Today

Security vs risk management

Adversarial thinking

Abstraction and its problems

Trust and TCBs

Risk management

Computers not the only risky systems!

- reliability
- safety
- fraud detection
- epidemiology

Q: what do these have in common?

A: a couple of things

- like security: hidden problems that come to light
- unlike security: quantitative analysis

Stochastic threats

Reliability: probability of failure / time between failures

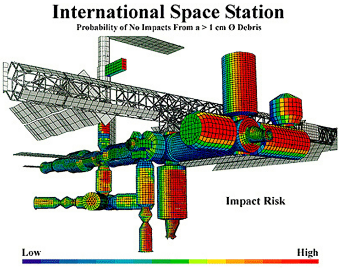
Safety: probability of failures causing safety incident

Epidemiology: probability of infection after exposure

Risk equation:

$$R = P \times C = T \times V \times C$$

Q: On what do these probabilities depend?



We often assume that different risks are _____. This can be quite reasonable in the case of safety engineering, reliability engineering, etc.. If rust can rust, _____. How much? _____ If a virus can infect you, _____.

Know your enemy

Classical risk management

- an impersonal force of nature

Computer security (and crime, and geopolitics...)

- defending against **people** taking **intentional** actions
- not just a force, an **adversary**, an **attacker**

Crime isn't just a matter of means and opportunity: it's also a question of _____ (as well as _____, _____ and _____).

The presence of an adversary (or adversaries) is what makes security different from mere risk management.

Adversarial thinking

The attacker:

a directed, strategic, *adaptive* adversary

_____ ***wants*** something
_____ _____ makes ***choices*** and ***plans*** to enhance effectiveness
A flood or a virus doesn't choose where or when to strike
Example: lighting and bird strikes
_____ will change attacks as you change defences

Thinking about adversaries

Adversaries vary in their:

- Objectives
- Capabilities
- Methods
- Insider access
- Support

Adversary models

Can do some formal modeling

e.g., the *Dolev-Yao* attacker is very important in network security

Informal shorthands often more immediately useful

Informal adversary models

Accidental	Intelligence service
APT	Military
Competitor	Lookie-loo
Hacktivist	Organized crime
Honest-but-curious	Scammer
Insider	Script kiddie

Accidental	Violates security policy without meaning to
APT	Well-resourced, operate with impunity
Competitor	Industrial espionage
Hacktivist	Social or political motivation
Honest-but-curious	Executes protocols faithfully but sneaks a peek
Insider	Disgruntled employee, whistleblower, etc.
Intelligence service	Well-resourced, connected to non-cyber assets
Lookie-loo	Motivated by curiosity
Military	Connected to physical-world objectives
Organized crime	Financial incentive, well-organized markets
Scammer	Financial incentive, low effort
Script kiddie	Want to see what they can do

Abstraction

What is abstraction?

You've been thinking in a structured way about abstraction since your _____ _____, and informally for long before that! Abstraction is useful; in some ways, it's the core of what all engineers do.

Abstraction

What is abstraction?

Why is it helpful?

How is it deceptive?

"Towards a New Model of Abstraction in the Engineering of Software", G Kiczales, *IMSA'92: Proceedings of the 1992 Workshop on Reflection and Meta-level Architectures*, 1992.
"The Law of Leaky Abstractions", J Spolsky, *Joel on Software*, 2002.

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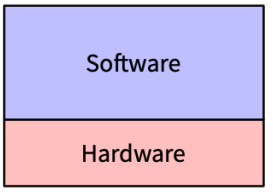
Abstraction is useful, as it allows us to _____ some aspects of a problem while we _____ on others — we can't _____! For example, it would be much harder to write Python code that translates objects to JSON respresentations if we had to be concerned with the implementation details of how, say, a hash map is implemented (what Marsenne prime is being used?), or what the virtual address of an object is, or how that virtual address is translated to a physical address, or which L2 cache line it's occupying!

On the other hand, abstractions are _____. A remote method invocation interface may hide all of the details of network configuration and method enumeration, but if the network goes down, it can't hide that problem (or at least not well!). Complex systems require thinking _____; if you aren't, you can be sure that your attackers are!

Abstraction layers

Common model of a computing system:

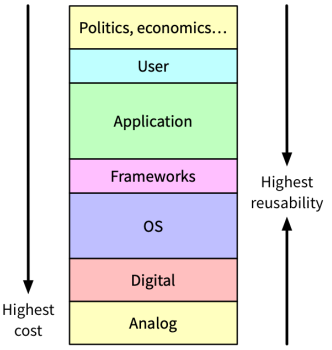
- attacker can attack the software
- attacker can attack the hardware



More abstraction layers!

More realistic model of a computer system:

- attacks can come at *any* layer
- defence must happen at *every* layer
- attacks can be as hidden as implementation details



The real world is complicated. We have lots of abstractions that go into the making of a computer system, and all of them leak! None of them fully hide the details of the layers below, and none are immune from the influence of the layers that sit on top of them. Security is _____ and _____.

Critically for security, the attacker often gets to meet you on a _____. If one abstraction layer of your system defends effectively against an attacker, they can often come at layers _____ or _____ your work. A bank's smart card can perform a lot of cryptographic operations to help safeguard your information, but those aren't enough by themselves. In a _____ layer, an adversary can attempt to exploit _____ _____ of the card itself to learn secret information like cryptographic keys. At a _____ layer, if the adversary can gather card details including the CVV2 code via a skimmer or by fooling the cardholder, all the side-channel security in the world can't protect you. Thus, your defences are often only as strong as _____. Example: Bunker Buster, *The Daily WTF*

Technical people like engineers often don't like to think about the highest-level abstractions on this chart, but they are real! The best cryptography and other technical measures can be easily subverted if you can trick users into misusing systems, or if the economic incentives of a larger sociopolitical system reward bad behaviour.

Really? Users?

Security is a *human* discipline

- attacker motivations
- defender motivations
- insider motivations

Office Space (1999)

Insiders can _____ malicious

Secondary goal

> *Security is usually a **secondary goal**. People do not generally sit down at their computers wanting to manage their security; rather, they want to send email, browse web pages, or download software, and **they want security in place to protect them** while they do those things. It is easy for people to put off learning about security, or to optimistically assume that their security is working, while they focus on their primary goals. Designers of user interfaces for security should not assume that users will be motivated to read manuals or to go looking for security controls that are designed to be unobtrusive.*

Usability of Security: A Case Study, Whitten and Tygar, CMU-CS-98-155

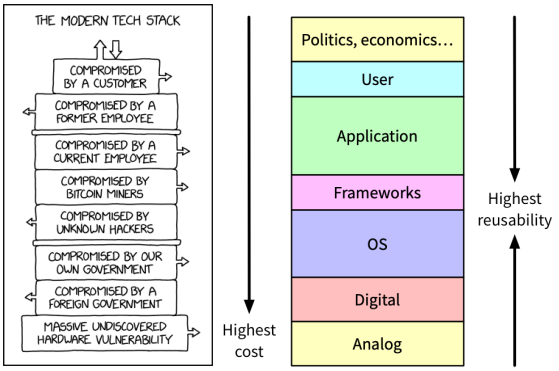
This quote is from Dr Whitten's 1999 PhD thesis (which came out during the same year as Office Space!).

Don't make users' lives _____! You may turn them into _____.

Trust and TCBs

What is trust?

"Trusted" vs "Trustworthy"



Trust is typically a word that brings _____, but not in this course!

Do you trust your bank? _____ You actually trust a combination of your bank teller, double-entry bookkeeping, security cameras, time vaults, police and security guards, but also — much more than most people think about — the Canada Deposit Insurance Corporation.

Someone that you might really trust is a _____. If you meet with a _____, you will explain your clever idea for a _____ but they will not _____. You will have no guarantee that they won't just _____... now ***that*** is trust. Do you feel _____ _____ about that?

We should build systems that are _____ without assuming that they are _____.

One definition of "trusted"

> *A trusted system is one whose failure can break the security policy*

Anderson, Security Engineering

In this view:

Something you *have* to trust, not *want* to trust

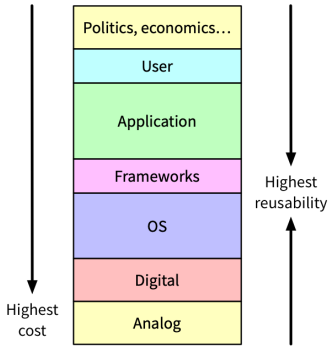
Or: "one that can get you fired"

Or: "one that you can't really validate"

TCB: Trusted Computing Base

Everything you have to trust

Goal: minimize!



A ***trusted computing base*** is everything in a system that you are trusting, i.e., everything you are depending on in order for your part of a system to work correctly.

Attacks against different layers have different costs and different levels of applicability. A supply-chain attack against a common Node.js package can be as cheap as a _____ and as easy as a modified _____, introducing vulnerabilities into tens of thousands of other packages. A supply-chain attack against a motherboard, however (also described here) takes a lot more work, both to implement and then to exploit. However, it is also much more difficult to defend against!

Our goal, then, is not to _____ but to _____. The less we have to depend on, the better.

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Next time:

Software security