Introduction to cybersecurity

SIO

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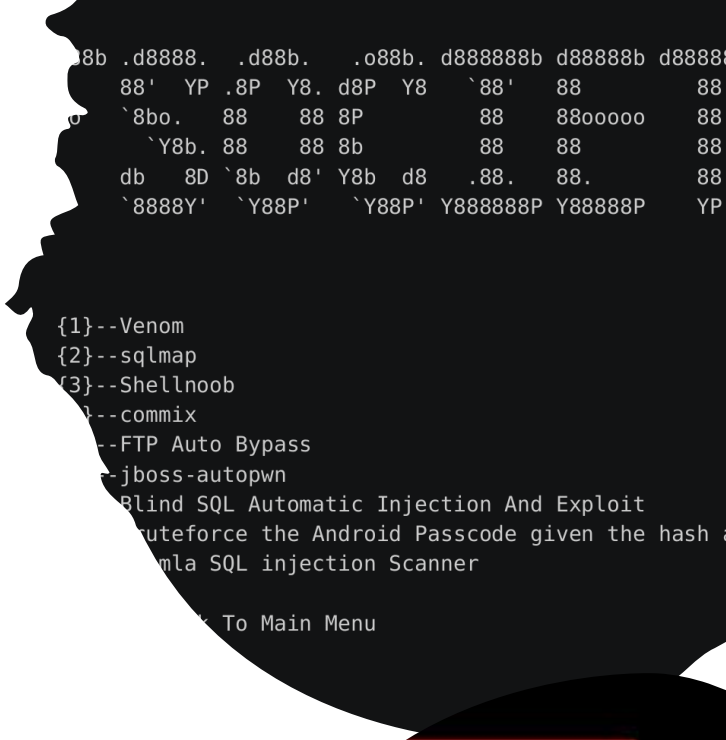
Is this Cybersecurity ?

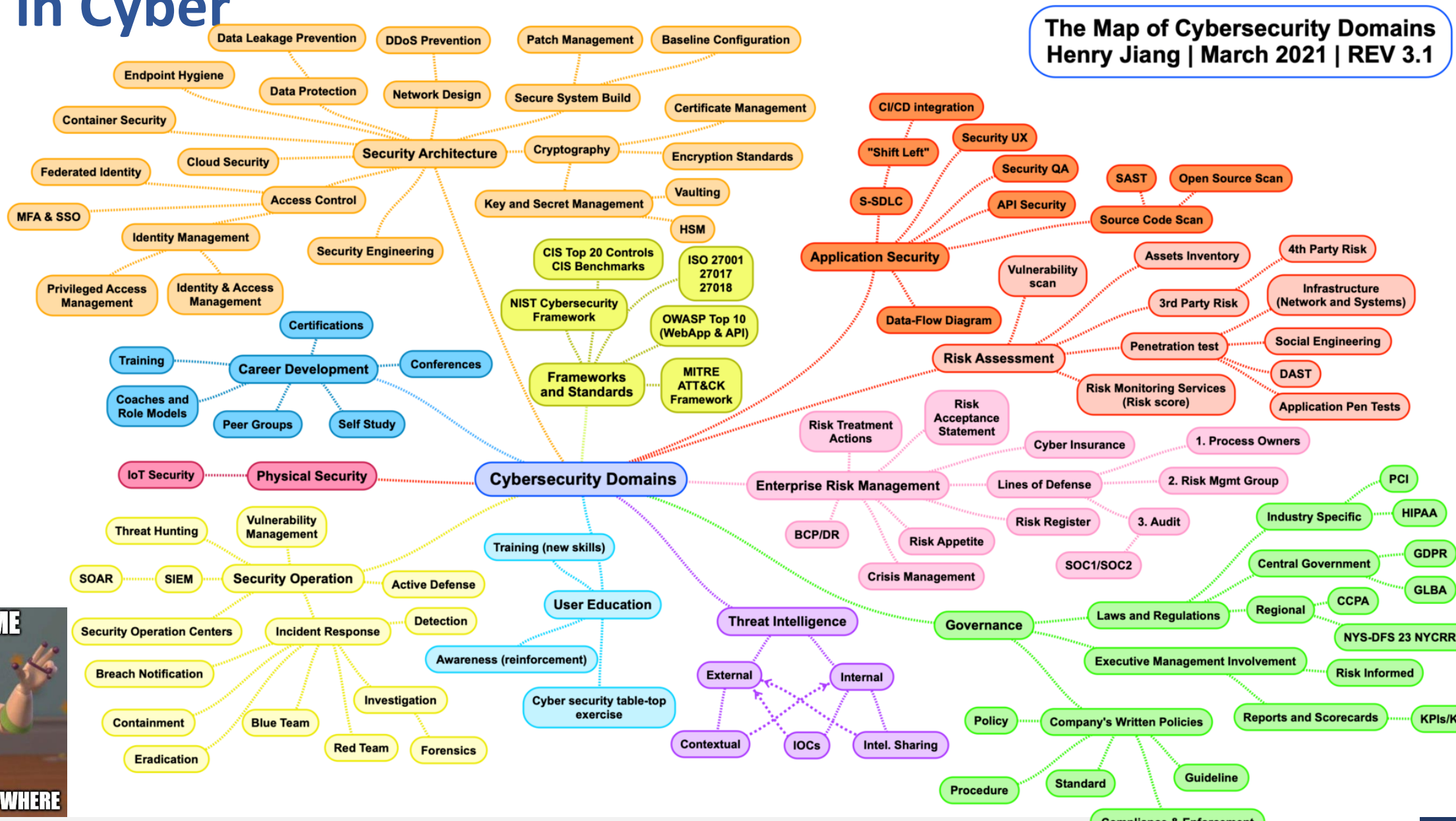


Cybersecurity

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

- Across all aspects of a (business, system, organization) life cycle:
  - Planning
  - Development
  - Execution and operations
  - Processes
  - Human resources and clients
  - Supply Chain
  - Mechanisms and Controls
  - Standards, Compliance and Laws, …

Areas in Cyber



Security Domains or Areas

Security is scoped into domains with many overlaps

- **Organizational Security**
- Physical Security
- **Information Security**
- System Security
- Operacional Security
- Secure Development

Security Domains

Organizational Security (ISO 27001)

- Measures to **protect data** (electronic and otherwise) collected, held, and processed,
- and to protect its **computer systems**, **devices**, **infrastructure**, **computing environment**, **information and data stored** and all **other relevant equipment**
- from damage and **threats** whether internal, external, **deliberate, or accidental**.

Security Domains

Information Security (ISO 27001)

- preservation of **confidentiality**, **integrity**, and **availability** (CIA) of information.

- **Confidentiality**: Ensuring that information is accessed only by authorized individuals.
- **Integrity**: Maintaining the accuracy and completeness of information.
- **Availability**: Ensuring that information is accessible when needed by authorized users.

Information Security Objectives

- **Confidentiality**: Ensuring that information is accessed only by authorized individuals.

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

Information Security Objectives

- **Integrity**: Maintaining the accuracy and completeness of information.

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Information Security Objectives

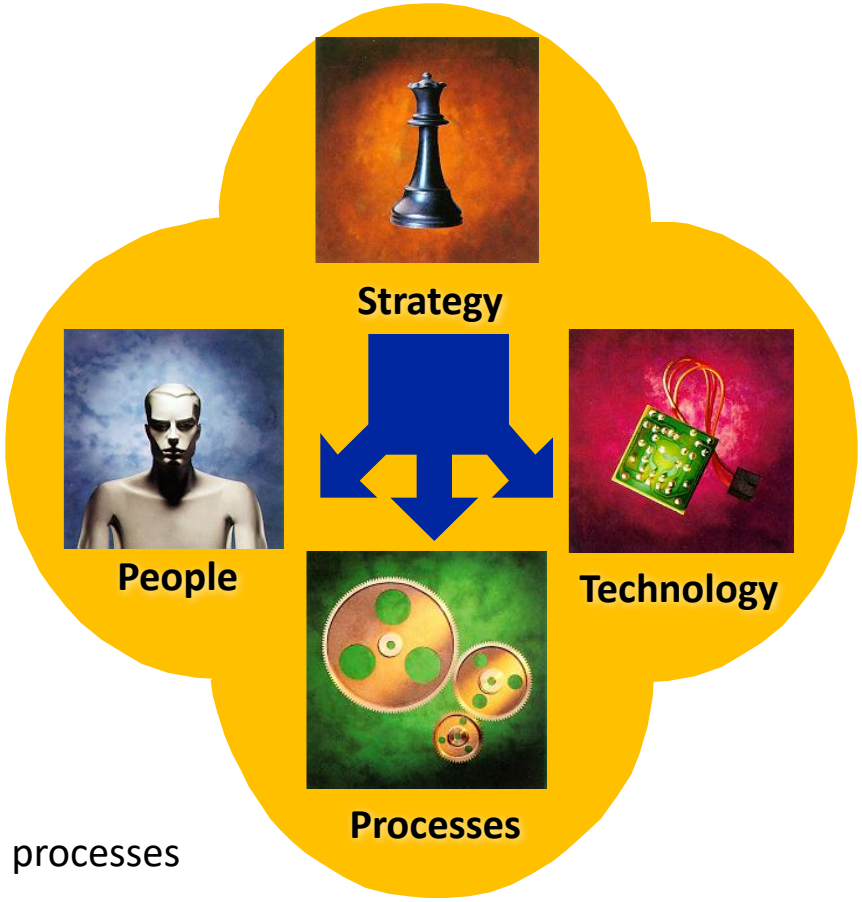
- **Availability**: Ensuring that information is accessible when needed by authorized users.

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

How can use security in an organization?

With a strategy following the organizational dimensions

- 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

Pitfalls

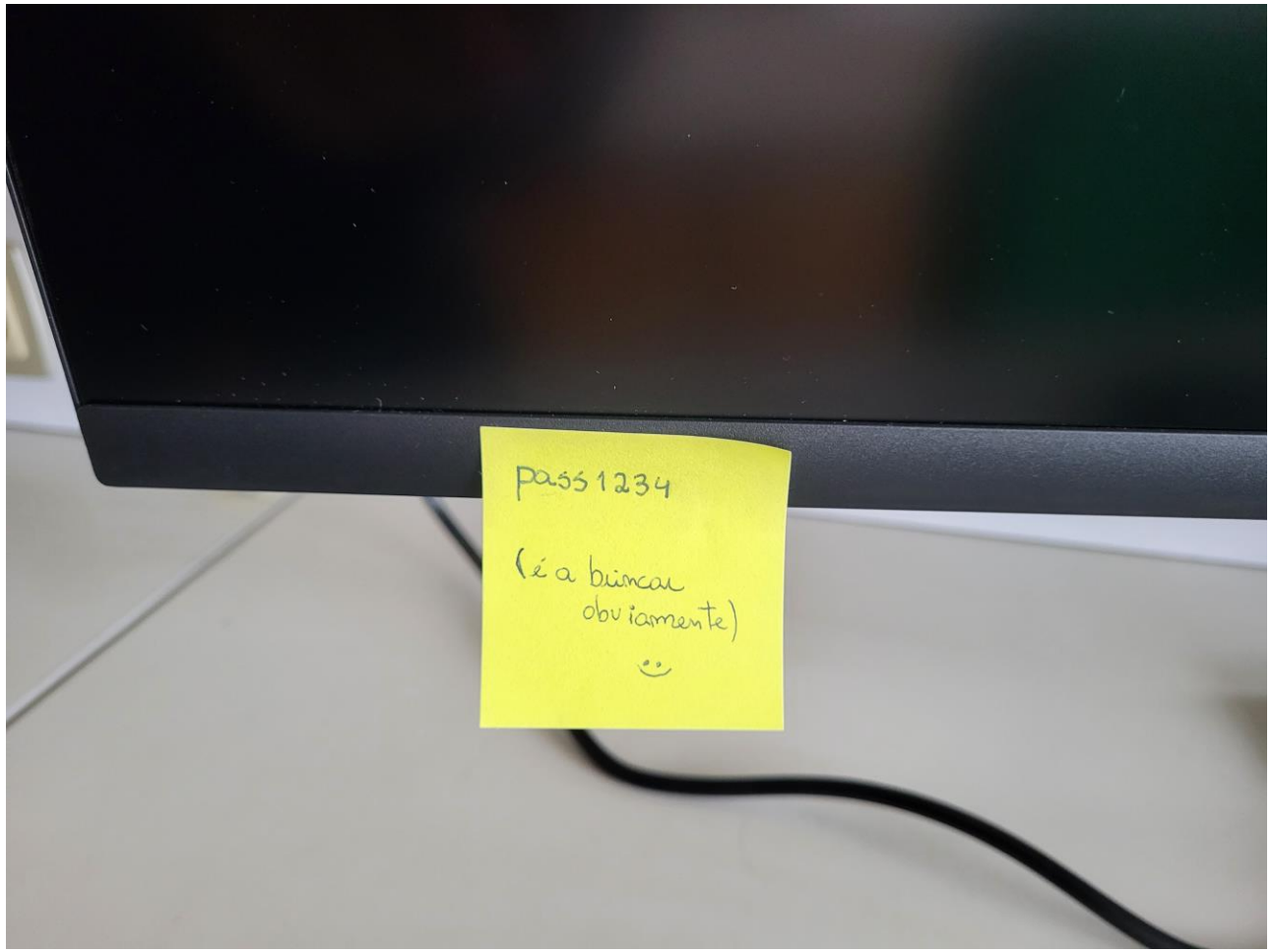
Pushing one dimensions without the other weakens the security posture

- What may have failed?
  - Technology?
  - Processes?
  - People?
  - Strategy?
- Walls, firewalls, processes… everything bypassed

Pitfalls

Pushing one dimensions without the other

- When it works and there is a security culture



Security objectives

1/3 – Intrinsic and unhavoidable aspects

- 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 – Unpredictable ordinary failures

- 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 – Threats

- Defense against non-authorized activities (adversaries)
  - Initiated by someone “from outside”, “from inside” or “through a supplier”

- Types of non-authorized activities:
  - Information access
  - Information alteration
  - Resource usage
    - CPU, memory, print, network, wallets, etc…
  - Denial of Service
  - Vandalism
  - Interference with the normal system behavior without any benefit for the attacker

Security Perspectives

Which type of approaches

- Defensive tasks: focus on maintaining predictability and building layers
  - Deployment of Firewalls, Backups, Alert systems
  - Creation of processes and compliance
- Offensive: focus on exploiting vulnerabilities in entities
  - 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

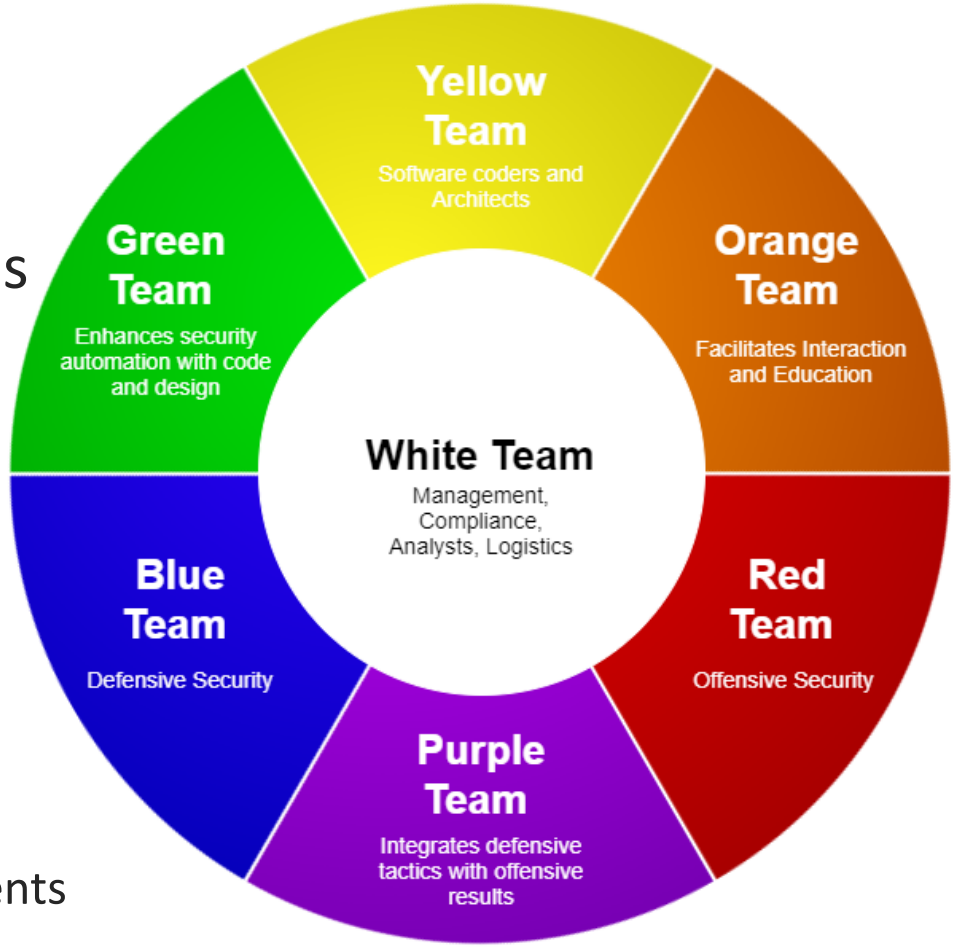


Image from: https://medium.com/@dancovic/the-infosec-color-wheel-7e52fd822ae4

Core Concepts

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

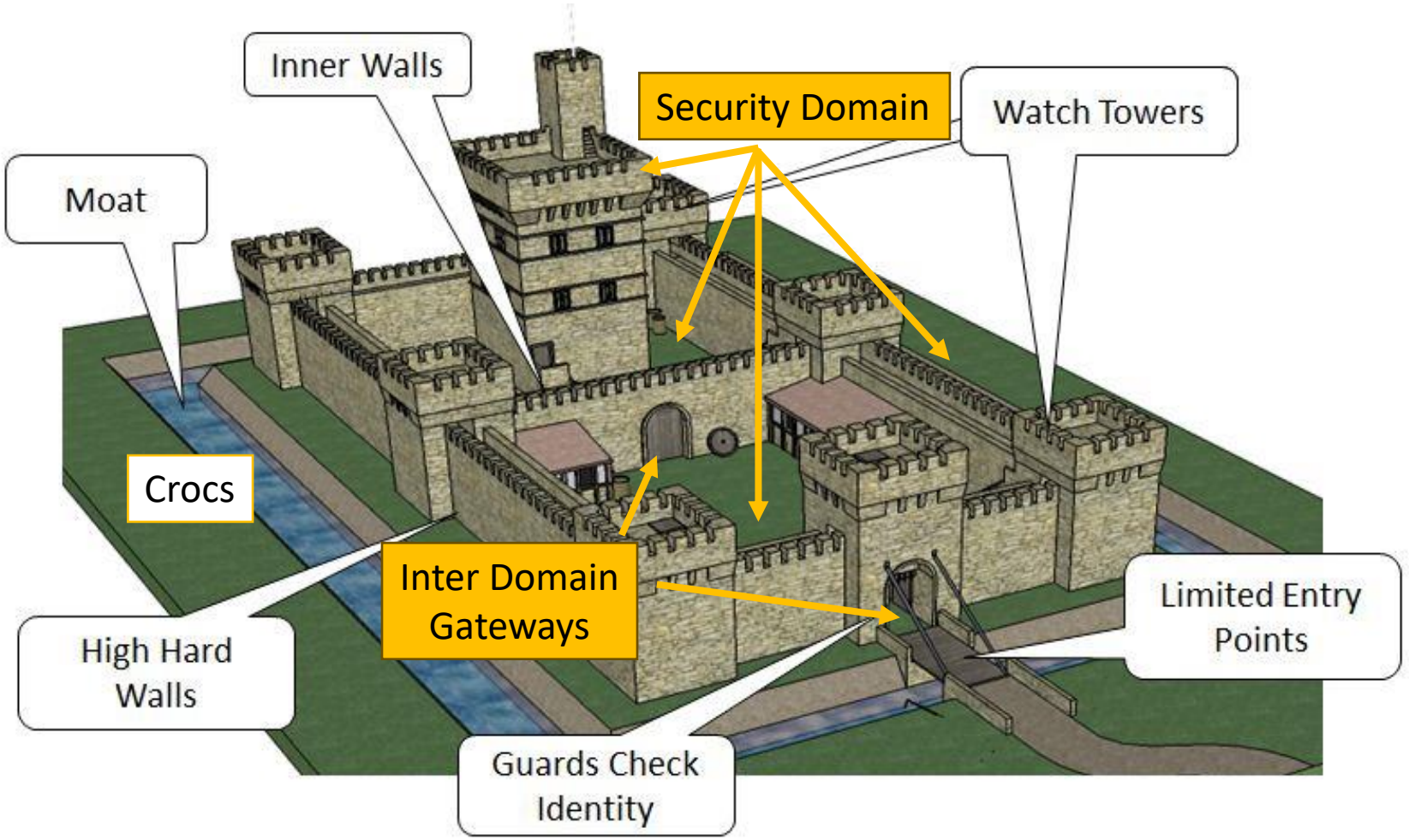
Security Domains

A system or subsystem that is under the authority of a single trusted authority. Security domains may be organized (eg, hierarchically) to form larger domains.

- 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 ruled by homogeneous rules inside the domain
- Domains can be organized in a flat of hierarchical manner
  - Flat: Domains do not overlap but have frontiers, and exist at the same abstraction level
  - Hierarchical: Domains have different levels of abstraction (Organization -> devices -> Servers -> ServerA)
- Interactions between domains are usually controlled
  - With gateways the limit, change or log interactions

Security Domains

Popular application of security domains circa year 1500



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

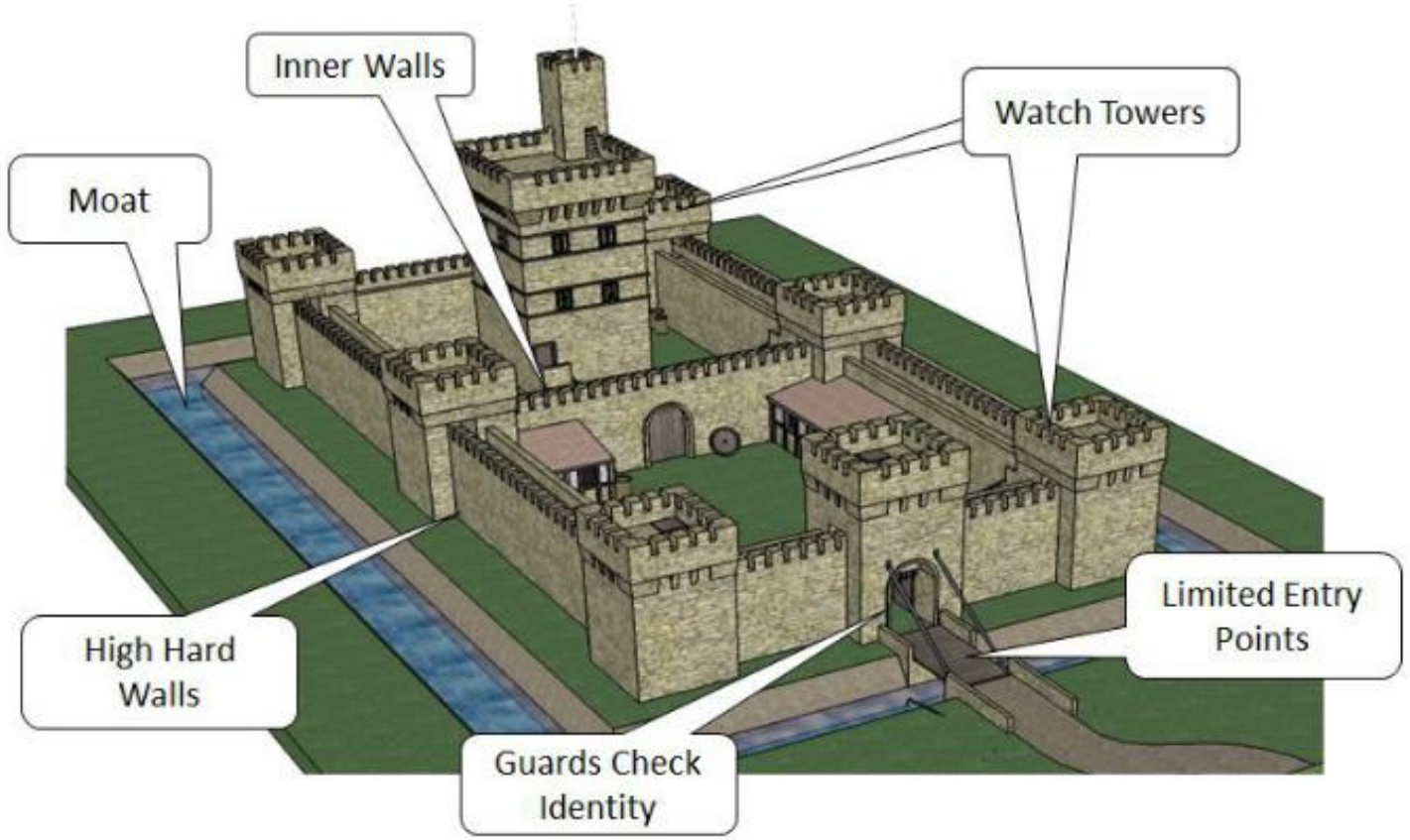
Security Mechanisms

- 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

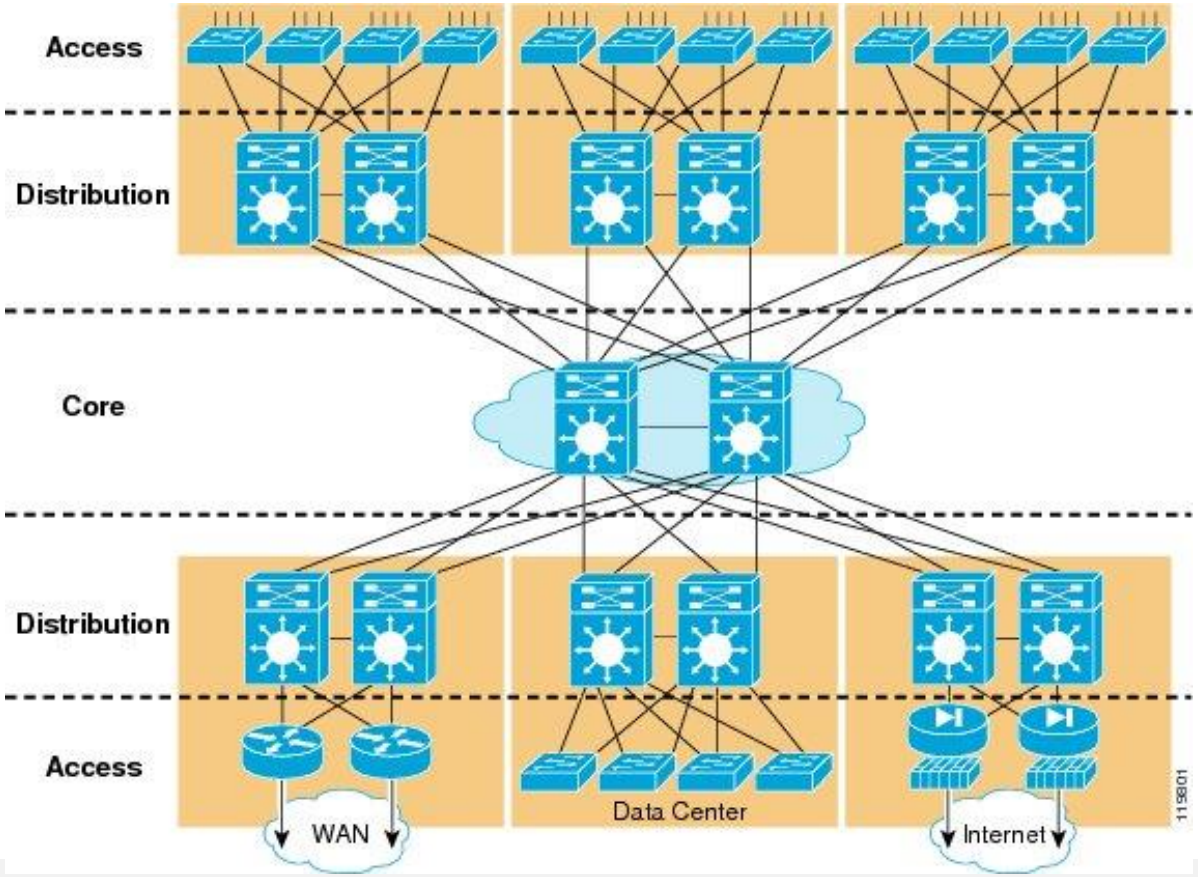
Security Mechanisms

- **Policy**: Movement between domains is restricted
- **Mechanisms**: Doors, guards, passwords, objects/documents, training, salary



Security Mechanisms

- **Policy:** systems must be resilient to arbitrary failures of one component
- **Mechanisms:** equipment and links are doubled, protocols are developed



Security Controls

A safeguard or countermeasure prescribed for an information system or an organization designed to protect the confidentiality, integrity, and availability

- 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, incident 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

Ex. CCTV is a Physical, Detection Control

Practical security

Key concept: Realistic Prevention

- Consider that **perfect security is impossible**!
- Focus on the **most probable events** for the **most relevant assets**
  - 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
  - Security mechanisms must cost less than the asset it protects
- Consider all domains and entities
  - A single breach can be escalated to a more serious situation

Practical security

Key concept: Realistic Prevention

- Consider the impact of an attack
  - Under the light of CIA and other potential impact areas (e.g., brand or legal)
- Consider the cost and recover time
  - Data, 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 assuming that everything else failed

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

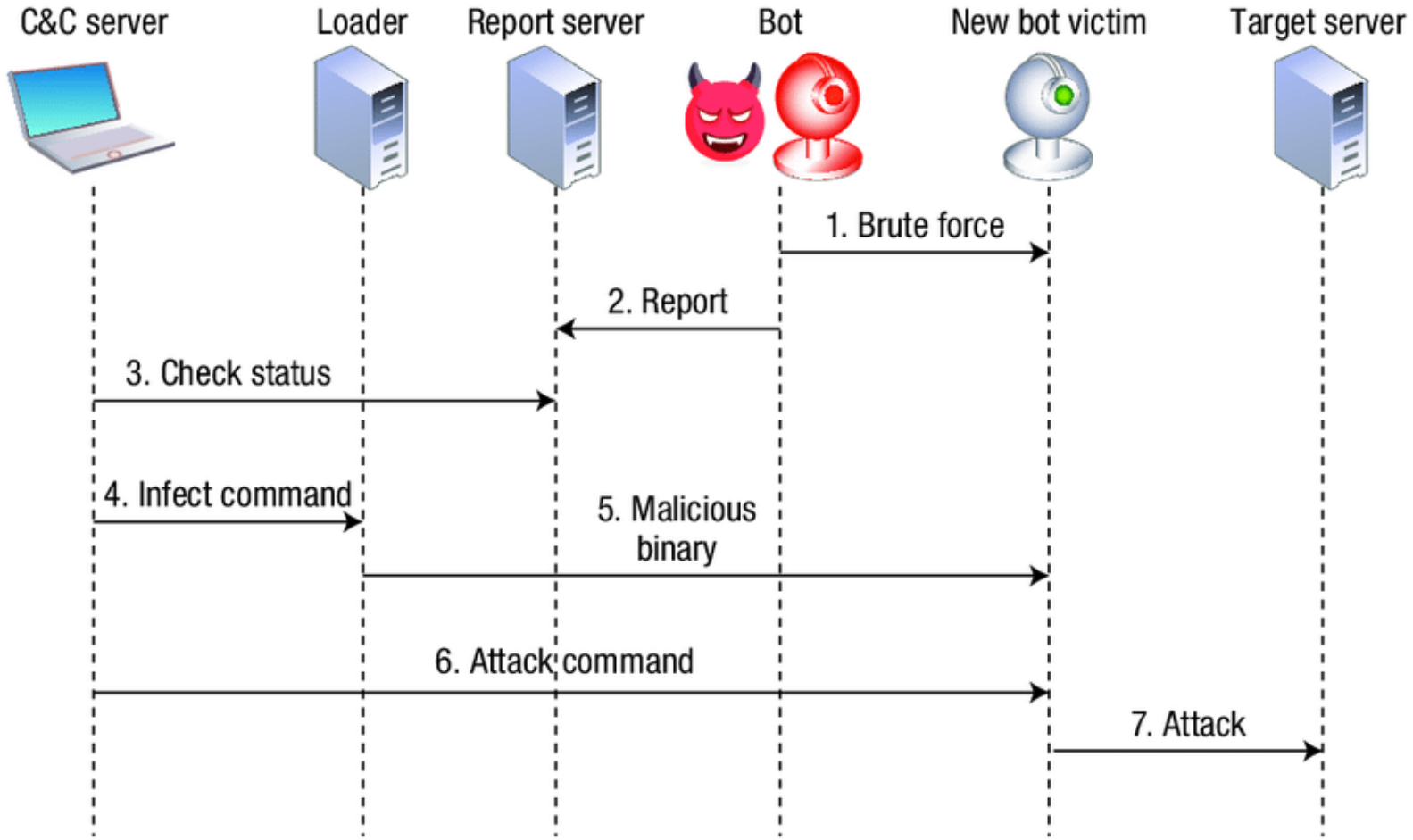
- The number of weaknesses **is always growing**
  - Due to the increased complexity
  - Due to every reducing time-to-market, or cost

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

Causes Distributed Denial of Service (DDoS) attacks to a set of services, by constantly propagating to weakly configured IoT Devices. Observe that victims are used to conduct further attacks to other victims

t

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

Main sources of issues

- 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 sources of issues

- 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 Model

Minimal defense, frequently not sufficient. The most common.

Inside / Internal Network

Outside / Internet

Firewall

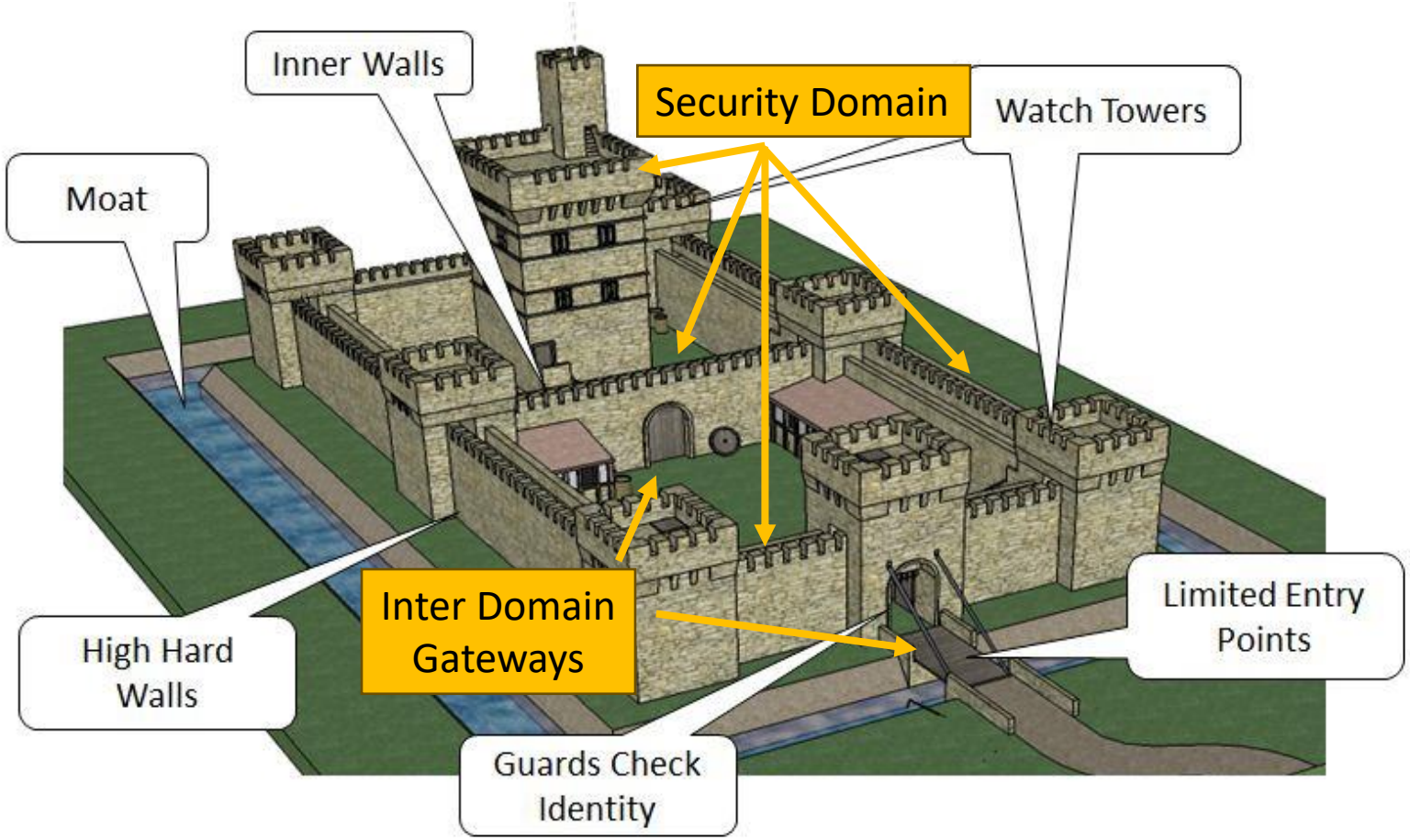
System that acts as the gateway between the a trusted (inside) and a untrusted domain (outside)

Perimeter Defense Model

- 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 Model

Layered approach with multiple domains (better)



Defense in Depth Model

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

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

- Limitations
  - Needs coordination between the different 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 Model

- 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
  - Requires detailed knowledge, controls and observability between all entities

- 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

In practice?

- Cibersecurity is limited by economics, operations and logisticts
  - All entities have limited resources
    - Even attackers!
  - Security is a business continuity activity, it cannot prevent business

- Cybersecurity deals with building and applying a strategy
  - under an operational and legal context
  - preventing issues that may never happen

- Try this: http://targetedattacks.trendmicro.com/cyoa/en/