Active Adversary

Lecture 7

CCA Security

MAC

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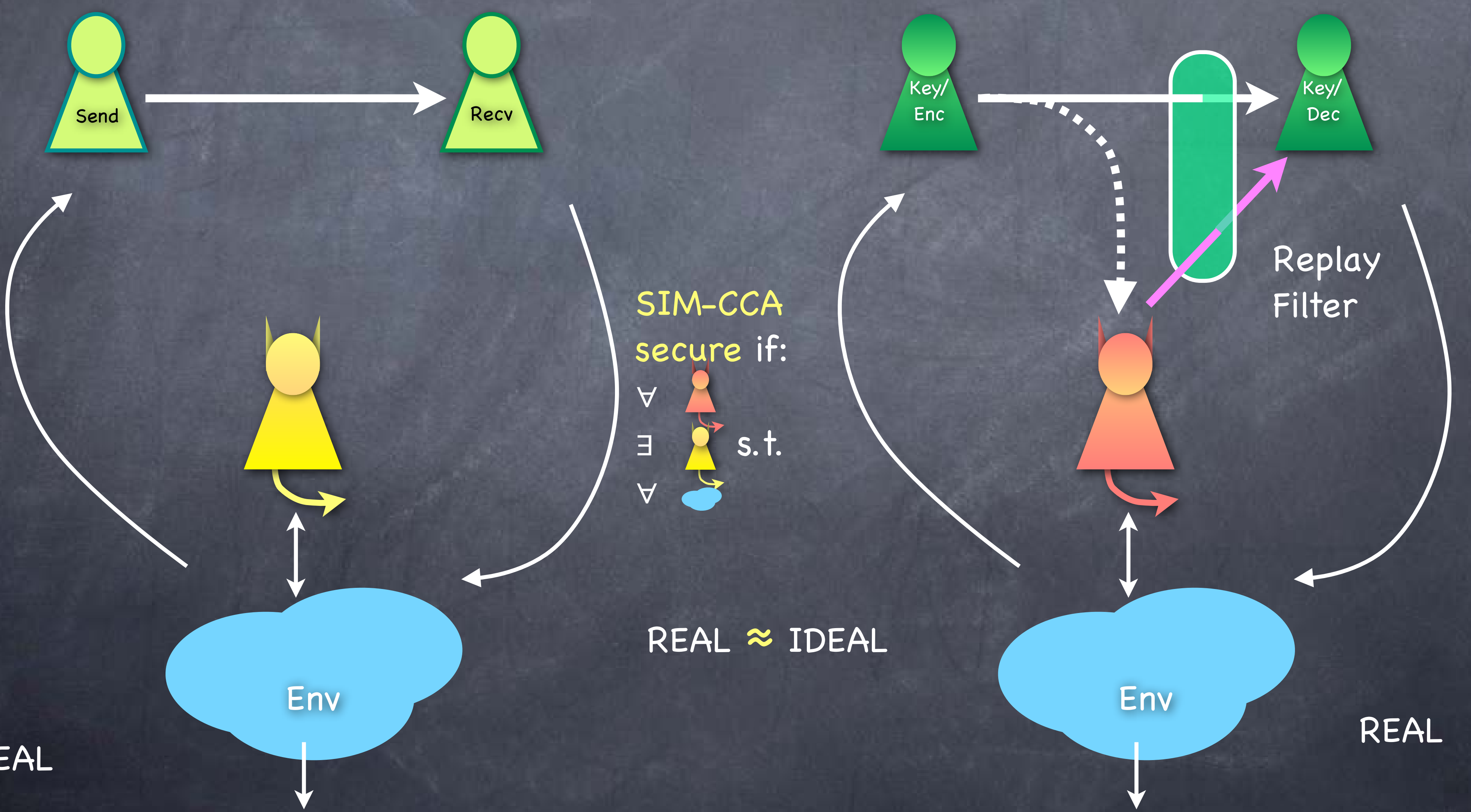
    - What can Bob do?

Symmetric-Key Encryption

SIM-CCA Security



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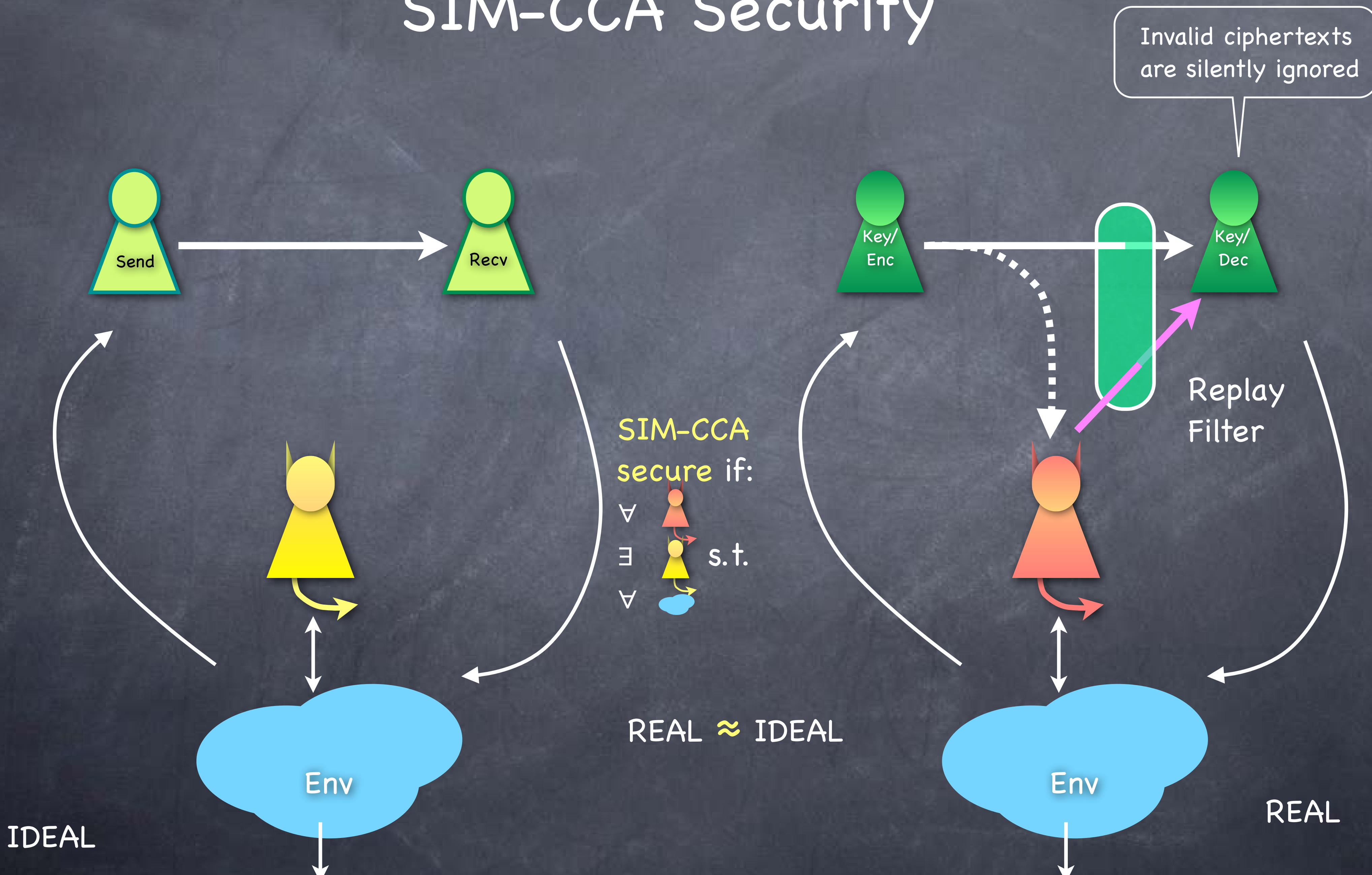
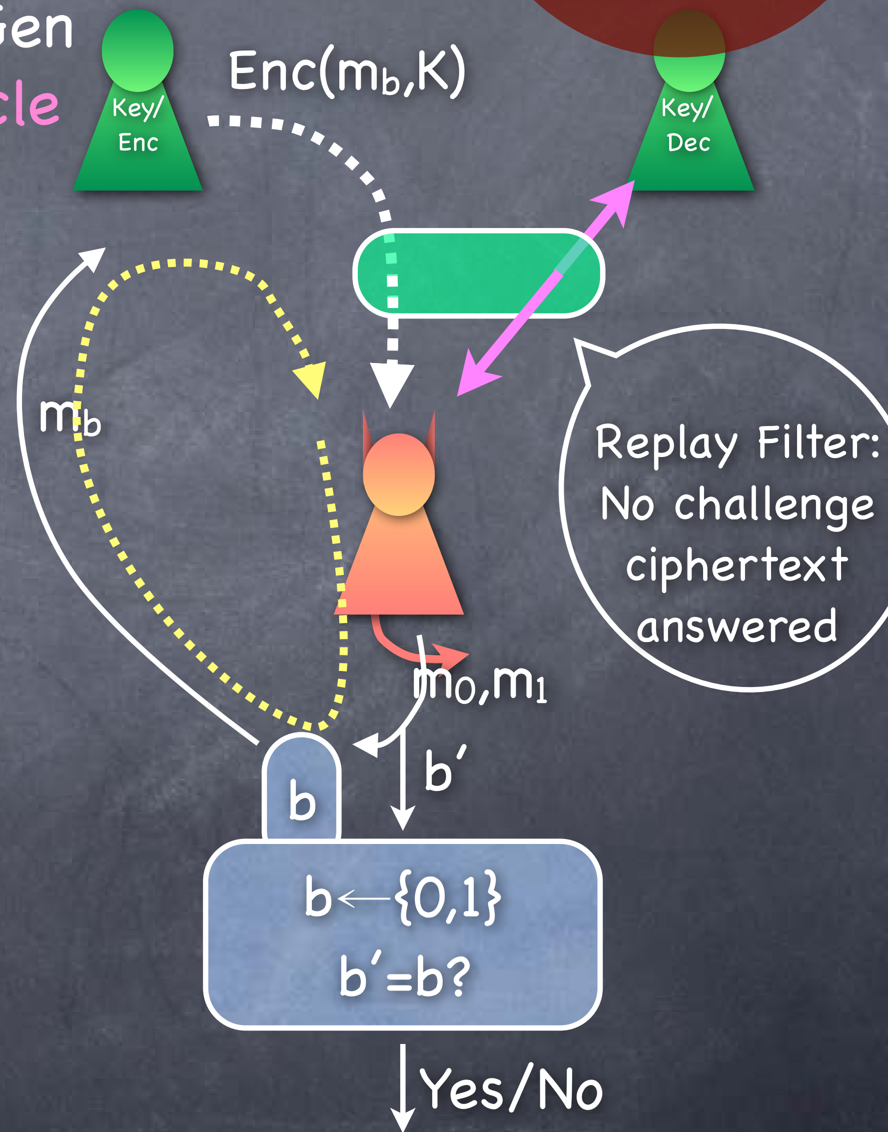


Symmetric-Key Encryption

IND-CCA Security

IND-CCA + ~correctness equivalent to SIM-CCA

- Experiment picks $b \leftarrow \{0,1\}$ and $K \leftarrow$ KeyGen
  Adv gets (guarded) access to Dec_K oracle
  - For as long as Adversary wants
    - Adv sends two messages m_0, m_1 to the experiment
    - Expt returns $Enc(m_b,K)$ to the adversary
- Adversary returns a guess b'
- Experiments outputs 1 iff $b'=b$
- IND-CCA secure if for all feasible adversaries $Pr[b'=b] \approx 1/2$



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  - MAC: Message Authentication Code

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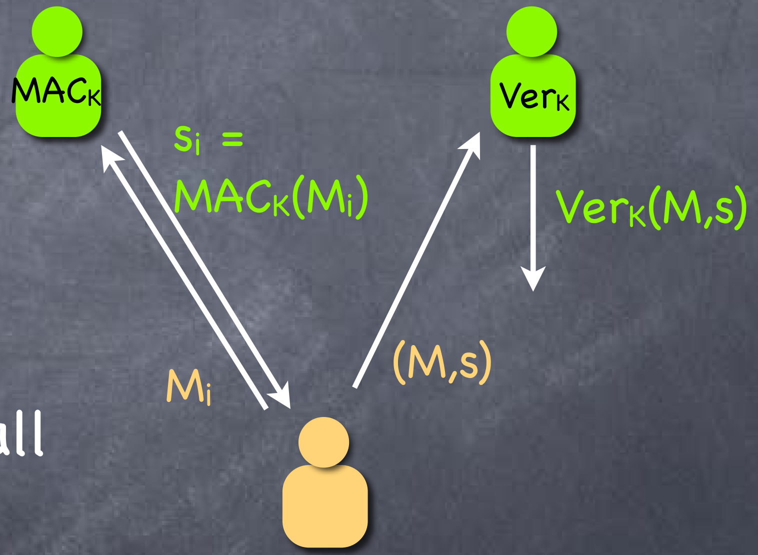
- A triple (KeyGen, MAC, Verify)
- Correctness: For all K from KeyGen, and all messages M, $Verify_K(M,MAC_K(M))=1$
- Security: probability that an adversary can produce (M,s) s.t. $Verify_K(M,s)=1$ is negligible unless Alice produced an output $s=MAC_K(M)$



Advantage
$= Pr[\, Ver_K(M,s)=1$ and $(M,s) \notin \{(M_i,s_i)\}\,]$

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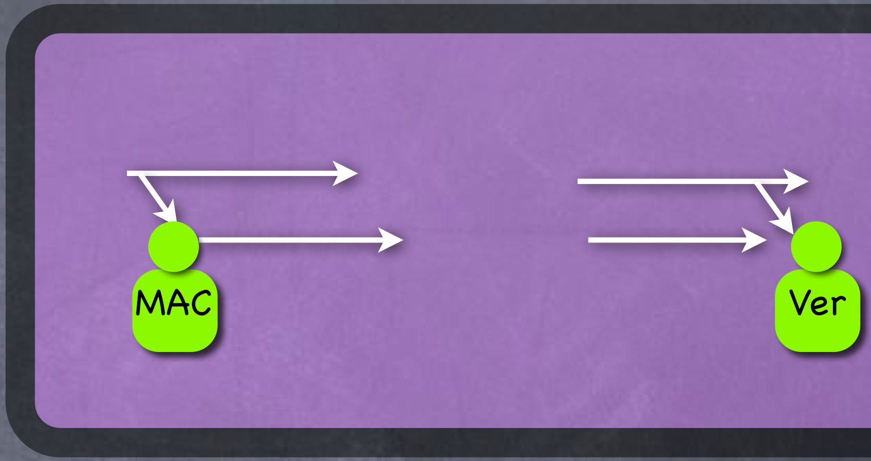
- In principle, PRFs can be constructed (less efficiently) based on any One-Way Permutation or even any One-Way Function

Making a MAC

One-time MAC



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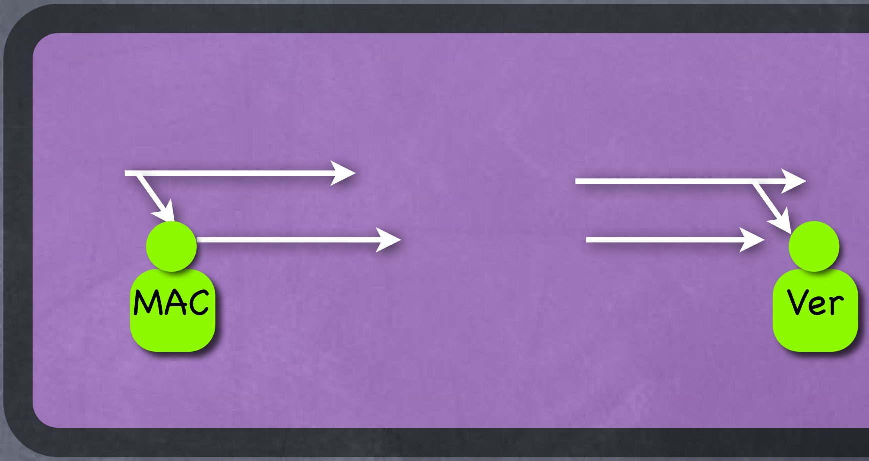

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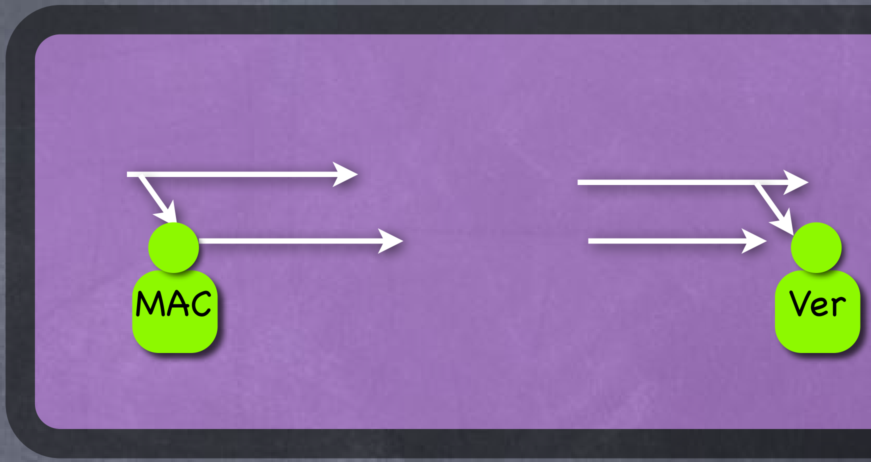

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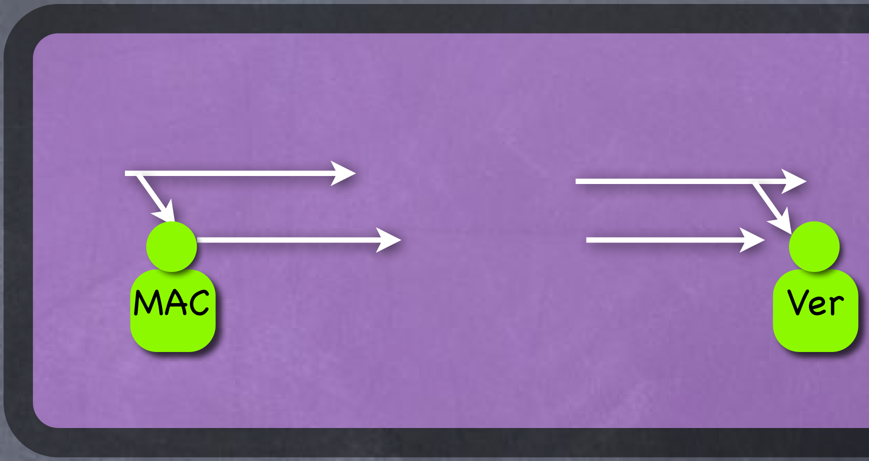

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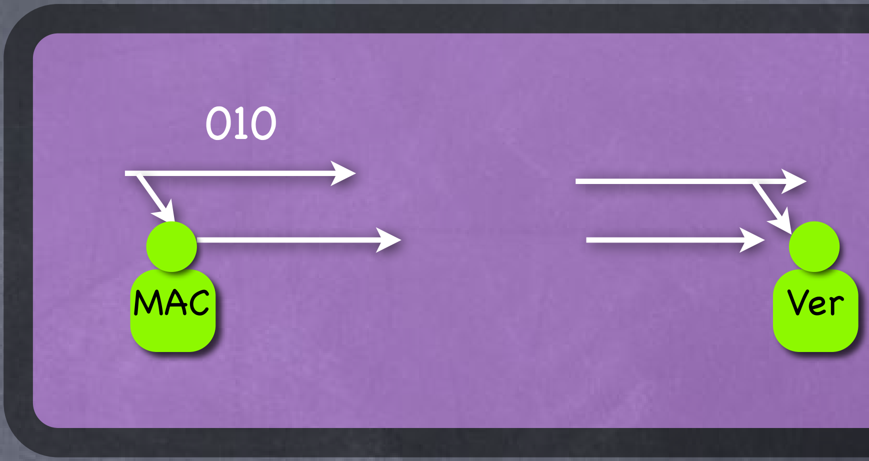

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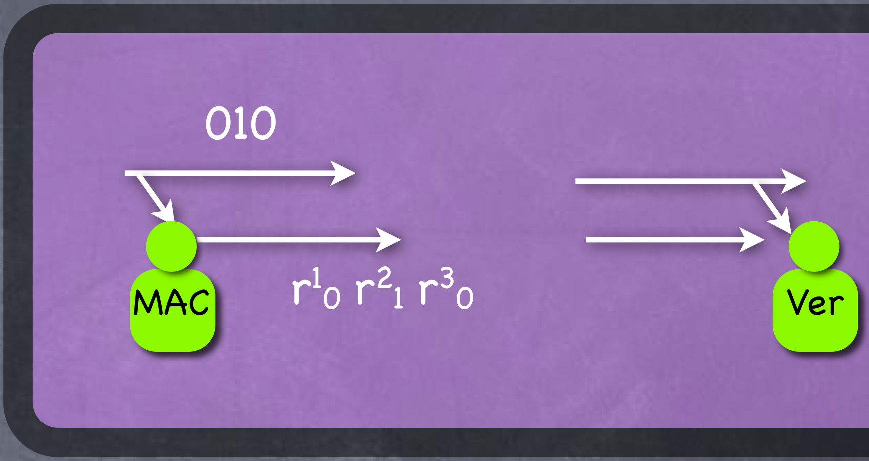

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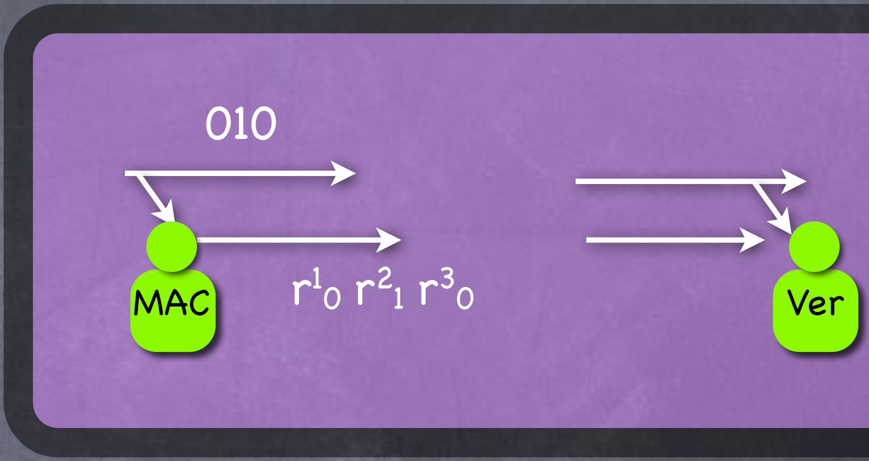

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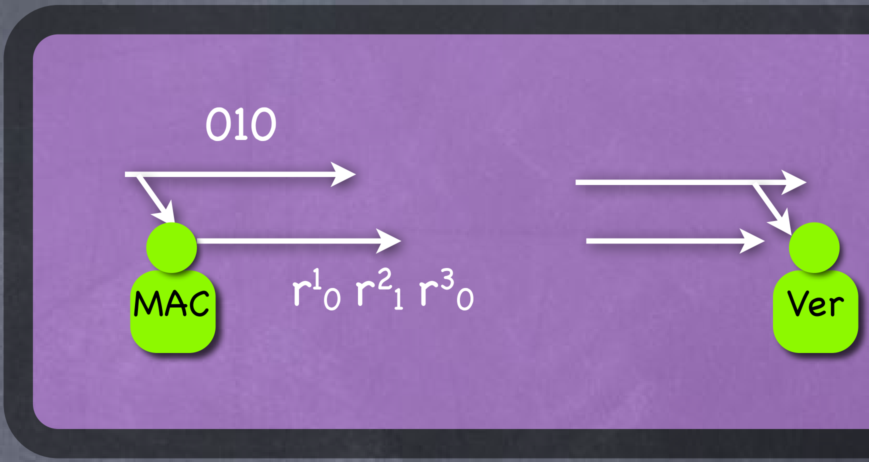

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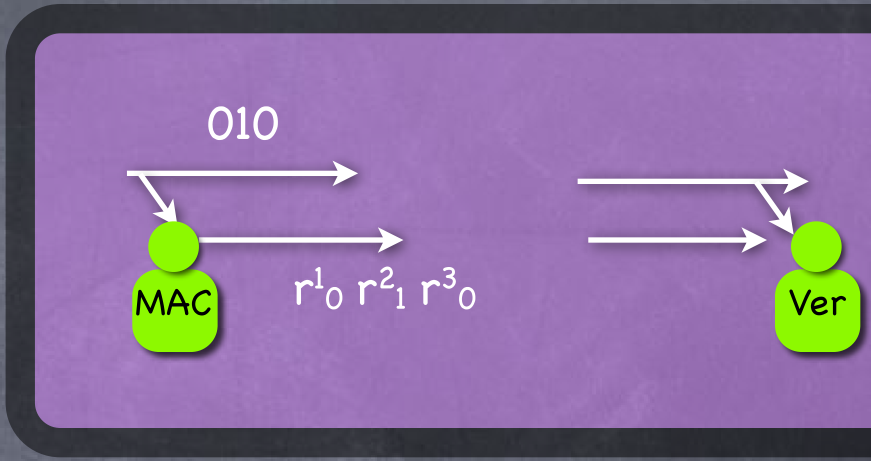

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- Doesn't require any computational restrictions on adversary!
- More efficient one-time MACs exist (later)

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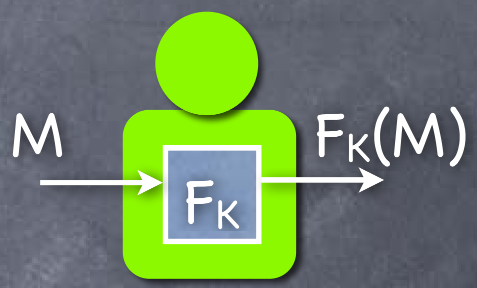

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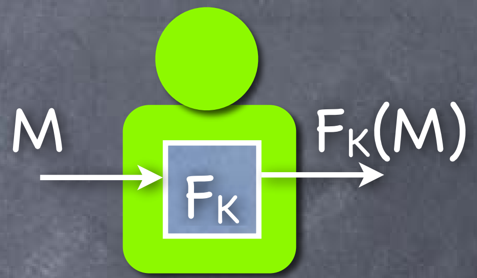

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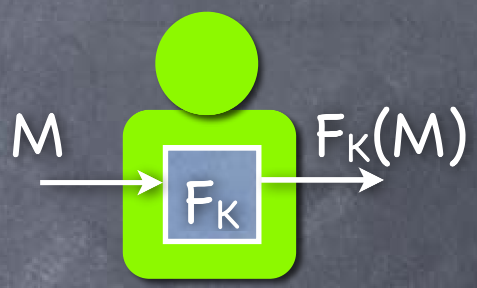

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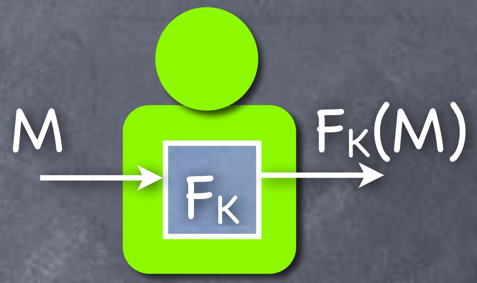

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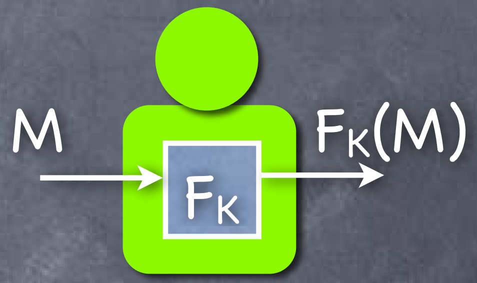

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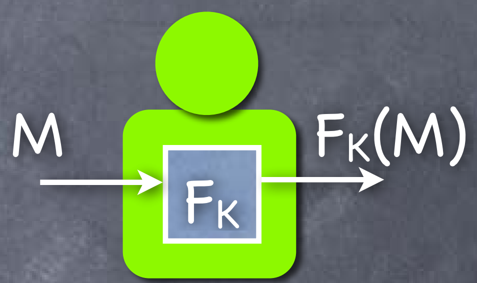

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  - If random function R used as MAC, then probability of forgery, $\varepsilon_{MAC^*} = 2^{-m(k)}$

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- Can we use a PRF with a fixed block-length (i.e., a block cipher)?

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- Inefficient! Tag length increases with message length

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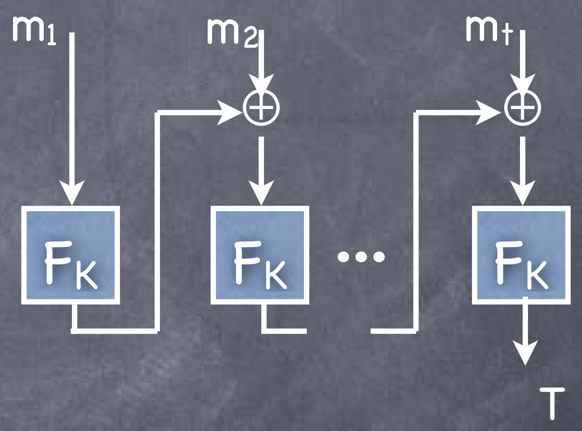

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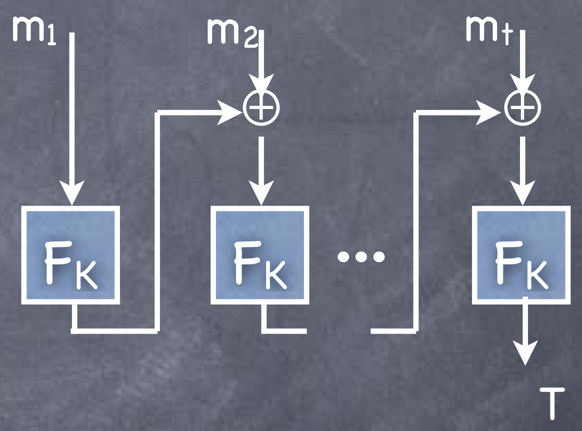

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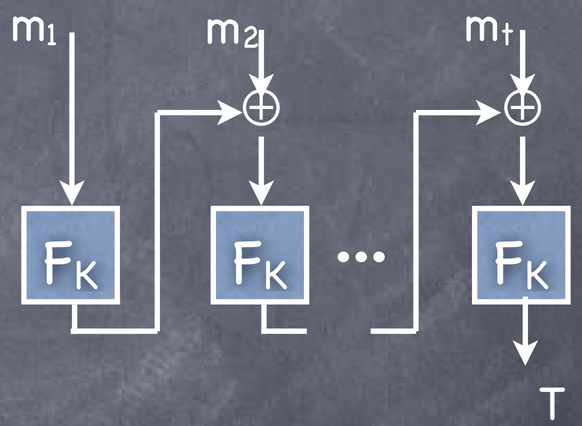

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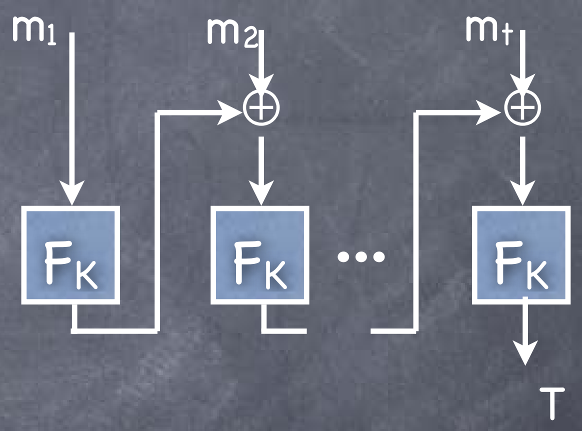

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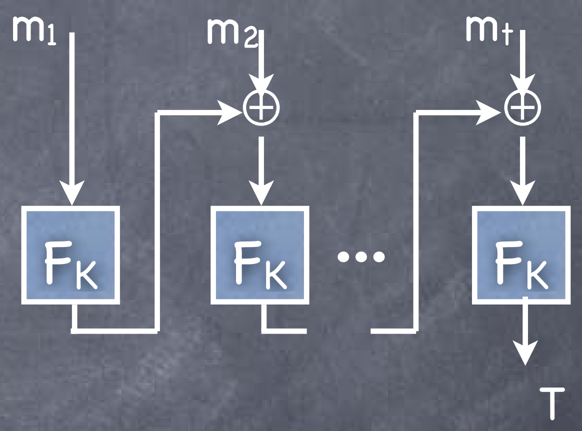

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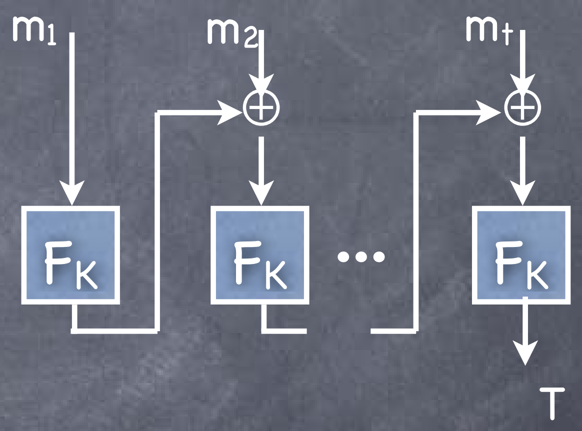

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  - CMAC: XOR last message block with a key (derived from the original key using the block-cipher). Also avoids padding when message is integral number of blocks. ← NIST Recommendation. 2005
- Later: Hash-based HMAC used in TLS and IPSec ← IETF Standard. 1997

SKE in Practice

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- NIST Standard: For multi-message encryption, use a block-cipher in CTR mode

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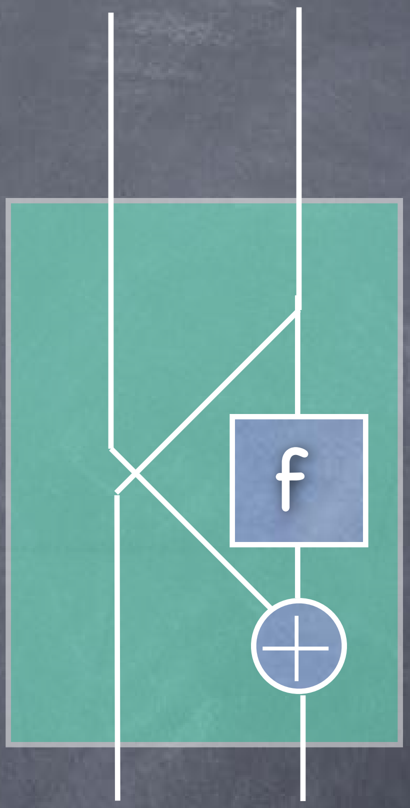

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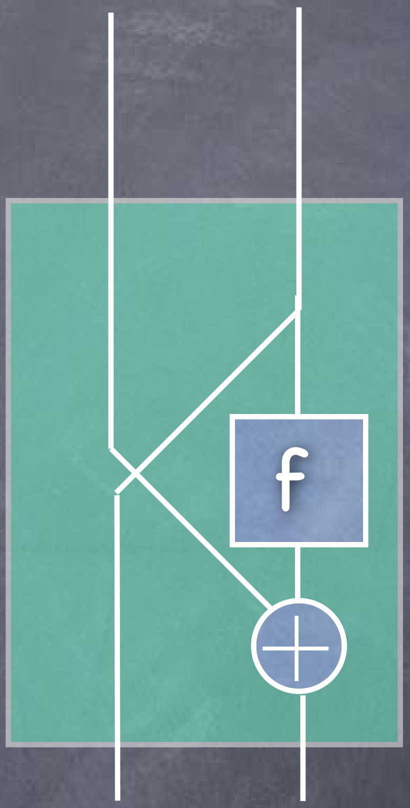

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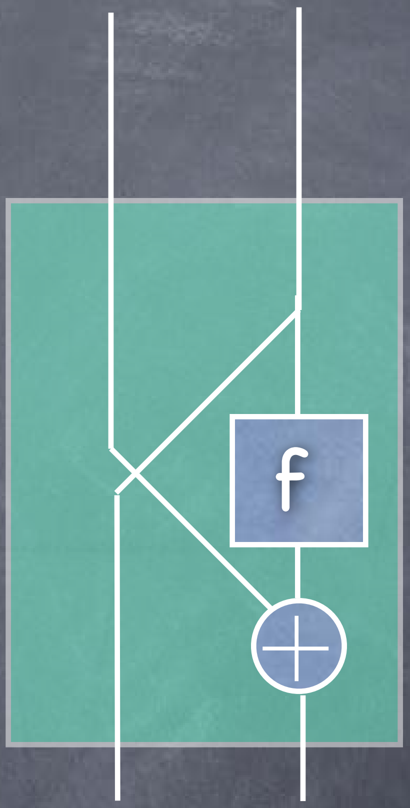

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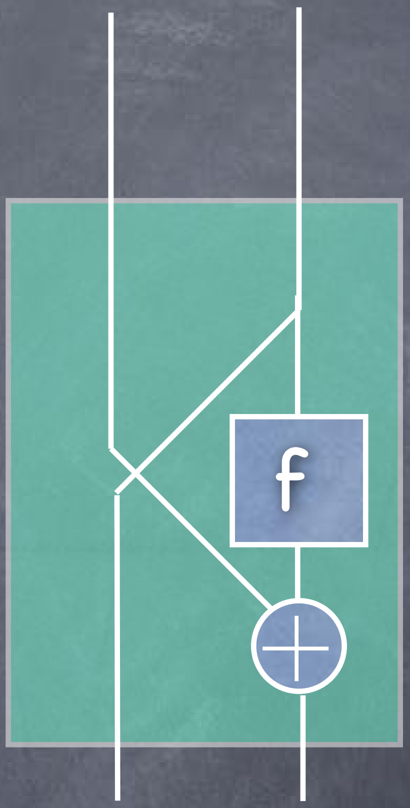

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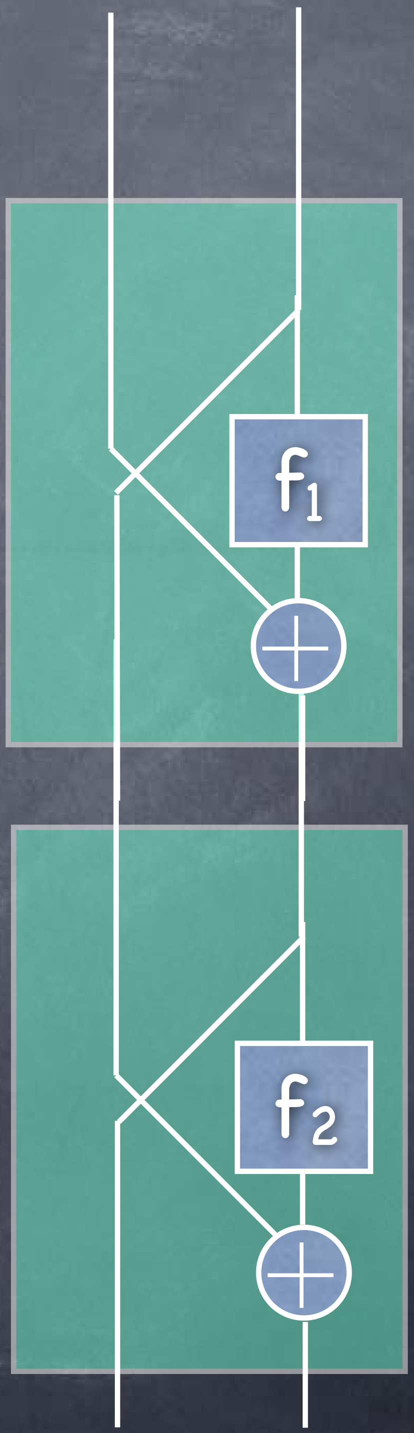

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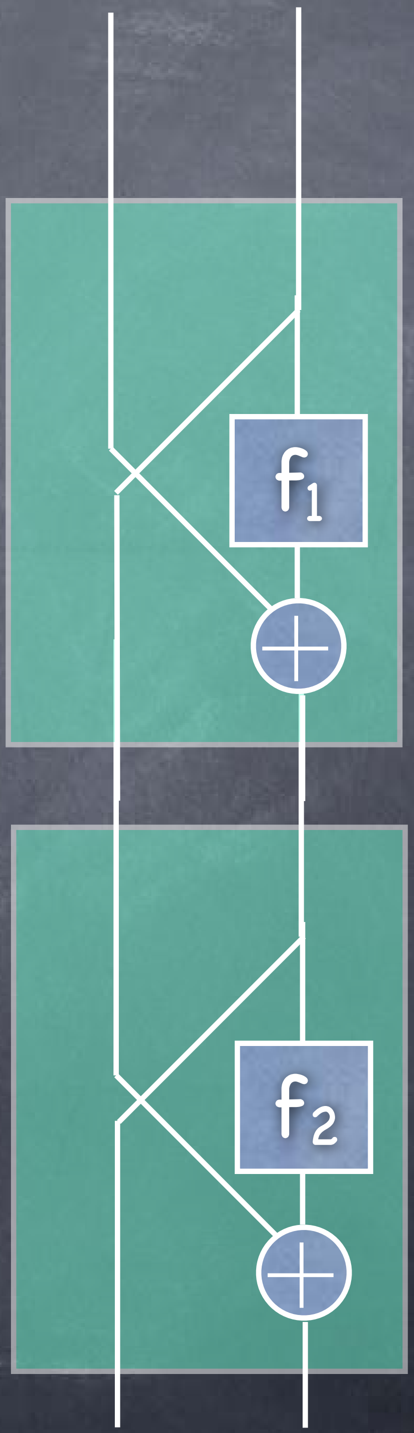

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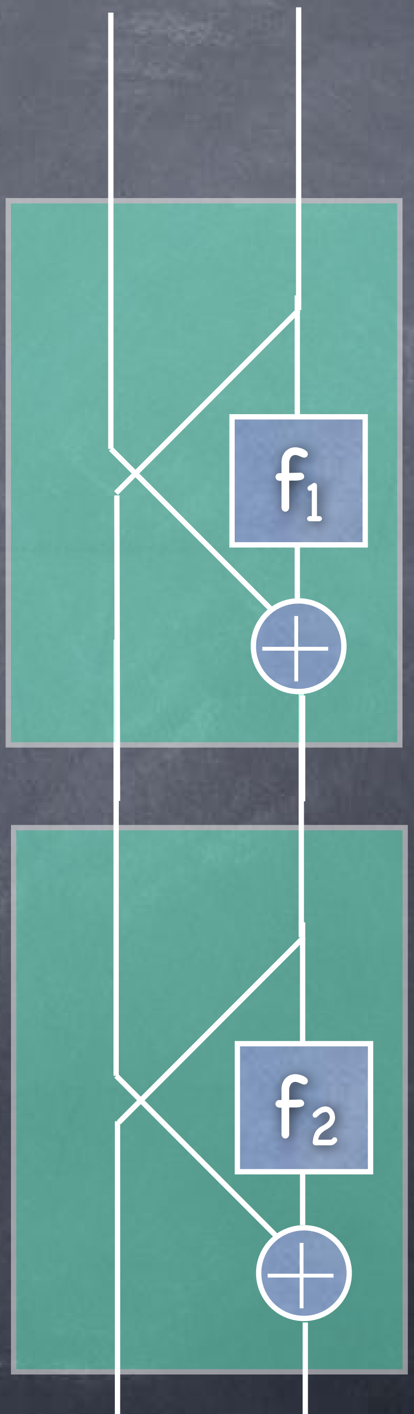

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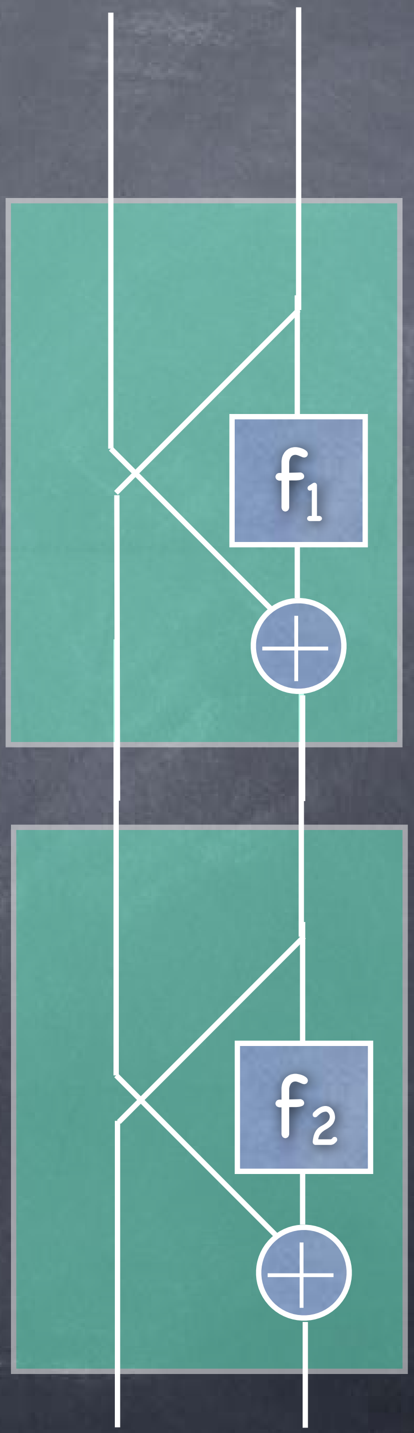

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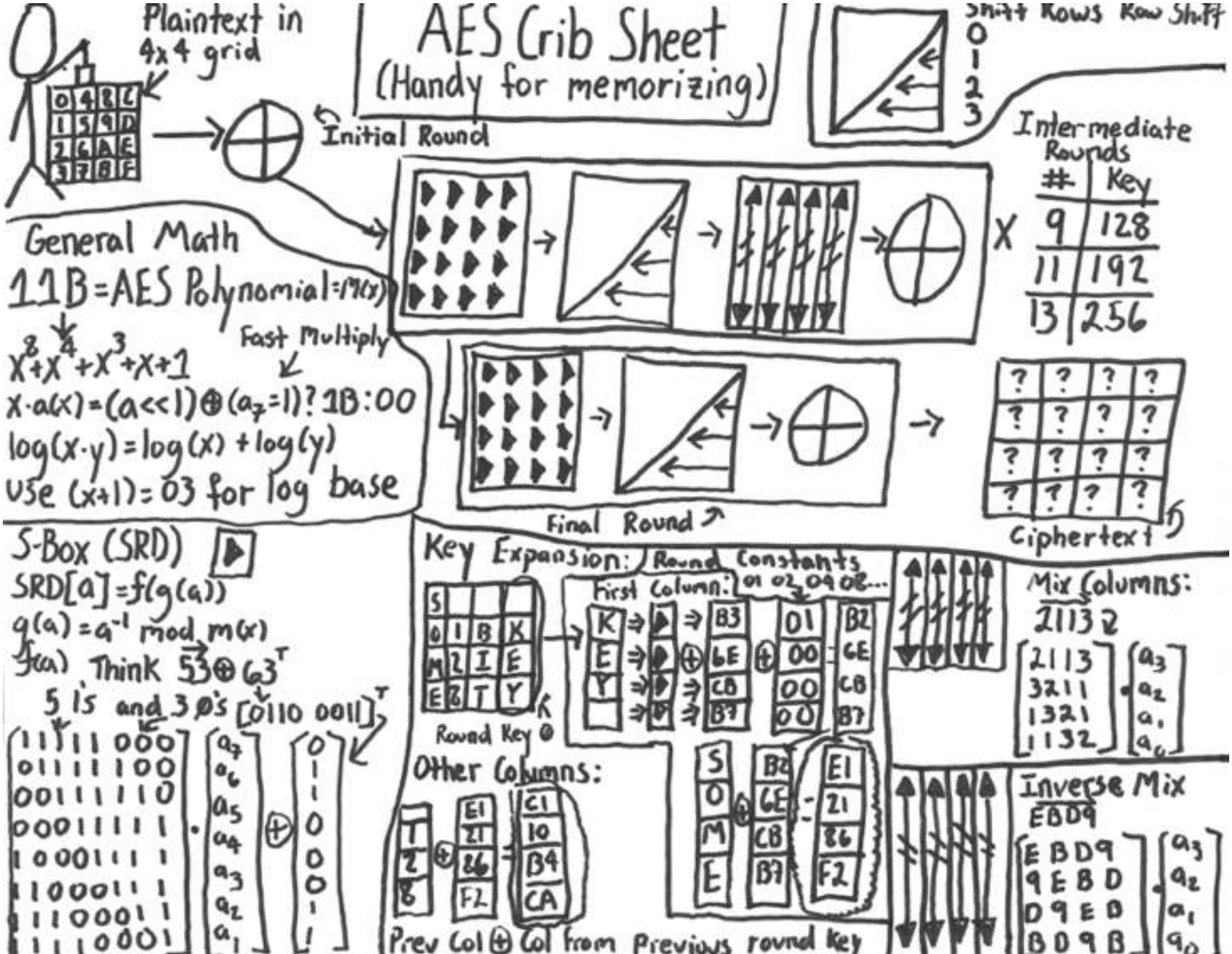

By Jeff Moser (http://www.moserware.com/2009/09/stick-figure-guide-to-advanced.html)

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  - Meet-in-the-middle, linear cryptanalysis, differential cryptanalysis, impossible differential cryptanalysis, boomerang attack, integral cryptanalysis, cube attack, ...

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  - AE with Associated Data: Allows unencrypted (but authenticated) parts of the plaintext, for headers etc.

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