Some challenges in heavyweight cipher design

Daniel J. Bernstein

University of Illinois at Chicago &
Technische Universiteit Eindhoven

Protocol generates new AES-128 key k.

Protocol encrypts message block
m_1 as $\text{AES}_k(1) \oplus m_1$,
m_2 as $\text{AES}_k(2) \oplus m_2$,
m_3 as $\text{AES}_k(3) \oplus m_3$,
etc. Also authenticates.

First block m_1 is predictable:
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We constantly tell people: "No! AES is secure! This is all safe!"

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(Side discussion: Is 192 enough?)

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2014 Bernstein–Chou "Auth256": 29 bit ops/message bit for differential probability $<2^{-255}$. Or try EHC from 2013 Nandi?

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Much simpler: 256-bit blocks.

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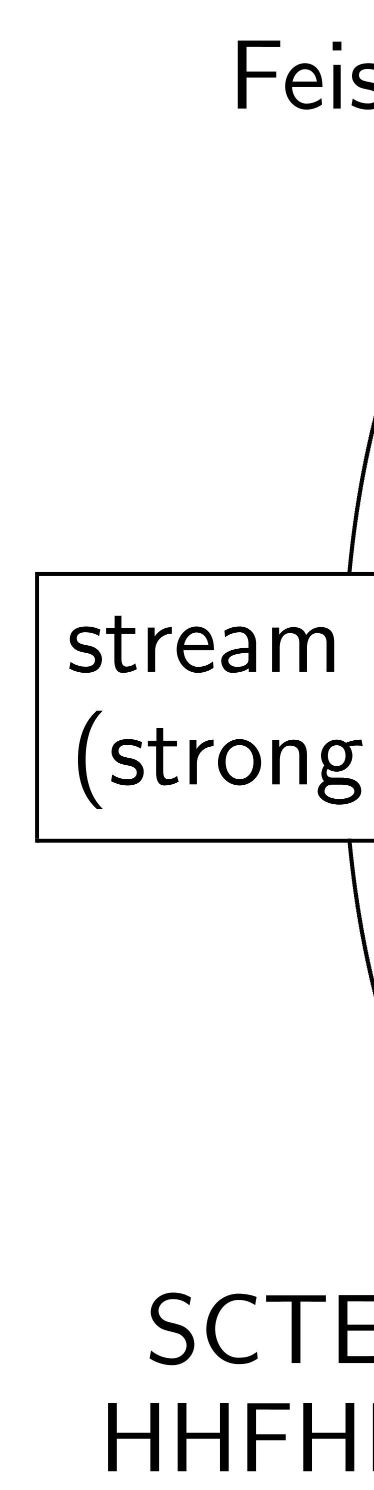

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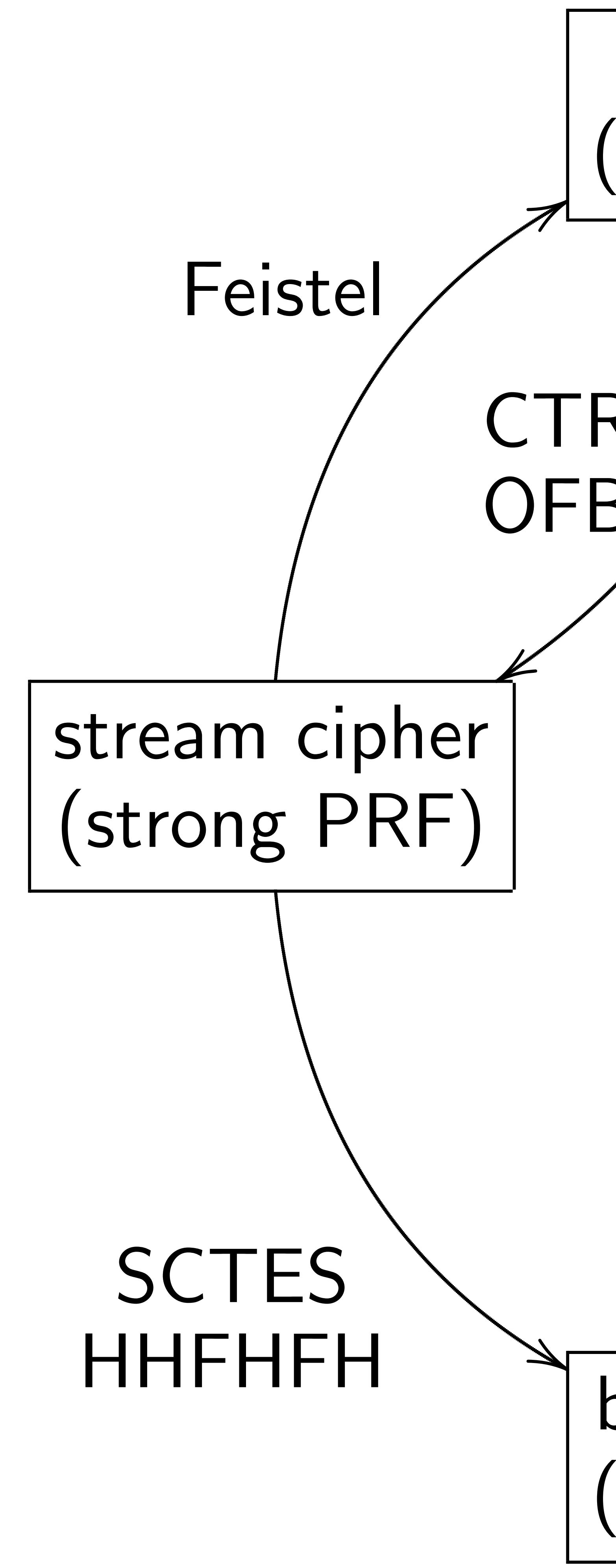

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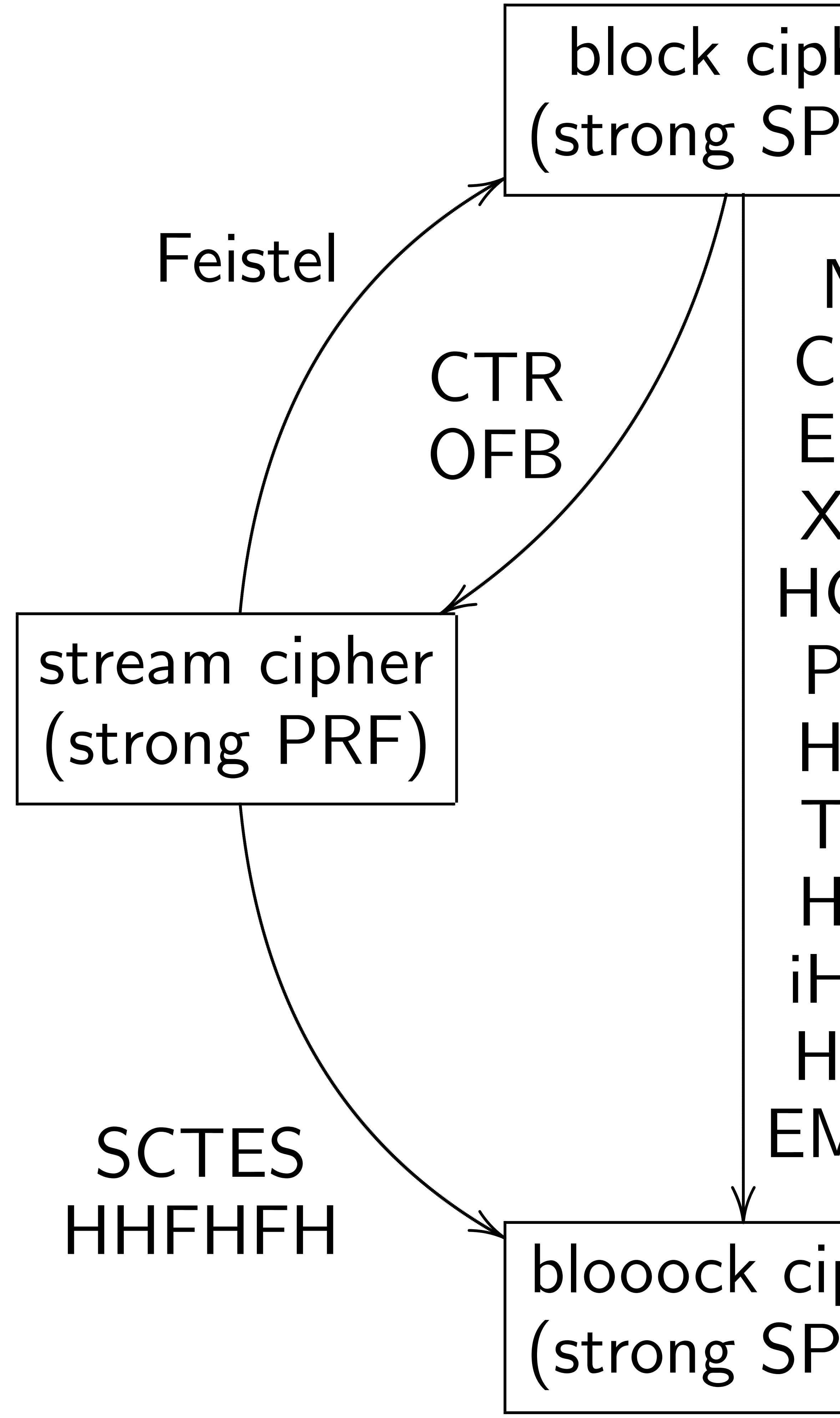

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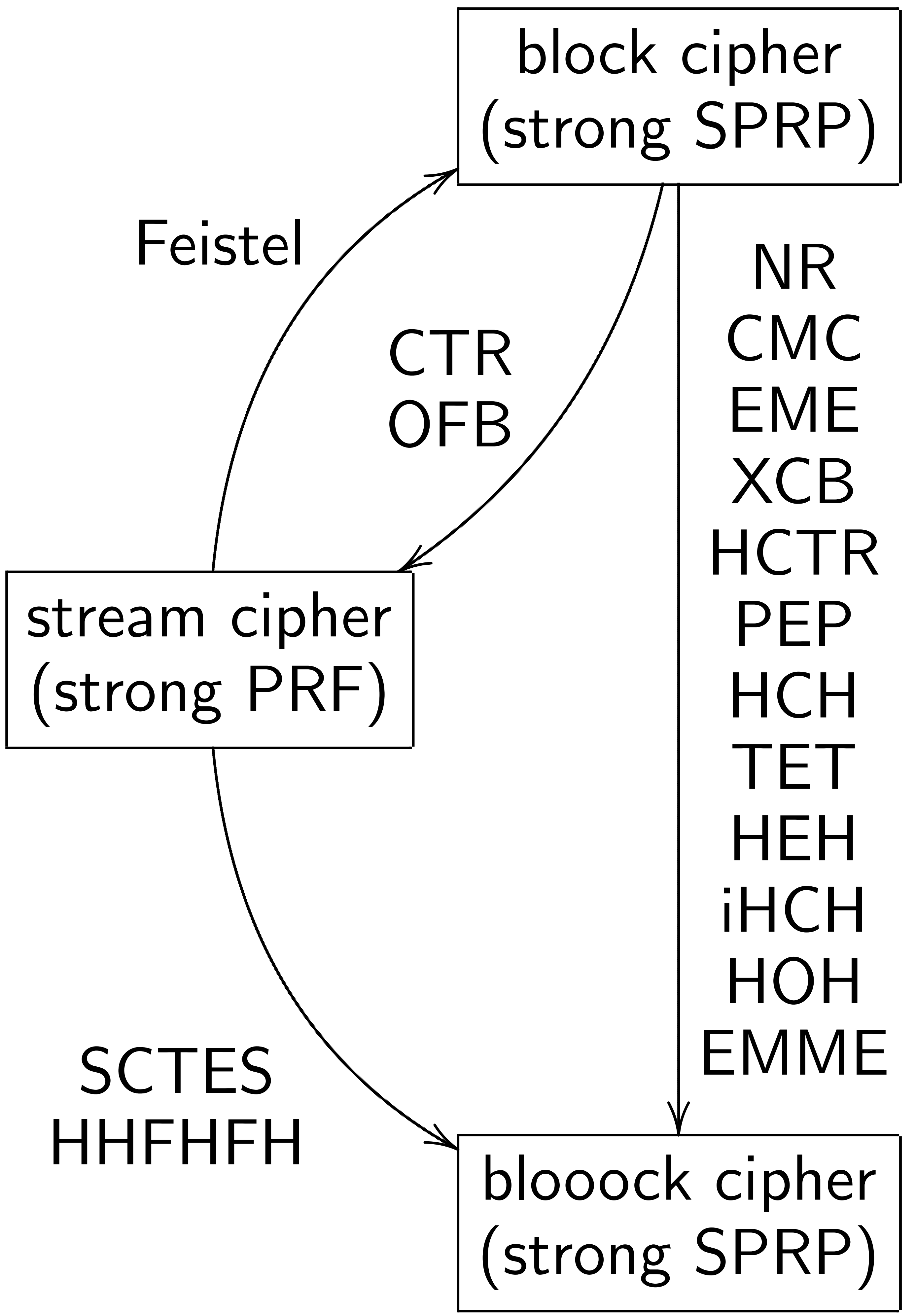

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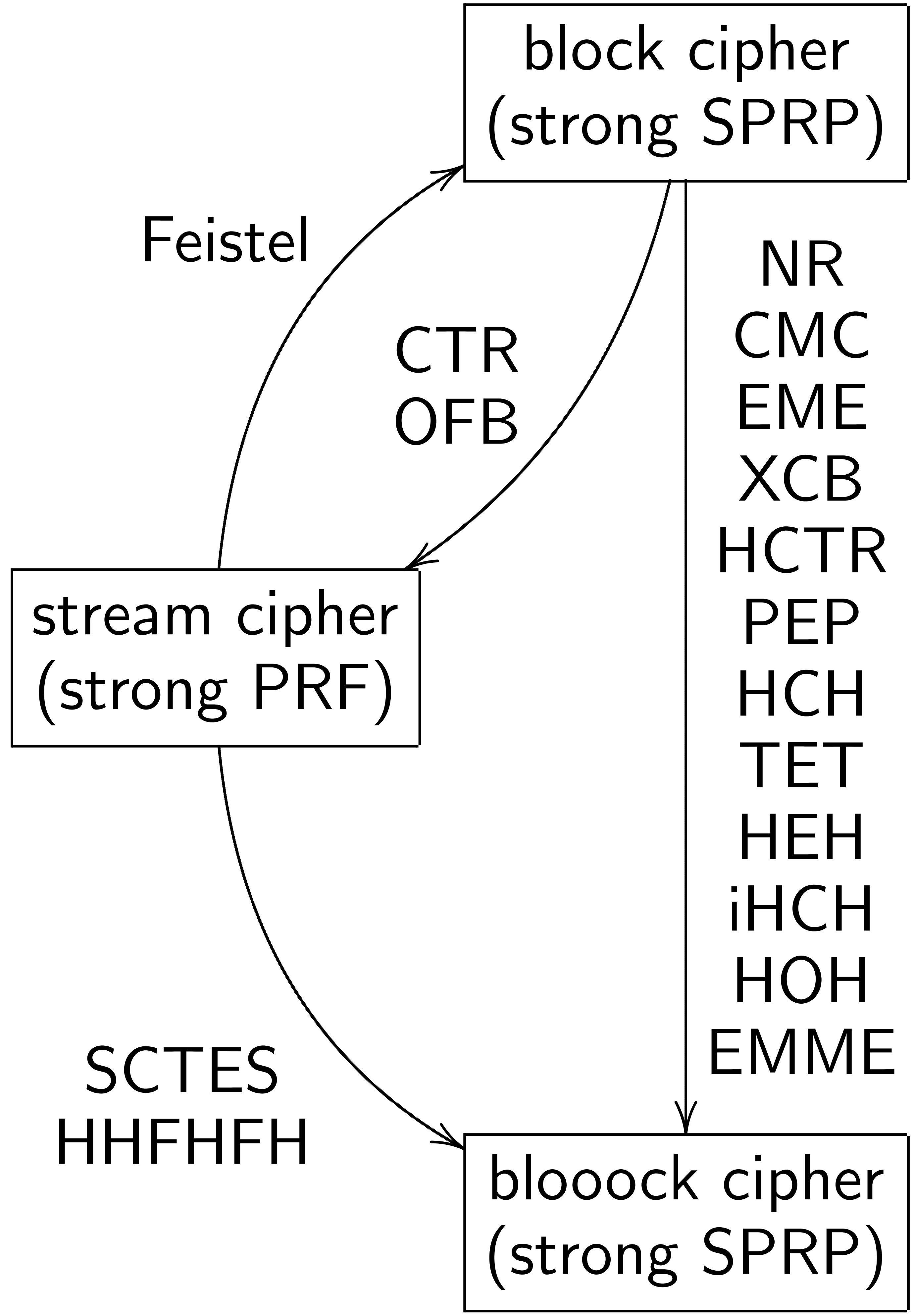

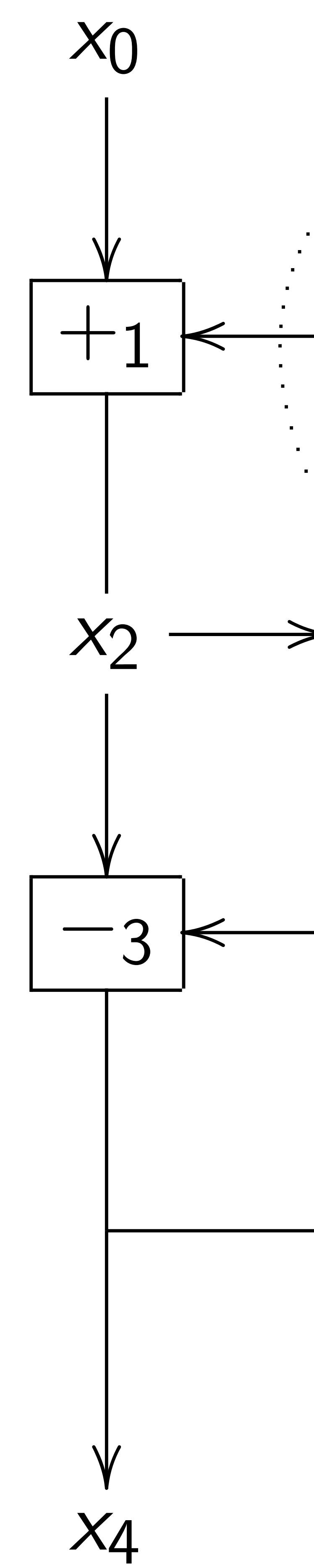

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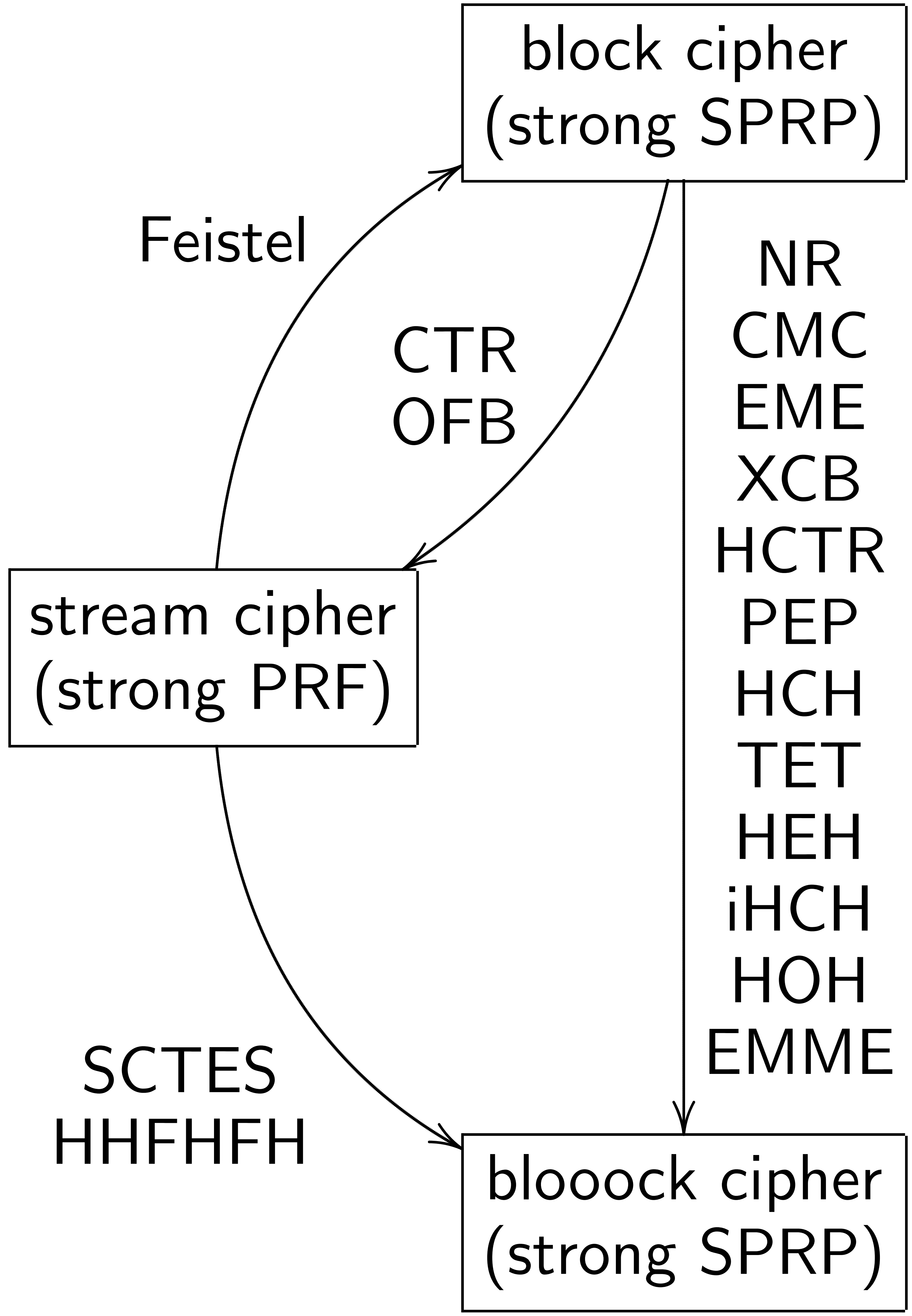

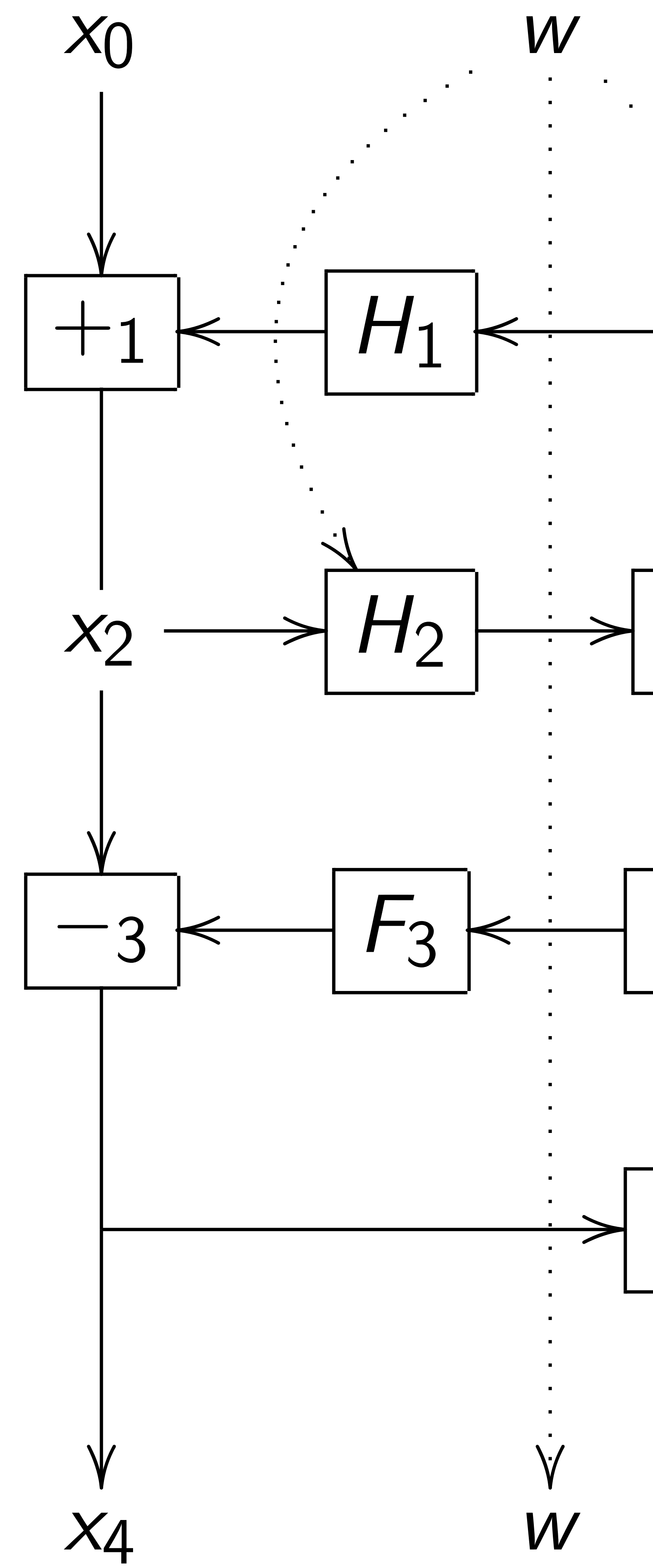

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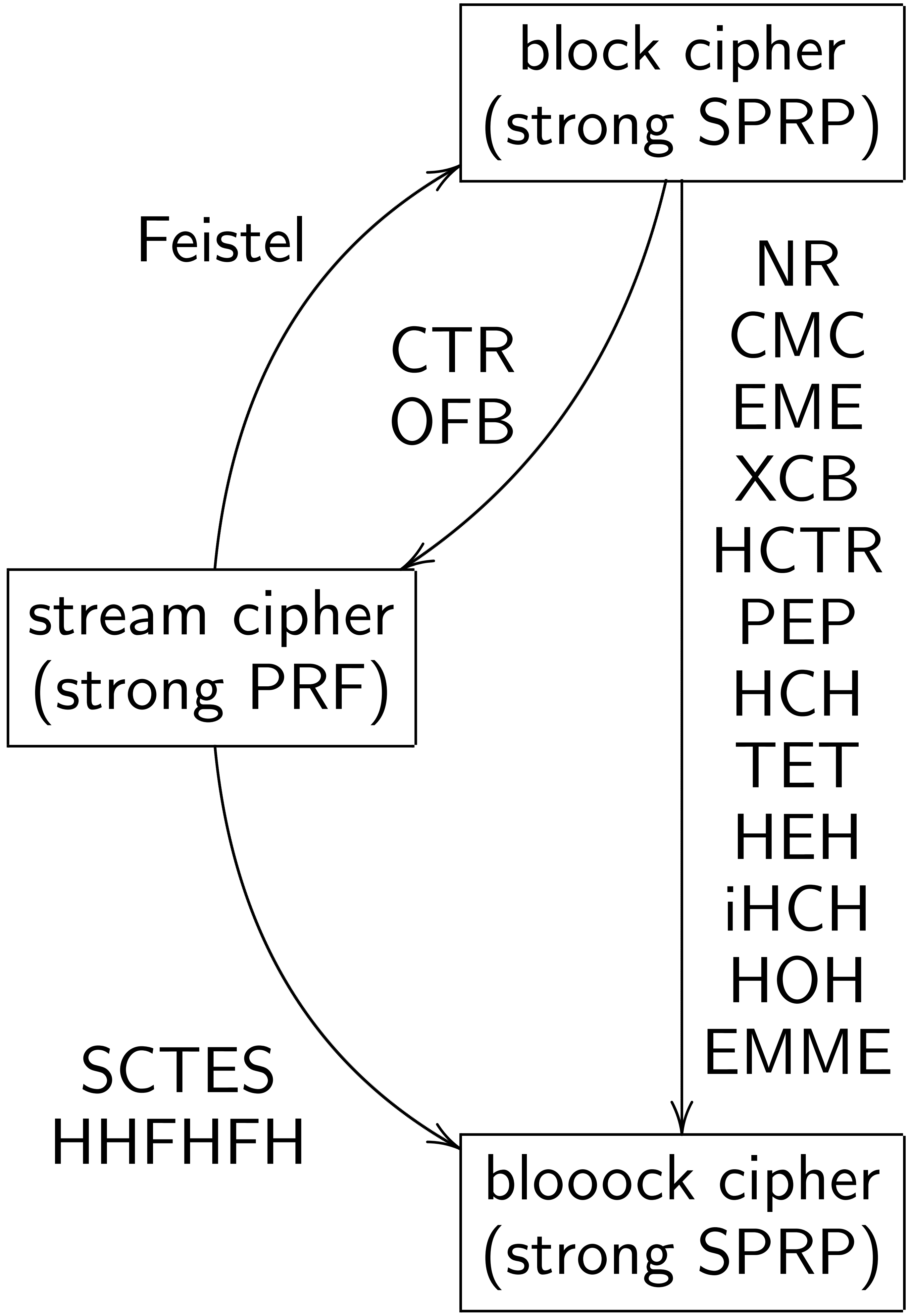

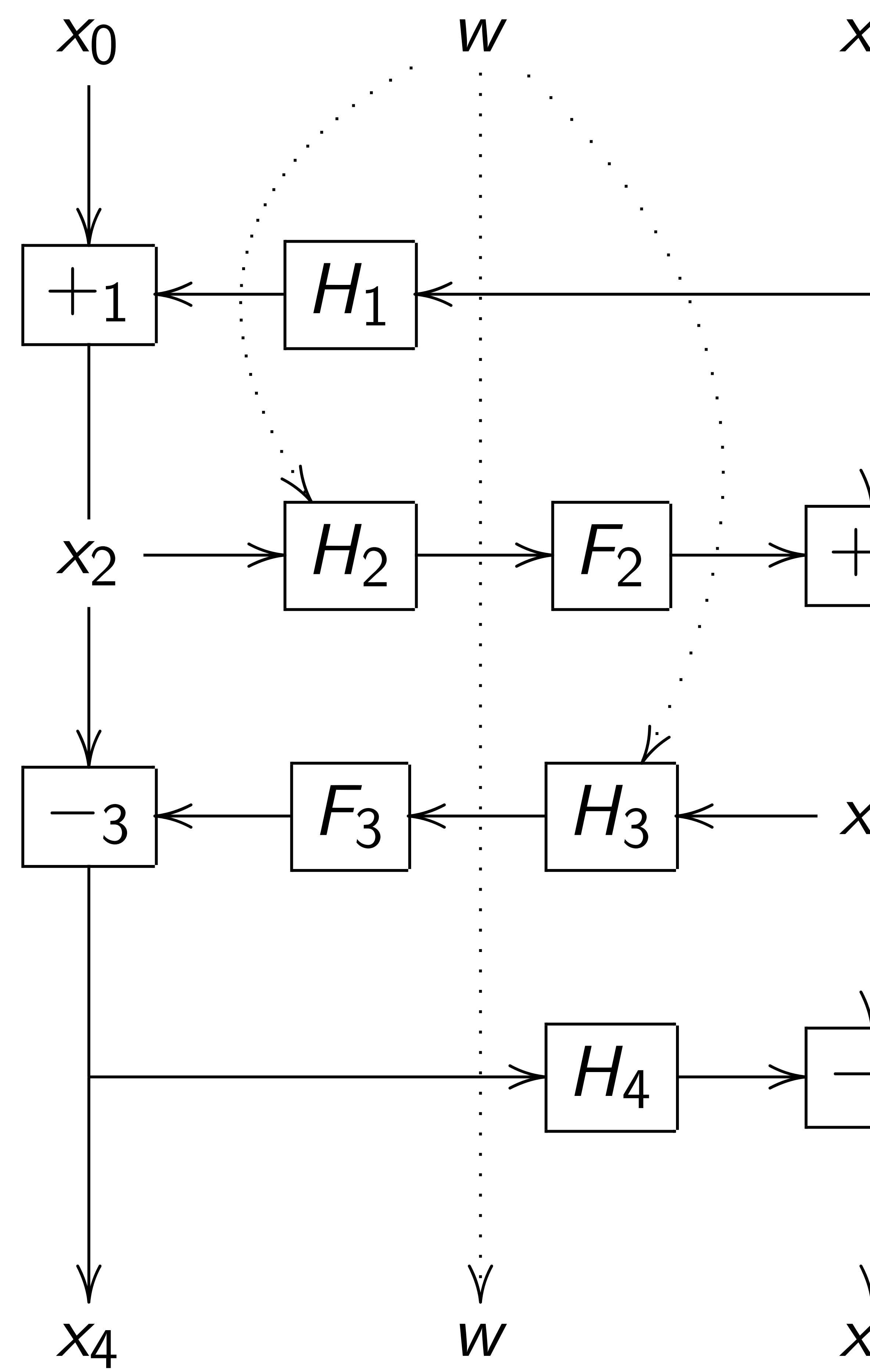

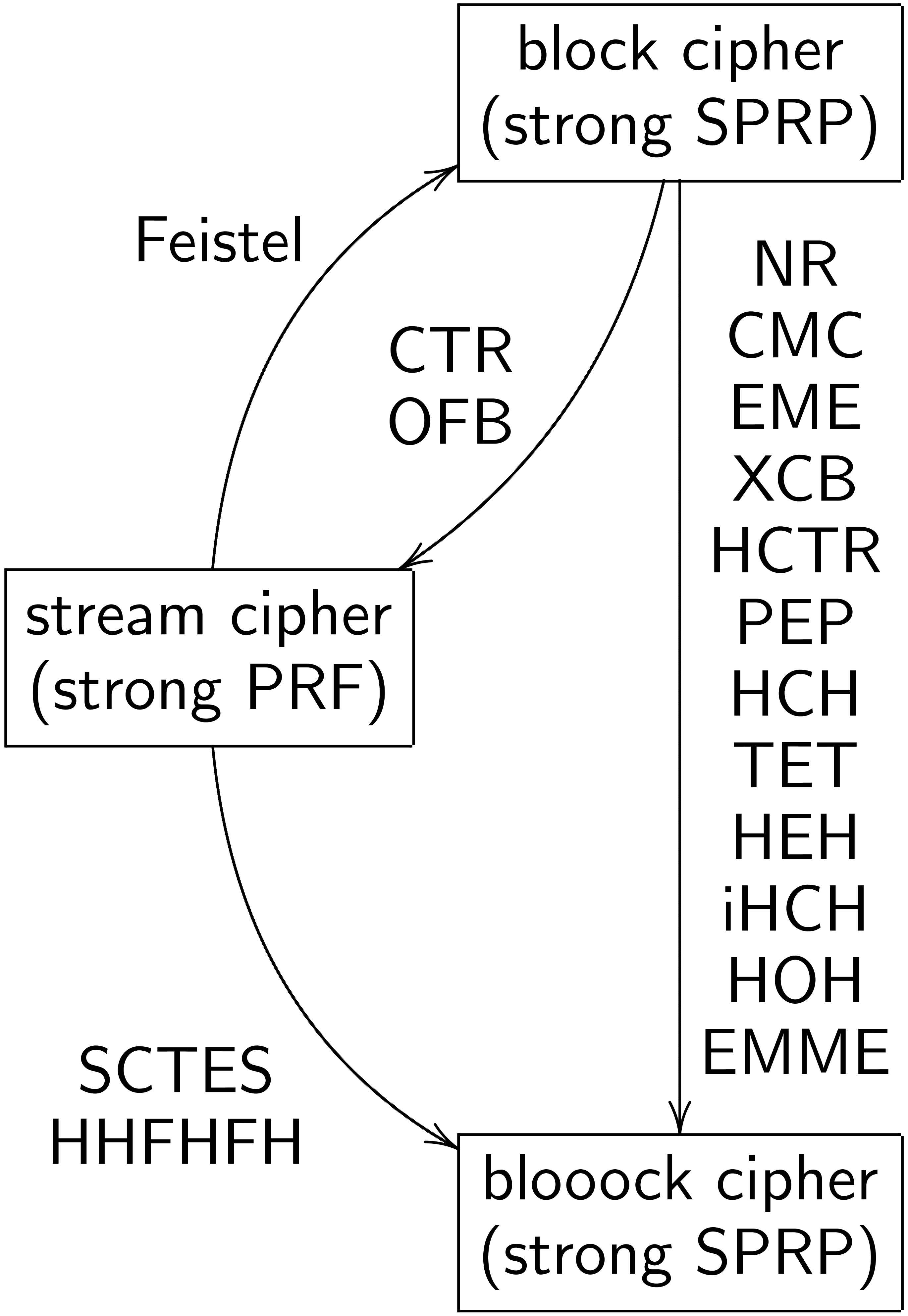
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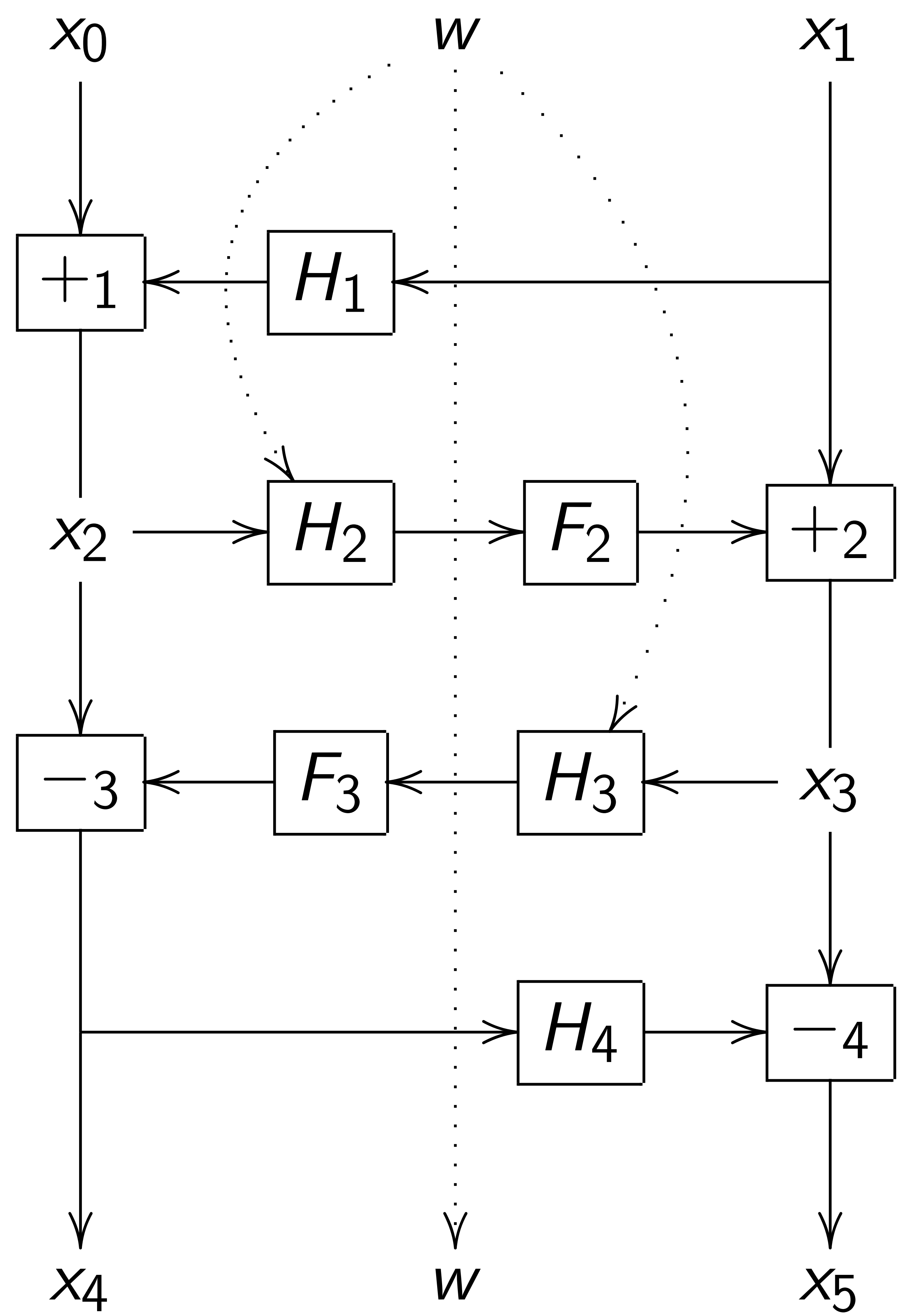
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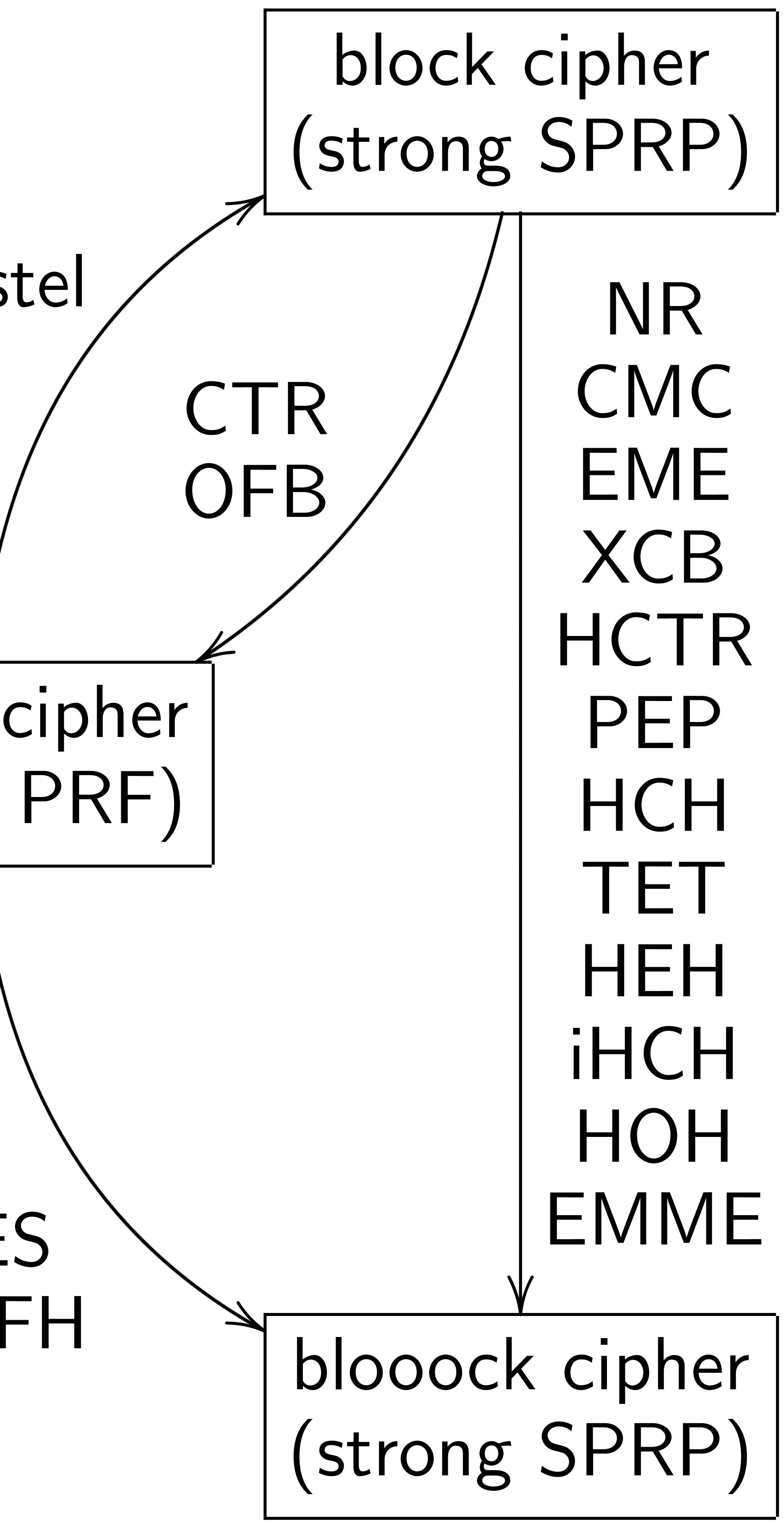

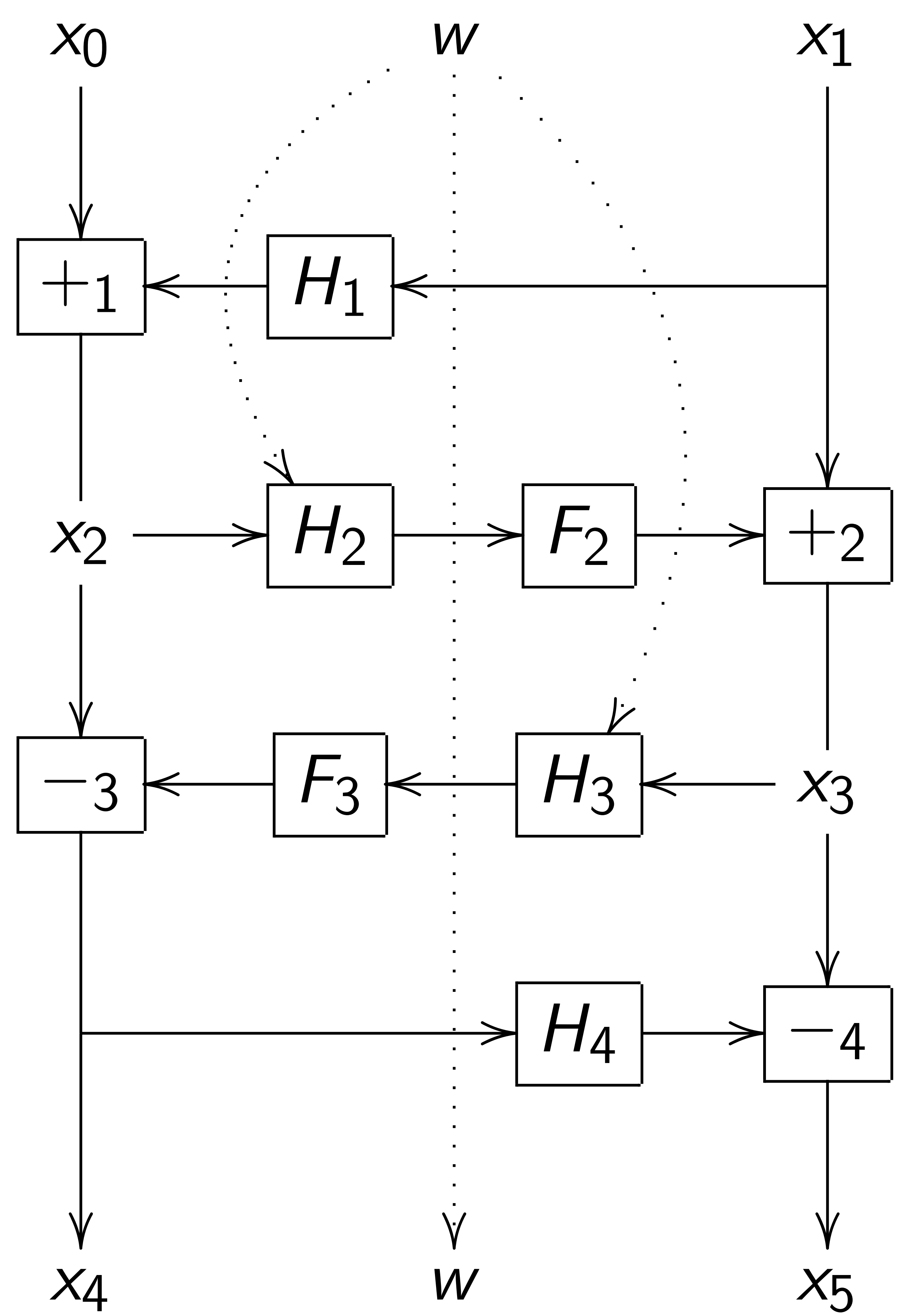

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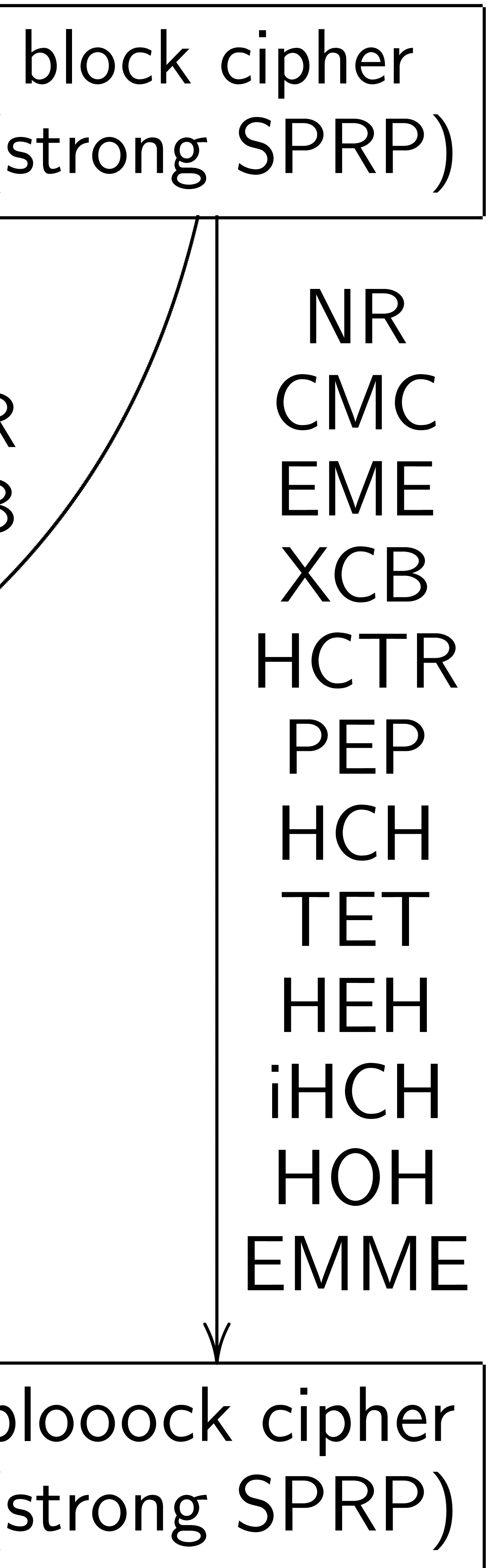

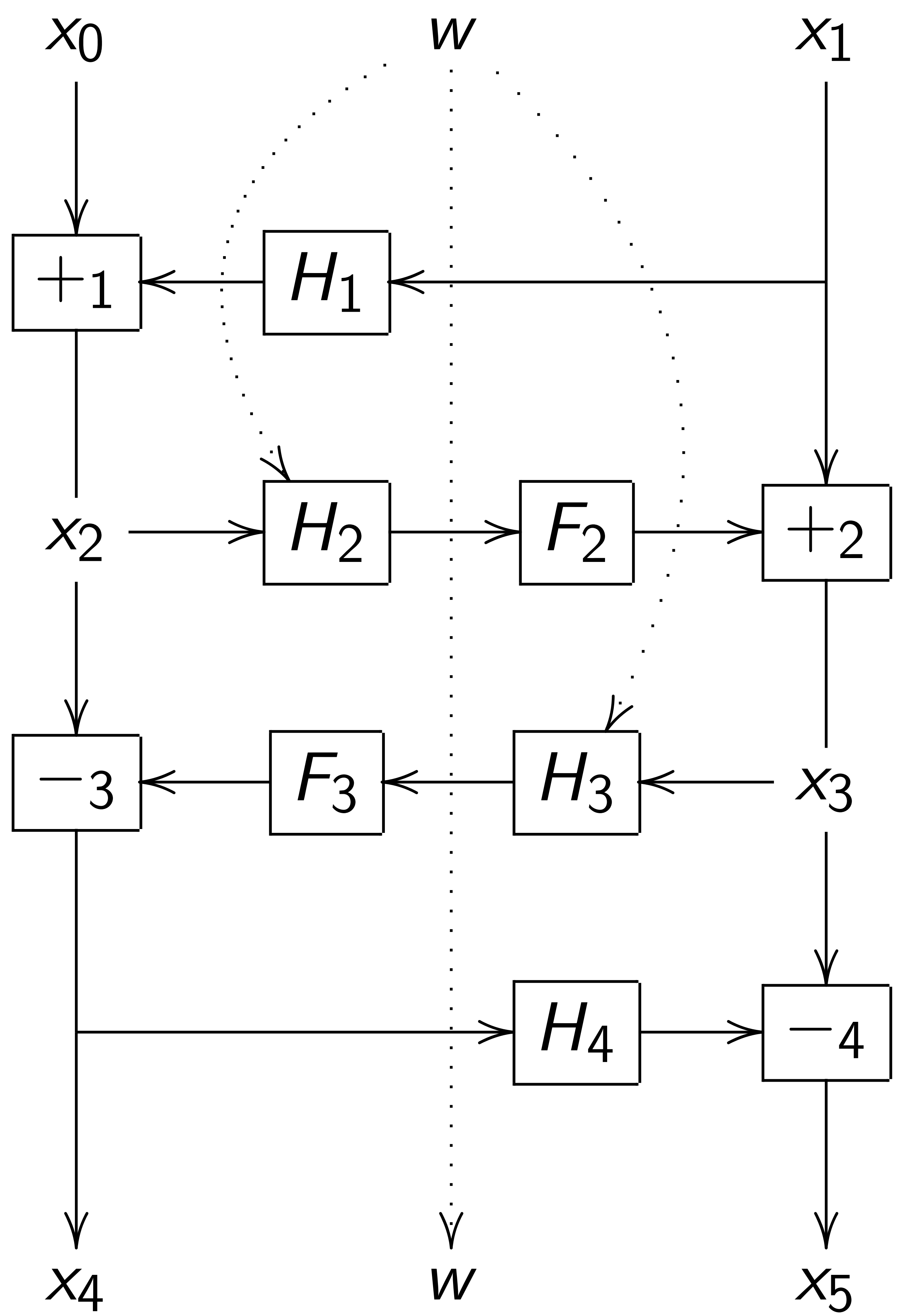

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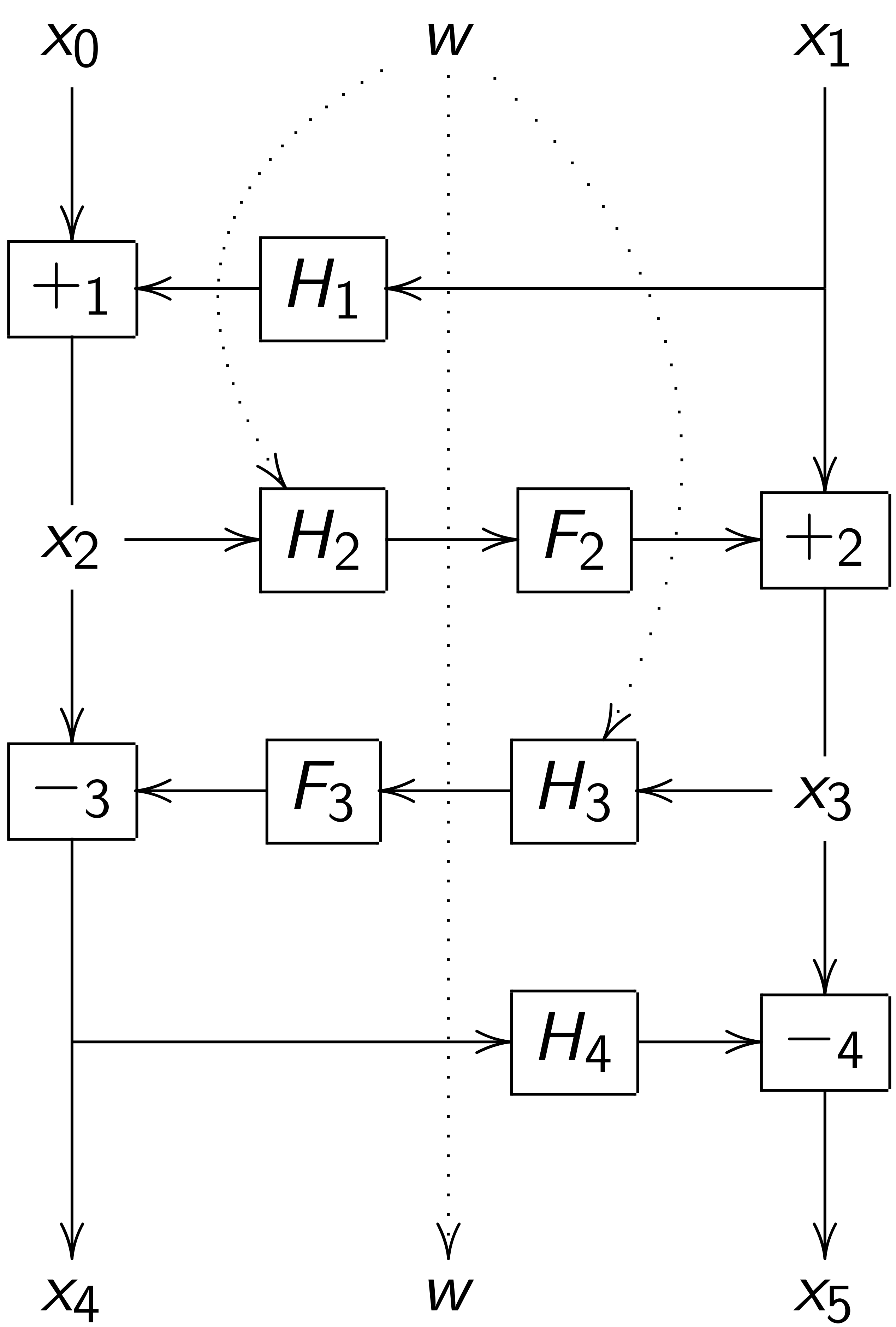

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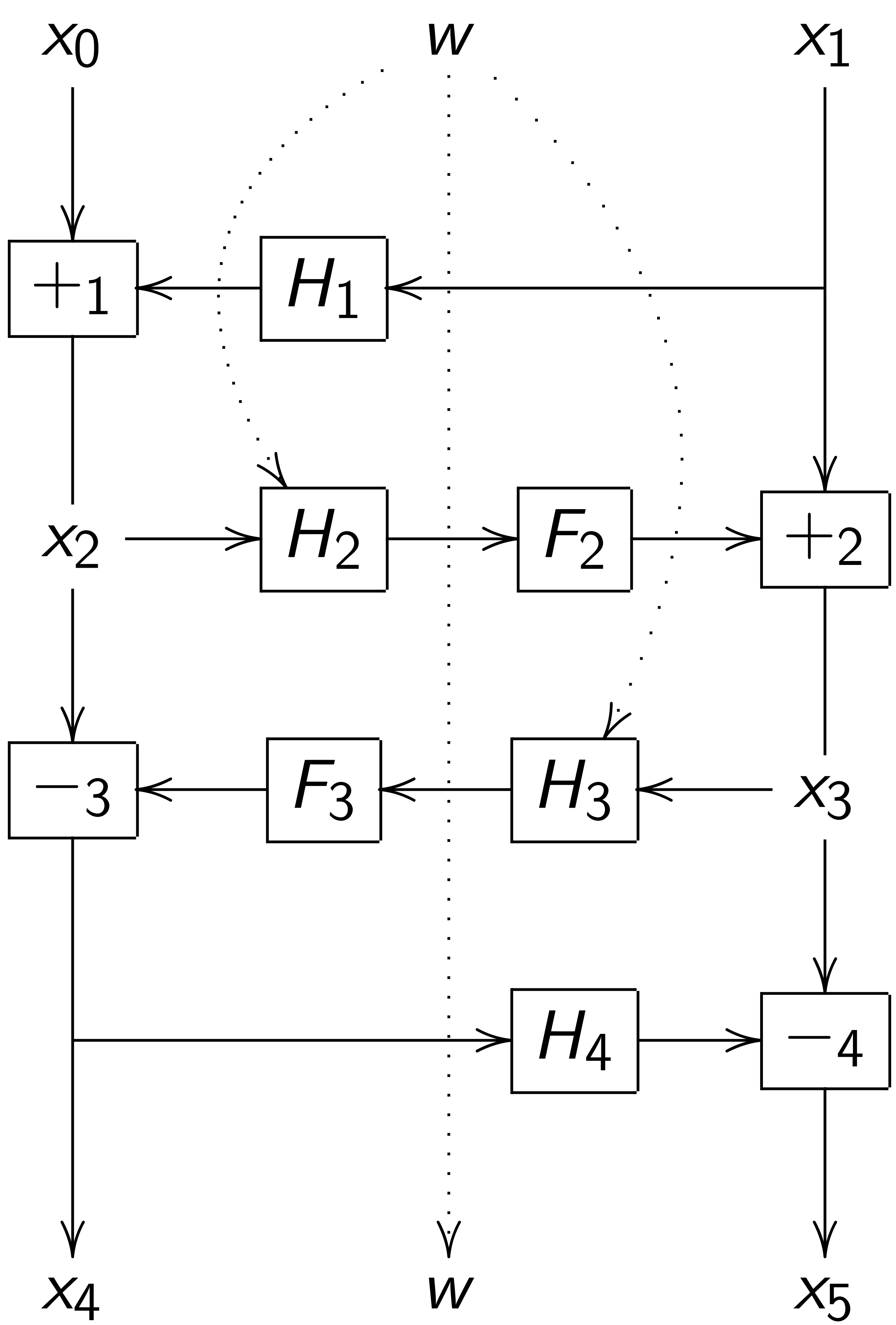

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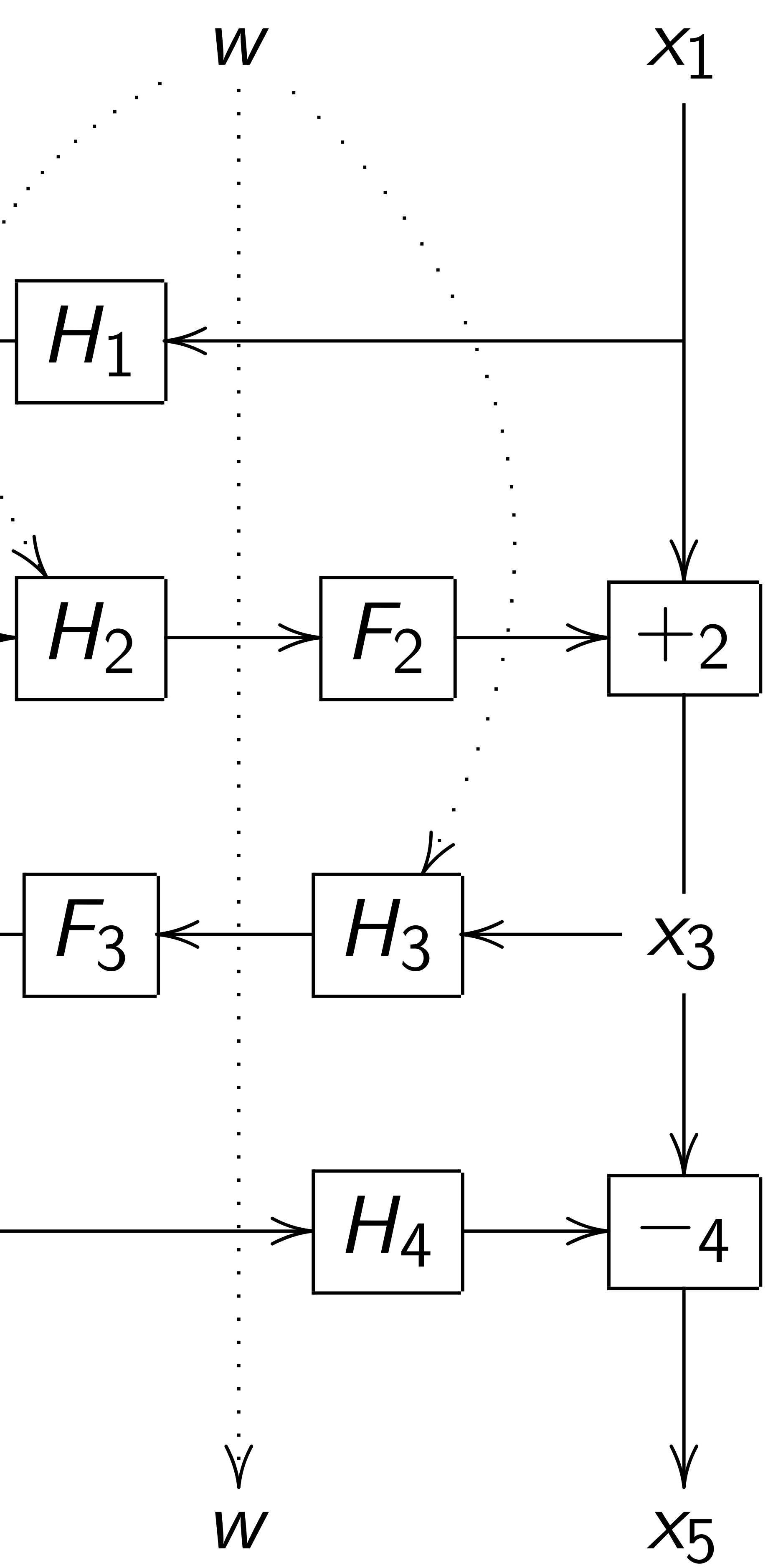

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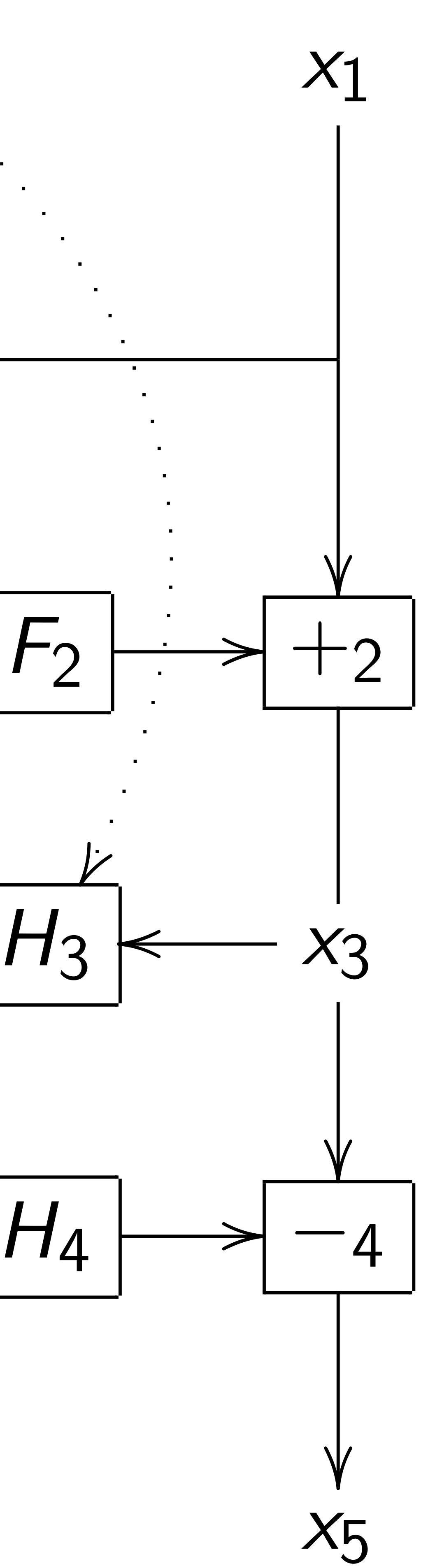

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Security loss of mode compared to security of F: basically $q^2/2^{128}$, assuming 128-bit blocks and typical choice of H.

Is this 2^{128} "security"?

Fragile fix: "beyond-birthday-bound security." Complicates implementation, security analysis.

Simpler fix: "bigger-birthday-bound security." Use 256-bit blocks, security $q^2/2^{256}$.

Is 256-bit n safe in ChaCha?

Heavyweight ciphers

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Occasional designs: Rijndael, OMD (SHA-2), Keccak, BLAKE2, NORX, Simpira, ... This needs far more attention, optimization. **Hash** designs are usually overkill.

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PRF inside EdDSA signature

EdDSA generates per-signat
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H is SHA-512; s is subkey.

2015 Bellare–Bernstein–Tess
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Another optimization target: PRF inside EdDSA signatures.

EdDSA generates per-signature random number mod 256-bit ℓ as truncated hash: $H(s, m) \bmod \ell$. H is SHA-512; s is subkey.

2015 Bellare–Bernstein–Tessaro: truncated prefixed MD hash is a high-security multi-user MAC.

Even with the constraint of reusing preimage-resistant hash, surely can build better design in both software and hardware.