CISC 7320X - COMPUTER SECURITY

Introduction

CISC 7320X - Computer Security

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  Ingersol room 2156A
- Book:
  - Charles P. Pfleeger, Shari Lawrence Pfleeger and Jonathan Margulies, *Security in Computing,* 5th edition, Prentice Hall imprint, Pearson Education, Inc., 2015

Course Structure

- Assignment+ project - 33%
  - Done individually or in small groups
- Exams + quizzes + participation – 33%
  - Done individually
- Final exam - 34%

Class Policies

- Late homework/project: reduced credit
- Never share homework, solutions, code, etc.,
  - Don’t let any other student see them
  - Work on your own
    - unless assignment states otherwise
    - Don’t look at other students’ homework or past assignments you may find online
- Quote and properly cite references used in your work

INTRODUCTION

Class Objectives

- Define *information 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 Information?

- Meaning conveyed by a sequence of symbols
- Examples:
  - Bits
  - Alphabetic
  - Genetic sequence
- Can information be measured?
  - Yes, using information theory
    - Developed by Shannon

What is Security?

- State of being free from dangers or threats
- Protection of a person, building, organization, country against threats or crime

What is Information Security?

- The practice of protecting information by mitigating information risks
- The practice of defending information from unauthorized access, use, disclosure, disruption, modification, inspection, recording or destruction
-
- Wikipedia

What Is Computer Security?

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

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

FIGURE 1-2 Computer Objects of Value

What Is Computer Security?

- What is the value of the assets?
  - Is the asset easily replaced?
    - Cost of replacement.
  - Is the asset unique?

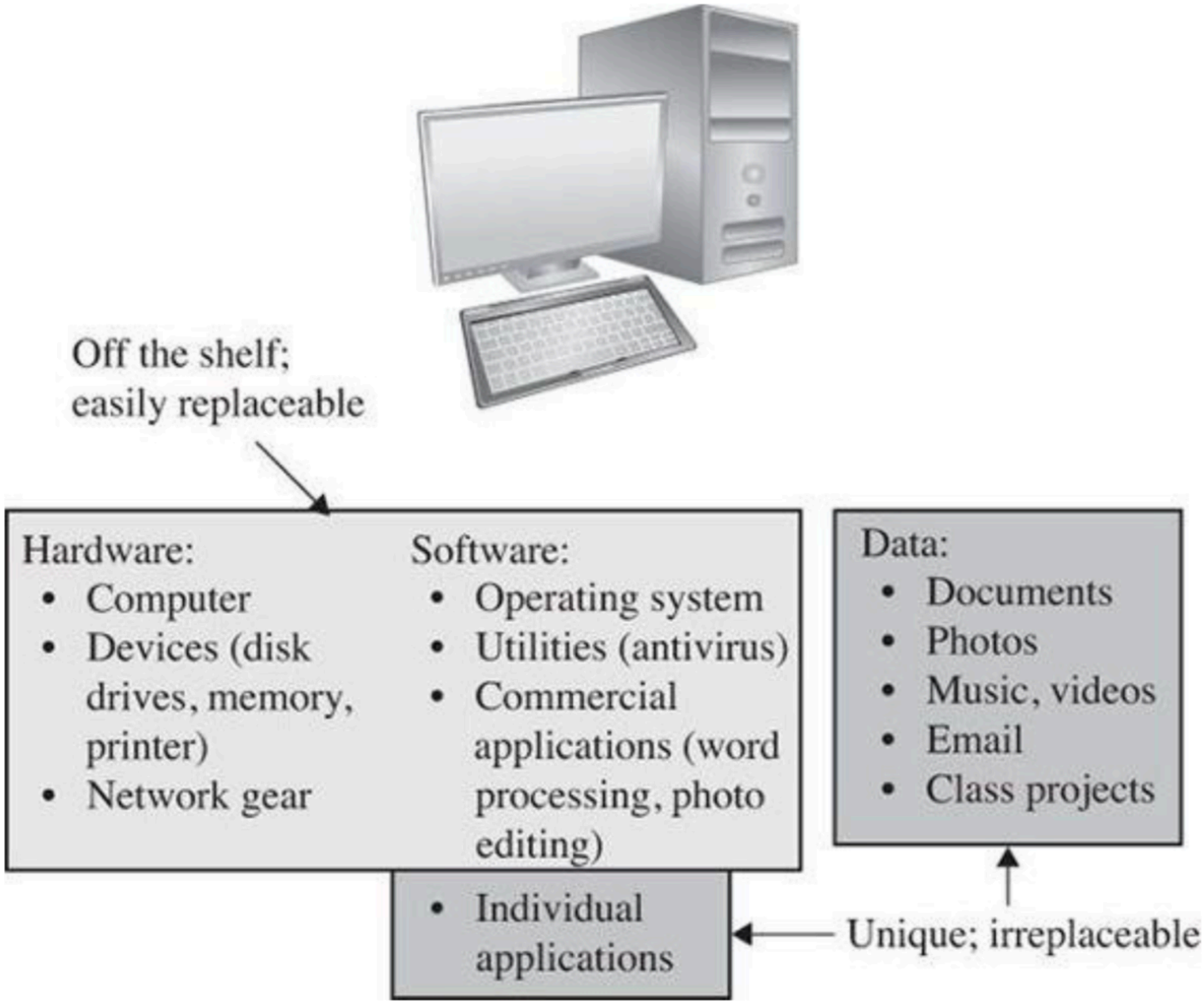

FIGURE 1-3 Values of Assets

What is Computer Security?

- Traditionally, computers are protected against:
  - Theft/damage to hardware
  - Theft/damage to information
  - Disruption of service

Growing Importance of Computer Security

- Increasing reliance on computer systems and the Internet
- Use of wireless networks such as Bluetooth and Wi-Fi
- Expanding array of smart devices
  - and ‘Internet of Things’ (IoT) devices

Why is computer security important?

- Attacks Impact everyone's day-to-day life
  - Millions of compromised computers
  - Millions of stolen passwords
    - Risk of identity theft
- Serious financial damage caused by security breaches

CYBERCRIME REPORT

FROM THE EDITORS AT CYBERSECURITY VENTURES

2017 Edition

The Official 2017 Annual Cybercrime Report is sponsored by **Herjavec Group**, a leading global information security advisory firm and Managed Security Services Provider (MSSP) with offices across the United States, Canada, and the United Kingdom. Read the Official Press Release or Download a PDF Version of the Report.

DAMAGE COSTS

Cybersecurity Ventures predicts cybercrime damages will cost the world $6 trillion annually by 2021

Cybercriminal activity is one of the biggest challenges that humanity will face in the next two decades.

– *Steve Morgan, Editor-In-Chief*

Menlo Park, Calif. — Oct. 16, 2017

Cybercrime is the greatest threat to every company in the world, and one of the biggest problems with mankind. The impact on society is reflected in the numbers.

https://cybersecurityventures.com/hackerpocalypse-cybercrime-report-2016/

NEWS

Cyber attacks cost U.S. enterprises $1.3 million on average in 2017

IT security budgets, as well the costs of data breaches, are up for North American enterprises and SMBs.

U.S. Army illustration

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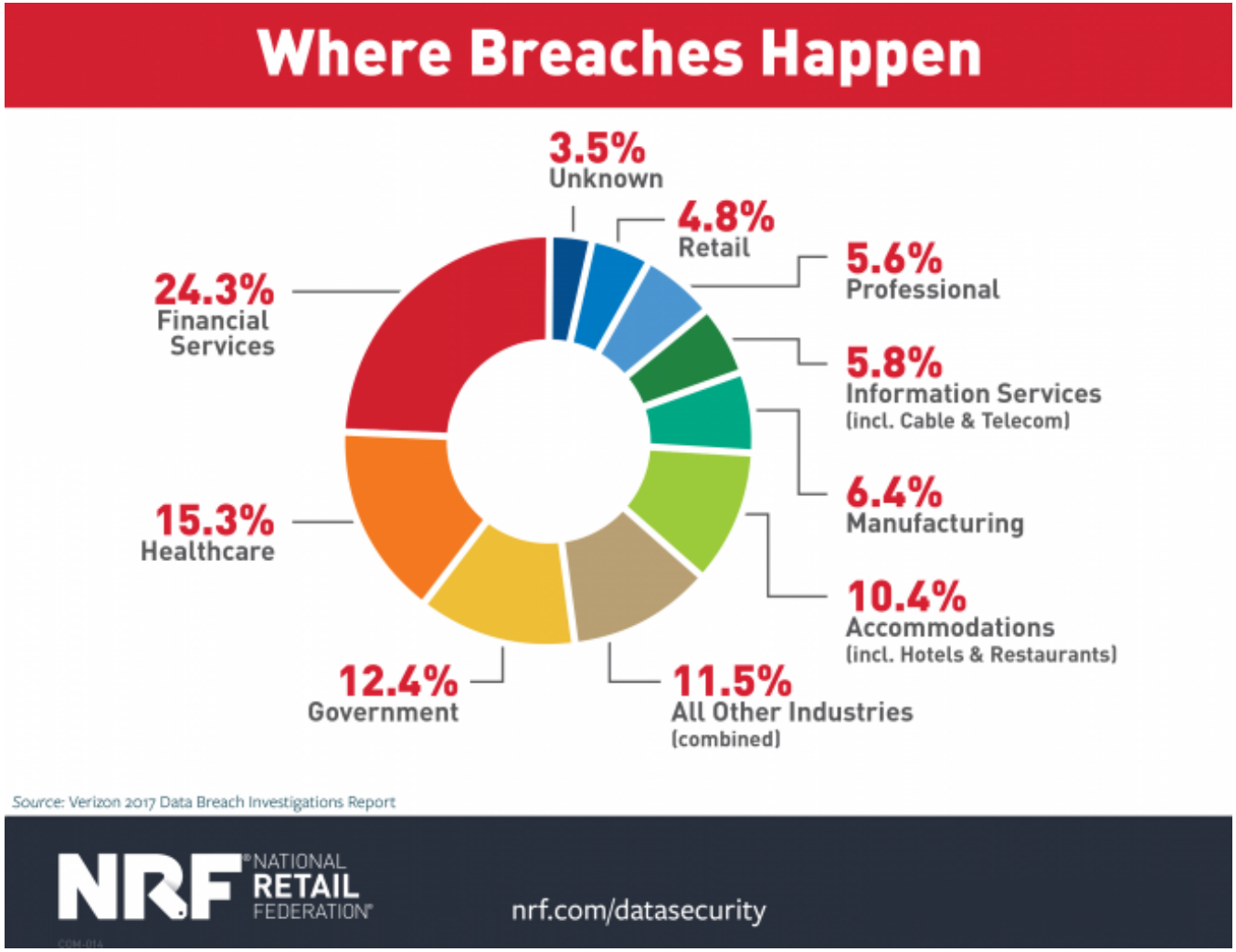

https://nrf.com/advocacy/policy-agenda/data-security

How can we help?

- Security education can help us
  - Avoid attacks
  - Create safer systems
- We start by defining risk management

What describes best ”Information”?

- A discipline developed by Claude Shannon in the 1940’s
- Data, such as census, medical or readings from sensors etc.
- A sequence of symbols that convey some meaning in a given context
- Documents such as books, the content on the World Wide Web (WWW) etc

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FUNDAMENTAL CONCEPTS

Computer Network

- A digital telecommunications network which allows nodes to share resources
- Networked computing devices exchange data with each other using a data link
- The connections between nodes are established using either cable media or wireless media

https://nizamtaher.wordpress.com/topics/topic-1-introduction-of-computer-network/

Cyber Vulnerabilities

- **Vulnerability** is a **cyber**-security term that refers to a flaw in a system
  - can leave it open to attack.
- May refer to any type of weakness in a computer system itself
  - Either in a set of procedures, or in anything that leaves information security exposed to a threat
- Cutting down vulnerabilities provides fewer options for malicious users to gain access to secure information.

https://www.techopedia.com/definition/13484/vulnerability
http://blog.escanav.com/2014/06/vulnerabilities-recorded-by-us-cert-cyber-security-bulletin/

Threats, Attacks and Controls

- A ***threat*** to a computing system is a set of circumstances with potential to cause loss or harm
  - Vulnerabilities make threat outcome possible
- A human who exploits a vulnerability perpetrates an ***attack*** on the system
- A ***control*** is an action, device, procedure, or technique that removes or reduces a vulnerability

Threats, Attacks and Controls

- ***Controls*** prevent ***threats*** from exercising vulnerabilities.
- A ***threat*** is blocked by control of a ***vulnerability***

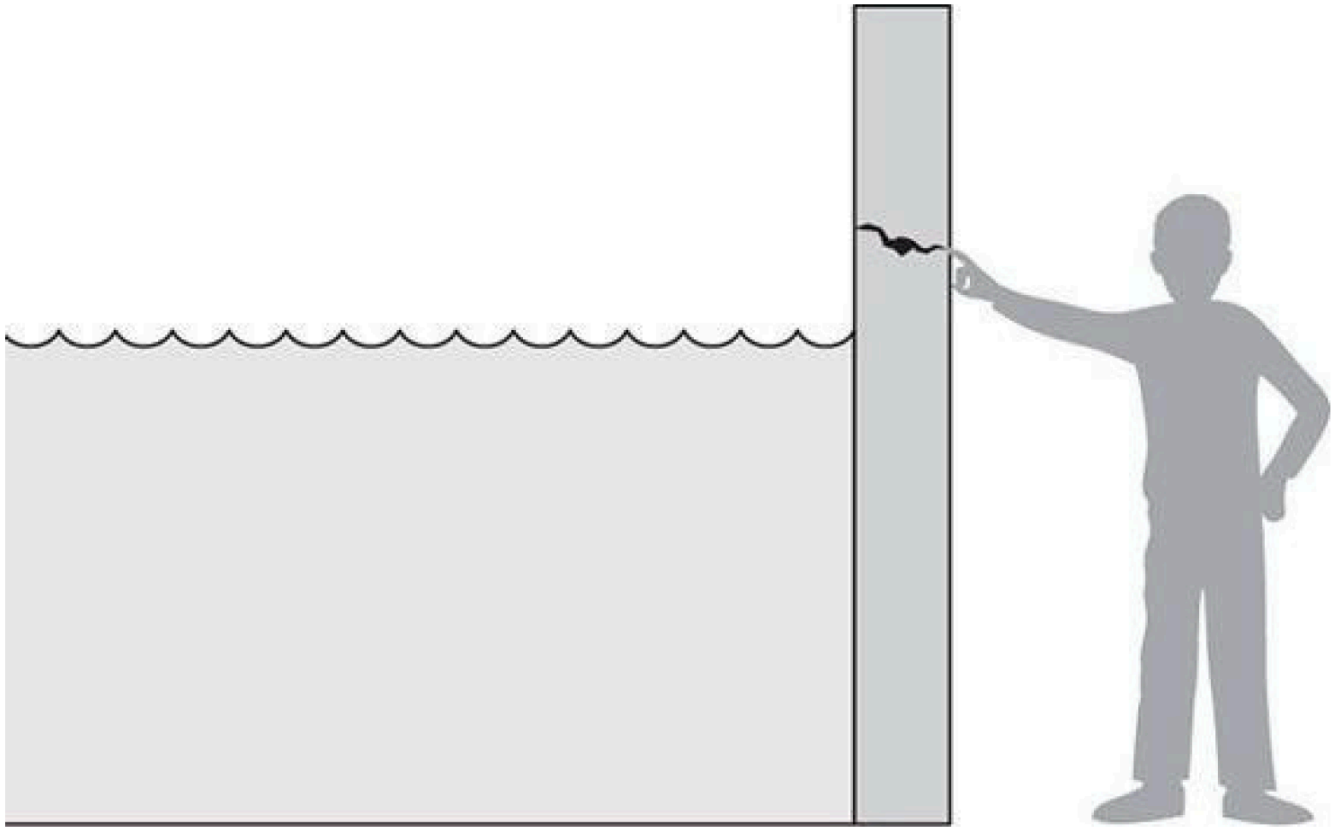


FIGURE 1-4 Threat and Vulnerability

Threats and Vulnerabilities

- Example: A crack in the wall, man standing next to wall
- ***Vulnerability*** is the crack
- ***Threat*** is that the man will drown if the water level rises

Zero-Day Vulnerability

- A vulnerability that is not known to the software developer or vendor
- However, it is known to the attacker
- Name refers to the number of days the developer had to fix the problem
  - Zero days

Exploit

- Software that is used to take advantage of a security bug or a vulnerability

Threat Model

- Key notion of threat model:
  - what/who are you defending against?
    - Determines which defenses to consider
      - E.g., where are valuable assets stored, where is the system most vulnerable to attacks, etc.

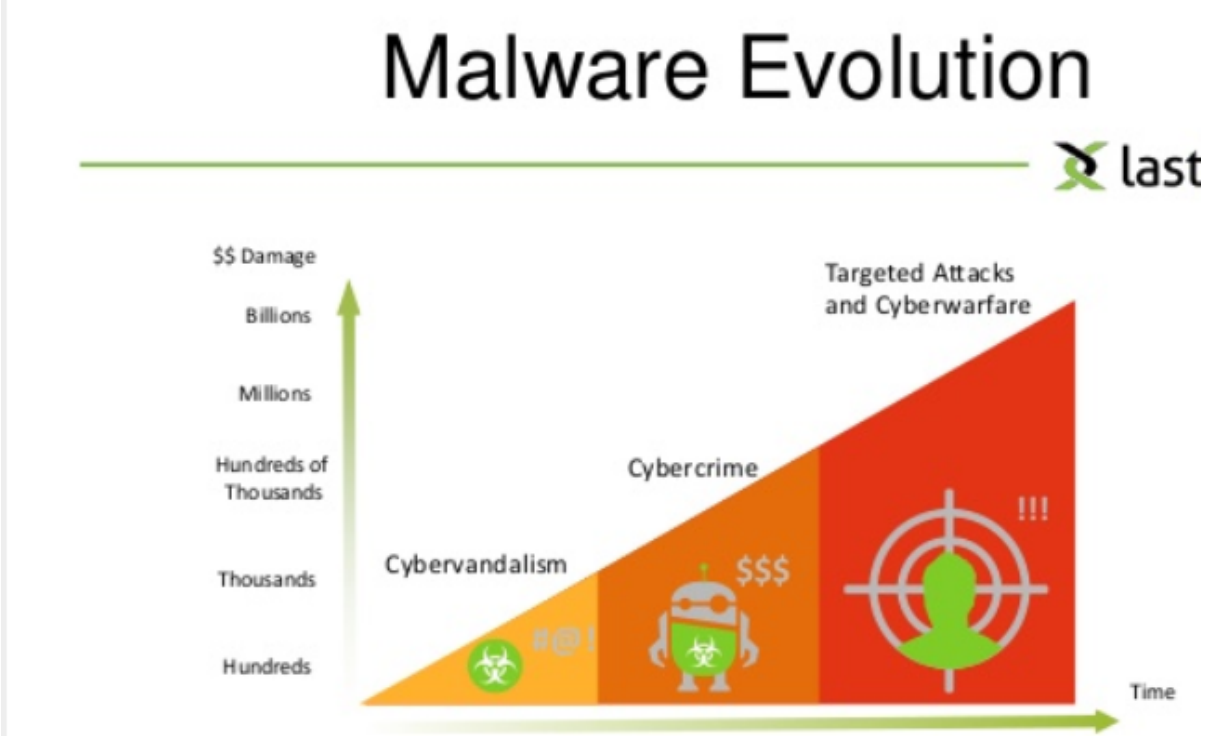
SECURITY THREATS

Security Threats History

- 1990's: fewer attacks, attackers gained fame,
  - Some attacks accidental,
- late 2000's: financially motivated
  - pharmaceuticals, credit card theft, identity theft
  - Phishing evolved into spear-phishing
    - More targeted form of attack
    - Uses target personal information to impersonate a trusted source
- 2010's: politically motivated
  - Government actors: Stuxnet, Flame, Aurora
  - Private activism: Anonymous, Wikileaks

Security Threats History

- Threats Have Evolved
  - Attackers have become more sophisticated;
- Arms race between attackers and defenders fuels rapid innovation in malware
- Many attacks aim for profit
  - are facilitated by a well-developed “underground economy” or cyber-crime organizations



https://www.slideshare.net/lastlinesecurity/ip-expo-oct-2014

How to protect from loss, destruction and illegal access

- Identify vulnerabilities – weaknesses that can be exploited to cause harm
- Monitor for threats – methods or situations that can cause harm
- Recognize an attack that exploits the vulnerabilities
- Take countermeasures or use methods to control an attack

Conclusions

- To protect computer systems, you must know your enemy
- Security is not about perfection: it's about defenses that are good enough to stop the threats you're likely to encounter

CONFIDENTIALITY, INTEGRITY AND AVAILABILITY (C.I.A.)

Confidentiality

- Avoidance of the unauthorized disclosure of information
  - Protect data, keep information secret
  - Provide access only to authorized users

Confidentiality

- How secure is the information?
  - How secure does it need to be?
- Example:
  - Information on our course website
    - Public for everyone to see
  - Personal information
    - Some method of protection should be used

Confidentiality

- Examples of failure of data confidentiality:
  - An unauthorized person accesses a data item.
  - An unauthorized process or program accesses a data item.
  - A person authorized to access certain data accesses other data not authorized
    - specialized version of “an unauthorized person accesses a data item

Confidentiality

- Examples of failure of data confidentiality (cont.):
  - An unauthorized person accesses an approximate data value
    - E.g., knowing that someone's salary falls in a particular range
      - But not knowing someone's exact salary
  - An unauthorized person learns the existence of a piece of data
    - E.g., knowing that a company is developing a certain new product

Tools to ensure confidentiality

- Encryption:
  - Information encrypted using a secret key
  - Transformed info can be read using decryption key
    - Info essentially can not be read without this key
- Access Control:
  - Policies that limit access to confidential info
    - To people/systems with a “need to know”
    - May be based on person’s id, name or his role

Tools to ensure confidentiality (cont.)

- Authentication:
  - Determination of someone's ID or role
  - Maybe based on:
    - Something that the person has
      - Smart card, radio key, etc.
    - Something the person knows:
      - Password, etc
    - A physical trait of a person:
      - Fingerprints, etc.

Tools to ensure confidentiality (cont.)

- Authorization:
  - Is the person allowed access to the info?
    - Based on access control policy
  - Mechanism should be secure, prevent an attacker from tricking the system and gaining unauthorized access

Tools to ensure confidentiality (cont.)

- Physical Security:
  - Physical barriers that limit access to protected info
    - Such as locks, cabinets, doors.
    - Placing a computer in a windowless room.
    - Building a Faraday cage to prevent electromagnetic signals
      - To prevent side-channel attacks

Integrity

- Ensure information has not been altered in an unauthorized way
- Information may be compromised maliciously or by accident
  - Through hard drive crashes
  - Through a computer virus

Integrity

- How correct is the information?
- Has the data been modified during retrieval, in transit, or in storage?

- Failure of integrity occurs if:
  - Someone modifies the data stored or in transit
    - Unauthorized to do so

Tools to protect integrity

- ***Regular backups***
- ***Checksums***: map the content to a numerical value and save that value.
  - Read it back upon reading the information
- ***Data correcting codes***: store data in such a way that small changes can be easily detected
  - And corrected

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  - And corrected
- What do all the above tools use?
  - The above tools all use redundancy
    - Replication of some of the information content or content

Availability

- Information is available when it is needed
  - Accessible and modifiable
    - to those authorized to do so
- How much uptime is the system providing?
- Is the data accessible by users all the time?

Availability

- Tools for ensuring availability:
  - Physical protections: housing that can withstand unexpected situations
    - Such as earthquakes, storms, etc.
    - Powered with generators
  - Computational redundancies:
    - Extra disks or web servers, such that failure of a single device will not degrade availability of data

Availability

- We are looking to build systems that are reliable
  - provide service across a wide range of operating states
- A system should remain accessible to authorized users for a range of operating conditions
  - such as if under attack, or being heavily used

C-I-A Triad

- A person or system can do three basic things with a data item: view it, modify it, or use it
  - Viewing relates to confidentiality
    - Only authorized users can view data
  - Modifying relates to integrity
    - Is the data correct
  - Using relates to availability
    - Can I access the data

C-I-A Triad - Summary

- Confidentiality – only those individuals or accounts who have permission can access a system.
- Integrity – a system or account can be altered only by authorized users
- Availability – a system/account is available when expected

C-I-A Triad

- C-I-A

Approaches to CIA

- We may have different priorities
  - We may have high Integrity and Confidentiality
    - But low availability
      - I.e., data kept secret and integrity secure, but not easily available
    - High Integrity, Availability and low Confidentiality
      - Example?
        - An ad on a website
- So not all aspects may be equally important in any scenario

SOME QUESTIONS

A message has integrity if:

- Is is authenticated
- It is verifiably unaltered
- It contains the sender's handwritten signature
- It contains the truth

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A third party (e.g. a spy) is not able to read a message when:

- The message is sent with integrity
- The message is sent using a nonrepudiation technique
- The message has high availability
- The message is using a cryptographic protocol to implement confidentiality

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THREATS AND ATTACKS

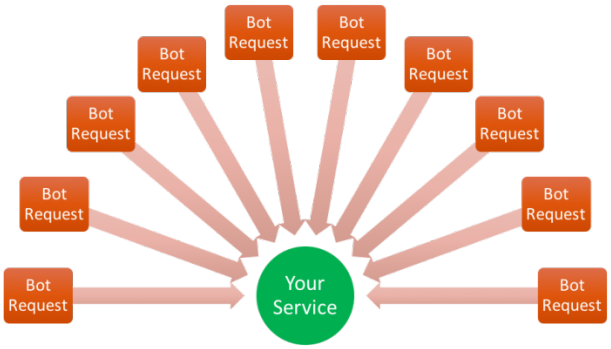
Threats and Attacks

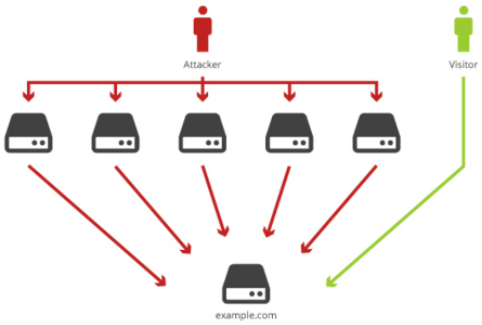
- Eavesdropping: interception of information during transmission
  - Includes side channel attacks
  - May be audio, electromagnetic, power, etc.
- Alteration: unauthorized modification of information
  - False information may be installed

http://blog.jammer-store.com/2011/09/cell-phone-spying-with-eavesdropping-trojan-danger/

Threats and Attacks (cont.)

- Denial-of-service: interruption or degradation of data or information
  - This is an attack on availability
  - For example, email spam, which fills the mailbox





https://www.cyberdominance.com/cybersecurity/your-local-supermarket-holds-the-key-to-defending-against-distributed-denial-of-service-attacks/
https://steemit.com/ddos/@clumsysilverdad/dos-and-ddos-attacks

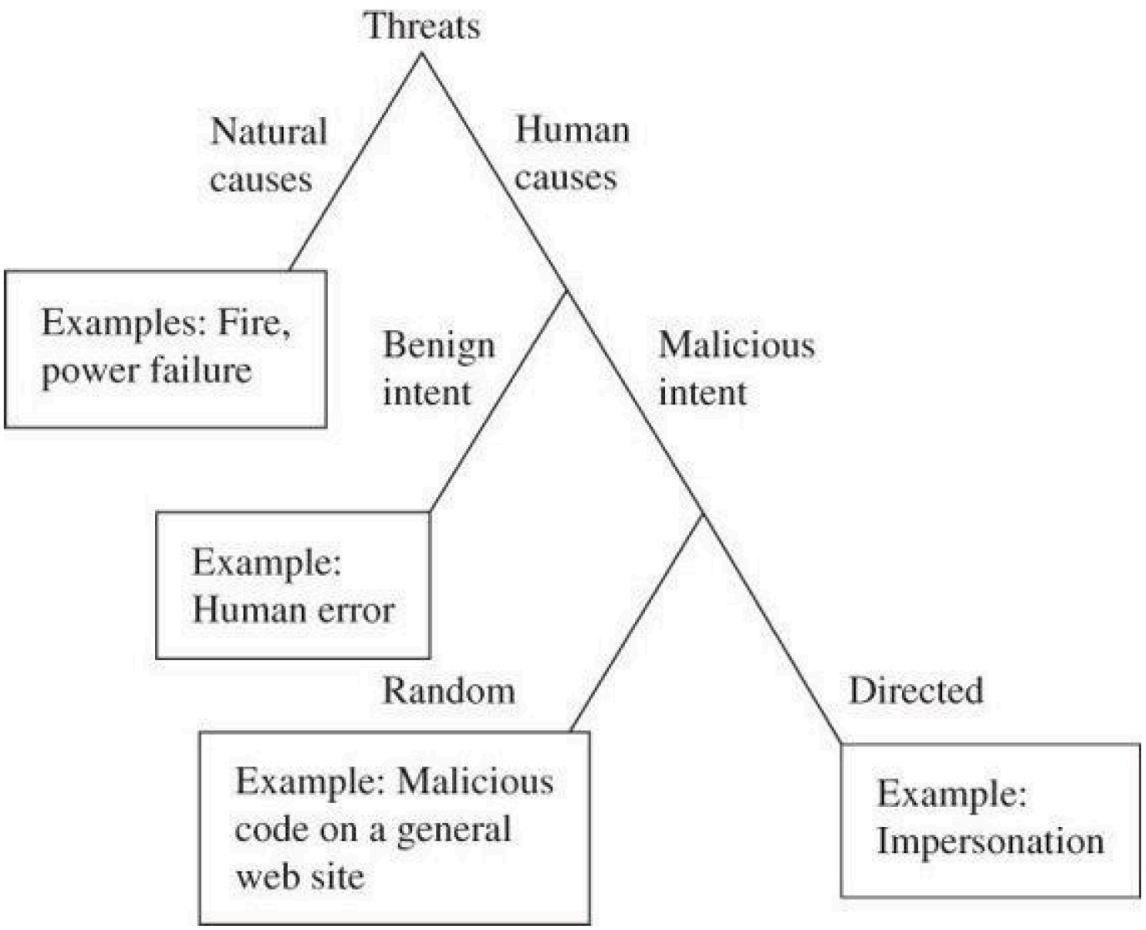
Threats and Attacks (cont.)

- Masquerading: fabrication of information, purported to be from some who is not the actual author
  - For example, phishing and spear-phishing attacks
- Repudiation: denial of commitment or data receipt
  - Attempt to back out of a contract
  - Non-repudiation = assurance that someone can not deny something

Attacks

- Attacks may be random or directed
- In a random attack, the attacker wants to harm any computer or user
- In a directed attack, the attacker intends harm to specific computers

Source of the threat



Advanced Persistent Threat (APT)

- An attack that lasts for a long period of time
  - Organized
  - Directed
  - Well financed
  - Patient
  - Silent

APT

- APT

Types of Attackers

- Individuals
  - Perpetrators of original computer attacks
  - May act with motives of fun, challenge, or revenge
- Organized, Worldwide Groups
  - More recent attacks have involved groups of people
  - heavily influenced by financial gain

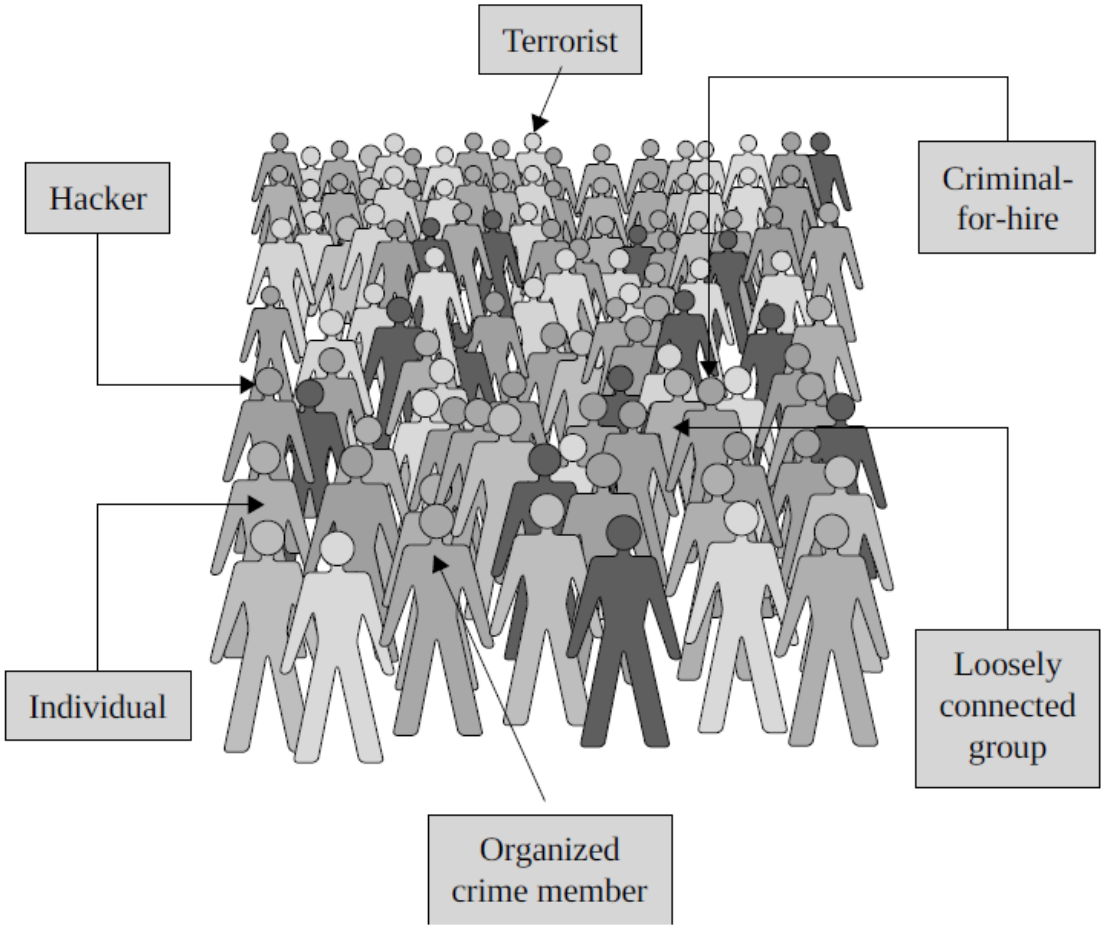
Types of Attackers

- Organized Crime
  - Organized crime groups are discovering that computer crime can be lucrative
    - goals may include fraud, extortion, money laundering, and drug trafficking
  - May use computer crime to finance other crime aspects
    - such as stealing credit card numbers or bank account details

Types of Attackers

- Terrorists may use:
  - Computer as target of attack
    - E.g. Denial of service attacks
  - Computer as method of attack
    - E.g. Stuxnet
  - Computer as enabler of attack
    - Allow people to coordinate through websites
  - Computer as enhancer of attack
    - E.g., recruit terrorists

Who are the attackers?



Vulnerabilities Databases

- http://cve.mitre.org - a list of information security vulnerabilities and exposures that aims to provide common names for publicly known cybersecurity issues.
- https://nvd.nist.gov - the U.S. government repository of standards-based vulnerability management data

How are attacks accomplished?

- Method of attack:
  - a group or individual uses their knowledge of the hardware or software to access the system
  - a group or individual downloads the information needed to access the system
- Opportunity for an attack – unsecured access or data
- Motive – why is the attack occurring

Controls

- A control or countermeasure is a means to counter threats
- What can we do to prevent potential harm?

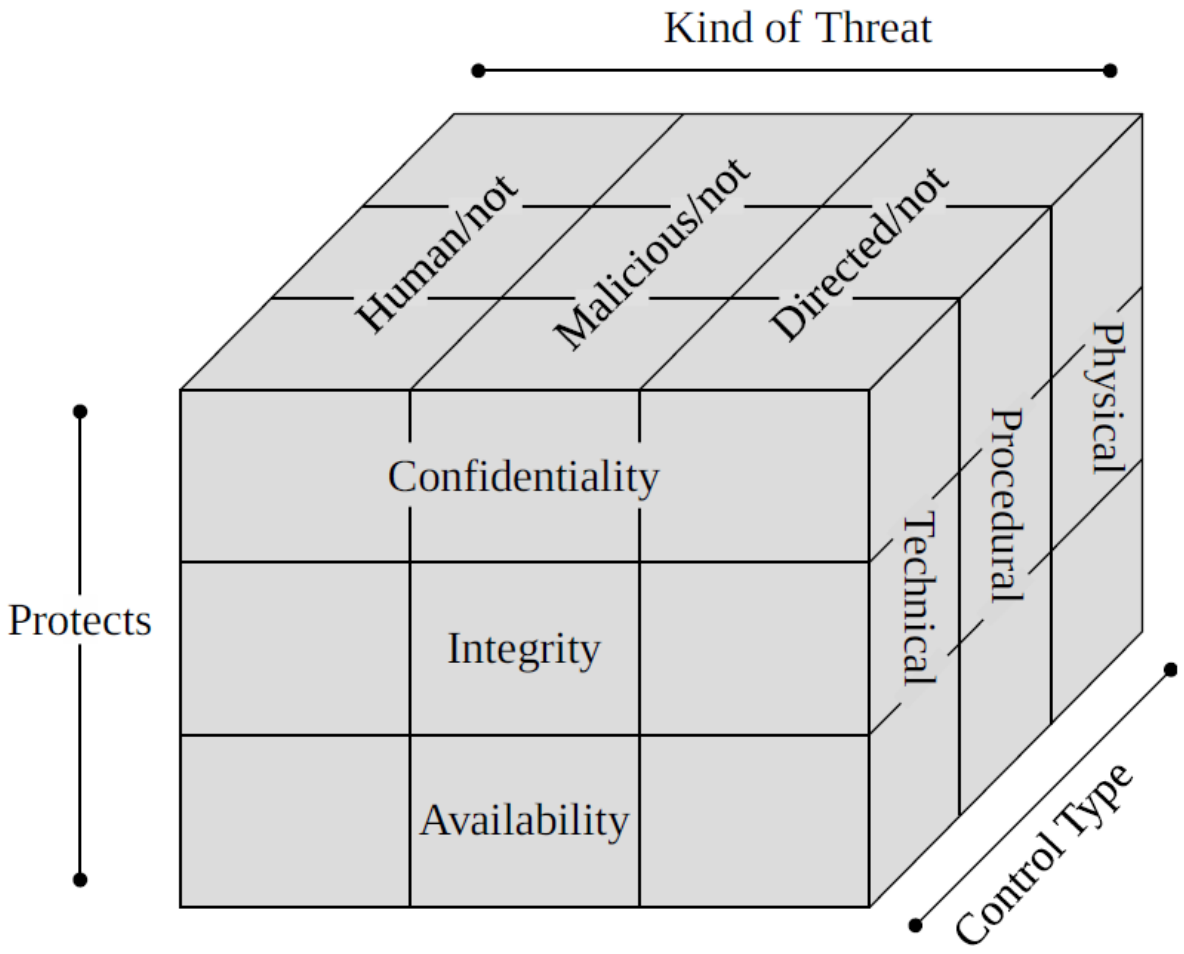
How to prevent or respond to an attack

- Block the attack or remove the vulnerability
- Make the attack harder to accomplish
- Decrease the attractiveness of the target
- Have counter measures that make the attack less severe
- Detect that an attack is in progress and take counter measures
- Have a plan to recover from an attack

Controls

- Physical controls:
  - stop or block an attack by using something tangible
    - such as walls and fences, locks, etc.
- Procedural or administrative controls
  - use a command or agreement that requires or advises people how to act
    - E.g. laws, regulations
- Technical controls counter threats with technology
  - hardware or software
    - E.g. passwords, firewall, encryption

Controls/Countermeasures



Risk Management

- Can not protect against every attack:
  - Decide what is most valuable and analyze how to protect it
  - Estimate how likely an attack is
  - What is the impact of the attack

Risk Management

- High-level goals of computer security:
  - identification, evaluation, prioritization of risks
    - Defined as a threat model
    - Estimate the effects of uncertainty
  - Not perfect protection
  - Efforts concentrate on making it harder to attack
    - Finding ways to spend time & money efficiently
    - minimize the probability or impact of unfortunate events

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

Summary

- 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

Questions?