PRIMATEs

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PRIMATEs

PRIMATEs

APE

misuse
resistance

PRIMATEs

APE

misuse
resistance

HANUMAN

security with
ideal
permutation

PRIMATEs

APE

misuse resistance

HANUMAN

security with ideal permutation

GIBBON

trade-off speed/security

PRIMATEs



- Sponge inspired (9)

PRIMATEs

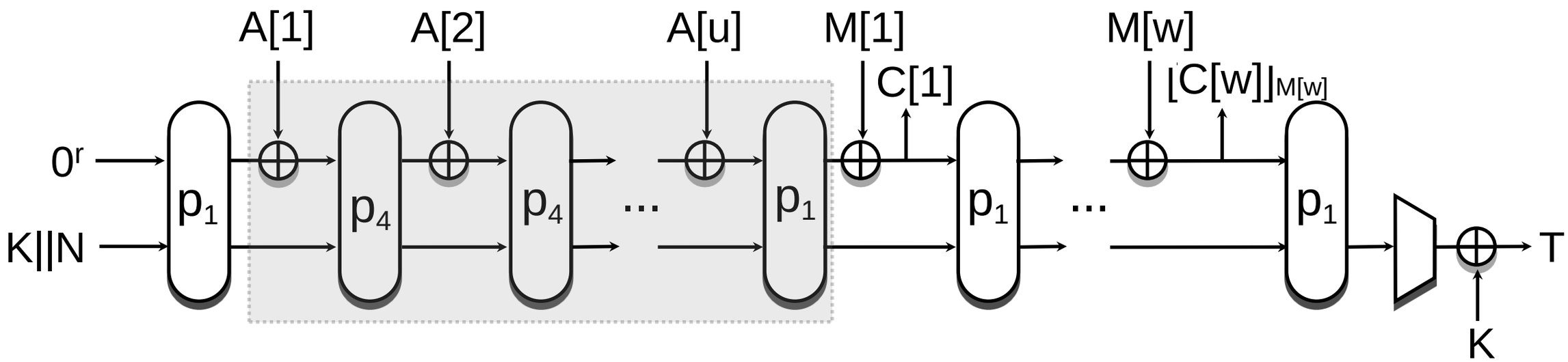


- Sponge inspired

permutation	PRIMATE–80	PRIMATE–120
security	80 bits	120 bits
b (state size)	200 bits	280 bits
c (capacity size)	160 bits	240 bits
r (rate size)	40 bits	40 bits

- Lightweight
- Substitution-Permutation-Network (SPN)
- Efficient threshold implementation
- Ideal permutation proof

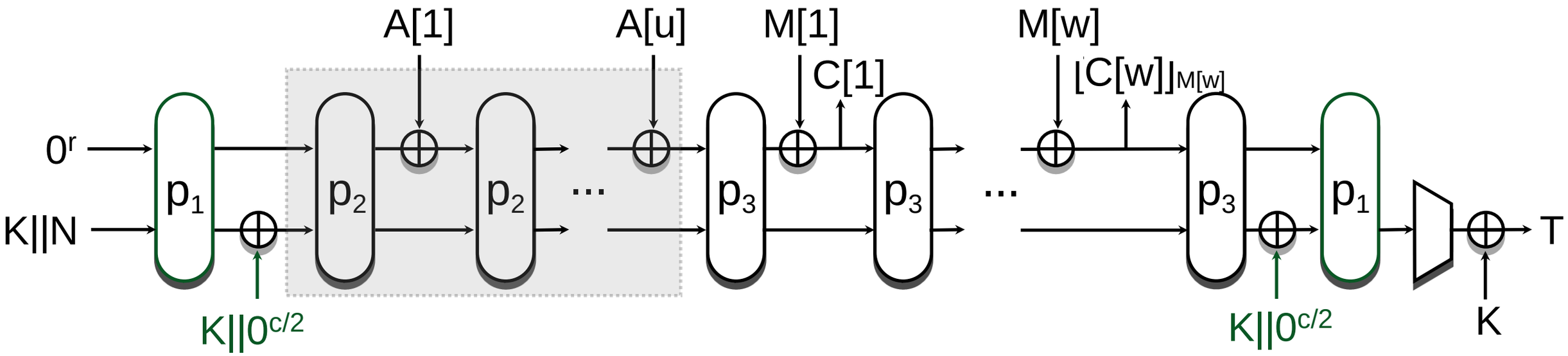
HANUMAN



K, N and T are 80 (resp. 120) bits

- Nonce-based
- Online encryption
- Domain separation: p_1, p_4
- No ciphertext expansion

GIBBON

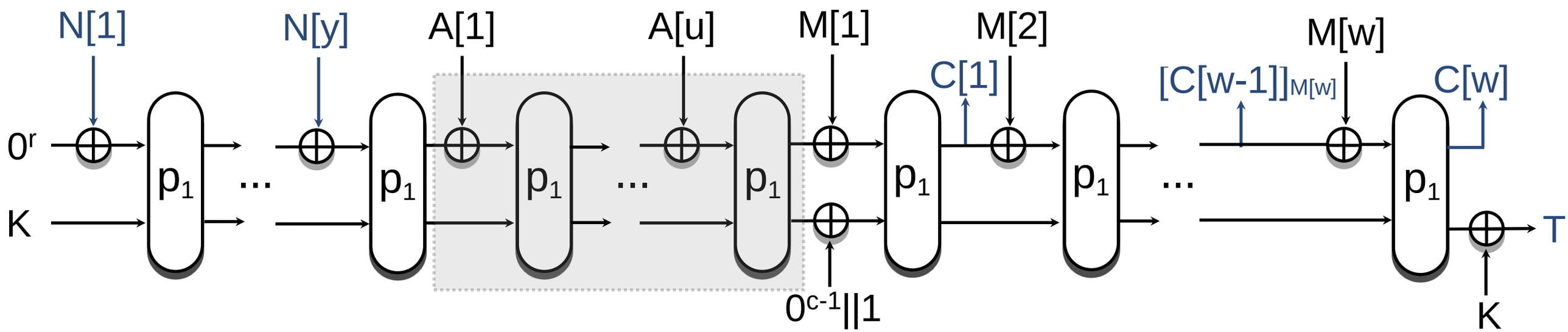


K, N and T are 80 (resp. 120) bits

Differences with HANUMAN:

- Key addition: state recovery → no key recovery
- Three permutations: p_1, p_2, p_3
- Reduced round permutations (p_2&p_3: 6 rounds) → faster

APE



N is 80 (resp. 120) bits
K and T are 160 (resp. 240) bits

Differences with HANUMAN:

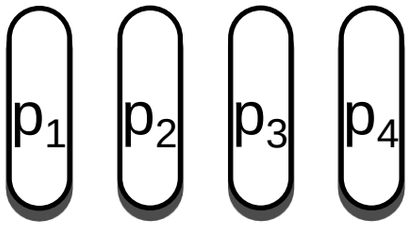
- Nonce misuse resistant (common prefix)
- Secure in Releasing Unverified Plaintext (RUP) setting
- Inverse permutation needed

Also using APE: PRØST

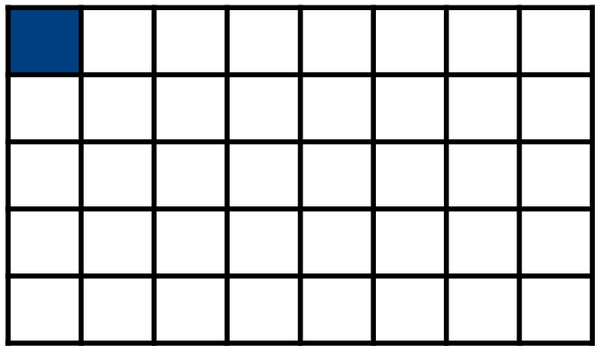
PRIMATEs Permutation

PRIMATEs

Structure



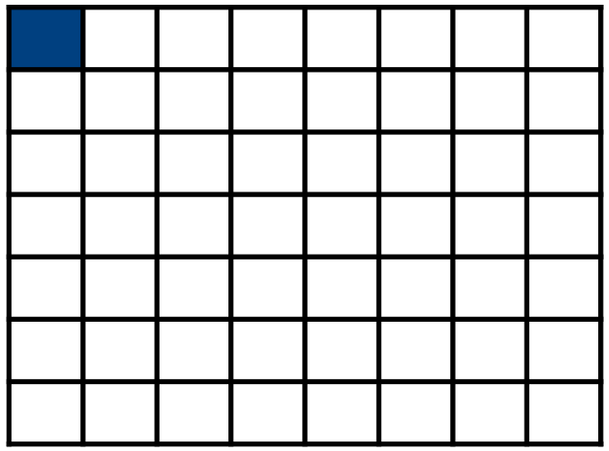
Primate–80



5x8

200-bit state

Primate–120

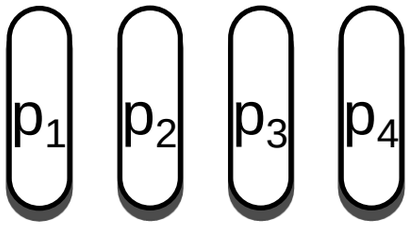


7x8

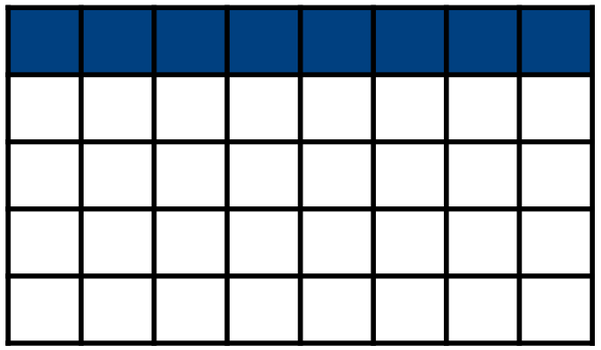
280-bit state

PRIMATEs

Structure



Primate–80



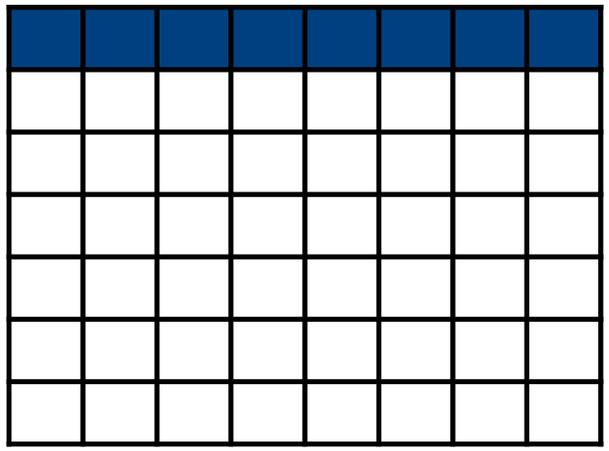
5x8

200-bit state

5-bit elements

40-bit rate

Primate–120



7x8

280-bit state

5-bit elements

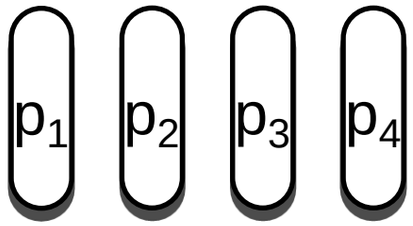
40-bit rate

Round Update: CA o MC o SR o SE

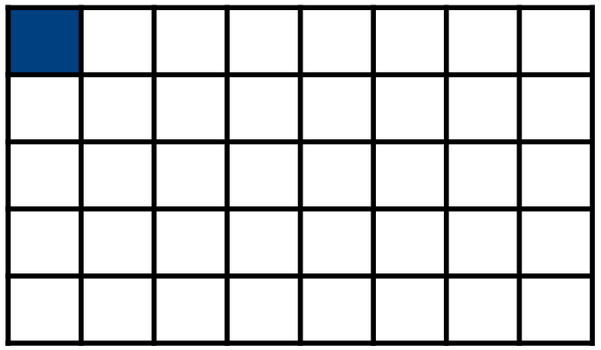
p_1, p_2, p_3 and p_4 differ in # of rounds and constants

PRIMATEs

SubElements (S-box)

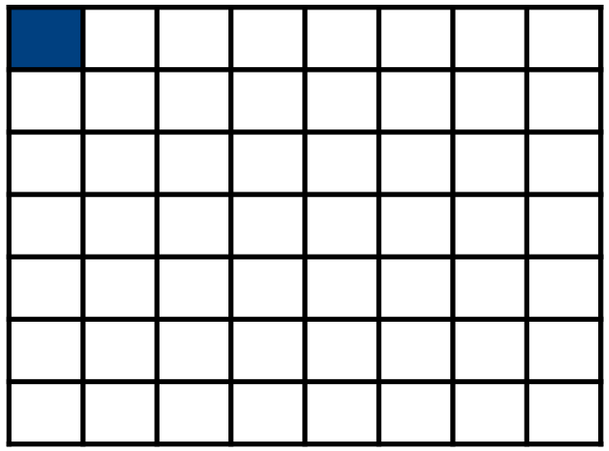


Primate–80



5x8

Primate–120

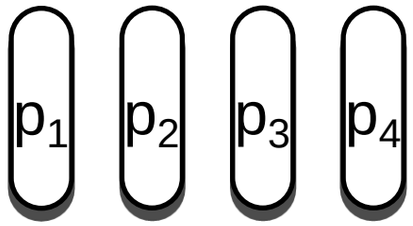


7x8

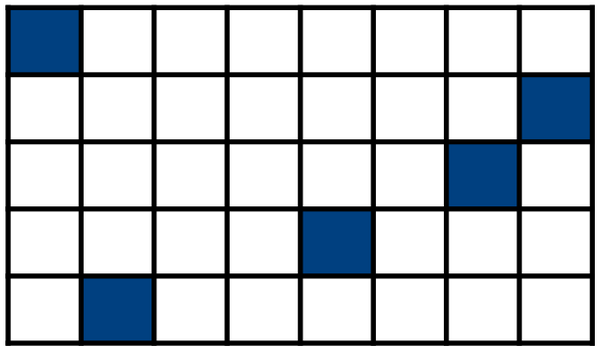
- Almost bent permutation
- Optimal linear/differential probabilities
- Small area for both plain and DPA-secure implementation

PRIMATEs

ShiftRows



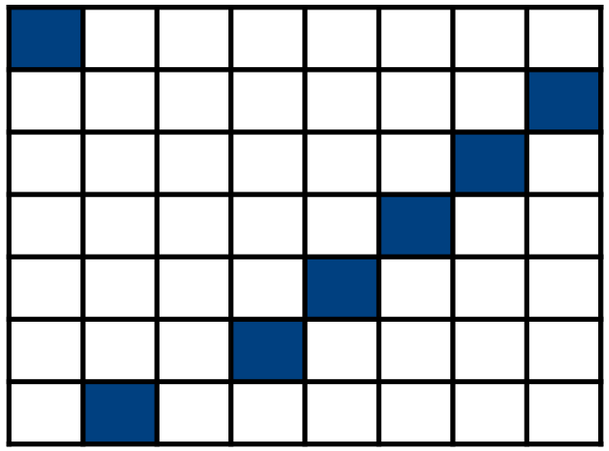
Primate–80



5x8

<< 0
<< 1
<< 2
<< 4
<< 7

Primate–120

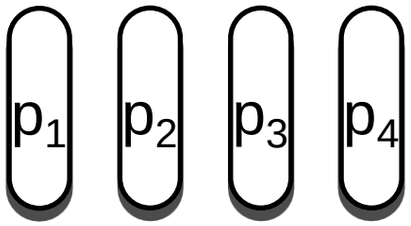


7x8

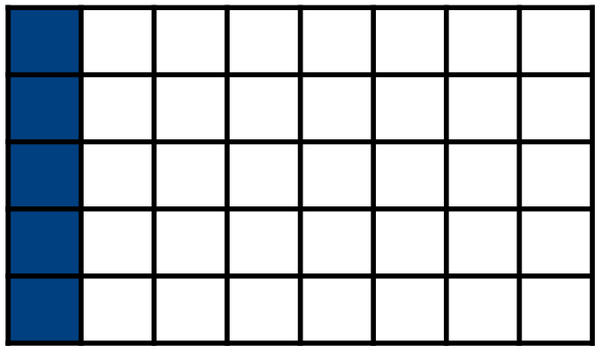
<< 0
<< 1
<< 2
<< 3
<< 4
<< 5
<< 7

PRIMATEs

MixColumns

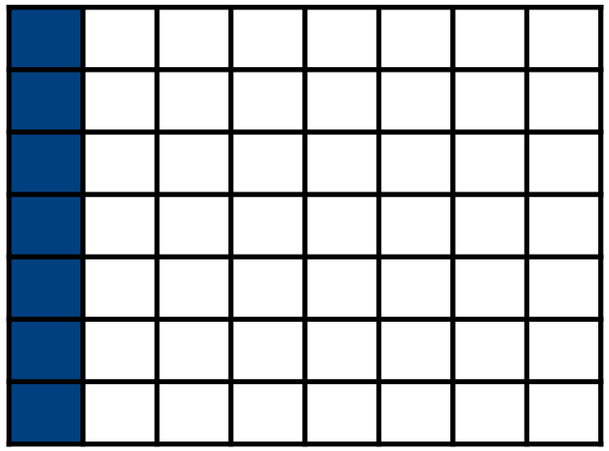


Primate–80



5x8

Primate–120



7x8

Recursive MDS matrix

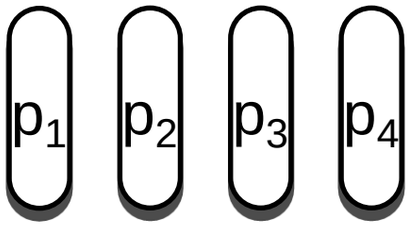
$$\otimes \begin{bmatrix} 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 1 & 18 & 2 & 2 & 18 \end{bmatrix}^5$$

$$\otimes \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 1 & 2 & 15 & 9 & 9 & 15 & 2 \end{bmatrix}^7$$

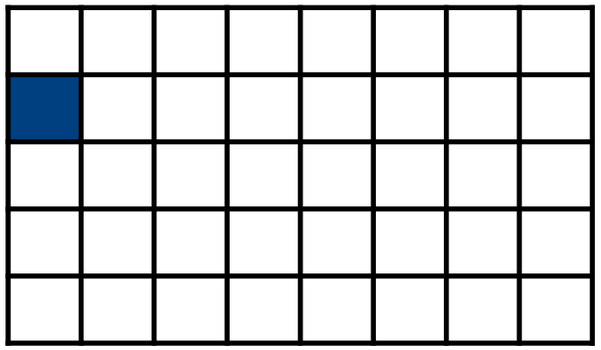
Lightweight implementation

PRIMATEs

ConstantAddition

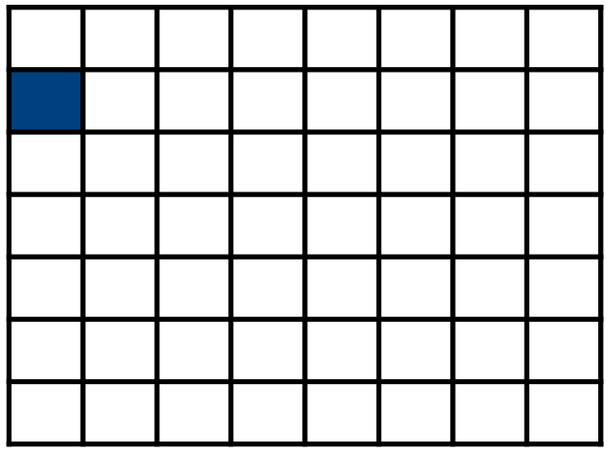


Primate–80



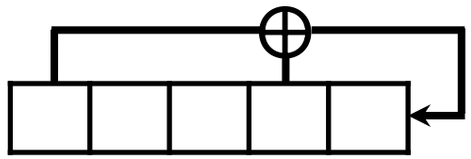
5x8

Primate–120



7x8

- 5-bit Fibonacci LFSR



- Break symmetry between rounds
- Generate different permutations

	p_1	p_2	p_3	p_4
Number of rounds	12	6	6	12
Initial value of the LFSR	1	24	30	24

PRIMATEs

Security of PRIMATEs–80/120

- Differential/linear trails for 12 rounds: max. $2^{-100}/2^{-196}$
- Impossible differentials: 5/6 rounds
- Collision trails
  - 6 rounds: 84/128 active S-boxes
  - 12 rounds: 162/224 active S-boxes

PRIMATEs vs. Other AE

PRIMATEs

- ~1300 GE (resp. ~1900 GE)
- 55 cpr (resp. 61 cpr)

AES-GCM

- AES alone is 2600 GE (21 cpr)
- Not all nonce lengths handled in same way

PRIMATEs vs. Ketje

- Ketje Jr.: ~1270 GE reg.
- Ketje Sr.: ~2500 GE reg.

PRIMATEs

General Info

http://primates.ae

PRIMATEs

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PRIMATEs: HANUMAN, GIBBON and APE

PRIMATEs are a family of **permutation-based authenticated encryption** algorithms for **lightweight applications**. They are currently under submission to the CAESAR competition.

There are **three PRIMATEs**: the basic SpongeWrap-variant **HANUMAN**, **GIBBON** for speed-critical applications, and **APE** for additional security when nonces are reused or unverified plaintext is released.

When resistance against **hardware side-channel attacks** is required, the PRIMATEs permutation has been designed to offer an **efficient threshold implementation** to counter first-order DPA attacks, based on glitch-free secret-sharing-based masking.

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- PRIMATEs: HANUMAN, GIBBON and APE
- Drunken Monkey Competition
- Software implementation v1
- Specification v1

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Drunken Monkey Competition

For the **most interesting cryptanalysis** of PRIMATEs as submitted to first round of the CAESAR competition, we give away an **entire crate** (24 bottles of 33 cl) of the **best beer in the world**: the Westvleteren XII Trappist beer.

Entries must be sent to the crypto-competitions mailing list before the start of DIAC 2014. The choice of the winner is at the discretion of the

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SW implementation

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Coming soon: HW implementation

Monkey Competition

For the **most interesting cryptanalysis** of PRIMATEs as submitted to first round of the CAESAR competition, we give away an **entire crate** (24 bottles of 33 cl) of the **best beer in the world**: the Westvleteren XII Trappist beer.

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Up to date specifications

SW implementation

Drunken Monkey Competition

For the most interesting cryptanalysis of PRIMATEs

Deadline: DIAC 2014

Runner-up

In a Nutshell

PRIMATEs

- Permutation-based AE
- Lightweight

Three designs

- APE: misuse resistance
- HANUMAN: ideal permutation
- GIBBON: trade-off speed/security

Efficient threshold implementation

Thank You!

Supporting Slides

PRIMATEs

Ranking w.r.t security



- APE–120
- HANUMAN–120
- GIBBON–120
- APE–80
- HANUMAN–80
- GIBBON–80