Hash-based signatures IV

Stateless signatures

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(with some slides by Daniel J. Bernstein and by Andreas Hülsing)

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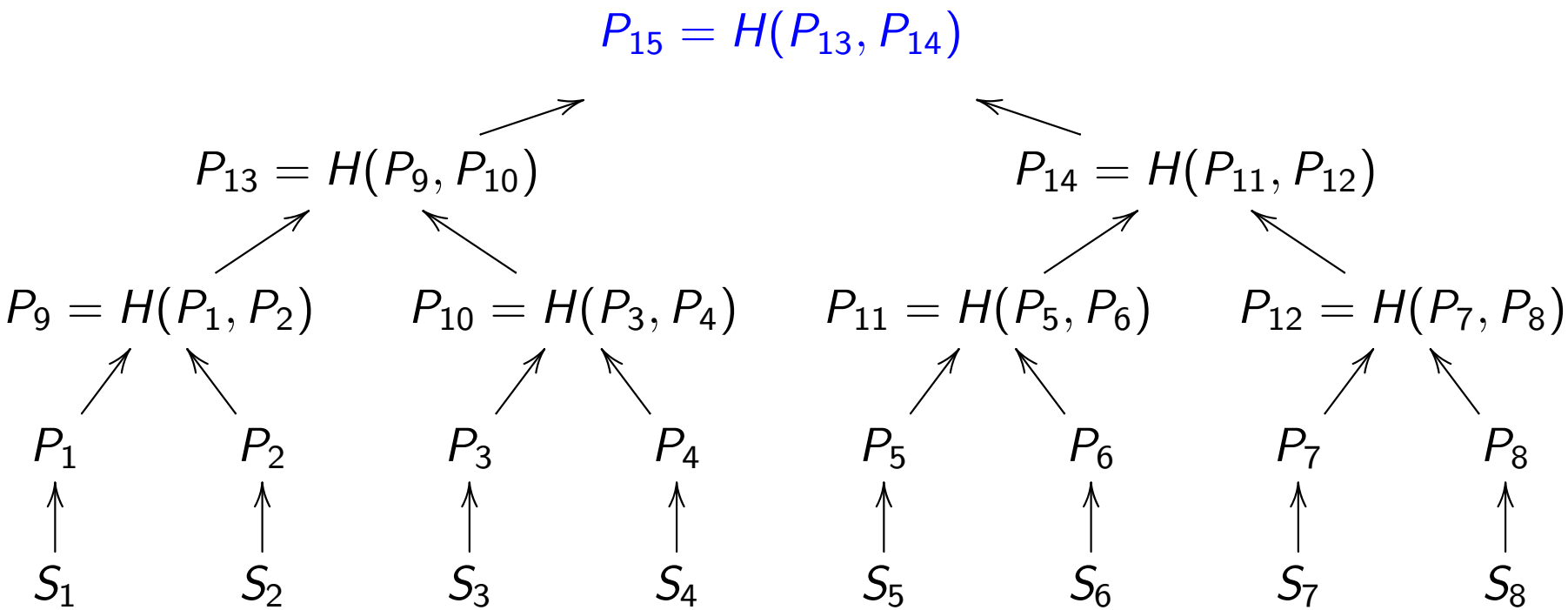
SAC – Post-quantum cryptography

Trees of Merkle trees



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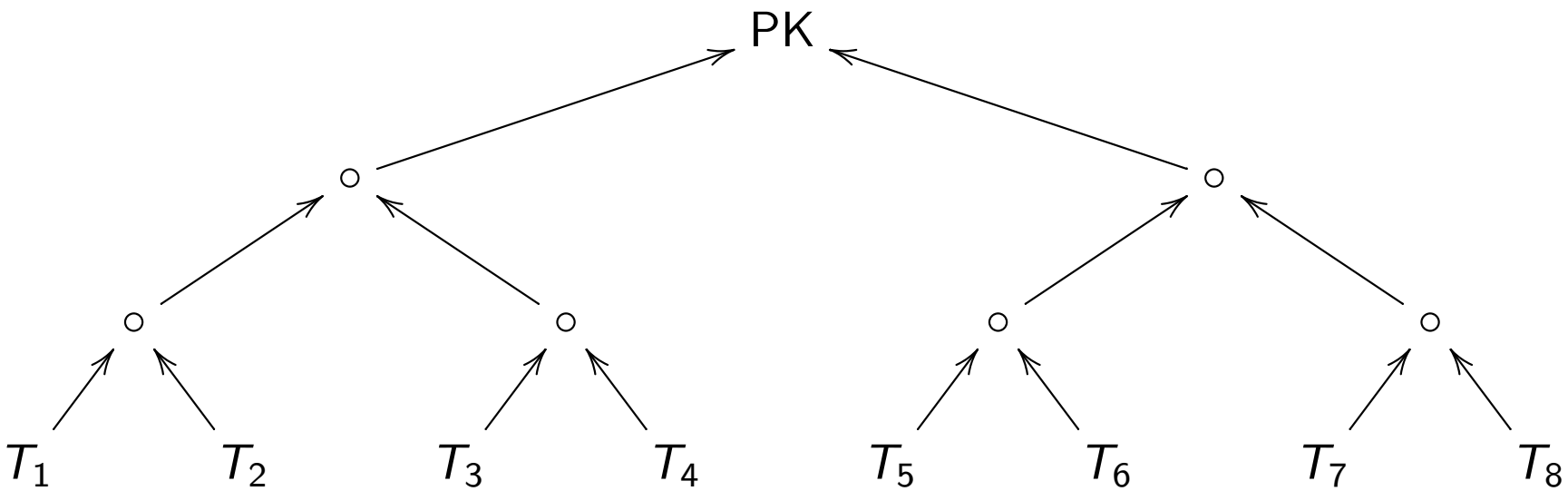

T_i are one-time signatures.
$\uparrow$ indicates input to hash function.

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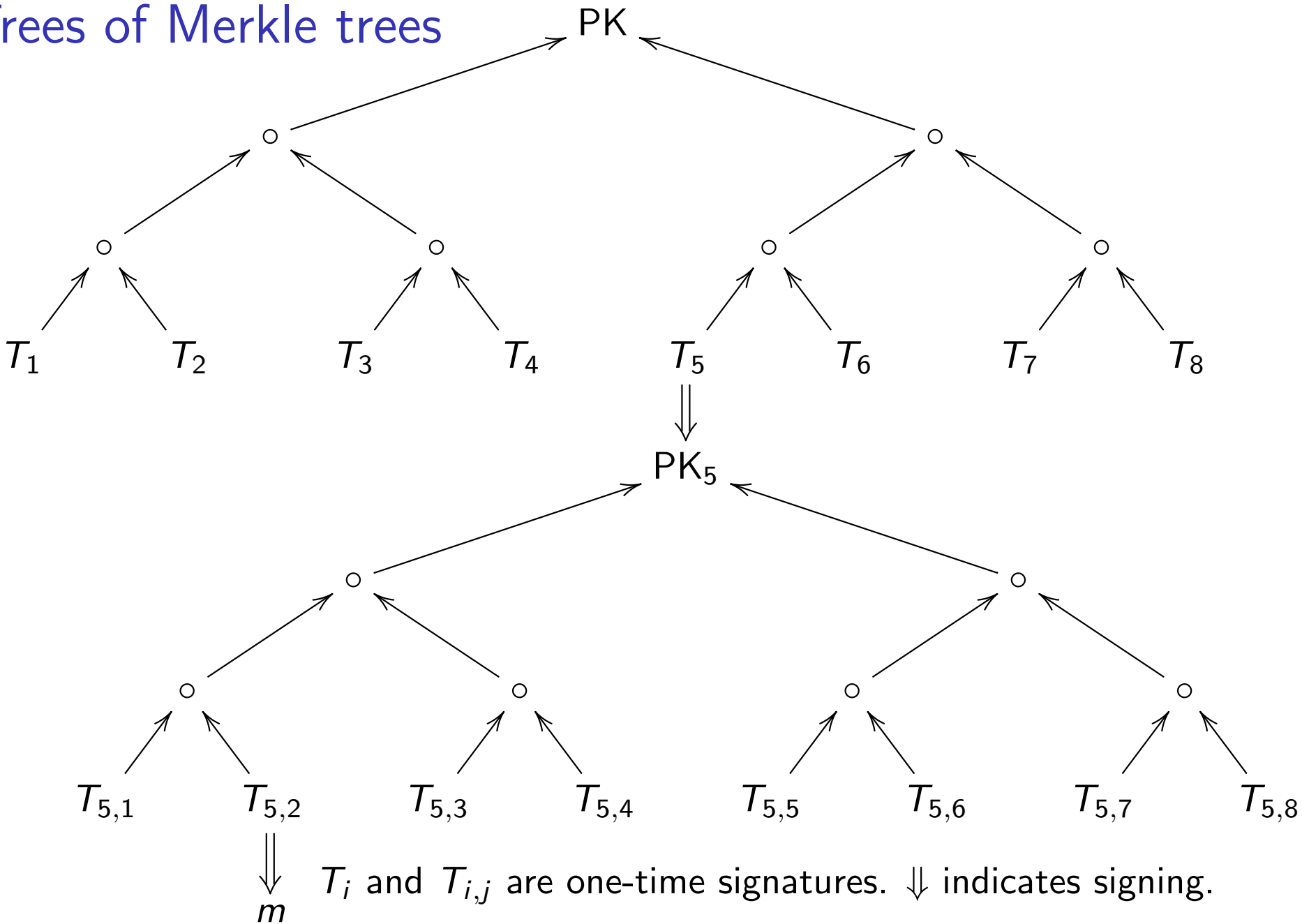

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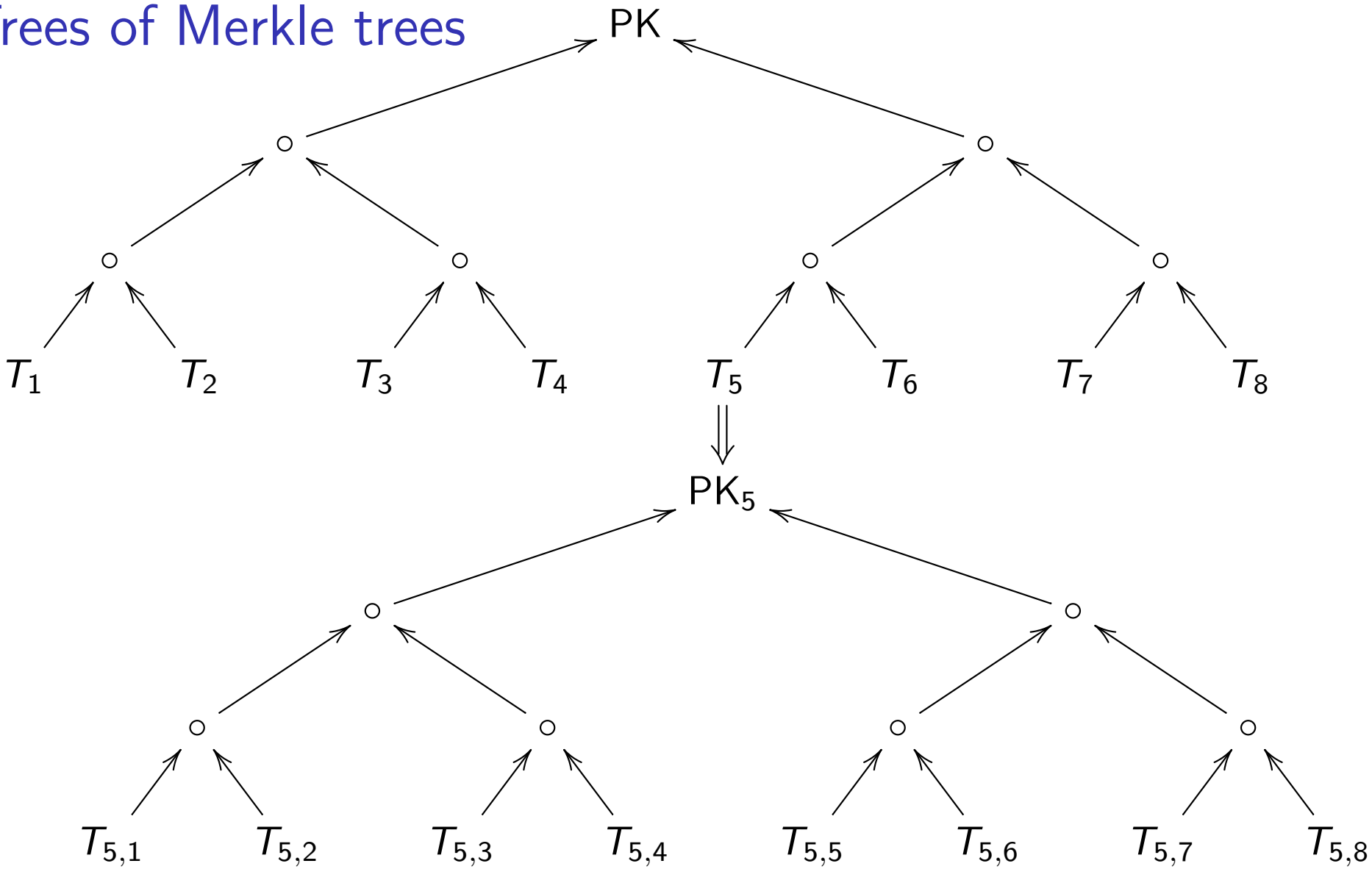

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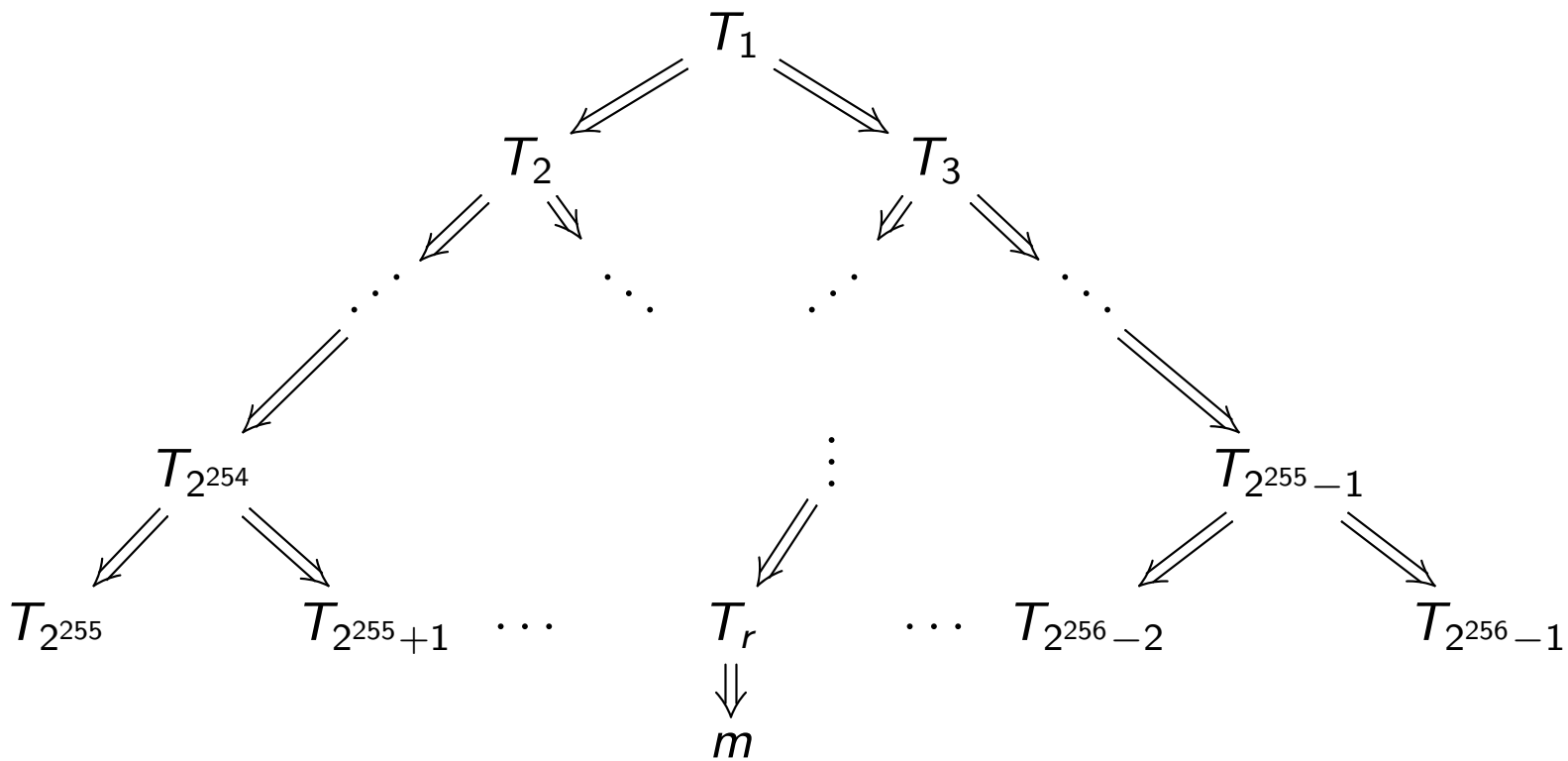
No need to know PK_5 when generating the top tree.

Huge trees (1987 Goldreich), keys on demand (Levin)

Signer chooses random $r \in \{2^{255}, 2^{255}+1, \ldots, 2^{256}-1\}$,
uses one-time public key T_r to sign message;
uses one-time public key T_i to sign (T_{2i}, T_{2i+1}) for $i < 2^{255}$.
Generates ith secret key as $H_k(i)$ where k is master secret.



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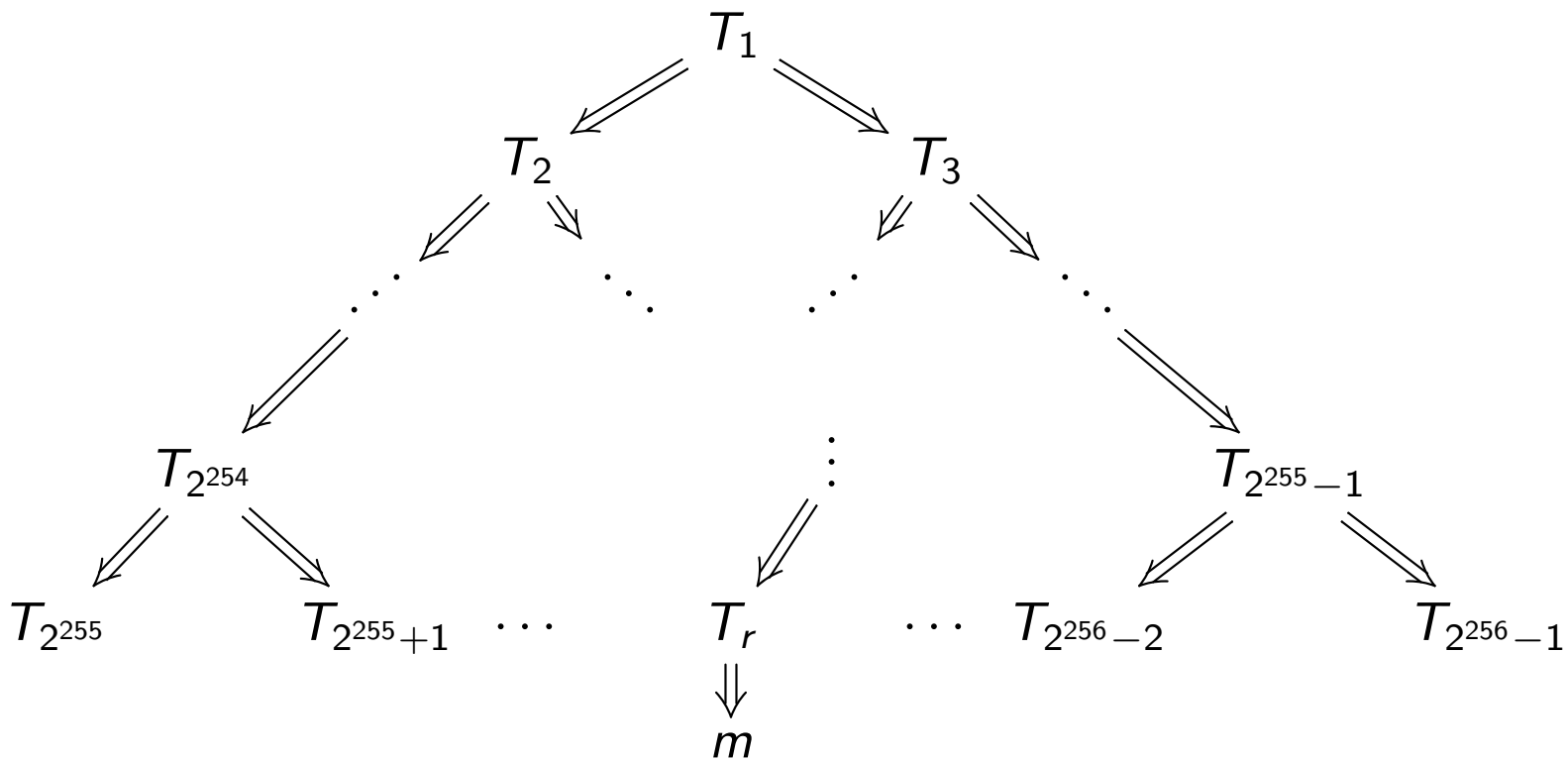

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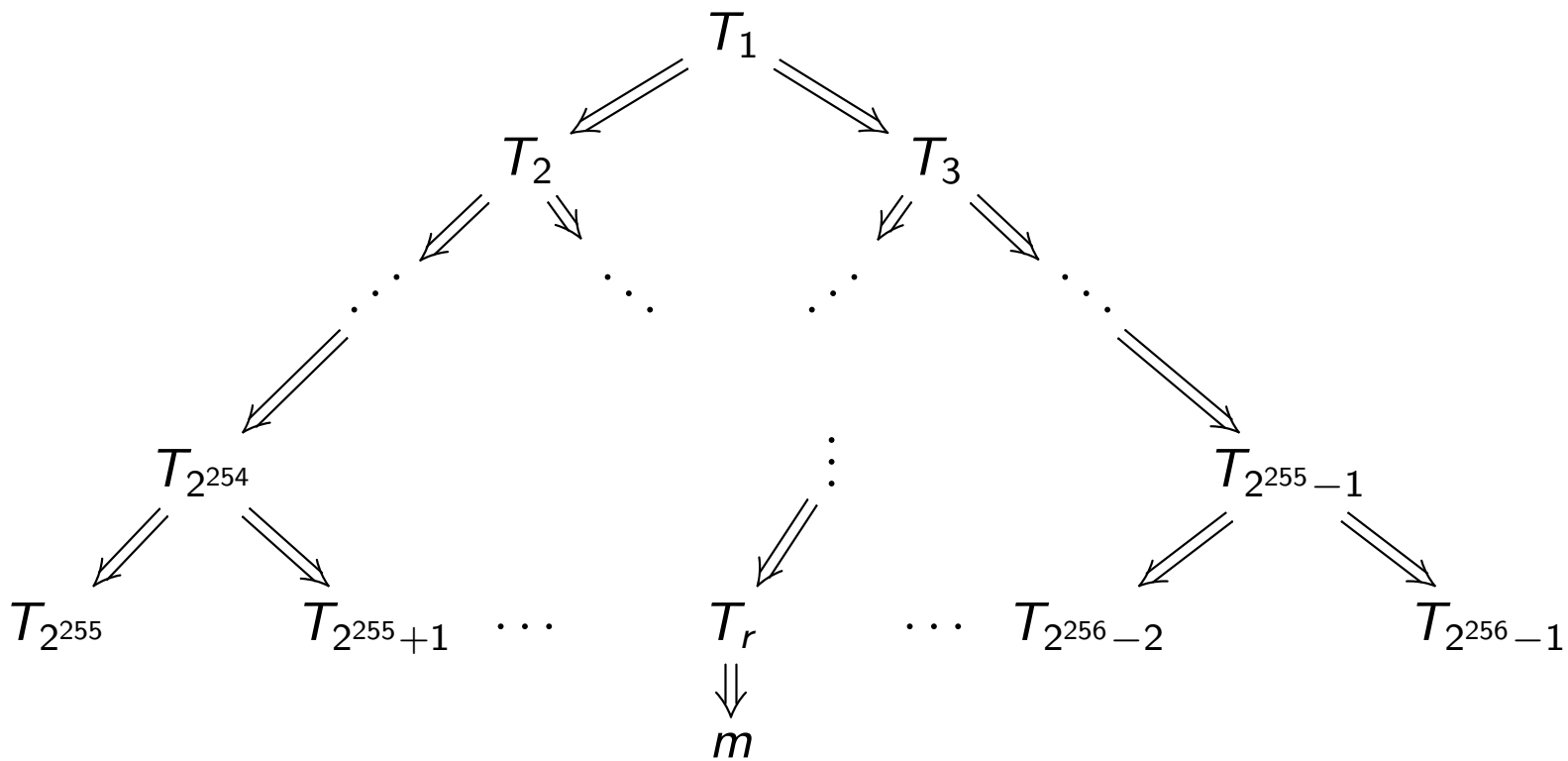

T_i for small i gets used repeatedly (each time an m falls in that sub-tree) but $H_k(i)$ being deterministic means it signs the same value, so no break.

Use Goldreich to create stateless hash-based signatures

0.6 MB for hash-based Goldreich signature using
short-public-key Winternitz-16 one-time signatures.

Would dominate traffic in typical applications,
and add user-visible latency on typical network connections.

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Example:
HTTPS typically sends multiple signatures per page.
1.8 MB average web page in Alexa Top 1000000.

Ingredients of SPHINCS (and SPHINCS-256)

Drastically reduce tree height (to 60).

Replace one-time leaves with few-time leaves.

Optimize few-time signature size *plus* key size.
New few-time HORST, improving upon HORS
(see exercise sheet 4).

Use hyper-trees (12 layers), as in GMSS.

Use masks, as in XMSS and XMSS^{MT},
for standard-model security proofs.

Optimize short-input (256-bit) hashing speed.
Use sponge hash (with ChaCha12 permutation).

Use fast stream cipher (again ChaCha12).

Vectorize hash software and cipher software.

See paper for details: sphincs.cr.yp.to

Updated version is NIST submission SPHINCS+
https://sphincs.org/.