Semantic Security

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- Mechanism: Shannon Ciphers.

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- First to formalize the notion of security

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- The D function takes in two arguments: a key k and a ciphertext c, and produces a plaintext m
- While E maybe random, D must be deterministic

$$m = D(k, c)$$

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- $\mathcal{E}$ is defined over $(\mathcal{K}, \mathcal{M}, \mathcal{C})$

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- A one time pad is a Shannon Cipher s.t.

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- Future HW: Write out a mathmatical justification that the one time pad meets the earlier correctness requirement (Decryption *undoes* Encryption)

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- A secure cipher text should not increase this probability of guessing correctly.
- Suppose there are 90 keys k_0 s.t. $E(k_0, m_0) = c$ and 10 keys k_1 s.t. $E(k_1, m_1) = c$, the probability that a given message c is m_0 is $90/(90 + 10) = 90\%$, increasing our adversaries odds of guessing correctly.

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- Let $\mathcal{E} = (E, D)$ be a Shannon Cipher defined over $(\mathcal{K}, \mathcal{M}, \mathcal{C})$
- If for all $m_0, m_1 \in \mathcal{M}$, for all $c \in \mathcal{C}$, and $\mathbf{k} \xleftarrow{R} \mathcal{K}$ we have

$$Pr[E(\mathbf{k}, m_0) = c] = Pr[E(\mathbf{k}, m_1) = c]$$

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thus, $N_c = 1$, satisfiying the above result.

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- It is impractical to have keys that are at least as large as the size of the message we are transmitting .
- Really, what we are concerned about are real world, computationally bounded adversaries.
- We are also interested in efficient algorithms for encrypting and decrypting. By efficient, we mean polynomial functions.

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- $\mathcal{A}$ outputs b^*, guessing which experiment was selected by the Challenger

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- In order to be semantically secure, the advantage has to be negligible. We can think of negligible as $1 + \lambda \approx 1, \lambda = 2^{-100}$

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- $\mathcal{A}$ outputes message m^*

Semantic Security to Message Recovery: cont

Now let's use our adversary $\mathcal{A}$ to break semantic security, violating our original assumption.

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Thus, if we can recover the message, we have broken semantic security.

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Alice's security is $1/n$ where n is the number of messages sent along the network.