Message Authentication Code

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Course “Information and Network Security”
Lecture 5
4 апреля 2020 г.

Confidentiality & Integrity

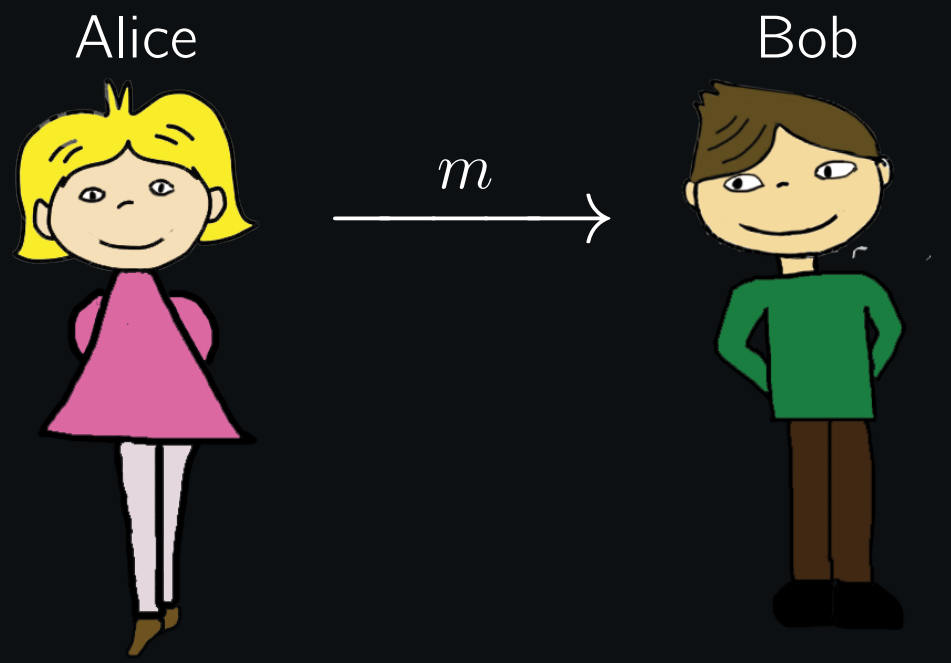
- Previous lectures dealt with confidentiality
- This lecture's goal: integrity (целостность)

Primitive: Message Authentication Code (MAC)

Имитовставка или Код Аутентификации Сообщения

MAC: definition

Goal: send a message m from Alice to Bob s.t. an adversary cannot modify m without Bob noticing



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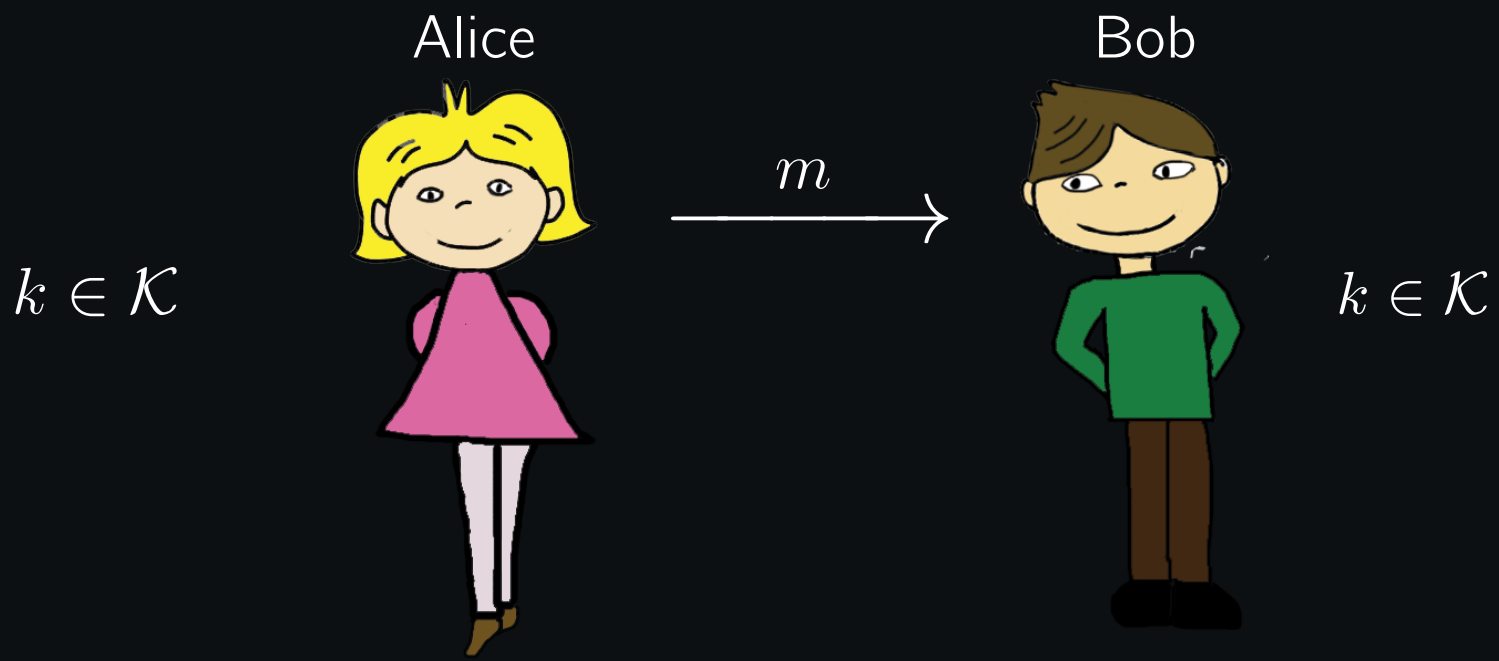

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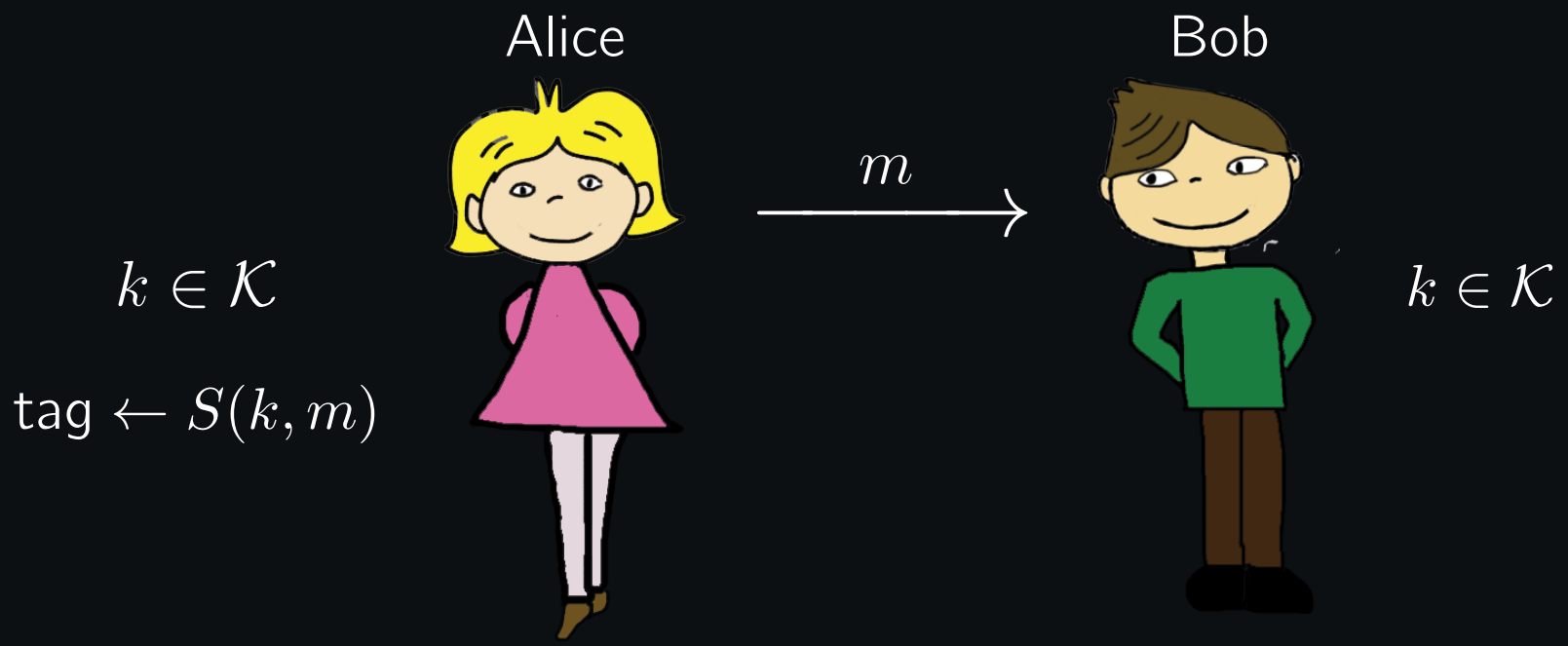

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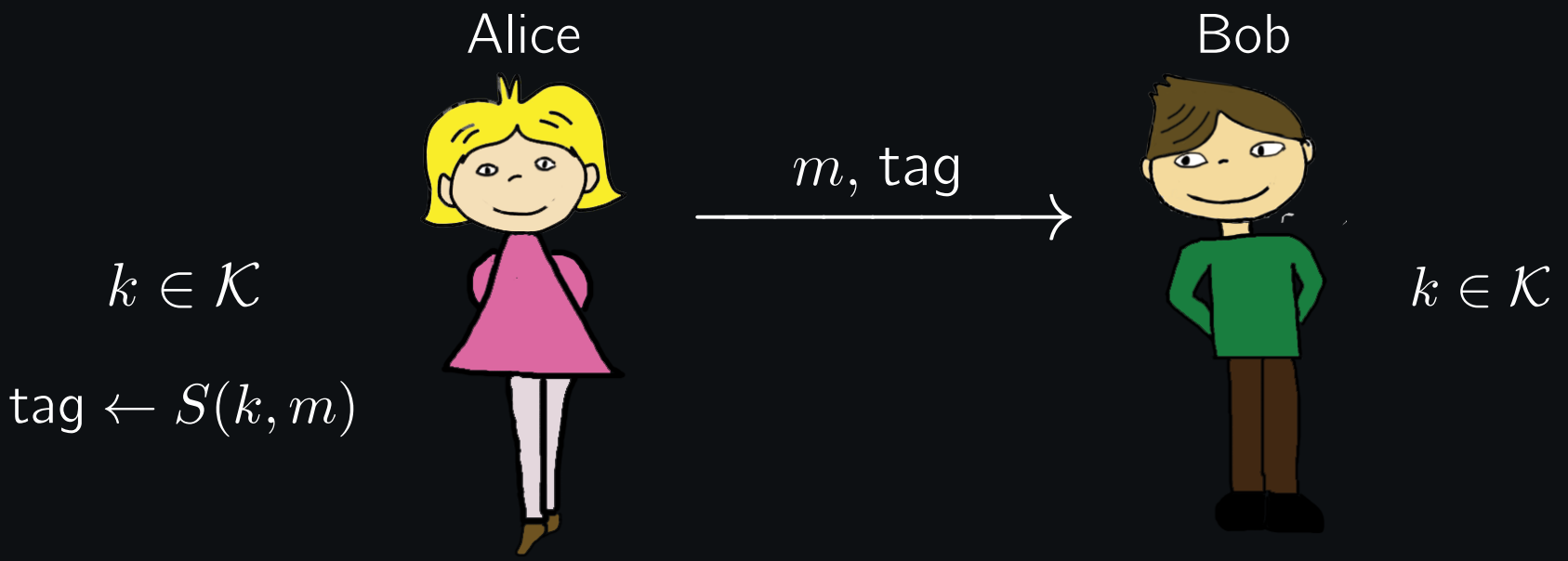

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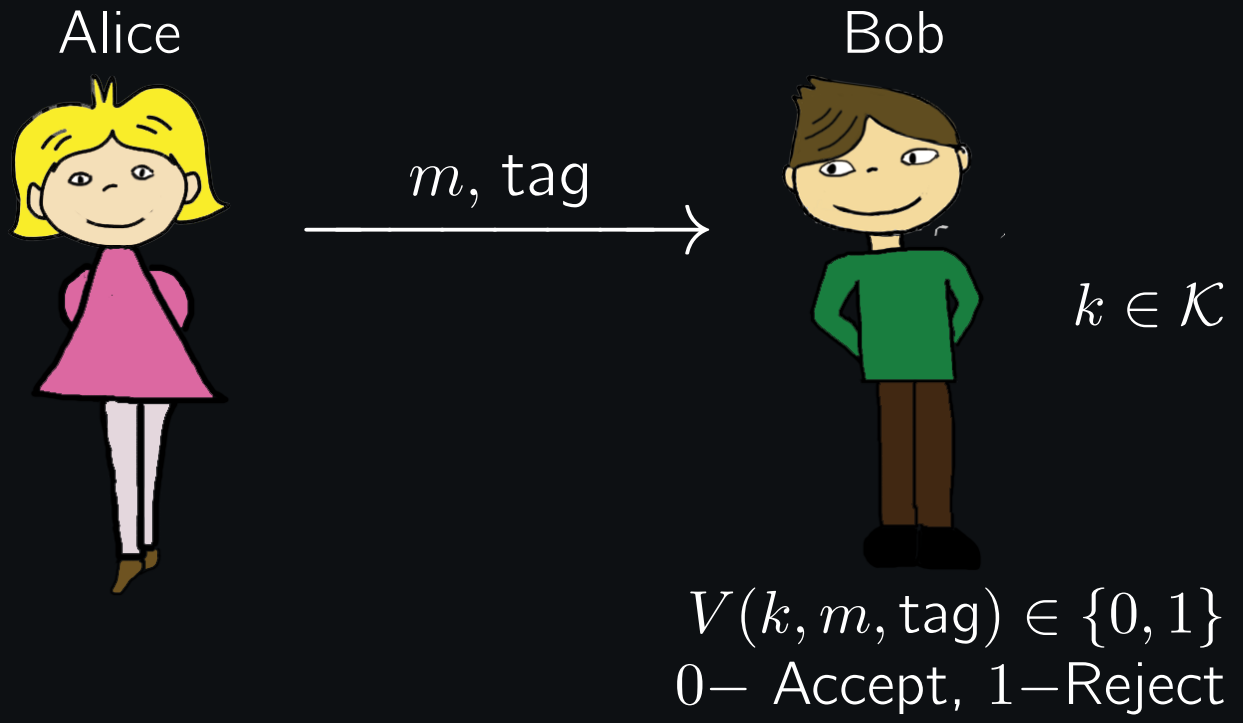

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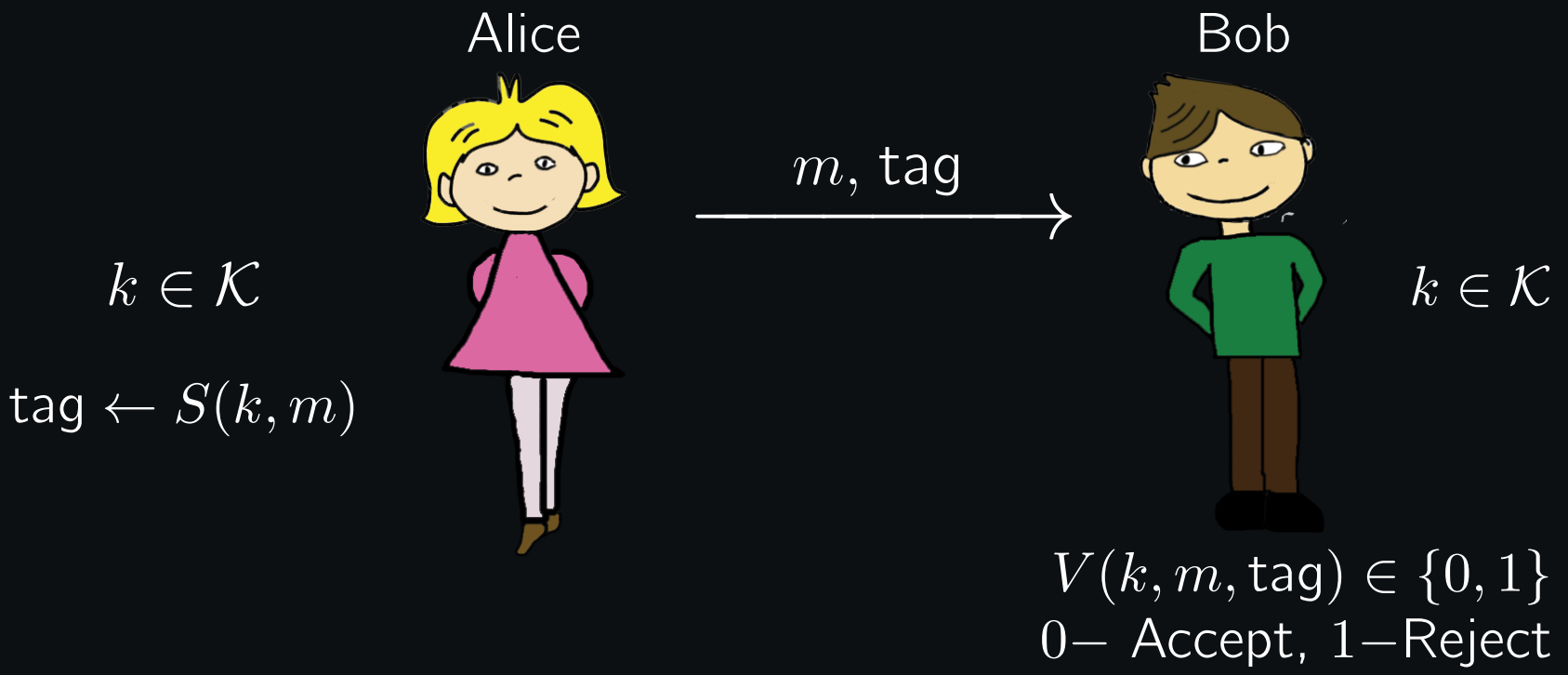

A Message Authentication Code consists of three ppt algorithms:

- Key generation: $\text{KeyGen}(1^\lambda) : k \leftarrow \mathcal{K}$
- Tag generation: $S(k, m) : \text{tag} \leftarrow \mathcal{T}$
- Tag verification: $V(k, m, \text{tag}) : \{0, 1\}$

MAC: correctness and security

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Correcntess: $V(k, m, S(k, m)) = \mathsf{Accept}\ \forall\ m \in \mathcal{M}, k \in \mathcal{K}$

Security: For a ppt adversary $\mathcal{A}$ who sees many (message, tag) pairs $\{(m_1, t_1), \ldots, (m_N, t_N)\}$ of its choice, $\mathcal{A}$ cannot produce a new valid (message, tag) pair (m, t)

$$(m, t) \notin \{(m_1, t_1), \ldots, (m_N, t_N)\}$$

Therefore, secure tag length: $96, 128, 256$ bits.

Constructions of MACs

1. A block-cipher (AES, GOST) can be used to instantiate MAC for 16-bytes messages

2. For longer messages:
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   Standards: ANSI, FIPS 186-3, GOST
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This time: CBC-MAC

CBC-MAC

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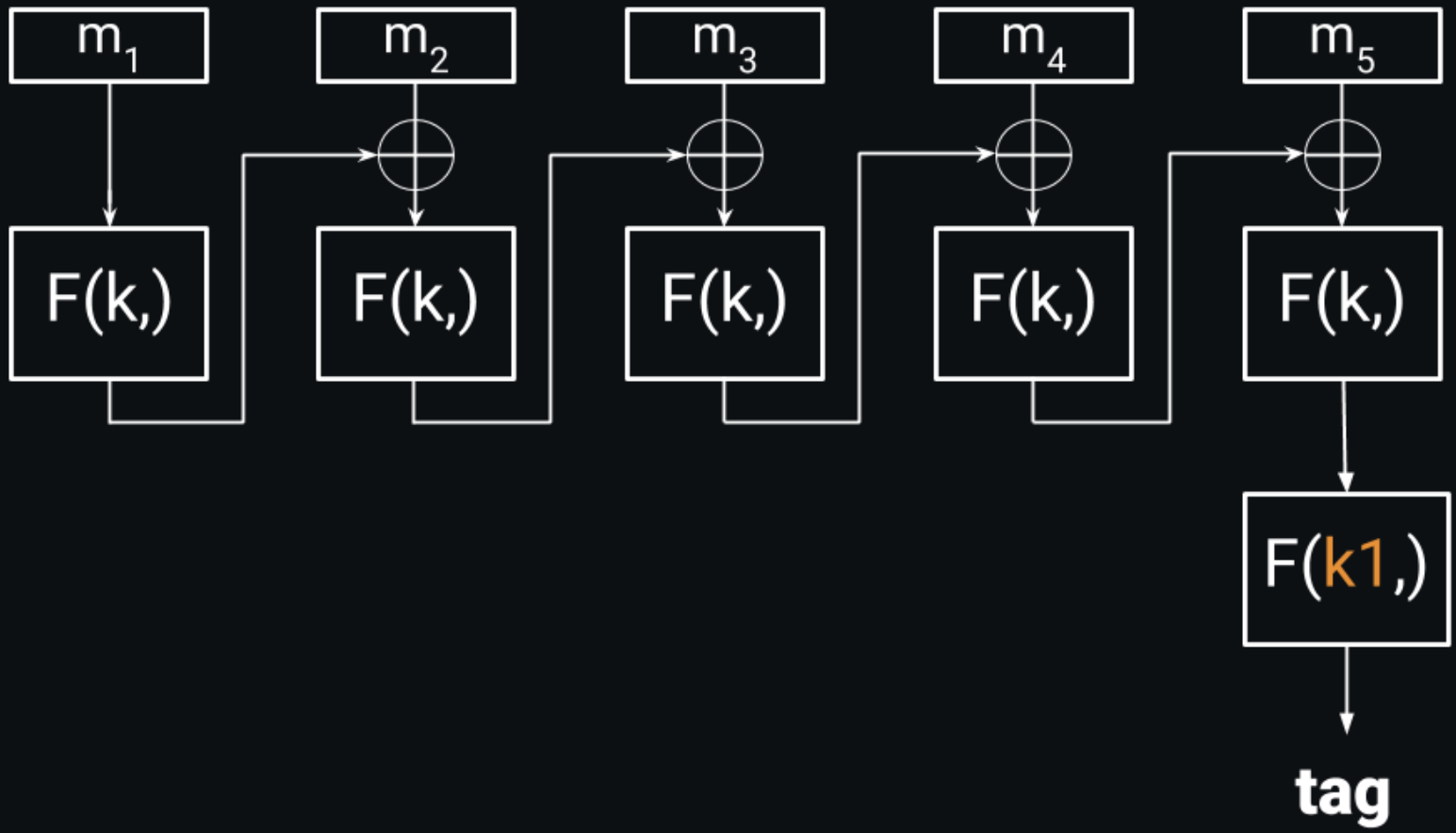

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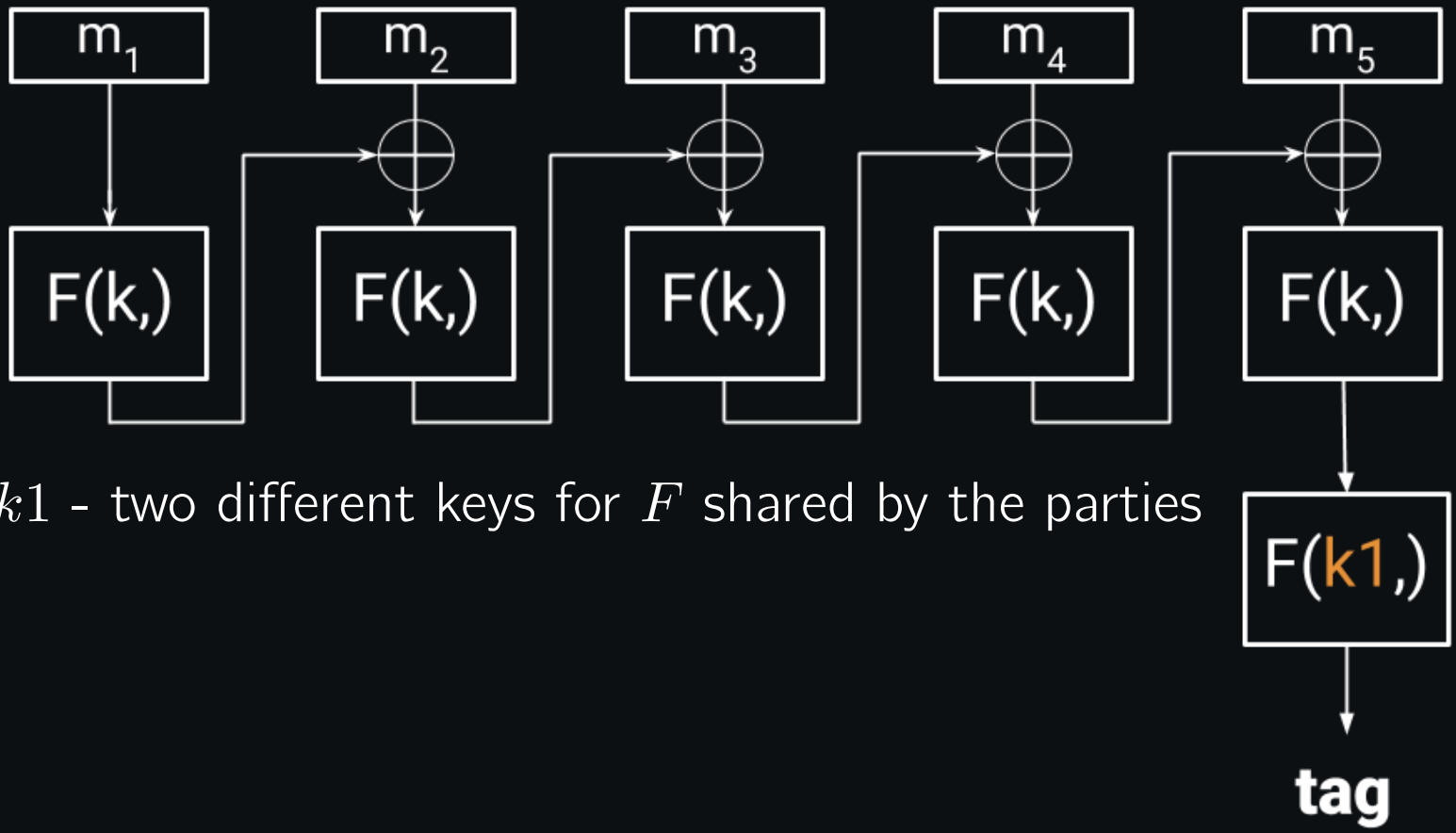

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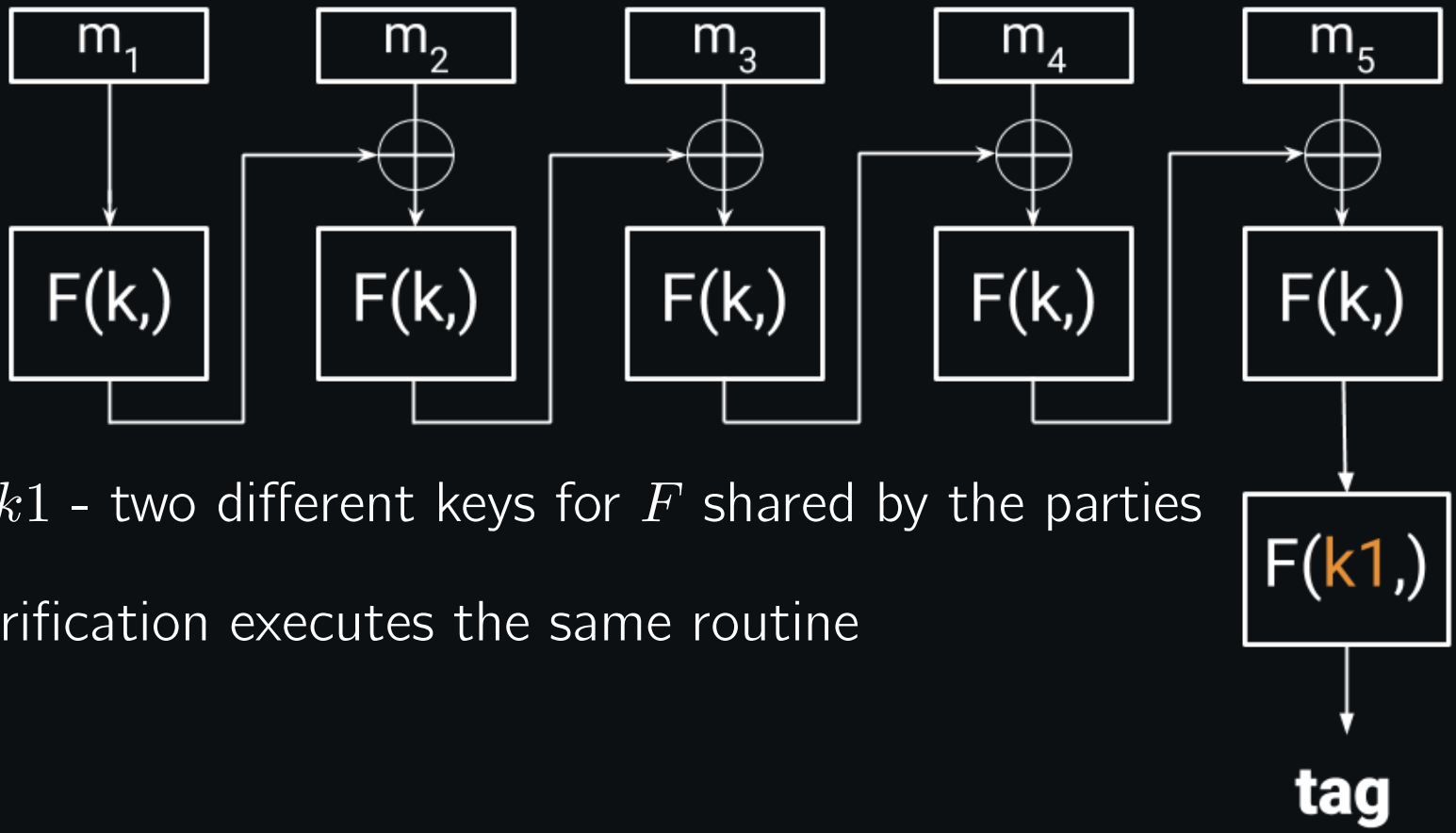

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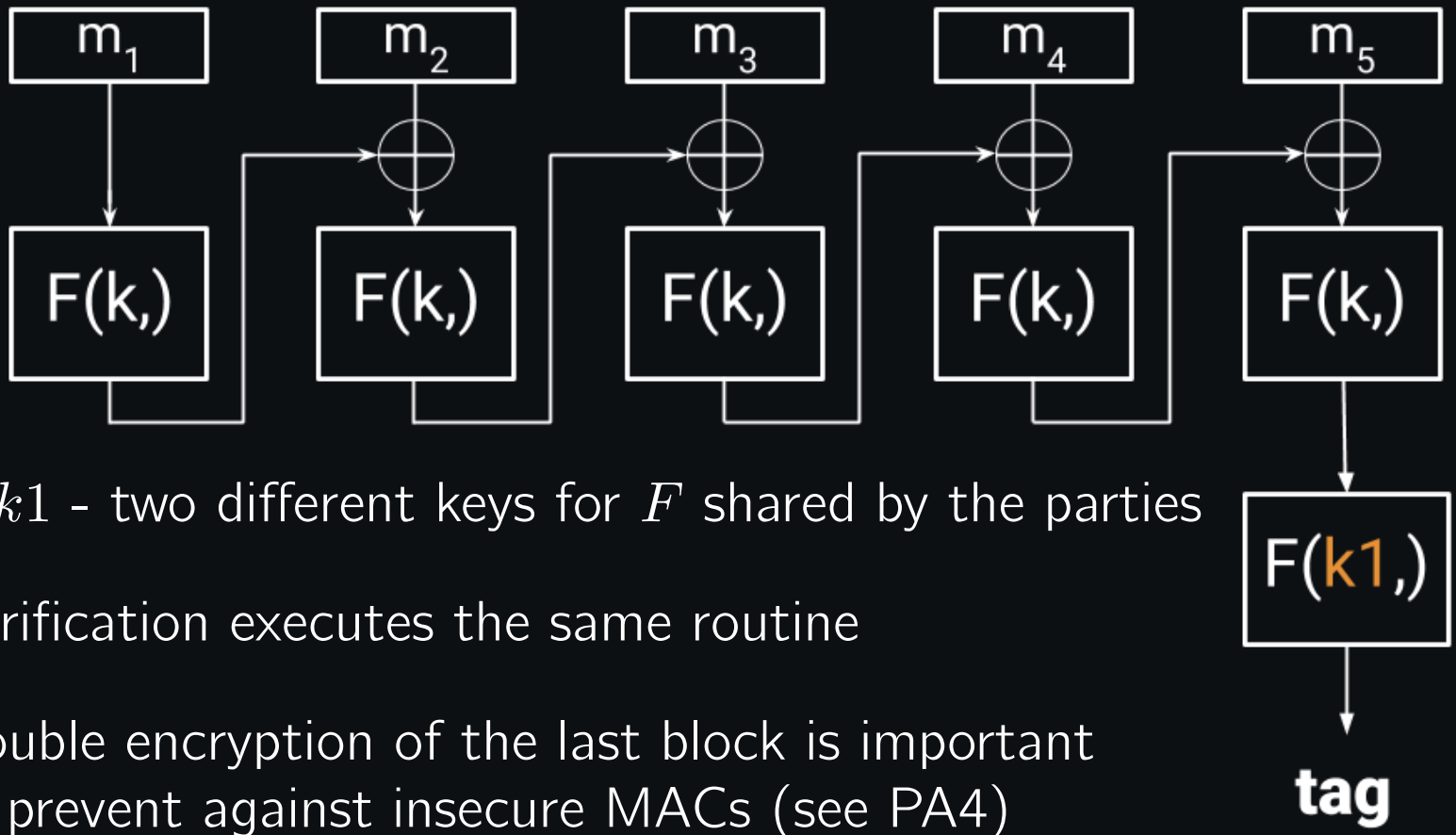

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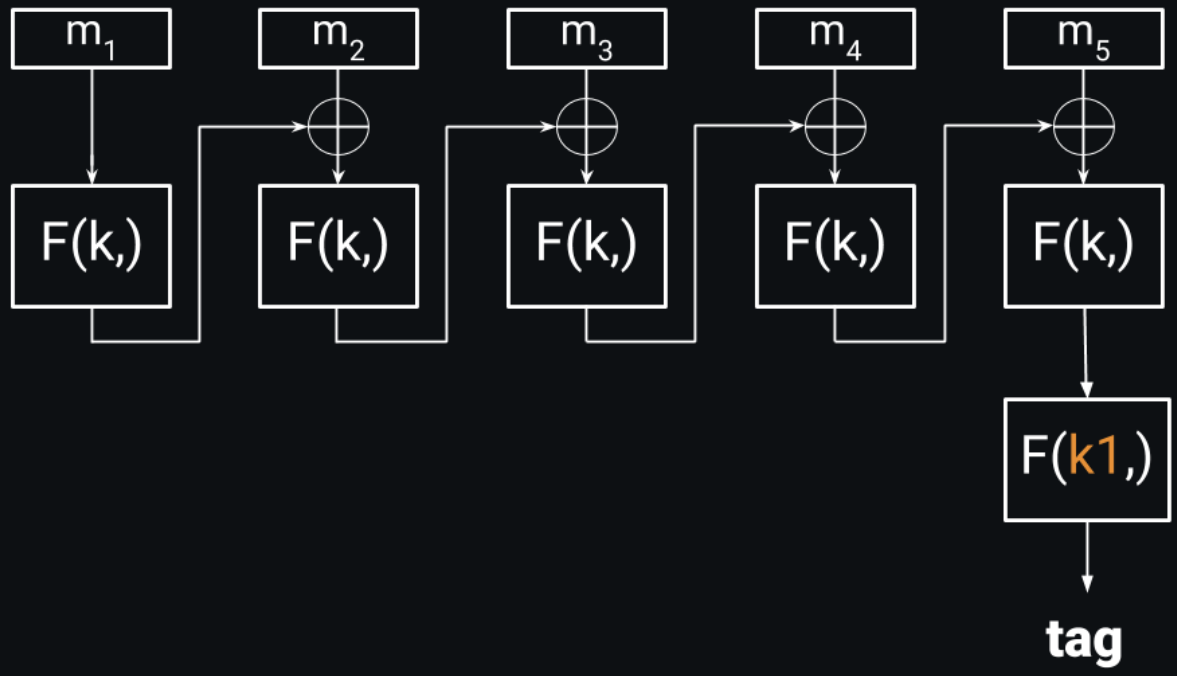
Verification executes the same routine

Double encryption of the last block is important
to prevent against insecure MACs (see PA4)

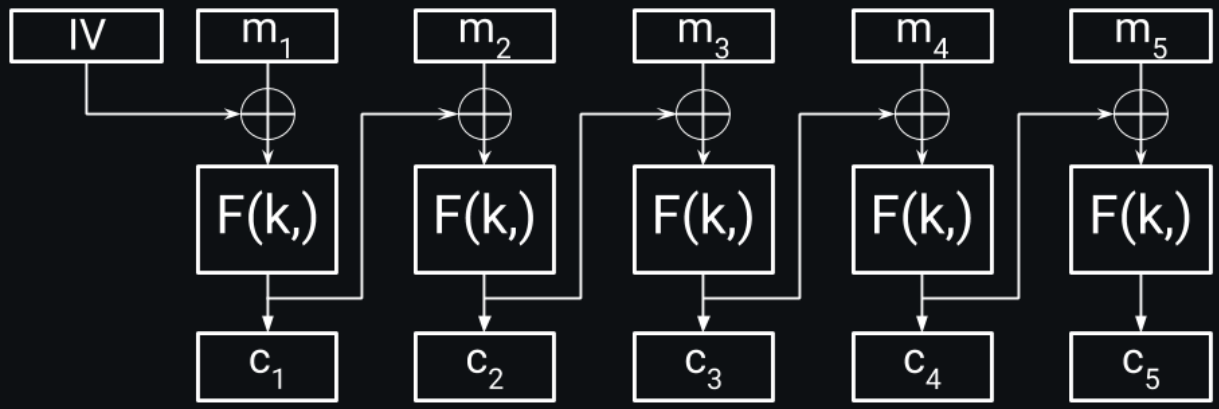
The output tag can be truncated to the desired bit length, but not less than 64 bits.

Compare CBC-MAC with CBC-mode for block-ciphers

CBC-MAC:



CBC-mode:



Padding

What if $\mathbf{m} = (m_1, m_2, ...)$ is not a multiple of the block length?

Example of bad padding: filling up with $0'$s.

$$m = (\star\star\star)$$

that has length $<$ block length. Padding of such message:

$$m_{\text{padded}} = (\star\star\star\, 0 \ldots 0)$$

. Then for another message m':

$$S(k, m_{\text{padded}}) = S(k, m' = (\star\star\star\, 0 \ldots 0))$$

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For $\mathbf{m} \neq \mathbf{m}'$ we want $\mathbf{m}||\text{pad} \neq \mathbf{m}'||\text{pad}$. In particular, padding must be $1 \leftrightarrow 1$.

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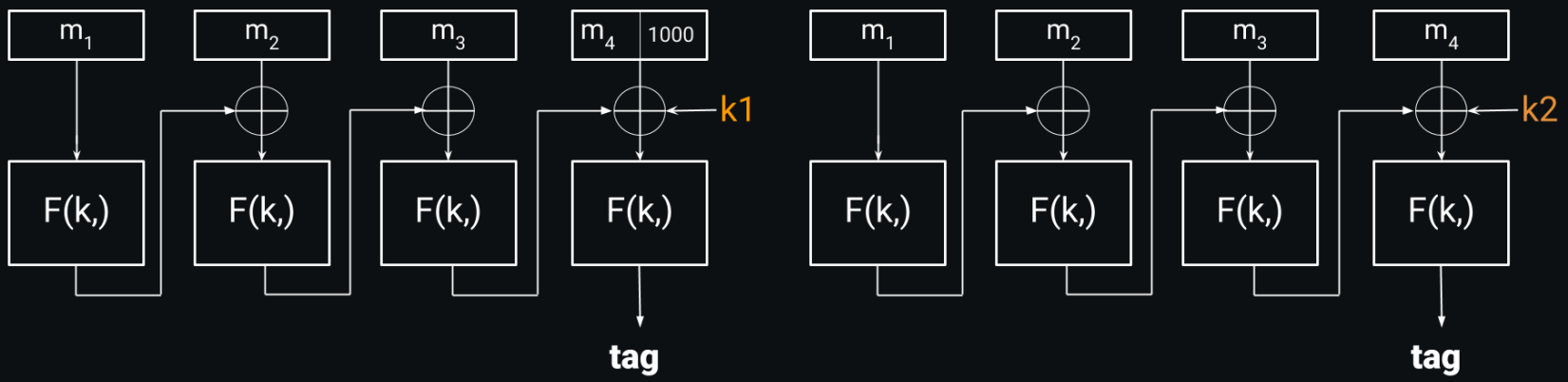
2. NIST, GOST



$m_4 <$ block-length

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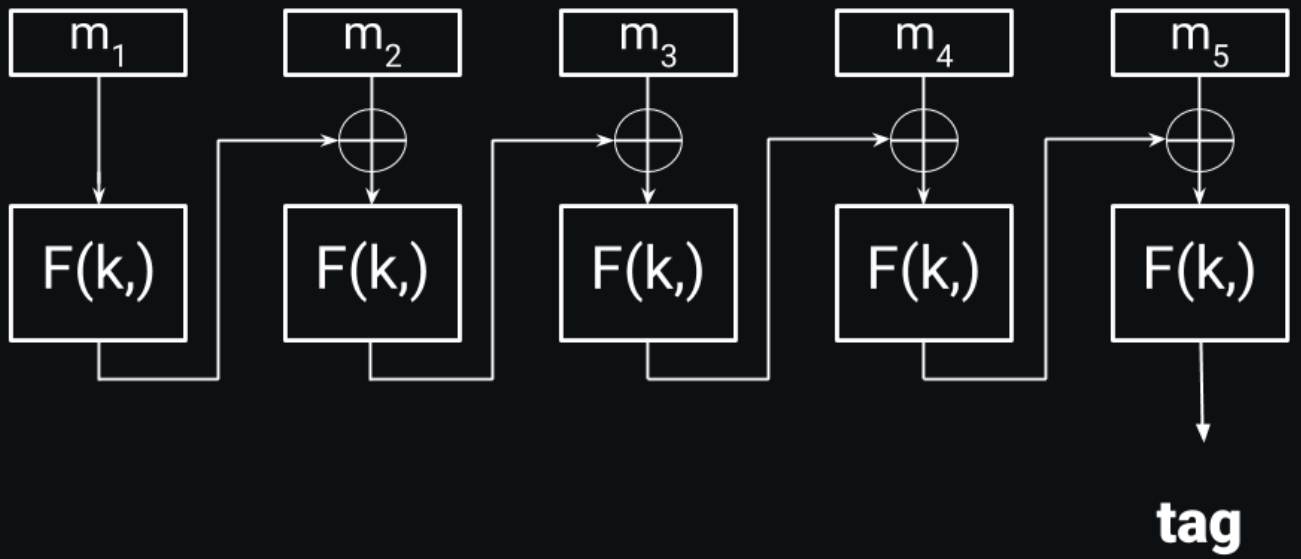
Advantages: No dummy block, no additional application of F.

Some details on Programming Assignment 4

Assume our tag is generated without the last encryption step for one-block message m ($|m| = 128$ bits).



Your task is to demonstrate an efficient tag forgery for such construction: by having (m, t) - a valid (message, tag) pair, provide another valid pair (m', t).
Hint: m' might consist of two blocks.

Concluding slide

1. Other types of MACs exist: Parallel Mac (PMAC), One-time MAC
2. MACs are not Checksums! MACs require secret keys
3. DO NOT follow the Russian Wikipedia article on MACs
4. For Russian project follow GOST'15 guidelines (link is on the course's webpage)

Next time: Message integrity with cryptographic hash functions