Generic Attacks on Duplex-based AEAD modes

Small cycles and large components

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We call $\mu(x)$ and $\lambda(x)$ the cycle length and tail length respectively

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DEFINITION ((s, ν)-COMPONENT)

let $0 < \nu < \frac{1}{2}$ and $0 < s < 1$. A (s, ν)-component is a component whose size is greater or equal to ns and whose cycle is of size at most $n^{\frac{1}{2}-\nu}$.

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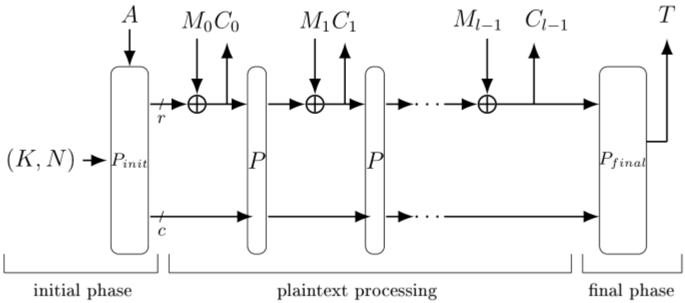
  De Laurentis, Crypto 1987, "Components and Cycles of a random function"

DUPLEX AEAD



A
$M_0 C_0$
$M_1 C_1$
M_{l-1}
C_{l-1}
T
(K, N)
P_{init}
r
c
P
P
P_{final}
initial phase
plaintext processing
final phase

SECURITY OF DUPLEX

Simplified Beyond conventional security in sponge-based authenticated encryption modes [Jovanovic, Luykx, Mennink, Sasaki, Yasuda, JoC 2019]

$$\mathcal{T} \ll \min\{2^{\frac{b}{2}}, \frac{2^c}{\alpha}, 2^\kappa\} \text{ and } q_d \ll 2^\tau$$

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where, $\alpha < r$, where q_d is the number of forgery attempts.
So duplex construction is proven for $2^{\frac{c}{2}}$, and known generic attacks are in $\frac{2^c}{\alpha}$

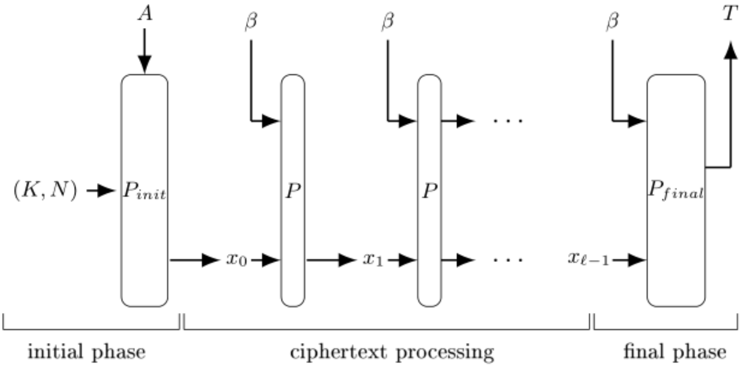
OBSERVATION IN DECRYPTION MODE

Let $C_{\beta}^{\ell} = \beta_{\ell} = \underbrace{\beta || \cdots || \beta}_{\ell}$.

Observation in decryption mode

Let $C^{\ell}_{\beta} = \beta_{\ell} = \underbrace{\beta || \cdots || \beta}_{\ell}$. Then the decryption of C^{ℓ}_{β} corresponds to the iteration of

$$\begin{array}{rcrcl} f_{\beta} & : & \mathbb{F}_2^c & \longrightarrow & \mathbb{F}_2^c \\ & & x & \longmapsto & \lfloor P(\beta || x) \rfloor_c . \end{array}$$



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Online : input (N, A, C, T) with N, A possibly different and $C = C_\beta^\ell$ with $\ell = \gamma 2^{\frac{c}{2}}$. And T being derived from a value of the cycle of f_β ($n^{\frac{1}{2}-\nu}$ possibilities at most)

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- (s, ν) costs too much, so we use an approximation (CLT)

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Complexity $\mathcal{O}\left(2^{\frac{3c}{4}}\right)$

Experimental verification

Statistics verified up to small c values.

Specific modes and padding

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- Motorist : Keyak

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- Adding key material in the final phase
- Use a ρ-like application (Beetle, Subterranean)