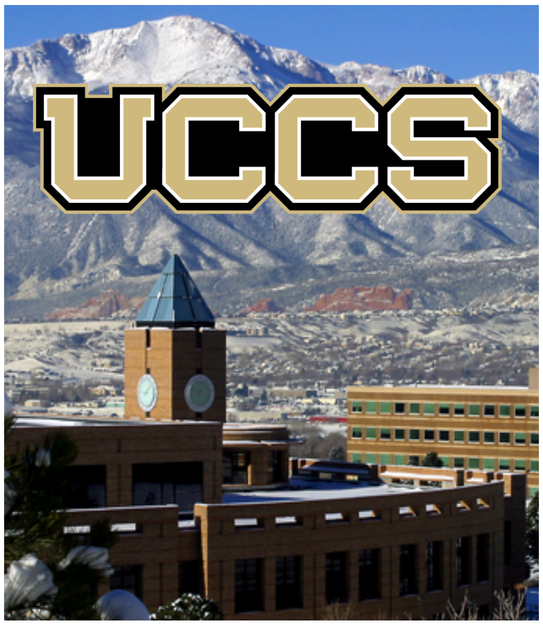


Cryptography and
Information Theory

Brute Force and Cryptanalysis

Sang-Yoon Chang, Ph.D.

Module Objectives

1. Brute Force Attack

2. Cryptanalysis

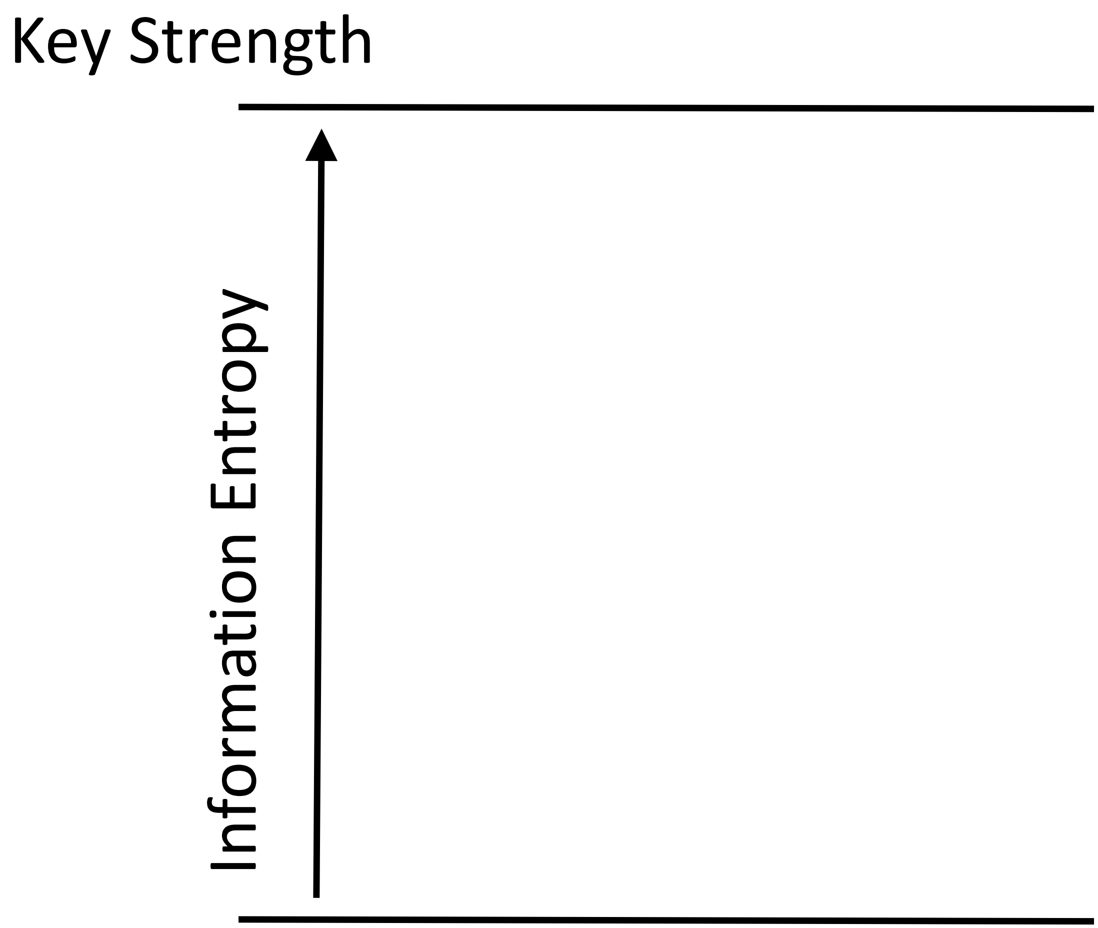
3. Perfect Secrecy

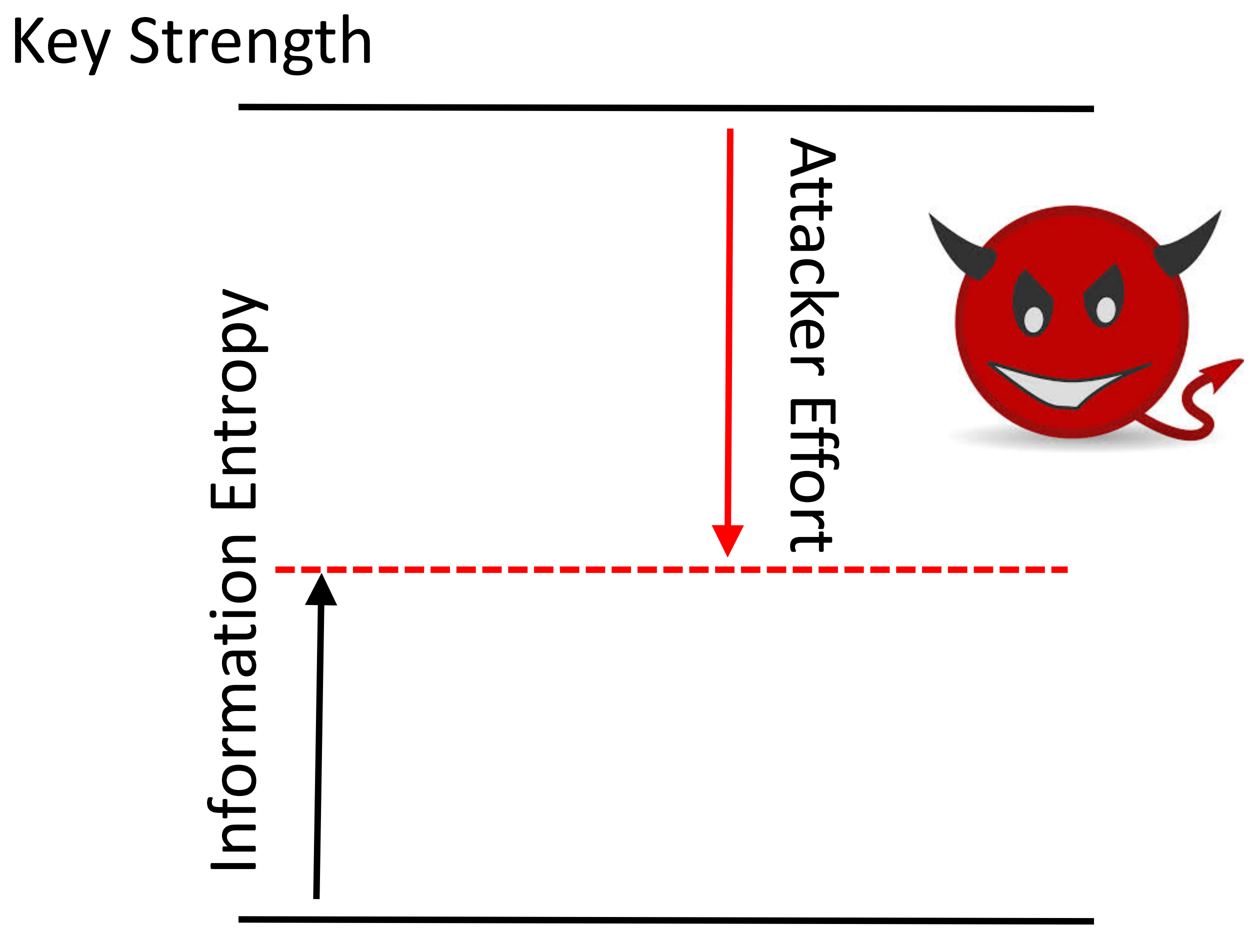
Brute Force Attack 

Attacker tries all possible keys until it finds the correct key

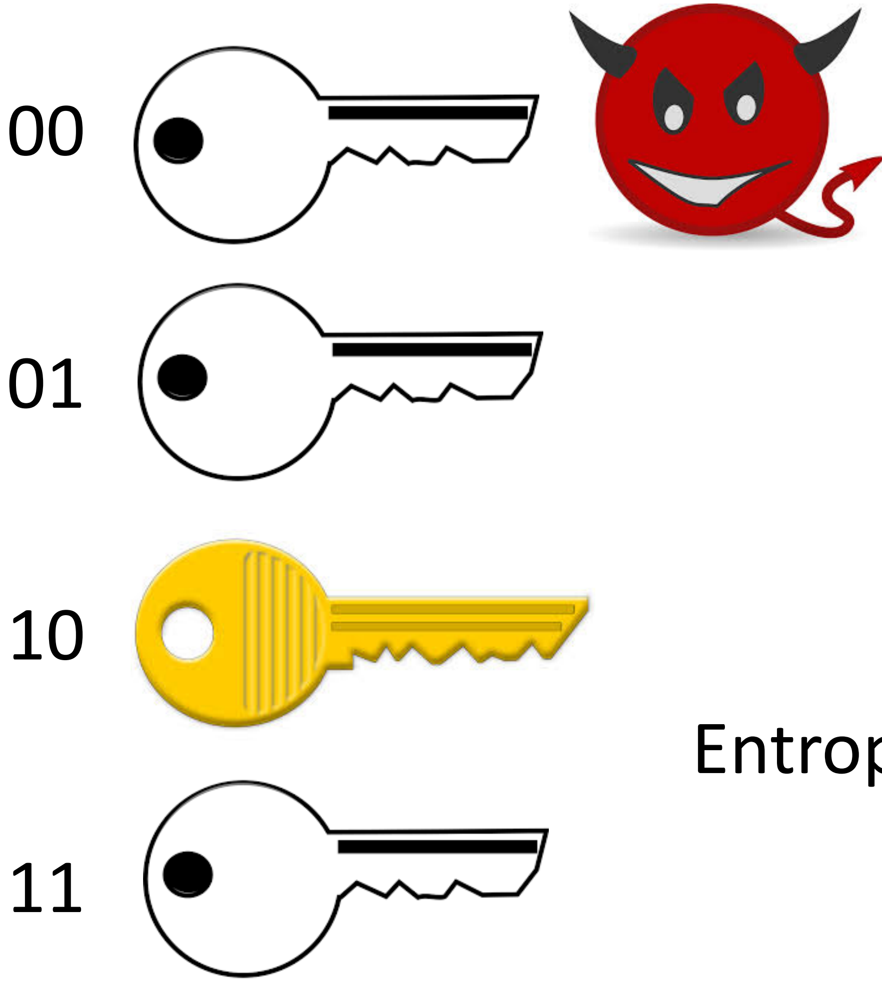
Attacker selects the keys (to try) randomly

Assume that attacker can distinguish the correct and the incorrect key after trials

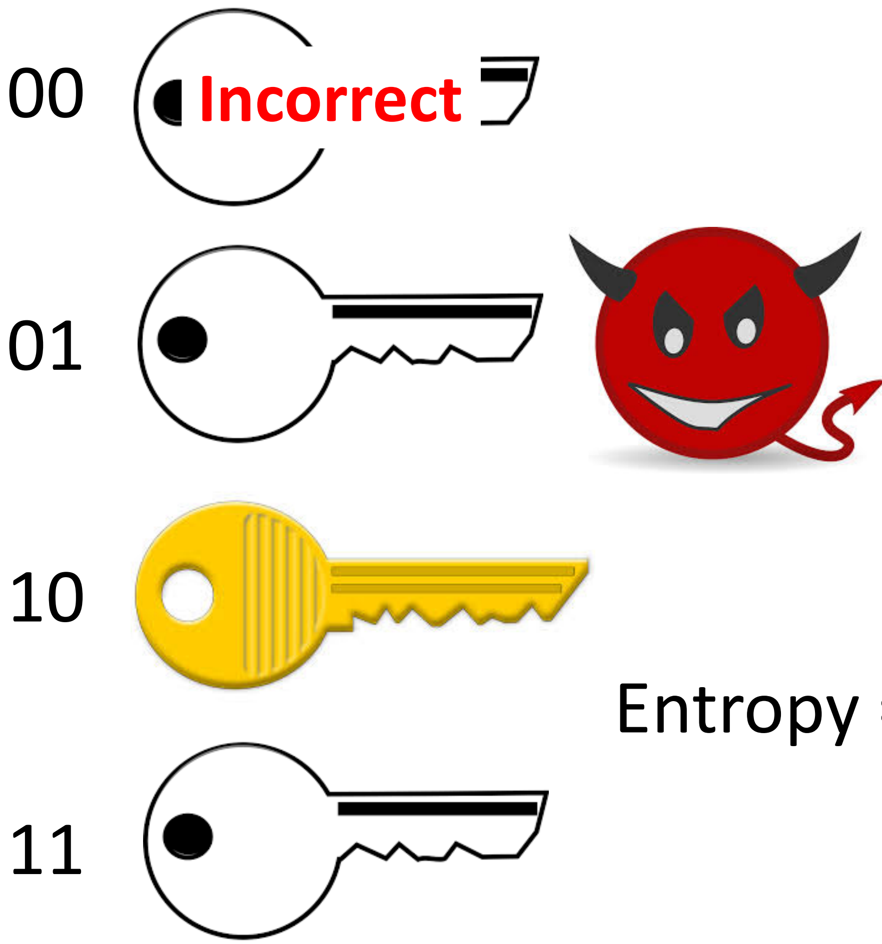

Key Strength
Information Entropy



Key Strength
Information Entropy
Attacker Effort



Entropy = 2 bits



Entropy = $\log_2 3$ bits

Brute Force Attack 

With keys that are "n" bits long, there are 2^n possible keys

Attacker can succeed in the attack in the 1st try (best case) or the last try (worst case; 2^n tries)

On average, attacker will try 2^{n-1} tries

Cryptanalysis 

Studying and analyzing the cryptosystem in order to effectively decipher the coded message *without* the key

Cryptanalysis 

Attacker can know which keys are more likely than others

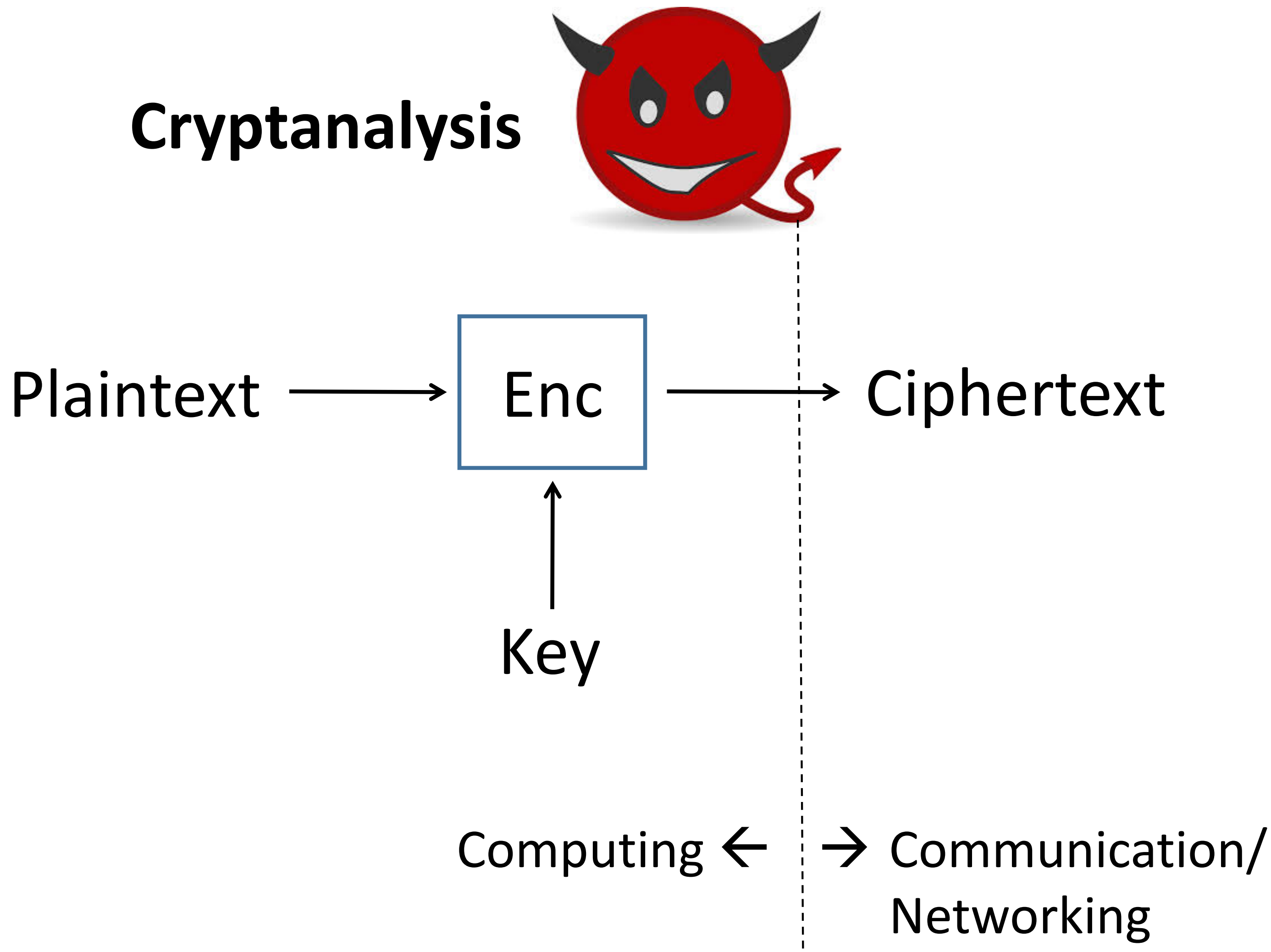
Use the information to more quickly find the key

The non-uniform distribution of the key selection yields entropy reduction

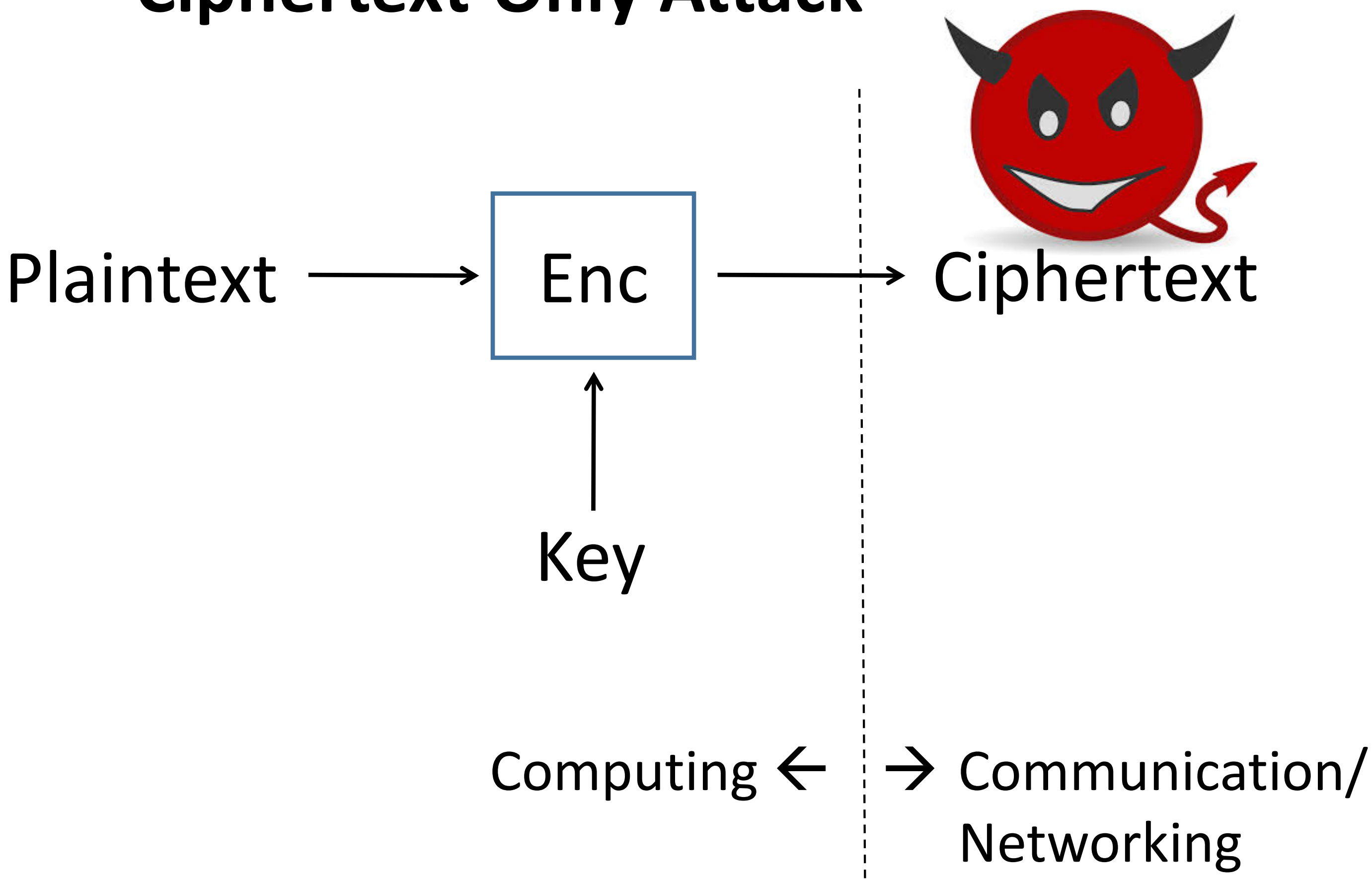

INSURANCE PAYS 2 to 1


INSURANCE PAYS 2 to 1

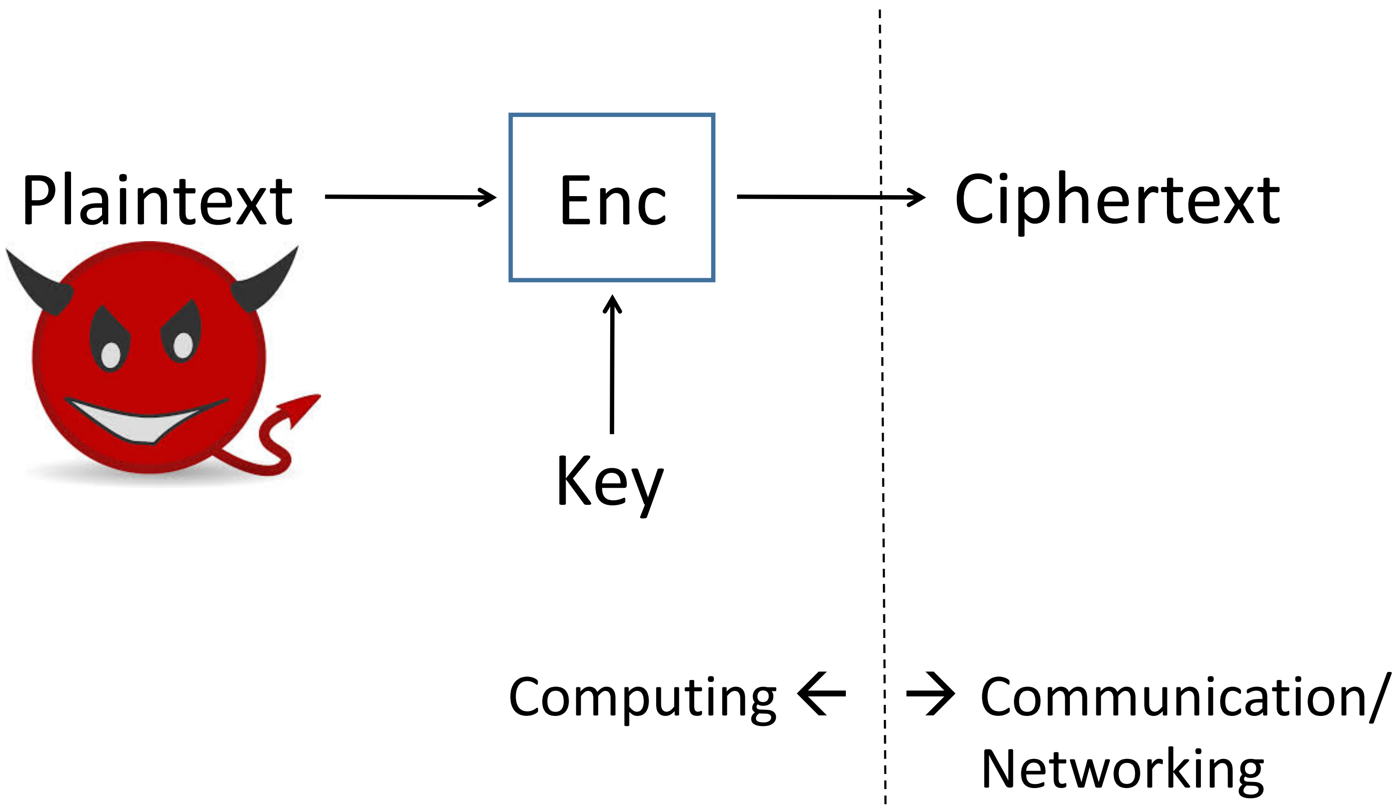

INSURANCE PAYS 2 to 1


Cryptanalysis
Plaintext
Enc
Ciphertext
Key
Computing
Communication/
Networking

Ciphertext-Only Attack



Known-Plaintext Attack



Known-Plaintext Attack

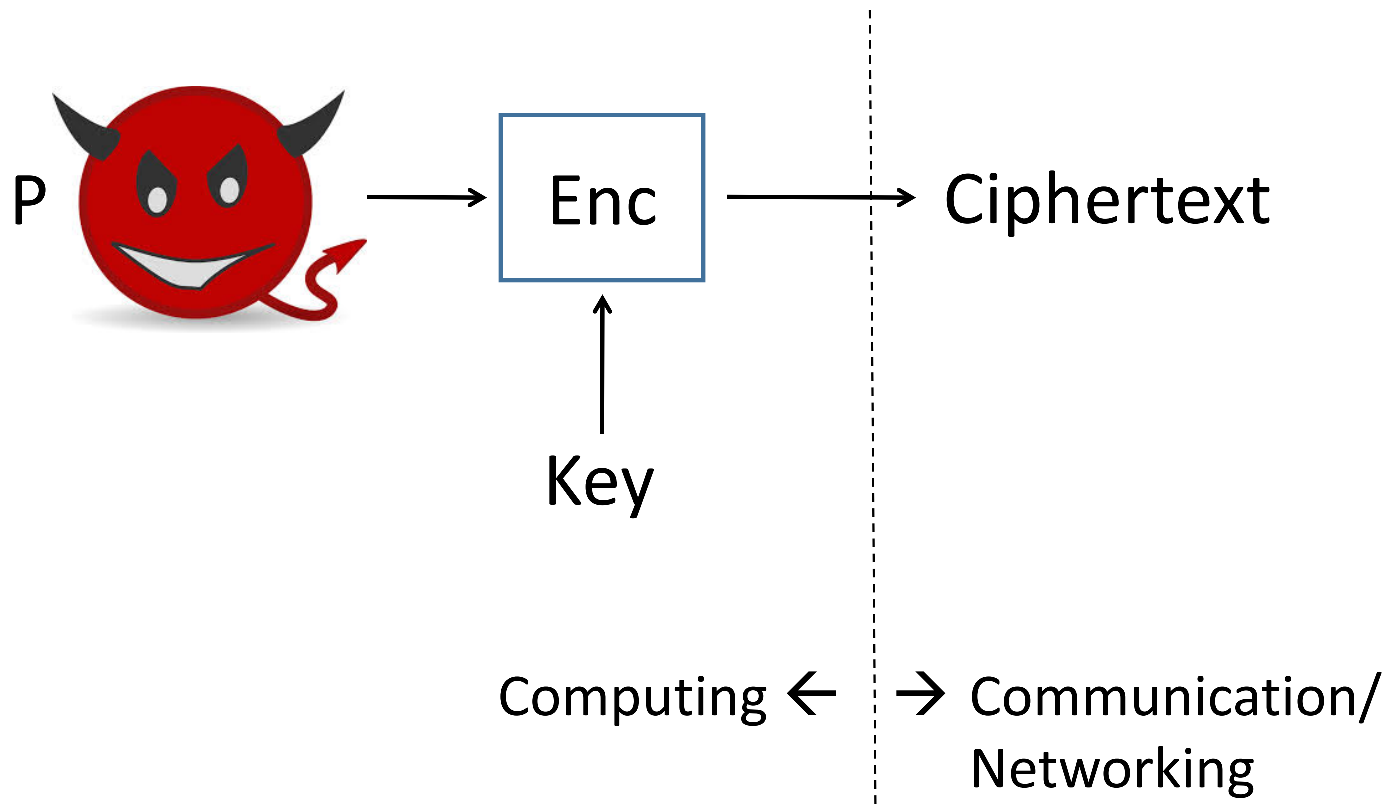
Plaintext → Enigma → Ciphertext

Key

E.g., in WW2, Weather, “Nothing to report”

uting ← → Communication/ Networking

Chosen-Plaintext Attack



Chosen-Plaintext Attack

P  → Enigma → Ciphertext

↑

Key

E.g., in WW2,
Location
(staging events)

Computing ← ¦ → Communication/
Networking

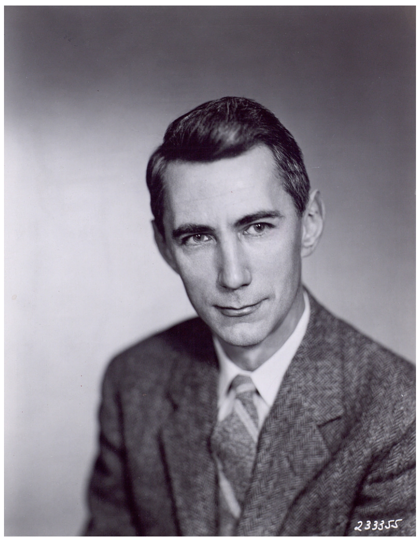
Perfect Secrecy 

Ciphertext provides no information about the plaintext without the key

Holds regardless of the attacker’s computational capabilities

Cryptanalytically unbreakable

One-Time Pad



The key entropy is as great as the message entropy, even as the message grows

Achieves perfect secrecy

Practicality of One-Time Pad

Two challenges that limit its practicality:

- Key and randomness generation
- Key distribution and agreement

Practicality of One-Time Pad

Two challenges that limit its practicality:

- Key and randomness generation
- Key distribution and agreement

Examples of its use:

- Low-bandwidth applications
  (e.g., mission-critical messages)
- Cryptosystem design, e.g., key refresh