CS 453/698: Software and Systems Security

Module: Introduction
Lecture: basic concepts

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Spring 2025

Outline

The big picture

security

cybersecurity

infomation security

attacks & defenses

. . . . . .

The big picture

What we talk about when we talk about security?

cybersecurity?

infomation security?

attacks & defenses?

. . . . . . ?

The big picture

Cryptography **Privacy** **Security**

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IF YOU SECURE EVERYTHING WITH A KEY, HOW ARE YOU GOING TO PROTECT THE KEY?
WITH ANOTHER KEY
imgflip.com

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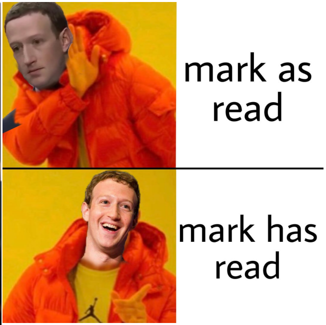

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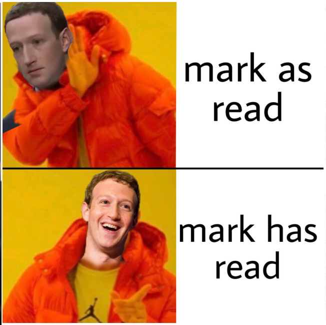

When you type 'password' in the password field and it works

The big picture (a more formal definition)

Cryptography **Privacy** **Security**

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Cryptography | **Privacy** | **Security**

Secure communication in the presence of adversaries

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- What property is secured?
- What data is communicated?
- What are malicious activities?

e.g., encryption
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However, whether “good things will eventually happen” is a security concern is debatable

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A computing system is said to be secure if it has all three properties

Security and reliability

Security has a lot to do with "reliability"

A secure system is one you can rely on to (for example):

1. Keep your personal data confidential
2. Allow only authorized access or modifications to resources
3. Ensure that any produced results are correct
4. Give you correct and meaningful results whenever you want them
5. . . .

Who are the adversaries?

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Who's trying to mess with us?

- Murphy: "Anything that can go wrong, will go wrong"
- Amateurs
- "Script kiddies"
  - people who access downloadable malicious programs; they often have limited technical skills.
- Hackers
- Organised crime
- Government "cyberwarriors"
- Terrorists
- Insiders
- . . .

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- Detect it: notice that attack is occurring (or has occurred)
- Recover from it: mitigate the effects of the attack

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Often, we'll want to do many things to defend against the same threat — "Defense in depth".

Example of defense

Threat: Your car may get stolen. How to defend?

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- **Recover**: Insurance

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NOTE: These methods of defense are not mutually exclusive.

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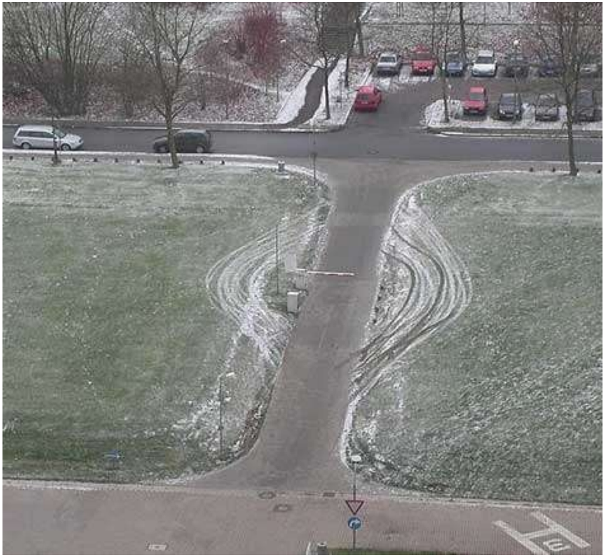
- **Principle of Easiest Penetration**
  - "A system is only as strong as its weakest link"
  - The attacker will go after whatever part of the system is easiest for them, not most convenient for you.
  - In order to build secure systems, we need to learn how to think like an attacker!

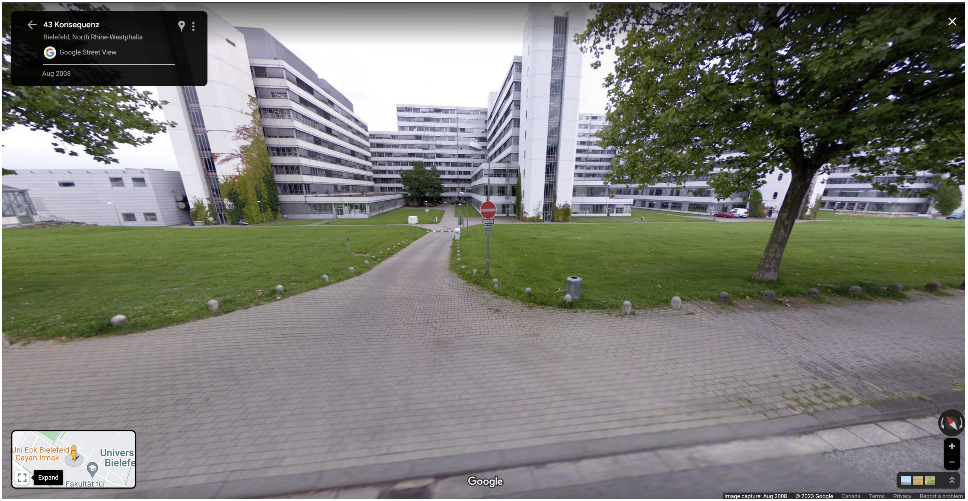
- **Principle of Adequate Protection**
  - "Security is economics"
  - Don't spend $100,000 to protect a system that can only cause $1,000 in damage

Think like an attacker



Sources unknown, but would like to acknowledge

Defend like an attacker... too



Captured from Google Map Street View

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Software security landscape

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- Exploitation:
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- Prevention!
  But that's usually the area of Programming Languages (PL)

Weird machine

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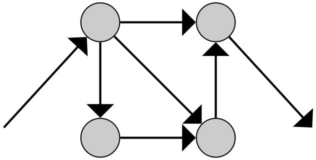

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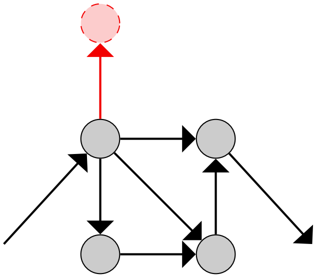

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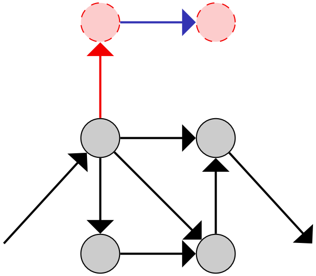

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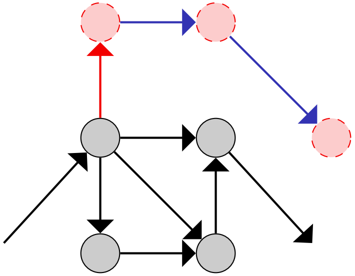

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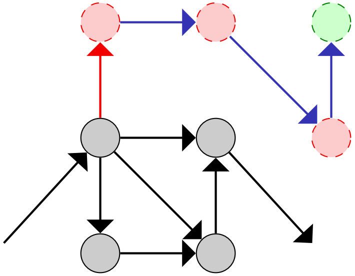

A general framework to appreciate software security work

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For example: given two defense works P_1 and P_2 on the same bug:

$$P_1(Code_1, \{...Bug...\}, \{...Action_1...\}) \rightarrow Blockage_1$$

$$P_2(Code_2, \{...Bug...\}, \{...Action_2...\}) \rightarrow Blockage_2$$

- Is $Code_2$ more complicated than $Code_1$?
- Is $Action_2$ larger than $Action_1$ (i.e., protection scope is larger)?
- Is $Blockage_2$ more efficient $Blockage_1$ (i.e., lower overhead)?

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For example: given two detection tools T_1 and T_2 on the same code base:

$$T_1(Code, Bug_1, [Action_1]) \rightarrow Signal_1$$

$$T_2(Code, Bug_2, [Action_2]) \rightarrow Signal_2$$

- Is Bug_2 more challenging than Bug_1?
- Is $Action_2$ simpler than $Action_1$ (i.e., easier to detect)?
- Is $Signal_2$ more accurate $Signal_1$ (i.e., lower false positives)?

A general framework to create new security tools

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For example: given an attack and detection tool

$$P(Code_1) \rightarrow Bug \quad || \quad P(Code_1, Bug, [Action_1]) \rightarrow Signal_1$$

we can ask ourselves, is another code base $Code_2$ also vulnerable to the same (or similar) type of bug?

$$P(Code_2) \rightarrow Bug \quad || \quad P(Code_2, Bug, [Action_2]) \rightarrow Signal_2$$

$\langle$ **End** $\rangle$