Security in Computing

Chapter 1: Introduction

Objectives for Chapter 1

- Define *computer security* as well as basic computer security terms
- Introduce the C-I-A Triad
- Introduce basic access control terminology
- Explain basic threats, vulnerabilities, and attacks
- Show how controls map to threats

What is Computer Security?

- The protection of the assets of a computer system
  - Hardware
  - Software
  - Data
  - People

Assets

Hardware:

- Computer
- Devices (disk drives, memory, printer)
- Network gear

Software:

- Operating system
- Utilities (antivirus)
- Commercial applications (word processing, photo editing)
- Individual applications

Data:

- Documents
- Photos
- Music, videos
- Email
- Class projects

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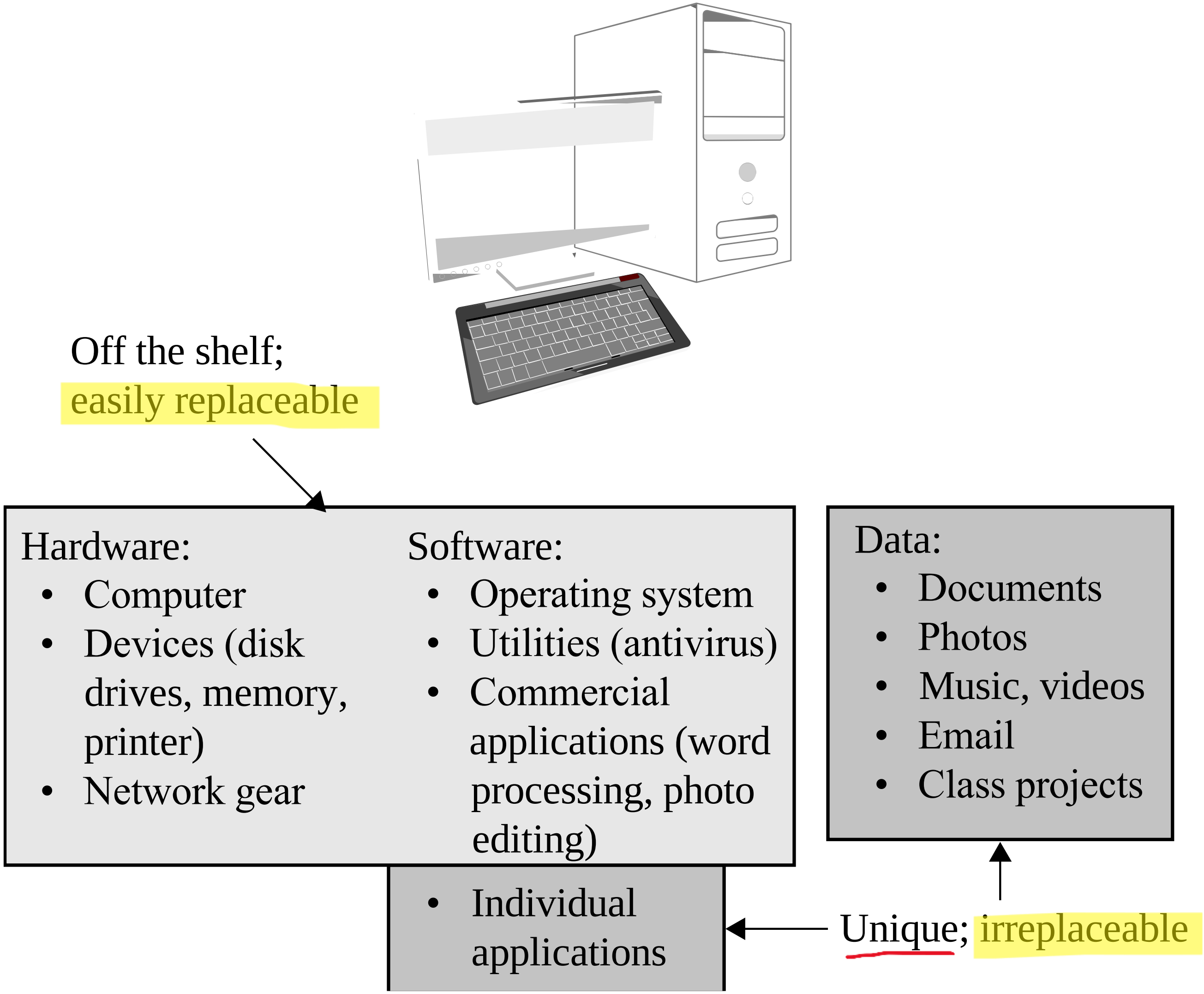
Values of Assets



Off the shelf; easily replaceable

Hardware:

- Computer
- Devices (disk drives, memory, printer)
- Network gear

Software:

- Operating system
- Utilities (antivirus)
- Commercial applications (word processing, photo editing)
- Individual applications

Data:

- Documents
- Photos
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Unique; irreplaceable

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People

People may include

- System admins and engineers
- Users (including managers)
- Customers and other indirect users

All these people are valuable to the system, and may be considered assets

They may also be used to attack the system

Basic Terms

- Vulnerability
- Threat
- Attack
- Countermeasure or control

Vulnerabilities, Threats, Attacks, Controls

- **Vulnerability** is a weakness in the security system
  - (i.e., in procedures, design, or implementation), that might be exploited to *cause loss or harm*.

- **Threat** to a computing system is a set of circumstances that has the *potential to cause loss or harm*.
  - a potential violation of security

- A human (*criminal*) who exploits a vulnerability perpetrates an **attack** on the system.

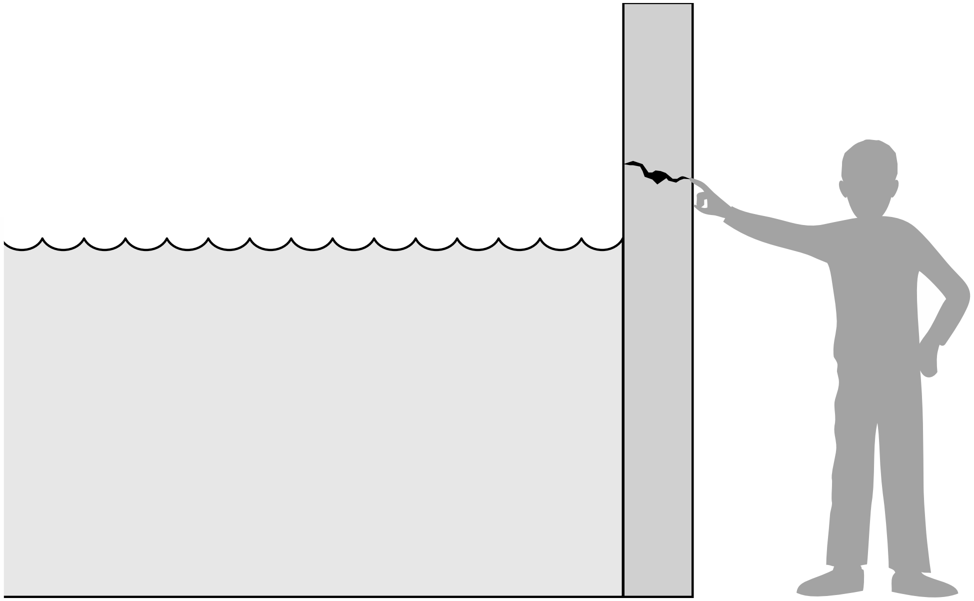
- How do we address these problems?
  - We use a **control** as a protective measure.
  - That is, a control is an action, device, procedure, or technique that *removes or reduces a vulnerability*.

Threat and Vulnerability

Relationship among threats, controls, and vulnerabilities:

- A threat is blocked by control of a vulnerability.
- To devise controls, we must *know as much about threats as possible*.

The fact that the violation might occur means that the actions that might cause it should be guarded against.



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C-I-A Triad

- **Confidentiality** – make sure that the unauthorized people can’t access
- **Integrity** – not letting unauthorized person to change the data
- **Availability** – If you have permission, and you want, data will be there, otherwise no
- Sometimes two other desirable characteristics:
  - **Authentication**
    - the process or action of proving or showing something to be true, genuine, or valid.
  - **Nonrepudiation**
    - is the assurance that someone cannot deny something.
    - i.e. **nonrepudiation** refers to the ability to ensure that a party to a contract or a communication cannot deny the authenticity of their signature on a document or the sending of a message that they originated

- Repudiation
  ex – Agree on something based on words and later saying that he didn’t agree and deny the argument

- Nonrepudiation
- Make a person agree in well organized manner such that they can’t refuse it later.

The National Institute of Standards and technology (NIST) Computer Security Handbook defines the term Computer Security as:

“The protection afforded to an automated information system in order to attain the applicable objectives of preserving the integrity, availability and confidentiality of information system resources” (includes hardware, software, firmware, information/data, and telecommunications).

Confidentiality

- **preserving authorized restrictions on information access and disclosure, including means for protecting personal privacy and proprietary information**

Integrity

- **guarding against improper information modification or destruction, including ensuring information nonrepudiation and authenticity**

Availability

- **ensuring timely and reliable access to and use of information**

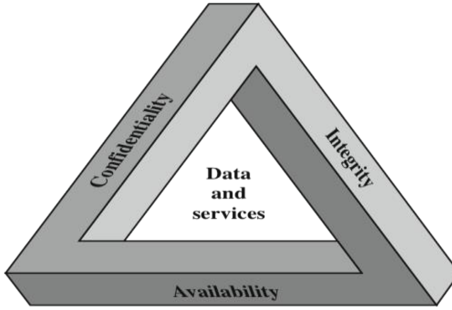
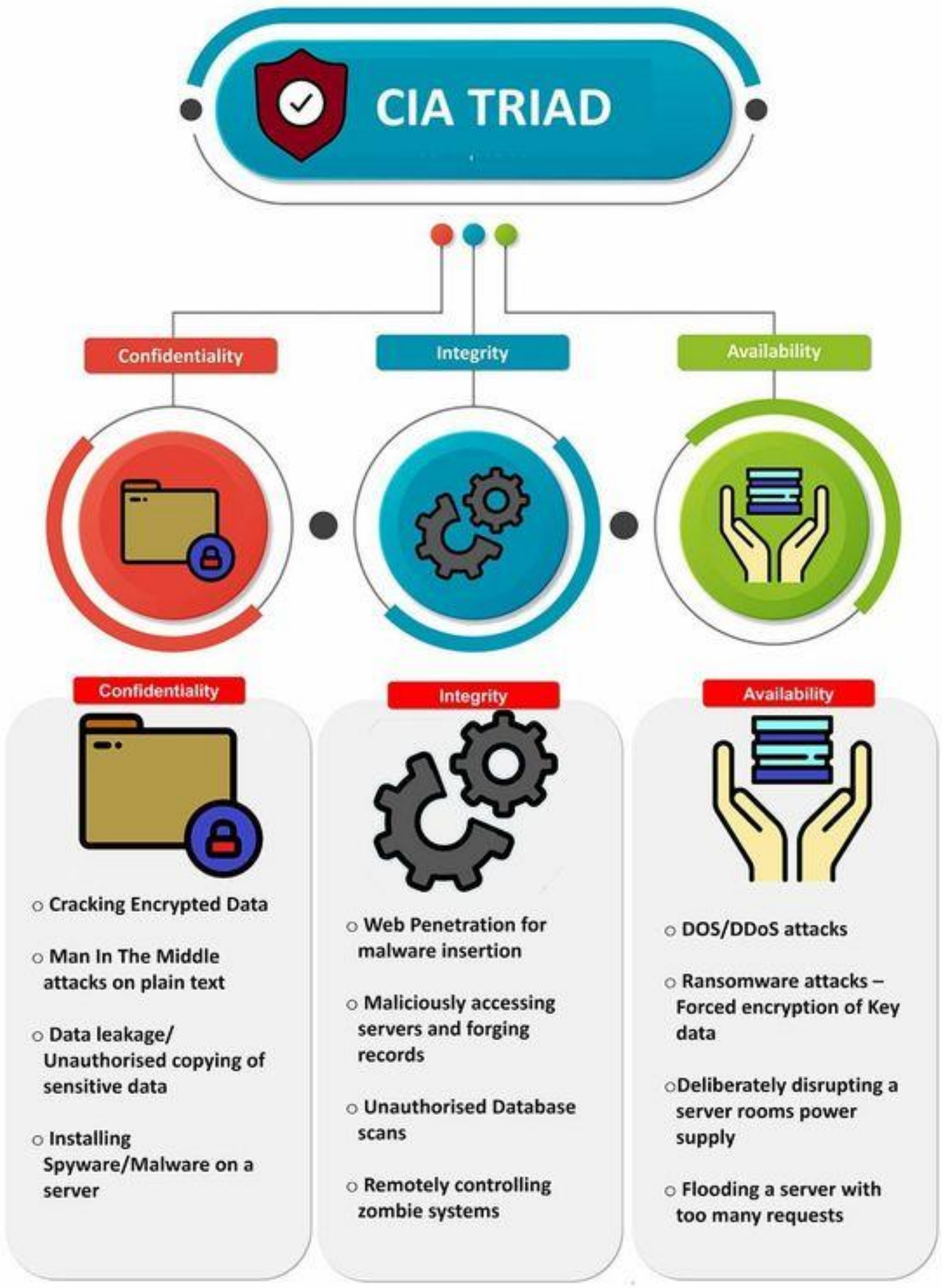


Figure 1.1 The Security Requirements Triad

The CIA Triad



Confidentiality

- ○ Cracking Encrypted Data
- ○ Man In The Middle attacks on plain text
- ○ Data leakage/ Unauthorised copying of sensitive data
- ○ Installing Spyware/Malware on a server

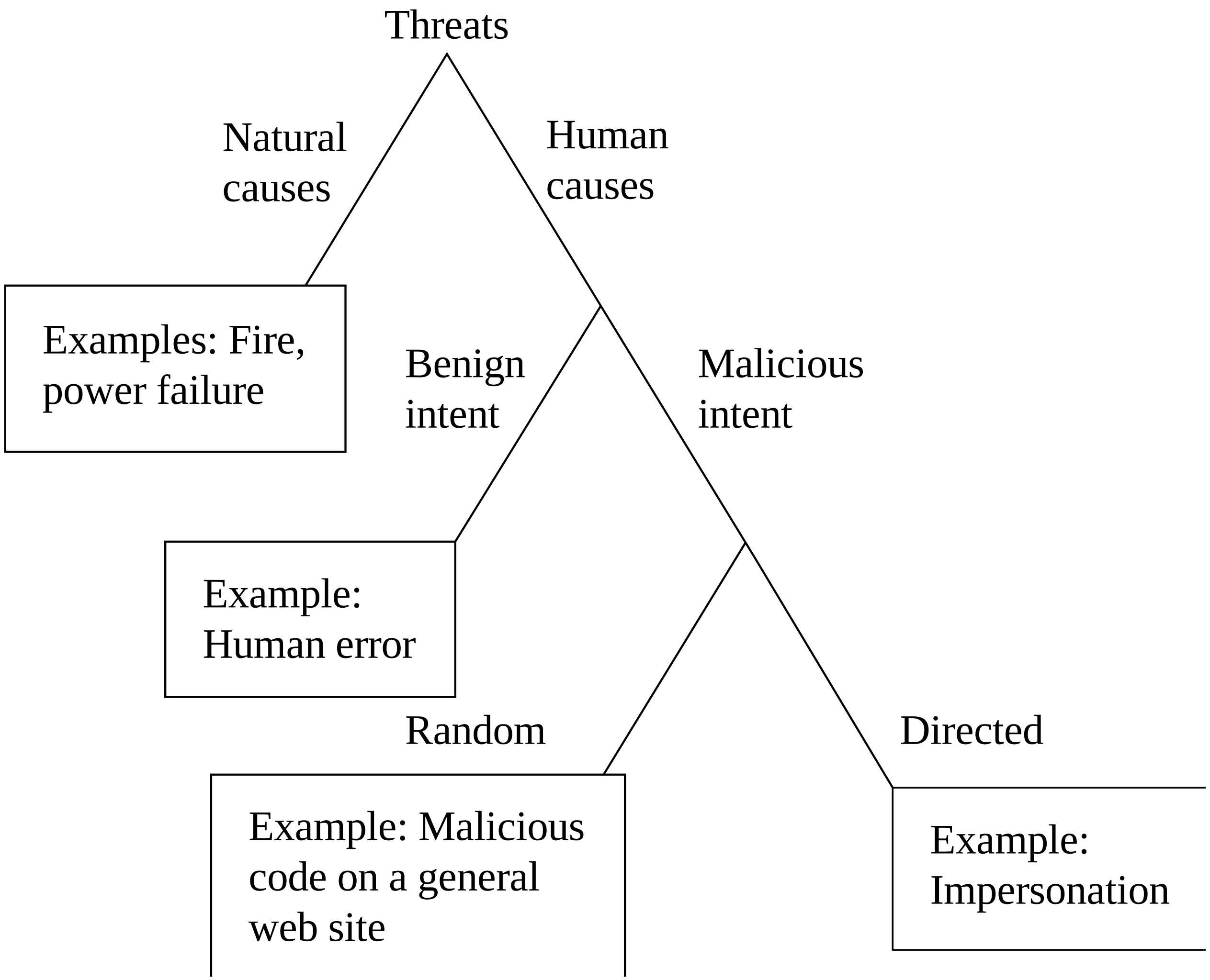
Integrity

- ○ Web Penetration for malware insertion
- ○ Maliciously accessing servers and forging records
- ○ Unauthorised Database scans
- ○ Remotely controlling zombie systems

Availability

- ○ DOS/DDoS attacks
- ○ Ransomware attacks – Forced encryption of Key data
- ○Deliberately disrupting a server rooms power supply
- ○ Flooding a server with too many requests

Types of Threats



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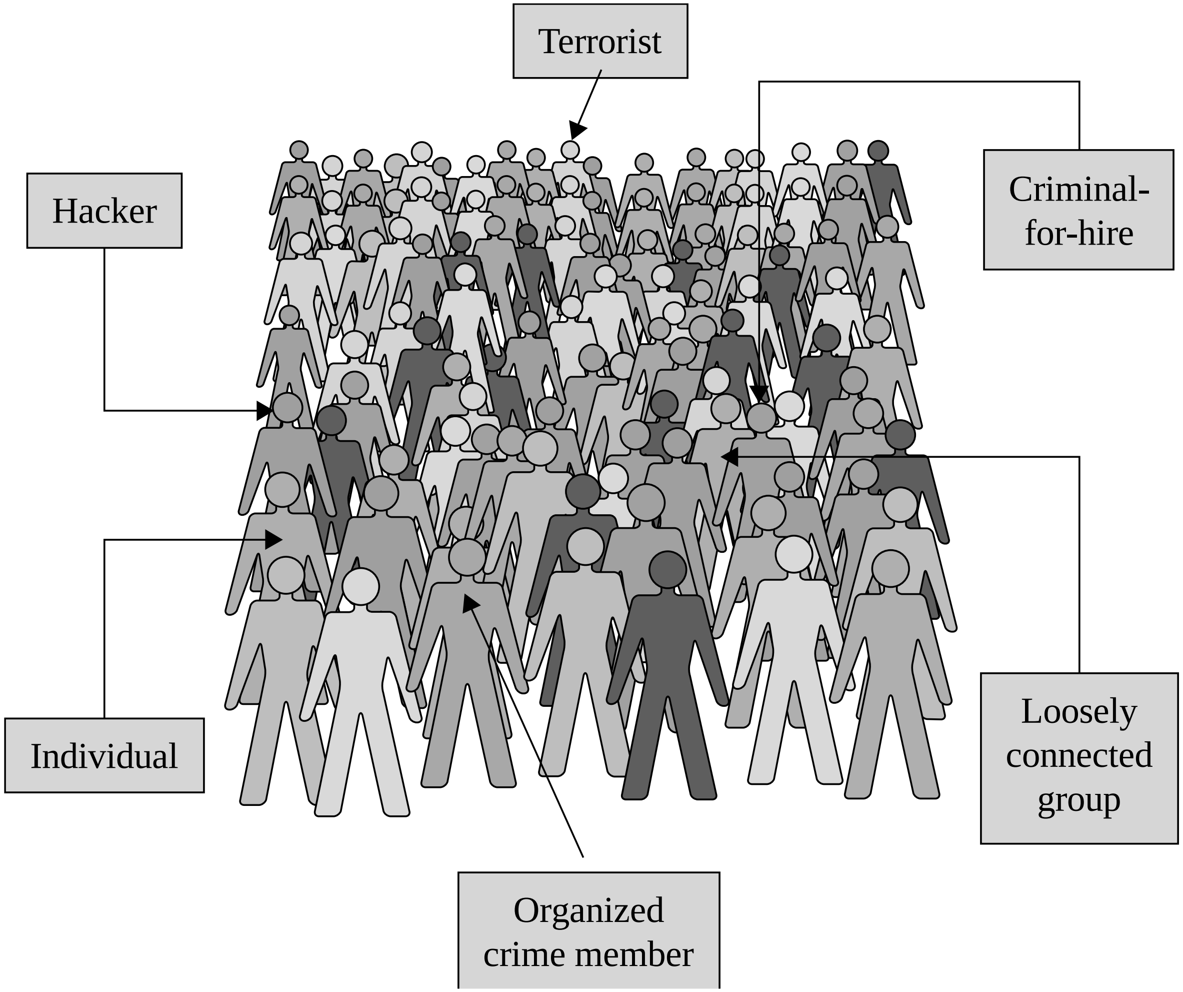
Advanced Persistent Threat (APT)

- Organized
- Directed
- Well financed
- Patient
- Silent

APT is a special type of threat that has only been taken seriously by the broad security community over the past decade. In general, security experts believe that no one who becomes a high-priority target can truly be safe from APT.

Types of Attackers



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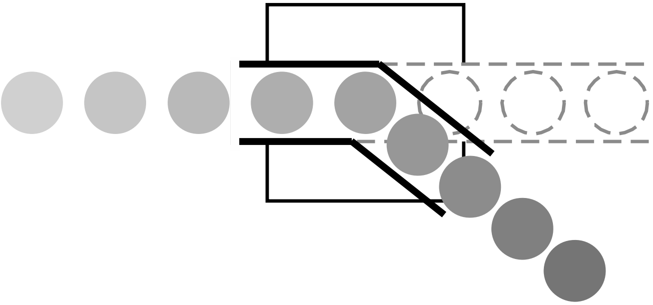
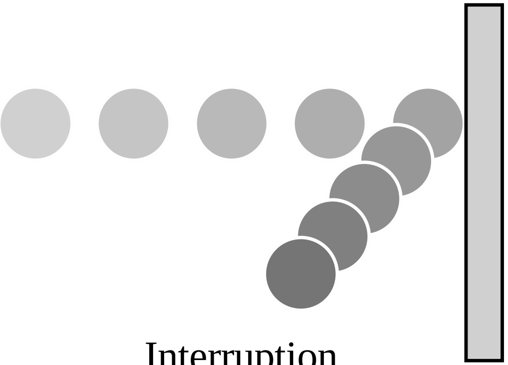
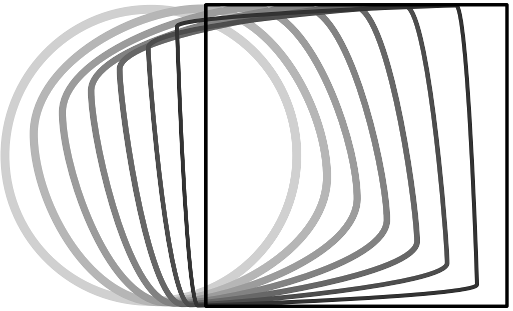
Types of Harm



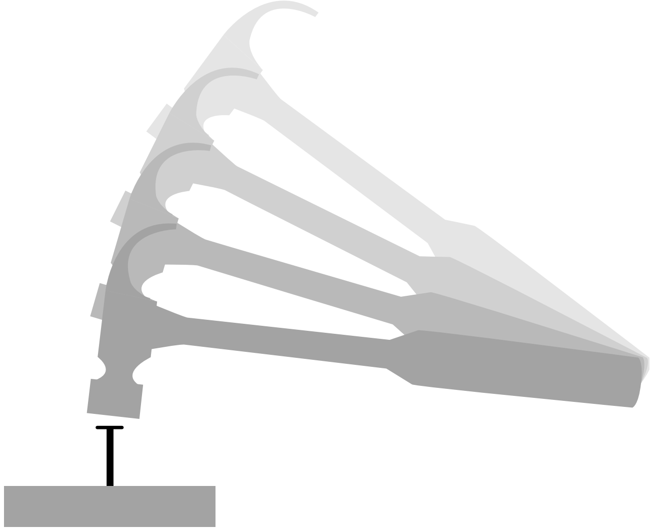
Interception



Interruption



Modification



Fabrication

Harm

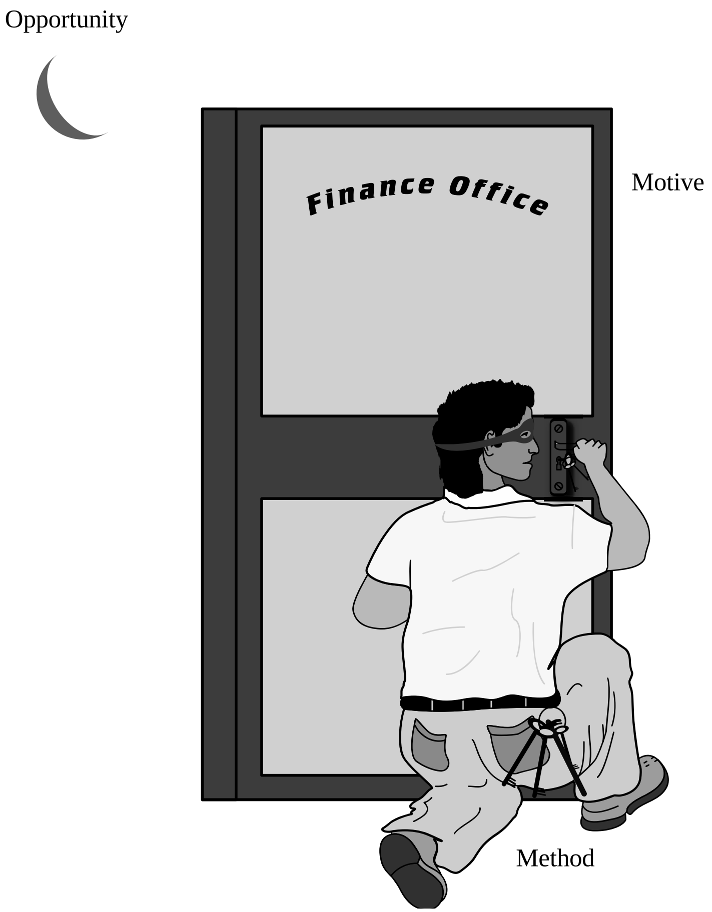
- In an **interception** means that some unauthorized party has gained access to an asset.

- In an **interruption**, an asset of the system becomes lost, unavailable, or unusable.

- If an unauthorized party not only accesses but **tampers** (forges) with an asset, the threat is a **modification**.

- Finally, an unauthorized party might create a **fabrication** of ***counterfeit*** objects on a computing system.

Method—Opportunity—Motive (MOM)



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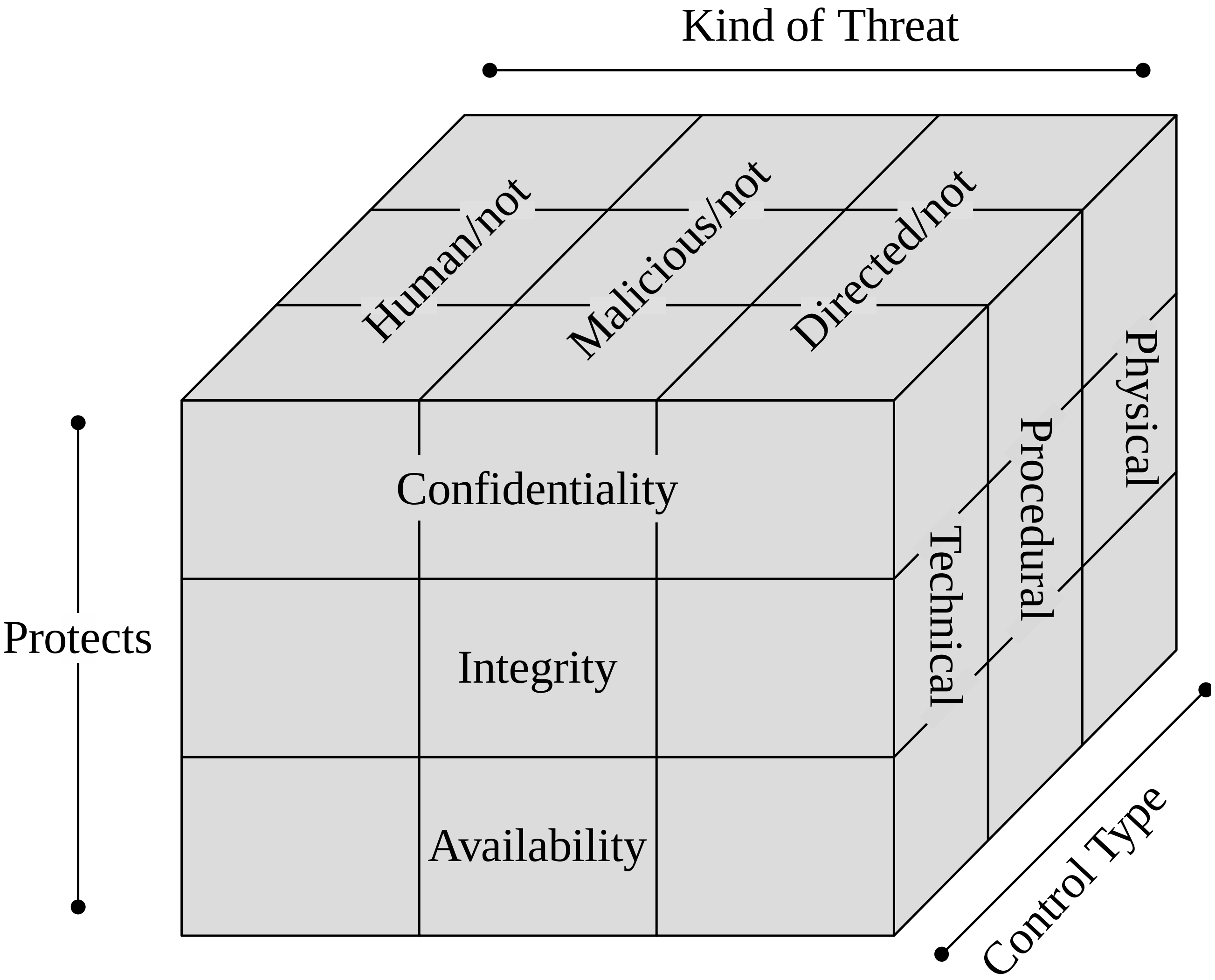
Method, Opportunity, and Motive

- A malicious attacker must have **three things (MOM)**:
  - *method:* the **skills**, **knowledge**, **tools**, and other things with which to be able to pull off the attack
    - Knowledge of systems are widely available
  - *opportunity:* the **time** and **access** to accomplish the attack
    - Systems available to the public are accessible to them
  - *motive:* a **reason** to want to perform this attack against this system

Controls/Countermeasures

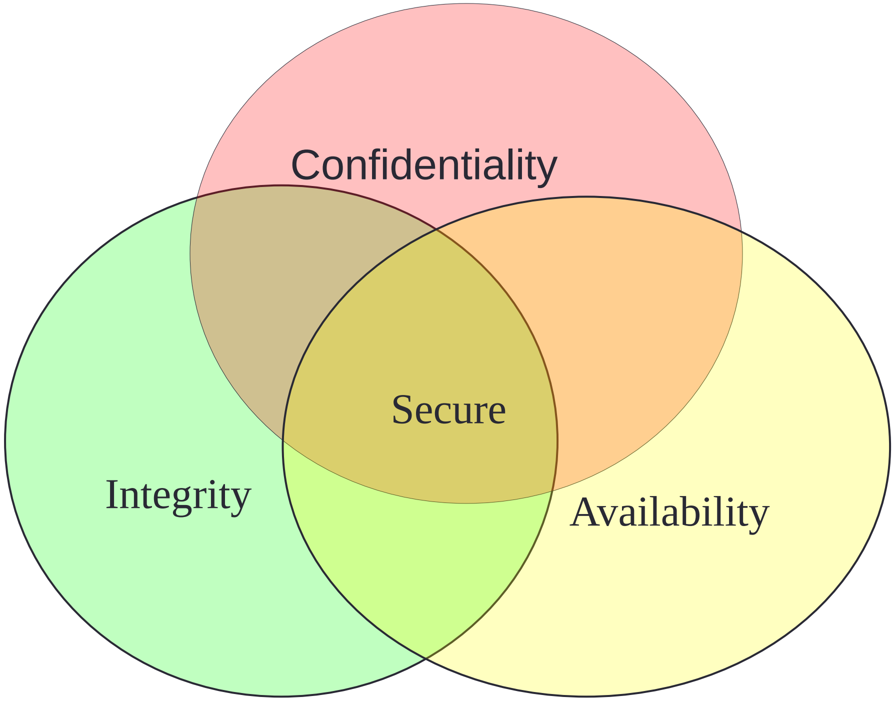


Security Goals

- When we talk about computer security, we mean that we are addressing three important aspects of any computer-related system: **confidentiality, integrity,** & **availability (CIA)**
  - **Confidentiality** ensures that computer-related assets are accessed only by authorized parties.
    - **i.e**. reading, viewing, printing, or even knowing their existence
    - Secrecy or privacy
  - **Integrity** means that assets can be modified only by authorized parties or only in authorized ways.
    - **i.e**. writing, changing, deleting, creating
  - **Availability** means that assets are accessible to authorized parties at appropriate times.
    - i.e. often, availability is known by its opposite, denial of service.

Relationship between Confidentiality Integrity and Availability

- In fact, these three characteristics can be independent, can overlap, and can even be mutually exclusive.



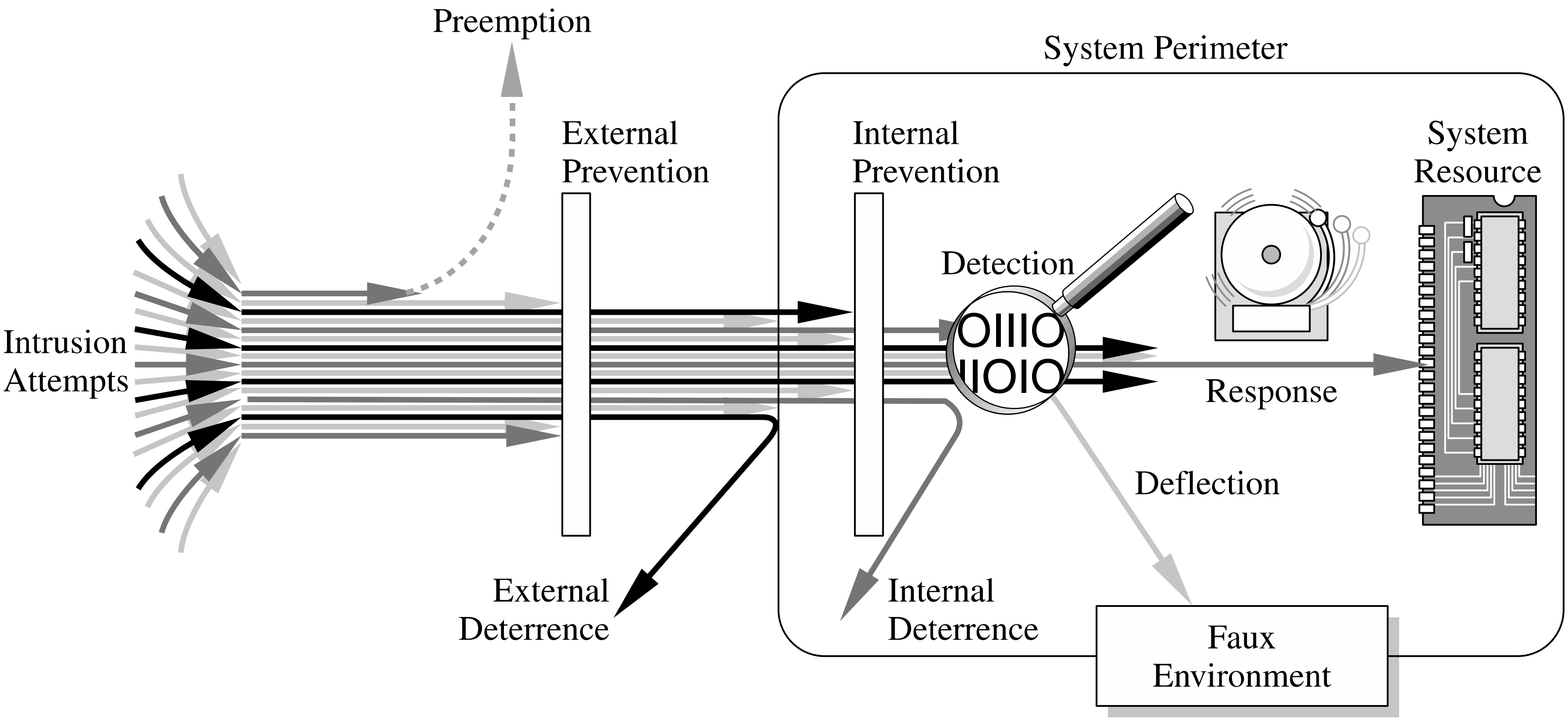
Goals of Security

- Prevention
  - Prevent attackers from violating security policy
- Detection
  - Detect attackers' violation of security policy
- Recovery
  - Stop attack, assess and repair damage
  - Continue to function correctly even if attack succeeds

Trust and Assumptions

- Trust underlies *all* aspects of security
- Policies
  - Unambiguously partition system states
  - Correctly capture security requirements
- Mechanisms
  - Assumed to enforce policy
  - Support mechanisms work correctly

Different Types of Controls



Controls Available

- **Encryption**
  - We take data in their normal, unscrambled state, called:
    - **cleartext** or **plaintext**, and transform them so that they are unintelligible to the outside observer; the transformed data are called **enciphered** text or **ciphertext**.
  - **Encryption** clearly addresses the need for **confidentiality** of data.
  - Additionally, it can be used to ensure **integrity**;
    - *data that cannot be read generally cannot easily be changed in a meaningful manner.*

Controls Available

- **Encryption** does **not solve all** computer security problems, and other tools must complement its use.
  - if encryption is not used properly, it may have no effect on security or could even degrade the performance of the entire system.

- **Weak encryption** can actually be **worse than no encryption** at all,
  - because it gives users an unwarranted sense of protection.

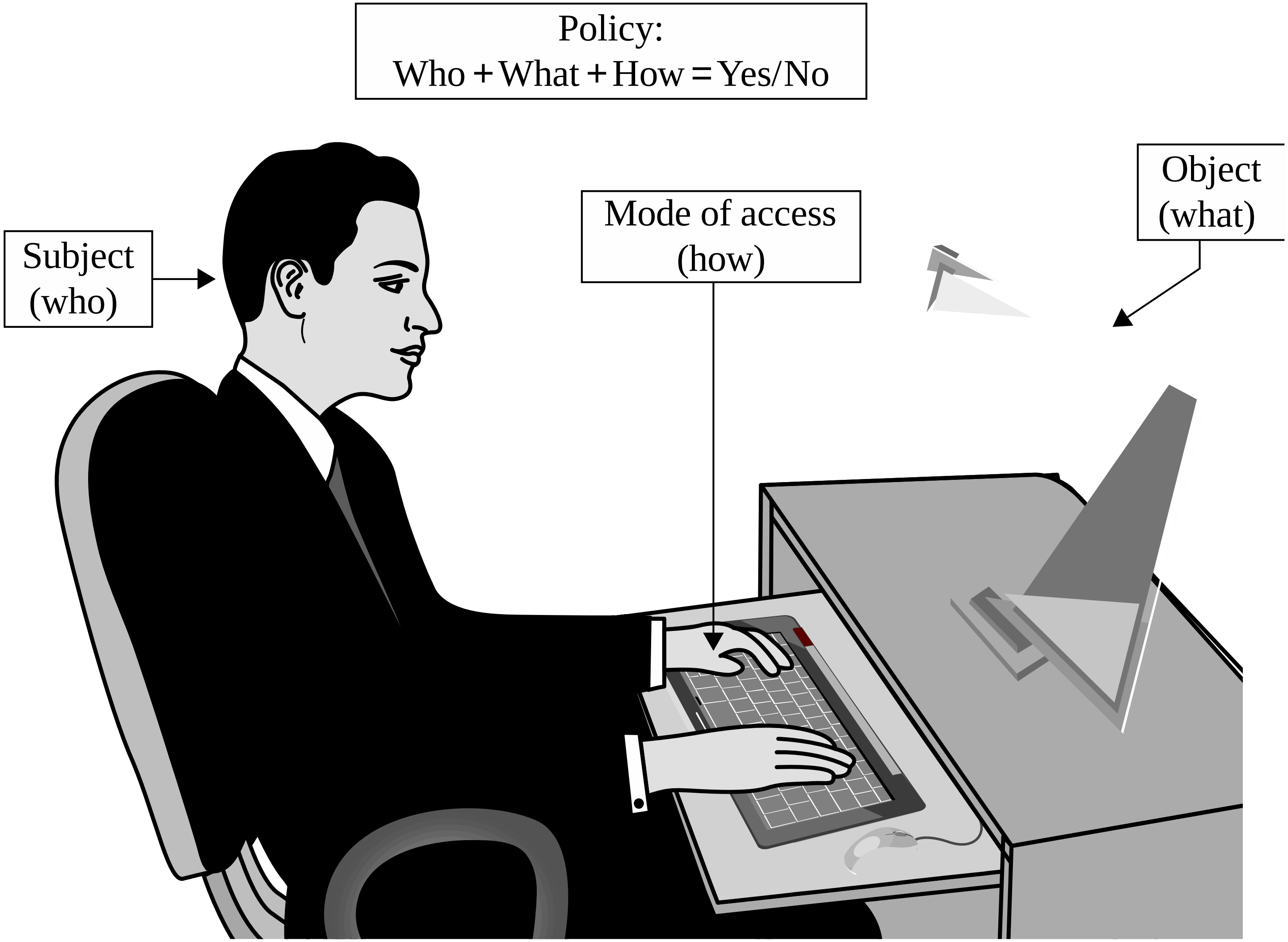
- *Therefore, we must understand those situations in which encryption is most useful as well as ways to use it effectively.*

Controls Available

- **Software/Program Controls**
  - Programs must be secure enough to *prevent outside attack*
  - They must also be developed and maintained so that we can be confident of the programs' dependability.

- **Program controls include the following:**
  - **Internal program controls**: parts of the program that enforce security restrictions,
    - i.e. *access limitations in a database* management program
  - **Operating system and network system controls**: *limitations enforced by the operating system* or network to protect each user from all other users
    - i.e. chmod on UNIX: (Read, Write, Execute) ***vs***. (Owner, Group, Other)
  - **Independent control programs**: application programs,
    - i.e. *password checkers*, intrusion detection utilities, or *virus scanners*, that protect against certain types of vulnerabilities

Access Control



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Controls Available

- **Development controls**:
  - quality standards under which a program is **designed**, **coded (implementation)**, **tested**, and maintained to prevent software faults from becoming exploitable vulnerabilities
    - i.e. **Penetration testing** (pen testing or ethical hacking), is the practice of testing a computer system, network or web application to *find security vulnerabilities that an attacker could exploit*.

- Software controls frequently affect users directly ?
  - i.e. when the user is interrupted and asked for a password before being given access to a program or data.
  - Because they influence the usability of the system, software controls must be carefully designed.
    - Ease of use and capabilities are often competing goals in the design of a collection of software controls.

Controls Available

- **Hardware Controls**
  - Numerous hardware devices have been created to assist in providing computer security. These devices include a variety of means, such as
    - hardware or smart card implementations of encryption
    - locks or cables limiting access or deterring theft
    - devices to verify users' identities
    - firewalls
    - intrusion detection systems
    - circuit boards that control access to storage media

Controls Available

- **Policies and Procedures**
  - Sometimes, we can rely on agreed-on procedures or policies among users rather than enforcing security through hardware or software means
    - i.e. frequent changes of passwords
  - We must not forget the value of community standards and expectations when we consider how to enforce security.

- **Physical Controls**
  - i.e. locks on doors,
  - guards at entry points,
  - backup copies of important software and data, and
  - physical site planning that reduces the risk of natural disasters.

Effectiveness of Controls

- **Awareness of Problem**
  - People using controls must be convinced of the need for security. That is, people will willingly cooperate with security requirements only if they understand
    - why security is appropriate in a given situation.

Effectiveness of Controls

- **Likelihood of Use**
  - Of course, no control is effective unless it is used

  - **Principle of Effectiveness:**
    - Controls must be used properly to be effective.
      - They must be efficient, easy to use, and appropriate.

    - This principle implies that computer security controls
      - must be efficient enough, in terms of time, memory space, human activity, or other resources used,
      - using the control does not seriously affect the task being protected.
      - Controls should be selective so that they do not exclude legitimate accesses.

Effectiveness of Controls

- **Overlapping Controls**
  - Several different controls may apply to address a single vulnerability.
- **Periodic Review**
  - Just when the security specialist finds a way to secure assets against certain kinds of attacks, the opposition doubles its efforts in an attempt to defeat the security mechanisms. Thus, judging the effectiveness of a control is an ongoing task.

Principle of Weakest Link

- **Security can be no stronger than its weakest link** !!!
  - Whether it is the power supply that powers the firewall or the operating system under the security application or the human who plans, implements, and administers controls, a failure of any control can lead to a security failure.

Summary

- Vulnerabilities are weaknesses in a system;
    - threats exploit those weaknesses;
    - controls protect those weaknesses from exploitation
- Confidentiality, integrity, and availability are the three basic security primitives
- Different attackers pose different kinds of threats based on their capabilities and motivations
- Different controls address different threats; controls come in many flavors and can exist at various points in the system