ARMed SPHINCS:

Computing a 41 KB signature in 16 KB of RAM

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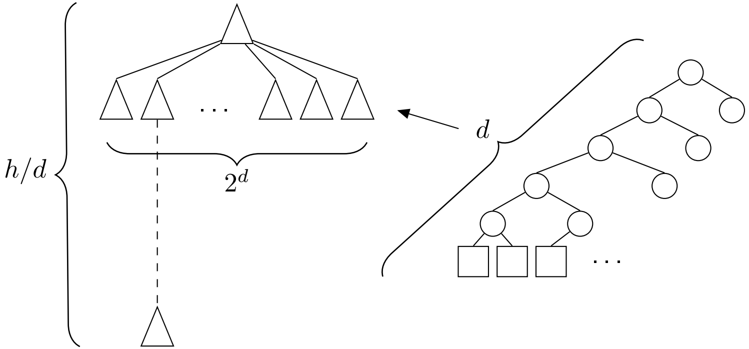
PQCRYPTO
ICT-645622

SPHINCS

- SPHINCS: Stateless, practical, hash-based, incredibly nice cryptographic signatures [BHHLNPSW15].
- Hash-based schemes: conservative choice
  - Hash functions do not fall to Shor (but halved by Grover)
  - One-way functions necessary for signatures [Rom90]
  - Tight security reductions
- SPHINCS-256 in PQCRYPTO's 'Initial recommendations'

SPHINCS-256

- Large hash-tree, height $h = 60$
- Every $d = 12$-th layer: sign child node
  - Effectively a hypertree of $h/d = 5$ Merkle trees [Mer90]
  - Trade signature size for time
- Sign messages using 2^{60} leaf nodes



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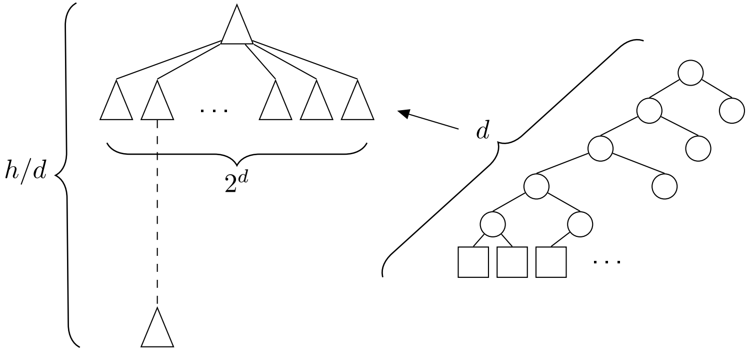
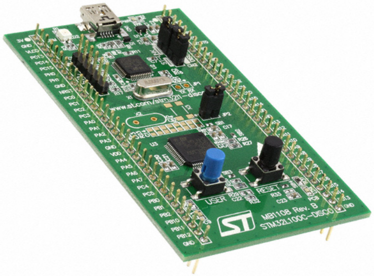
- No need to remember index: **stateless** [Gol87]



Platform

- STM32L100C development board
- Cortex M3, ARMv7-M
- libopencm3 firmware
- 32MHz, 32-bit architecture
- 16 registers
- 256KB Flash
- **16KB RAM**



Treehash

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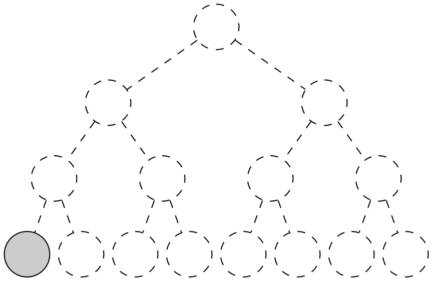

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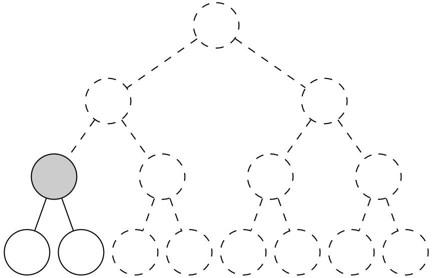

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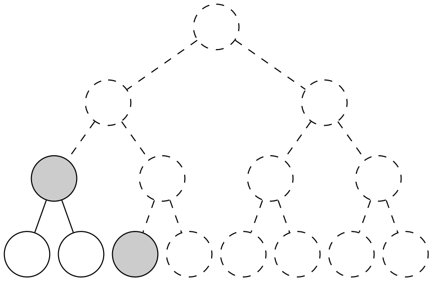

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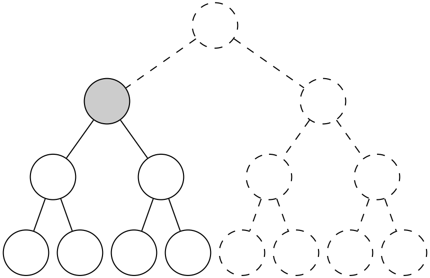

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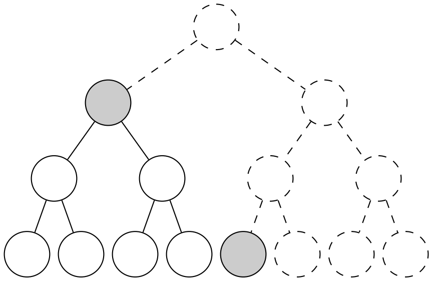

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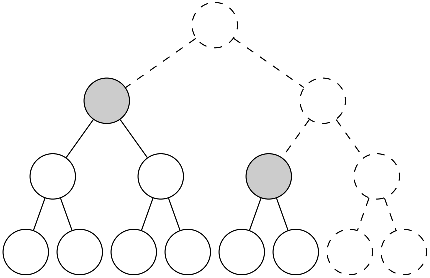

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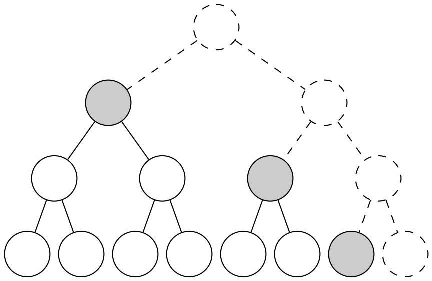

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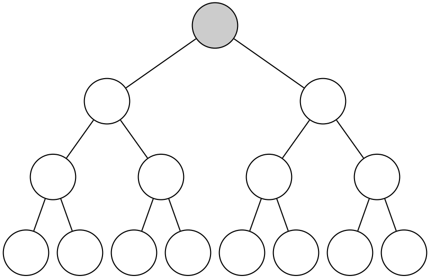

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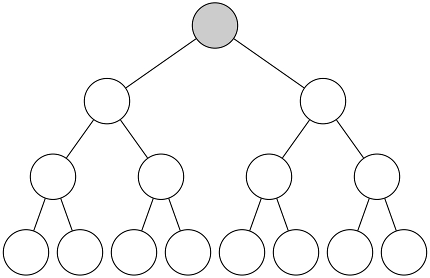
- Trace 32 ‘random’ paths through tree



Other aspects

- Streaming data
  - Signature does not fit in memory
    - ..and is generated out of order
  - Sizable messages do not fit in memory
  - Key material does not fit in memory
  - . . .
- Optimising ChaCha$_{12}$
  - 685818 calls per signature
  - 65% of total computation costs

Performance

- Works on 16KB RAM ✓
  - Uses less than 7KB

- Key generation: 0.88 seconds
- Signing: 18.41 seconds
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- Implemented XMSS^{MT} [HRB13], configured similarly
  - Stateful: process leafs incrementally

Conclusions

- Stateless is expensive, but not prohibitively so
  - Signing 30x as expensive as XMSS^{MT}
  - Verification similar to XMSS^{MT}
  - (Key generation much cheaper)
- Feasible on limited platforms
  - ..although not very practical for interactive applications
- Code is available (public domain):
  https://joostrijneveld.nl/papers/armedsphincs/

Reference I

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