Introduction

INFORMATICS AND ORGANIZATIONAL SECURITY

Security

Subject focused on the predictability of systems, processes, environments…

Across all aspects of the life cycle:

- Planning
- Development
- Execution
- Processes
- People
- Clients and Supply Chain
- Mechanisms
- Standards and Laws
- Intellectual Property

Security: Planning

Design of a solution complying with some requirements under a normative context

Without flaws

- All operation states are the ones predicted
- There are no additional states escaping the expected logic
  - Even if forced transitions are used

Under the scope of a normative context

- Specific for each activity or sector
- Ex: ISO 27001, ISO 27007, ISO 37001

Security: Development

Implement a solution complying with the design, without other operation modes

Without bugs compromising the correct execution

- No crashes
- Without invalid or unexpected results
- With the correct execution times
- With adequate resource consumption
- Without information leaks

Software:

- Requires careful implementation
- Requires tests to obtain an implementation with the expected… and only the expected behavior

Security: Execution

Code executes as it was written, with all predicted processes

Environment is controlled, cannot be manipulated or observed

Without the existence of anomalous behavior, introduced by environmental aspects

- Such as: storage speed, RAM amount, trusted communications

Source: https://www.verificient.com/

ISO 27001 – Clean Desk Policy

Security: people and partners

Staff behavior cannot have a negative impact to the solution

Norms are in place to regulate what actions are expected

Staff is trained to distinguish correct from incorrect behavior

Staff has the correct incentives to behave adequately

When staff is compromised, or deviate, actions have limited impact

Security: Analysis and Auditing

What is the actual behavior of the solution?

Identify deviations from the expected atributes

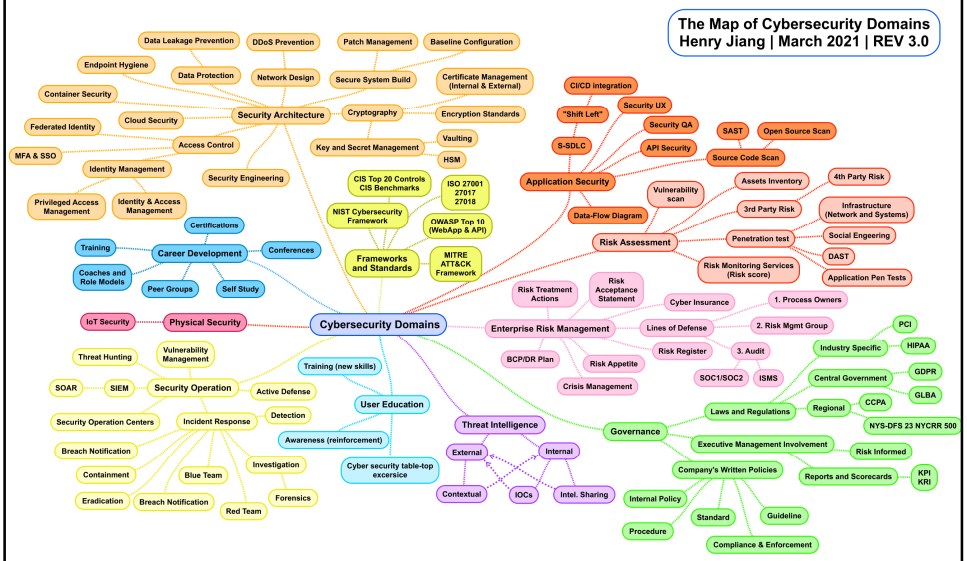
- Faults, errors, behavior

Identify the risk for the solution to be modified

- Exposition to possible attackers
- Incentives one may have to modify it
- Identify potential actors (threats)

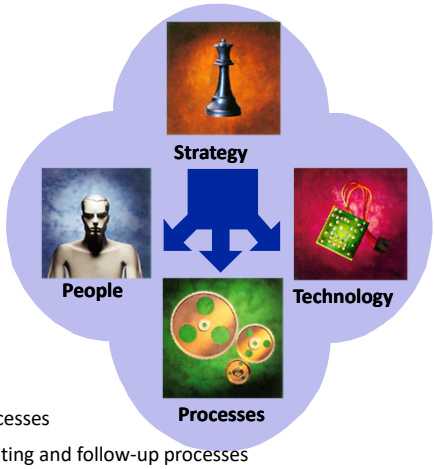
Identify the impact of the deviations

- Total loss of data? Denial of Service? Increase Operation Cost?



Dimensions to consider

- Selection
- Training
- Awareness
- Organization of security



- Vulnerability scanning
- Firewalls
- Authentication
- Access Control
- Cryptography
- Digital Signatures
- Certification authorities
- Certification hierarchies
- etc...

- Security policies
- Security administration processes
- Continued evolution of auditing and follow-up processes

Perspectives

Security has multiple intertwined perspectives

Defensive: focus on maintaining predictability

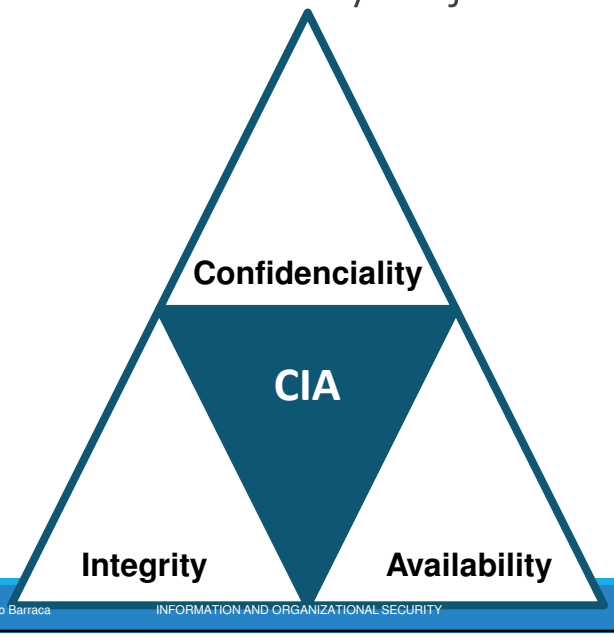
Offensive: focus on exploiting predictability

- May have malicious/criminal intent
- May have the purpose of validating the solution (Red Teams)

Other:

- Reverse Engineering: Recovery of design from built products
- Forensics: extract information and reconstruct previous events
- Disaster Recovery: minimize the impact of attacks
- Auditing: validate the solution complies with some set of requirements

Information Security Objectives



Information Security Objectives

<u>Confidentiality</u>: Information may only be accessed by a restricted group of entities

Measures:

- Encrypt information
- Use access passwords (strong)
- Use Identity Management and Authentication systems
- Doors, Strong walls
- Security personel
- Training

Information Security

Integrity: Information remains unchanged

- Can be applied to behavior of devices and services

Measures:

- Identity control (hashes)
- Backups
- Access Controls
- Robust Storage Devices
- Data verification processes

Information Security

Availability: Information is available to target entities

- Can be applied to services and devices

Measures:

- Backups
- Disaster recovery plans
- Redundancy
- Virtualization
- Monitoring

Information Security - Others

Privacy: how personal information is handled

- Acquired
- Processed
- Stored
- Shared
- Deleted

Measures:

- Access control
- Transparent processes
- Ciphers
- Integrity and authenticity controls
- Logs

Security objectives (1/3)

Defense against catastrophic events

- Natural phenomena
- Abnormal temperature, lightning, thunder, flooding, radiation, …

Degradation of computer hardware

- Failure of power supplies
- Bad sectors in disks
- Bit errors in RAM cells or SSD, etc.

Security objectives (2/3)

Defense against ordinary faults / failures

- Power outages
- Systems' internal failures
  - Linux Kernel panic, Windows blue screen, OS X panic
  - Deadlocks
  - Abnormal resource usage
- Software faults / Communication faults...

Security objectives (3/3)

Defense against non-authorized activities (adversaries)

- Initiated by someone “from outside” or “from inside”

Types of non-authorized activities:

- Information access
- Information alteration
- Resource usage
  - CPU, memory, print, network, etc.
- Denial of Service
- Vandalism
  - Interference with the normal system behavior without any benefit for the attacker

Core Concepts

1. **Domains**
2. **Policies**
3. **Mechanisms**
4. **Controls**

Security Domains

A set of entities sharing similar security attributes

Allow managing security in an aggregated manner

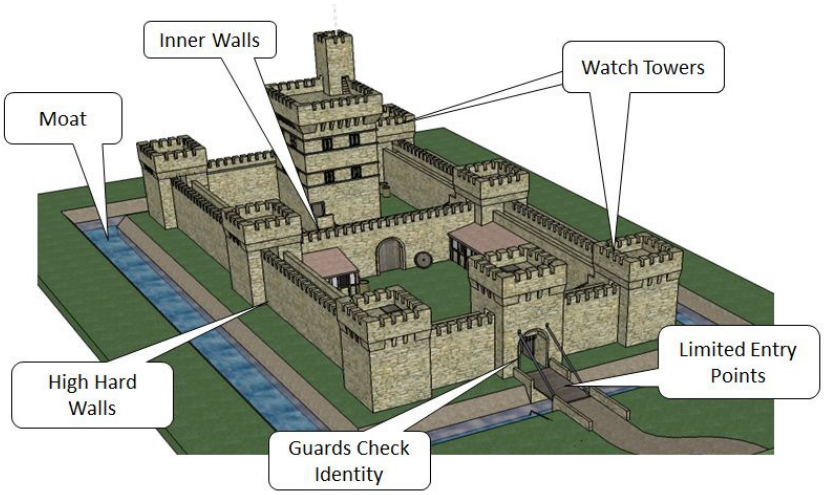
- Management will set the attributes of the domain
- Entities are added do the domain and will get the "group" attributes

Behavior and interactions are homogenous inside the domain

Domains can be organized in a flat of hierarchical manner

Interactions between domains are usually controlled

Security Domains



Security Policies

Set of guidelines related to security, that rule over a domain

Organization will contain multiple policies
- Applicable to each specific domain
- They may overlap and have different scopes/abstraction levels

The multiple policies must be coherent

Examples
- Users can only access web services
- Subjects must be authenticated in order to enter the domain
- Walls must be made of concrete
- Communications must be encrypted

Security Policies

Define the power of each subject

- Least privilege principle: each subject should only have the privileges required for the fulfillment of his duties

Define security procedures

- Who does what in which circumstances

Define the minimum security requirements of a domain

- Security levels, Security Groups
- Required authorization
  - And the related minimum authentication requirements (Strong/weak, single/multifactor, remote/face-to-face)

Security Policies

Define defense strategies and fight back tactics

- Defensive architecture
- Monitoring of critical activities or attack signs
- Reaction against attacks or other abnormal scenarios

Define what are legal and illegal activities

- Forbid list model: Some activities are denied, the rest are allowed
- Permit list model: Some activities are allowed, the rest is forbidden

Security mechanisms

Mechanisms implement policies

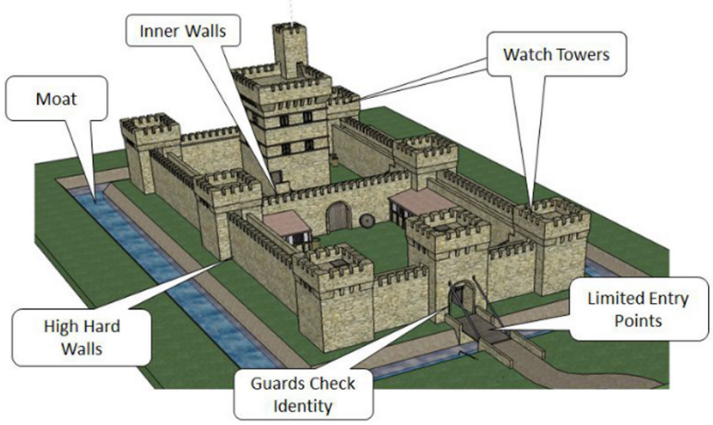
- Policies define, at a higher level, what needs to be done or exist
- Mechanisms are used to deploy policies

Generic security mechanisms

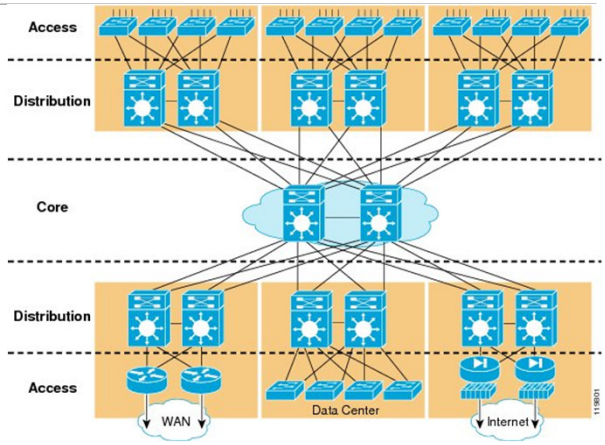
- Confinement (sandboxing)
- Authentication
- Access control
- Privileged Execution
- Filtering
- Logging
- Auditing
- Cryptographic algorithms
- Cryptographic protocols

Security mechanisms

Policy: Movement between domains is restricted
Mechanisms: Doors, guards, passwords, objects/documents



Policy: systems must be resilient
Mechanisms: equipments and links are doubled, arquitecture



Source: CISCO

Security Controls

Controls are any aspect allowing to minimize risk (protect the CIA properties)

Controls include policies & mechanisms, but also:

- Standards and Laws
- Processes
- Techniques

Controls are explicitly stated and can be auditable

- E.g.: ISO 27001 defines 114 controls in 14 groups
  - … asset management, physical security, incidente management…

Types of Security Controls

	Prevention	Detection	Correction
Physical	- Fences - Gates - Locks	- CCTV	- Repair Locks - Repair Windows - Redeploy access cards
Technical	- Firewall - Authentication - Antivirus	- Intrusion Detection Systems - Alarms - Honeypots	- Vulnerability patching - Reboot Systems - Redeploy VMs - Remove Virus
Administrative	- Contractual clauses - Separation of Duties - Information Classification	- Review Access Matrixes - Audits	- Implement a business continuity plan - Implement an incident response plan

Types of Security Controls

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Green: in relation to an event

Red: in relation to its nature

Practical Security

Realistic Prevention

Consider that perfect security is impossible!

Focus on the most probable events
- May depend on physical location, legal framework, …

Consider cost and profit
- A great number of controls has a low cost
- However, there is no upper limit on the cost of a security strategy

Consider all domains and entities
- A single breach can be escalated to a more serious situation

Practical Security

Realistic Prevention

Consider Impact
- Under the light of CIA and other potential impact areas (e.g., brand)

Consider the cost and recover time
- Monetary cost, reputation, market access

Characterize attackers
- Define controls specific for those attackers
- There will always exist more resourceful attackers

Consider that the system will be compromised
- Have recovery plans

Security in computing systems: Complex problems

Computers can do much damage in short time frames

- Computers manage huge amounts of information
- Process and communicate with very high speed

The number of weaknesses is always growing

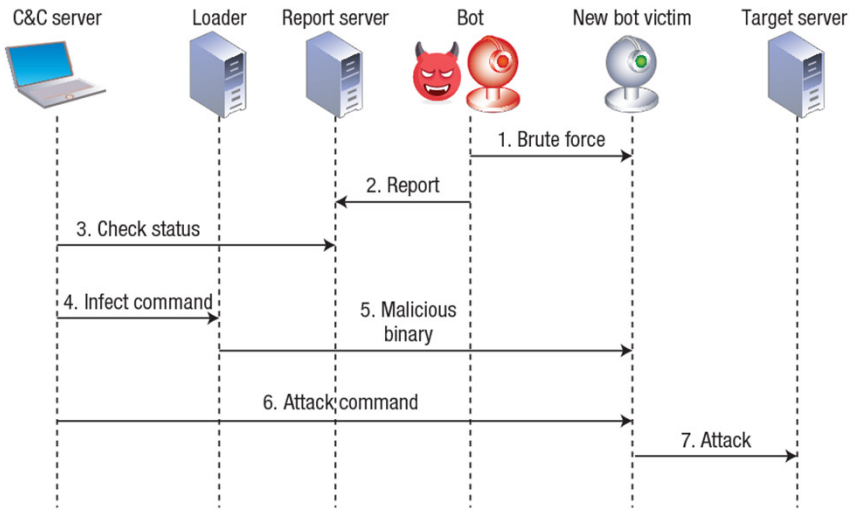
- Due to the increased complexity
- Due to every reducing time-to-market, or cost

Security in computing systems: Complex problems

Networks allow novel attack mechanisms

- "Anonymous" attacks from any place in the planet
- Fast spread across geographical boundaries
- Exploitation of insecure hosts and applications

- **Attackers can build complex attack chains**
  - First exploration
  - Lateral movement
  - Exfiltration
  - Check: https://attack.mitre.org/matrices/enterprise/



Mirai botnet operation and communication.
Mirai causes a distributed denial of service (DDoS) to a set of target servers by constantly propagating to weakly configured Internet of Things (IoT) devices.

source: Kolias, Constantinos et al. "DDoS in the IoT: Mirai and Other Botnets." Computer 50 (2017): 80-84.

Security in computing systems: Complex problems

Users are mostly unaware of the risks

- They do not know the problems,
- ... the impact
- ... the good practices
- ... nor the solutions

Users are mostly careless

- Because they take risks
- Do not care (do not have/identify any responsibility)
- Do not estimate the risk correctly

Main vulnerability sources

Hostile applications or bugs in applications

- Rootkits: Insert elements in the operating system
- Worms: Software programs controlled by an attacker
- Virus: Pieces of code that infect other files (e.g., macros)

Users

- Ignorant, careless or reckless
  - Use insecure alternatives instead of secure ones
  - Trust on security tools to solve all problems
  - Search and download illegal stuff
- Hostile

Main vulnerability sources

Defective administration

- Default configuration is seldom the most secure
- Security restriction vs flexible operation
- Exceptions to individuals

Communication over uncontrolled/unknown network links

- Public hotspots, campus networks, hostile governments

Perimeter Defense

(minimal defense, frequently not sufficient)

Perimeter Defense

Protection against external attackers
- Internet
- Foreign users
- Other organizations

Assumes that internal users are trusted and share the same policies
- Friends, family, collaborators

Used in domestic scenarios or small offices

Limitations
- Too simple
- Doesn't protect against internal attackers
  - Previously trusted users
  - Attackers that acquired internal access

Defense in Depth

Protection against internal and external attackers
- From the Internet
- Users
- Other organizations

Assumes well-defined domains across the organization
- Walls, doors, authentication, security personell, ciphers, secure networks

Limitations
- Needs coordination between the diferent controls
  - May end with overlapping controls, but also with holes in the security perimeters
- Cost
- Requires training, changes to processes and frequent audits

Zero Trust

Defense model without specific perimeters
- There is no inherent trust in entities just because they are internal
  - Actually, there may be no notion of internal and external

Model recommended for new systems
- Traditional systems should migrate to it
- Implies the design of systems/services specific for this model
- Legacy systems will need additional protection layers
  - Firewalls, filters, adapters, plugins

Zero Trust – Principles (NCSC)

1. **Know your architecture**
   - Users, devices, services and data
2. **Know your identities**
   - Users, devices, services and data
3. **Assess user behaviour, service and device health**
4. **Use policies to authorize requests**

Zero Trust – Principles (NCSC)

5. **Authenticate and Authorize everywhere**
   - No open APIs, or IP address-based access
6. **Focus your monitoring on users, devices and services**
7. **Don't trust any network, including your own**
   - Internal attackers should not have more rights than external attackers
8. **Choose services designed for Zero Trust**
   - Legacy services to be avoided, but can be integrated