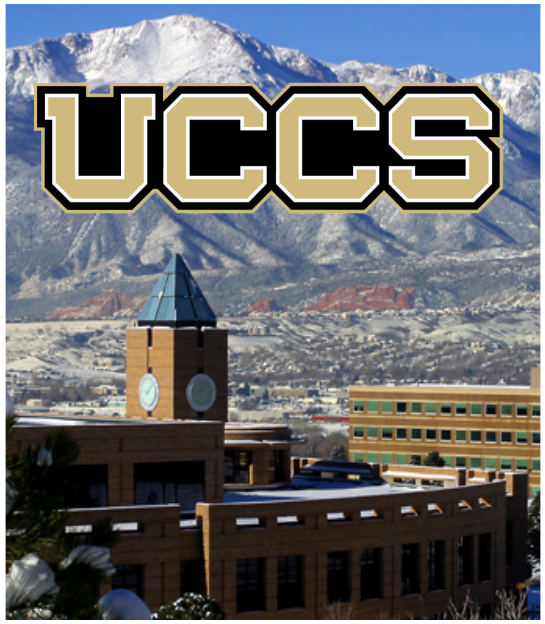


Cryptography and
Information Theory

Brute Force and Cryptanalysis

Sang-Yoon Chang, Ph.D.

Module Objectives

1. Brute Force Attack

2. Cryptanalysis

3. Perfect Secrecy

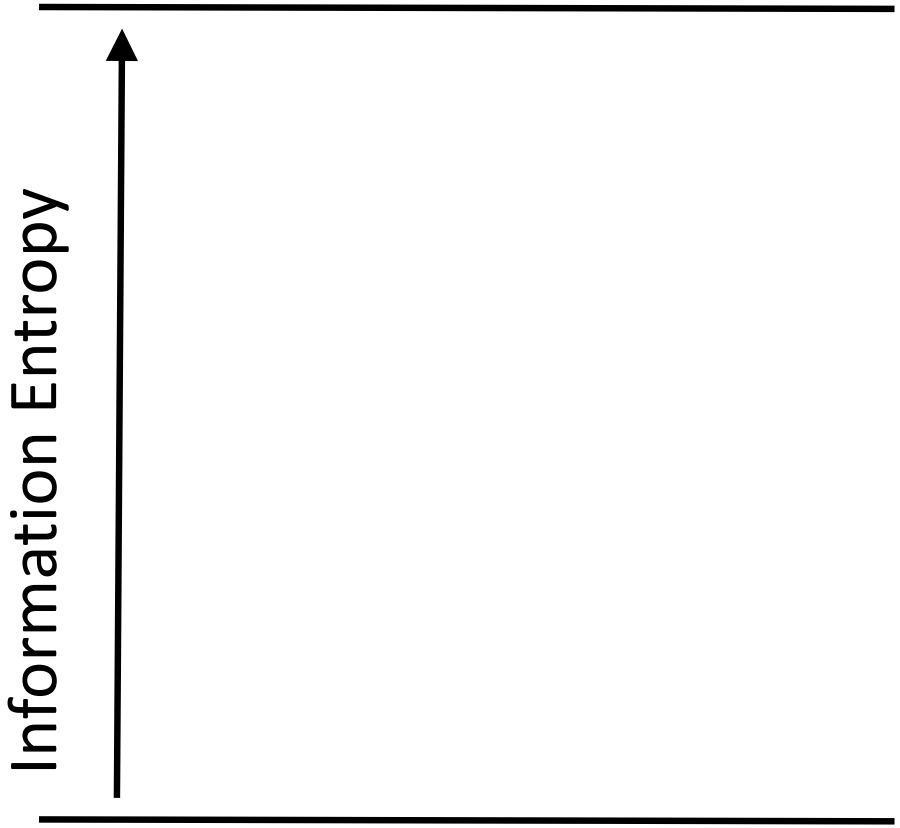
Brute Force Attack

Attacker tries all possible keys until
it finds the correct key

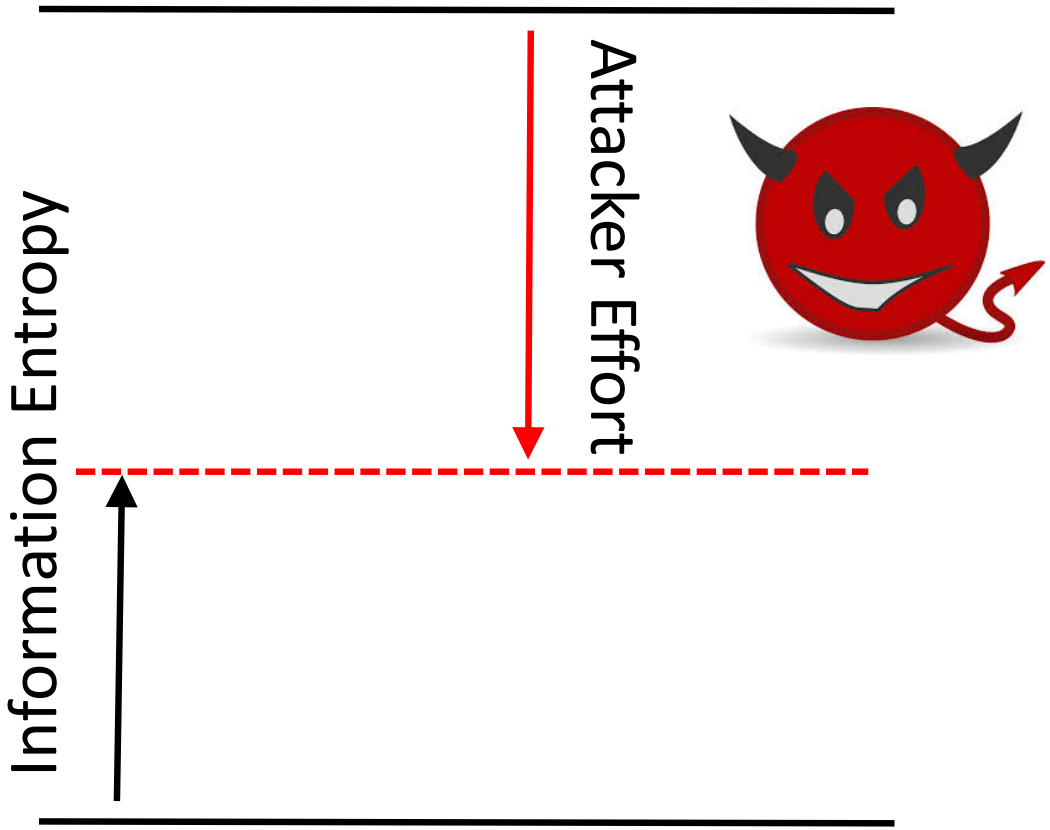
Attacker selects the keys (to try) randomly

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

Key Strength



Key Strength



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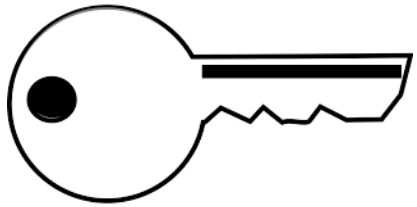

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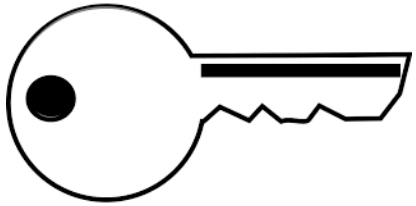

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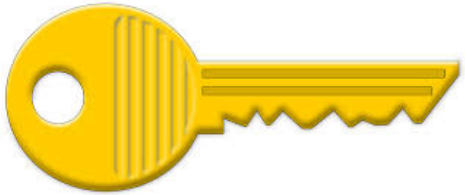

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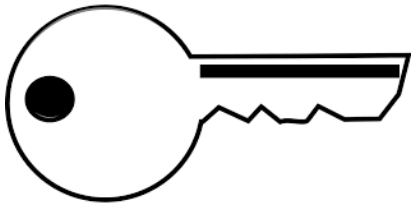
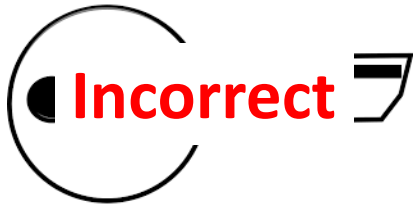
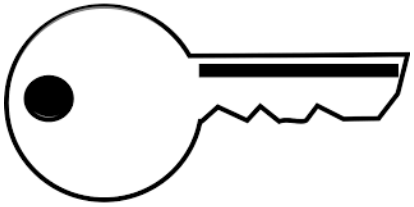
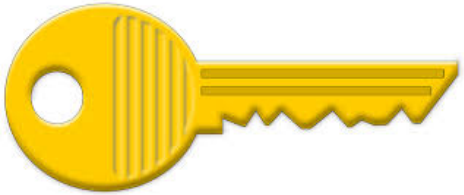


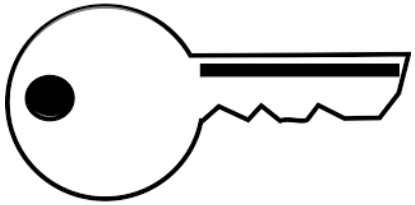
Entropy = 2 bits

00 

01 

10 

Entropy = $\log_2 3$ bits

11 

Brute Force Attack

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

Attacker can succeed in the attack in the 1^{st} 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

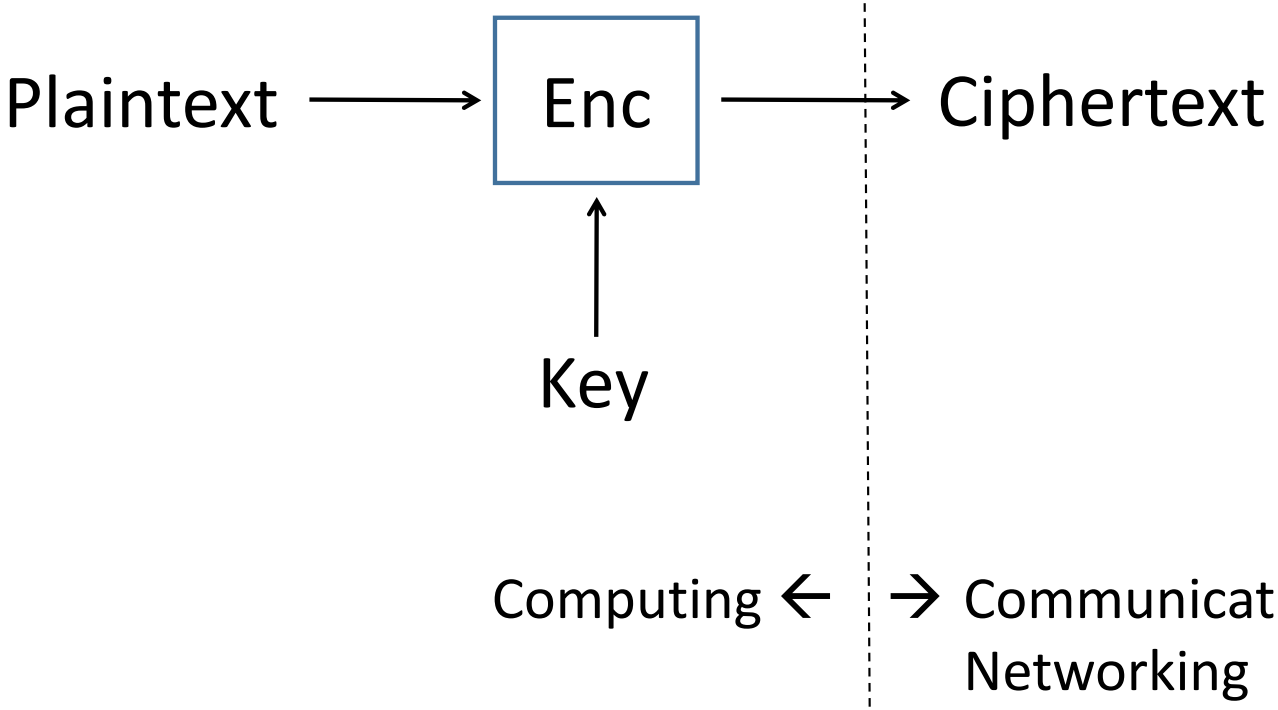
The non-uniform distribution of the key selection yields entropy reduction


BLACKJACK PAYS 3 TO 2
Dealer must stand on 17 and must draw to 16
INSURANCE PAYS 2 TO 1

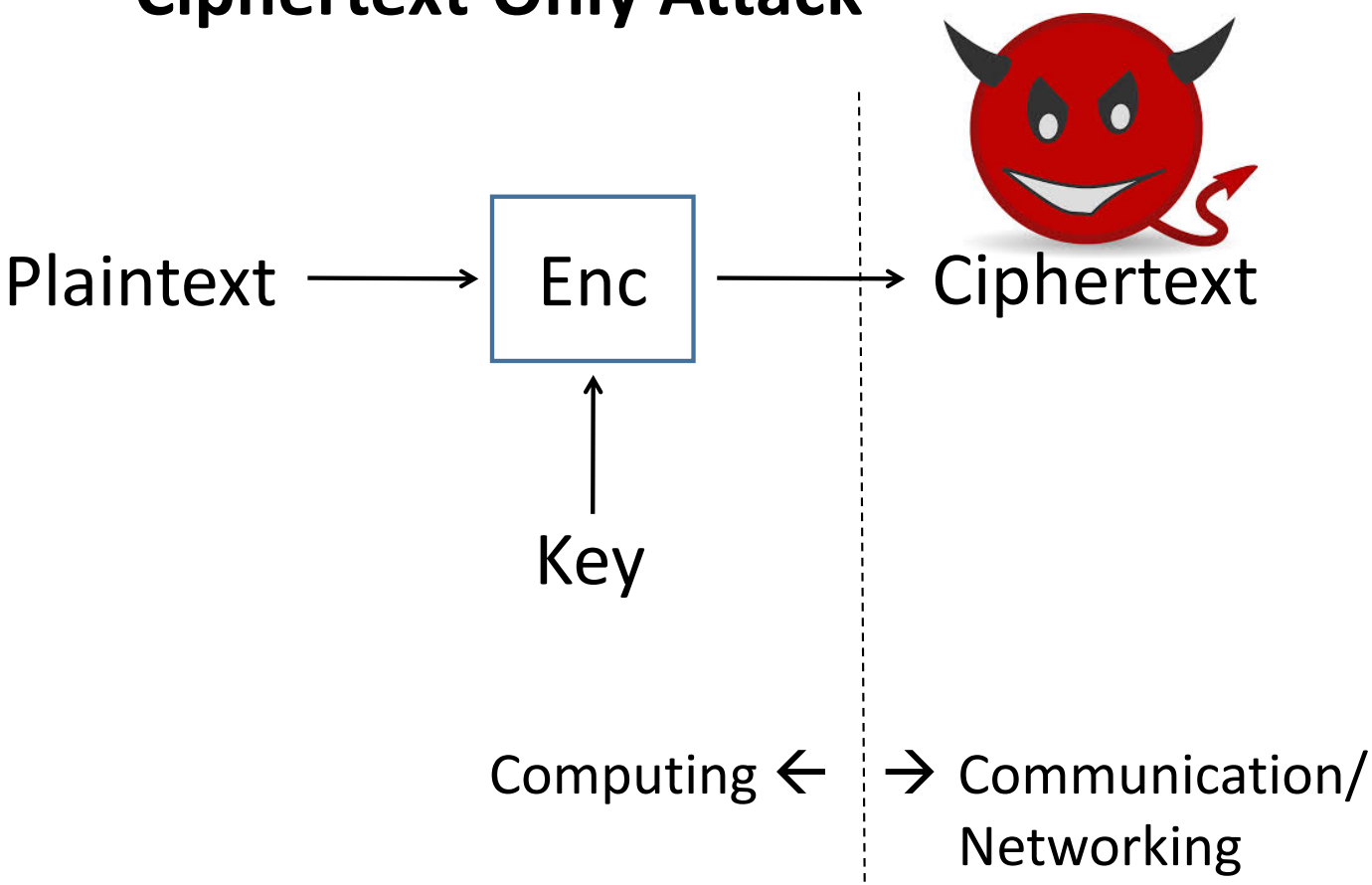

Dealer must stand on 17 and
INSURANCE PAYS 2 to 1
TO 2
st draw to 16


INSURANCE PAYS 2 TO 1

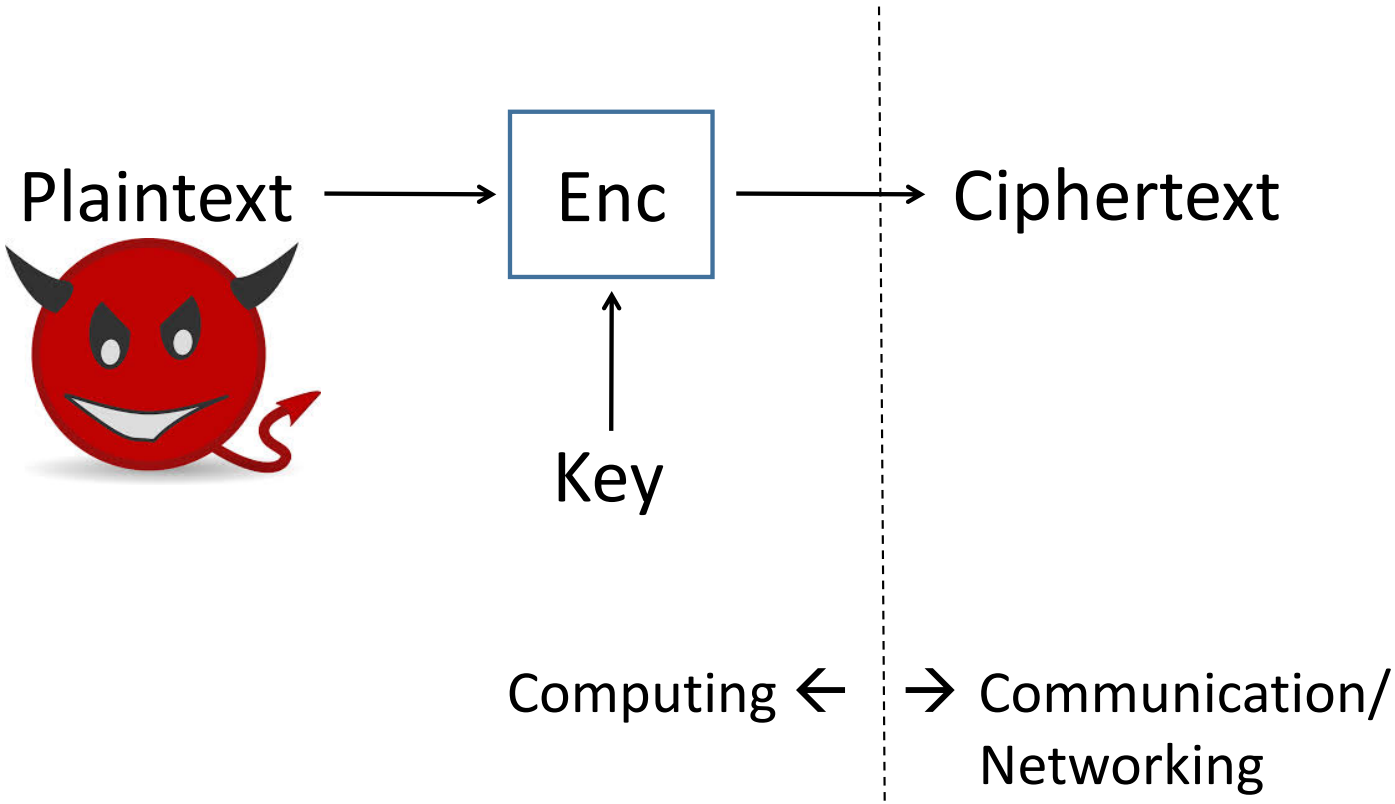
Cryptanalysis



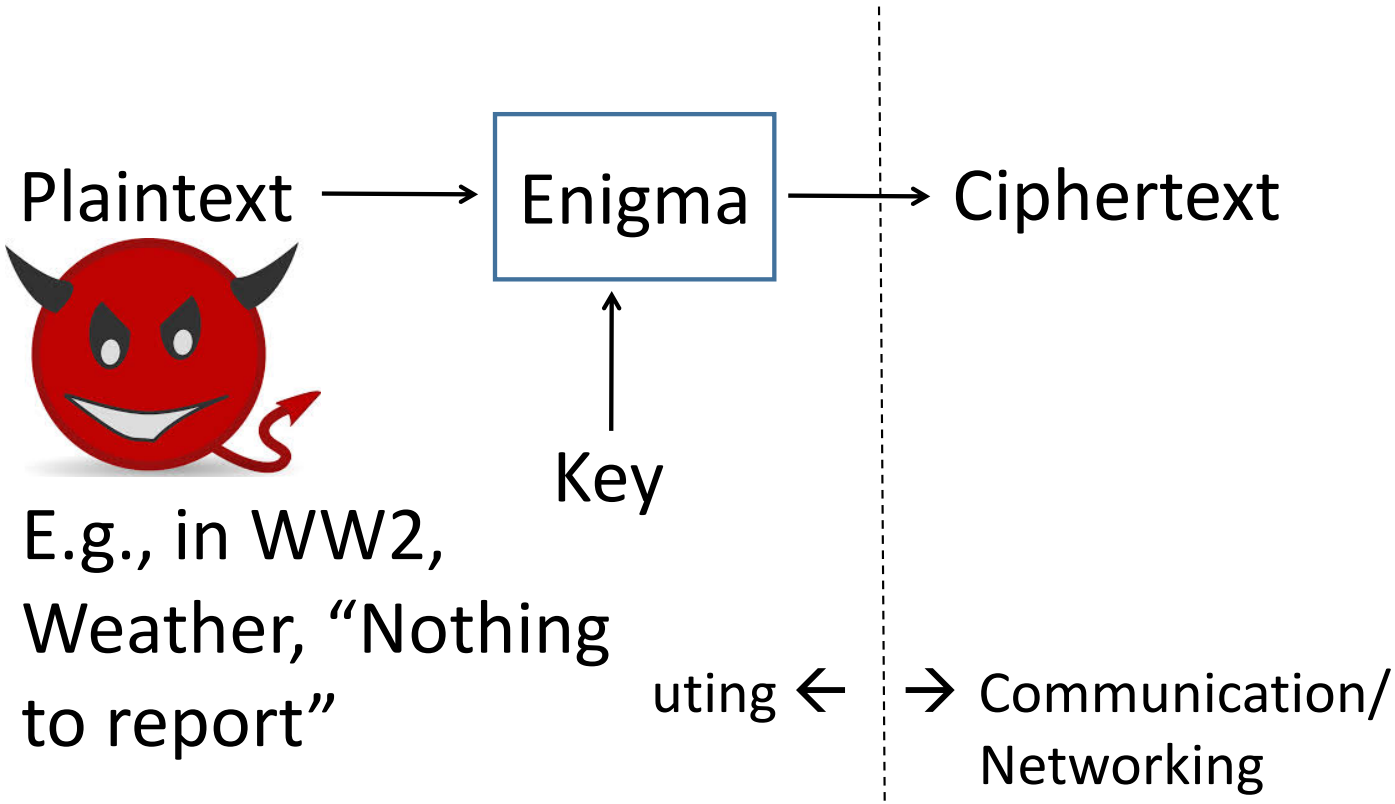
Ciphertext-Only Attack



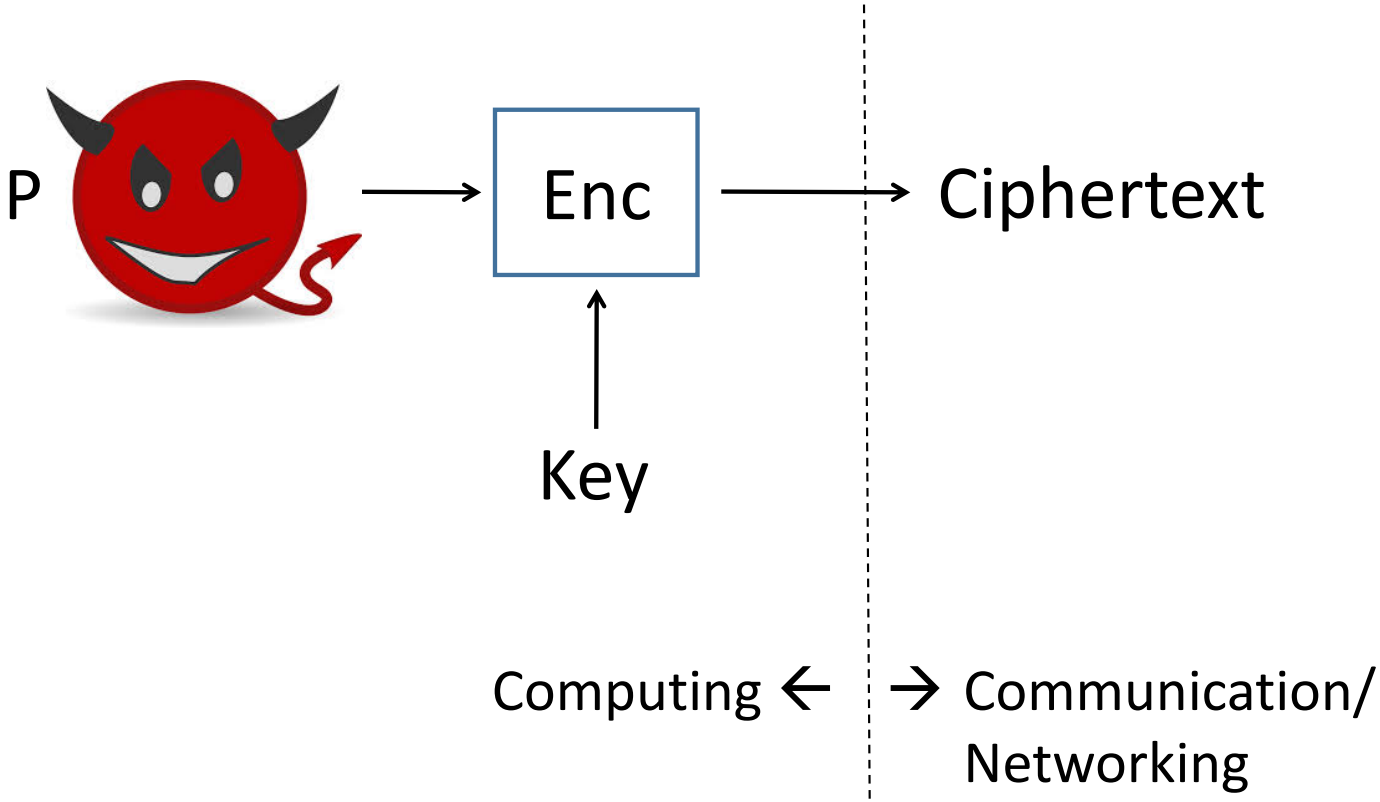
Known-Plaintext Attack



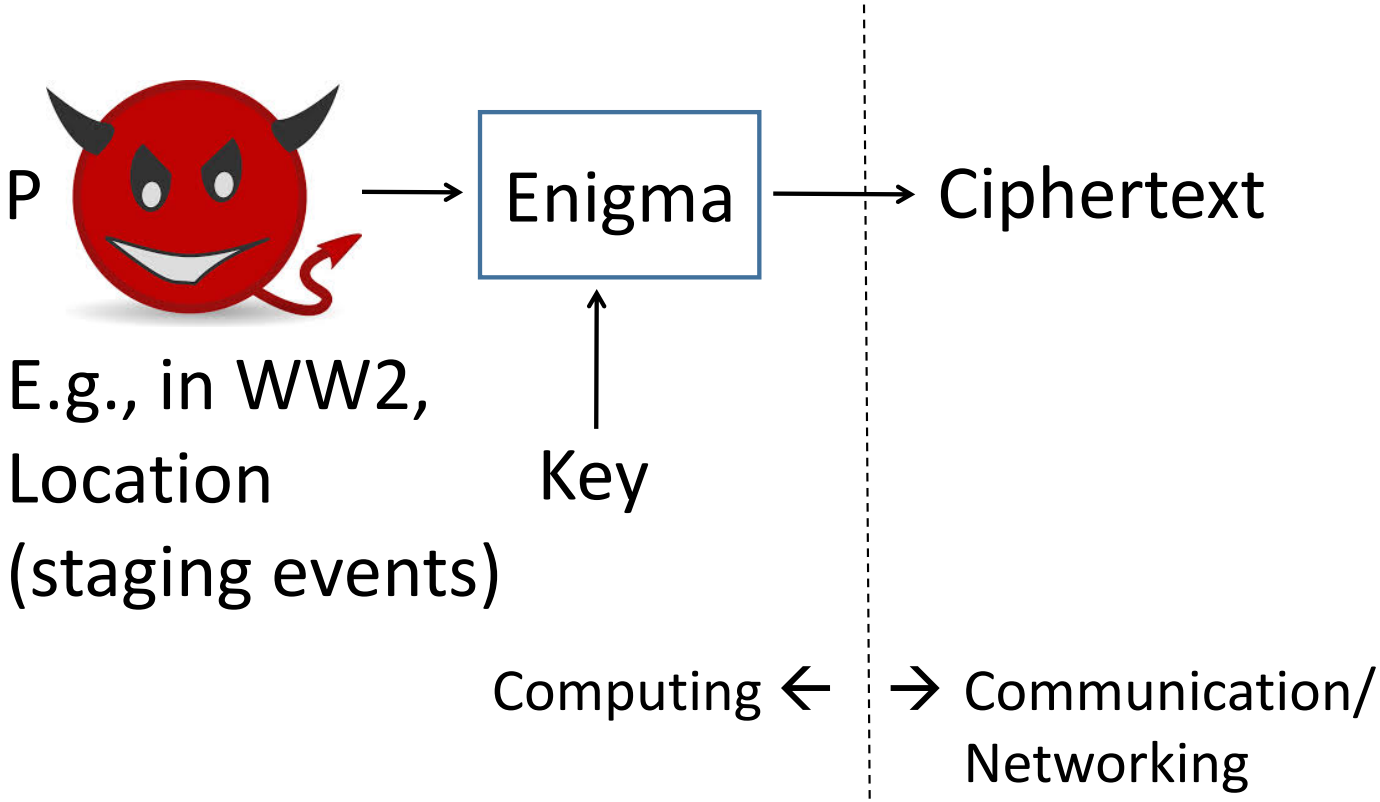
Known-Plaintext Attack



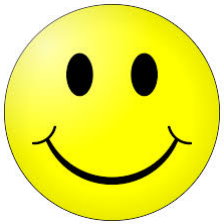
Chosen-Plaintext Attack



Chosen-Plaintext Attack



Perfect Secrecy

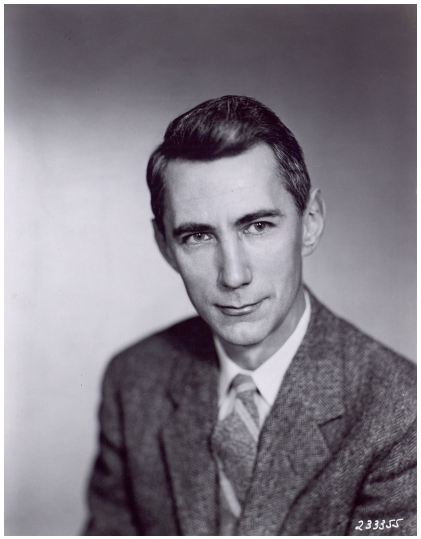


Ciphertext provides no information about the plaintext without the key

Holds regardless of the attacker's computational capabilities

Cryptanalytically unbreakable

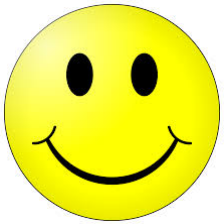
One-Time Pad



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

Achieves perfect secrecy

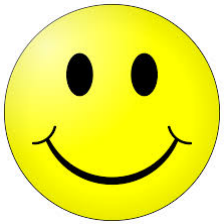
Practicality of One-Time Pad



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