# Computer Security and Privacy
## What is computer security? Definitions and basic vocabulary

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Some slides/ideas adapted from: Philippe Oechslin, George Danezis, Emiliano de Cristofaro, Gianluca Stringhini

# Goals
## What should you learn today?

- Understand what is security engineering and why it is different than most other topics you have ever studied
- Learn basic vocabulary to speak about security and learn how to characterize the adversary
- Learn what a security mechanism is and how security engineers show systems are secure
  - Understand that in security, composition is not trivial
  - Understand that security is relative to the considered adversary

# Why a course on computer security?
# What makes **security problems** special?

When we design systems / programs we seek:

- **Correctness**: for a given input, provide expected output

- **Safety**: well-formed programs cannot have bad (even dangerous) outputs

- **Robustness**: cope with errors (input and execution)

We consider what could go wrong, and try to take it into account

# What is computer security?

## COMPUTER SECURITY

**Properties** of a computer system must hold
in the presence of a **resourced** **strategic** **adversary**

# What **Properties**?

## TRADITIONAL PROPERTIES

- **Confidentiality** – prevention of unauthorized disclosure of information

  (*e.g. The adversary should not be able to read my bank statement*)

- **Integrity** – prevention of unauthorized modification of information

  *(e.g. The adversary should not be able to change my bank balance)*

- **Availability** – prevention of unauthorized denial of service

  *(e.g. The adversary should not prevent me accessing my bank account)*

# What Properties?

## NOT-SO-TRADITIONAL (BUT IMPORTANT) PROPERTIES

Authenticity

Anonymity

Non-repudiation

….

There are many more complex properties relevant in modern security

# The Security policy

**SECURITY POLICY**: a high level description of the *security properties* that must hold in the system in relation to *assets* and *principals*.

- **Assets (objects)**: anything with value (e.g., data, files, memory) that needs to be protected.

- **Principals (subjects)**: people, computer programs, services,… *(may not contain the adversary)*

**Examples of security properties in terms of principals and assets**

| | | |
|---|---|---|
| **Confidentiality** | prevention of unauthorized disclosure of information | **< authorized users may read a file** |
| **Integrity** | prevention of unauthorized modification of information | **< authorized programs may write a file** |
| **Availability** | prevention of unauthorized denial of service | **< authorized services can access a file** |

# The **Resourced** Strategic **Adversary**?

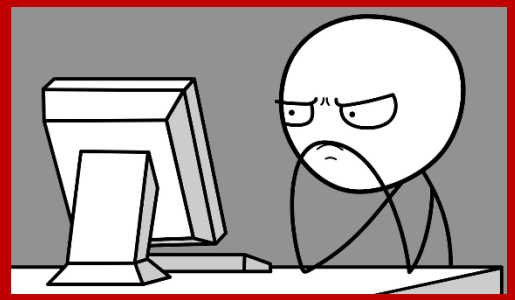
**COMPUTER SECURITY**
Properties of a computer system must hold in presence of a **resourced** strategic adversary

**THREAT MODEL**: describes the **resources** available to the **adversary** and the adversary's capabilities (observe, influence, corrupt,…)

The **adversary** is a malicious entity aiming at breaching the security policy

The **adversary** is **strategic**: the adversary will choose the **optimal** way to use her resources to mount an attack that violates the security properties

**THREAT MODELLING IS A VERY HARD TASK!!**



# Key vocabulary to talk about the adversary

### THREAT MODEL

Technical term to define the adversary's capabilities.

*The adversary can observe my connection*

*The adversary can corrupt my machine*

*The adversary controls a bank employee*

### VULNERABILITY

Specific weakness that could be exploited by adversaries with interest in a lot of different assets

*The banking API is not protected*

*The password appears in plain text in my screen*

### THREAT

What is the feared event, the goal of the adversary that we don't want materialized

*A hacker wants to retrieve money breaking into the bank's system*

*A student wants to learn my password by looking over my shoulder*

### HARM

The bad thing that happens when the threat materializes

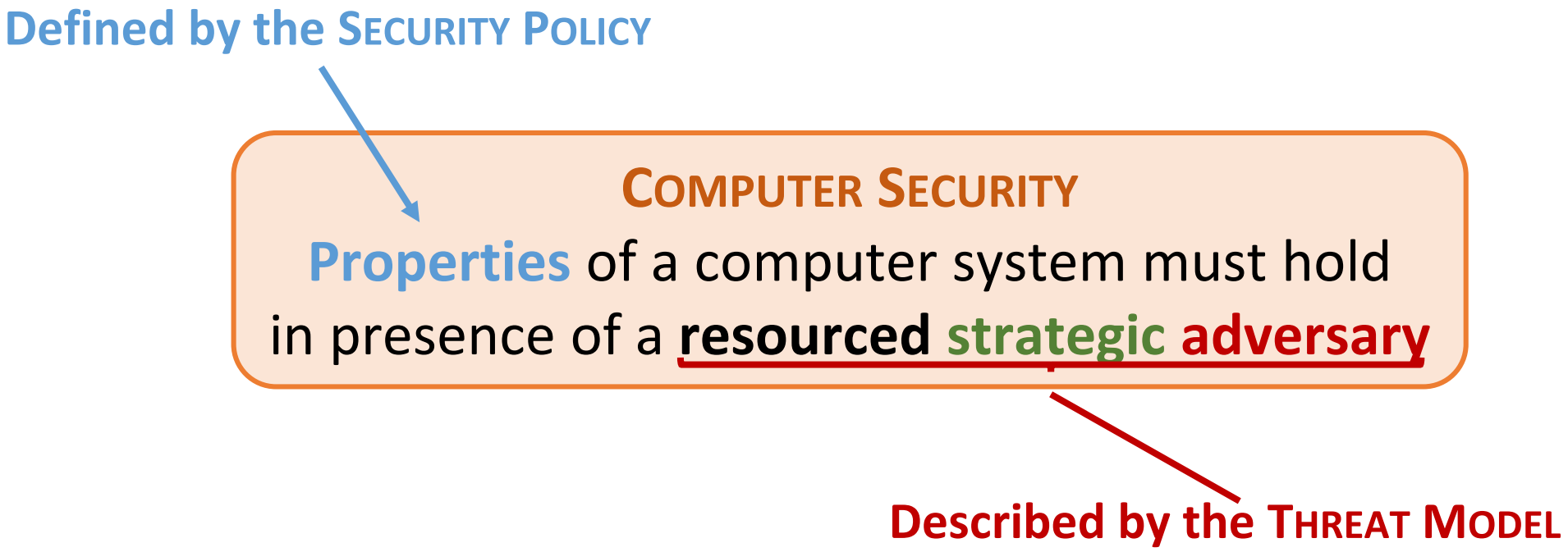
*The adversary steals money*

*The adversary blocks access to the bank*

*The adversary learns my password*

*The adversary reads the message*

# All together




If the **properties** hold within the **threat model**, it means that there are no **vulnerabilities** that can be exploited to materialize **threats,** and no **harm** happens

# Computer Security and Privacy
## Basic concepts of security engineering

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# Securing a system

**SECURITY MECHANISM**: Technical mechanism used to ensure that the security policy is not violated by an adversary within the threat model.

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Software (programs) + Hardware + Maths (cryptography) & Distributed systems, people and procedures

Security mechanisms can be engineered!!

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Security mechanisms can be engineered!!

**Example** 1

Policy: ensure the log of transactions is not tampered with by a single employee

Mechanism: keep a copy of the log on multiple computers, such that no single employee has access to all of them

**Example** 2

Policy: ensure messages cannot be read by anyone but the sender and the receiver

Mechanism: encrypt the message before sending

# Systems are big! Need security mechanism**S**

Security **does not necessarily increase linearly** with the number of mechanisms!

Two ways of composing

**Defence in depth**
As long as one remains
Security policy ✓

**Weakest Link**
If any one fails
Security policy ✗

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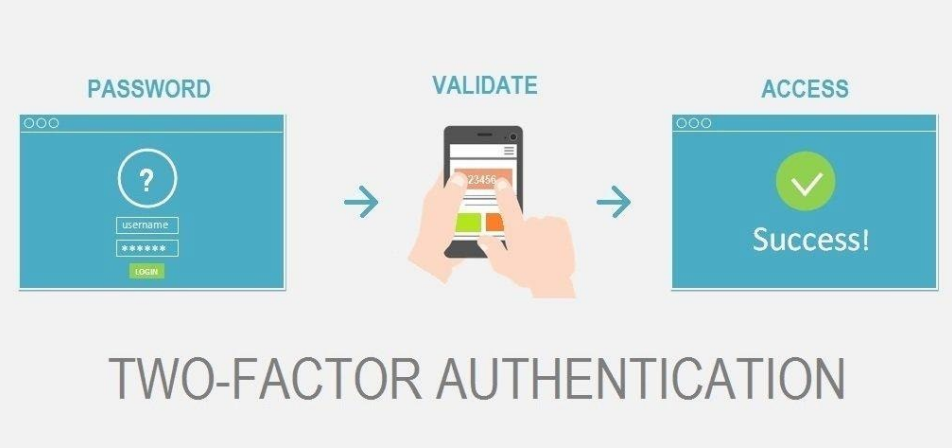


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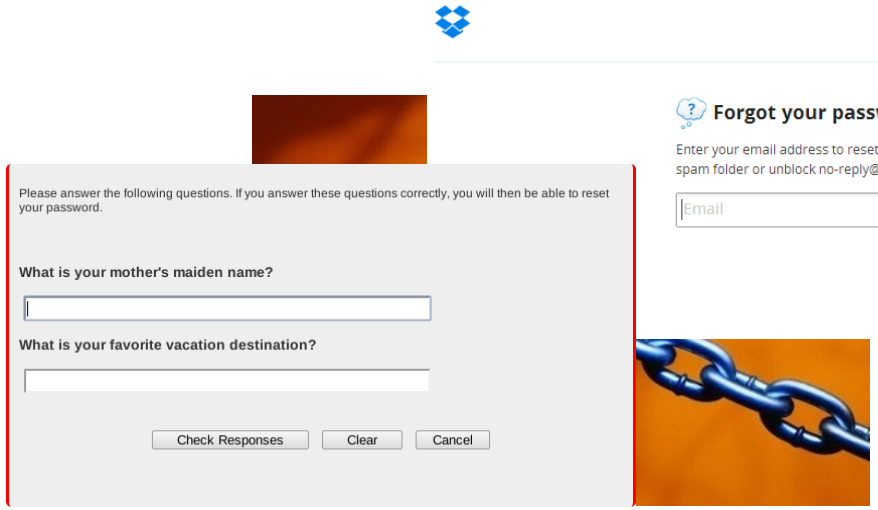


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# Humans are part of the system

**Social Engineering**

**Phishing attacks**

**Bad use of passwords** — **Weak**, **Written down**, **Repeated**

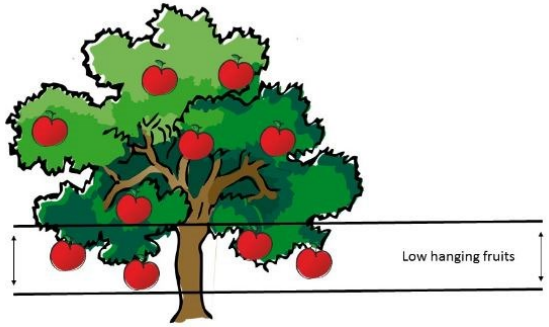
**It does not mean you should not care about the rest!!**

http://www.slate.com/blogs/future_tense/2016/01/22/calling_humans_the_weakest_link_in_computer_security_is_dangerous.html

# How do we show systems are secure?

**ATTACKER**

*Just **one** **way*** to violate ***one*** security property is enough!
(within the threat model)



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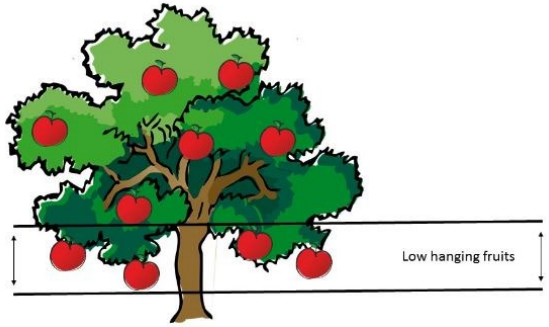
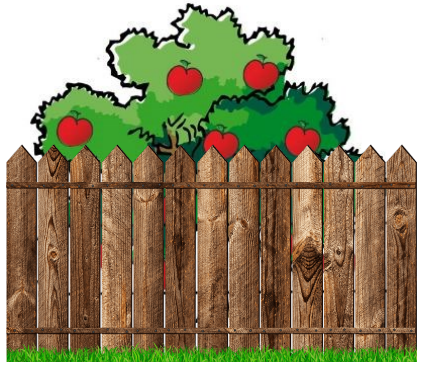



**DEFENDER**

**No adversary strategy** can violate the security policy



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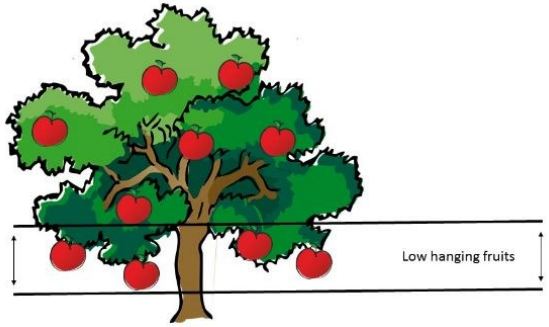


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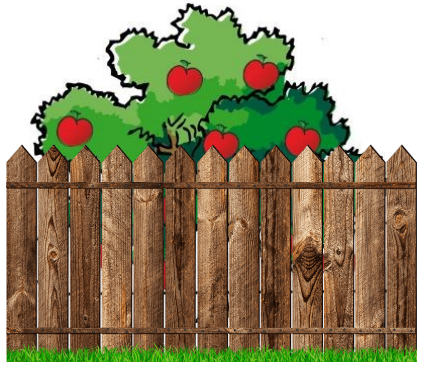
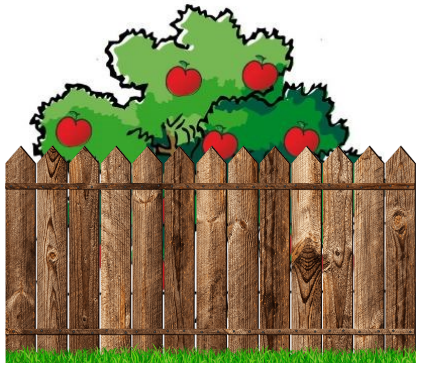


*"One of the major problems right now is script kiddies. These are people who just download open source tools that are meant for good, and they point them at whatever they want, press 'Go,' and it fires a suite of exploits at a system hoping one of them will work."*

Richard Moore. Security Specialist (IBM)

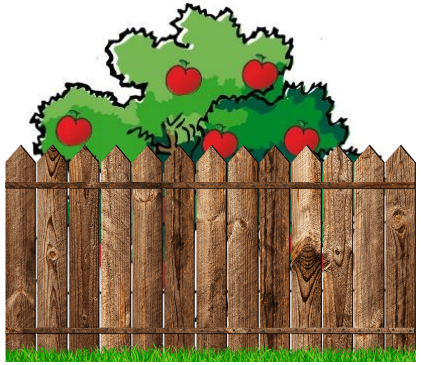
https://securityintelligence.com/security-gamification-engineer-richard-moore-proves-that-anyone-can-be-a-hacker/

# Is this system secure?



~~Is this system secure?~~

Is this system secure under **this** threat model?



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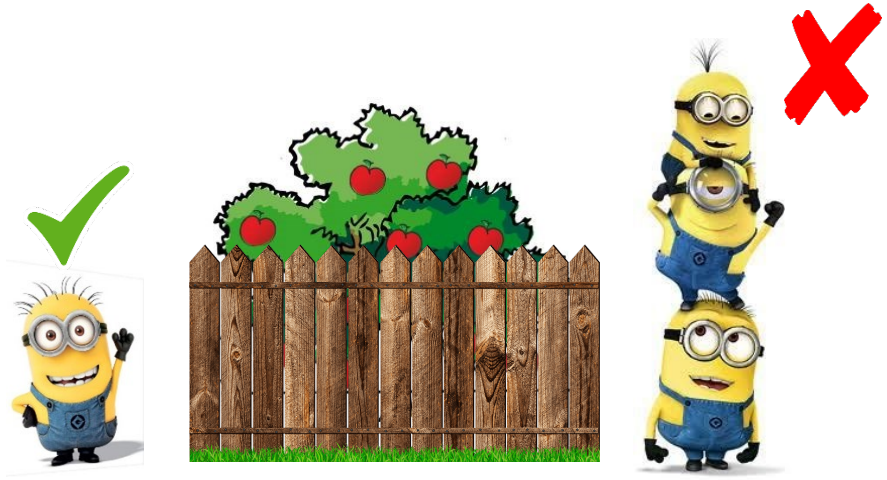

A system is “secure” if an adversary constrained by a **specific threat model** cannot violate the security policy

# How do we show systems are secure?

**SECURITY ARGUMENT**: rigorous argument that the security mechanisms in place are indeed effective in maintaining the security policy (*verbal* or *mathematical*).

Subject to the assumptions of the threat model.

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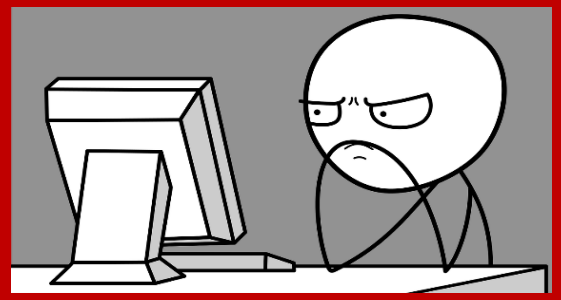
**SECURITY ARGUMENTS FOR COMPOSITION OF MECHANISMS ARE VERY HARD TO GET RIGHT!!**



# Security engineering

**1.- High-level specification**

- Define the **architecture** of the system (e.g., high level block diagram)
- Define the **security policy** (principals, assets, security properties)
- Define the **threat model** **why is this very important?**

**2.- Security design**

- Select / Design **security mechanisms**
- State your **security argument**: which controls maintain which properties?

**3.- Secure implementation**

- **Implement** mechanisms
- Ensure they **conform** to the design model
- Security **testing**

# Summary

Security problems always involve an **adversary**

The adversary is **strategic**, will take the most damaging approach

The adversary's capabilities define a **threat model**

**Security mechanisms** aim at fulfilling a **security policy within a threat model**

Showing security implies providing a **security argument**