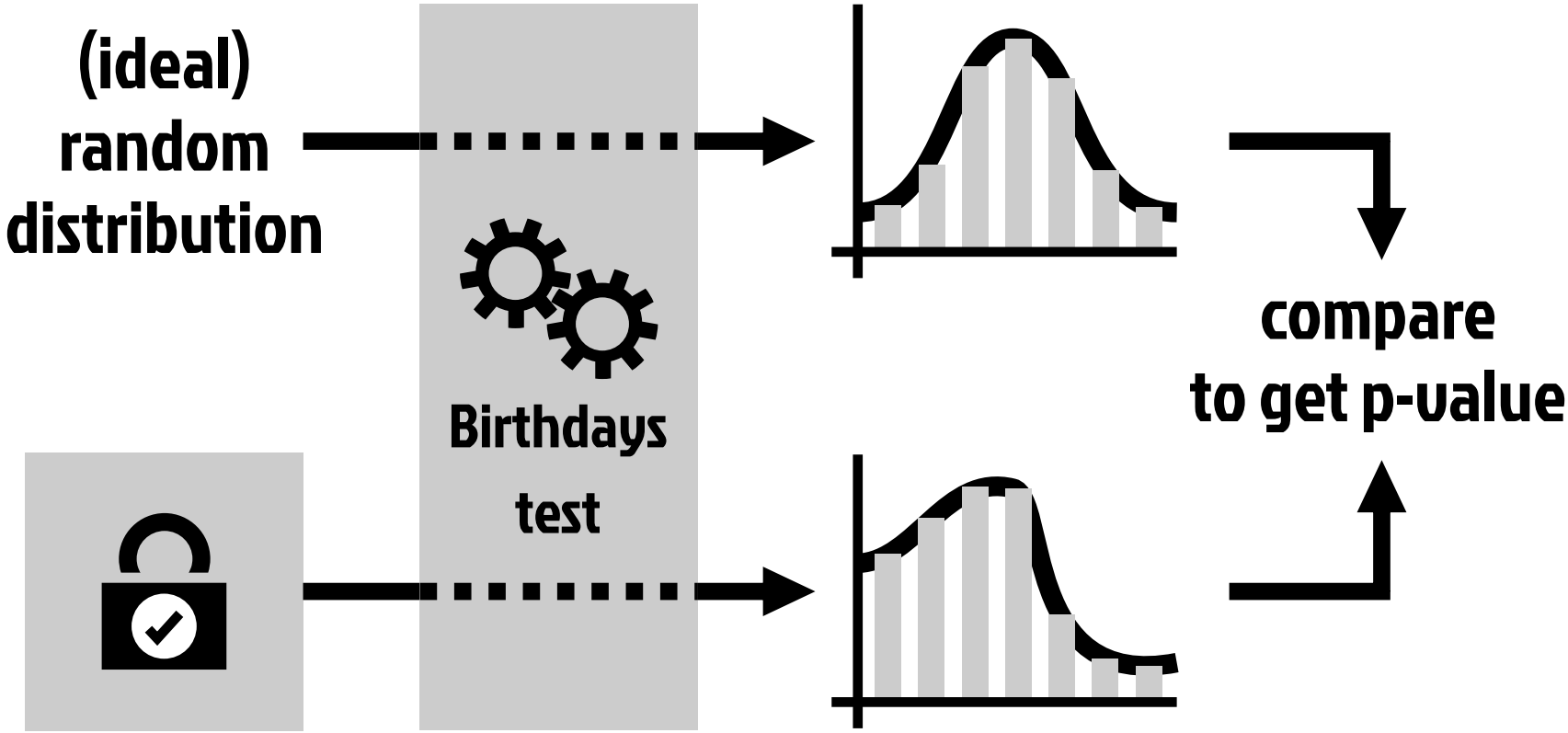
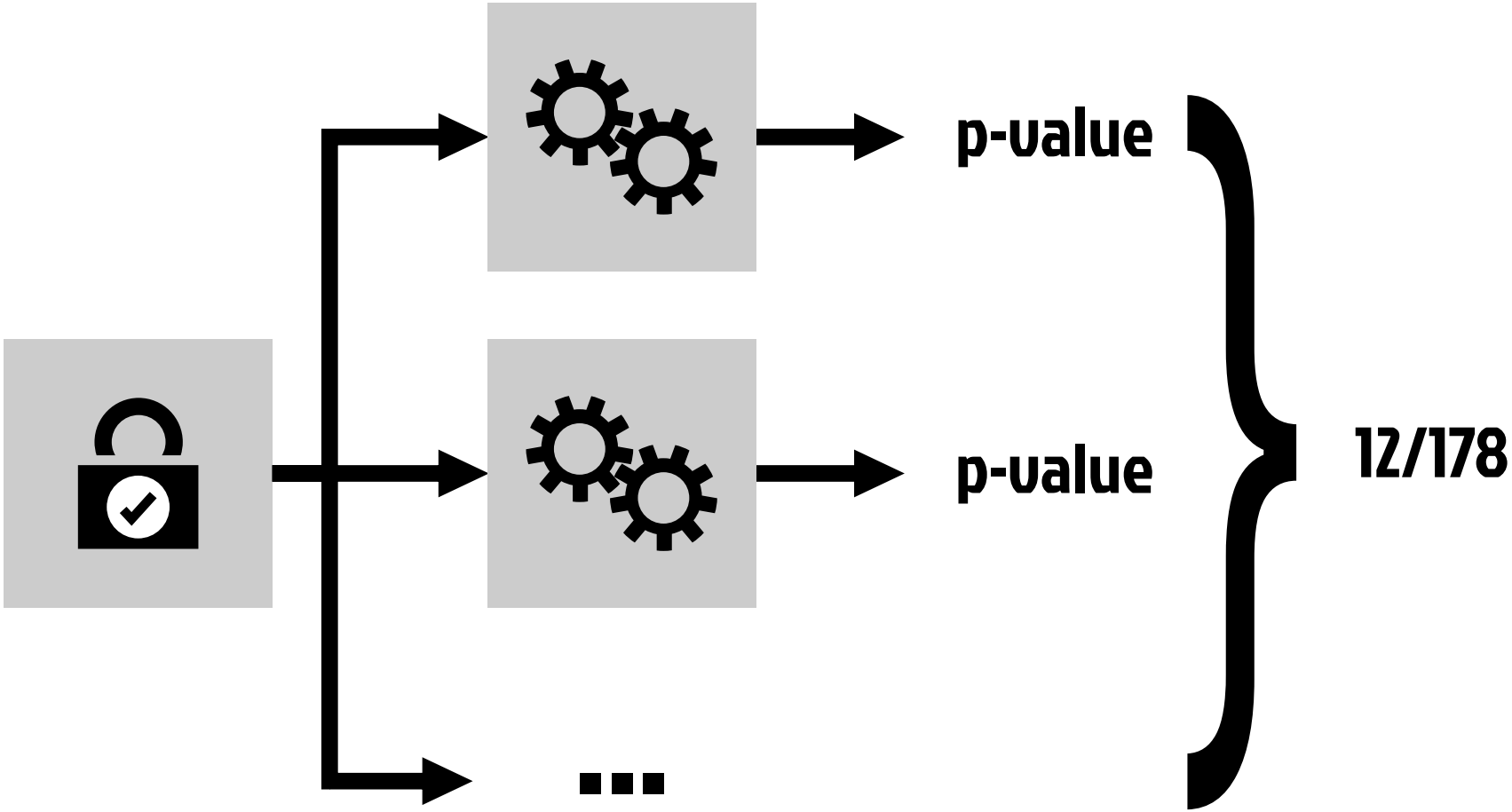
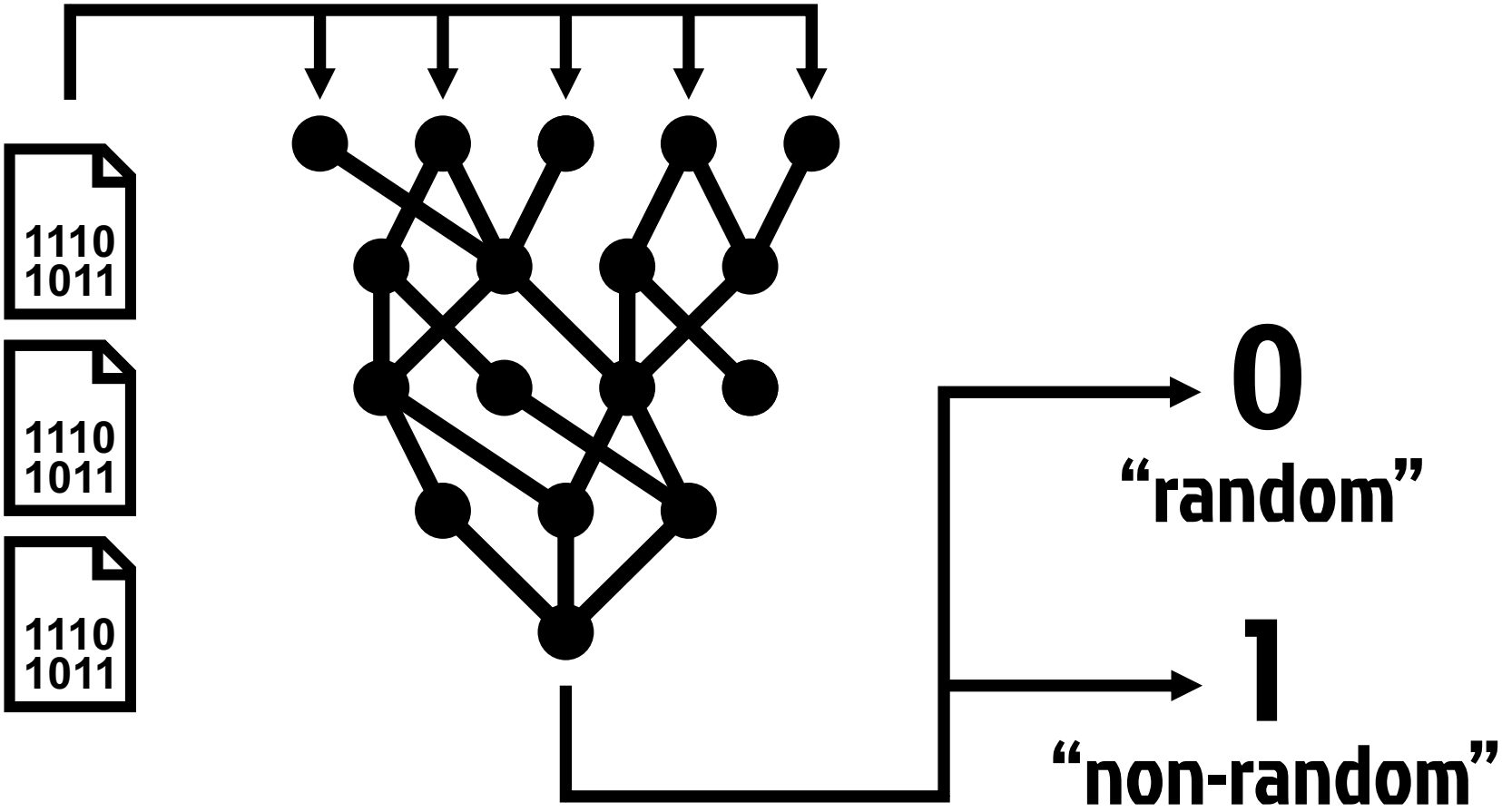


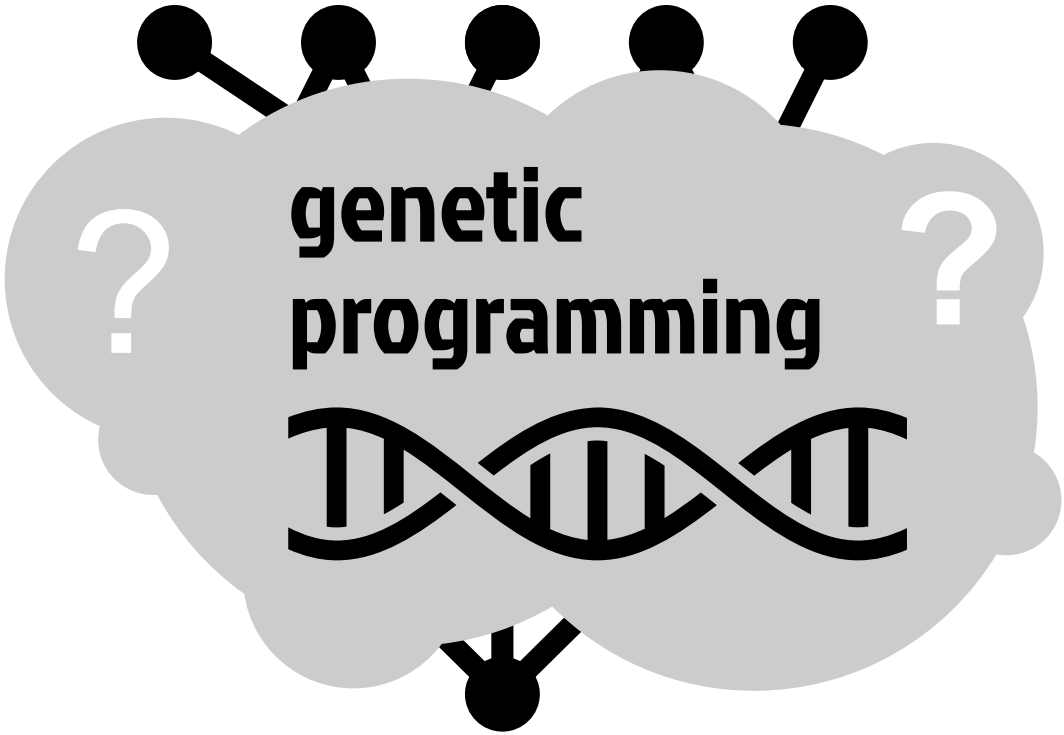
Statistical batteries



Distinguish randomness with EACirc



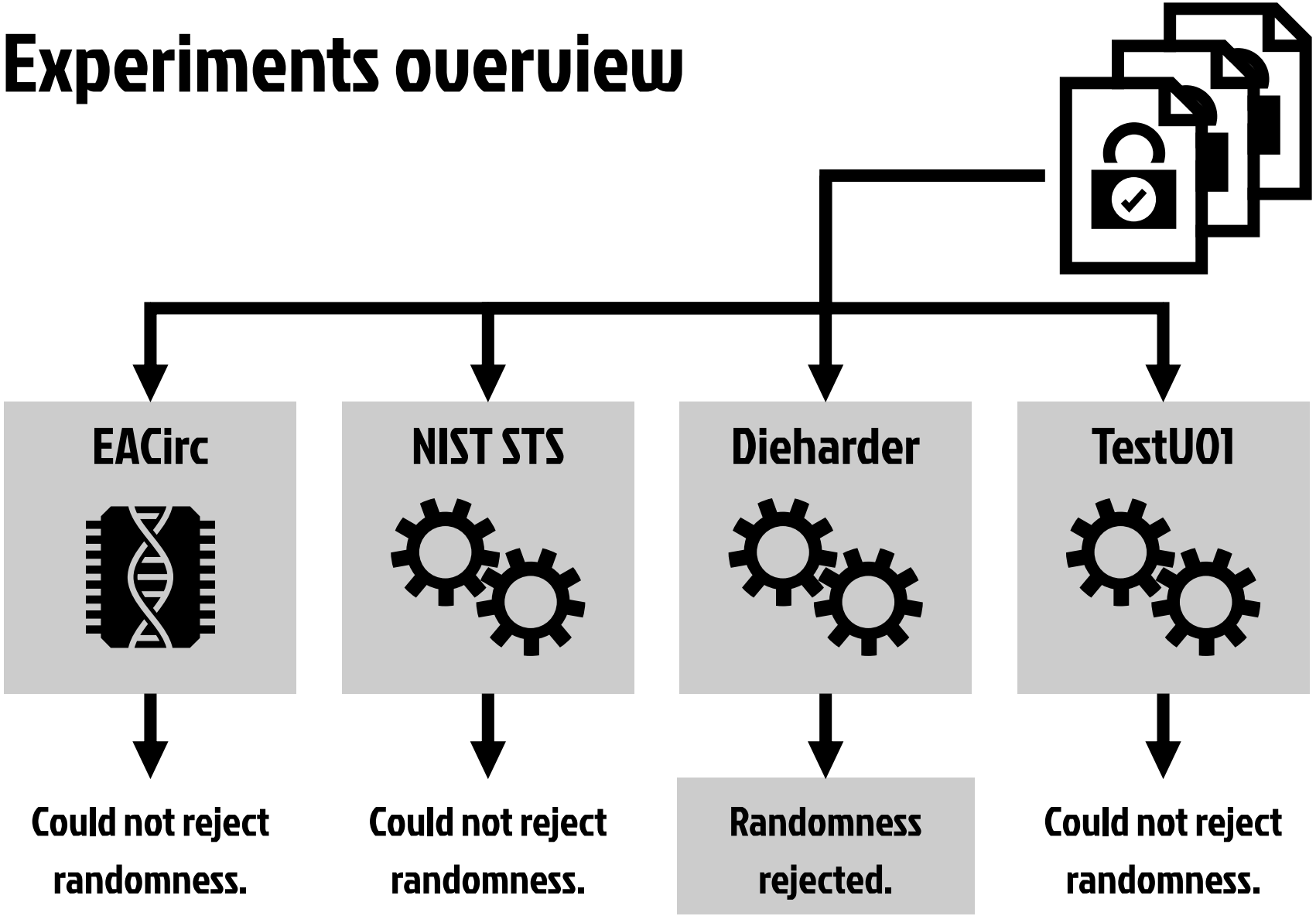
...using evolutionary algorithms



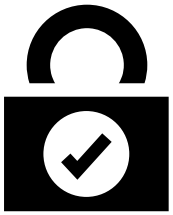
EACirc

Fork me on GitHub!
github.com/crocs-muni/EACirc

Experiments overview



Tested scenarios



Tested data streams

- authentication tags from CAESAR candidates
- 52/56 designs tested (168/172 schemes)
- 1 reference design (AES/GCM)
- 3 different public message number modes

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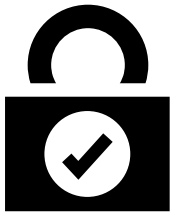

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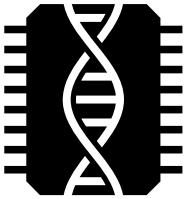
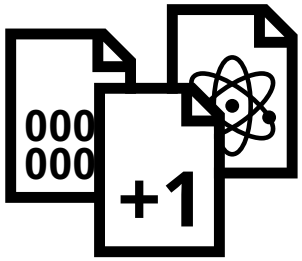


Randomness assessment tools

- statistical batteries (NIST STS, Dieharder, TestU01)
- genetically inspired framework (EACirc)

Results interpretation



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- random: Marble, (AES-CMCC), ((Raviyoyla))

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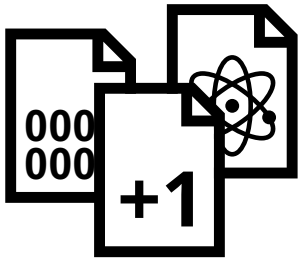

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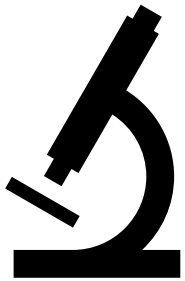

High-level observations

- as expected: zero < counter < random
- worse candidates not in further rounds of CAESAR
- statistical tools generally comparable
- EACirc significantly worse (1 exception)

Study limitations

Testing stream length

- NIST STS: 12MiB (~700 000 tags)
- Dieharder: 916 MiB (~60 000 000 tags)
- TestU01: 128 MiB (~8 400 000 tags)
- EACirc: 2.24 GiB (~150 000 000 tags)

Not inspected

- ciphertext randomness
- other plaintext modes
- ...

Definitions of good security

Semantic security

- No probabilistic polynomial-time algorithm with ciphertext has advantage to PPTAs having only message length
- No plaintext info can be <u>feasibly</u> extracted from ciphertext

Perfect secrecy

- information-theoretical analogy to sematic security
- ciphertext reveals no information about plaintext

Chosen-plaintext attack ciphertext indistinguishability

- equivalent to semantic security (Goldwasser and Micali, 1982)

Conclusion

“Not even state-of-the-art AE schemes have avalanche effect strong enough for zero-initialized PMN mode.”

no direct practical attack

yet semantic security broken

Thank you!

The avalanche of questions is very welcome.

Pre-print, presentation and all data avaliable at crcs.cz/papers/memics2016