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CS355: Cryptography

Lecture 10: Security of block ciphers.

Ideal block cipher

- An ideal block cipher is a substitution cipher from $\{0,1\}^n$ to $\{0,1\}^n$
  - Also known as a random permutation
  - Each key determines one permutation on the plaintext space
  - A random key is chosen
- Why is this an ideal block cipher?
  - Known-plaintext, chosen plaintext, and chosen ciphertext attacks are totally ineffective

Security Goal of Block Cipher

- Indistinguishable from an ideal block cipher (i.e., a random permutation)
- The best block cipher should be a pseudo-random permutation (PRP)
- For all existing block ciphers, if there is no known attack, they are assumed to be PRP for some suitable parameters.

Symmetric Encryption Schemes

- A block cipher operates on one block
- An encryption scheme encrypts much longer messages
- Randomized vs. deterministic schemes
  - CBC is randomized

What Does Security Mean?

- What does insecurity mean?
  - can recover the encryption key
  - can recover the plaintext of some ciphertexts
  - can recover partial information of some ciphertexts

What Does Security Mean?

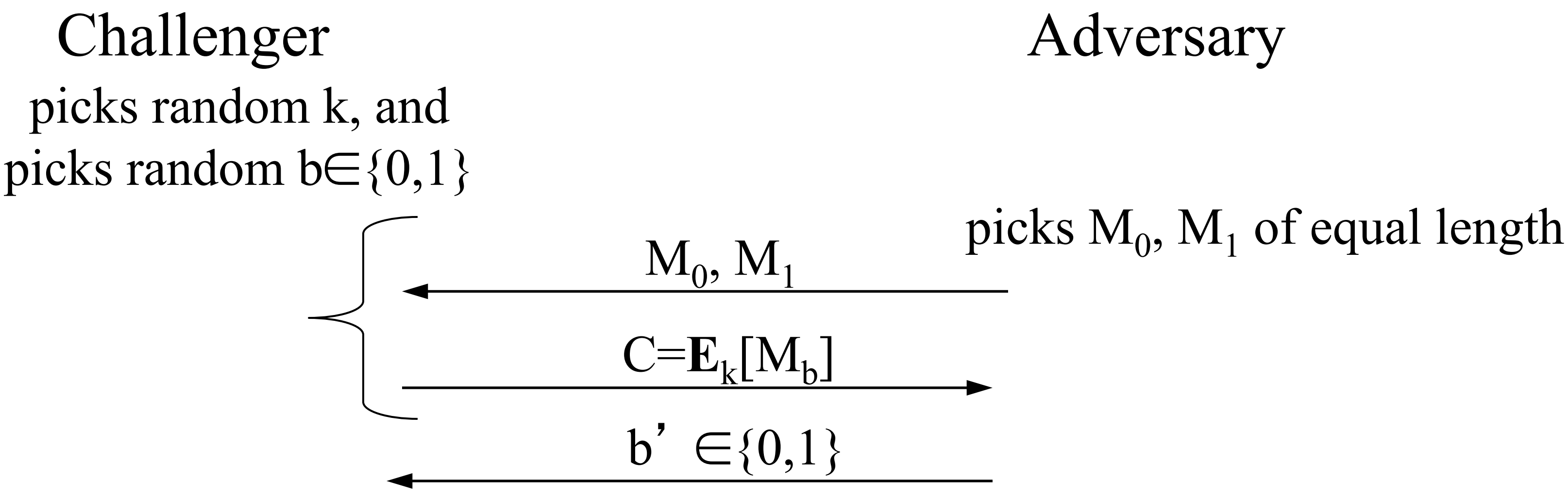
- Perfect secrecy
  - Given ciphertexts, cannot learn anything (other than the length of the message) about the plaintext
  - not very useful as requires long keys
- Approximate perfect secrecy?
  - With limited computing resources, it is extremely unlikely one can learn anything (other than the length) about the plaintexts from the ciphertexts
- How to formalize this?

Towards Semantic Security

- Suppose that the adversary knows that a ciphertext results from one of two possible plaintexts, the adversary should not be able to tell that which one plaintext is more likely to be the actual one.

IND-CPA

- a.k.a Semantic Security
- A cipher is (t,ε) IND-CPA secure if no t-time adversary wins the following game with prob. ≥ 0.5 + ε



Challenger

picks random k, and picks random $b \in \{0,1\}$

Adversary

picks M_0, M_1 of equal length

M_0, M_1

$C=\mathbf{E}_k[M_b]$

$b' \in \{0,1\}$

Attacker wins game if $b=b'$

Summary

- If a block cipher is a PRP, then using this cipher under the CBC, CTR modes has semantic security.
- For all existing block ciphers, if there is no known attack, they are assumed to be PRP for some suitable parameters.