Applied Cryptography

Ms. Swati Mali
B-215
swatimali@gmail.com
Assistant Professor, Department of Computer Engineering
K. J. Somaiya College of Engineering
Somaiya Vidyavihar University

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What is this course about?

- Objectives
  - Security needs / threats
  - Security Goals
  - Cryptography

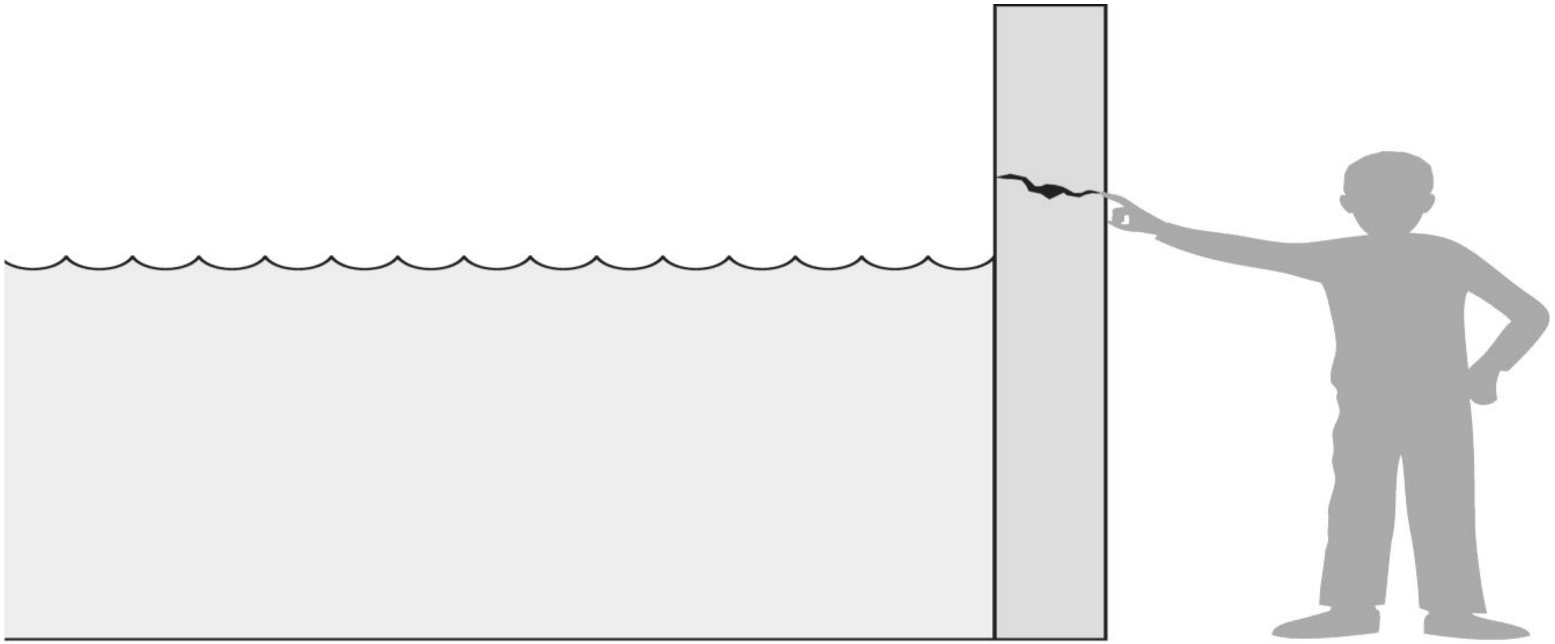
What we will cover?

- –Vulnerabilities, threats, security Goals, and methods of defense
- –Cryptography
- –Symmetric
- –Asymmetric
- –Message authentication and digital signature
- –Advances in Cryptography

Vulnerability, Threat and Control

- A vulnerability is a weakness in the security system, in procedure, design, or implementation that might be exploited to cause loss or harm
- A threat to a computer system is a set of circumstances that has the potential to cause loss or harm
- Control is an action, device, procedure, or technique that removes or reduces a vulnerability
- A threat is blocked by control of a vulnerability

Threats, Controls, and Vulnerabilities



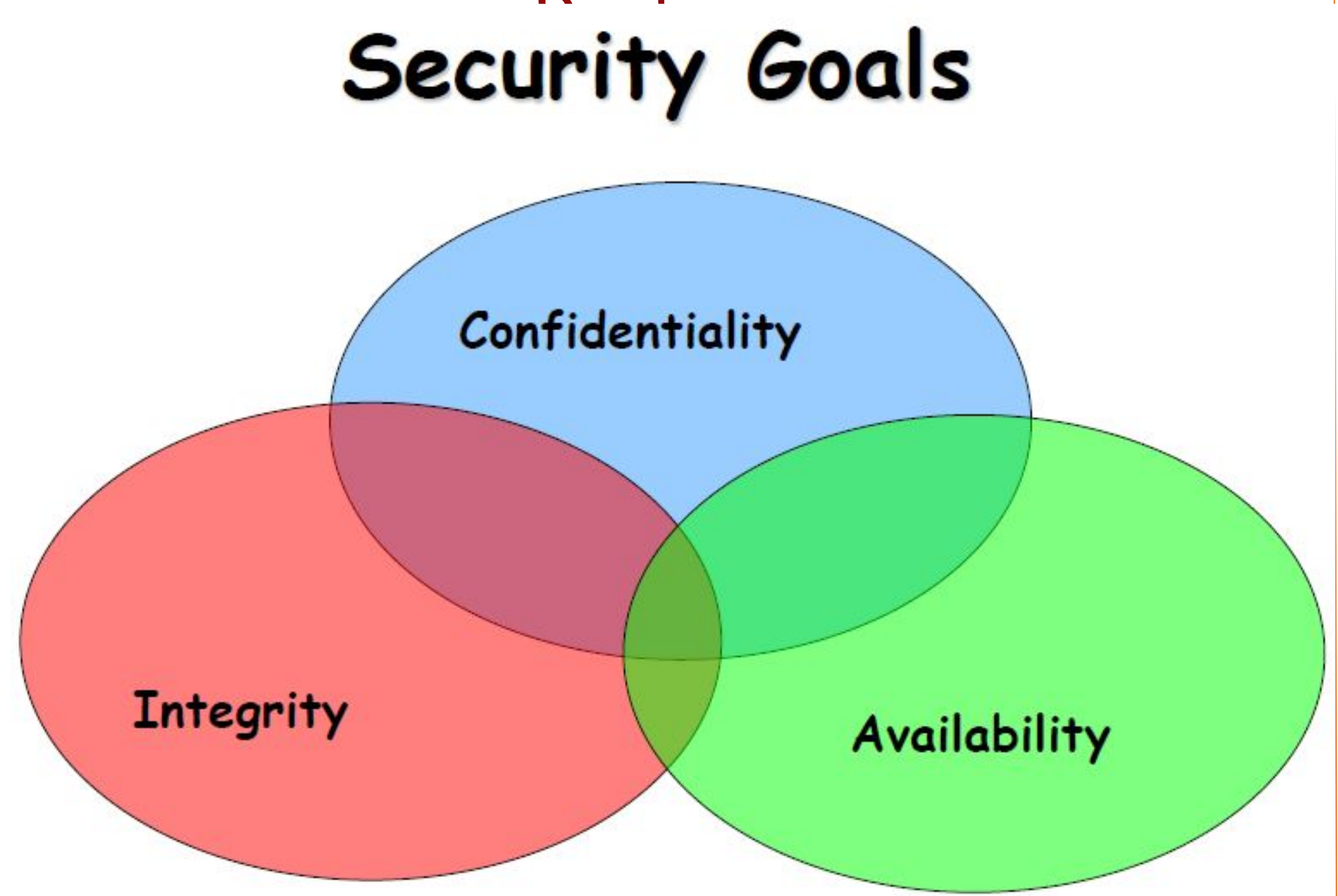
Pfleeger/Pfleeger Fig. 01-01

Threats, Controls, and Vulnerabilities

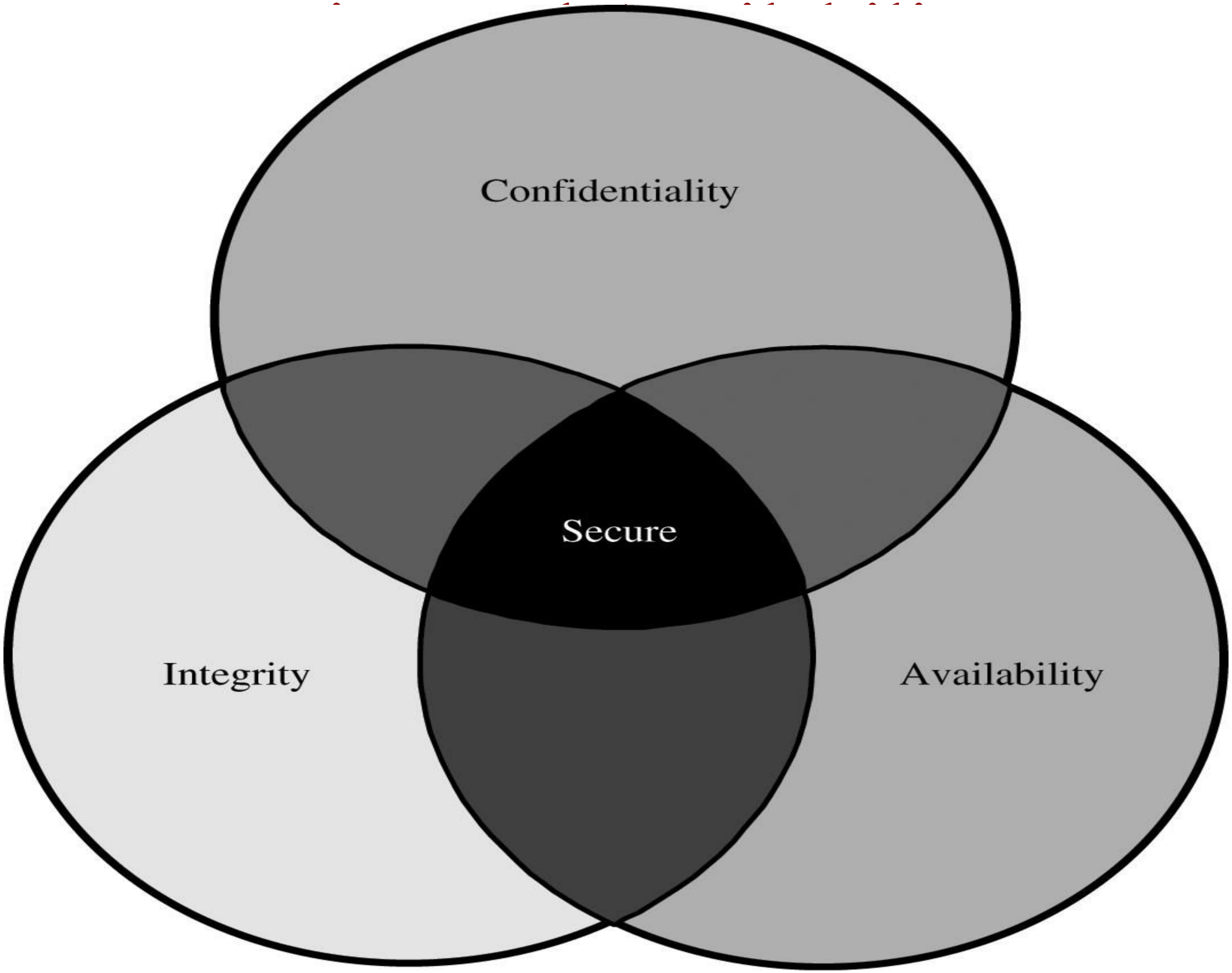
- Glass home
- Social media
- Land slide
- Bank transaction
- Covid vaccine booking
- Online zoom calls

Attacks, Services and Mechanisms

- Security Attack: Any action that compromises the security of information.
- Security Mechanism: A mechanism that is designed to detect, prevent, or recover from a security attack.
- Security Service: A service that enhances the security of data processing systems and information transfers. A security service makes use of one or more security mechanisms.


Security Goals
Confidentiality
Integrity
Availability

Relationship Between Confidentiality,



Confidentiality

- It ensures that computer-related assets are accessed only by authorized parties
- Access means reading, viewing, printing, or simply knowing that a particular asset exists
- It is sometimes also called secrecy or privacy

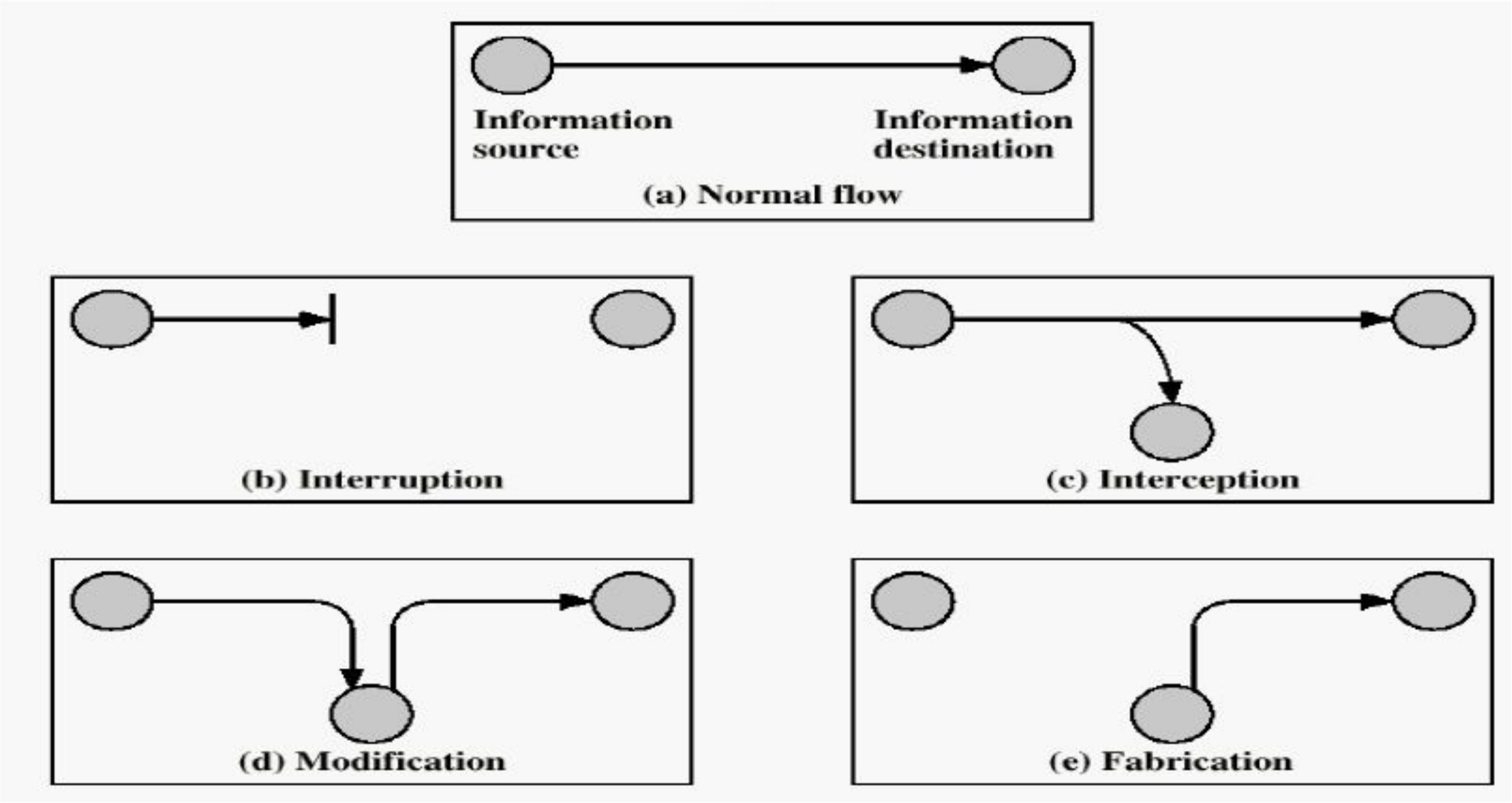
Integrity

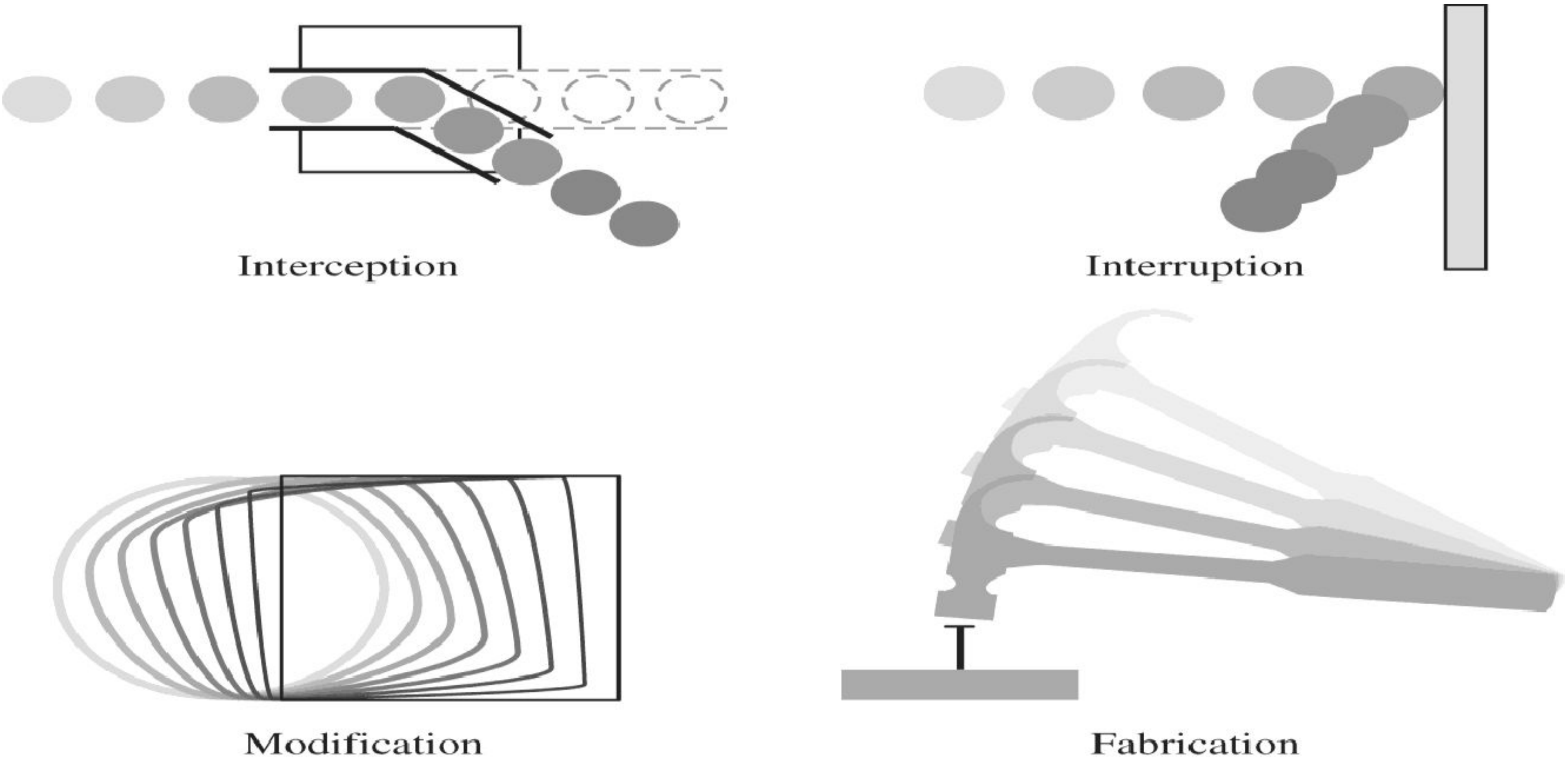
- It means that assets can be modified only by authorized parties only in authorized ways.
- The integrity of an item is preserved if it is:
  - Precise, accurate, unmodified, modified only in acceptable ways, modified by authorized people, modified by authorized processes, consistent, meaningful and usable.

Availability

- It applies to both data and data processing
- A data item, service or system is available if
  - There is a timely response to our request
  - Fair to all i.e. some requesters are not favored over others
  - Fault tolerant
  - There is controlled concurrency, deadlock management, and exclusive access as required

Security Attacks





Interception

Interruption

Modification

Fabrication

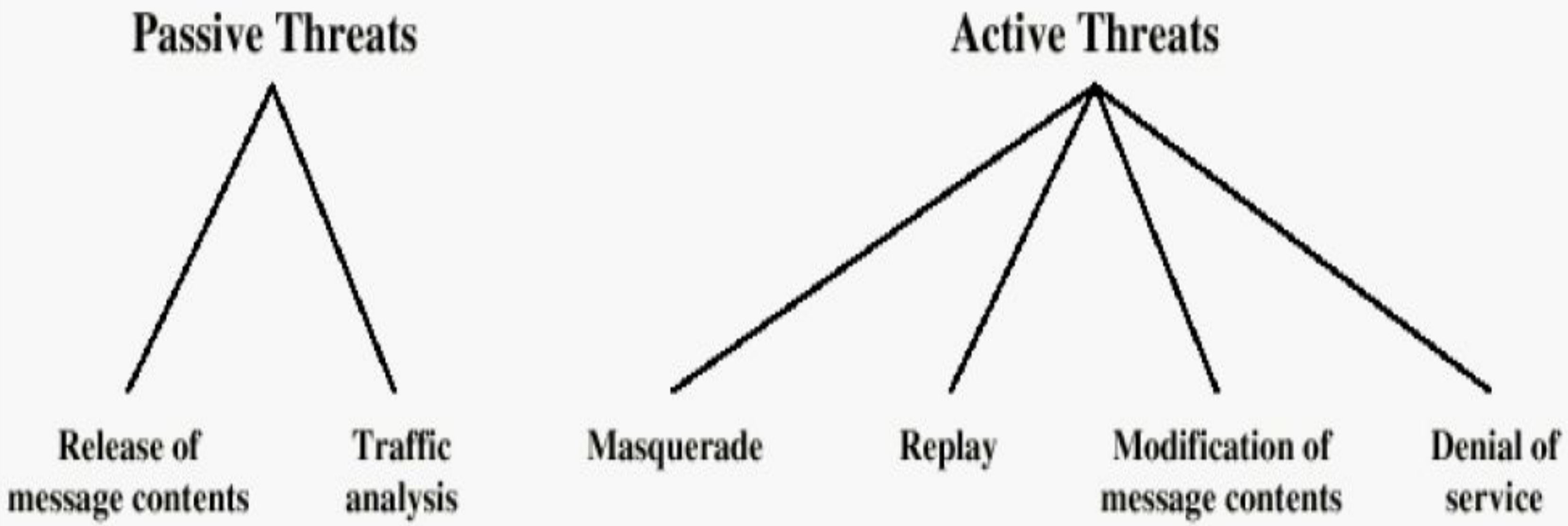
Pfleeger/Pfleeger Fig. 01-02

Security Attacks

- **Interruption:** This is an attack on availability, confidentiality
- **Interception:** This is an attack on confidentiality
- **Modification:** This is an attack on integrity
- **Fabrication**: This is an attack on authenticity

Classical attacks on security

- Eavesdropping
- Traffic Analysis attack
- Replay attack
- non-repudiation attack
- Man-in-the-Middle attack
- Data Tampering
- Denial of Service (DoS) attack
- Brute Force Attack
- zero day exploit attack,
- Phishing and social engineering
- Spoofing
- Malware
- Session hijacking attack



Passive Threats

Release of message contents

Traffic analysis

Active Threats

Masquerade

Replay

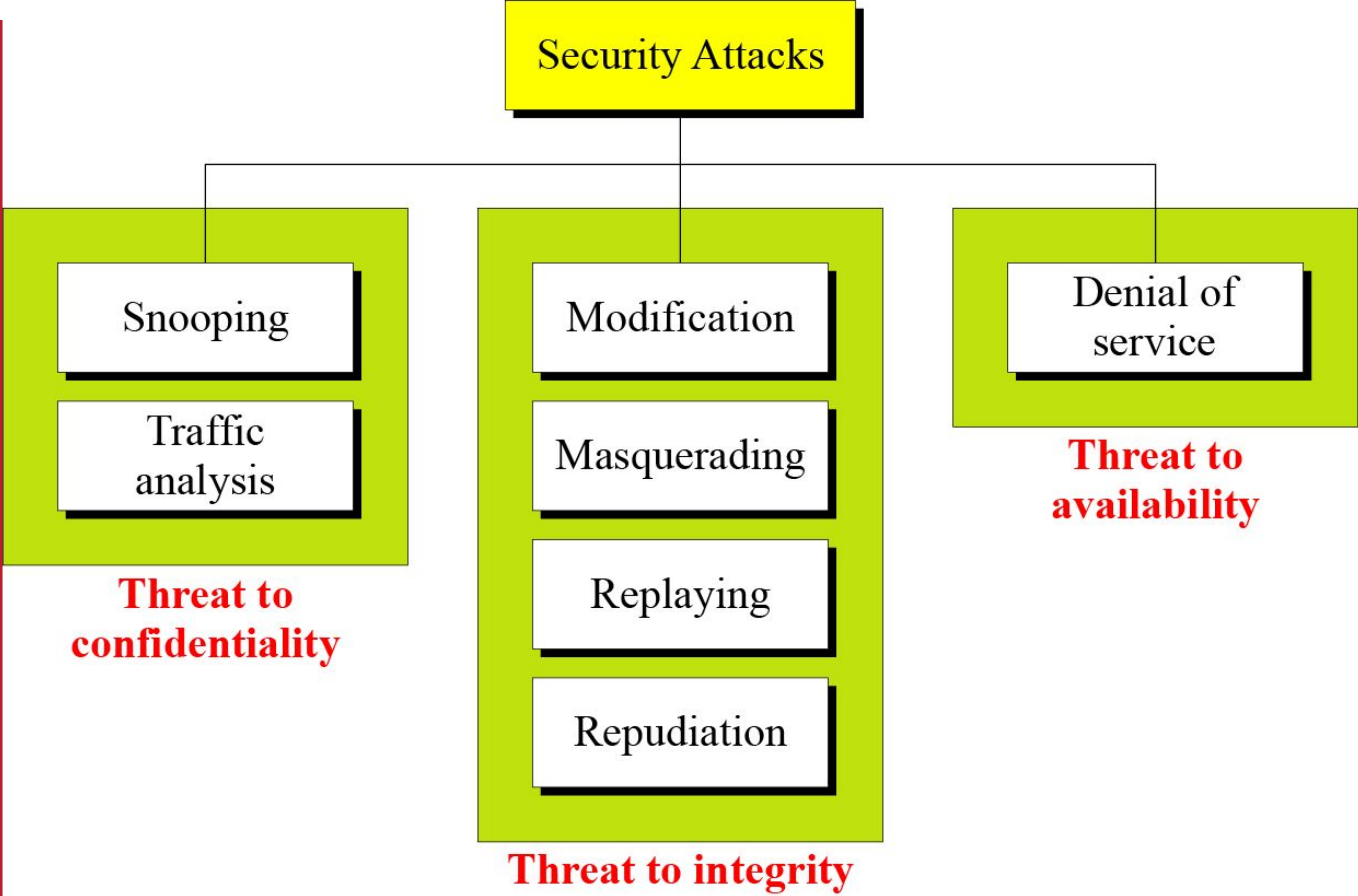
Modification of message contents

Denial of service

Figure 1.2 Active and Passive Security Threats

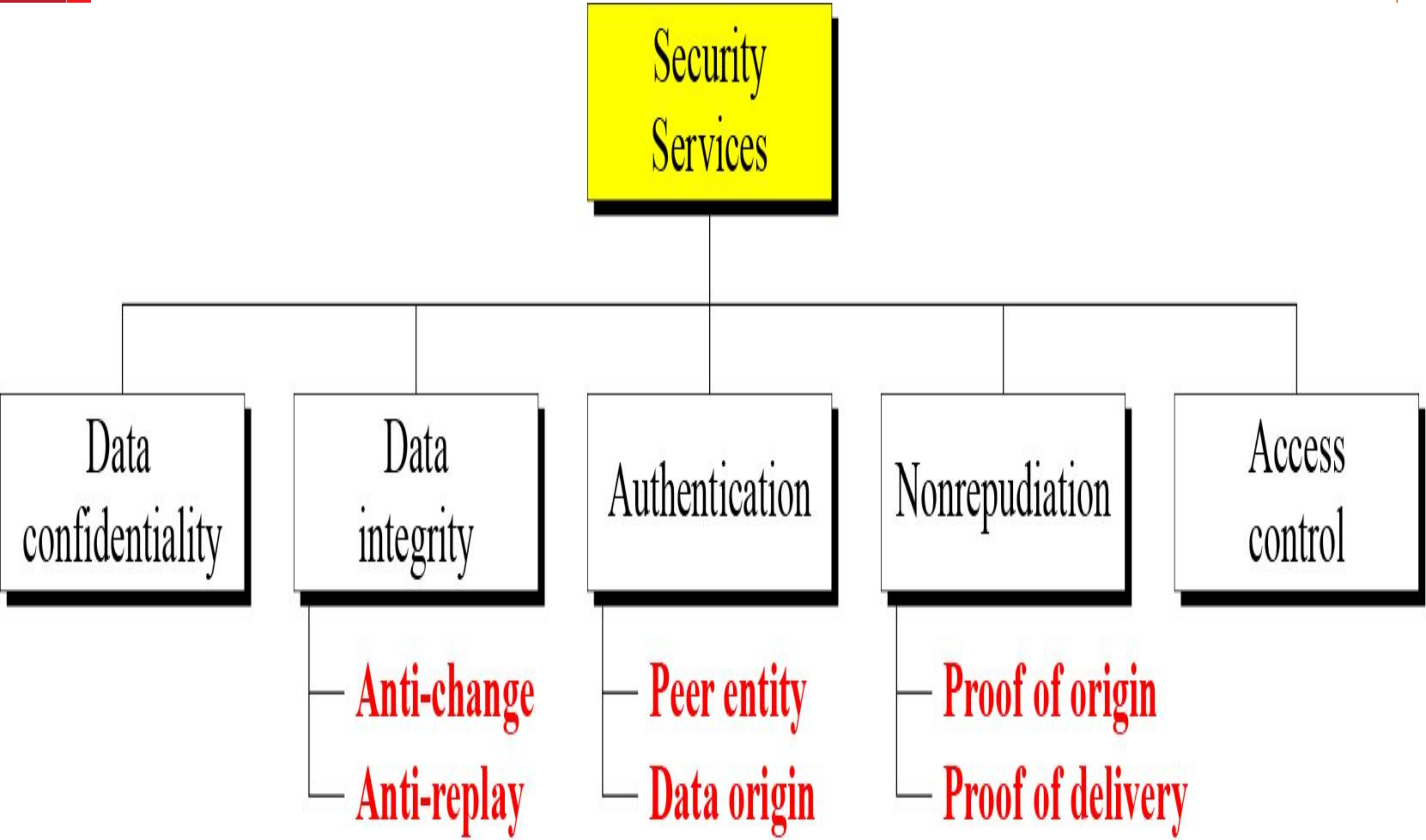
Attacks

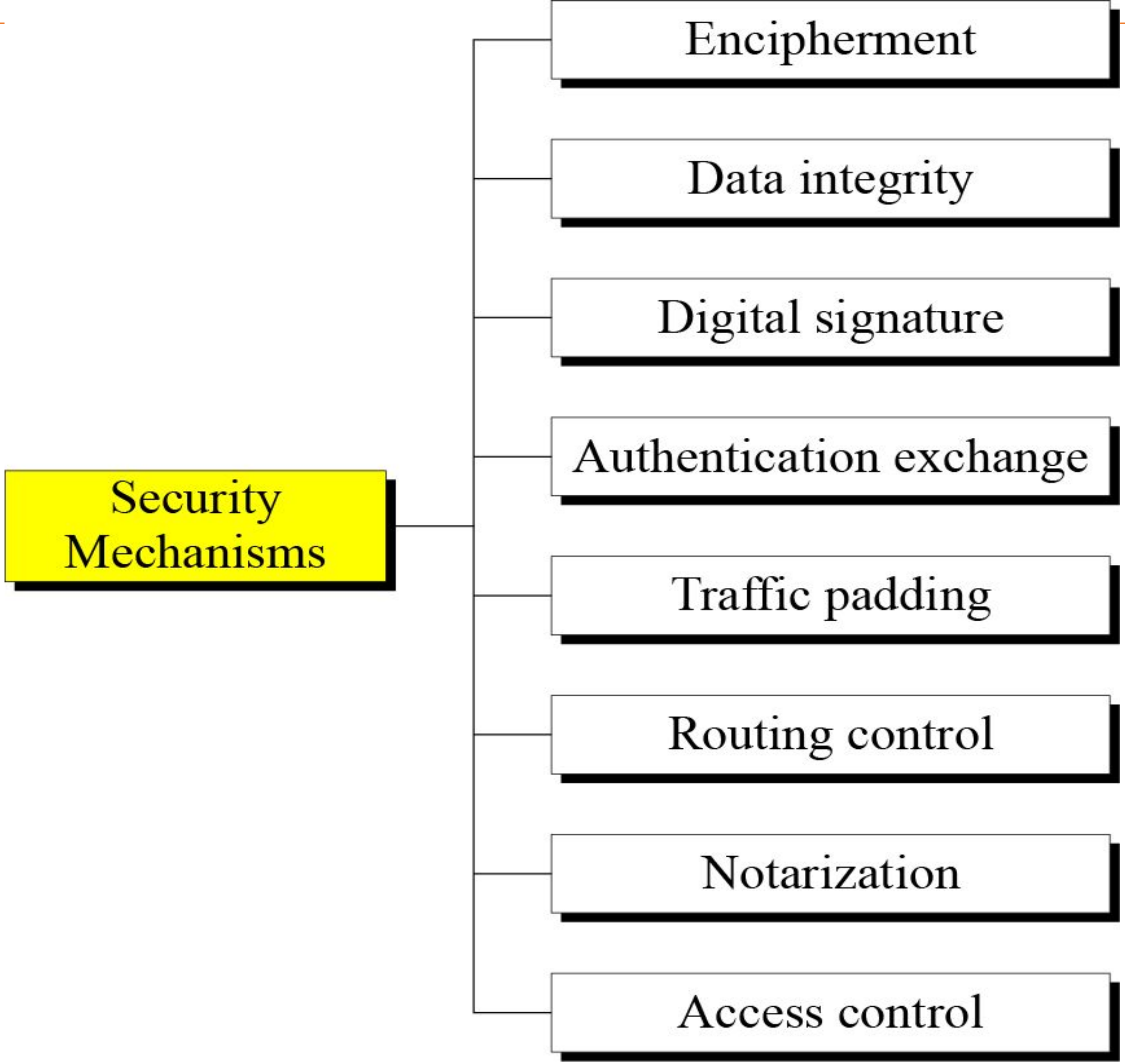
- Cryptanalytic Attacks
  - Exploit mathematical weakness of cryptographic algorithm
- Non-cryptanalytic Attacks
  - Threats to goal of security


Security Attacks
Snooping
Traffic analysis
Threat to confidentiality
Modification
Masquerading
Replaying
Repudiation
Threat to integrity
Denial of service
Threat to availability

Security Services

- Confidentiality (privacy)
- Authentication (who created or sent the data)
- Integrity (has not been altered)
- Non-repudiation (the order is final)
- Access control (prevent misuse of resources)
- Availability (permanence, non-erasure)
    - Denial of Service Attacks
    - Virus that deletes files


Security Services
Data confidentiality
Data integrity
Authentication
Nonrepudiation
Access control
Anti-change
Anti-replay
Peer entity
Data origin
Proof of origin
Proof of delivery



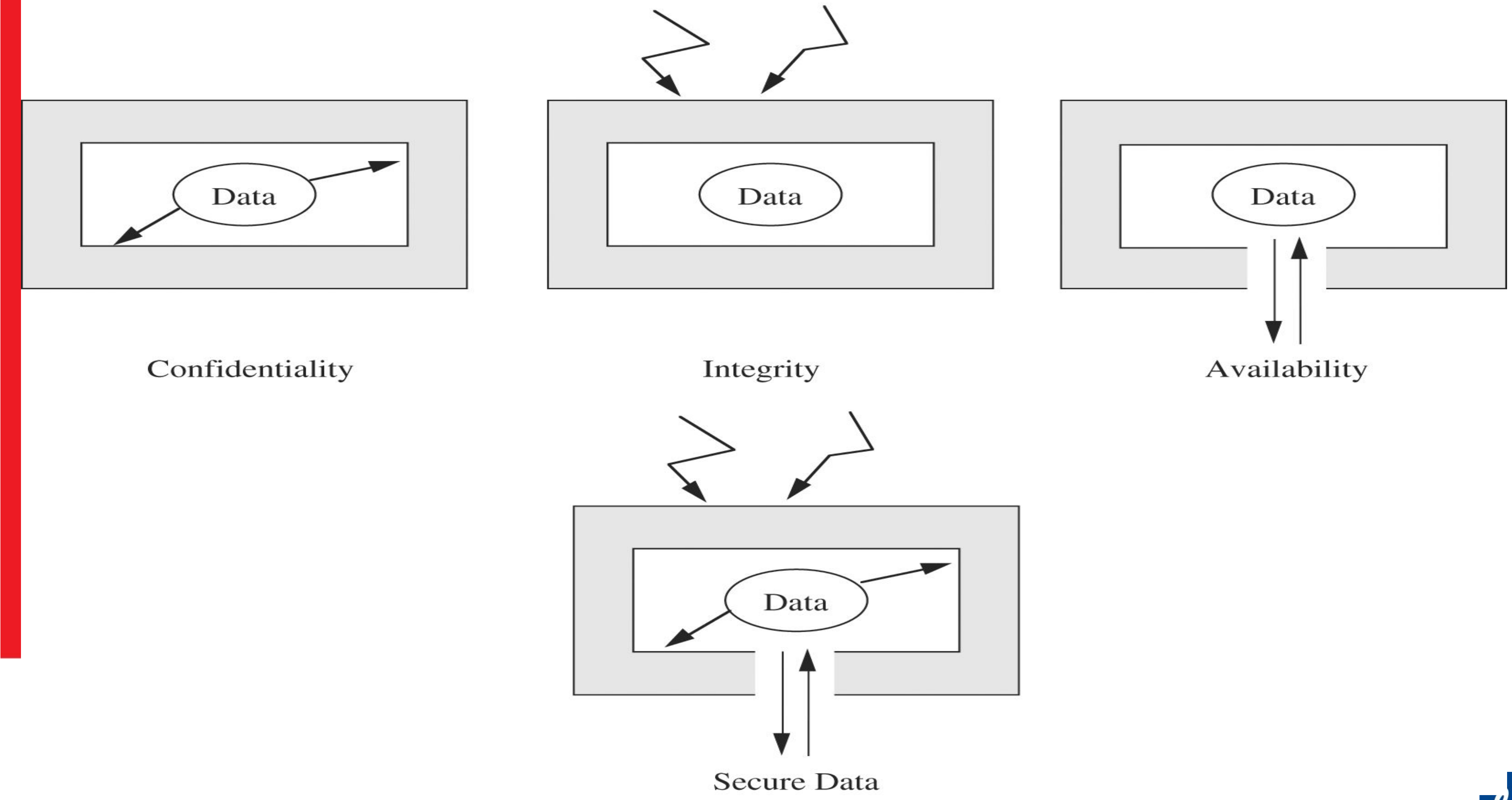
Security Mechanisms

- Encipherment
- Data integrity
- Digital signature
- Authentication exchange
- Traffic padding
- Routing control
- Notarization
- Access control

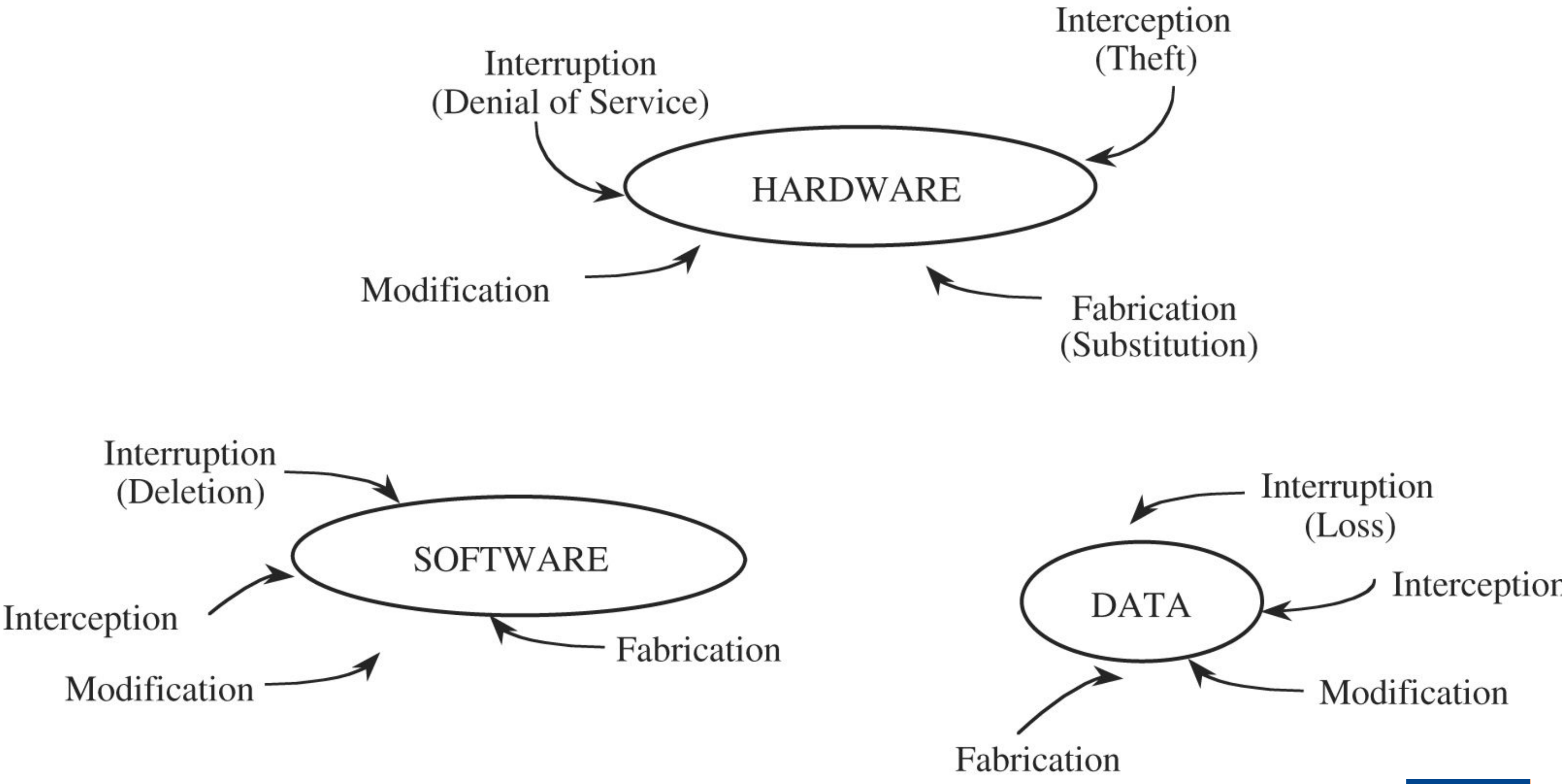
Vulnerabilities

- Hardware vulnerabilities
- Software vulnerabilities
    - Software deletion
    - Software modification
        - Viruses etc.
    - Software theft
- Unauthorized copying etc.
- Data vulnerabilities

Data Security



Computing system vulnerabilities

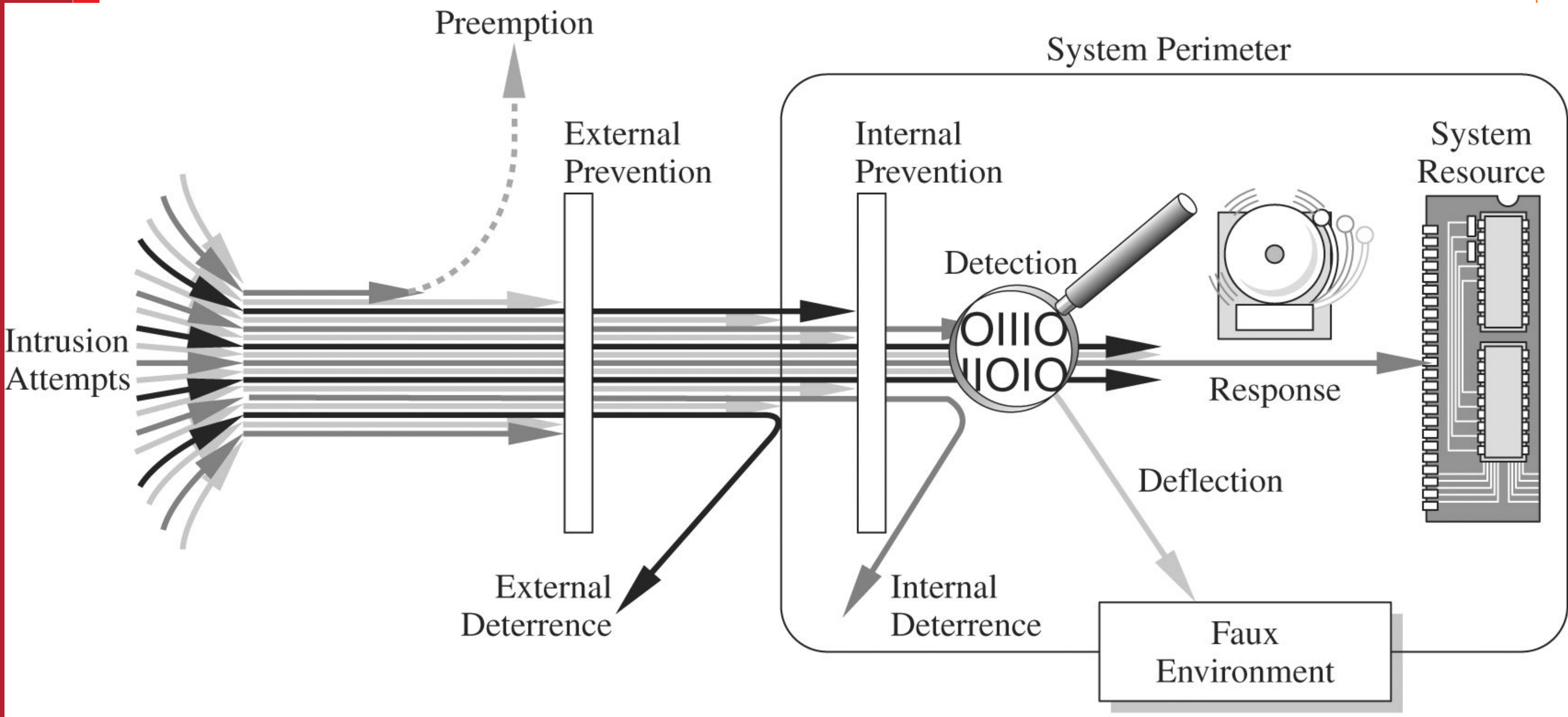


Methods of Defense

- *Prevent it*, by blocking the attack or closing the vulnerability
- *Deter it*, by making attack harder if not impossible
- *Deflect it*, by making another target more attractive
- *Mitigate it,* by making its impact less severe
- *Detect it*, either as it happens or some time after the fact
- Recover from its effects

Multiple levels of Defence

Multiple levels of Defence



Pfleeger/Pfleeger Fig. 01-06

Methods of Defense

- Controls
  - Encryption
  - Hardware Controls
    - Hardware/smart card implementations of encryption
    - Locks or cables limiting access
    - Devices to verify users’ identity
    - Firewalls
    - Intrusion detection systems
  - Software Controls
    - Internal program controls,
    - OS and Network system controls
    - Independent control program (anti virus, passwords etc.)
    - Development control
  - Policies and Procedures
    - Time restrictions
    - Geofencing
    - Standard development Environment
    - Non Disclosure Agreement
  - Physical Controls
    - locks
    - biometrics
    - guards

Reading slides:Computer Criminals

- Amateurs
  - Personal works
- Crackers
  - Trying to access computing facilities for which they are not authorized
  - The perception that nobody is hurt or even endangered by a little stolen machine time
  - Others attack for curiosity, personal gain, or self-satisfaction
- Career Criminals

Reading slides:Method, Opportunity and Motive

- Method : the skills, knowledge, tools and other things with which to be able to pull off the attack
- Opportunity : the time and access to accomplish the attack
- Motive : a reason to want to perform this attack against this system

DENY ANY OF THESE THREE THINGS AND ATTACKS WILL NOT OCCUR

Reading slides:MOM

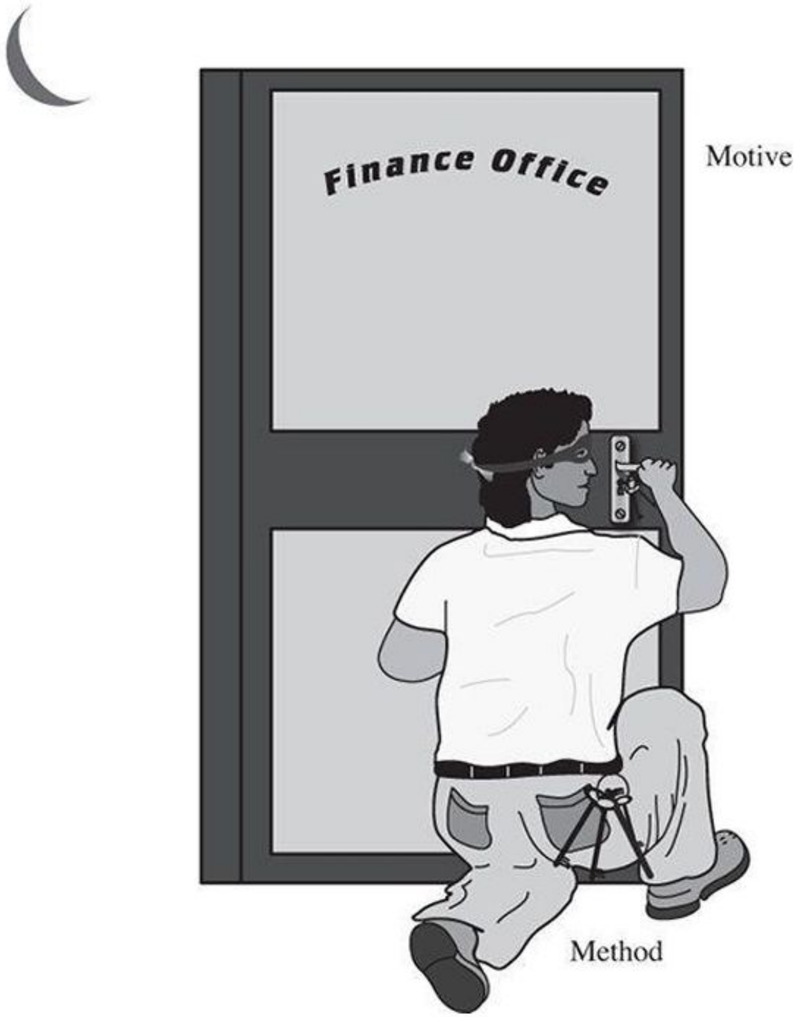


FIGURE 1-11 Method–Opportunity–Motive

Reading slides:MOM : EVM – breaking

Method

- **Skills and Knowledge**: Understanding of EVM hardware and software, including operating systems, communication protocols, and cryptographic systems.
- **Tools**: Specialized hardware (e.g., card readers, microcontrollers, or probes), software tools to analyze or reverse-engineer firmware, and pre-designed attack scripts available online.
- **Resources**: Access to programming manuals, technical specifications, and publicly available security research papers on EVMs.
- **Attack Variants**: Techniques like malware injection, side-channel attacks, or exploiting software/firmware vulnerabilities to alter results or compromise integrity.

Opportunity

- **Access Points**: Physical access during storage, transport, or voting; insider threats from technicians or election staff.
- **System Weaknesses**: Poorly implemented security protocols, use of default settings, lack of tamper-evident features, or absence of robust monitoring mechanisms during elections.
- **Operational Gaps**: Temporary loss of custody during transit, inadequate auditing of results, or lack of rigorous testing for vulnerabilities.
- **Public Accessibility**: In some cases, older or widely used EVM models are studied extensively, making their weaknesses well-known.

Motive

- **Political**: Altering election outcomes to favor specific candidates or parties.
- **Financial**: Bribes or monetary gains in exchange for compromising election integrity.
- **Ideological**: Disrupting democratic processes to undermine trust in governance or to promote political agendas.
- **Reputation**: Demonstrating technical prowess by hacking high-profile systems like EVMs.
- **Sabotage**: Creating confusion, delaying results, or delegitimizing election outcomes by spreading misinformation about the security of EVMs.

Reading slides:MOM : EVM – breaking

Actor	Method	Opportunity	Motive
Amateur Hackers	- Using publicly available hacking tools.	- Insecure endpoints (voting kiosks, admin panels).	- Gaining recognition or thrill.
	- Exploiting weak or reused passwords.	- Lack of encryption in communication.	- Testing their hacking skills for personal satisfaction.
	- Basic phishing or social engineering techniques.	- Minimal technical safeguards in place.	
Anti-Social Individuals	- Spreading misinformation via fake e-voting portals.	- Overloaded servers.	- Causing disruption and chaos.
	- DDoS attacks to disrupt voting processes.	- Lack of traffic filtering mechanisms.	- Undermining public trust in technology and elections.
	- Tampering with voters' devices.	- High dependence on online systems without backup mechanisms.	

Reading slides:MOM : EVM – breaking

Actor	Method	Opportunity	Motive
Anti-Democratic Groups	- Altering vote tallies by breaching databases.	- Poorly secured servers and databases.	- Undermining democracy to destabilize the nation.
	- Installing backdoors in e-voting infrastructure.	- Insider access to the election systems.	- Promoting authoritarian control.
	- Manipulating algorithms in vote counting software.	- Lack of robust access control mechanisms.	
Notorious-Studious Hackers	- Creating custom malware to infiltrate systems.	- Lack of regular security audits.	- Gaining fame or infamy.
	- Exploiting zero-day vulnerabilities.	- Use of outdated software/hardware.	- Demonstrating technical superiority.
	- Reverse-engineering voting software to identify flaws.	- Absence of real-time anomaly detection in e-voting systems.	- Selling vulnerabilities to third parties.
Politicians	- Colluding with insiders to manipulate vote records.	- Access to campaign funds and influence over infrastructure.	- Gaining an unfair advantage to win elections.
	- Funding professional hackers to breach systems.	- Exploiting politically aligned insiders.	- Ensuring their political power remains intact.
	- Using legal loopholes to influence voting systems.	- Weak regulatory oversight of election systems.	

Reading slides:MOM : EVM – breaking

Actor	Method	Opportunity	Motive
Foreign Governments	- Advanced persistent threats (APTs) targeting critical election systems.	- Cross-border jurisdiction limits enforcement.	- Undermining the country's political stability.
	- Spreading propaganda and misinformation campaigns.	- Geopolitical tensions creating vulnerabilities.	- Influencing policies to favor their own geopolitical interests.
		- Lack of robust international cybersecurity coordination.	
Criminal Organizations	- Stealing voter data for identity theft.	- Weak encryption on databases.	- Financial gain through data sales.
	- Selling vote manipulation as a service (election fraud as a business).	- Lack of robust authentication for accessing systems.	- Running election fraud services for profit.
		- High black-market demand for personal and voter information.	
Disgruntled Employees/Insiders	- Leaking sensitive data about voters or systems.	- Direct access to e-voting infrastructure.	- Personal vendetta against employers or the government.
	- Tampering with configurations to enable external breaches.	- Minimal monitoring of employee activity.	- Financial gain from selling information or services.
	- Intentionally bypassing security measures.	- Insufficient background checks or employee screening.	

Reading slides:

Actor	Method	Opportunity	Motive
Activist Groups (Hacktivists)	- Defacing e-voting portals to spread their message.	- Overreliance on online platforms without redundancy.	- Advocating for their causes.
	- Blocking systems through DDoS.	- Lack of regular penetration testing.	- Exposing perceived flaws in the democratic system.
	- Manipulating results to make a statement.	- Misconfigured public-facing services.	- Drawing attention to their ideologies.
Curious Researchers	- Ethical hacking to identify flaws.	- Access to test environments or real systems due to weak authorization checks.	- Publishing findings to improve security.
	- Testing various attack methods (often with consent).	- Collaboration with system administrators without strict boundaries.	- Building a reputation in cybersecurity circles.

Reading slides: Effectiveness of Controls

- Awareness of Problem
  - Highlighting Need of security
- Likelihood of Use
  - They must be efficient, easy to use, and appropriate
- Overlapping Controls
  - Use several different controls, layered defense
- Periodic reviews
  - Judging the effectiveness of control is an ongoing task

Others Exposed Assets

- Networks
  - Network’s lack of physical proximity
  - Use of insecure, shared media
  - Inability to identify remote users positively
- Access
  - Computer time
  - Malicious access
  - Denial of service to legitimate user
- Key People

- An attacker secretly intercepts communication between two parties to steal credentials.

- A user receives a fake email asking to update bank details, which leads to credential theft.

- A hacker floods a website with traffic until it becomes unavailable to real users.

- An attacker captures and reuses valid authentication messages to gain unauthorized access.

- An attacker installs spyware to collect sensitive user information without consent.

- A hacker modifies data in transit to alter financial transactions.

- An attacker sends thousands of password attempts to crack a user's account.

- A cybercriminal exploits an unknown vulnerability before the vendor can patch it.

- An attacker impersonates a trusted website to steal login credentials.

Your understanding of System Security

private network
authentications
anti virus protection
data leaking
encryption and decryption
ciphertext
secure network
cyberattacks
protection
penetration testing
prevent piracy
sha-256 hash algo
integrity of os
end to end encryption
ethical hacking
prevention data breach
data encoding
adware
pharming
decryption
cia triad
firewalls
anti virus
encryption
hashing
blockchain
finding loopholes
secure
safety
privacy
dmz
virus
password
secrecy
firewall
encoding
phishing
trojans
public key private key
networking
domain
confidentiality
software updates
botnets
alan turing
hacking
data leaks
antivirus
protection from scam
unique
malware
ensuring confidentiality
dos attack
unintelligible
data protection
sql injection
threat protection
malware protection

Questions?