Computer Security
CS 426
Lecture 2

Cryptography: Terminology & Classic Ciphers

Announcements

- Join class mailing list: CS426_Fall2010@cs.purdue.edu

Security Goals

- Confidentiality (secrecy, privacy)
  - only those who are authorized to know can know
- Integrity
  - only modified by authorized parties and in authorized ways
- Availability
  - those authorized to access can get access

Tools for Information Security

- Cryptography
- Access control
- Hardware/software architecture for separation
- Processes and tools for developing more secure software
- Monitoring and analysis
- Recovery and response

Goals of Cryptography

- The most fundamental problem cryptography addresses: ensure security of communication over insecure medium
- What does secure communication mean?
  - confidentiality (privacy, secrecy)
    - only the intended recipient can see the communication
  - integrity (authenticity)
    - the communication is generated by the alleged sender
- What does insecure medium mean?
  - the adversary can eavesdrop
  - the adversary has full control over the communications

Approaches to Secure Communication

- Steganography
  - "covered writing"
  - hides the existence of a message
  - depends on secrecy of method

- Cryptography
  - "hidden writing"
  - hide the meaning of a message
  - depends on secrecy of a short key, not method

Cryptography, cryptanalysis, and cryptology

- Cryptography,
  - Traditionally, designing algorithms/protocols
  - Nowadays, often synonym with cryptology
- Cryptanalysis
  - Breaking cryptography
- Cryptology: both cryptography & cryptanalysis
  - Becoming less common,

History of Cryptography

- 2500+ years
- An ongoing battle between codemakers and codebreakers
- Driven by communication & computation technology
  - paper and ink
  - cryptographic engine & telegram, radio
  - modern cryptography: computers & digital communication

Basic Terminology

• Plaintext	original message
• Ciphertext	transformed message
• Key	secret used in transformation
• Encryption	
• Decryption	
• Cipher	algorithm for encryption/decryption

Shift Cipher

- The Key Space:
  - [1 .. 25]
- Encryption given a key K:
  - each letter in the plaintext P is replaced with the K'th letter following corresponding number (shift right)
- Decryption given K:
  - shift left

History: K = 3, Caesar's cipher

Shift Cipher: Cryptanalysis

- Can an attacker find K?
  - YES: by a bruteorce attack through exhaustive key search,
  - key space is small (<= 26 possible keys).

- Once K is found, very easy to decrypt

General Mono-alphabetic Substitution Cipher

- The key space: all permutations of $\Sigma = \{A, B, C, \ldots, Z\}$
- Encryption given a key π:
  - each letter X in the plaintext P is replaced with $\pi(X)$
- Decryption given a key π:
  - each letter Y in the cipherext P is replaced with $\pi^{-1}(Y)$

Example:

```
   A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
π= B A D C Z H W Y G O Q X S V T R N M L K J I P F E U
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BECAUSE $\rightarrow$ AZDBJSZ

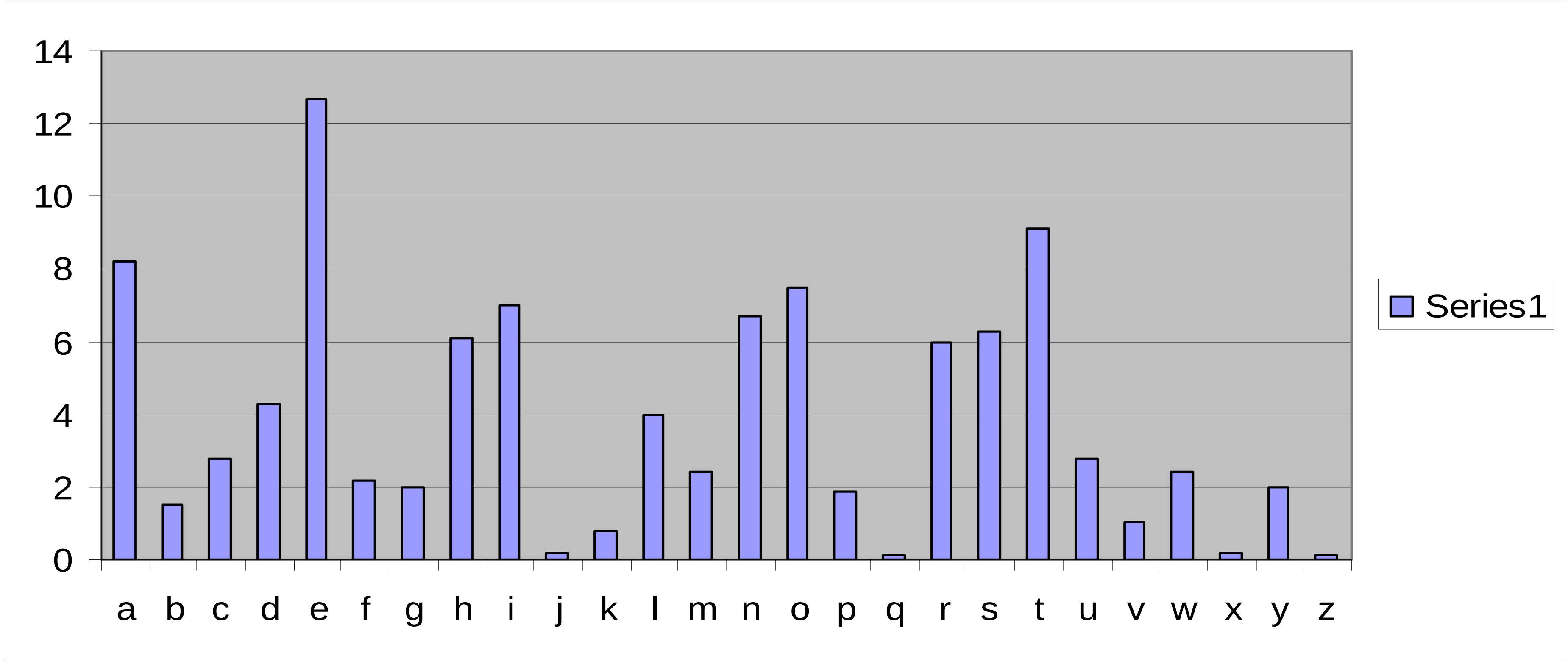
Strength of the General Substitution Cipher

- Exhaustive search is difficult
  - key space size is 26! $\approx 4\times10^{26}$
- Dominates the art of secret writing throughout the first millennium A.D.
- Thought to be unbreakable by many back then

Cryptanalysis of Substitution Ciphers: Frequency Analysis

- Basic ideas:
  - Each language has certain features: frequency of letters, or of groups of two or more letters.
  - Substitution ciphers preserve the language features.
  - Substitution ciphers are vulnerable to frequency analysis attacks.

Frequency of Letters in English



Security Principles

- Security by obscurity doesn’t work

- Should assume that the adversary knows the algorithm; the only secret the adversary is assumed to not know is the key

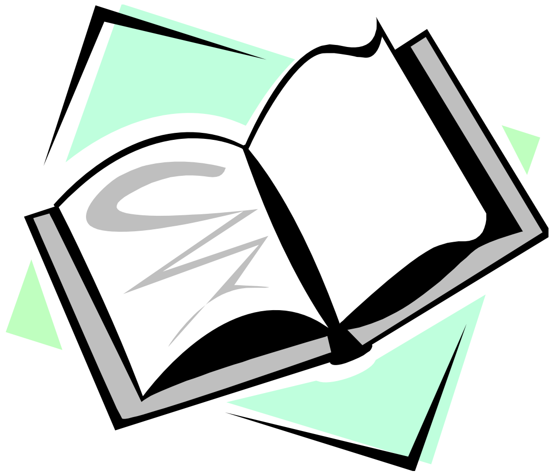
Readings for This Lecture

Required readings:

- Cryptography on Wikipedia

Optional Readings:

- Security in Computing
  - Chapter 2: Basic Encryption and Decryption



Interesting reading

- The Code Book by Simon Singh

Coming Attractions …

- Cryptography: One-time Pad, Informational Theoretical Security, Stream Ciphers