Introduction and Security Principles

Adapted from CS 161 Spring 2022 - Lecture 1

First: Introduction

- Staff introductions: Nick and course staff
- Course overview: What will you learn in this class?
- Course logistics
  - Lectures, discussions, office hours, and exams
  - Resources and communication platforms
  - Collaboration and academic honesty
  - DSP and extenuating circumstances
  - Stress management and mental health
  - Ethics
  - Case studies and blue slides
- What is security? Why is it important?

Staff Introductions

Who Am I? Nick Weaver

- A *lecturer* in the CS department
  - I am paid *exclusively* to care about my students & TA staff
- A researcher at the International Computer Science Institute
- Research focuses
  - Online criminality (including cryptocurrency)
    - Cryptocurrency is an amazing resource for comedy godl.
  - Online privacy
  - Public policy
  - Drones

Course Overview

Learning Objectives

- How to think adversarially about computer systems
- How to assess threats for their significance
- How to build computer systems with robust security properties
- How to gauge the protections and limitations provided by today's technology
- How attacks work in practice

- What mistakes *not to make!*

Course Outline

- Introduction to Security
  - What are some general philosophies when thinking about security?
- Memory Safety
  - How do attackers exploit insecure software? How do we defend against these attacks?
- Cryptography
  - How do we securely send information over an insecure channel?
- Web Security
  - What are some attacks on the web, and how do we defend against them?
- Network Security
  - What are some attacks on the Internet, and how do we defend against them?
- Miscellaneous Topics
  - Useful, interesting, or fun applications of topics

Extra Tools and Skills

- Some extra non-security-related skills you can take away from this class:
- Memory safety
  - x86 assembly: A commonly-used assembly language
  - Using GDB: Debugging C code
- Cryptography
  - Becoming a better consumer: Be able to analyze security products and pick the right security tools for your software
- Web Security
  - Software engineering: Understanding how websites are built and how your web browser interacts with remote web servers (CS 169 preview)
- Network Security
  - Networking: How the Internet works (CS 168 preview)

Prerequisites

- CS 61B: Ability to work with large and complex codebases, data structures
  - Relevant for Project 2 (500–1000 lines of Go code)
- CS 61C: Familiarity with low-level memory layouts and assembly
  - We'll have a lecture reviewing all the 61C material you need to succeed
  - Relevant for the memory safety unit (Project 1, first two weeks of class only)
- CS 70: Familiarity with basic mathematical notation and proof structures
  - Relevant for the cryptography unit
  - We'll review CS 70 material as we encounter it during the cryptography lectures
- An ability to pick up new programming languages quickly
  - Project 2 will be in Go

Resources

- Textbook: https://textbook.cs161.org/
  - Free! There's no textbook you need to pay for.
  - Readings are optional, but past students have said the textbook is helpful
- Course website: https://cs161.org/
  - Course schedule, lecture slides, assigned readings, and other resources are all posted here

Class Policies: Academic Honesty

- We’re here to help! There are plenty of staff and resources available for you
  - You can always talk to a staff member if you’re feeling stressed or tempted to cheat
- Academic dishonesty policies
  - At minimum, the student will receive negative points on the assignment
    - Example: If the midterm is worth 150 points, the student will receive a score of -150 on the midterm.
  - The student will be referred to Nick Weaver and the Center for Student Conduct
    - CSC often doesn’t care that much about first-time cases! They are there to make sure a student doesn’t make the same mistake a second time.
  - If you take the class honestly, you don’t need to worry about these!

Class Policies: Academic Honesty

- As a computer security class, we view potential cheaters as “attackers.”
- Our threat model assumes “rational” attackers.
  - A rational attacker will only launch an attacker if (expected benefit) > (expected cost)
    - (expected cost) = (cost of launching attack) + *(cost of getting caught)* * (probability of getting caught)
- Two-fold approach to academic integrity:
  - Detection: Use our tools to analyze and detect instance of academic dishonesty.
    - You will learn that “security through obscurity” is bad, but *obscurity can help*. We have ways.
  - Response: *At minimum*, you will receive negative points on the assignment.
- “Nick doesn’t make threats. He keeps promises.”

Ethics

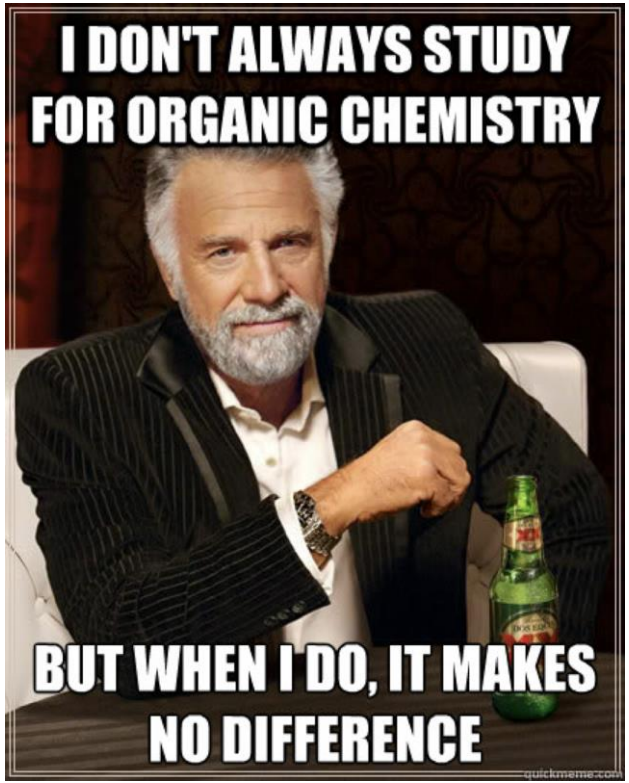
- In this class, you will learn a lot about attacks out of necessity
  - To be able to defend against the attacker, you must learn the techniques that attackers use
- It is usually okay to break into your own systems
  - This is a great way to evaluate your own systems
- It is usually okay to break into someone else's systems with their explicit permission
- It is **grossly unethical** and **exceedingly criminal** to break into someone else's systems without their permission

Stress Management and Mental Health

- We want to reduce your stress where we can
  - Project 2 (mid-semester) is going to be the most intensive part of this class, but we've made things lighter towards the end (when every other class has stuff due)
- **Your health is more important than this course**
- If you feel overwhelmed, there are options
  - Academically: Ask on Piazza, talk to staff in office hours, set up a meeting with staff to make a plan for your success this semester
  - Non-academic:
    - Counselling and Psychological Services (CAPS) has multiple free, confidential services
      - Casual consultations: https://uhs.berkeley.edu/counseling/lets-talk
      - Crisis management: https://uhs.berkeley.edu/counseling/urgent
    - Check out UHS's resources: https://uhs.berkeley.edu/health-topics/mental-health

Stress Management and Mental Health

- Failure is always an option
  - If something bad happens near the end of the semester, there are withdrawals and incompletes.
  - It is OK to fail or just barely pass… Nick's grades as a Berkeley Undergrad included:
    - B- in Physics 111BSC & Thermodynamics
    - C+ in Chem 112A (O-chem)
    - C in Physics 137A (Quantum)
  - Don't believe me? Stop by my office and see my transcript!



Case Studies and Blue Slides

- Security is often best taught through real-world case studies and stories
  - Lectures will sometimes use real-world examples to demonstrate concepts
  - Slides with a blue background are case study slides
- Content on blue slides are not tested on exams
  - You *do not* need to remember the exact details of the story
- Some blue slides will end in a **takeaway** that describes the moral of the story
  - You *do* need to understand the takeaway from the story

One Other Thing...

- There exists a classic game theory problem called the Prisoner's Dilemma.
  - For single-round Prisoner's Dilemma, the optimum strategy is "always-defect."
  - For multi-round Prisoner's Dilemma, the optimum strategy in practice is "tit-for-tat."
    - In other words, be nice unless someone isn't nice to you.
- **Takeaway**: Life is multi-round so be excellent to each other!
  - Making things hostile for others makes the world worse for all.
  - Stopping things from being hostile to others makes the world better for you.

What is security?

What is security?

Enforcing a desired property *in the presence of an attacker*

data confidentiality

user privacy

data and computation integrity

authentication

availability

…

Why is security important?

- It is important for our
  - physical safety
  - confidentiality/privacy
  - functionality
  - protecting our assets
  - successful business
  - a country’s economy and safety
  - and so on…

Why is security important?

- Consider: Physical Safety

The Washington Post

Link

FBI probe of alleged plane hack sparks worries over flight safety

Drew Harwell *May 18, 2015*

PCWorld

Link

Pacemaker hack can kill via laptop

Pacemakers from several manufacturers can be commanded to deliver a deadly, 830-volt shock from someone on a laptop up to 50 feet away, the result of poor software programming by medical device companies.

Jeremy Kirk *October 21, 2012*

心律调节器 (Artificial cardiac pacemaker)

Why is security important?

- Consider: Privacy/Confidentiality

Link

91 Percent of Healthcare Organizations Suffered Data Breaches in the Past Two Years

Jeff Goldman *May 12, 2015*

Link

Data Breach Tracker: All the Major Companies That Have Been Hacked

Karavbrandeisky *October 30, 2014*

In 2020, there were over 1001 breaches, affecting the data of 155,000,000 individuals

Why is security important?

- Consider: National security

THE WALL STREET JOURNAL.

Link

America's Electric Grid Has a Vulnerable Back Door—and Russia Walked Through It

Rebecca Smith and Rob Barry

January 10, 2019

A Wall Street Journal reconstruction of the worst known hack into the nation's power system reveals attacks on hundreds of small contractors

Why is security important?

掌握用户采购寻呼机的供应链信息

↓

进入供应链，更换其中的设备结构
（即在其中安放微量炸药）

↓

攻击寻呼服务公司，发出引爆信息

What is hackable?

- Everything!
  - Especially things connected to the Internet
  - Assume that every system is a target
  - A casino was hacked because a fish-tank thermometer was hacked within the network

SLATE

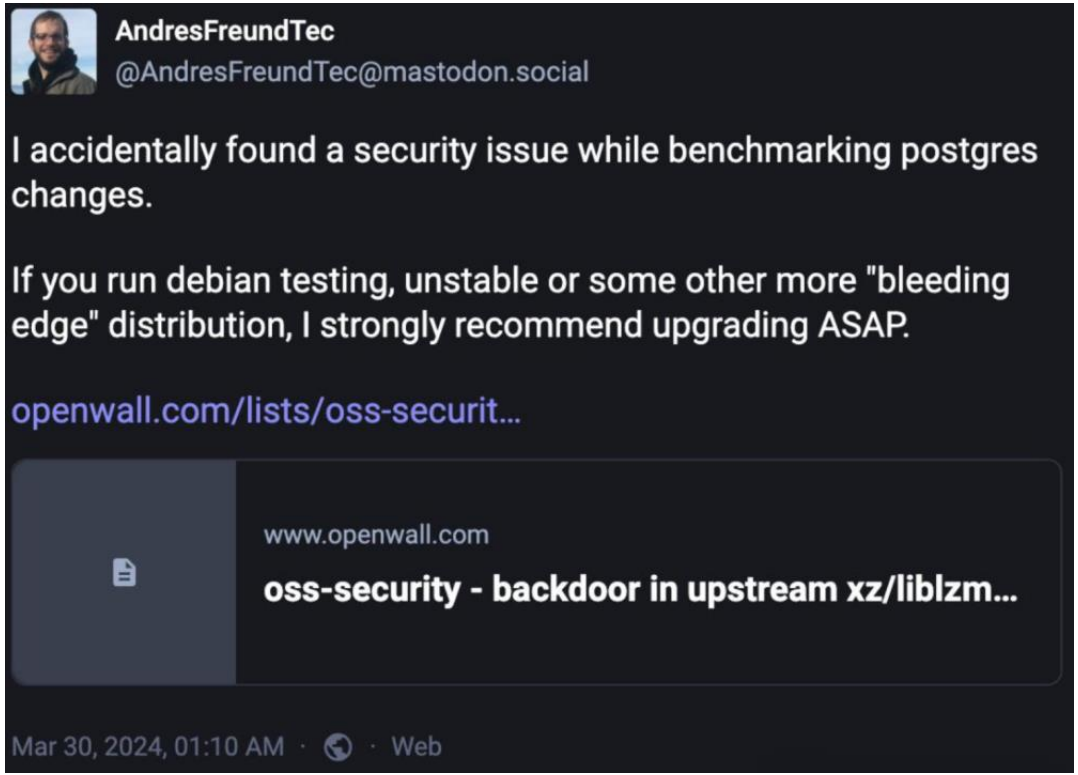
Link

For the First Time, Hackers Have Used a Refrigerator to Attack Businesses

Julie Bort *January 17, 2014*

Open Source Software

XZ-Utils



Timeline:

2021年，一个用户创建了名为“JiaT75”的GitHub账户（以下简称JT），并开始为多个项目做出贡献。在那一年，JT共提交了546次代码。

2022年，XZ项目缺乏人手，“JiaT75”成为管理员。

2023年7月8日，JT在oss-fuzz项目中提交了一个请求防止oss-fuzz发现XZ项目中潜藏的恶意代码。

2024年2月23日，JT在XZ项目的测试文件夹中加入了两个含有隐藏后门的测试文件。

Next: Security Principles

- Security principles
  - Know your threat model
  - Consider human factors
  - Security is economics
  - Detect if you can’t prevent
  - Defense in depth
  - Least privilege
  - Separation of responsibility
  - Ensure complete mediation
  - Don’t rely on security through obscurity
  - Use fail-safe defaults
  - Design in security from the start

Know Your Threat Model

Textbook Chapter 1.1 & 1.12

The Parable of the Bear Race

Reminder: blue slides are case studies. Remember the takeaway, not the story!

"I don't have to outrun the bear. I just have to outrun *you*."

Takeaway: Even if a defense is not perfect, if it is more advantageous for attackers to attack somewhere else, it can be effective

Know Your Threat Model

- **Threat model**: A model of who your attacker is and what resources they have
- It all comes down to people: The attackers
  - No attackers = No problem!
  - One of the best ways to counter an attacker is to attack their reasons
- Why do people attack systems?

Money

Advertisers

Politics

Anonymous

NSA

Fun

To watch the world burn

Security Principle: Know Your Threat Model

- Consider: Personal security
- Who and why might someone attack *you*?
  - Criminals might attack you for money
  - Teenagers might attack you for laughs or to win online games
  - Governments might spy on you to collect intelligence
  - Intimate partners might spy on you
    - This is a surprisingly dangerous threat model!

The National Security Agency (NSA)

- Stated purpose: To collect information to protect US national security
- Since its founding in 1952, the NSA has:
  - Decoded secret enemy communications in wars
  - Spied on people in the US and other countries (sometimes legally, sometimes illegally)
  - Participated in security research and helped develop security standards
  - Developed secret techniques for surveillance and cyberattacks

Threat Model: Common Assumptions for Attackers

- Assume the attacker…
  - Can interact with systems without notice
  - Knows general information about systems (operating systems, vulnerabilities in software, usually patterns of activity, etc.)
  - Can get lucky
    - If an attack only succeeds 1/1,000,000 times, the attacker will try 1,000,000 times!
  - May coordinate complex attacks across different systems
  - Has the resources required to mount the attack
    - This can be tricky depending on who your threat model is
  - Can and will obtain privileges if possible

Trusted Computing Base

- **Trusted computing base** (**TCB**): The components of a system that security relies upon
- Question: What would you want from a TCB?
- Properties of the TCB:
  - Correctness
  - Completeness (can't be bypassed)
  - Security (can't be tampered with)
- Generally made to be as small as possible
  - A smaller, simpler TCB is easier to write and audit.
  - **KISS principle**: Keep It Simple, Stupid

Consider Human Factors

Textbook Chapter 1.2

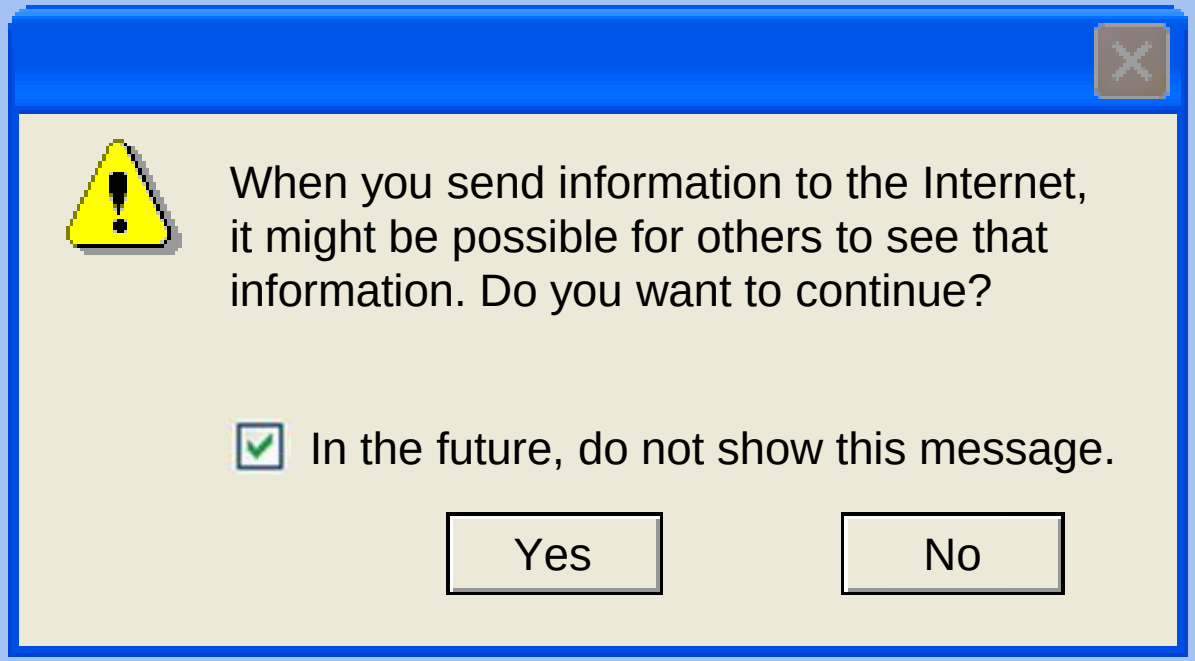
It All Comes Down To People

- The users
  - Users like convenience (ease of use)
  - If a security system is unusable, it will be unused
  - Users will find way to subvert security systems if it makes their lives easier
- The programmers
  - Programmers make mistakes
  - Programmers use tools that allow them to make mistakes (e.g. C and C++)
- Everyone else
  - Social engineering attacks exploit other people's trust and access for personal gain
- Consider the tools presented to users, and make them *fool*-proof

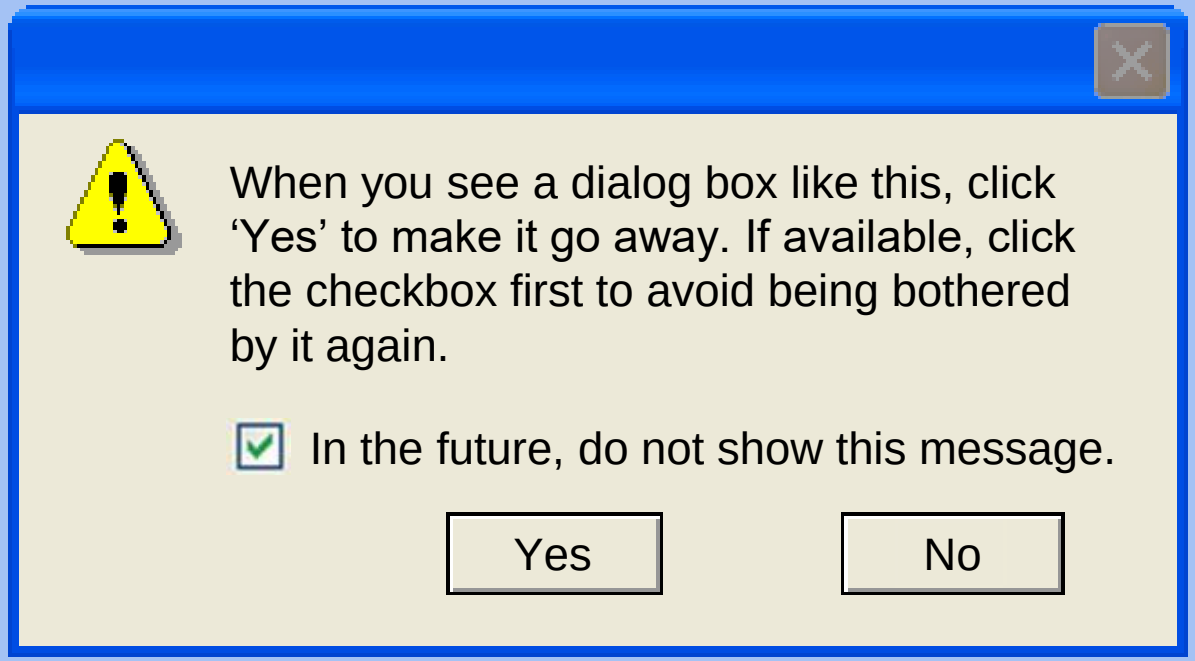
Physical security keys are designed to look like keys because humans are trained to protect keys

It All Comes Down To People

Warning Dialogs



Warning Dialogs



Warning Dialogs

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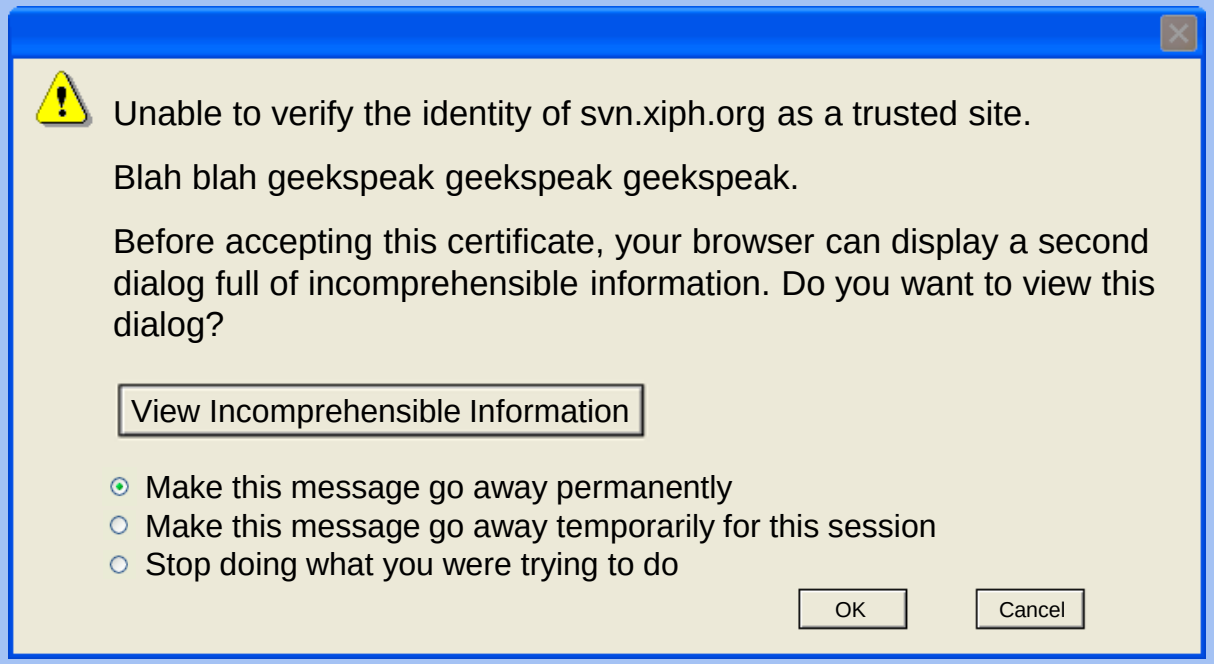

The presence of warning dialogs often represent a failure: How is the user supposed to know what to do?
Takeaway: Consider human factors