Symmetric-Key Encryption: constructions

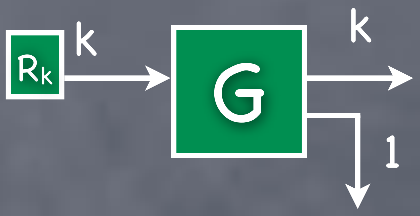
Lecture 5

PRF, Block Cipher

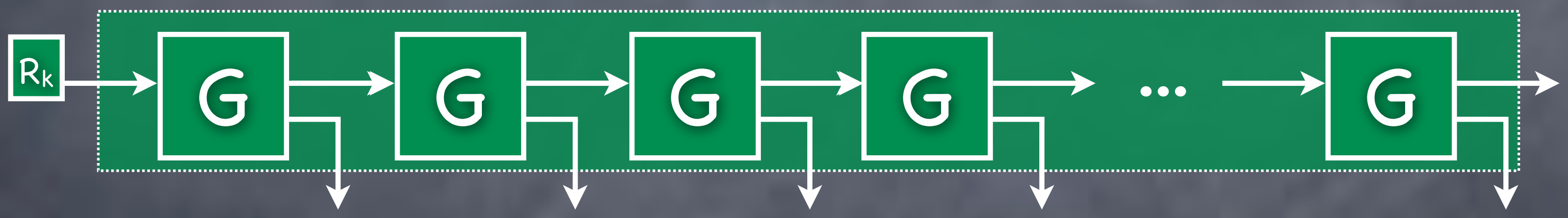
RECALL

PRG from One-Way Permutations

- One-bit stretch PRG, $G_k: \{0,1\}^k \to \{0,1\}^{k+1}$



- Increasing the stretch
  - Can use part of the PRG output as a new seed

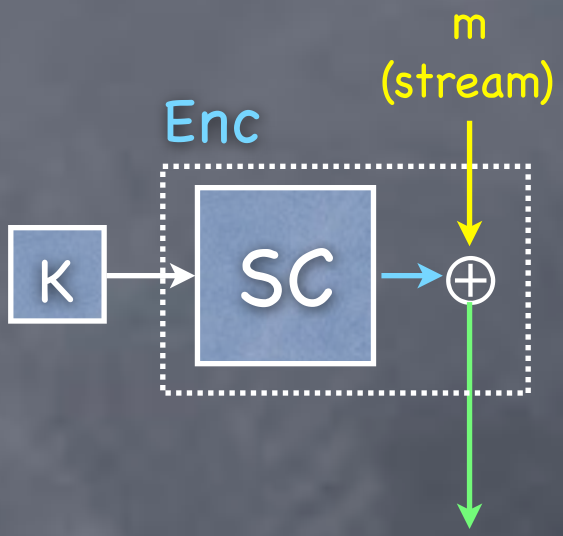


  - If the intermediate seeds are never output, can keep stretching on demand (for any "polynomial length")
  - A stream cipher

One-time CPA-secure SKE with a Stream-Cipher

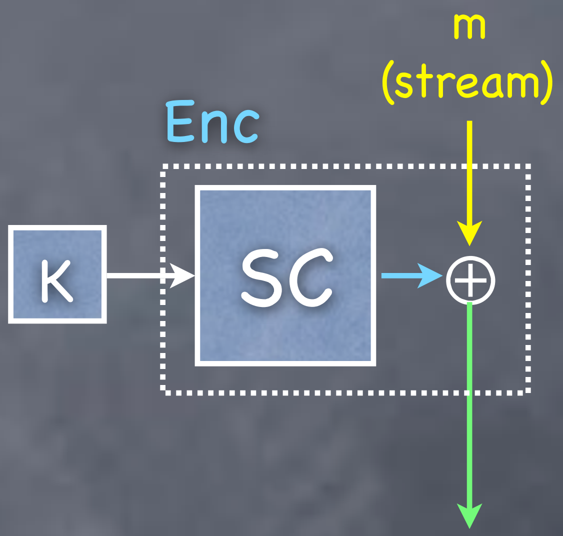
RECALL

- One-time Encryption with a stream-cipher:
  - Generate a one-time pad from a short seed
  - Can share just the seed as the key
  - Mask message with the pseudorandom pad



- Decryption is symmetric: plaintext & ciphertext interchanged
- SC can spit out bits on demand, so the message can arrive bit by bit, and the length of the message doesn't have to be a priori fixed
- Security: indistinguishability from using a <u>truly</u> random pad

One-time CPA-secure SKE with a Stream-Cipher



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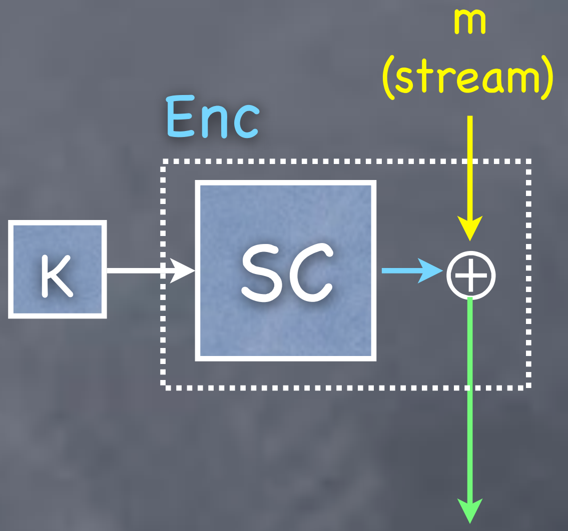

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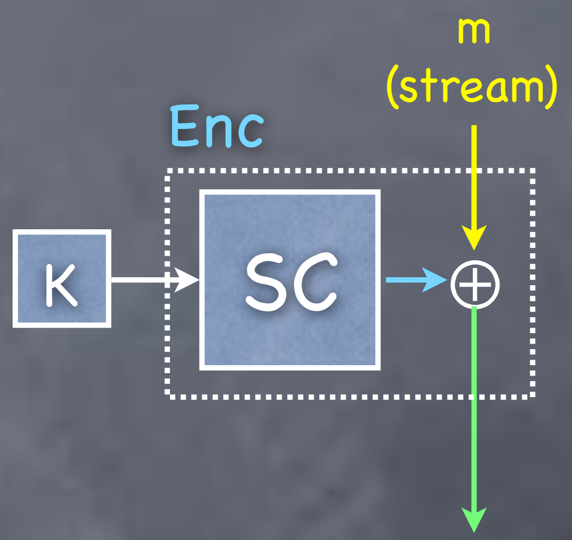

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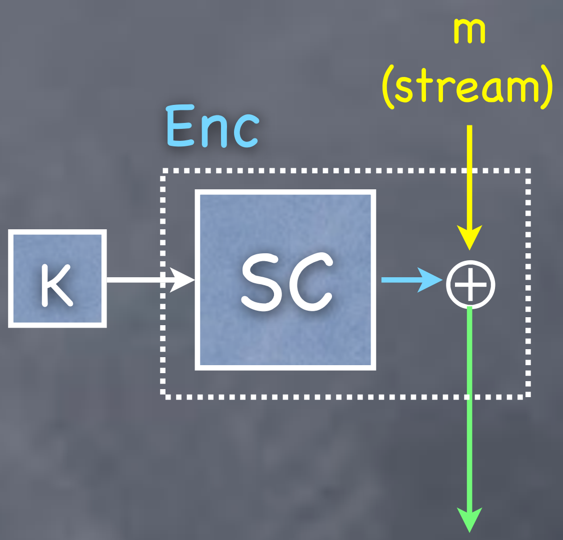

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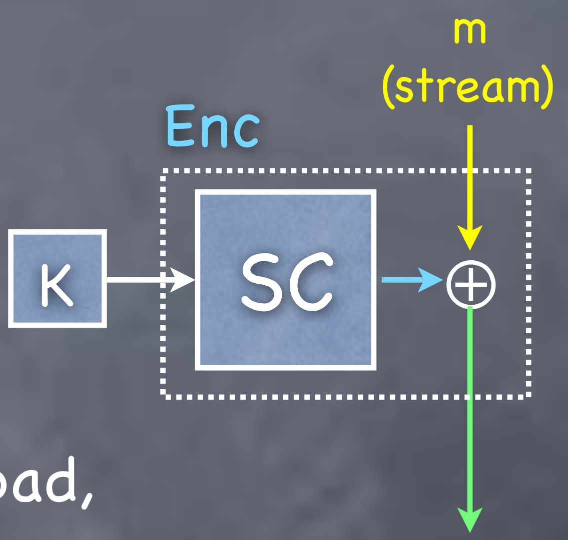

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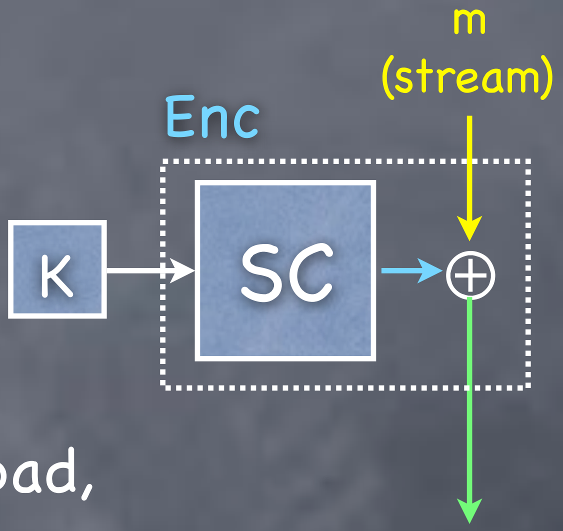

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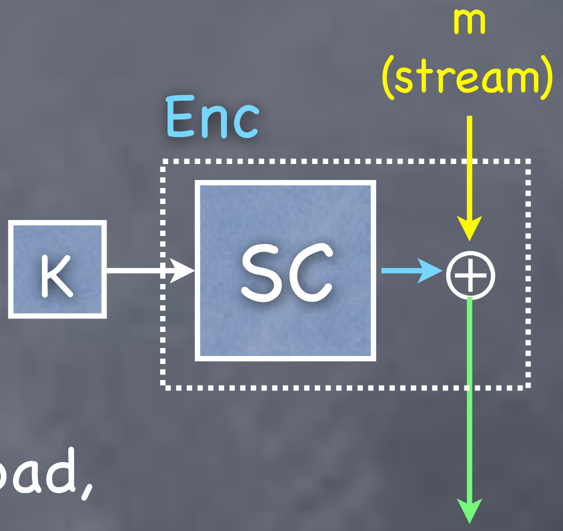

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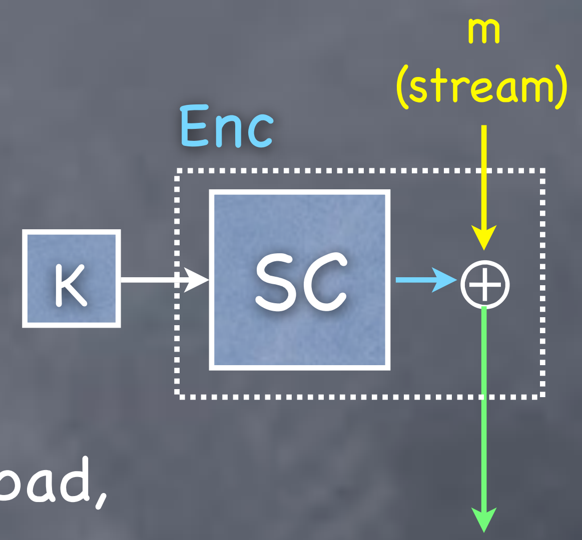

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    - Consider the experiments as a system that accepts a pad from outside (R′ = SC(K) for a random K, or truly random R) and outputs the environment's output. This system is PPT, and so can't distinguish pseudorandom from random.

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  - Need to define pseudorandomness for a function (not a string)

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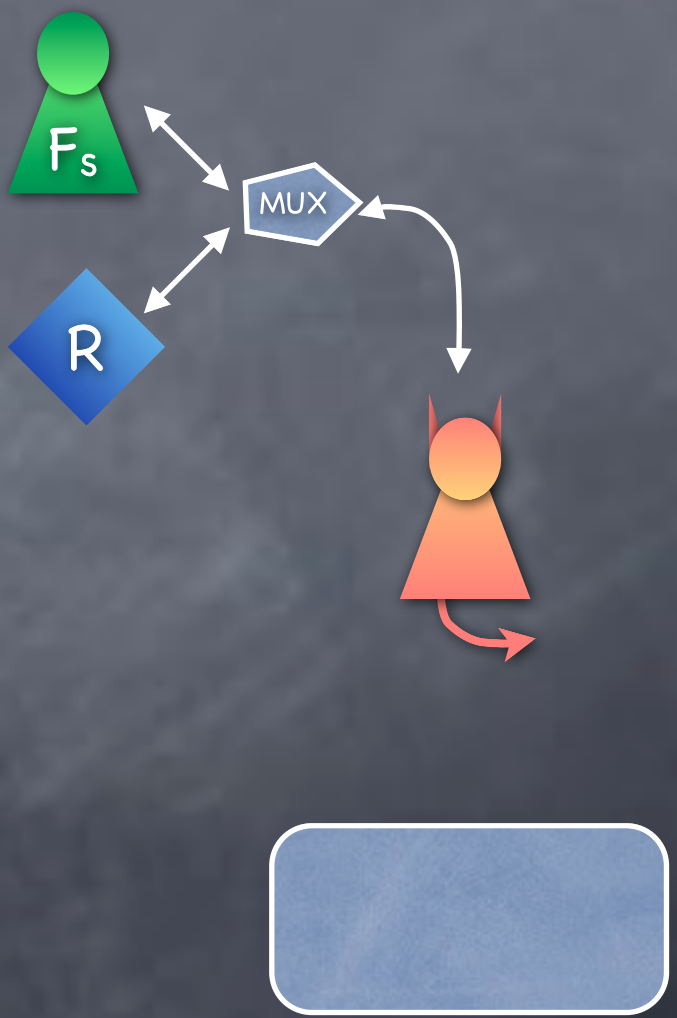

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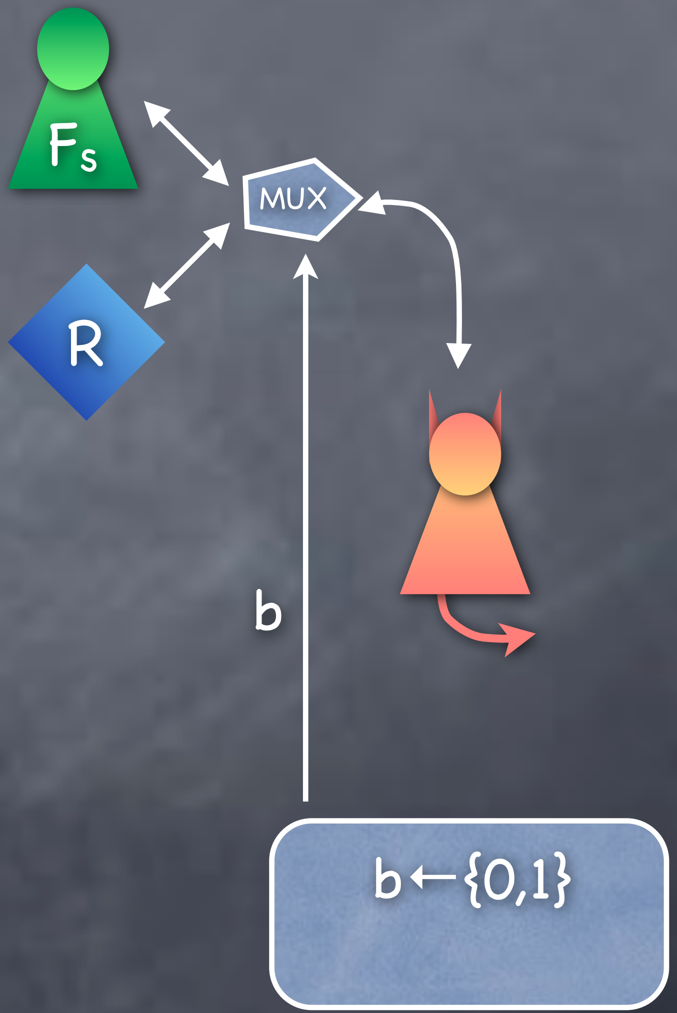

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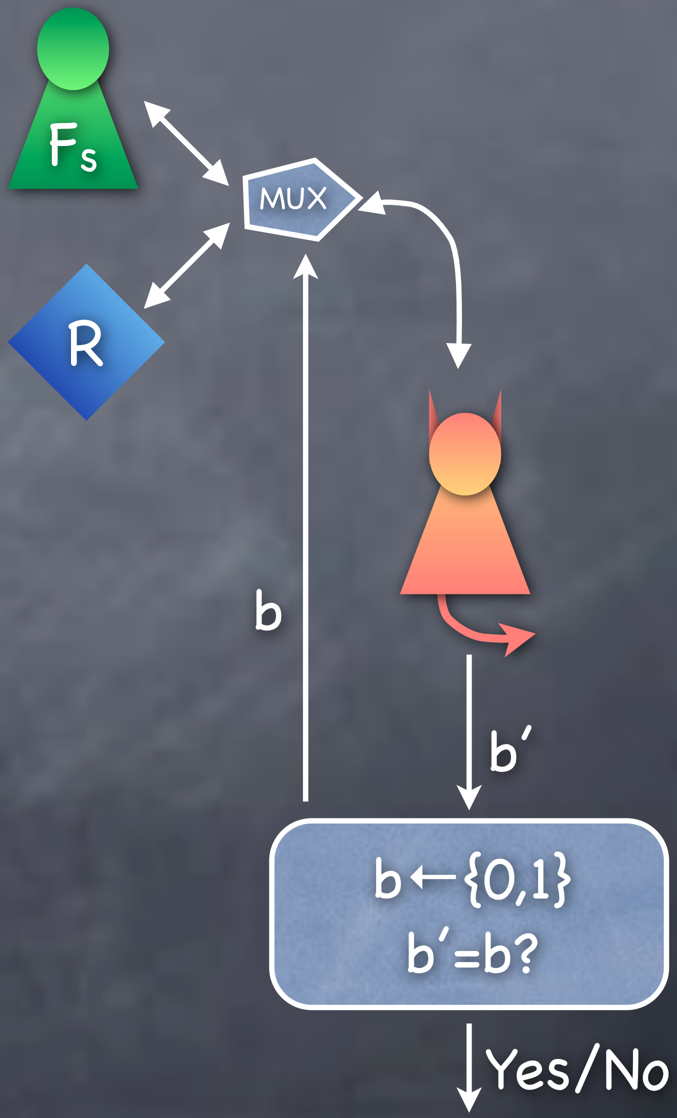

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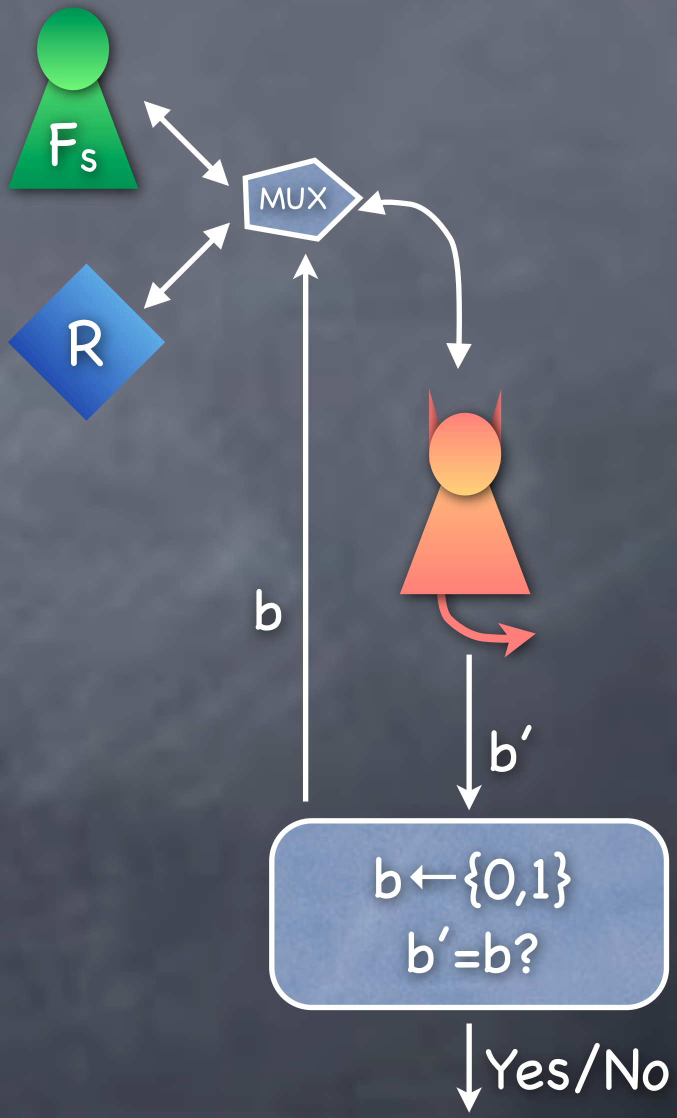

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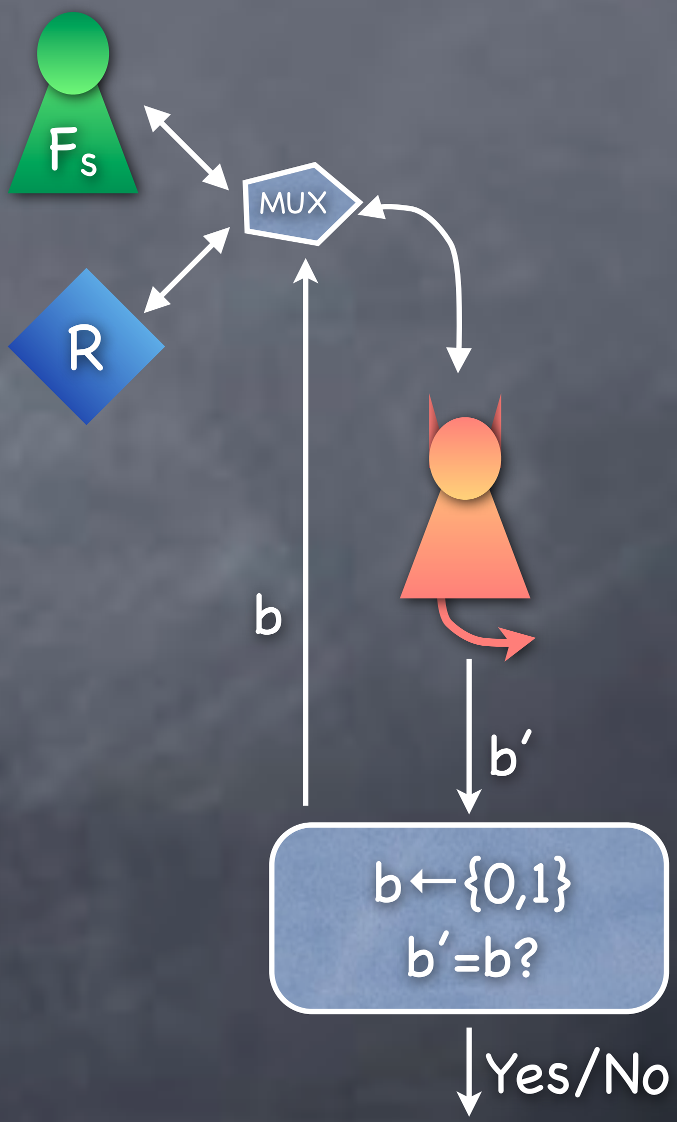

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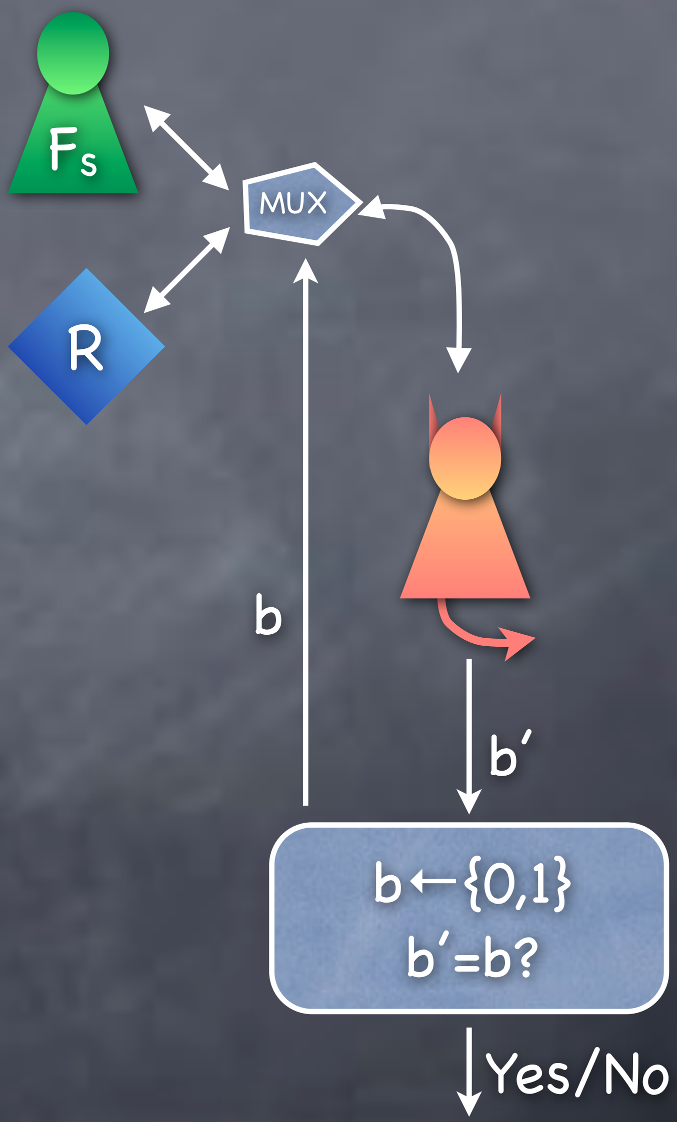
    - PRF stretches k bits to $n2^m$ bits



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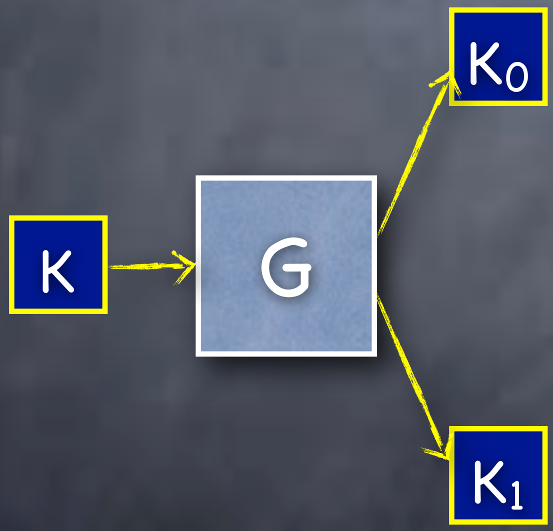

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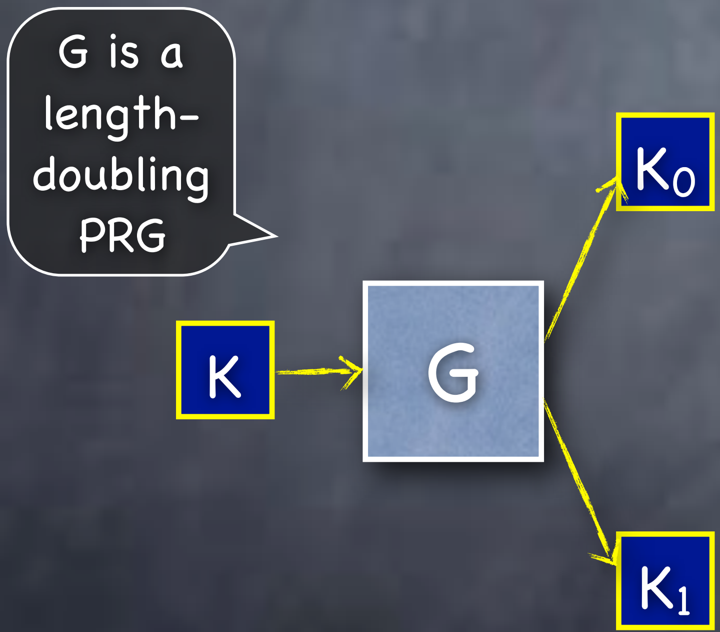

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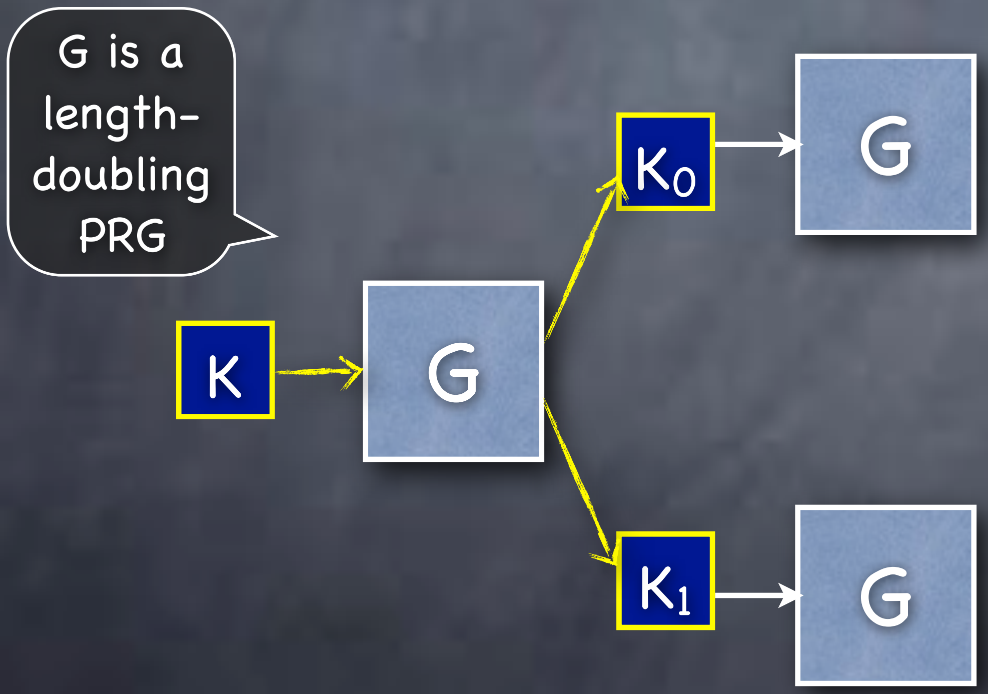

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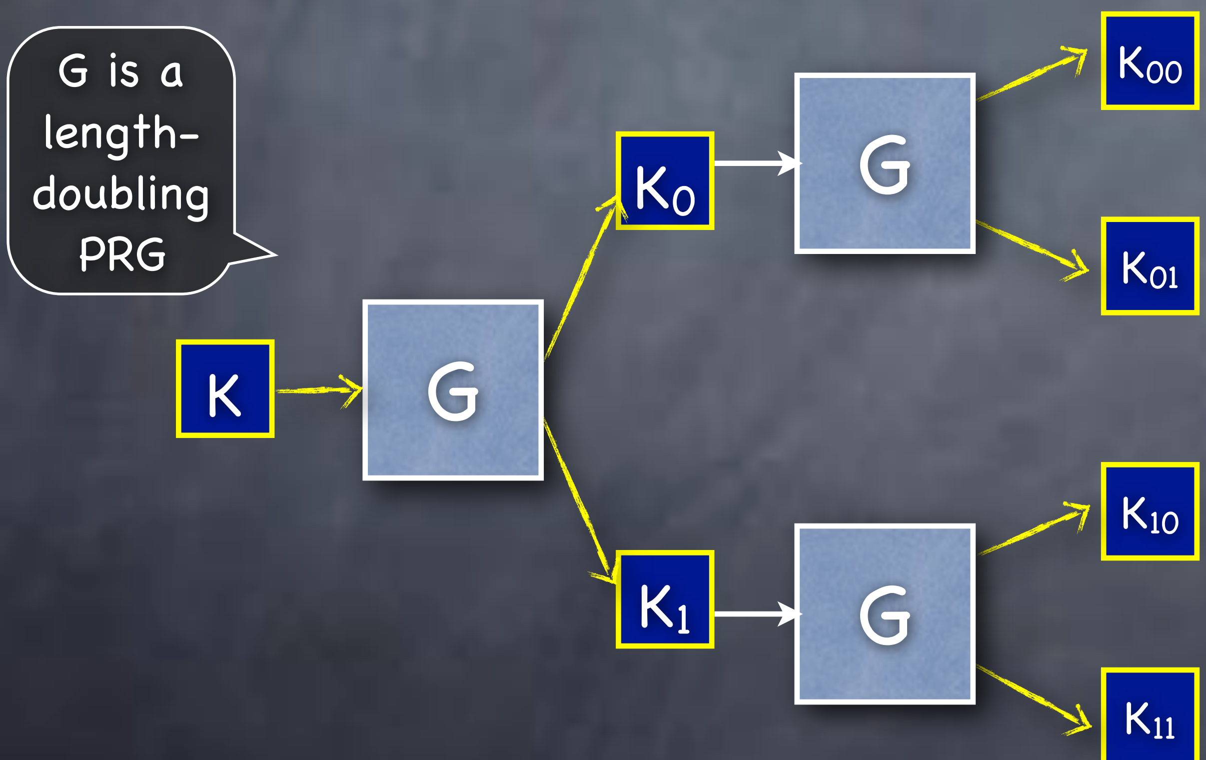

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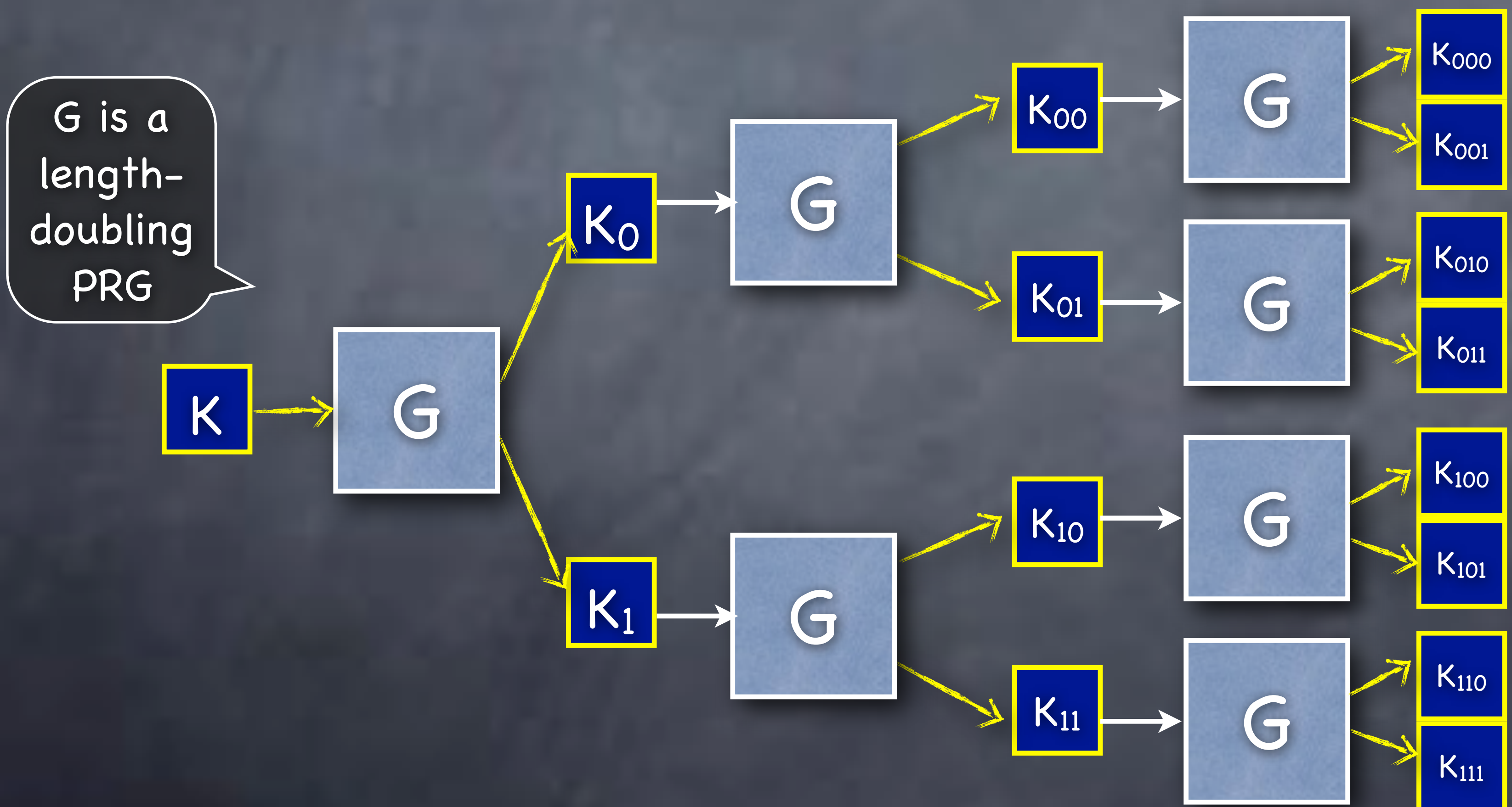

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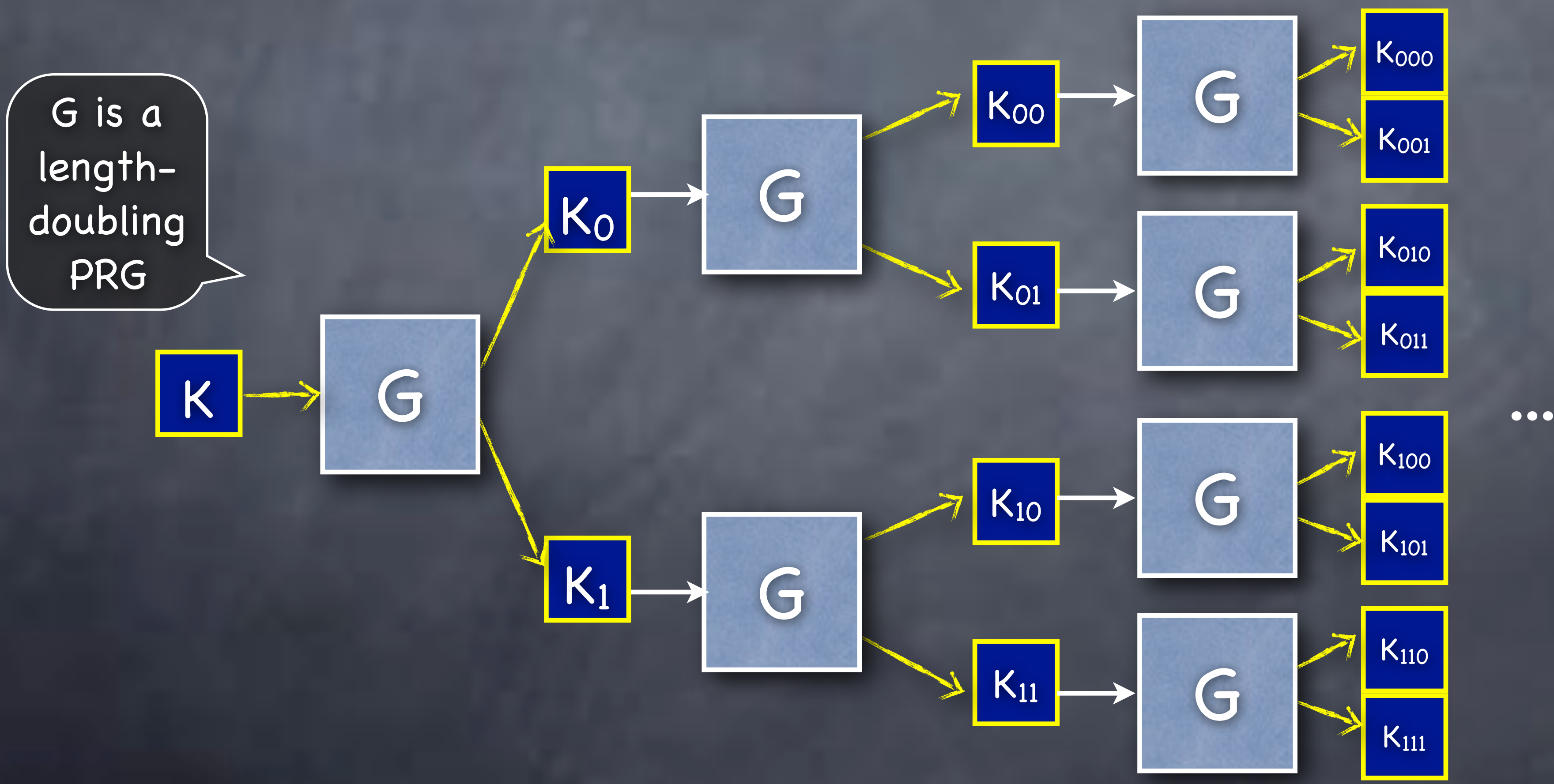

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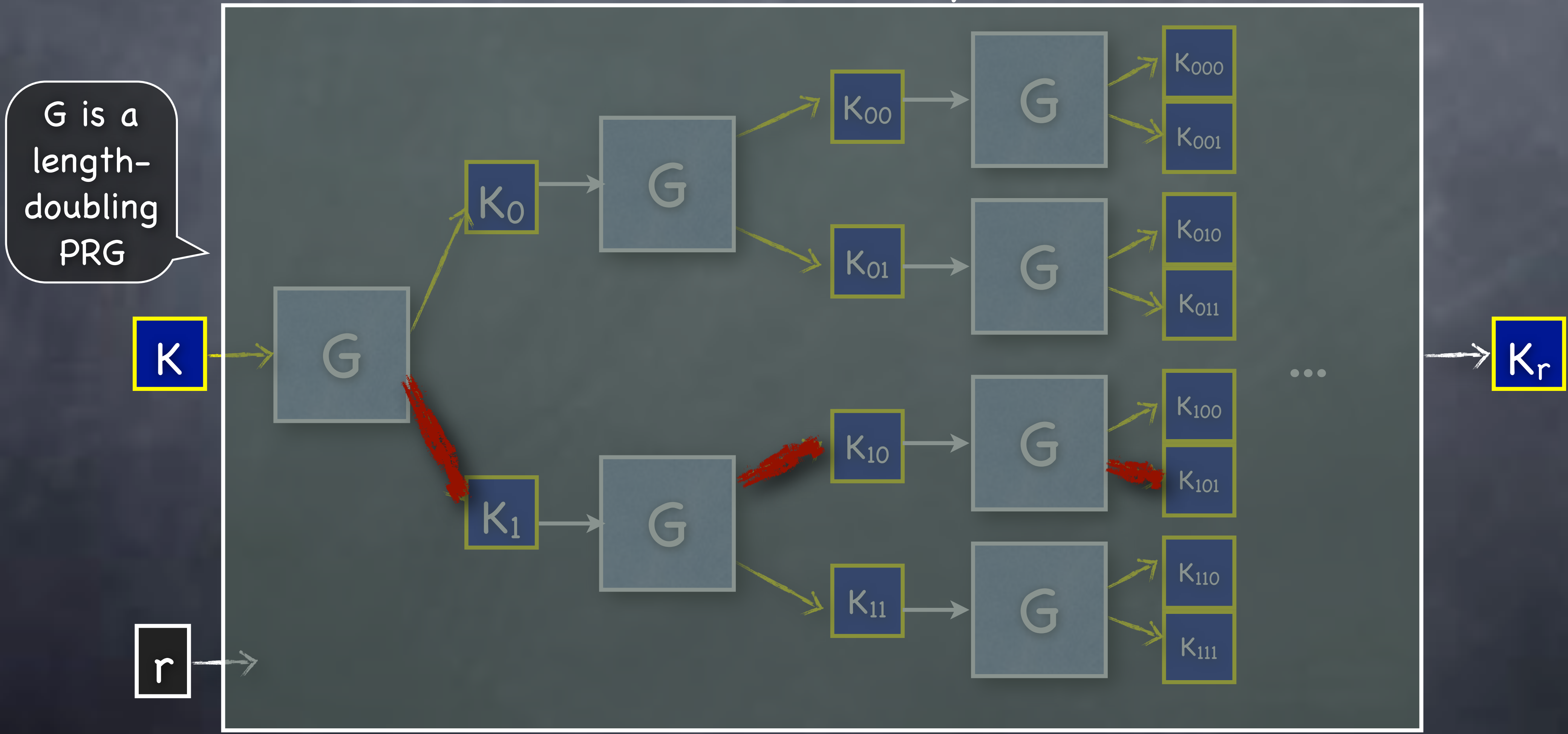

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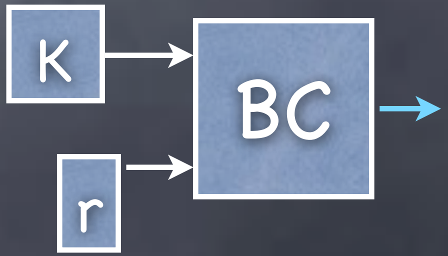

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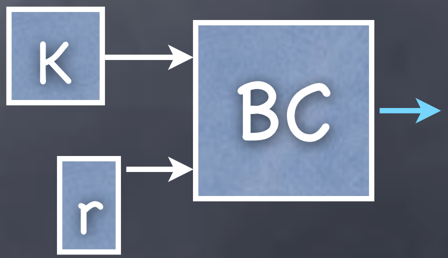

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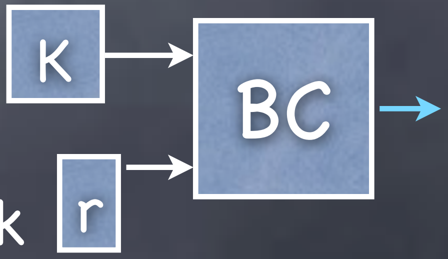

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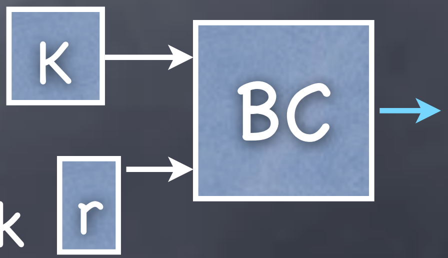

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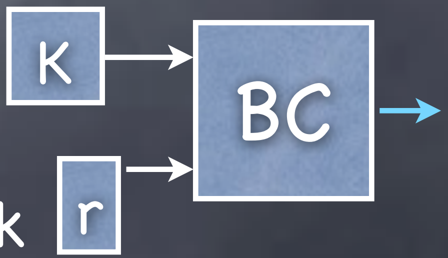

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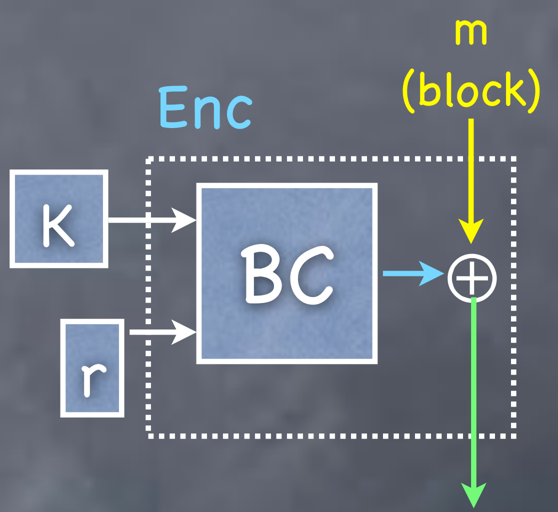

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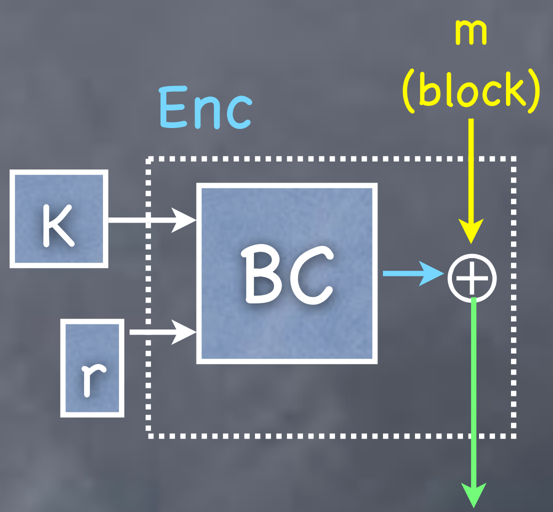

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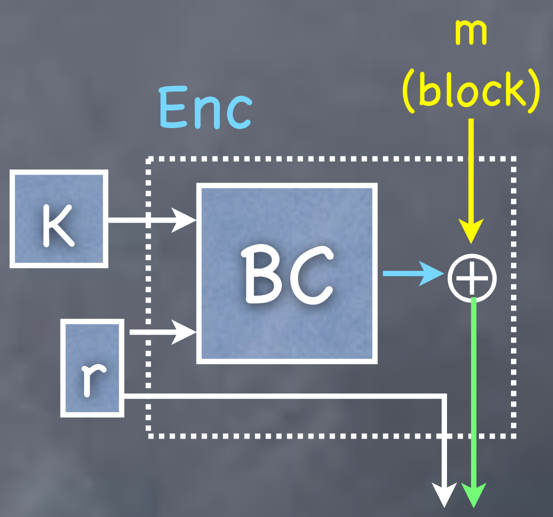

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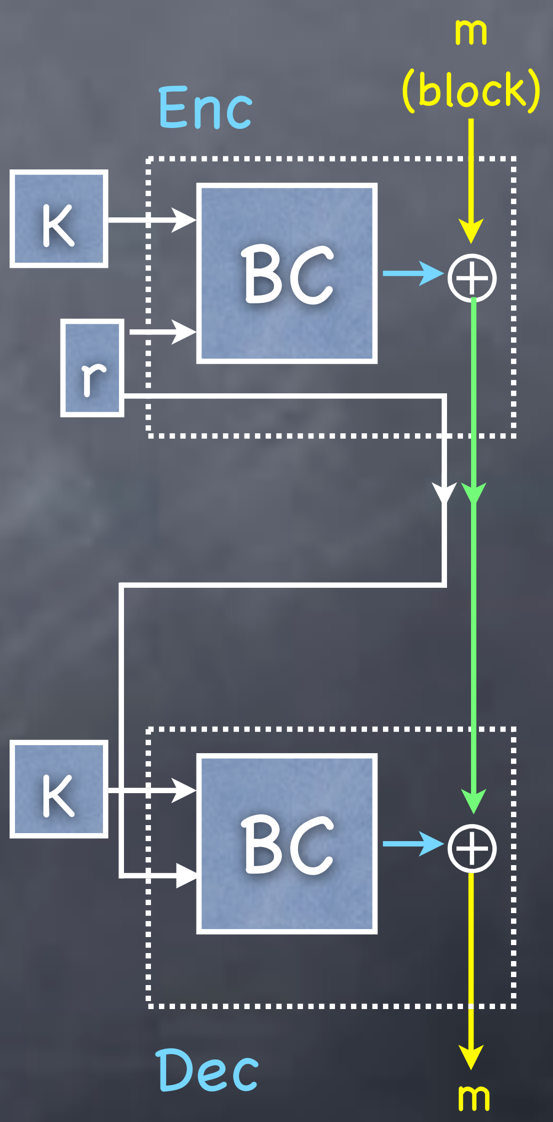

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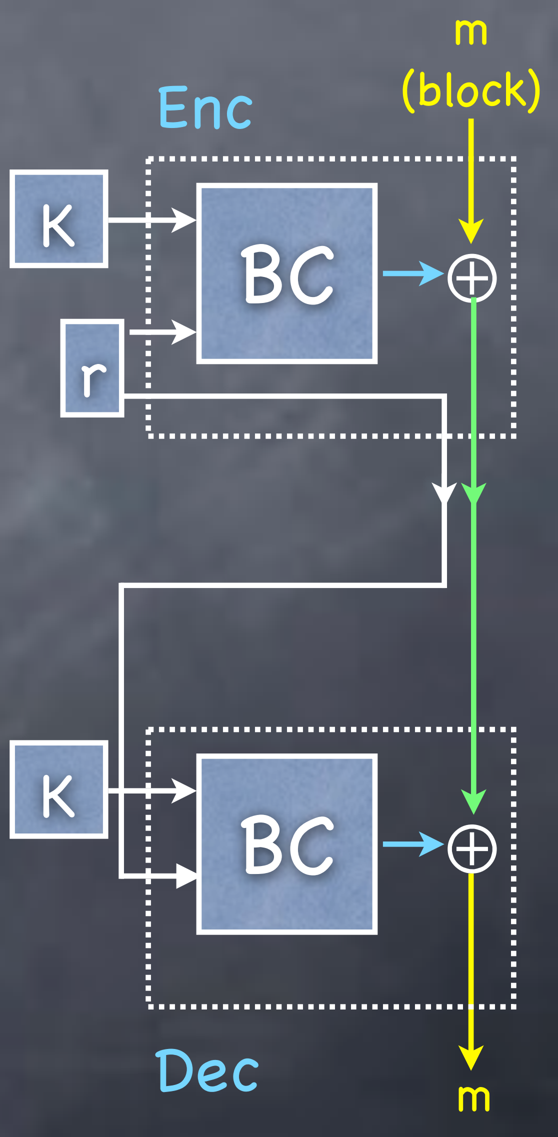

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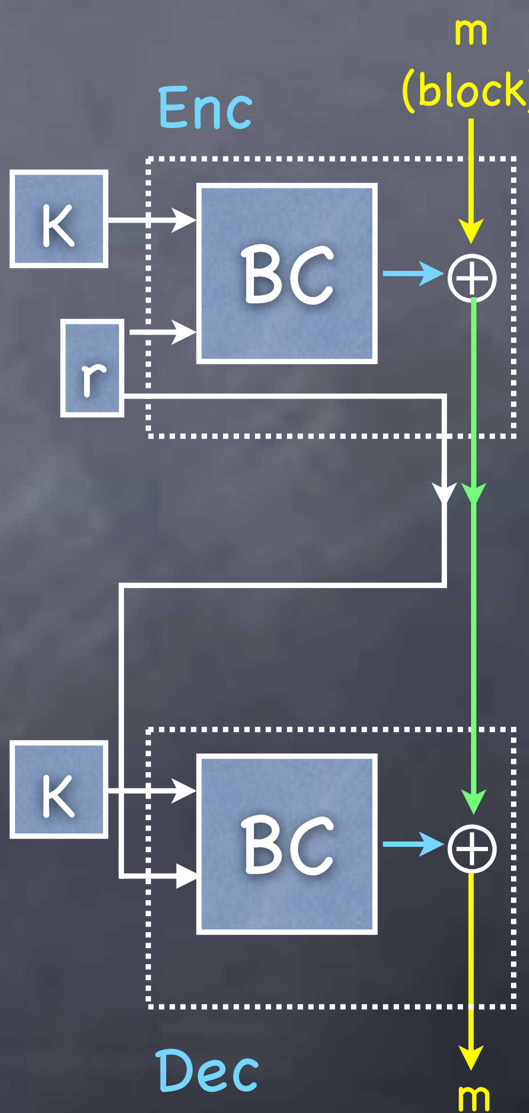

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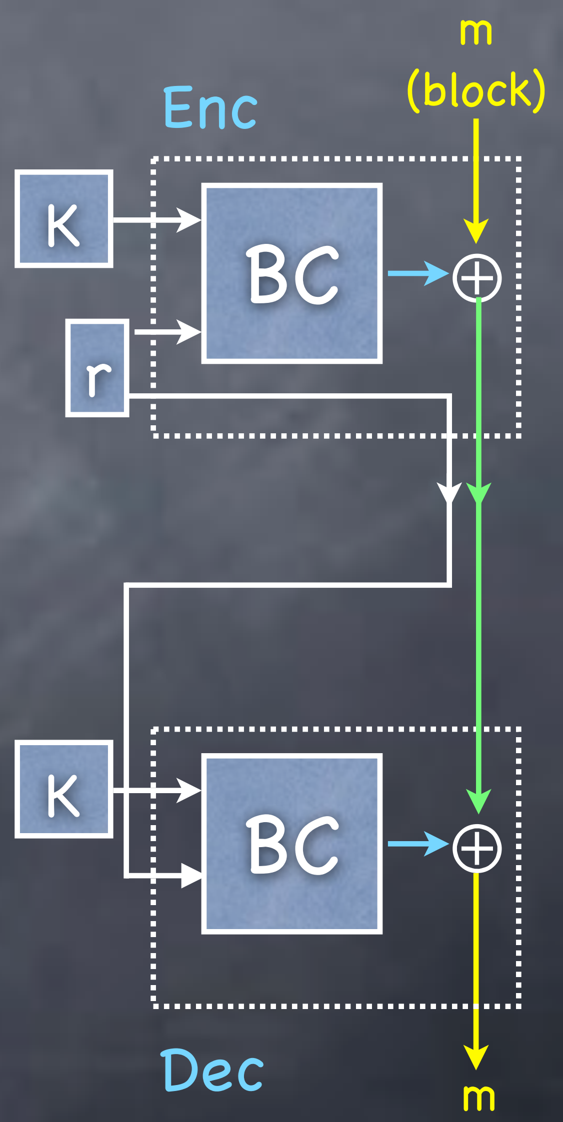
  - Pick at random!



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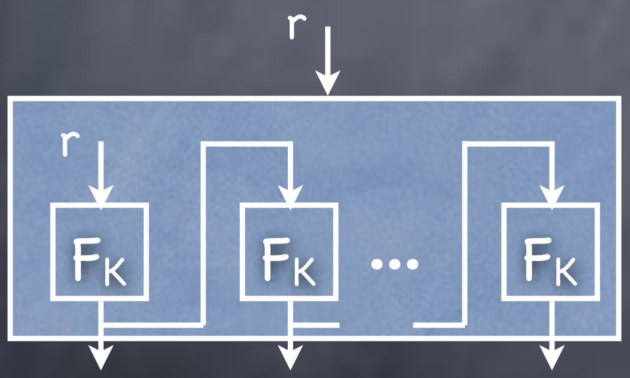

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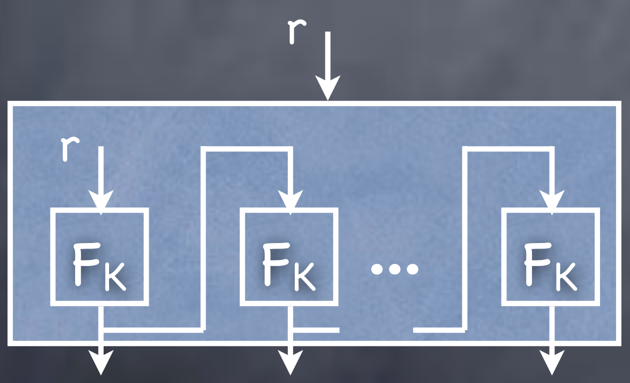

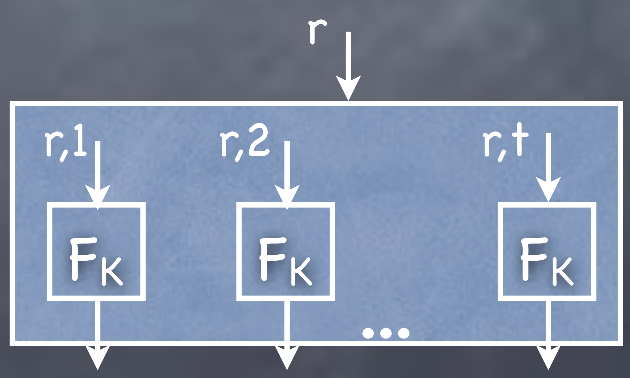

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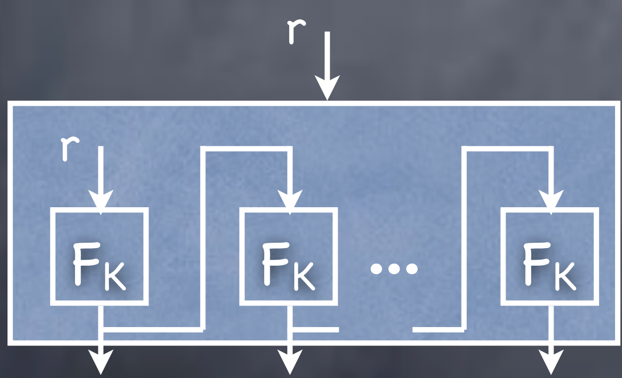

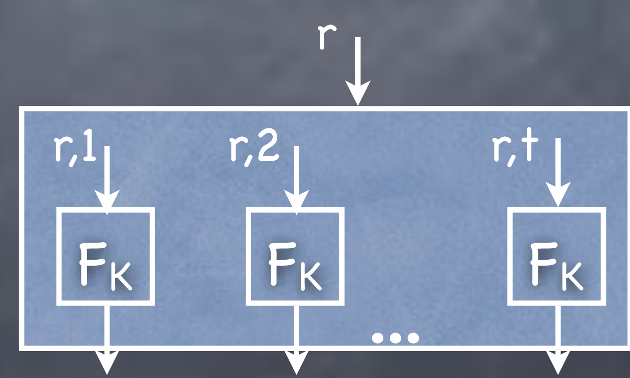

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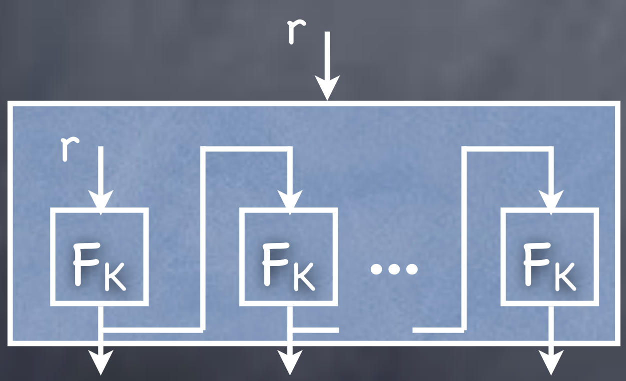

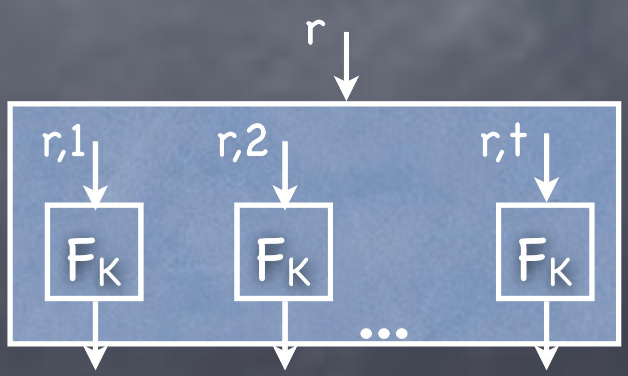

input length slightly decreased, based on t

- Output is indistinguishable from t random blocks (even if input to F_K known/chosen)

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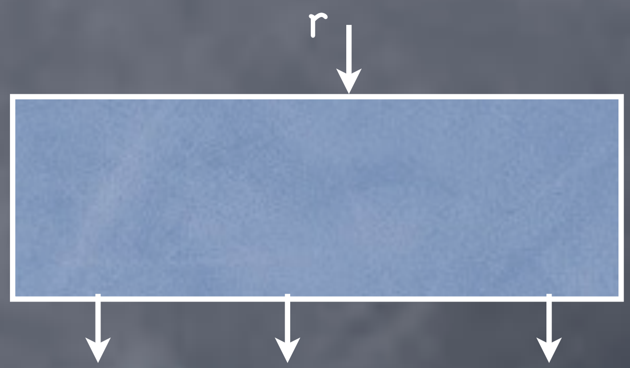

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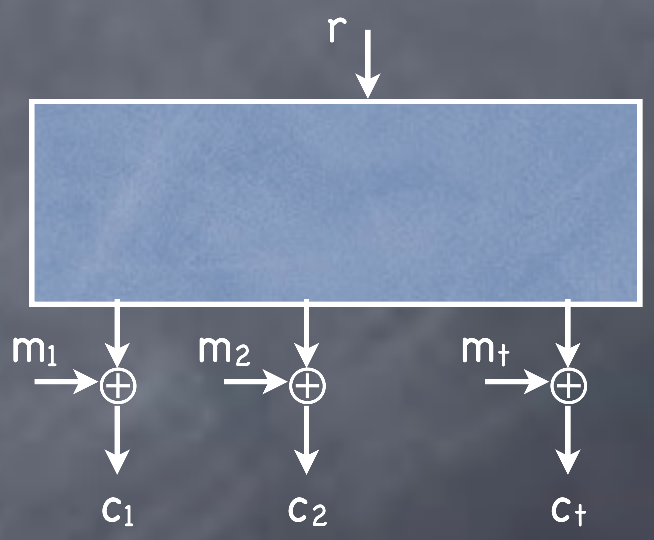

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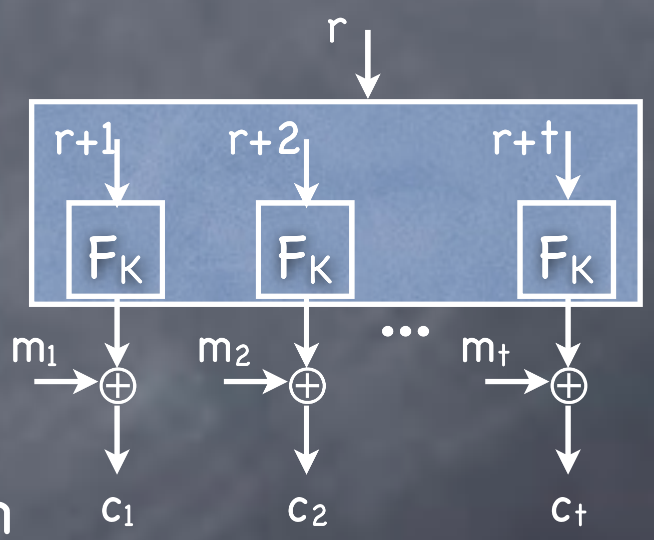

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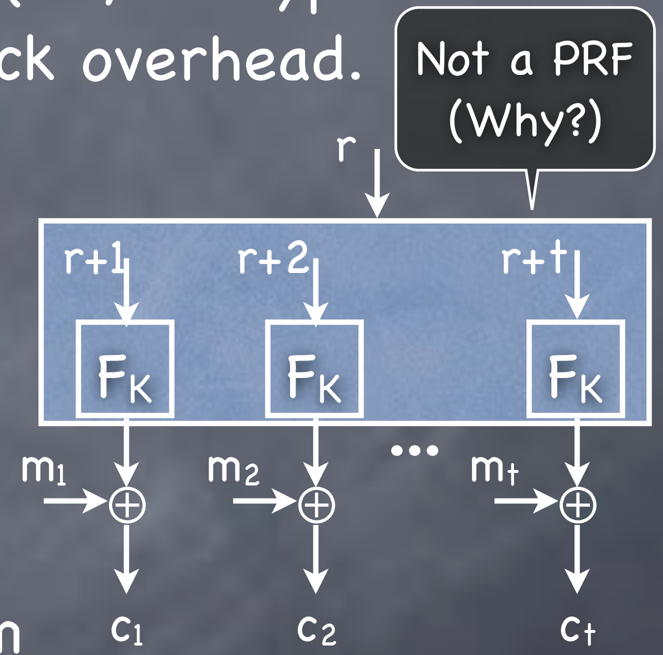

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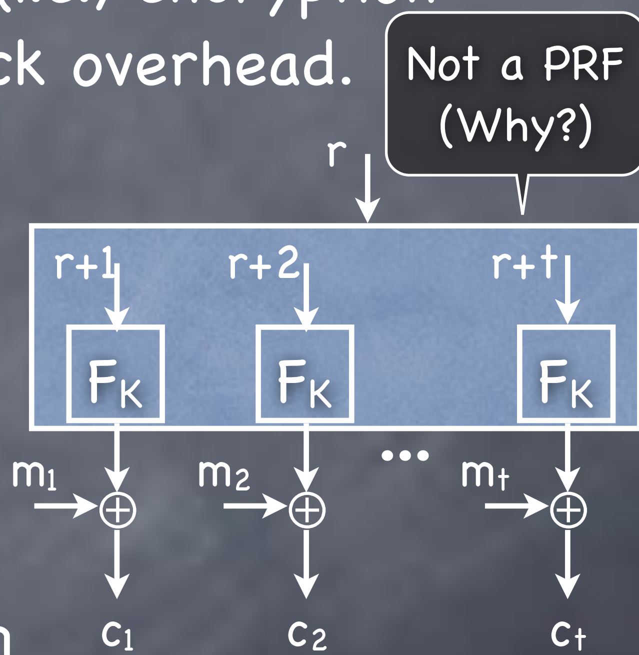
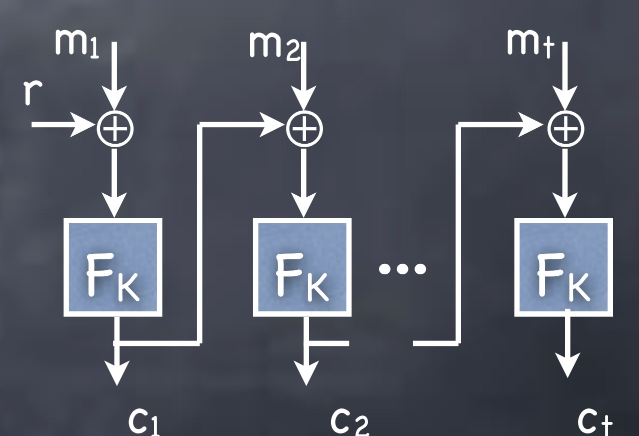


  - **Cipher Block Chaining (CBC) mode:** Sequential encryption. Decryption uses F_K^{-1}. Ciphertext an integral number of blocks.



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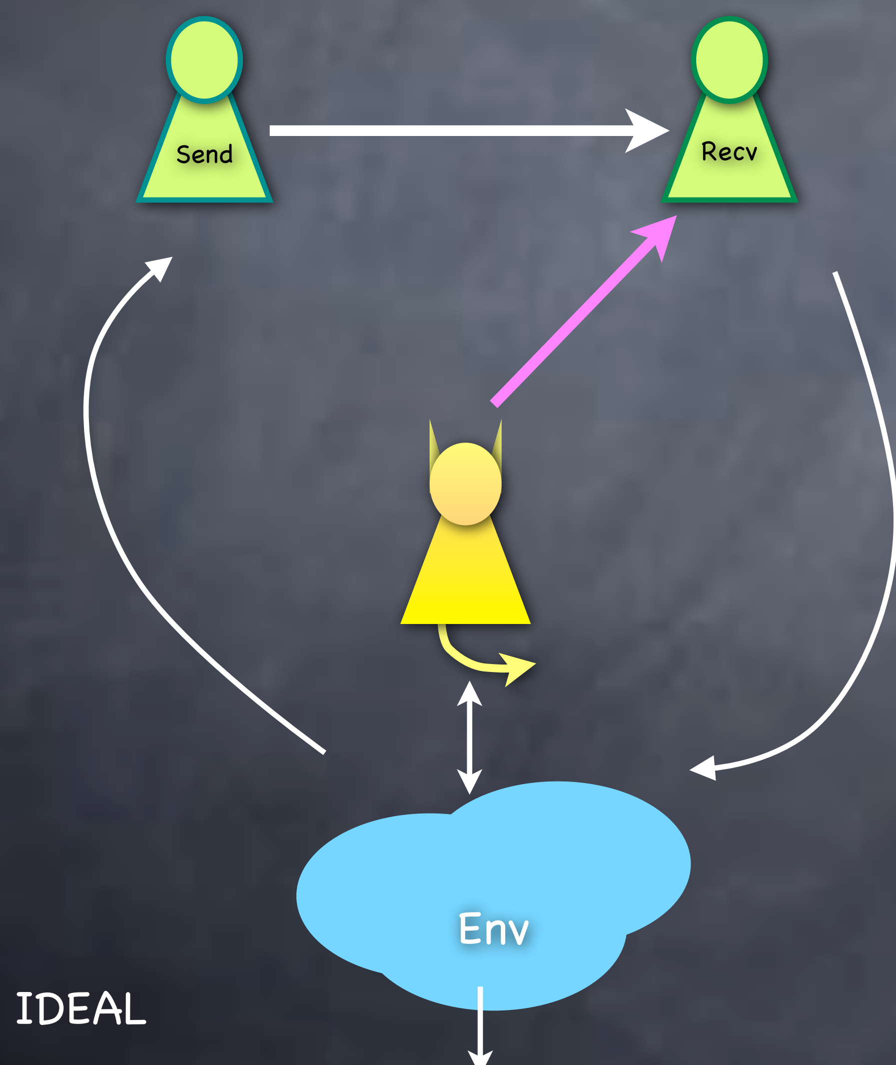
    - What can Bob do?

RECALL

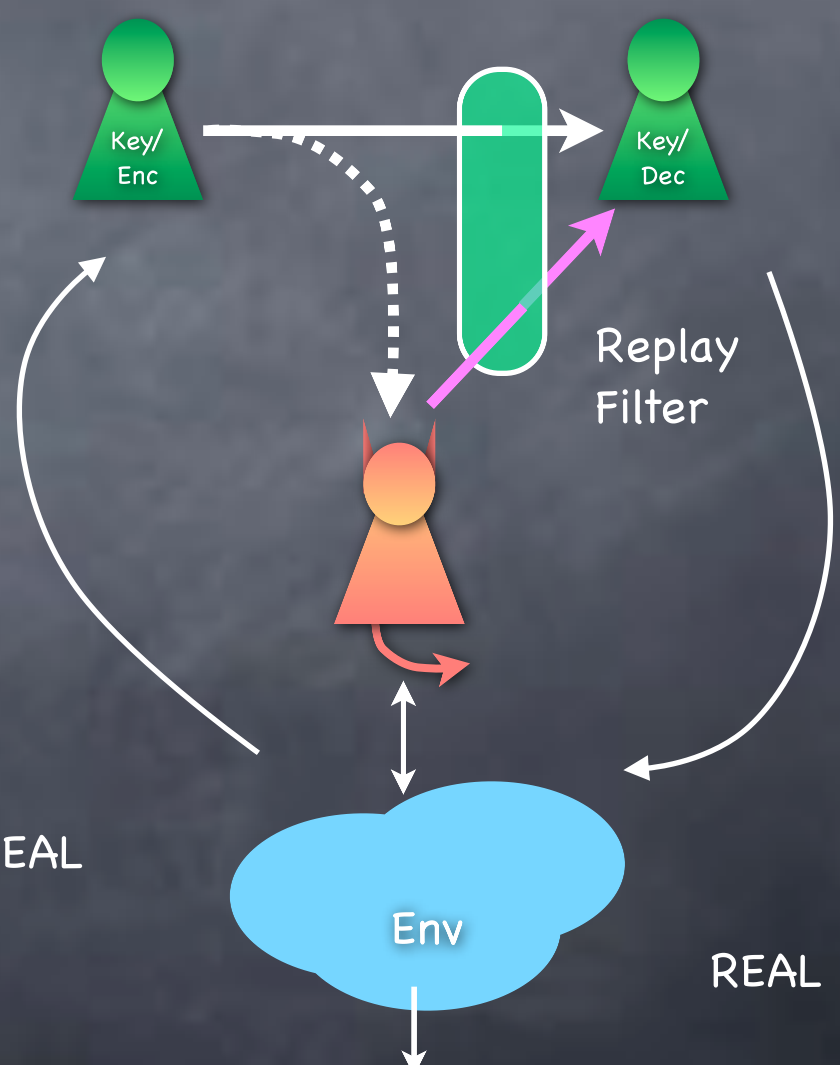
Symmetric-Key Encryption

SIM-CCA Security



SIM-CCA secure if: ∀ ∃ s.t. ∀

REAL ≈ IDEAL



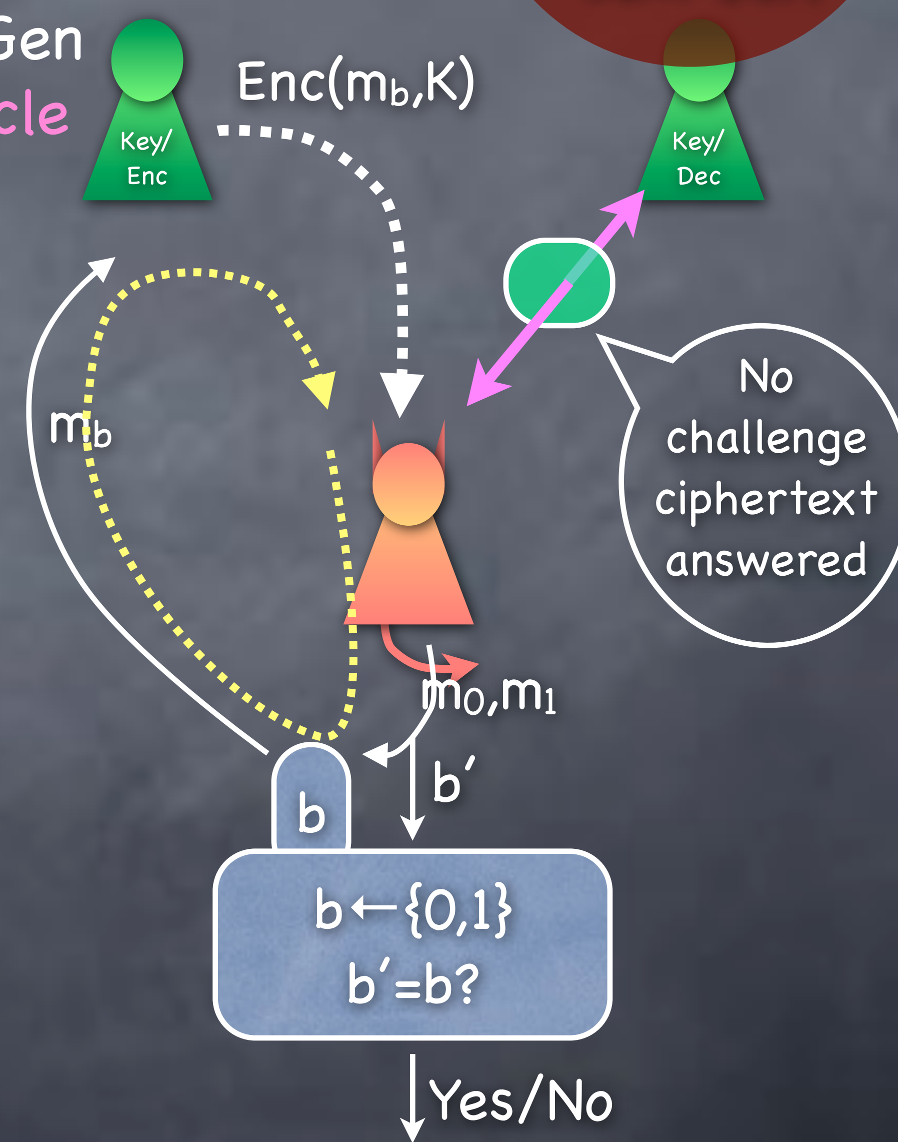
RECALL

Symmetric-Key Encryption

IND-CCA Security

IND-CCA + ~correctness equivalent to SIM-CCA

- Experiment picks b←{0,1} and K←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] ≈ 1/2



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  - MAC: Message Authentication Code

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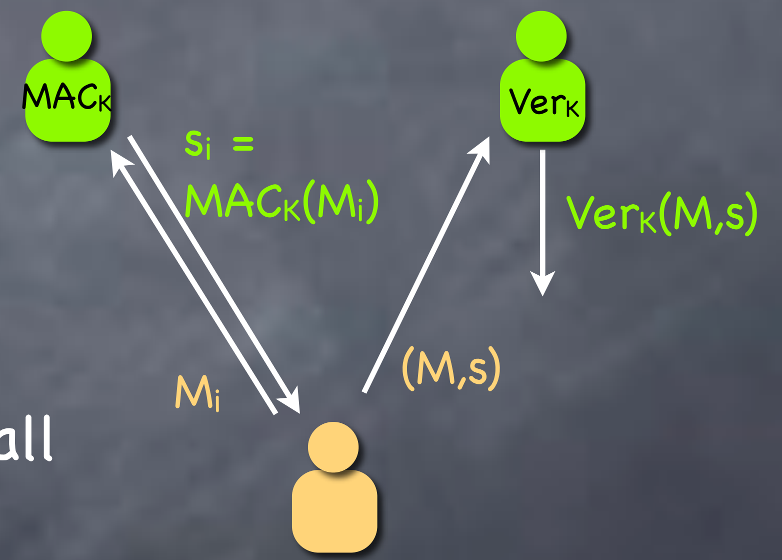
- Correctness: For all K from KeyGen, and all messages M, $\mathrm{Verify}_K(M,\mathrm{MAC}_K(M))=1$
- Security: probability that an adversary can produce (M,s) s.t. $\mathrm{Verify}_K(M,s)=1$ is negligible unless Alice produced an output $s=\mathrm{MAC}_K(M)$



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

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- SKE in practice uses Block-Cipher standards (next time)
- In principle, constructions (less efficient) possible based on any One-Way Permutation or even any One-Way Function