



# 1. Introduction to Computer Security

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# Introduction to Security

## Outline

1. Examples – Security in Practice
2. What is „Security?“
3. Pillars of Security:  
Confidentiality, Integrity, Availability (CIA)
4. Vulnerabilities, Threats, and Controls
5. Attackers
6. How to React to an Exploit?
7. Methods of Defense
8. Principles of Computer Security



Information hiding  
Applications Security Negotiation  
Privacy  
Integrity Data provenance Access control Threats  
Semantic web security Biometrics  
Fraud  
Trust  
Policy making Computer epidemic Encryption  
Data mining Anonymity  
Formal models  
System monitoring  
Vulnerabilities Network security



# 1. Examples – Security in Practice

Barbara Edicott-Popovsky and Deborah Frincke, CSSE592/492, U. Washington]

## From CSI/FBI Report 2002

- 90% detected computer security breaches within the last year
- 80% acknowledged financial losses
- 44% were willing and/or able to quantify their financial losses.  
These 223 respondents reported \$455M in financial losses.
- The most serious financial losses occurred through theft of proprietary information and financial fraud:
  - 26 respondents: \$170M
  - 25 respondents: \$115M
- For the fifth year in a row, more respondents (74%) cited their Internet connection as a frequent point of attack than cited their internal systems as a frequent point of attack (33%).
- 34% reported the intrusions to law enforcement. (In 1996, only 16% acknowledged reporting intrusions to law enforcement.)



# More from CSI/FBI 2002

- 40% detected external penetration
- 40% detected denial of service attacks.
- 78% detected employee abuse of Internet access privileges
- 85% percent detected computer viruses.
- 38% suffered unauthorized access or misuse on their Web sites within the last twelve months. 21% didn't know.  
[includes insider attacks]
- 12% reported theft of transaction information.
- 6% percent reported financial fraud (only 3% in 2000).

# Critical Infrastructure Areas

- Include:

- Telecommunications
- Electrical power systems
- Water supply systems
- Gas and oil pipelines
- Transportation
- Government services
- Emergency services
- Banking and finance
- ...



## 2. What is a “Secure” Computer System?

- To decide whether a computer system is “secure”, you must first decide what “secure” *means to you*, then identify the threats you care about.

### **You Will Never Own a Perfectly Secure System!**

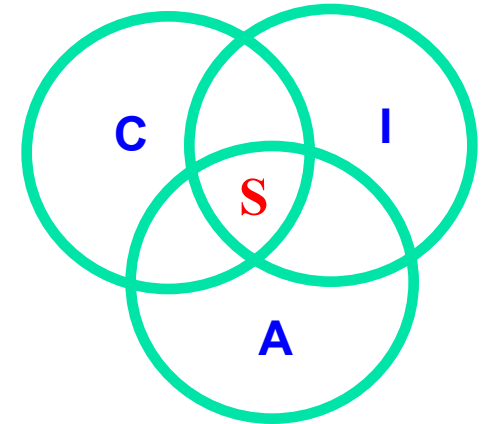
- Threats - examples
  - Viruses, trojan horses, etc.
  - Denial of Service
  - Stolen Customer Data
  - Modified Databases
  - Identity Theft and other threats to personal privacy
  - Equipment Theft
  - Espionage in cyberspace
  - Hack-tivism
  - Cyberterrorism
  - ...



# 3. Basic Components of Security: Confidentiality, Integrity, Availability (CIA)

## ■ CIA

- **Confidentiality**: Who is authorized to use data?
- **Integrity**: Is data „good?“
- **Availability**: Can access data whenever need it?



**S** = Secure

## ■ CIA or CIAAAN... 🏖️

(other security components added to

CIA)

- Authentication
- Authorization
- Non-repudiation
- ...



# Need to Balance CIA

- Example 1: C vs. I+A
  - Disconnect computer from Internet to increase confidentiality
  - Availability suffers, integrity suffers due to lost updates
- Example 2: I vs. C+A
  - Have extensive data checks by different people/systems to increase integrity
  - Confidentiality suffers as more people see data, availability suffers due to locks on data under verification)



# Confidentiality

- “Need to know” basis for data access
  - How do we know who needs what data?  
Approach: **access control** specifies *who* can access *what*
  - How do we know a user is the person she claims to be?  
Need her **identity** and need to **verify** this identity  
Approach: **identification** and **authentication**
- Analogously: “Need to access/use” basis for physical assets
  - E.g., access to a computer room, use of a desktop
- Confidentiality is:
  - difficult to ensure
  - easiest to assess in terms of success (binary in nature: Yes / No)



# Integrity

- Integrity vs. Confidentiality
  - Concerned with **unauthorized modification** of assets (= resources)  
Confidentiality - concerned with *access* to assets
  - Integrity is more difficult to *measure* than confidentiality  
**Not binary** – degrees of integrity  
**Context-dependent** - means different things in different contexts  
Could mean *any subset* of these asset properties:  
{ precision / accuracy / currency / consistency /  
          meaningfulness / usefulness / ...}
- Types of integrity—an example
  - Quote from a politician
  - Preserve the quote (data integrity) but misattribute (origin integrity)



# Availability <sup>(1)</sup>

- Not understood very well yet
  - „[F]ull implementation of availability is security's next challenge”
    - E.g. Full implementation of availability for Internet users (with ensuring security)
- Complex
  - Context-dependent
    - Could mean *any subset of* these asset (data or service) properties :
      - { usefulness / sufficient capacity /  
progressing at a proper pace /  
completed in an acceptable period of time / ... }

[Pfleeeger & Pfleeeger]



# Availability <sup>(2)</sup>

- We can say that an asset (resource) is **available** if:
  - Timely request response
  - Fair allocation of resources (no starvation!)
  - Fault tolerant (no total breakdown)
  - Easy to use in the intended way
  - Provides controlled concurrency (concurrency control, deadlock control, ...)

[Pfleeger & Pfleeger]

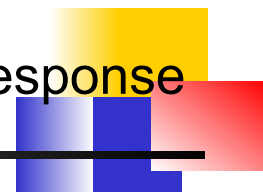


# 4. Vulnerabilities, Threats, and Controls

- Understanding Vulnerabilities, Threats, and Controls
  - **Vulnerability** = a weakness in a security system
  - **Threat** = circumstances that have a *potential* to cause harm
  - **Controls** = means and ways to block a threat, which tries to exploit one or more vulnerabilities
    - Most of the class discusses various controls and their effectiveness

[Pfleeger & Pfleeger]

- Example - **New Orleans disaster** (Hurricane Katrina)
  - Q: What were city vulnerabilities, threats, and controls?
  - A: **Vulnerabilities**: location below water level, geographical location in hurricane area, ...
    - Threats**: hurricane, dam damage, terrorist attack, ...
    - Controls**: dams and other civil infrastructures, emergency response plan, ...



- **Attack** (materialization of a vulnerability/threat combination)
    - = exploitation of one or more vulnerabilities by a threat; tries to defeat controls
      - Attack may be:
        - *Successful* (a.k.a. an *exploit*)
          - resulting in a breach of security, a system penetration, etc.
        - *Unsuccessful*
          - when controls block a threat trying to exploit a vulnerability
- [Pfleeger & Pfleeger]



# Threat Spectrum

- Local threats
  - Recreational hackers
  - Institutional hackers
- Shared threats
  - Organized crime
  - Industrial espionage
  - Terrorism
- National security threats
  - National intelligence
  - Info warriors



# Kinds of Threats

- Kinds of threats:
  - **Interception**
    - an unauthorized party (human or not) gains access to an asset
  - **Interruption**
    - an asset becomes lost, unavailable, or unusable
  - **Modification**
    - an unauthorized party changes the state of an asset
  - **Fabrication**
    - an unauthorized party counterfeits an asset
- Examples?

[Pfleeger & Pfleeger]



# Levels of Vulnerabilities / Threats

(reversed order to illustrate interdependencies)

- D) for other assets (resources)
  - including. people using data, s/w, h/w
- C) for data
  - „on top” of s/w, since used by s/w
- B) for software
  - „on top” of h/w, since run on h/w
- A) for hardware



# A) Hardware Level of Vulnerabilities / Threats

- Add / remove a h/w device
  - Ex: Snooping, wiretapping

Snoop = to look around a place secretly in order to discover things about it or the people connected with it. [Cambridge Dictionary of American English]
  - Ex: Modification, alteration of a system
  - ...
- Physical attacks on h/w => need physical security: locks and guards
  - Accidental (dropped PC box) or voluntary (bombing a computer room)
  - Theft / destruction
    - Damage the machine (spilled coffee, mice, *real* bugs)
    - Steal the machine
    - „Machinicide:” Axe / hammer the machine
    - ...



# Example of Snooping:

## Wardriving / Warwalking, Warchalking,

- **Wardriving/warwalking** -- driving/walking around with a wireless-enabled notebook looking for unsecured wireless LANs
- **Warchalking** -- using chalk markings to show the presence and vulnerabilities of wireless networks nearby
  - E.g., a circled "W" -- indicates a WLAN protected by Wired Equivalent Privacy (WEP) encryption



## B) Software Level of Vulnerabilities / Threats

- Software **Deletion**
  - Easy to delete needed software by mistake
  - To prevent this: use *configuration management software*
- Software **Modification**
  - Trojan Horses, , Viruses, Logic Bombs, Trapdoors, Information Leaks (via covert channels), ...
- Software **Theft**
  - Unauthorized copying
    - via P2P, etc.



# Types of Malicious Code

**Bacterium** - A specialized *form of virus* which does not attach to a specific file. Usage obscure.

**Logic bomb** - Malicious *[program] logic* that *activates when specified conditions are met*.

Usually intended to cause denial of service or otherwise damage system resources.

**Trapdoor** - A hidden *computer flaw known to an intruder*, or a hidden computer mechanism (usually software) installed by an intruder, *who can activate the trap door to gain access to the computer without being blocked by security services or mechanisms*.

**Trojan horse** - A computer *program that appears to have a useful function*, but also has a hidden and potentially malicious function that evades security mechanisms, sometimes by exploiting legitimate authorizations of a system entity that invokes the program.

**Virus** - A hidden, *self-replicating section of computer software*, usually malicious logic, that *propagates by infecting* (i.e., inserting a copy of itself into and *becoming part of*) *another program*. A virus cannot run by itself; it requires that its host program be run to make the virus active.

**Worm** - A computer *program* that can run independently, *can propagate a complete working version of itself* onto other hosts on a network, and may consume computer resources destructively.

**More types of malicious code exist...**

[cf. <http://www.ietf.org/rfc/rfc2828.txt>]



# C) Data Level of Vulnerabilities / Threats

- How valuable is your data?
  - Credit card info vs. your home phone number
  - Source code
  - Visible data vs. context
    - „2345” -> Phone extension or a part of SSN?
- Adequate protection
  - Cryptography
    - Good if intractable for a long time
- Threat of Identity Theft
  - Cf. Federal Trade Commission: <http://www.consumer.gov/idtheft/>



# Identity Theft

- Cases in 2003:
  - Credit card skimmers plus drivers license, Florida
  - Faked social security and INS cards \$150-\$250
  - Used 24 aliases – used false id to secure credit cards, open mail boxes and bank accounts, cash fraudulently obtained federal income tax refund checks, and launder the proceeds
  - Bank employee indicted for stealing depositors' information to apply over the Internet for loans
  - \$7M loss, Florida: Stole 12,000 cards from restaurants via computer networks and social engineering
- Federal Trade Commission:  
<http://www.consumer.gov/idtheft/>



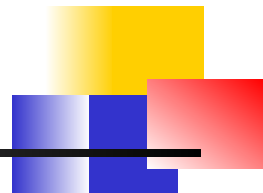
# Types of Attacks on Data CIA

- Disclosure
  - Attack on data *confidentiality*
- Unauthorized modification / deception
  - E.g., providing wrong data (attack on data *integrity*)
- Disruption
  - DoS (attack on data *availability*)
- Usurpation
  - Unauthorized use of services (attack on data *confidentiality, integrity or availability*)



# Ways of Attacking Data CIA

- Examples of Attacks on Data Confidentiality
  - Tapping / snooping
- Examples of Attacks on Data Integrity
  - Modification: salami attack -> little bits add up
    - E.g./ „shave off” the fractions of cents after interest calculations
  - Fabrication: replay data -> send the same thing again
    - E.g., a computer criminal replays a salary deposit to his account
- Examples of Attacks on Data Availability
  - Delay vs. „full” DoS
- Examples of Repudiation Attacks on Data:
  - Data origin repudiation: „I never sent it”  
Repudiation = refusal to acknowledge or pay a debt or honor a contract (especially by public authorities).  
[<http://www.onelook.com>]
  - Data receipt repudiation: „I never got it”



# D) Vulnerabilities / Threats at Other Exposure Points

## ■ Network vulnerabilities / threats

- Networks multiply vulnerabilities and threats, due to:
  - their complexity => easier to make design/implement./usage mistakes
  - „bringing close” physically distant attackers
- Esp. wireless (sub)networks

## ■ Access vulnerabilities / threats

- Stealing cycles, bandwidth
- Malicious physical access
- Denial of access to *legitimate* users

## ■ People vulnerabilities / threats

- Crucial weak points in security
  - too often, the *weakest* links in a security chain
- Honest insiders subjected to skillful **social engineering**
- Disgruntled employees



# 5. Attackers

- Attackers need MOM

- Method

- Skill, knowledge, tools, etc. with which to pull off an attack

- Opportunity

- Time and access to accomplish an attack

- Motive

- Reason to perform an attack



# Types of Attackers

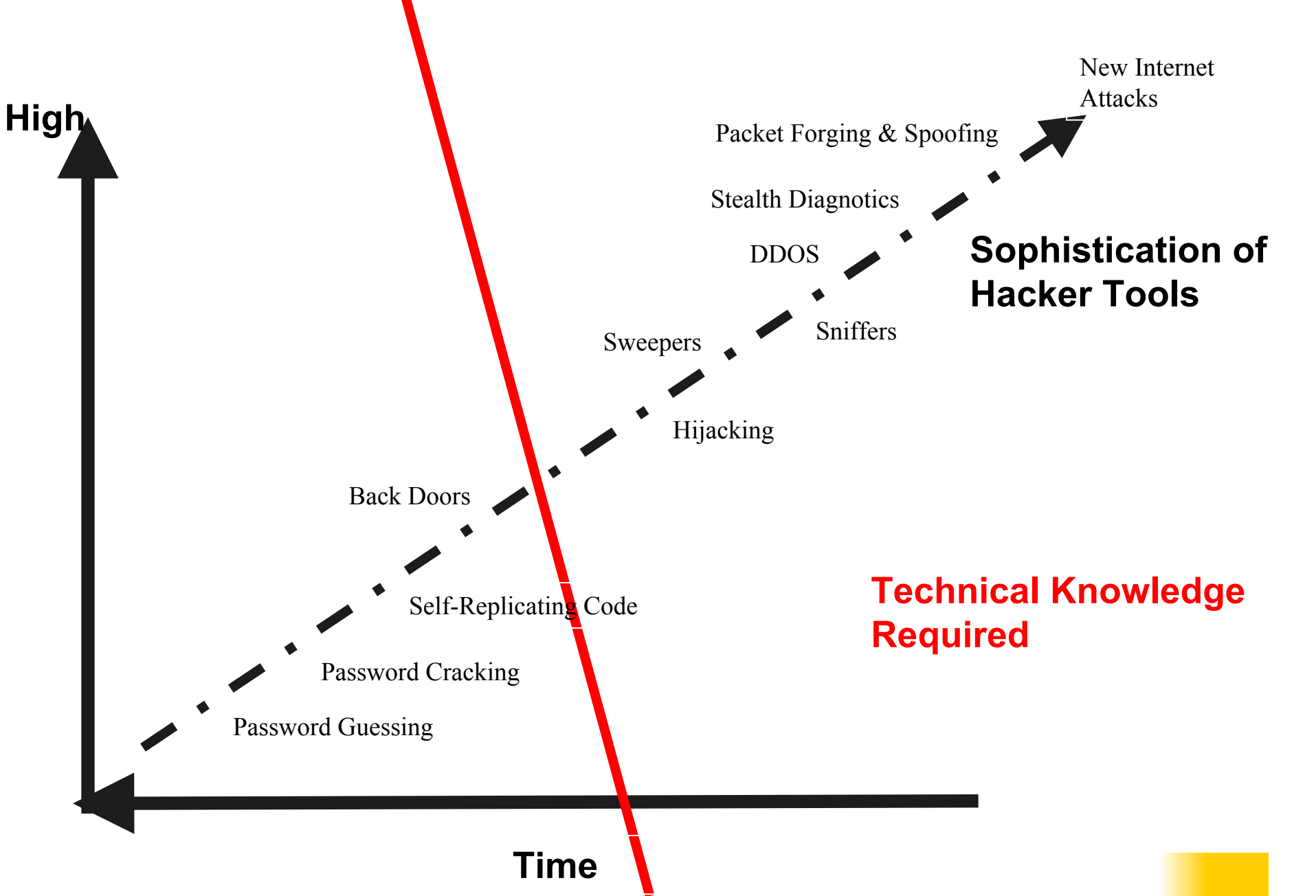
- **Types of Attackers - Classification 1**
  - **Amateurs**
    - Opportunistic attackers (use a password they found)
    - Script kiddies
  - **Hackers** - nonmalicious
    - In broad use beyond security community: also malicious
  - **Crackers** – malicious
  - Career **criminals**
  - State-supported **spies and information warriors**
  
- **Types of Attackers - Classification 2** (cf. before)
  - Recreational hackers / Institutional hackers
  - Organized criminals / Industrial spies / Terrorists
  - National intelligence gatherers / Info warriors



# Example: Hacking As Social Protest

- Hactivism
- Electro-Hippies
- DDOS attacks on government agencies
- SPAM attacks as “retaliation”





# 6. Reacting to an Exploit

Exploit = successful attack

- Report to the vendor first?
- Report it to the public?
  - What will be public relations effects if you do/do not?
- Include source code / not include source code?
- Etc.



# “To Report or Not To Report:” Tension between Personal Privacy and Public Responsibility

An info tech company will typically lose between ten and one hundred times more money from shaken consumer confidence than the hack attack itself represents if they decide to prosecute the case.

Mike Rasch, VP Global Security, testimony before the Senate Appropriations Subcommittee, February 2000 reported in The Register and online testimony transcript



# Further Reluctance to Report

- One common fear is that a crucial piece of equipment, like a main server, say, might be impounded for evidence by over-zealous investigators, thereby shutting the company down.
- Estimate: fewer than one in ten serious intrusions are ever reported to the authorities.

Mike Rasch, VP Global Security, testimony before the Senate Appropriations Subcommittee, February 2000  
reported in The Register and online testimony transcript



# Computer Forensics Against Computer Crime

- Technology
- Law Enforcement
- Individual and Societal Rights
- Judiciary
- ...



# 7. Methods of Defense

- Five basic approaches to defense of computing systems
  - Prevent attack
    - Block attack / Close vulnerability
  - Deter attack
    - Make attack harder (can't make it impossible ? )
  - Deflect attack
    - Make another target more attractive than this target
  - Detect attack
    - During or after
  - Recover from attack



# A) Controls

## ■ Castle in Middle Ages

- Location with **natural obstacles**
- Surrounding **moat**
- **Drawbridge**
- Heavy **walls**
  - Arrow slits
  - Crenellations
- Strong **gate**
  - Tower
- Guards / passwords

## ■ Computers Today

- Encryption
- Software controls
- Hardware controls
- Policies and procedures
- Physical controls



## ■ Medieval castles

- location (steep hill, island, etc.)
- moat / drawbridge / walls / gate / guards / passwords
- another wall / gate / guards / passwords
- yet another wall / gate / guards / passwords
- tower / ladders up

## ■ Multiple controls in computing systems can include:

- **system perimeter** – defines „inside/outside”
- **preemption** – attacker scared away
- **deterrence** – attacker could not overcome defenses
- **faux environment** (e.g. **honeypot**, **sandbox**) – attack deflected towards a worthless target (but the attacker doesn't know about it!)

à Note **layered defense** /

**multilevel defense** / **defense in depth** (ideal!)



# A.1) Controls: Encryption

- Primary controls!
- **Cleartext** scrambled into **ciphertext** (enciphered text)
- Protects CIA:
  - confidentiality – by „masking” data
  - integrity – by preventing data updates
    - e.g., checksums included
  - availability – by using encryption-based protocols
    - e.g., protocols ensure availability of resources for different users



# A.2) Controls: Software Controls

- Secondary controls – second only to encryption
- Software/program controls include:
  - OS and network controls
    - E.g. OS: sandbox / virtual machine
    - Logs/firewalls, OS/net virus scans, recorders
  - independent control programs (whole programs)
    - E.g. password checker, virus scanner, IDS (intrusion detection system)
  - internal program controls (part of a program)
    - E.g. read/write controls in DBMSs
  - development controls
    - E.g. quality standards followed by developers
      - incl. testing



- Considerations for Software Controls:
  - Impact on user's interface and workflow
    - E.g. Asking for a password too often?



# A.3) Controls: Hardware Controls

- Hardware devices to provide higher degree of security
  - Locks and cables (for notebooks)
  - Smart cards, dongles, hardware keys, ...
  - ...



# A.4) Controls: Policies and Procedures

- Policy vs. Procedure
  - **Policy**: *What* is/what is not allowed
  - **Procedure**: *How* you enforce policy
- Advantages of policy/procedure controls:
  - Can replace hardware/software controls
  - Can be least expensive
    - Be careful to consider *all* costs
      - E.g. help desk costs often ignored for passwords (=> look cheap but might be expensive)



- Policy - must consider:
  - Alignment with users' legal and ethical standards
  - Probability of use (e.g. due to inconvenience)
    - Inconvenient: 200 character password,  
change password every week
    - (Can be) good: biometrics replacing passwords
  - Periodic reviews
    - As people and systems, as well as their goals, change



# A.5) Controls: Physical Controls

- Walls, locks
- Guards, security cameras
- Backup copies and archives
- Cables and locks (e.g., for notebooks)
- Natural and man-made disaster protection
  - Fire, flood, and earthquake protection
  - Accident and terrorism protection
- ...



# B) Effectiveness of Controls

- Awareness of problem
  - People convinced of the need for these controls
- Likelihood of use
  - Too complex/intrusive security tools are often disabled
- Overlapping controls
  - >1 control for a given vulnerability
    - To provide layered defense – the next layer compensates for a failure of the previous layer
- Periodic reviews
  - A given control usually becomes less effective with time
  - Need to replace ineffective/inefficient controls with better ones



# 8. Principles of Computer Security

[Pfleeger and Pfleeger]

- **Principle of Easiest Penetration** (p.5)

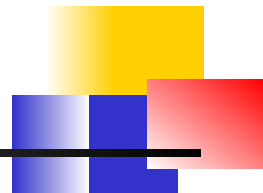
An intruder must be expected to use any available means of penetration.

The penetration may not necessarily be by the most obvious means, nor is it necessarily the one against which the most solid defense has been installed.

- **Principle of Adequate Protection** (p.16)

Computer items must be protected to a degree consistent with their value and only until they lose their value.

[modified by LL]



- **Principle of Effectiveness** (p.26)

Controls must be used—and used properly—to be effective.

They must be efficient, easy to use, and appropriate.

- **Principle of Weakest Link** (p.27)

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.



# End of Section 1: Introduction

