

CSE 127: Introduction to Security

Deian Stefan

UCSD

Fall 2020 Lecture 1

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- TA: Kevin Yu shy147@ucsd.edu
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 - Office Hours: Tue 1-2pm



Many amazing folks at UCSD working on security



Theory

Applied

Crypto Systems

Nadia Polikarpova



Ranjit Jhala



Sorin Lerner



kc Claffy



Lawrence Saul



Ryan Kastner



PL & Verification

Networking

ML

Embedded

My group's research

Memory safety and sandboxing (MS-Wasm, RLBox, Swivel)

Practical verification for security (VeRA, IODINE, VeriWasm)

Bugfinding for browsers and runtime systems (Sys, SafeV8)

Constant-time programming (CT-Wasm, FaCT, CTFP)

Web security and privacy

Security foundations

We focus on real-world impact

Securing Firefox with WebAssembly



By [Nathan Froyd](#)

Posted on February 25, 2020 in [Featured Article](#), [Firefox](#), [Rust](#), [Security](#), and [WebAssembly](#)

Protecting the security and privacy of individuals is a [central tenet](#) of Mozilla's mission, and so we constantly endeavor to make our users safer online. With a complex and highly-optimized system like Firefox, [memory safety](#) is one of the biggest security challenges. Firefox is mostly written in C and C++. These languages are notoriously difficult to use safely, since any mistake can lead to complete compromise of the program. We work hard to [find and eliminate memory hazards](#), but we're also evolving the Firefox codebase to address these attack vectors at a deeper level. Thus far, we've focused primarily on two techniques:

- [Breaking code into multiple sandboxed processes with reduced privileges](#)
- [Rewriting code in a safe language like Rust](#)

Once upon a time I even cofounded a startup

The screenshot shows the homepage of the Intrinsic website. At the top, there is a dark header bar with the word "intrinsic" in white. To the right of the logo are navigation links: PRODUCT, SOLUTIONS (with a dropdown arrow), COMPANY, DOCS, and BLOG. A blue button labeled "Request a Demo" is also in the header. Below the header, the main title "Software security, re-invented." is displayed in large, light-colored text. Underneath the title, a subtitle explains the product's purpose: "Intrinsic secures your sensitive data from bugs and malicious code, allowing you to run all code safely." To the right, a white callout box contains a testimonial: "'Intrinsic is the best way to secure your Node.js Lambda functions, period.' - Mathew Self, VP of Engineering, Box". The Box logo is shown next to the quote.

intrinsic

PRODUCT SOLUTIONS ▾ COMPANY DOCS BLOG Request a Demo

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box

Topics Covered

- The Security Mindset
 - Principles and threat modeling
- Systems/Software Security
 - Classic attacks and defenses on memory safety, isolation
- Web Security
 - Web architecture, web attacks, web defenses
- Network Security
 - Network protocols, network attacks, network defenses
- Cryptography
 - Public and private-key cryptography, TLS, PKI
- Privacy and Ethics

Course Goals

- Critical thinking
 - How to think like an attacker
 - How to reason about threats and risks
 - How to balance security costs and benefits

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- Learn to be a 1eet h4x0r, but an ethical one!

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80% Eight projects

- Own programming and writeup
- General discussion OK (even encouraged!)

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- Ask/answer questions, make comments, generate discussion!

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\leq 10% Lecture notes

- Work in groups
- Our goal: use notes in future classes!

Course Policies

Early policy:

- Can turn in assignments 3 days early to get 10% of your grade extra credit
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Academic integrity:

- UC San Diego policy:
<https://academicintegrity.ucsd.edu>
- We have to report suspected cases, don't make it weird
- If you are not sure if something is cheating, ask

Talk to us, it's a weird time



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<https://piazza.com/ucsd/fall2020/cse127>
- Lectures, section, office hours:
 - On this Zoom
 - Everything will be recorded and posted online

Ethics

We will be discussing and implementing real-world attacks.

Using some of these techniques in the real world may be unethical, a violation of university policies, or a violation of federal law.

This includes the course assignment infrastructure (e.g., grading system).

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Be an ethical hacker

- Ethics requires you to refrain from doing harm
- Always respect human, privacy, property rights
- There are many legitimate hacking capture-the-flags

18 U.S. CODE § 1030 - FRAUD AND RELATED ACTIVITY IN CONNECTION WITH COMPUTERS

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The punishment for an offense...

- a fine under this title or imprisonment for not more than one year, or both...,
- a fine under this title or imprisonment for not more than 5 years, or both... if—
 - (i) the offense was committed for purposes of commercial advantage or private financial gain;
 - (ii) the offense was committed in furtherance of any criminal or tortious act...; or
 - (iii) the value of the information obtained exceeds \$5,000

The Good, the Bad, and the Ugly

- Good** In 2012, FBI prosecuted weev for exposing data of 114K iPad users
- Bad** In 2011, Sony sued George Hotz for jailbreaking PlayStation 3
- Ugly** In 2011, FBI prosecuted Aaron Swartz for downloading academic articles on MIT network from JSTOR

What is security?

Robustness vs. Security



Robustness vs. Security



"Computer security studies how systems behave in the presence of *an adversary*."

**Actively tries to cause the system to misbehave.*

The Security Mindset

- Thinking like an attacker
 - Understand techniques for circumventing security
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- Thinking like an attacker
 - Understand techniques for circumventing security
 - Look for ways security can break, not why it won't
- Thinking like a defender
 - Know what you're defending, and against whom.
 - Weigh benefits vs. costs:
No system is ever completely secure.
 - Rational paranoia
Don't build bridges to sustain bombings

Thinking like an Attacker

- Look for weakest links
- Identify assumptions that security depends on
Are they false?

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Start practicing: When you interact with a system, think about what it means to be secure, and how it might be exploited.



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Exercise

How would you break into the CSE building?

Exercise

How would you identify who was at a protest?

Exercise

How would you steal my email password?

Exercise (open)

What security systems do you interact with?

Exercise (for home)

How would you steal an election?

Thinking like a Defender

- Security policy
 - What are we trying to protect?
 - What properties are we trying to enforce?
- Threat model
 - Who are the attackers? Capabilities? Motivation?
 - What kind of attack are we trying to prevent?
- Risk assessment
 - What are the weaknesses of the system?
 - What will successful attacks cost us?
 - How likely?
- Countermeasures
 - Costs vs. benefits?
 - Technical vs. nontechnical?

Security Policies

- What *assets* are we trying to protect?
- What properties are we trying to enforce?
 - Confidentiality
 - Integrity
 - Availability
 - Privacy
 - Authenticity
 - :

Threat Models

- Who are our adversaries?
 - Motives?
 - Capabilities?
- What kinds of attacks do we need to prevent?
(Think like the attacker!)
- Limits: What kinds of attacks we should ignore?

Example of Threat Modeling

Threat	Ex-girlfriend/boyfriend breaking into your email account and publicly releasing your correspondence with the My Little Pony fan club	Organized criminals breaking into your email account and sending spam using your identity	The Mossad doing Mossad things with your email account
Solution	Strong passwords	Strong passwords + common sense (don't click on unsolicited herbal Viagra ads that result in keyloggers and sorrow)	Magical amulets? Fake your own death, move into a submarine? YOU'RE STILL GONNA BE MOSSAD'ED UPON

Figure 1: Threat models

James Mickens "This World of Ours"

Example of Threat Modeling



Someone has your password

Hi John

Someone just used your password to try to sign in to your Google Account
john.podesta@gmail.com.

Details:

Saturday, 19 March, 8:34:30 UTC

IP Address: 134.249.139.239

Location: Ukraine

Google stopped this sign-in attempt. You should change your password immediately.

CHANGE PASSWORD

Best,
The Gmail Team

Who is John Podesta?

Assessing Risk

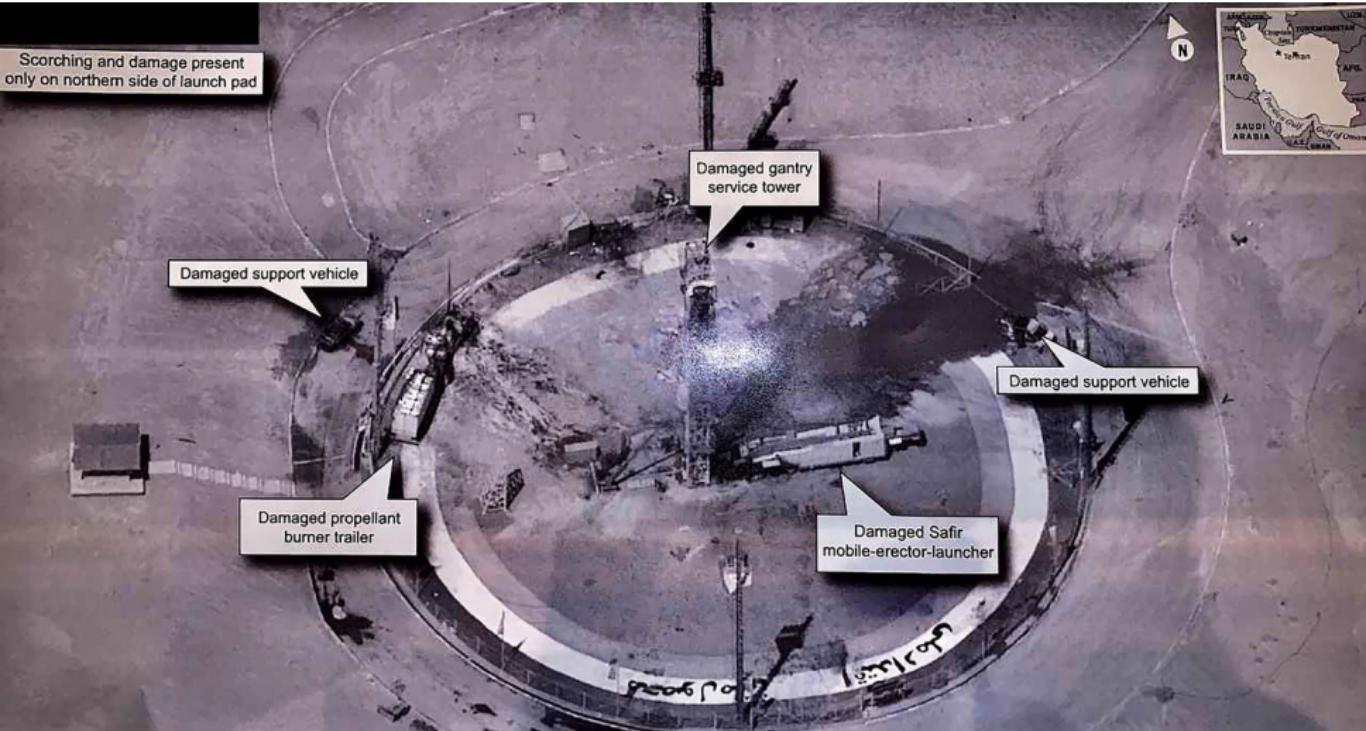
Remember: *Controlled paranoia*

- What would security breaches cost us?
 - Direct costs: Money, property, safety, ...
 - Indirect costs: Reputation, future business, well being,
...
- How likely are these costs?
 - Probability of attacks?
 - Probability of success?

Countermeasures

- Technical countermeasures
- Nontechnical countermeasures
Law, policy (government, institutional), procedures, training, auditing, incentives, etc.

How do we protect classified satellites?



Security Costs

- No security mechanism is free
 - Direct costs:
Design, implementation, enforcement, false positives
 - Indirect costs:
Lost productivity, added complexity
- Challenge is to rationally weigh costs vs. risk
 - Human psychology makes reasoning about high cost/low probability events hard

Exercise

Should you lock your door?

- Assets?
- Adversaries?
- Risk assessment?
- Countermeasures?
- Costs/benefits?

Exercise

Should you use automatic software updates?

- Assets?
- Adversaries?
- Risk assessment?
- Countermeasures?
- Costs/benefits?

Exercise

Should we protect the CSE bear?

- Assets?
- Adversaries?
- Risk assessment?
- Countermeasures?
- Costs/benefits?

Secure Design

- Common mistake:
Convince yourself that the system is secure
- Better approach:
Identify *weaknesses* of design, focus on correcting them
Formally prove that design is secure (soon)
- Secure design is a **process**
Must be practiced continuously
Retrofitting security is super hard

Where to focus defenses

- *Trusted components*
Parts that must function correctly for the system to be secure.
- *Attack surface*
Parts of the system exposed to the attacker

Security Principles

- Simplicity, open design, and maintainability
- Privilege separation and least privilege
- Defense-in-depth and diversity
- Complete mediation and fail-safe

Exercise

Preventing cheating on an online exam?

Exercise

Preventing you from stealing my password?

Assignment 1 out tomorrow.

Next lecture: Buffer overflows!