Computer Security

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1 Introduction to Computer Security

1.1 Security requirements

CIA Paradighm

Confidentiality Information can be accessed only by authorized entities

Integrity information can be modified only by authorized entities, and only how they're entitled to do

Availability information must be available to entitled entities, within specified time constraints

The engineering problem is that **A** conflicts with **C** and **I**

2 Computer Security Concepts

2.1 General concepts

Vulnerability Something that allows to violate some CIA constraints

- The physical behaviour of pins in a lock
- A software vulnerable to SQL injecton

Exploit A specific way to use one or more vulnerability to violate the constraints

- lockpicking
- the strings to use for SQL injection

Assets what is valuable/needs to be protected

- hardware
- software
- data
- reputation

Thread potential violation of the CIA

- DoS
- data break

Attack an <u>intentional</u> use of one or more exploits aiming to compromise the CIA

- Picking a lock to enter a building
- Sending a string creafted for SQL injection

Thread agent whoever/whatever may cause an attack to occour

- a thief
- an hacker
- malicious software

Hackers, attackers, and so on

Hacker Someone proficient in computers and networks

Black hat Malicious hacker

White hat Security professional

Risk statistical and economical evaluation of the exposure to damage because of vulneravilities and threads
$Risk = \underbrace{Assets \times Vulnerabilities}_{\text{controllable}} \times \underbrace{Threads}_{\text{independent}}$

Security balance of (vulnerability reduction+damage containment) vs cost

2.2 Security vs Cost

Direct cost

- Management
- Operational
- Equipment

Indirect cost

- Less usability
- Less performance
- Less privacy

Trust We must **assume** something as secure

- the installed software?
- our code?
- the compiler?
- the OS?
- the hardware?

3 Introduction to crypthography

Kerchoffs' Principle The security of a (good) cryptosystem relies only on the security of the key, never on the secrecy of the algorithm

3.1 Perfect Chipher

- $P(M = m)$ probability of observing message m
- $P(M = m|C = c)$ probability that the message was m given the observed cyphertext c

Perfect cypher: $P(M = m|C = c) = P(M = m)$

Shannon's theorem in a perfect cipher $|K| \geq |M|$

One Time Pad a real example of perfect chipher

Algorithm 1 One Time Pad

Require: $len(m) = len(k)$
Require: keys not to be reused
return $k \oplus m$

Brute Force perfect chyphers are immune to brute force (as many "reasonable" messages will be produced). Real world chiphers are not.
A real chipher is vulnerable if there is a way to break it that is faster then brute forcing

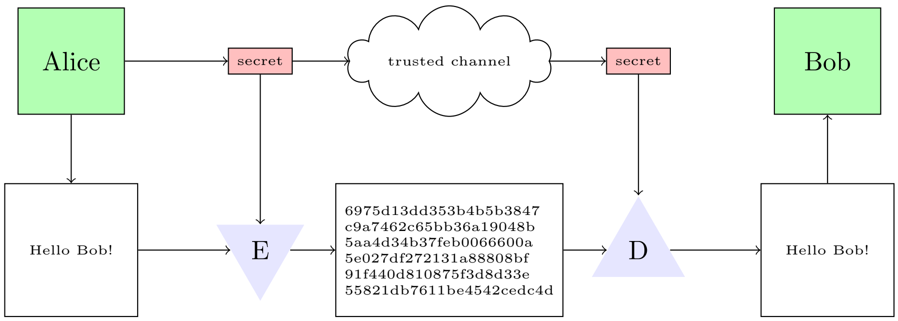
Types of attack

Ciphertext attack analyst has only the chipheertexts

Known plaintext attack analyst has some pairs of plaintext-chiphertext

Chosen plaintext attack analyst can choose plaintexts and obtain their respective ciphertext

3.2 Symmetric encryption



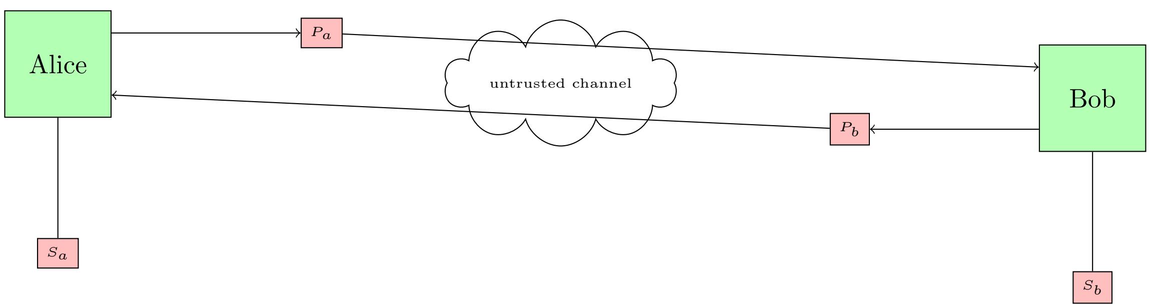
Use **K** to both encrypt and decript the message
Scalability issue
Key agreement issue

3.2.1 Ingredients

Substitution Replace each byte with another (ex: caesar chipher)

Transposition swap the values of given bits (ex: read vertically)

3.3 Asymetric encryption



Each user owns a private and a public key (S_i, P_i), where the public key is publicly available. The cryptoalgorithm is designed so that messages encrypted using P_i can only be decrypted using S_i. This allows Alice to encrypt a message using P_{bob}, and Bob (and nobody else) to decrypt is using S_{bob}. Also, to prove its identity, Bob could send a message encrypted using P_{bob}. When Alice manages to decrypt is using P_{bob}, she can be sure that the message came from Bob

3.4 Hash functions

A function $H : X \to Y$ having $|X| = \infty$ but $|Y| = k \in \mathbb{N}$. This means $|Y| < |X|$, leading to <u>collisions</u>: couples $x_1, x_2 \in X : H(x_1) = H(x_2)$.

Safery properties are proberties needed to ensure robustness of H. In particular, it must be computationally infeasible to find:

preimage attack resistance $x : H(x) = h$ with h known/crafted

second preimage attack resistance $y : y \neq x \wedge H(x) = H(y)$, where x is known/crafted

collision resistance $x, y : H(x) = H(y)$