Security Engineering

UT CS361S

FALL 2020

LECTURE NOTES

What is it?

"[It] is about building systems to remain dependable in the face of …"

- Malice
- Error
- Mischance.

"As a discipline, it focuses on the…"

- Tools
- Processes
- Methods

The Goal

Confidentiality, Integrity, Availability (CIA Triad)

For new systems:

- Design security
- Implement security
- Test security

For existing systems:

- Adapt them for increased security
- Adapt them as their *environment* evolves

Key Observation

and covertness. But many systems fail because their designers protect the wrong things, or protect the right things but in the wrong way.

Anderson, Ch 1, p. 4

A Framework

Policy

Mechanism

Assurance

Incentives

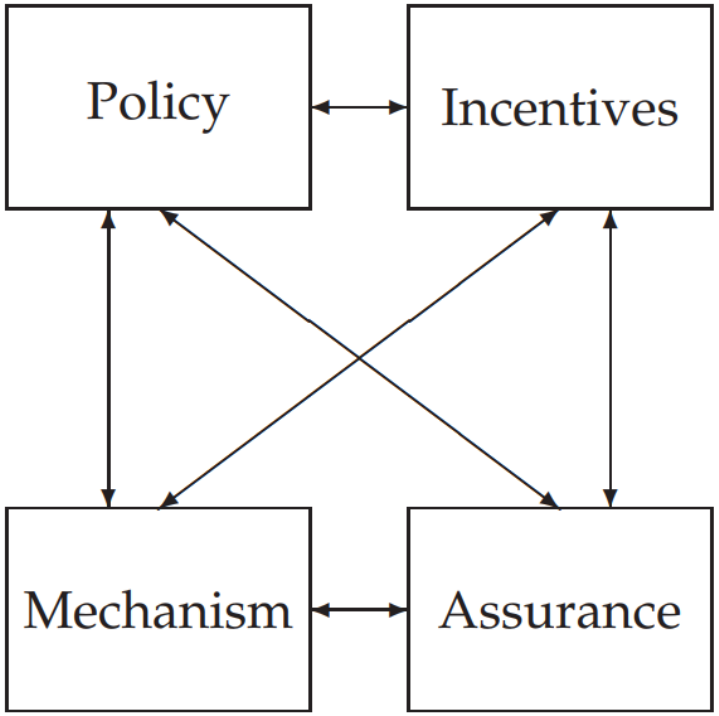


Figure 1.1: Security Engineering Analysis Framework

Some Definitions

System – Tech + Auxiliary Tech + Staff + Users + etc.

Subject – Physical “person”

Principal – Entity in the system

Identity – Unique label attached to a unique principal

Trusted – Failure results in compromise

Trustworthy – Failure is unlikely

CIA (Not the Spies)

Confidentiality – Cannot be read

Integrity – Cannot be altered

Availability – Cannot be interrupted

Understand This

So if you're the owner of the company, don't fall into the trap of believing that the only possible response to a vulnerability is to fix it, and distrust the sort of consultant who can only talk about 'tightening security'. Often it's too tight already, and what you really need to do is just focus it slightly differently.

Anderson, Ch 25, p. 816

Anderson's Examples

Bank

Military

Hospital

Home

IAAA

Identity – Unique label for a unique principal

Authentication – Validation of the principal's identity

Authorization – Permissions granted the prinicpal

Accountability – Metering and auditing of principal

(Message Authenticity – Integrity + Freshness)

Grasp the Context

SECURITY IS ABOUT CONTEXT (Repeat after me)

What does it mean when you say “system *X* is secure”?

- Secure against *whom*?
- Secure under *what conditions*?
- Are we even protecting what matters?!

Take voting security

- Who are the potential attackers?
- How does the context change if a nation decides to be the attacker?

Start with Policy

"…a succinct statement of a system's protection strategy" (Anderson ch1 p. 15)

Examples:

- Each credit must be matched by an equal and opposite debit
- All transactions over $1,000 must be authorized by two managers

Practice:

- What are the security policies for TLS?

Then figure out mechanism

This is where most security people like to start

But really we only need mechanism to enforce policy

Some mechanisms aren't even technical (e.g., legal)

MUST understand *threat model*

Assurance

Just how strong/resilient/comprehensive is the mechanism?

Requires a solid understanding of the threat model

Applications at every stage!

- Design – solid security engineering principles
- Implementation – coding practices, development processes
- Testing – adversarial, comprehensive assessment

Software Quality: Therac 25

http://sunnyday.mit.edu/papers/therac.pdf

Computer controlled radiation medical therapy machine

Between 6/’85 and 1/’87, it overdosed 6 people (3 died)

The problems were primarily software failures

Race Condition Bug

Real time operating system gathers details from the UI

Setting the bending magnets takes 8 seconds

Checks for data edits (in real time) as it is setting the magnets

However, cleared variable mean subsequent edits are not recorded (but show up in UI)

Overflow bug

Error-checking and integrity checking code protects software

One variable would perform a check if the value was non-zero

- But the variable was just 8 bit
- Every 256th check would overflow back to zero

When the tech hit “set” when this overflow happened would allow full, maximum exposure

Understanding Failures

Everything fails.

Everything.

Don’t be like AECL (“It can’t fail that way…”)

- I recently had engineers of a client say the exact same things
- They couldn’t understand why I thought their software would fail

How will *your* software fail?

- You have to ensure that you fail safely
- Some failures can never be tolerated; those features may need to be removed
- Related: Make sure you use *fail safe defaults*

Incentives

Anderson's example of airport security

What motivates the behavior?

What is "Security Theater?"

Everyone should learn a little game theory

- Read up on Prisoner's dilemma
- Understand "mechanism design"
- Anderson's "Moral Hazard" (Chapter 25)

Security Principles

Least privilege

Minimize attack surface

Defense in depth

Separation of duties and responsibilities

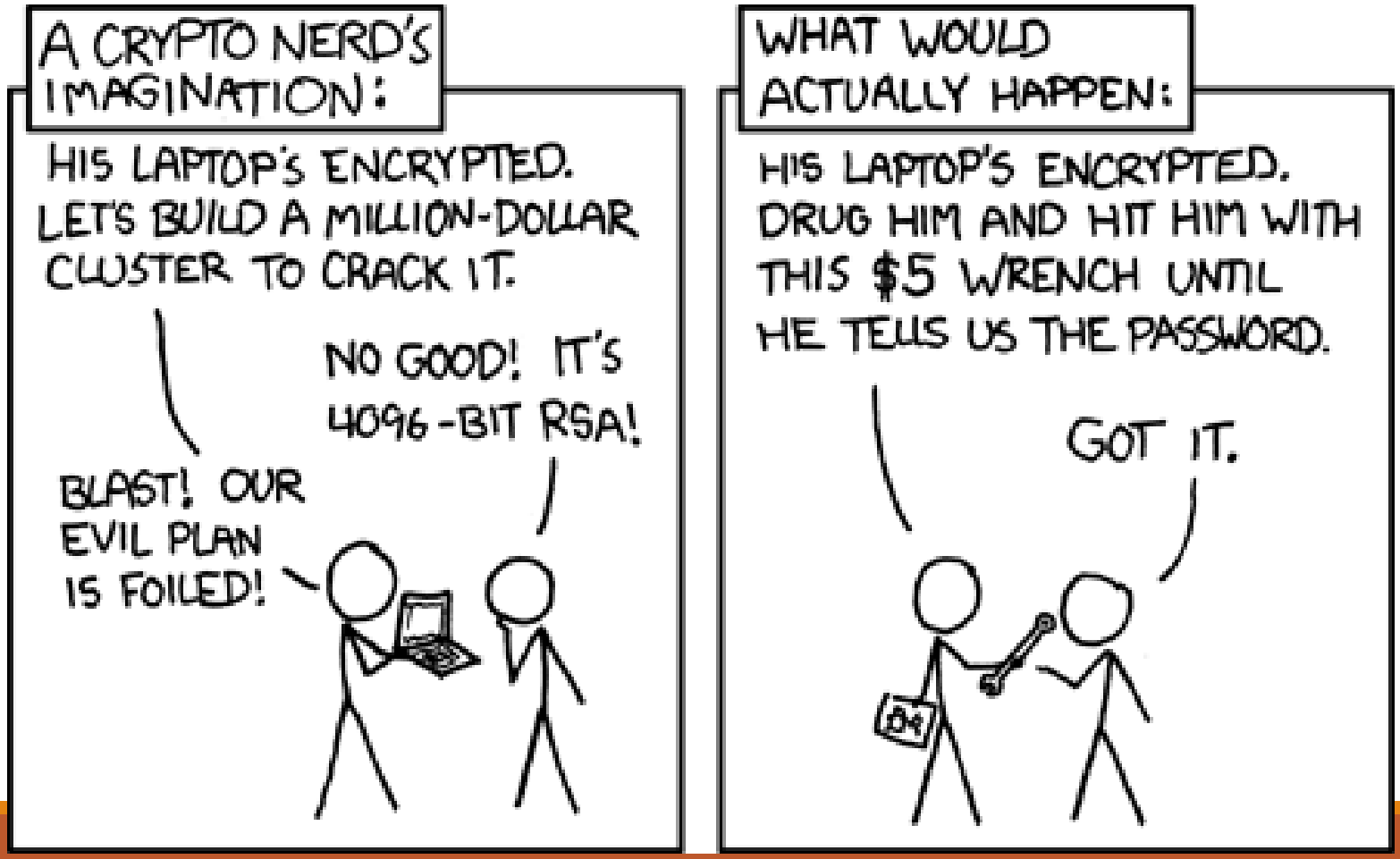
Crowdsourcing

Open systems

Fail Safe/Fail Secure

Illustrations

See http://xkcd.com/538/



Psychology

Much of computer security rests on ***psychology***

Phishing, email scams, etc all depend on user psych

Security mechanisms avoided because they clash with psych

Social Engineering: *Pretexting*

Pretexting: phone for info pretending to be someone else

The goal is to private information, credentials, etc

Attacks of this sort are often conducted in stages

- Attacker starts by getting non-sensitive information
- Attacker uses non-sensitive information to convince others of his deception

One health institution had 30 such calls a week!

Social Engineering: Phishing

Phishing: Sending an email that appears to be authentic to get private info

Easy to create an email that looks authentic.

- Especially modern emails with HTML and media
- The resources are often online, so the phishing email simply points to them
- Email is easily forgible

Example attacks:

- Tell user they need to change password (and enter old password first)
- Tell user they need to update profile including SSN

Understanding Human Bias

Humans are not rational

Humans are designed with a bias toward action

- If we thought about everything we'd never do anything
- We're programmed to act without thinking

Examples of bias:

- We're more afraid of dying in a plane crash than a car crash

When Emotion Takes Over

When human logic/thinking ends, emotions take over

If we don't know explicitly what to do, we respond emotionally

So, sometimes education has limited value

- Bad guys will always learn how to exploit what the users dont know

One solution is safe defaults (FAIL SAFE/FAIL SECURE!)

- "Our bank will never, ever send email"

Abuses of Authority

Read carefully the book's examples of how people behave

- Under someone else's authority
- When they have authority

Also, people do not like to admit they make mistakes

- "Hustlers" take advantage of this

AGAIN, you cannot design assuming the user is dispassionate and rational

CAPTCHAs

Good case study!

- Combine psychology, usability, and system design nicely
- Designed around what humans do well that computers do not
- “Completely Automated Public Turing Test to Tell Computers and Humans Apart”
- Thanks Alan Turing!

Network Security

Everyone wants a secure network. But how?

"***Whoever thinks his problem can be solved using cryptography, doesn't understand his problem and doesn't understand cryptography.***"

- — Attributed by Roger Needham and Butler Lampson to Each Other

This is what we're going to study this semester!