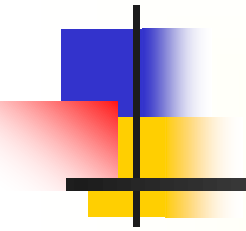


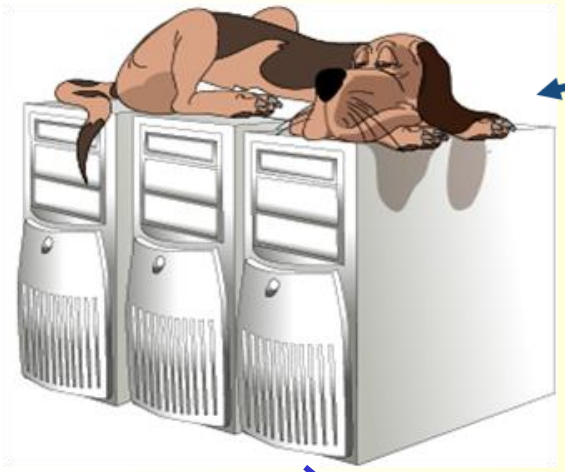
Chapter 1 – Introduction to Computer Security and Privacy

1.1 Overview

- Computer security is about provisions and policies adopted to protect information and property from unauthorized access, use, alteration, degradation, destruction, theft, corruption, natural disaster, etc. while allowing the information and property to remain accessible and productive to its intended use
- Privacy: The right of the individual to be protected against intrusion into his personal life or affairs, or those of his family

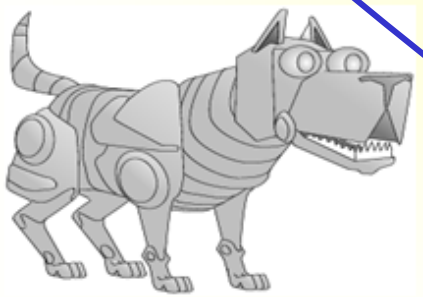
Physical Security

- Computer Security: when there is connection to networks (Network security) it deals with provisions and policies adopted to prevent and monitor unauthorized access, misuse, modification, or denial of the computer network and network-accessible resources

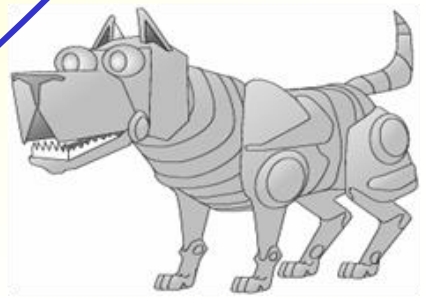


Physical Security

Not Sufficient!!



Internet

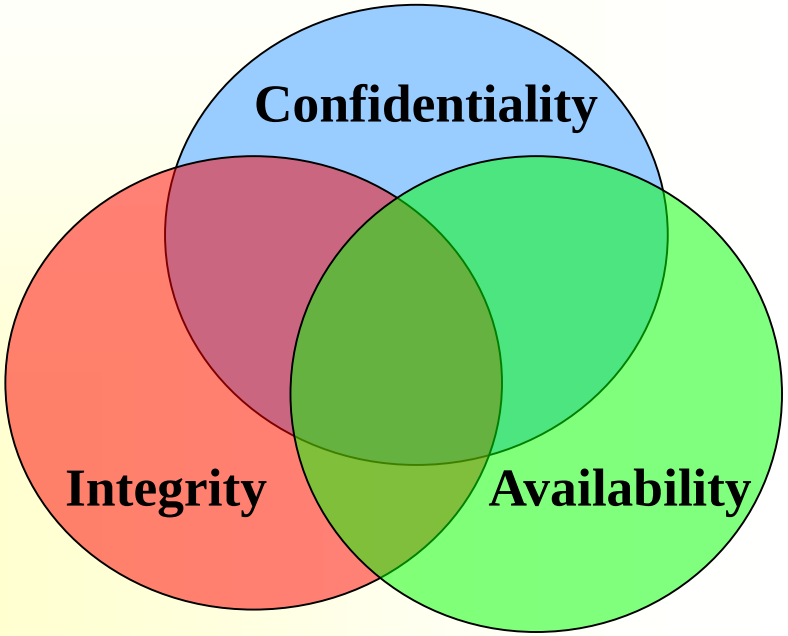


- “The most secure computers are those not connected to the Internet and shielded from any interference”

- Two extreme attitudes regarding computer security
  - There is no real threat; they believe that
    - Much of the negative news is simply unwarranted panic
    - If our organization has not been attacked so far, we must be secure
    - This is a reactive approach to security; wait to address security issues until an incident occurs
  - The opposite viewpoint overestimates the dangers
    - They tend to assume that talented, numerous hackers are an imminent threat to a system
    - They may believe that any teenager with a laptop can traverse highly secure systems at will
    - Such a worldview is unrealistic
    - The reality is that many people who call themselves hackers are less knowledgeable than they think they are. These people have a low probability of being able to compromise any system that has implemented even moderate security precautions

- This does not mean that skillful hackers do not exist
- However, they must balance the costs (financial, time) against the rewards (ideological, monetary)
- “Good” hackers tend to target systems that yield the highest rewards
- Keep in mind, too, that the greatest external threat to any system is not hackers, but malware and denial of service attacks. Malware includes viruses, worms, Trojan horses, logic bombs, etc.

1.1.1 Basic Security Objectives (Pillars) - CIA



- Confidentiality: This term covers two related concepts:
  - Data confidentiality: Assures that private or confidential information or resources (resource and configuration hiding) are not made available or disclosed to unauthorized individuals
    - Is compromised by reading and copying
    - In network communication, it means only sender and intended receiver should “understand” message contents
  - Privacy: Assures that individuals control or influence what information related to them may be collected and stored and by whom and to whom that information may be disclosed

- Integrity: This term covers two related concepts
  - Data integrity: Assures that information and programs are changed only in a specified and authorized manner
    - In network communication, sender and receiver want to ensure that the message is not altered (in transit or afterwards) without detection
  - System integrity: Assures that a system performs its intended function in an unimpaired manner, free from deliberate or inadvertent unauthorized manipulation of the system
  - Is compromised by deleting, corrupting, and tampering with
- Availability: Assures that systems work promptly and service is not denied to authorized users
- Authenticity: Some say it is a missing component of objectives in CIA. It is the property of being genuine and being able to be verified and trusted; confidence in the validity of a transmission, a message, or message originator; or sender and receiver want to confirm the identity of each other

1.1.2 Policy and Mechanism

- A security policy is a statement of what is, and what is not, allowed by users of a system
- A security mechanism is a method, tool, or procedure for enforcing a security policy
- More on this in Chapter 5 - Security Mechanisms and Techniques and Chapter 6 – Information Security

1.1.3 Goals of Security

- Given a security policy's specification of "secure" and "nonsecure" actions, security mechanisms can prevent (defend) the attack, detect the attack, or recover from the attack
  - Prevention/Defence: take measures to prevent the damage; it means that an attack will fail; e.g., passwords to prevent unauthorised users or Intrusion Prevention Systems (IPSs)
  - Detection: if an attack cannot be prevented; when, how and who of the attack have to be identified; e.g., when a user enters a password three times; Intrusion Detection Systems (IDSs)
  - Recovery/Reaction: take measures to recover from the damage; e.g., restore deleted files from backup; sometimes retaliation (attacking the attacker's system or taking legal actions to hold the attacker accountable)
- The three strategies are usually used together
- A fourth approach is deterrence; involves active steps to beat off attacks; discourage them even to try attacking

- Example 1: Protecting valuable items at home from a burglar
  - Prevention: locks on the door, guards, hidden places, etc.
  - Detection: burglar alarm, guards, Closed Circuit Television (CCTV), etc.
  - Recovery: calling the police, replace the stolen item, etc.
- Example 2: Protecting a fraudster from using our credit card in Internet purchase
  - Prevention: Encrypt when placing order, perform some check before placing order, or don't use credit card on the Internet
  - Detection: A transaction that you had not authorized appears on your credit card statement
  - Recovery: Ask for new card, recover cost of the transaction from insurance, the card issuer or the merchant

1.2 Brief History of Computer Security and Privacy

- Until the 1960s computer security was limited to physical protection of computers (Physical Security)
- In the 60s and 70s (System/Information Security)
  - Evolutions
    - Computers became interactive
    - Multiuser/Multiprogramming was invented
    - More and more data started to be stored in computer databases
  - Organizations and individuals started to worry about
    - What the other persons using computers are doing to their data
    - What is happening to their private data stored in large databases

- In the 80s and 90s (Network Security)
  - Evolutions
    - Personal computers were popularized
    - LANs and the Internet invaded the world
    - Applications such as E-commerce, E-government and E-health started to be developed
    - Viruses became majors threats
  - Organizations and individuals started to worry about
    - Who has access to their computers and data
    - Whether they can trust a mail, a website, etc.
    - Whether their privacy is protected in the connected world

- Famous Security Problems
  - Morris worm – Internet Worm
    - On November 2, 1988 a worm attacked more than 60,000 computers around the USA
    - The worm attacks computers, and when it has installed itself, it multiplies itself, freezing the computer
      - It exploited UNIX security holes in Sendmail and Finger
      - A nationwide effort enabled to solve the problem within 12 hours
      - Robert Morris became the first person to be indicted under the Computer Fraud and Abuse Act
        - He was sentenced to 3 years of probation, 400 hours of community service and a fine of $10,500

Robert Morris in 2008

- Bank theft
  - In 1984, a bank manager was able to steal $25 million through un-audited computer transaction
- NASA shutdown
  - In 1990, an Australian computer science student was charged for shutting down NASA's computer system for 24 hours
- Airline computers
  - In 1998, a major travel agency discovered that someone penetrated its ticketing system and has printed airline tickets illegally
- The list continues …

- Does anyone know any security problem stories in Africa and Ethiopia? Most incidents in Africa are not usually reported

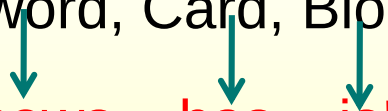
- Early Efforts
  - 1960s: Marked as the beginning of true computer security
  - 1970s: Tiger teams
    - Government and industry sponsored crackers who attempted to break down defenses of computer systems in order to uncover vulnerabilities so that patches can be developed
  - 1970s: Research and modeling
    - Identifying security requirements
    - Formulating security policy models
    - Defining guidelines and controls
    - Development of secure systems
  - Standardization
    - 1985: Orange Book for Security Evaluation (or TCSEC - Trusted Computer System Evaluation Criteria) - Chapter 7
      - Describes the evaluation criteria used to assess the level of trust that can be placed in a particular computer system
    - 1978: DES selected as encryption standard by the US

- Legal Issues
  - In the US, legislation was enacted with regards to computer security and privacy starting from late 1960s
  - The European Council adopted a convention on Cyber-crime in 2001
  - The World Summit for Information Society considered computer security and privacy as a subject of discussion in 2003 and 2005
  - In Ethiopia
    - The Ethiopian Penal Code of 2005 has articles on data and computer related crimes
    - Computer Crime Proclamation 2016

1.3 Computer Security Controls

- Security controls refer to mitigation techniques to achieve security goals (prevention, detection, recovery)

a. Authentication (Password, Card, Biometrics) - For Prevention



(What the entity knows, has, is!)

- Authentication is the binding of an identity to a subject
- An entity must provide information to enable the system to confirm its identity. This information comes from one (or a combination) of the following
  - What the entity knows (such as passwords or secret information)
    - User name: serves to identify user data stored in the system
    - Password: establishes authenticity
      - Password file contains not passwords, but their hash values (see later in Chapter 3)

- What the entity has (such as a badge or card)
- What the entity is (such as fingerprints or retinal characteristics - Biometrics)
  - Such attributes are suitable for biometric identification if the following requirements are met:
    - Pervasiveness: everybody has this attribute
    - Uniqueness: any two people differ in their values of this attribute
    - Permanence: attribute value does not change with time
    - Measurability: attribute can be measured
  - Biometric system practices pattern recognition or comparison
    - Attributes of a human are measured, and the measured data are compared with stored data

- The goal is either
  - verification: is it actually Alice? (comparison with Alice's stored data - typically for authentication) or
  - identification: who is it? - typically for fighting crime
- Practical Systems

(a) Fingerprint system for computer authentication

(b) Fingerprint system for authentication of customers, prior to charging a credit card

(c) Lock with fingerprint system

- Benefits with biometrics as opposed to passwords
  - Simple and intuitive usage
  - Forgery is difficult
  - No oblivion (not forgettable like passwords), loss, theft
  - The user must be present for authentication

b. Encryption - For Prevention and Detection

c. Auditing - For Recovery

- Auditing is essential for recovery and accountability
- Auditing is the process of analyzing systems to determine what actions took place and who performed them; It is the analysis of log records to present information about the system in a clear and understandable manner
- Logging is the basis for most auditing; It is the recording of events or statistics to provide information about system use and performance

d. Administrative procedures - For Prevention, Recovery and Deterrence

e. Standards and Best Practices - For Prevention

f. Physical Security - For Prevention

g. Laws - For Deterrence

h. Intrusion Detection/Prevention Systems - For Detection/Prevention

i. Software Patches - For Prevention

j. Anti-malware - For Prevention

k. Access Control Technologies (Firewalls, Authentication and Authorization Technologies) - For Prevention

- The Human Factor
  - The human factor is an important component of computer security
  - Some organizations view technical solutions as “their only solutions” for computer security
    - Technology is fallible (imperfect)
      - e.g., UNIX holes that opened the door for Morris worm
    - The technology may not be appropriate
      - e.g., It is difficult to define all the security requirements and find a solution that satisfies those requirements
    - Technical solutions are usually (very) expensive
      - e.g., Antivirus
  - Given all these, someone, a human, has to be there to implement the solution

- Competence of the security staff
  - e.g., Crackers may know more than the security team
- Understanding and support of management
  - e.g., Management does not want to spend money on security; difficult to convince them based on Return on Investment (ROI); a better approach is to view this investment as insurance
- Staff's discipline to follow procedures
  - e.g., Staff members choose simple passwords
- Staff members may not be trustworthy
  - e.g., Bank theft

1.4 Physical Security

“The most robustly secured computer that is left sitting unattended in an unlocked room is not at all secure !!” [Chuck Easttom]

- Physical security is the use of physical controls to protect premises, site, facility, building or other physical asset of an organization [Lawrence Fennelly]
- Physical security protects your physical computer facility (your building, your computer room, your disks and other media) [Chuck Easttom]
- Physical security was overlooked in the past few years by organizations because of the emphasis placed on improving cyber security

- In the early days of computing, physical security was simple because computers were big, standalone, expensive machines
  - It was almost impossible to move them (not portable)
  - They were very few and it is affordable to spend on physical security for them
  - Management was willing to spend money
  - Everybody understands and accepts that there is restriction

- Today
  - Computers are more and more portable (PC, laptop, Smart phone)
  - There are too many of them to have good physical security for each of them
  - They are not “too expensive” to justify spending more money on physical security until a major crisis occurs
  - Users don’t accept restrictions easily
  - Accessories (e.g., network components) are not considered as important for security until there is a problem
  - Access to a single computer may endanger many more computers connected through a network

$\Rightarrow$ Physical security is much more difficult to achieve today than some decades ago

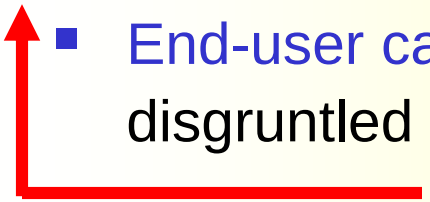
1.4.1 Types of Vulnerabilities

- Physical vulnerabilities (e.g., Buildings)
- Natural vulnerabilities - disasters (e.g., Earthquake)
- Hardware and Software vulnerabilities (e.g., Failures)
- Media vulnerabilities (e.g., Disks can be stolen)
- Communication vulnerabilities (e.g., Wires can be tapped)
- Inherent Technological weaknesses: Computer and network technologies have intrinsic security weaknesses. These include TCP/IP protocol weaknesses, operating system weaknesses, and network equipment weaknesses

Not in the area of physical security

- Configuration weaknesses: These include mis-configured hardware or software and poor network design. The major ones are the following.
  - Unsecured user accounts: User account information might be transmitted insecurely across the network, exposing usernames and passwords to snoopers
  - System accounts with easily guessed passwords: This problem is the result of poorly selected and easily guessed user passwords

- Security policy weaknesses
  - Lack of written security policy: A policy that is not written cannot be consistently applied or enforced
  - Software and hardware installation and changes do not follow policy: Unauthorized changes to the network topology or installation of unapproved applications create security holes
  - Disaster recovery plan nonexistent: Lack of a disaster recovery plan creates chaos, panic, and is a cause for confusion to occur when someone attacks the organization
- End-user carelessness and intentional end-user acts (that is, disgruntled employees or the insider threat)



- **Some of the vulnerabilities in brief**

1. Natural Disasters

   a. Fire and smoke

      - Fire can occur anywhere
      - Solution – Minimize risk
        - Good policies: No Food and Drinks, No Smoking, etc.
        - Fire extinguisher, good procedure and training
        - Fireproof cases (and other techniques) for backup tapes
        - Fireproof doors

b. Climate

- Heat
- Direct sun
- Humidity
- Hurricane, storm, cyclone
- Earthquakes
- Water
  - Flooding can occur even when a water tap is not properly closed
- Electric supply
  - Voltage fluctuation (Solution: Voltage regulator)
- Lightning

Avoid having servers in areas often hit by Natural Disasters!

2. People
   - Intruders
     - Thieves
     - People who have been given access unintentionally by insiders
     - Employees, contractors, etc., who have access to the facilities
   - External thieves
     - Portable computing devices can be stolen outside the organization’s premises
3. Loss of a computing device
   - Mainly laptop

1.4.2 Safe Area

- Safe area is often a locked place where only authorized personnel can have access
- Organizations usually have safe area for keeping computers and related devices
- Challenges
  - Is the area inaccessible through other opening (window, roof-ceilings, ventilation hole, etc.)?
    - Design of the building with security in mind
    - Know the architecture of your building
  - During opening hours, is it always possible to detect when an unauthorized person tries to get to the safe area?
    - Surveillance/guards, video-surveillance, automatic doors with security code locks, alarms, etc.
    - Put signs so that everybody sees the safe area

- Are the locks reliable?
  - The effectiveness of locks depends on the design, manufacture, installation and maintenance of the keys
  - Among the attacks on locks are
    - Illicit keys
      - Duplicate keys
        - Avoid access to the key by unauthorized persons even for a few seconds
        - Change locks/keys frequently
        - Key management procedure
      - Lost keys
        - Notify responsible person when a key is lost
        - There should be no label on keys
    - Circumventing of the internal barriers of the lock
      - Directly operating the bolt completely bypassing the locking mechanism which remains locked
    - Forceful attacks
      - Punching, Drilling, Hammering, etc.

- Surveillance with Guards
  - The most common in Ethiopia
  - Not always the most reliable since it adds a lot of human factor
  - Expensive in terms of manpower requirement
  - Not always practical for users (employees don’t like to be questioned by guards wherever they go)

- Surveillance with Video
  - Use of Closed Circuit Television (CCTV) that started in the 1960s
  - Became more and more popular with the worldwide increase of theft and terrorism
  - Advantages
    - A single person can monitor more than one location
    - The intruder doesn’t see the security personnel
    - It is cheaper after the initial investment
    - It can be recorded and be used for investigation
    - Since it can be recorded the security personnel are more careful
    - Today’s digital video surveillance can use advanced techniques such as face recognition to detect terrorists, wanted people, etc.
  - Drawback
    - Privacy concerns

1.4.3 Internal Human Factor - Personnel

- Choose employees carefully
  - Personal integrity should be as important a factor in the hiring process as technical skills
- Create an atmosphere in which the levels of employee loyalty, morale, and job satisfaction are high
- Remind employees, on a regular basis, of their continuous responsibilities to protect the organization's information
- Establish procedures for proper destruction and disposal of obsolete programs, reports, and data
- Act defensively when an employee must be discharged, either for cause or as part of a cost reduction program
  - Such an employee should not be allowed access to the system and should be carefully watched until s/he leaves the premises
  - Any passwords used by a former employee should be immediately disabled

- Guard Against Disgruntled Employees and Angry Former Employees
  - Many organizations have suffered damage by disgruntled employees or angry former employees. This is often referred to as the insider threat, or former insider threat
  - In situations where employees plan to do damage to the facilities or equipment of an organization, they have several advantages compared to outsiders who want to inflict physical damage
    - Knowledge of facility layout and design
    - Familiarity with the location of sensitive or expensive equipment
    - Duplicate keys that allow them easy access to buildings
    - Knowledge of access codes for alarm systems
    - The ability to gain access to buildings with the aid of a friend or relative who is still employed by the organization
    - Knowledge of organizational habits such as shift changes or which doors are not secured during working hours

- Some basic steps that can be taken to reduce those advantages
  - Notify security staff when an employee has been terminated or suspended
  - When you do not have a security staff, notify all managers and supervisors when an employee has been terminated or suspended
  - Maintain strict policies on access to facilities by nonemployees, and train all employees on those policies
  - If terminated or suspended employees had been issued keys, ensure that keys are returned
  - Change the locks for which any angry former employee had keys
  - Change key codes to electronic doors immediately after an employee has been terminated or suspended
  - Disable user rights for computers or communications systems held by a former or suspended employee