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CYBER SECURITY IN THE AGE OF LARGE-SCALE ADVERSARIES

Breaking HALFLOOP-24

Kobe, Japan, Thursday, March 23

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Swedish Defence University

Université de Rennes

RUHR UNIVERSITÄT BOCHUM

RUB

What is HALFLOOP

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« HALFLOOP is a parody of AES that can be summarized as "What if we take AES-128, add a tweak in the key and reduce the block size?". This paper focuses on HALFLOOP-24, which has a 24-bit block size. As one can expect it is completely broken. »

Reviewer B

Why HALFLOOP

Why HALFLOOP: High Frequency Radio

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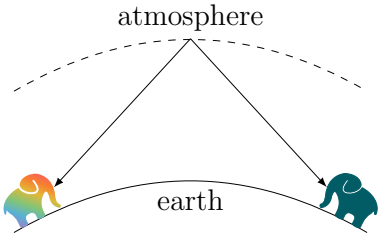
- Frequencies between 3MHz and 30MHz
- Skywave propagation: radio signals are reflected by upper atmosphere
- Enables communication across very large distances without any external infrastructure
- Users are the military, diplomatic services, disaster management agencies, etc.
- HALFLOOP is used for encrypting handshake messages (confidentiality and authentication)



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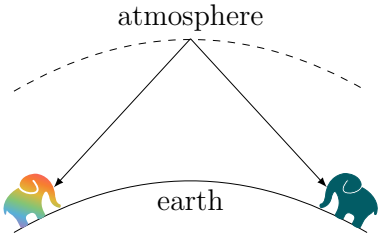

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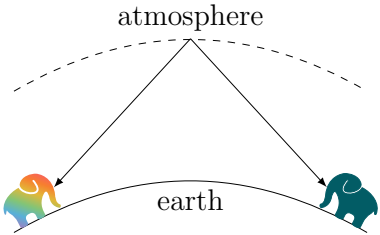

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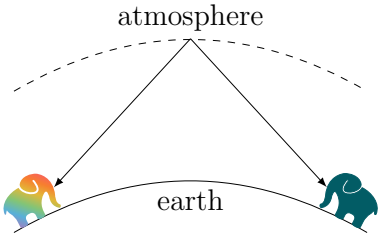

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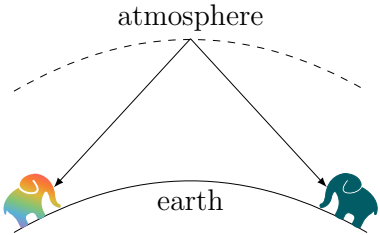
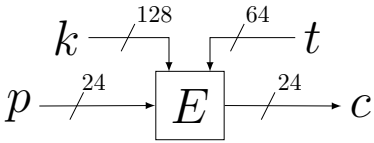


Description of HALFLOOP-24

Description of HALFLOOP-24 – Big Picture

- HALFLOOP-24 is a tweakable block cipher E
  - Tweak consists of current time, a word counter and the used frequency
  - Supersedes SoDark cipher which used **56-bit** keys
  - Specified in MIL-STD-188-141 since **2017**
  - No public cryptanalysis before
- HALFLOOP-24 is heavily inspired by AES
  - Uses the same SBox
  - Essentially the same key schedule
  - State is represented as 3×1 matrix over $\mathbb{F}_{2^8}$
  - 10 rounds



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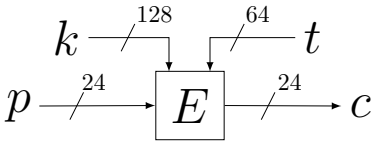

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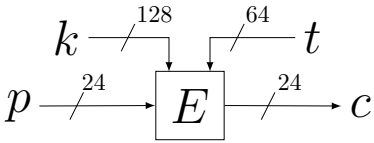

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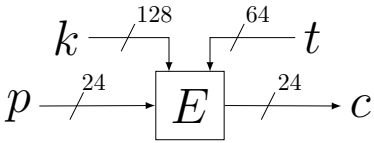

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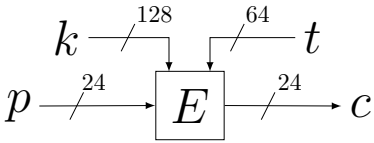

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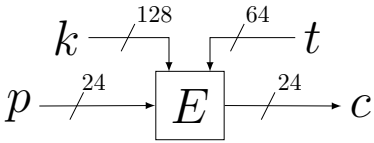

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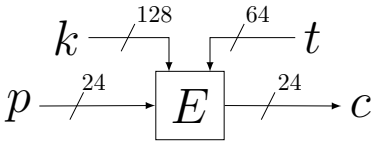

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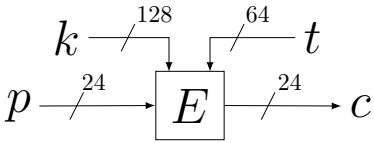

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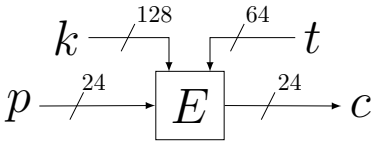

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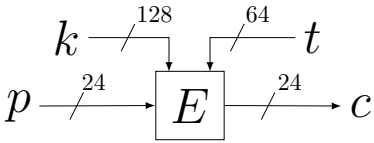
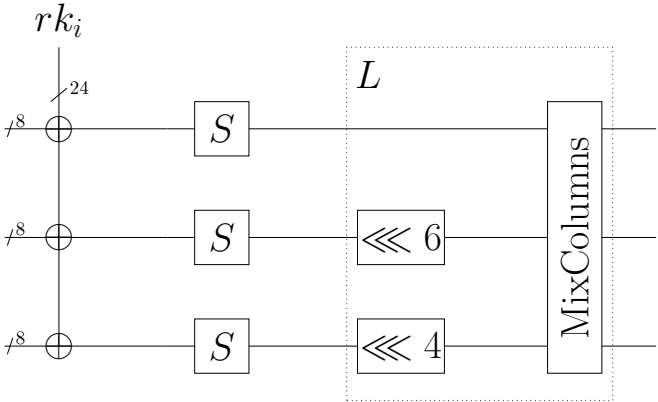
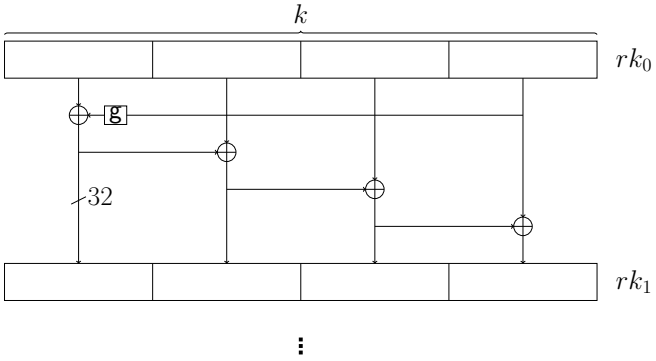


Description of HALFLOOP-24 – Round Function



MC: multiply with $c(x) = x^2 + 2x + 9$ modulo $x^3 + 1$

Description of HALFLOOP-24 – AES-128 Key Schedule



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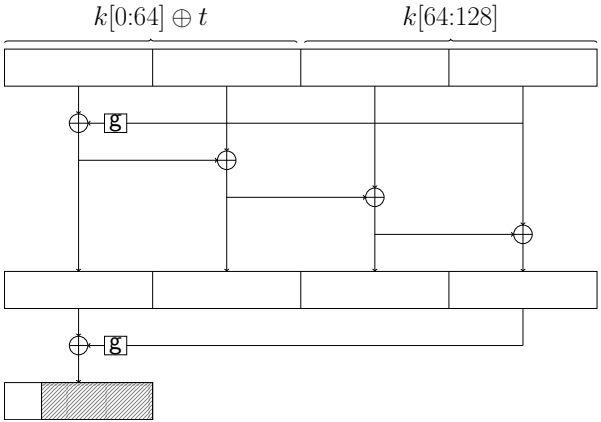

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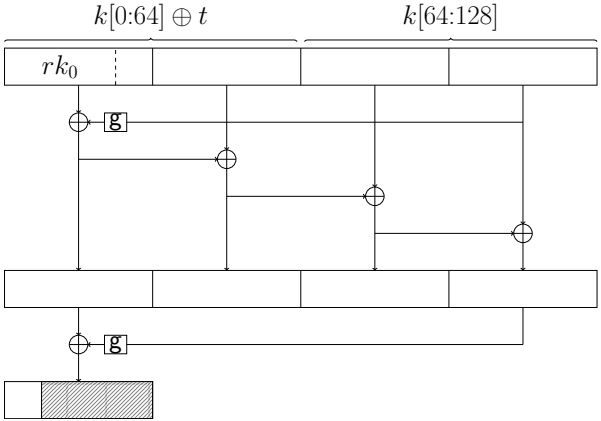

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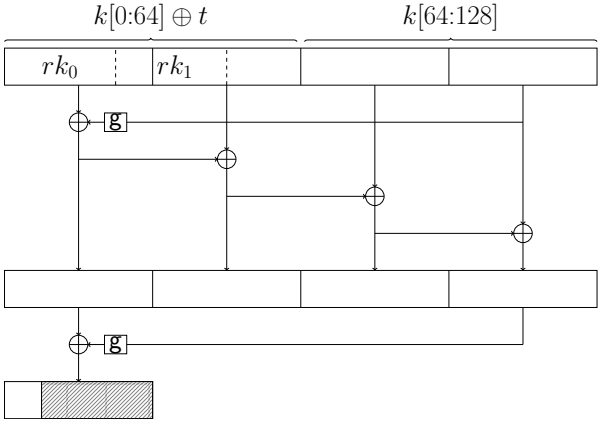

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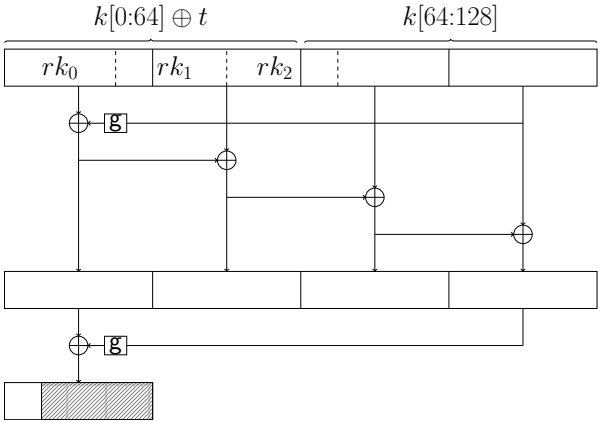

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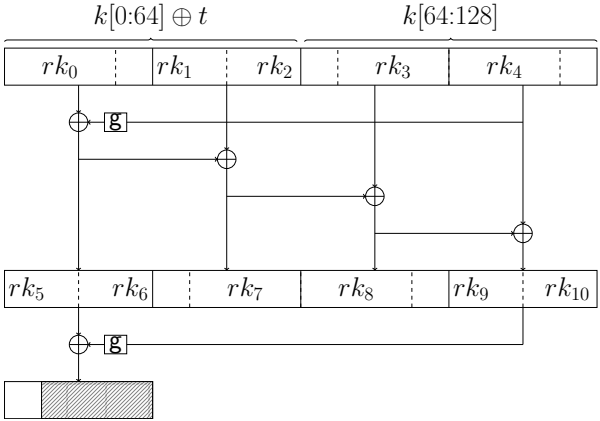

Our Attacks on HALFLOOP-24

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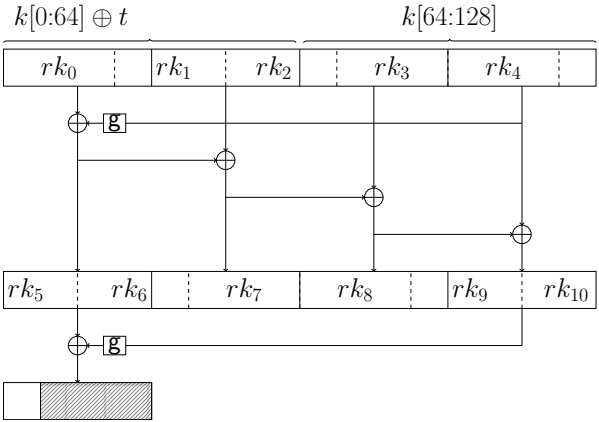

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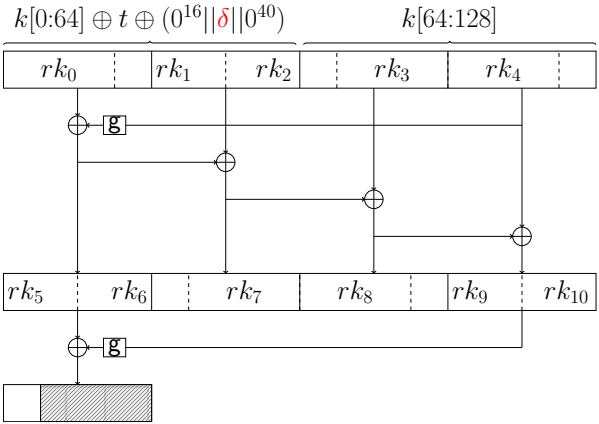

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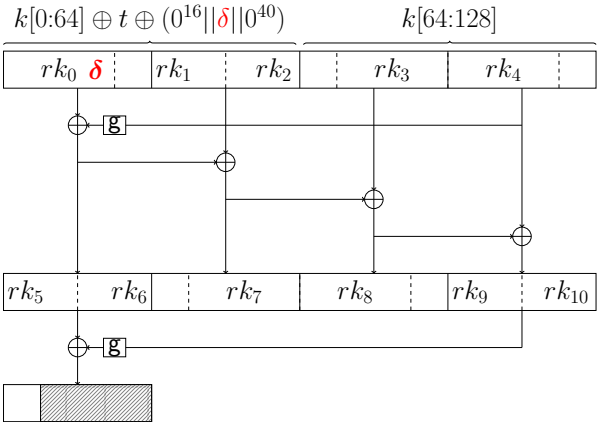

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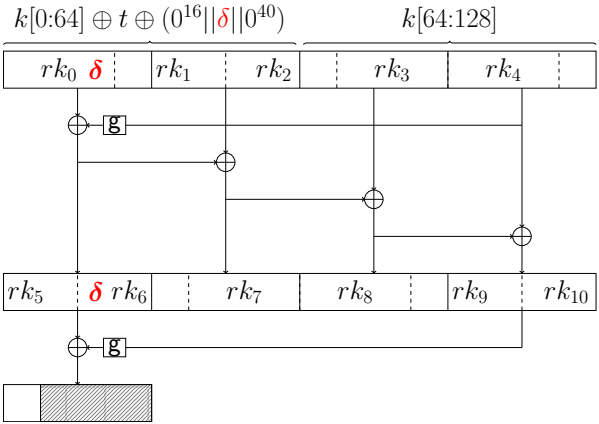

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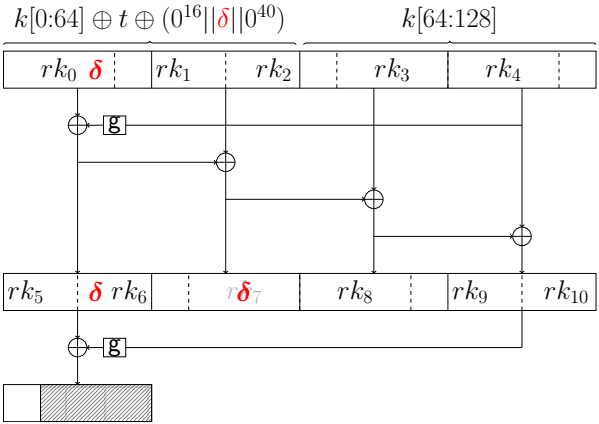

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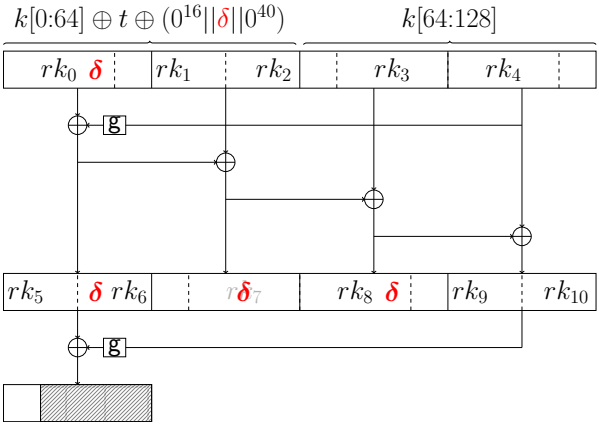

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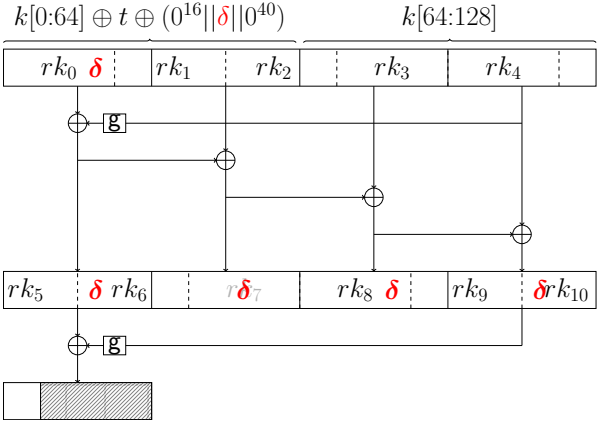

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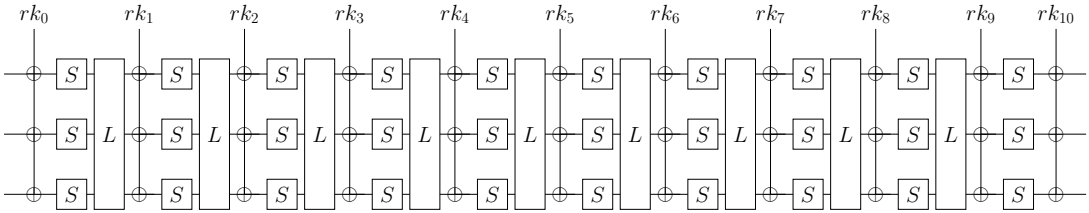

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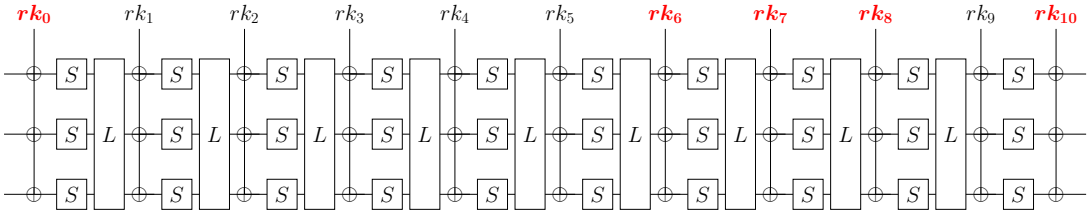

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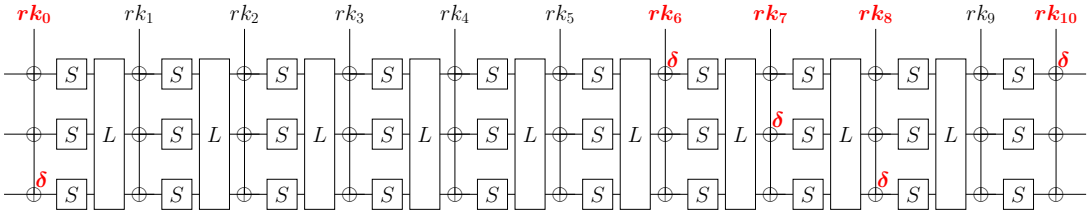

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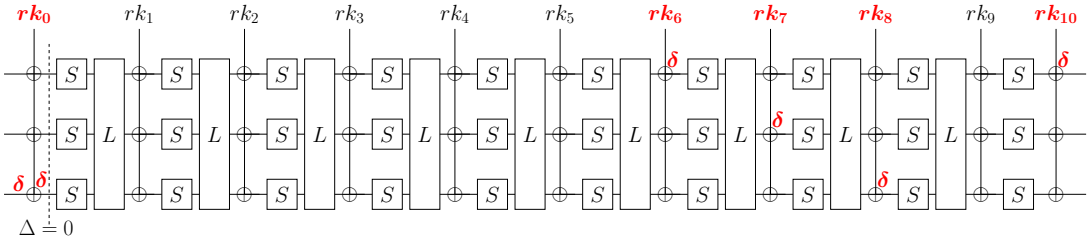

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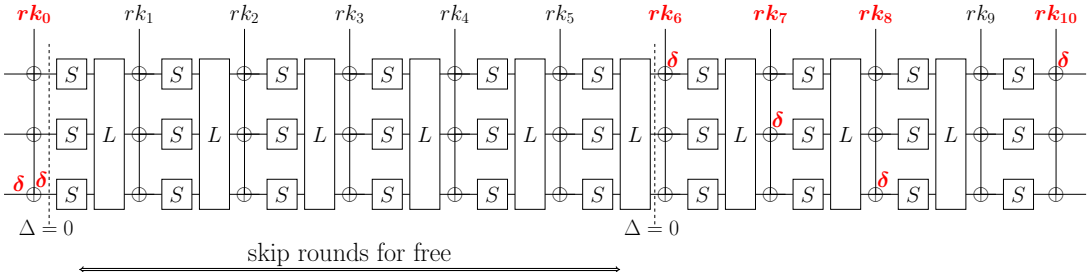

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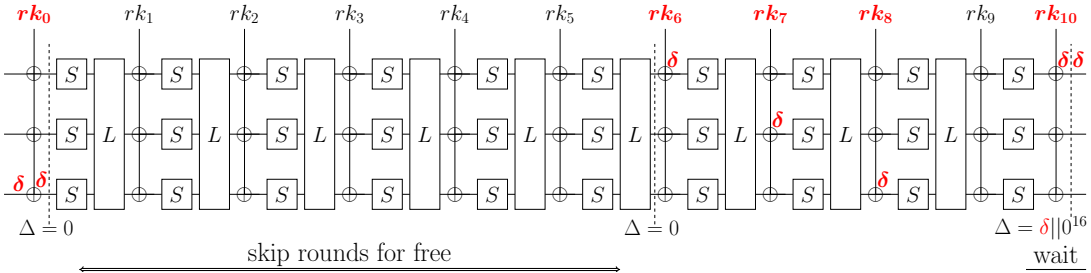

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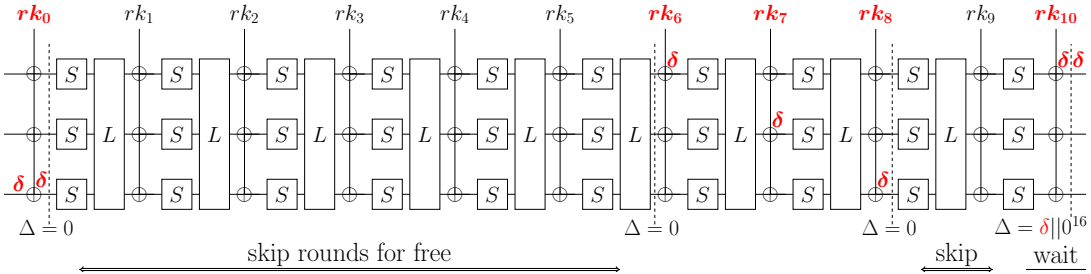

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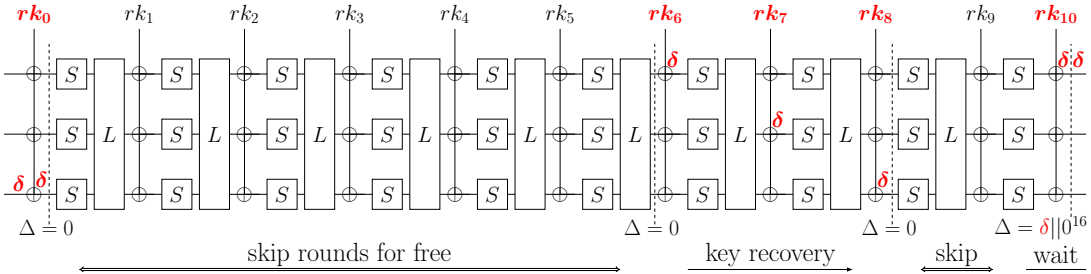

Our Attacks on HALFLOOP-24 – Overview

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Setting	Time	Data	Memory
Ciphertext only	2^{87}	2^{38}	2^{63}
Known-plaintext	2^{56}	2^{37}	2^{16}
Chosen-plaintext	2^{56}	2^{18}	2^{16}
Chosen-ciphertext	2^{10}	2^{10}	1

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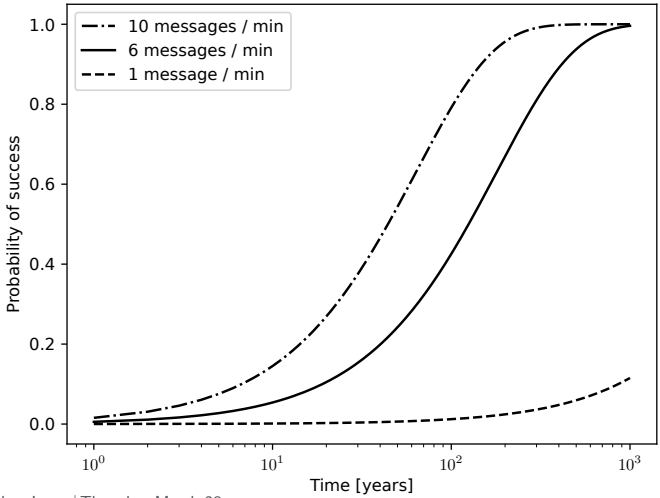

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- Conclusion
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- Possible future work
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Paper

Code

Thank You!