Computer Security

Chapter 1: Overview

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Focus: Three Fundamental Questions

- What assets do we need to protect?
- How are those assets threatened?
- What can we do to counter those threats?

Outline

- Computer Security Concept
- Threats, Attacks, and Assets
- Security Functional Requirements
- Fundamental Security Design Principles
- Attack Surfaces and Attack Trees
- Computer Security Strategy

Computer Security Concepts

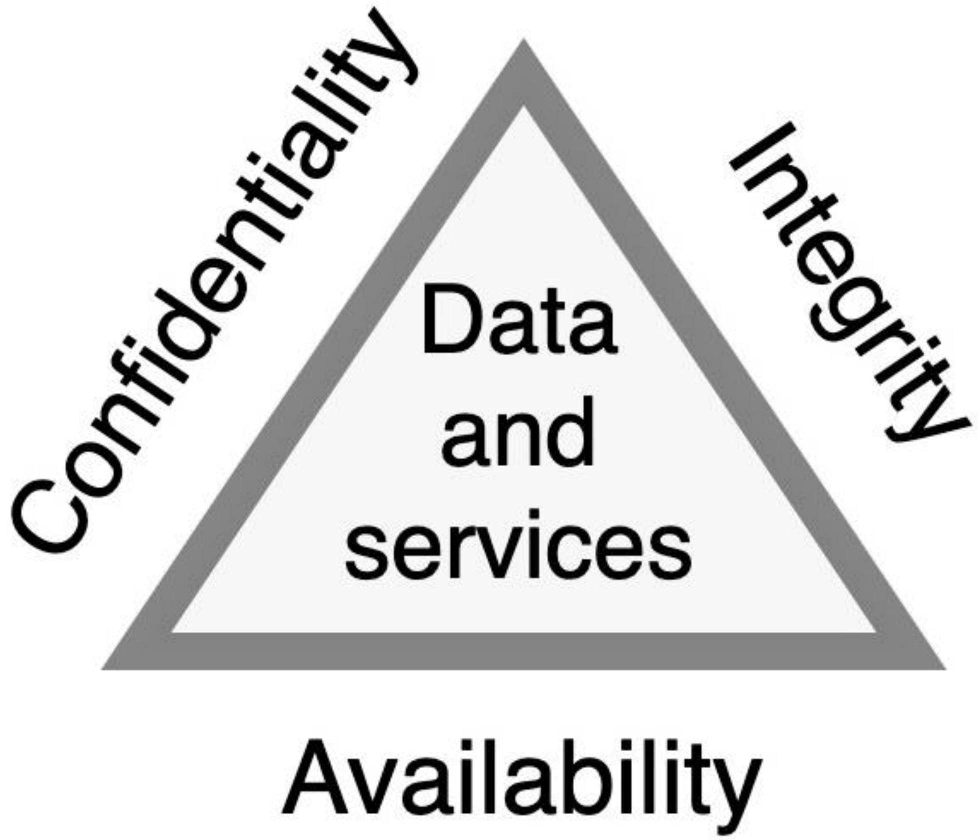
- Definition of Computer Security

Measures and controls that ensure ***confidentiality***, ***integrity***, and ***availability*** of information system assets including hardware, software, firmware, and information being processed, stored, and communicated.

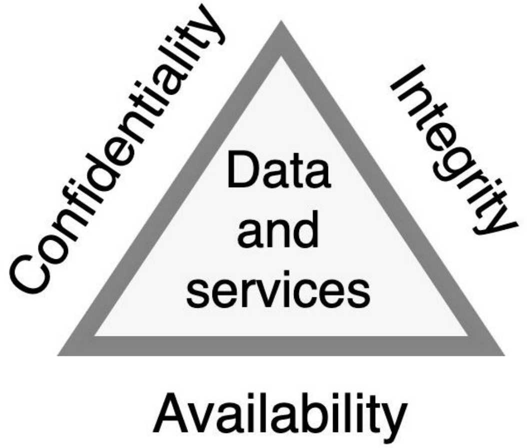
By the NIST Internal/Interagency Report (NISTIR) 7298
(Glossary of Key Information Security Terms, May 2013)

NIST (National Institute of Standards and Technology): a US federal agency that deals with measurement science, and technology related to US government use.

CIA Triad: Three Key Objectives

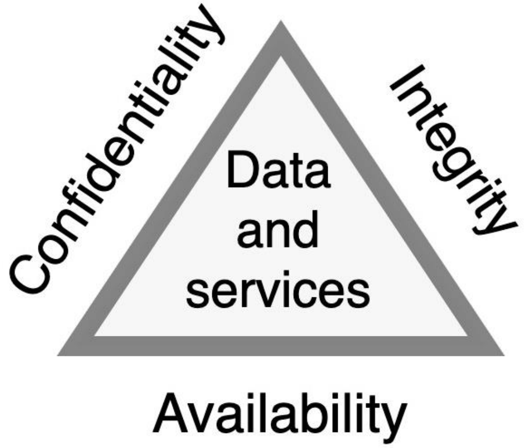


Confidentiality



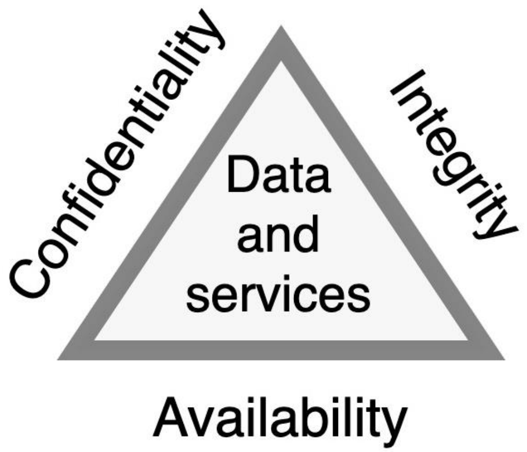
- Assurance
  - **Data confidentiality**: private or confidential info is not disclosed to unauthorized individuals
  - **Privacy**: individuals control or influence what information related to them may be collected and stored
- Requirements
  - Preserving authorized restrictions on information access and disclosure
  - Including means for protecting personal privacy and proprietary info
- Definition of loss
  - Unauthorized disclosure of information

Integrity



- Assurance
  - **Data integrity**: information and programs are changed only in a specified and authorized manner
  - **System integrity**: a system performs its intended function in an unimpaired manner
- Requirements
  - Guarding against improper info modification or destruction
  - Including ensuring info non-repudiation and authenticity
- Definition of loss
  - Unauthorized modification or destruction of information

Availability



- Assurance
  - Systems work promptly and service is not denied to authorized users
- Requirement
  - Ensuring timely and reliable access to and use of info
- Definition of loss
  - Disruption of access to or use of info or an info system

Other Two Concepts to a Complete Security Picture

- Authenticity
  - Property is genuine and able to be verified and trusted
  - Confident in the validity of a transmission, or a message, or its originator

- Accountability
  - Requirement for actions of an entity to be traced uniquely to that entity
  - Be able to trace a security breach to a responsible party

Three levels of Security Impact

- Defined in FIPS 199
  - Low: limited adverse effect (minor)
  - Moderate: serious adverse effect (significant)
  - High: catastrophic adverse effect (catastrophic)

- Confidentiality
  - Low: directory information of departments
  - Moderate: student enrollment information (covered by FERPA)
  - High: student grade information (covered by FERPA)

FIPS: Federal Information Processing System
FERPA: Family Educational Rights and Privacy Act

Three Levels of Security Impact (Cont.)

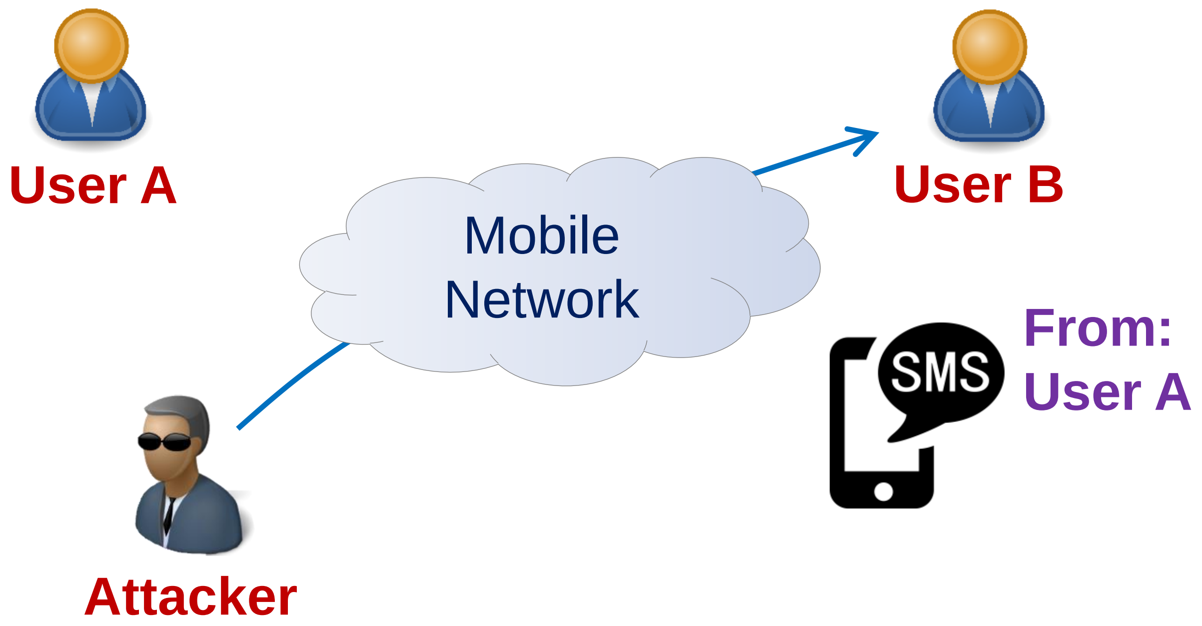
- Integrity
  - Low: anonymous online poll
  - Moderate: articles in a discussion forum
  - High: patient allergy information
- Availability
  - Low: online telephone directory lookup application
  - Moderate: a public website for a university
  - High: authentication services for critical systems

Challenges of Computer Security

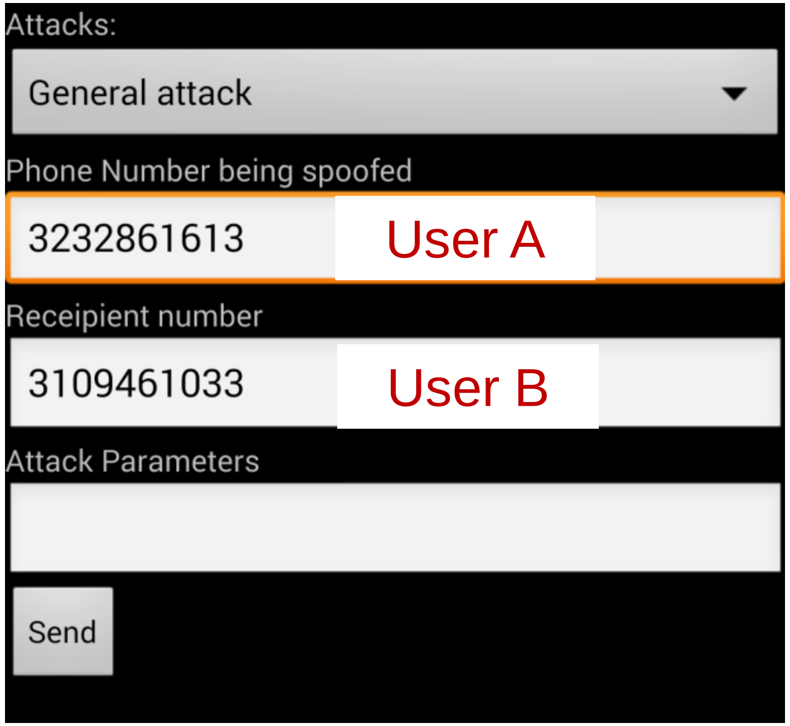
- Computer security is not simple
  - Requirements seem to be straightforward
  - Mechanisms can be quite complex
- One must consider potential (unexpected) attacks
  - Successful attacks look at the problem in a completely different way
  - Exploiting an unexpected weakness
- Procedures are usually counterintuitive
  - Typically, a security mechanism is complex
  - Make sense only when the various aspects of the threat are considered

SMS Spoofing Attack

- **Attacker** can send a spoofed SMS message to **User B**, on behalf of **User A**



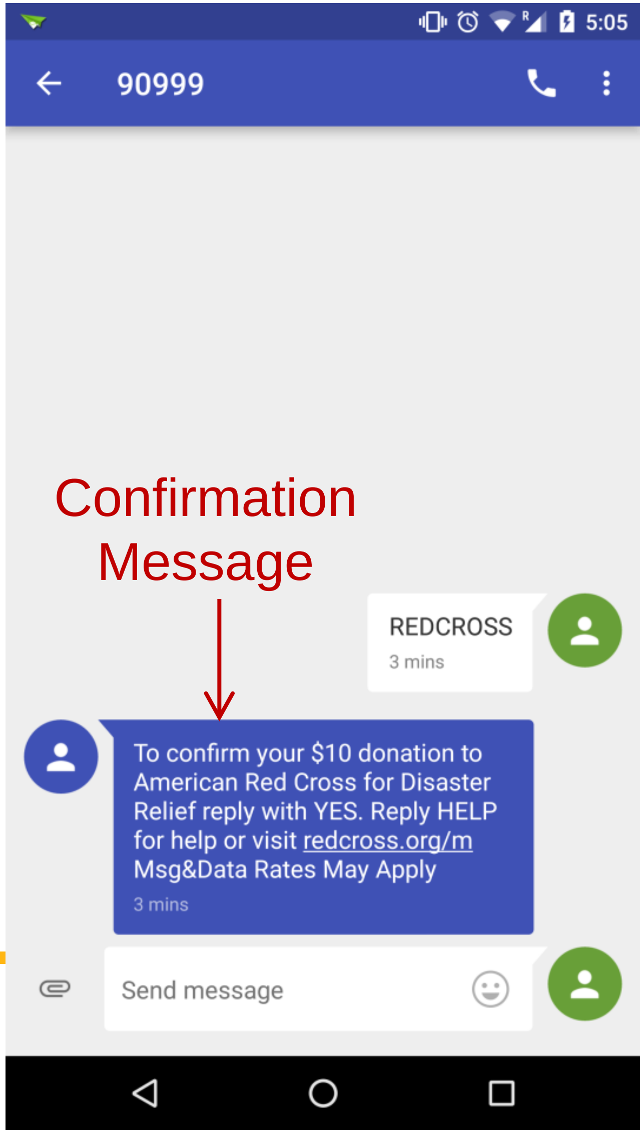
Our Prototype



Against SMS-powered Services

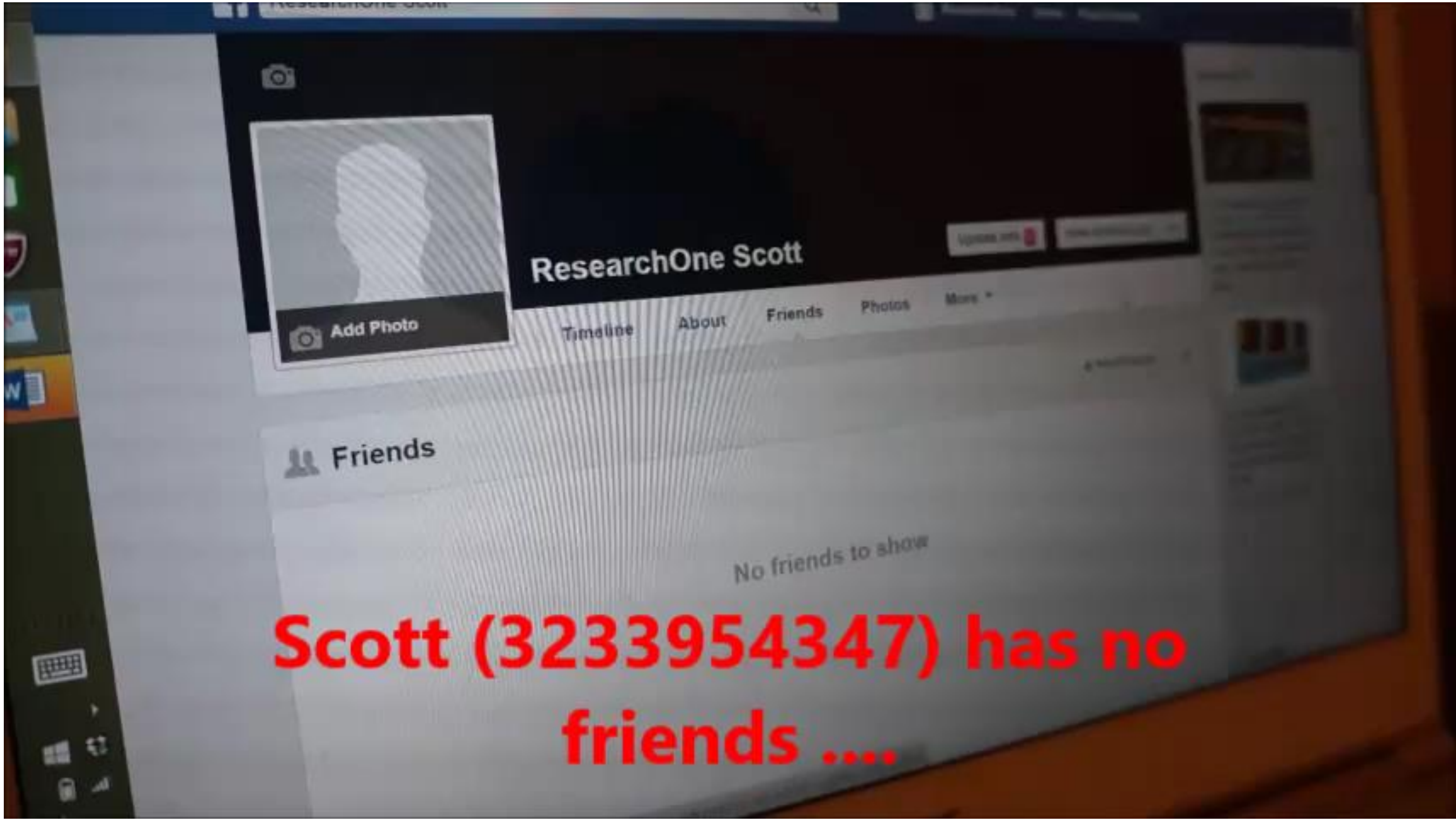
- Facebook Text Service Abuse
  - Abused operations: update status, add friend, like a page
  - Reported this issue to FB; got $1000 USD reward
- Unauthorized Money Transfer
  - Mobile giving: a service allows users to donate money to non-profit organization by SMS
    - The donated money will be charged in phone bills
  - E.g., text **REDCROSS** to 90999 to donate $10 to American Red Cross

An Example of Mobile Giving



SMS Spoofing Attack Against FB Users

- **Attacker: ReserachThree**
- **Victim: Scott**



Challenges of Computer Security (Cont.)

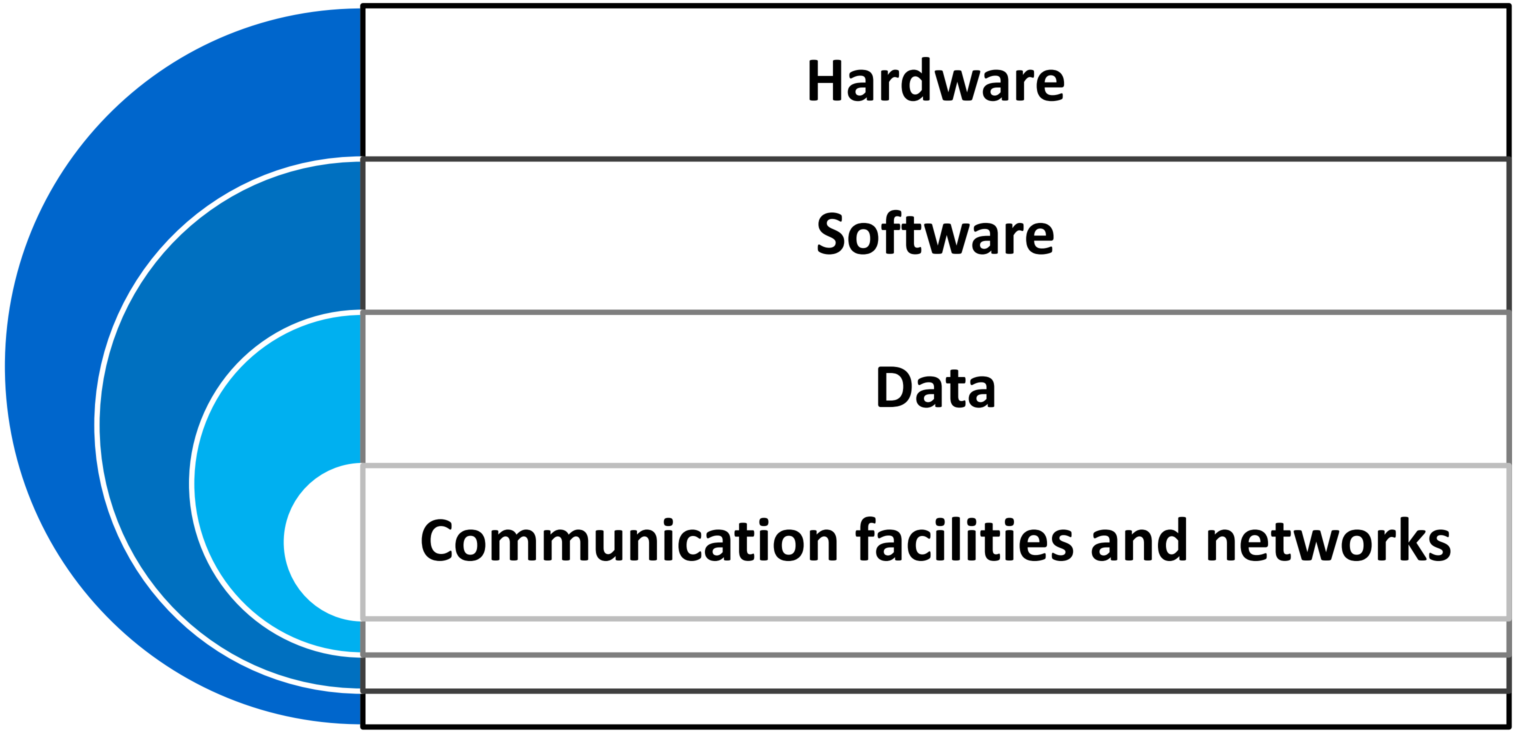
- Must decide where to deploy mechanisms
  - At what points in a network
  - At what layer of an architecture
- Involve algorithms and secret info (keys)
  - How to create, distribute, and protect secret info?
  - Relying on underlying protocols may complicate the development
- A battle of wits between attacker and admin
  - Attacker: find holes, need only find a single weakness
  - Designer: Close holes, eliminate all weaknesses

Challenges of Computer Security (Cont.)

- Users: not perceived on benefits until a security failure
- Requires constant monitoring
  - Difficult in today's short-term, overloaded environment
- Too often an after-thought (not integral)
  - Not an integral part of the design process
- Strong security is regarded as an impediment to use of system

A Model for Computer Security

- Assets of a computer system (or system resource)



A Model for Computer Security (Cont.)

- Vulnerability: weakness of system resources
  - Corrupted: loss of integrity
  - Leaky: loss of confidentiality
  - Unavailable or very slow: loss of availability
- Threat: capable of exploiting vulnerabilities
  - Potential harm to an asset

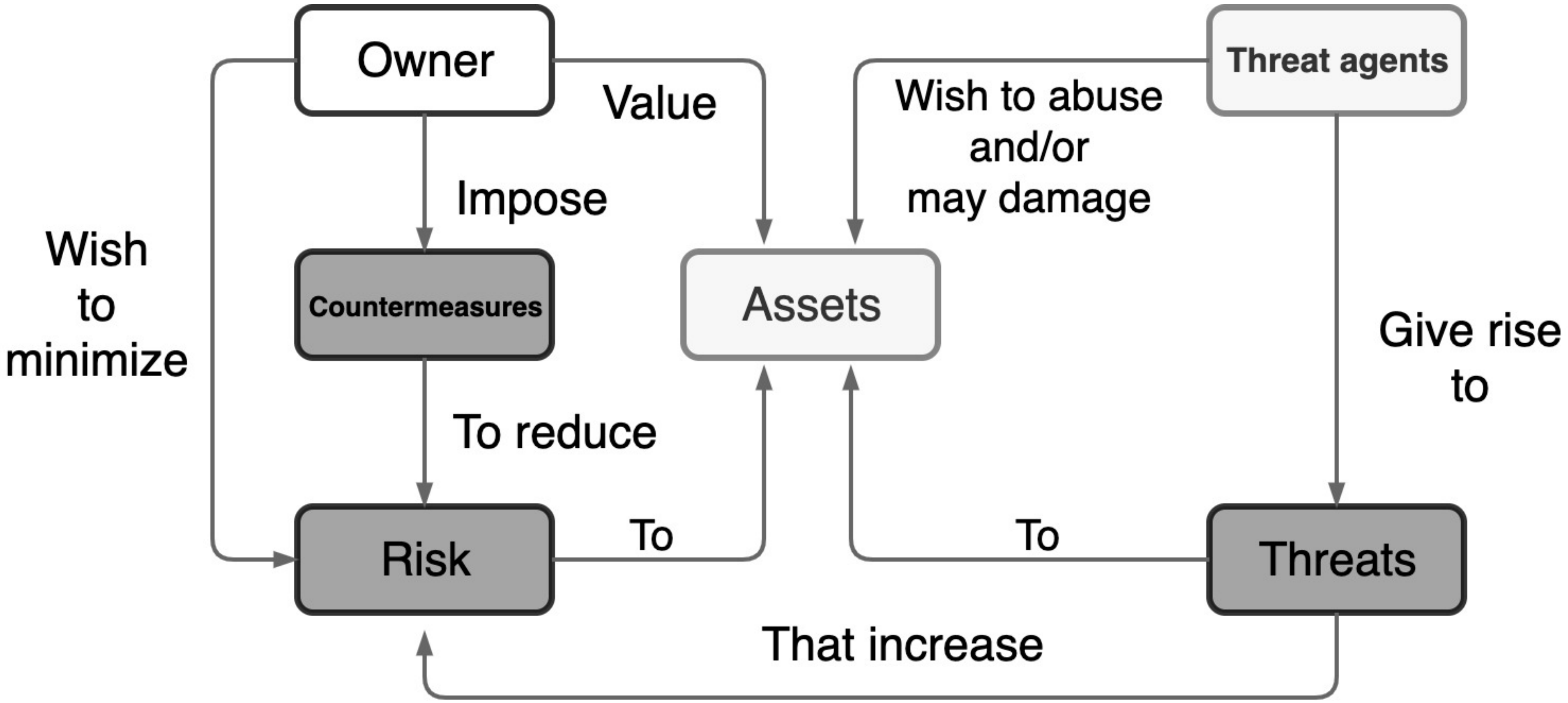
A Model for Computer Security (Cont.)

- Attack: a threat that is carried out (threat action)
  - Passive: learn or make use of info, but doesn't affect system resources
  - Active: alter system resources or affect their operation
  - Inside: by an authorized user (using authorized resources in a way not approved)
  - Outside: by an unauthorized user

A Model for Computer Security (Cont.)

- Countermeasures
  - Means used to deal with security attacks
    - Prevent attacks
    - Detect them and then recover
  - May itself introduce new vulnerabilities
  - Residual vulnerabilities may remain
  - Goal is to minimize residual level of risk to the assets
    - Residual risk: the amount of risk associated with an action/event remaining, after inherent risks have been reduced by risk controls

Security Concepts and Relationships



Threats and Attacks (RFC 4949)

Threat Consequence	Threat Action (Attack)
Unauthorized Disclosure - Threats to confidentiality	(1) **Exposure**; (2) **Interception**; (3) **Inference**: inferring data/info from traffic patterns or repeated queries; (4) **Intrusion**
Deception - Threats to system/data integrity	**(1) Masquerade**: an unauthorized user who gains access to a system by posing as an authorized user, or a Trojan horse behaves; **(2) Falsification**; **(3) Repudiation**: falsely denying responsibility for an act

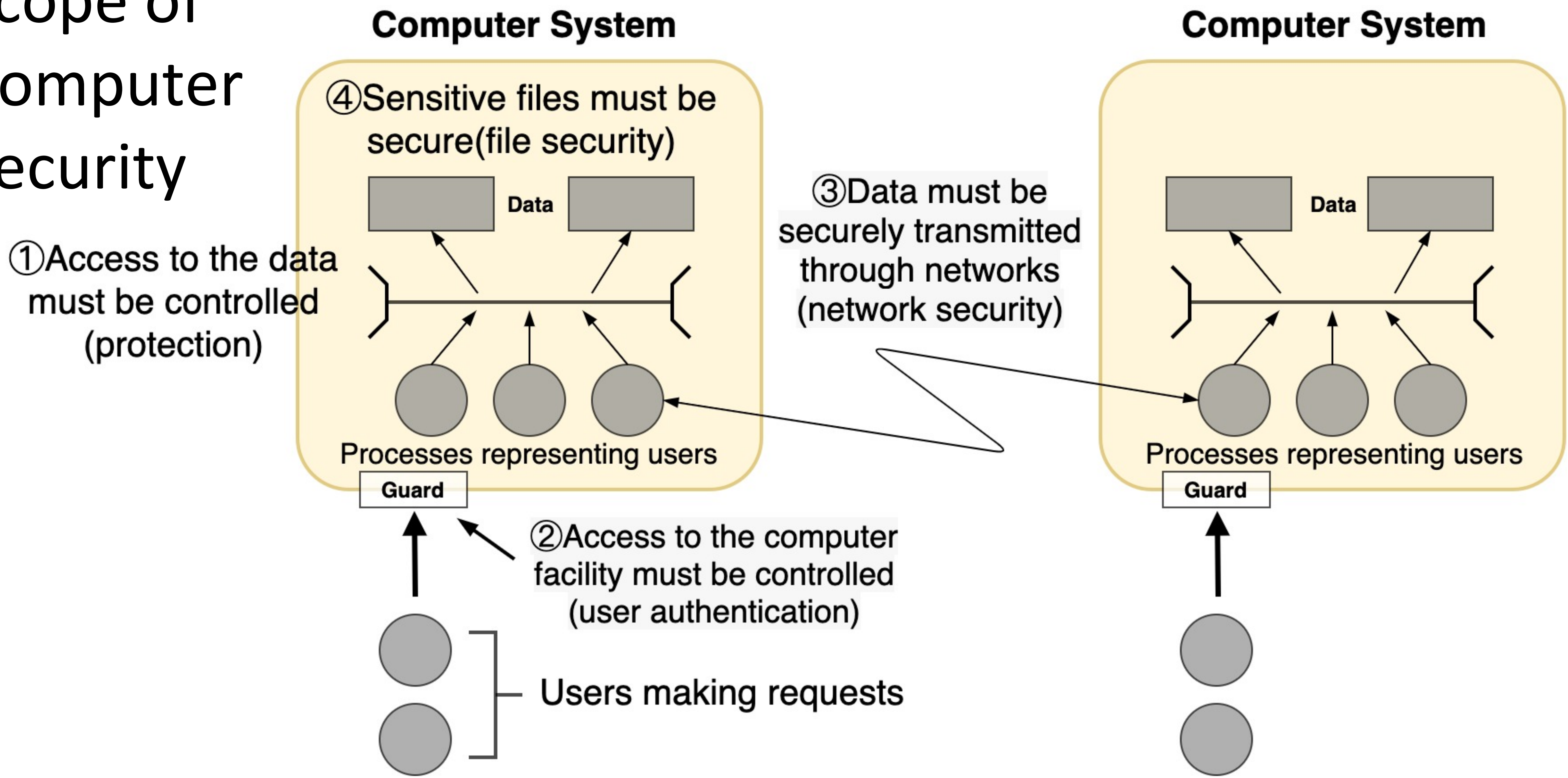
Threats and Attacks (RFC 4949)

Threat Consequence	Threat Action (Attack)
Disruption - Threats to availability or system integrity	**(1) Incapacitation**: prevents or interrupts system operation; **(2) Corruption**: undesirably alters system operation; **(3) Obstruction**: interrupts delivery of system services
Usurpation - Threats to system integrity	**(1) Misappropriation**: unauthorized logical or physical control of a system resource **(2) Misuse**: gaining unauthorized access to a system

Threats and Assets

- Assets: hardware, software, data, and communication lines and networks
  - Threats: breaches of availability, confidentiality, and integrity
- Network security attacks
  - Passive attacks
    - Eavesdropping on, or monitoring of, transmissions
    - Goal: to obtain info that is being transmitted
    - Two types: release of message content, and traffic analysis
  - Active attacks
    - Involving some modification of the data stream or the creation of a false stream
    - Four types: replay, masquerade, modification of messages, and DoS

Scope of Computer Security



Security Functional Requirements

- One computer security expert, Bruce Schneier, observed

> If you think technology can solve your security problems, then you don’t understand the problems and you don’t understand the technology.

- Why?

Security Functional Requirements (FIPS 200)

- Technical measures
  - Access control; identification & authentication; system & communication protection; system & information integrity
- Management controls and procedures
  - Awareness & training; audit & accountability; certification, accreditation, & security assessments; contingency planning; maintenance; physical & environmental protection; planning; personnel security; risk assessment; systems & services acquisition
- Overlapping technical and management
  - Configuration management; incident response; media protection

Outline

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Fundamental Security Design Principles

- Why do we need principles?
  - No security design and implementation techniques that can **systematically** exclude security flaws and prevent all unauthorized actions
  - But, good practices for good design have been documented

Fundamental Security Design Principles

- Economy of mechanism
  - Design should be as simple and small as possible
- Fail-safe defaults
  - Access decisions should be based on permission rather than exclusion
- Complete mediation
  - Every access must be checked against the access control mechanism
- Open design
  - Design should be open rather than secret (e.g., widespread adoption of NIST-approved algorithms)

Fundamental Security Design Principles (Cont.)

- Separation of privilege
  - Separate users and processes based on different levels of trust, needs, and privilege requirements
- Least privilege
  - Every process and every user of the system should operate using the least set of privileges necessary to perform the task
- Least common mechanism
  - Design should minimize the functions shared by different users for mutual security

Fundamental Security Design Principles (Cont.)

- Psychological acceptability
  - Should not interfere unduly with the work of users or hinder the usability or accessibility of resources
- Isolation
  - Resources at public access systems
  - Processes and files of individual users
  - Security mechanisms
- Encapsulation
  - A specific form of isolation based on object-oriented functionality

Fundamental Security Design Principles (Cont.)

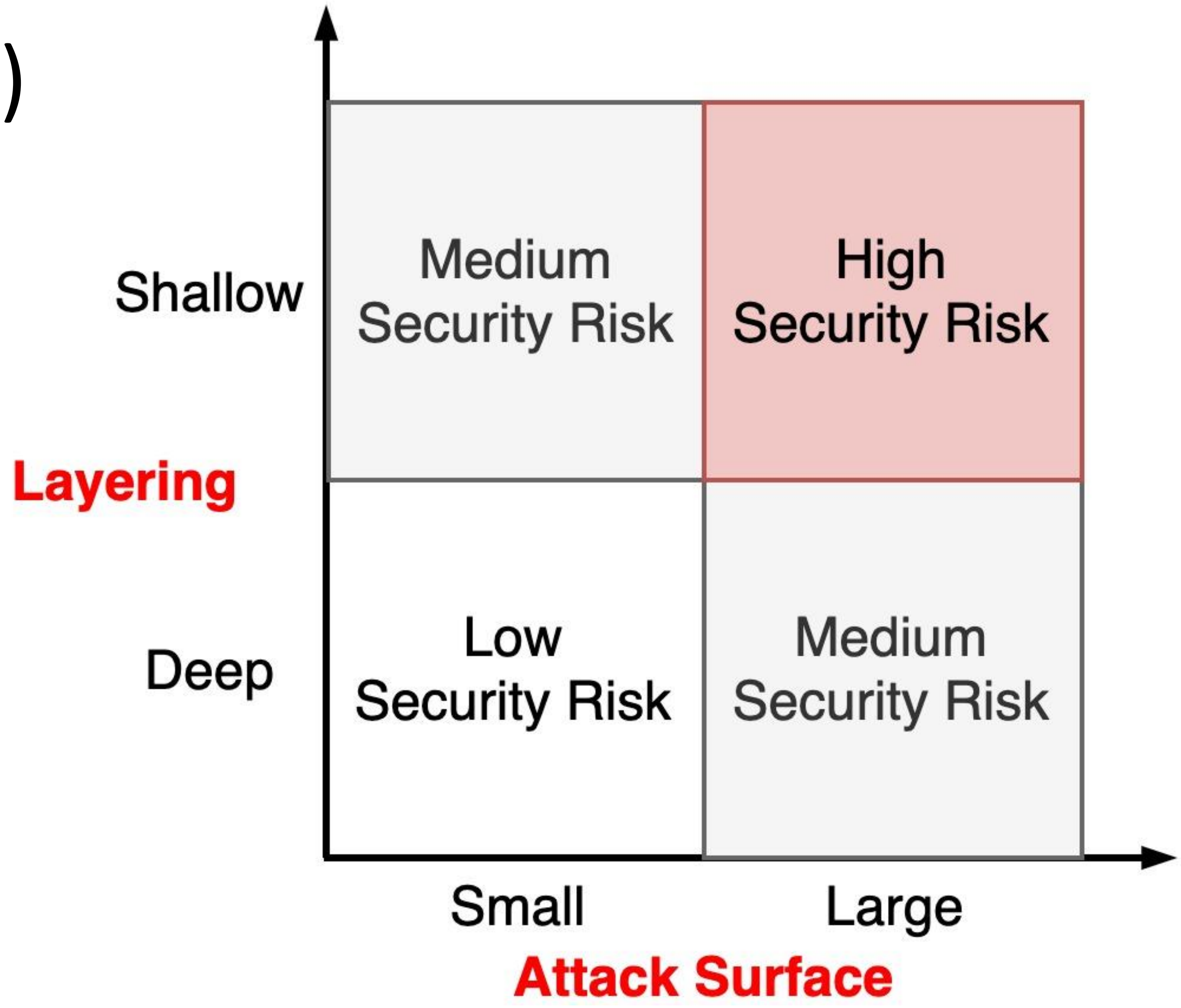
- Modularity
  - Development of security functions as separate, protected modules
  - Use of a modular architecture for mechanism design and implementation
- Layering
  - Use of multiple, overlapping protection approaches
- Least astonishment
  - A program or user interface should always respond in the way that is least likely to astonish the user

Attack Surfaces

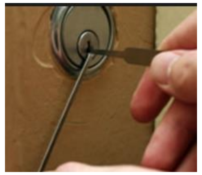
- Consist of the reachable and exploitable vulnerabilities in a system
  - Network attack surface
    - Network protocol vulnerabilities
    - e.g., open ports on outward facing Web and other servers
  - Software attack surface
    - Vulnerabilities in application, utility, or operating system code
    - e.g., interfaces, SQL, and web forms
  - Human attack surface
    - Vulnerabilities created by personnel
    - e.g., an employee with access to sensitive info vulnerable to a social engineering attack

Attack Surfaces (Cont.)

- Why is an attack surface analysis useful?
  - Assess the scale and severity of threats to a system
  - Make developers aware of where security mechanisms are required

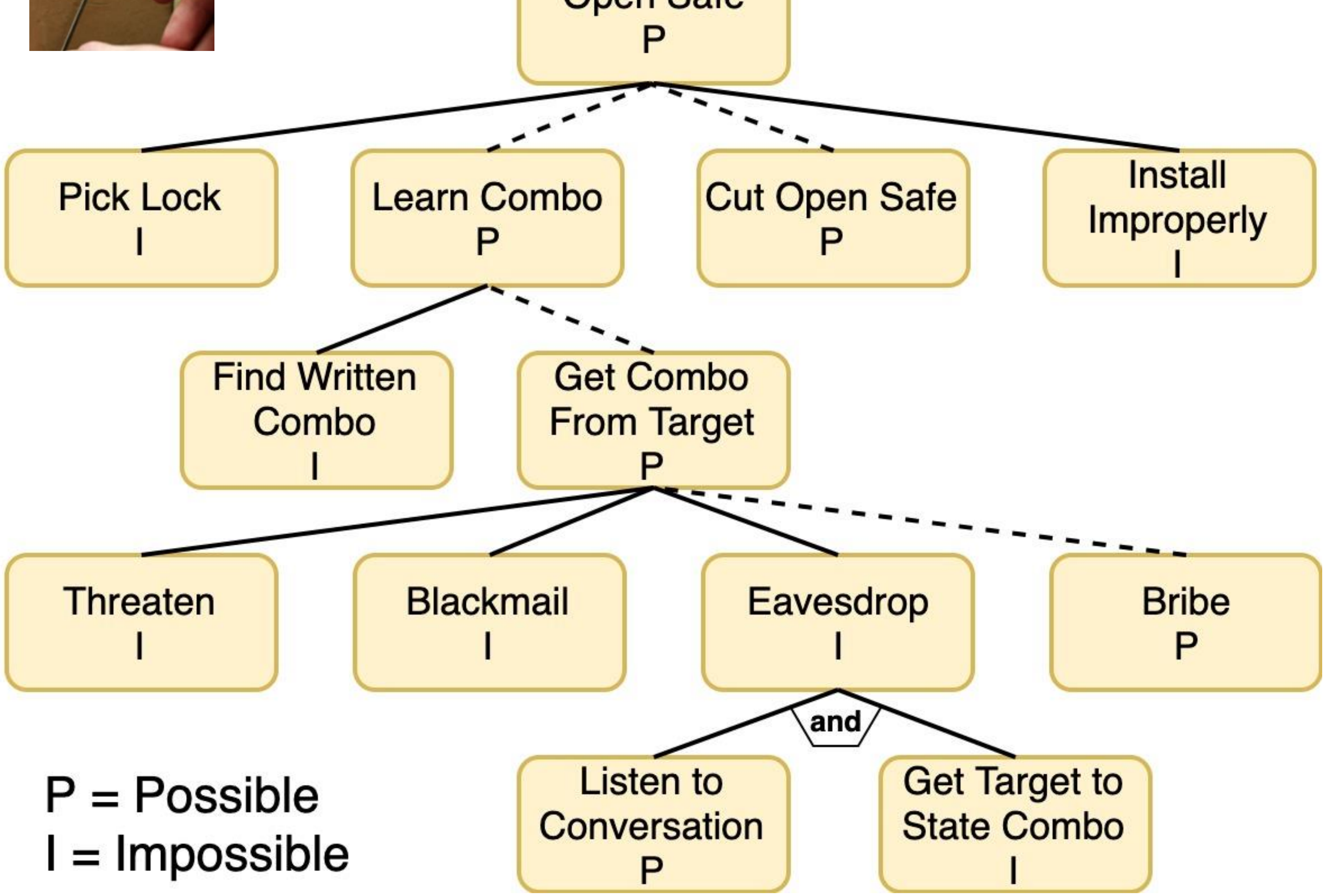


Attack Trees



- A branching, hierarchical data structure: a set of potential techniques for exploiting security vulnerabilities
  - Root: the attack goal
  - Leaf: different ways to initiate an attack
  - Each node (other than a leaf) is either an AND-node or an OR-node

- Why are attack trees needed?

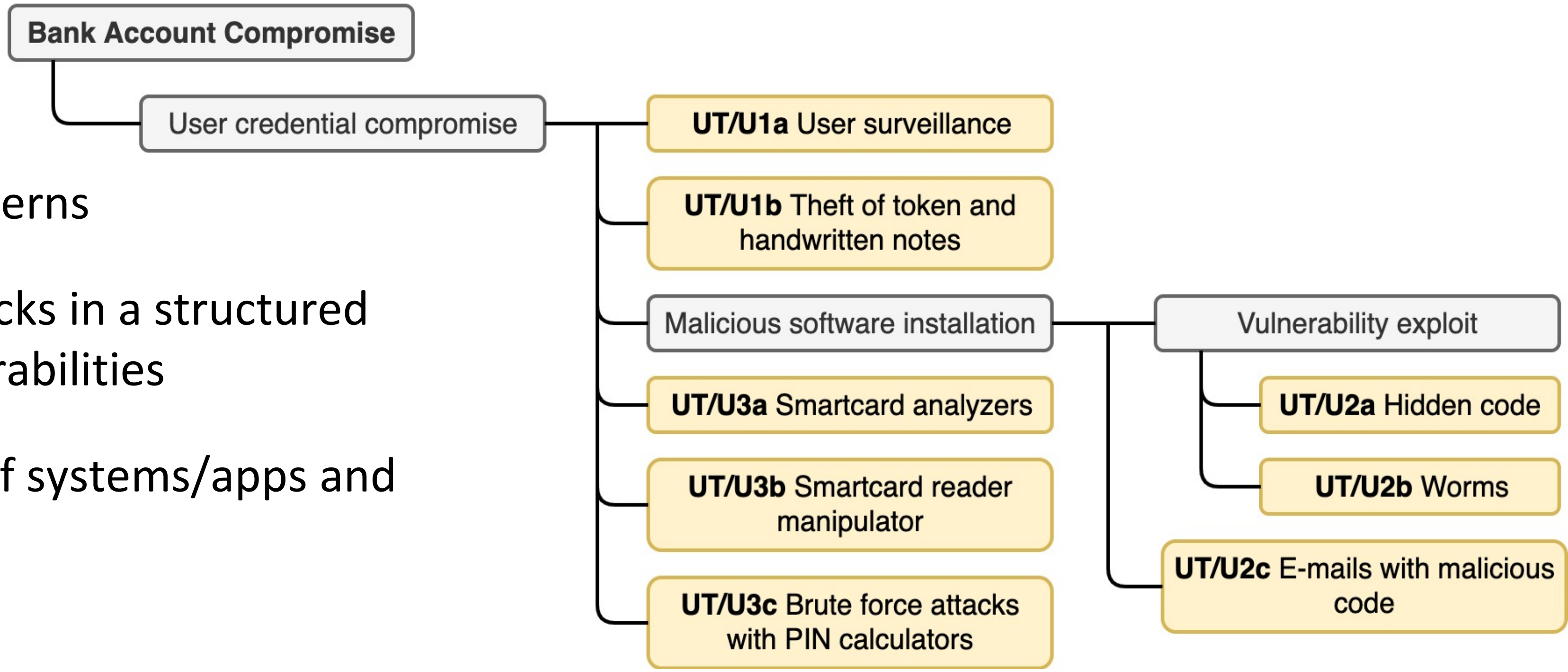


P = Possible
I = Impossible

Attack Trees (Cont.)

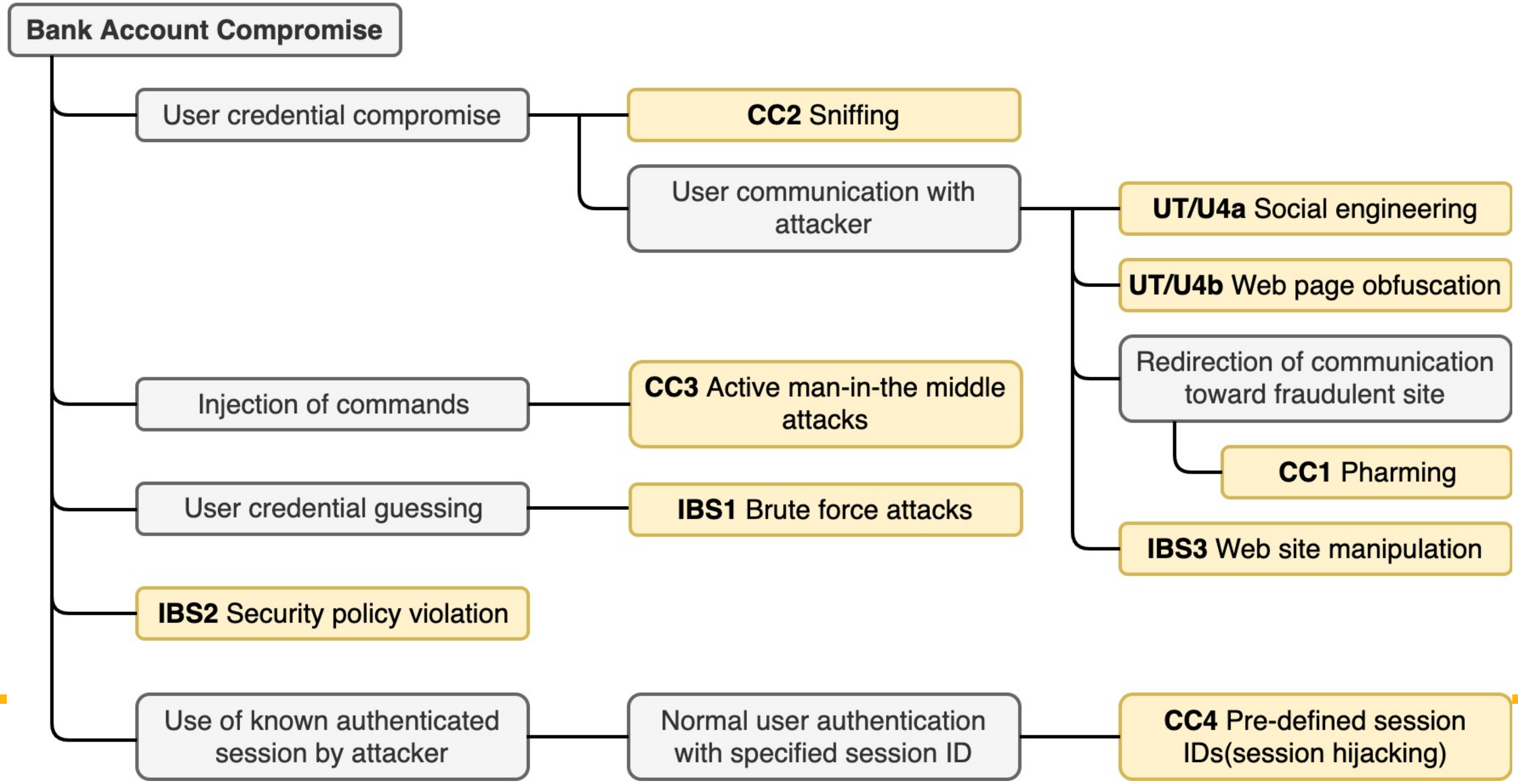
- Using attack trees
  - To effectively exploit the info available on attack patterns
  - To document security attacks in a structured form that reveals key vulnerabilities
  - To guide both the design of systems/apps and countermeasures

An Internet banking authentication app



UT/U: User terminal and user
CC: Communications channel
IBS: Internet banking server

Attack Trees (Cont.)



Computer Security Strategy

- Involves three aspects
  - Specification/policy: What is the security scheme supposed to do?
  - Implementation/mechanisms: How does it do it?
  - Correctness/assurance: Does it really work?

Security Policy

- A formal statement of rules and practices
  - that specify (or regulate) how a system (or organization) provides security services to protect critical system resources (RFC 4949)
- A security manager needs to consider:
  - The value of the assets being protected (e.g., critical files)
  - The vulnerabilities of the system (e.g., the system is open to guests)
  - Potential threats and the likelihood of attacks (e.g., data leakage)
  - Trade-off: ease of use vs. security (e.g., remember and type two passwords?)
  - Trade-off: cost of security vs. cost of failure and recovery

Security policy: a business decision, possibly influenced by legal requirements

Security Implementation and Assurance

- Security implementation
  - Prevention, detection, response, recovery
- Assurance: provides grounds for having confidence that the system operates such that the system's security policy is enforced
  - expressed as a degree of confidence
  - based on formal models

e.g., processes (ISO/IEC 21827),
products (ISO/IEC 15408),
security management (ISO/IEC 27001)

- Evaluation: examines a computer product or system w.r.t. certain criteria

Questions?