TÉCNICO LISBOA

Introduction to Network and Computer Security

Segurança Informática em Redes e Sistemas

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David R. Matos, Miguel Pardal

w/ Ricardo Chaves, Carlos Ribeiro, Miguel Correia

We live in a digital world…

- There are more than 5 billion individuals using the Internet
  - That is 5 000 000 000 people
  - Around 2/3 of the world population
- And the number is still increasing…
  - 45% increase in Internet usage since 2018

Sources:
Statista https://www.statista.com/statistics/617136/digital-population-worldwide/
ITU Statistics https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx

… but an insecure world …

- Just in the first half of 2023…
  - Data Breaches:
    - 694 data breaches, impacting 612.4 million records
  - Identity Theft:
    - 1.4 million identity theft cases reported to the FTC
  - Ransomware Attacks:
    - Attackers extorted at least € 420 million
    - Bitcoin represents about 98% of ransomware payments

Sources:
https://sites.udel.edu/threat/2023/08/08/major-security-breaches/
https://identitytheft.org/statistics/
https://www.stationx.net/ransomware-statistics/

… and costs are rising

- The cost of cyber-crime is projected to be approximately €7 billion at the end of 2023
  - 48% of organizations report an increase in cyberattacks
    - Compared to the previous year
    - Attack frequency is also on the rise
  - Estimate of a cost of over €9 billion by 2025

Sources:
Forbes https://www.forbes.com/sites/chuckbrooks/2023/03/05/cybersecurity-trends--statistics-for-2023-more-treachery-and-risk-ahead-as-attack-surface-and-hacker-capabilities-grow/

Cybersecurity

- A secure digital infrastructure is required for an open society
  - To provide personal, social, and economic confidence
- Cybersecurity is crucial for protecting **people**
  - Their **data**
  - The **systems** that store it

Cybersecurity definition

*"the prevention of damage to, unauthorized use of, exploitation of, and the restoration of electronic information and communications **systems**, and the **information** they contain, in order to strengthen the **confidentiality**, **integrity** and **availability** of these systems."*

(U.S. **N**ational **I**nstitute of **S**tandards and **T**echnology)

Fundamental Problem

- We live in a **shared environment**
  - Public spaces
  - Shared physical spaces
  - Use of common infrastructures
  - Resource sharing

Sharing in Computer Systems

- Computer systems are **designed to share data**
- Using shared resources
  - Files
  - Memory
  - Program code
  - Peripherals
  - **Networks / Internet**
    - Physical communication medium
    - Switching mechanisms

Sharing Violations

- Information **leakage**
  - Acquisition of information by unauthorized agents
- Information **corruption**
  - Unauthorized tampering of information
- **Vandalism**
  - Interference with the correct operation of the system without benefits to the attacker

Computers make security harder

- Attacks can be **automated**
  - Ability to reproduce an action millions of times, quickly
- Attacks can be **remote**
  - Distance is not a limiting factor due to the Internet
  - Rapid propagation of techniques

Isolation can limit sharing

- Most attack opportunities are enabled by sharing
  - So, we limit sharing with **isolation**
- Physical isolation
  - Safes, walls
- People isolation
  - Only a certain group is informed
- Logical isolation
  - Encrypting a document makes the information unintelligible

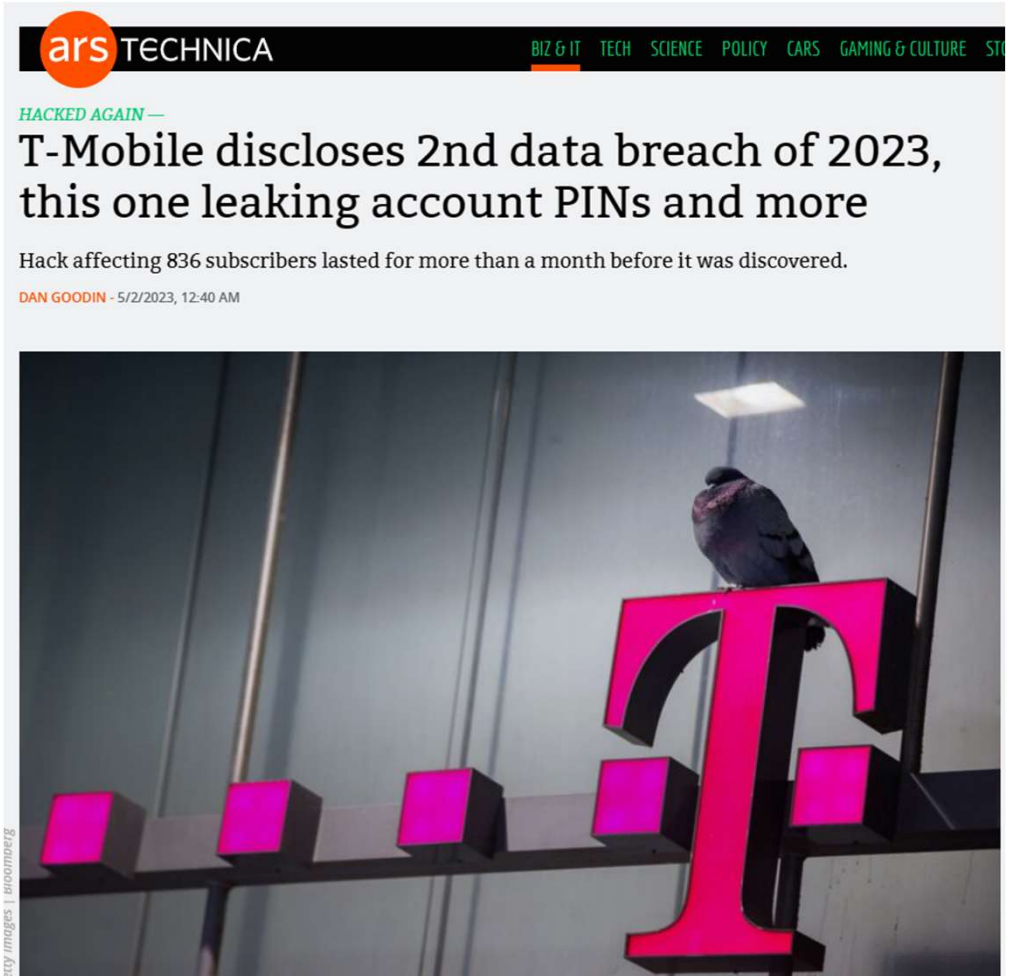
Computer Security

Main security properties / attributes (CIA):

- Confidentiality
- Integrity
- Availability

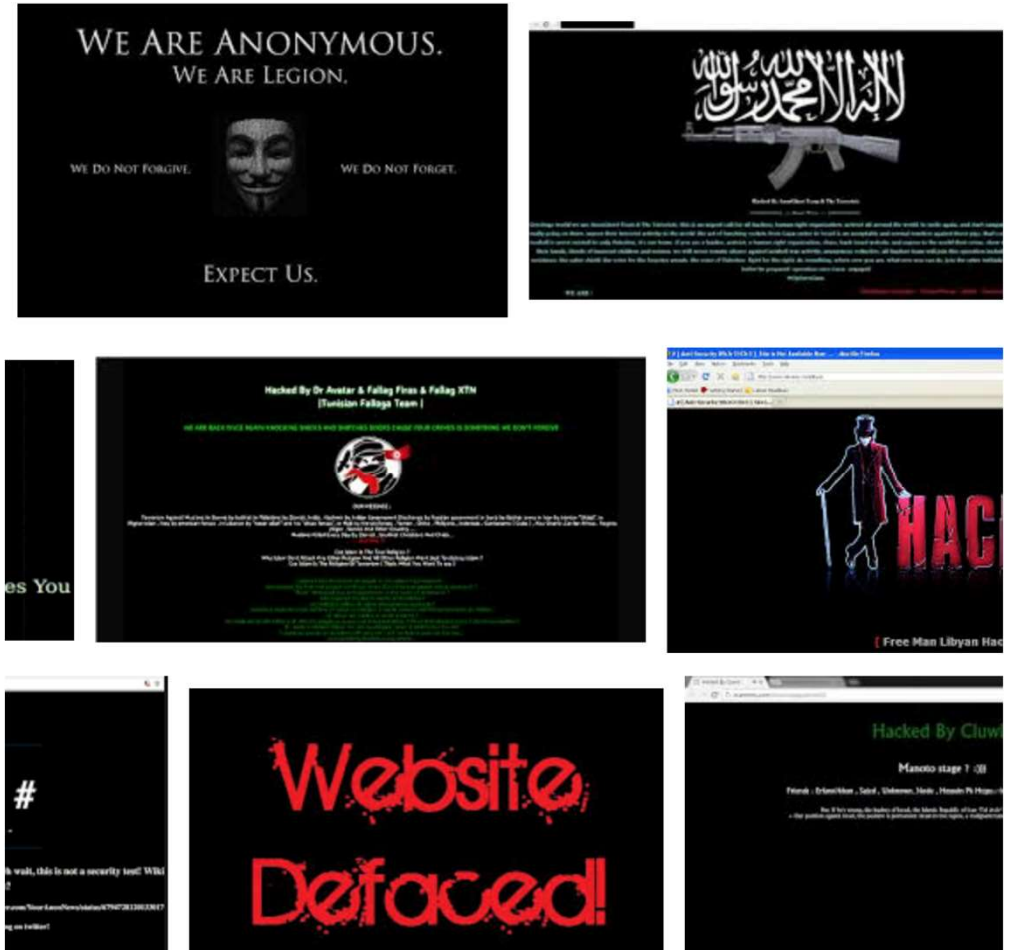
CIA: Confidentiality

- Confidentiality – absence of disclosure of **data** by non-authorized parties - "non-authorized" requires a security policy



CIA: Integrity

- Integrity – absence of invalid **data** or **system** modifications by non-authorized parties



CIA: Availability

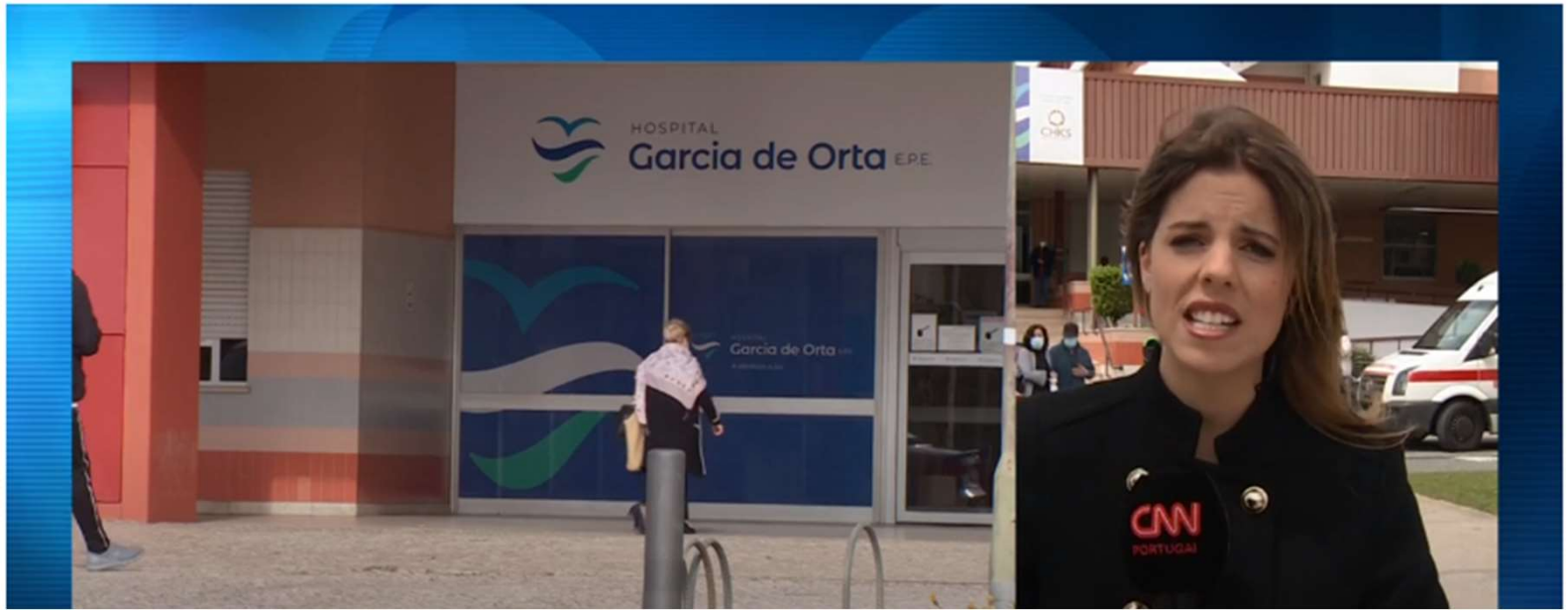
- Availability – readiness of **system** to provide service

CNN PORTUGAL

País Crime e Justiça Educação Meteorologia

Ataque informático cancela consultas e cirurgias no Hospital Garcia de Orta

26 abr 2022, 10:44



Computer Security

Main security properties / attributes (CIA):

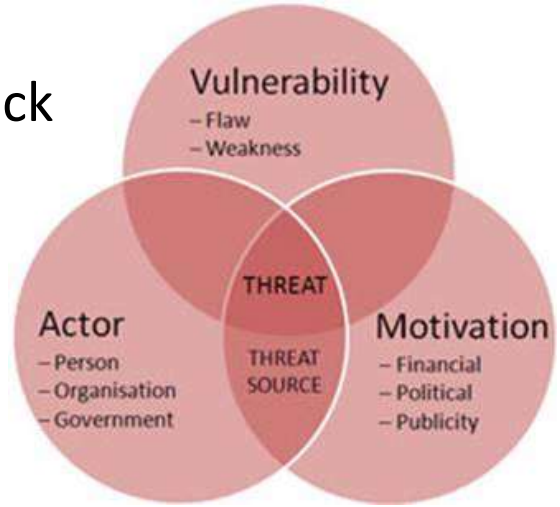
- **Confidentiality**
  - Privacy
  - Segregation of privileges
- **Integrity**
  - Authenticity – integrity of content and origin
  - Non-repudiation – do not deny action or authorship
    - Verifiable by others
- **Availability**

Excerpt from the GDPR: Confidentiality, integrity, availability?

- 'Personal data breach' is a security breach that accidentally or **unlawfully** leads to:
  - the destruction,
  - the loss,
  - alteration,
  - the disclosure, or
  - the unauthorized access
  - to **personal data** that has been transmitted, stored, or otherwise processed

Definitions

- Vulnerability
  - Characteristic of a system that makes it susceptible to attacks
- Attack
  - Actions that lead to the violation of a security attribute, often by exploiting vulnerabilities
- Threat
  - A *threat source* is an actor motivated to attack
  - A *threat* is a potential attack from a source facilitated by one or more vulnerabilities of the system



Attacker/Adversary

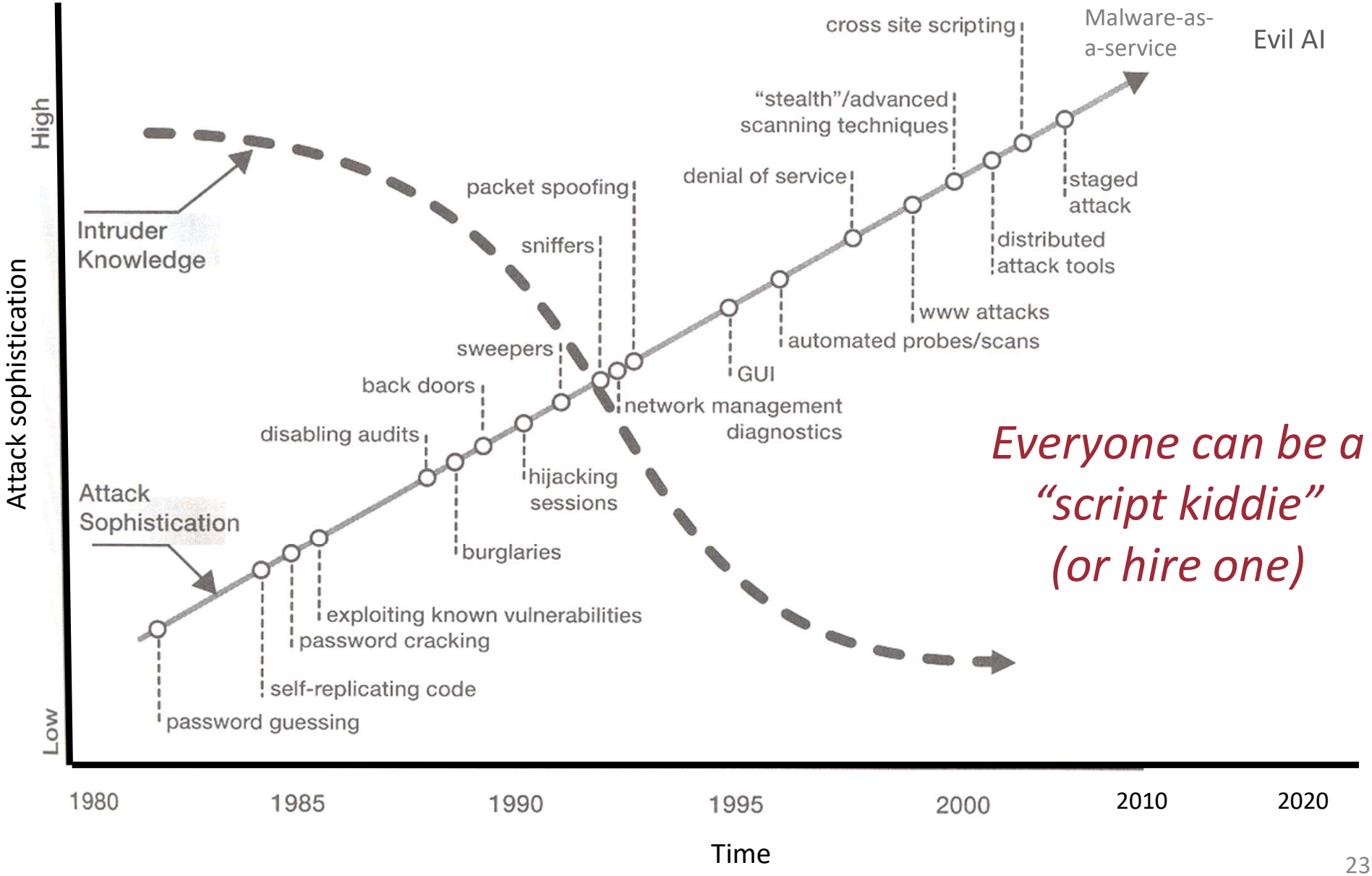
Attacker/Adversary

- In Cybersecurity, there is someone else, acting against us
  - From individual hackers to state entities
  - Attackers have varied motives and means
- Attackers adapt to defenses, creating new attacks
  - Continuous cycle
- Challenge: defenses must anticipate, understand, and adapt to ever-evolving threat sources

Possible attackers (with increasing capability)

- Journalists
- Hackers
- Individual criminals
- Organized crime
- Internal staff
- Terrorists
- Police
- Military organizations
- Industrial spies
- National security organizations

Attacks are becoming easier



Everyone can be a "script kiddie" (or hire one)

MP0

Add malware-as-a-service 2010
Add malAI 2020
Miguel Pardal; 2023-10-24T09:12:57.652

Threats / attack effects

- Unauthorized access to data (Disclosure)
  - Extracting data from repositories
  - Inference by aggregation or concentration of information
  - Covert channels
  - Viruses, Trojans, worms, logic bombs
    (also Hijacking, Disruption)
  - Concentration of responsibilities

Threats / attack effects

- Infrastructure
  - Equipment failures
  - Buggy software or operating systems
  - Network failures
- Performance
  - Reduced productivity
  - Delay in delivery of invoices
- Defective applications
  - *Bugs* causing procedural errors, etc.

Threats / attack effects

- Theft
  - Physical destruction (vandalism)
  - Theft of equipment or information
- Environmental
  - Failures of services
  - Natural disasters

Threats / attack effects

- Personnel
  - Unauthorized or uncontrolled internal access (impersonation)
  - Incorrect data entry (Deception)
  - Unhappy workers (Current or former)
- Warfare (Disruption)
  - Cyberattacks
  - Economical or military espionage
  - Computer terrorism

Top Threats

- Malware
  - Virus, worms, spyware, **ransomware**, crypto jacking, …
- Social networks and WWW
  - Accessing the site e.g. similar but fake bank website
  - Obtaining private information through social networks
- Internal
  - Intentional and accidental
- Sophisticated distributed denial of service (DDoS)
  - Faster networks; asymmetry of the threat
- DNS attacks
  - Cache poisoning; domain theft; etc.
- Attacks on routers
  - For use in other attacks (e.g., disclosure, disruption)
  - Exploring the trust relationship between routers (BGP)

Our challenge

- How to ensure security properties for a system?

- Answer: **security mechanisms**
  a.k.a. security controls

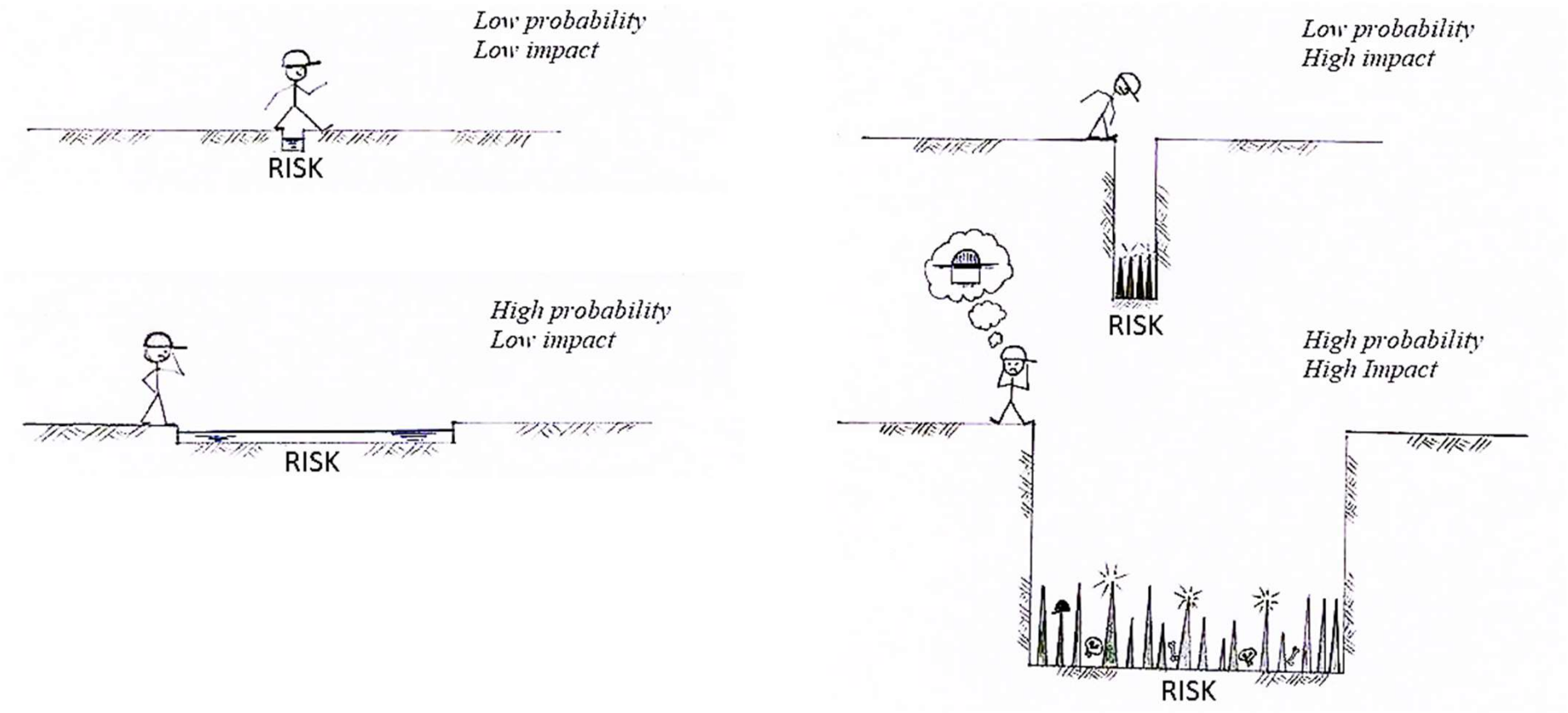
Defense / Protection

- Set of policies and security mechanisms aimed at
  - Reducing the vulnerability of a system
  - Detecting attacks as quickly as possible
    - Past or current
  - Reducing the risk level of a system

Risk

Risk = (level of) Threat x
(level of) Vulnerability x
Impact

} Probability



Security Policy

- A security policy ensures protection of the asset against expected attacks, within constraints
- When is a security policy necessary?
  - When there is an **asset** in a shared space

Defining a Security Policy

- What do we want to protect?
- What are the potential threats?
- Who can execute them?
  - Who are the attackers/adversaries?
- How are threats materialized?
- What are the attacks?
- Which procedures and protection mechanisms can prevent these attacks?
- What is the cost of the security policy?
  - Ultimately: the cost of security must be lower than the asset's value

Security Mechanisms

- Specific tools, techniques, or methods implemented to detect, prevent, and respond to security threats

Security policies are **enforced** (i.e., made effective) by an appropriate use of security mechanisms

Security Policy and Mechanism simple example

- Policy:
  - Only I can enter this room

- Mechanism:
  - Put a lock on the door and only I have the key

Security Policy and Mechanism technical example

- Policy:
  - A company policy stating that all sensitive data must be encrypted when stored or transmitted
- Mechanism:
  - Implement SSL/TLS encryption for data transmission

Security mechanisms

- What are they?
- How do they work?
- What are they used for?

Services mechanisms: What are they?

- Confidentiality mechanisms
  - Access control
  - Encryption
  - Steganography
  - Confinement
  - etc.
- Integrity mechanisms
  - Cryptography
  - Authentication
  - Repudiation
  - Identification
  - etc.
- Availability mechanisms
  - Fault tolerant replication
  - Crypto puzzles
  - etc.

Security mechanisms: How do they work?

- Prevention
  - Prevent the attack from succeeding
  - Very intrusive
  - Easy management
- Detection
  - Important for unpredictable attacks
  - Complex management
  - Not much intrusive
- Recovery
  - Restitution of the state before the attack
  - Tolerance to attacks

Security mechanisms: What are they used for?

- Defend ourselves against threats
- Against which threats?

Summary

- Sharing vs Isolation
- Main security properties
  - CIA
- Definitions
  - Vulnerabilities, Attacks, Threats
- Defense / protection
  - Security policy and mechanisms
  - Driven by risk assessment

Cybersecurity: Think Maliciously

- "Traditional" Computer Engineering
  - Focus: building for specific functionalities
  - Design, construct, and optimize
- Cybersecurity:
  - Focus: Understand vulnerabilities, potential breaches
  - Unbuild, reverse engineer to uncover flaws
  - Alter original intent to exploit
  - Build defenses against attacks