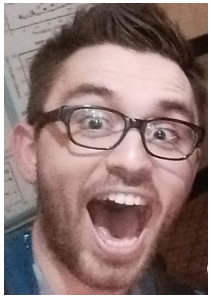
# CSE 127: Introduction to Security

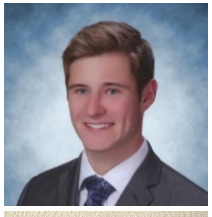
**Deian Stefan**

UCSD

Winter 2020 Lecture 1

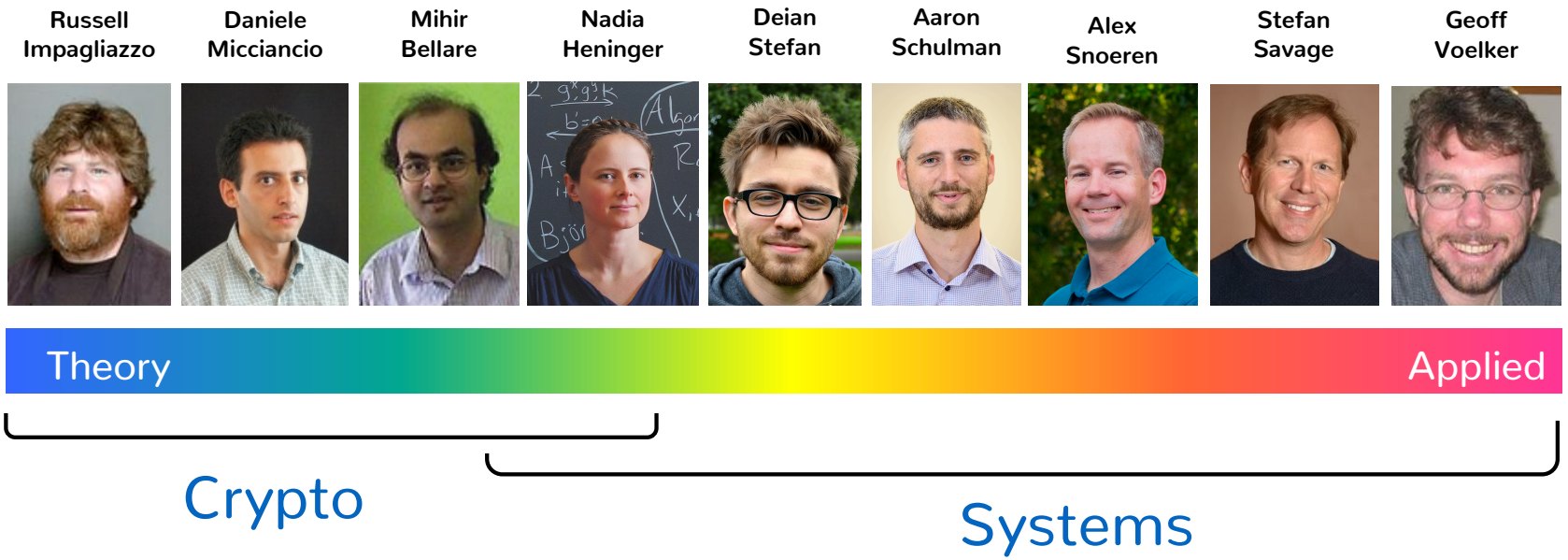
# Course staff





- Instructor: Deian Stefan deian@cs.ucsd.edu
  - Lecture: Mon & Wed 5-6:20pm Center 109
  - Discussion: Fri 2-2:50pm Center 216
  - Office Hours: Wed 3:00-4:00pm in 3126 EBU3B
- TA: Sunjay Cauligi scauligi@eng.ucsd.edu
  - Office Hours: Tue TBA
- TA: Riley Hadden rhadden@eng.ucsd.edu
  - Office Hours: Thu TBA
- TA: Zaki Siddiqui zsiddiqu@ucsd.edu
  - Office Hours: Mon 1:00-2:00pm in B270A EBU3B

# Many amazing folks at UCSD working on security




# My work: Language-based security


**CT-Wasm: Type-Driven Secure Cryptography for the Web Ecosystem**

CONRAD WATT, University of Cambridge, UK
JOHN RENNER, University of California San Diego, USA
NATALIE POPESCU, University of California San Diego, USA
SUNJAY CAULIGI, University of California San Diego, USA
DEIAN STEFAN, University of California San Diego, USA

# My work: Language-based security

**IODINE: Verifying Constant-Time Execution of Hardware**

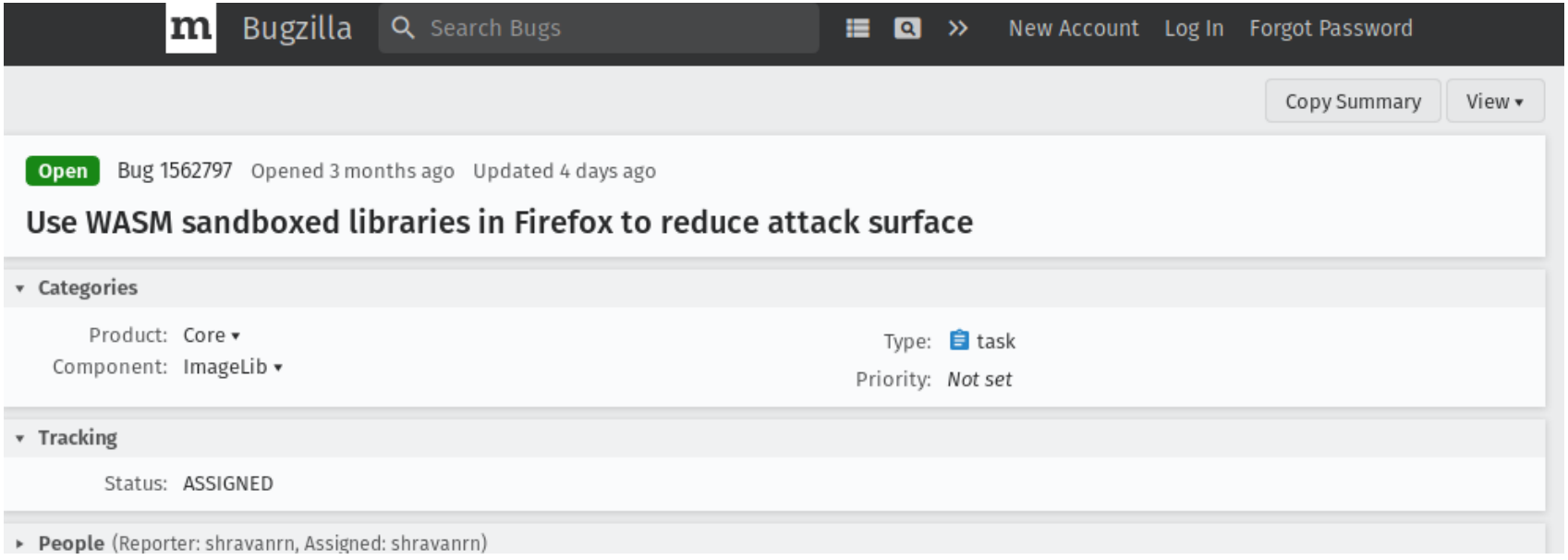
Klaus v. Gleissenthall
*University of California, San Diego*

Rami Gökhan Kıcı
*University of California, San Diego*

Deian Stefan
*University of California, San Diego*

Ranjit Jhala
*University of California, San Diego*

# My work: Systems security



# My work: Systems security

**Finding and Preventing Bugs in JavaScript Bindings**

Fraser Brown* Shravan Narayan† Riad S. Wahby*
Dawson Engler* Ranjit Jhala† Deian Stefan†

*Stanford University †UC San Diego

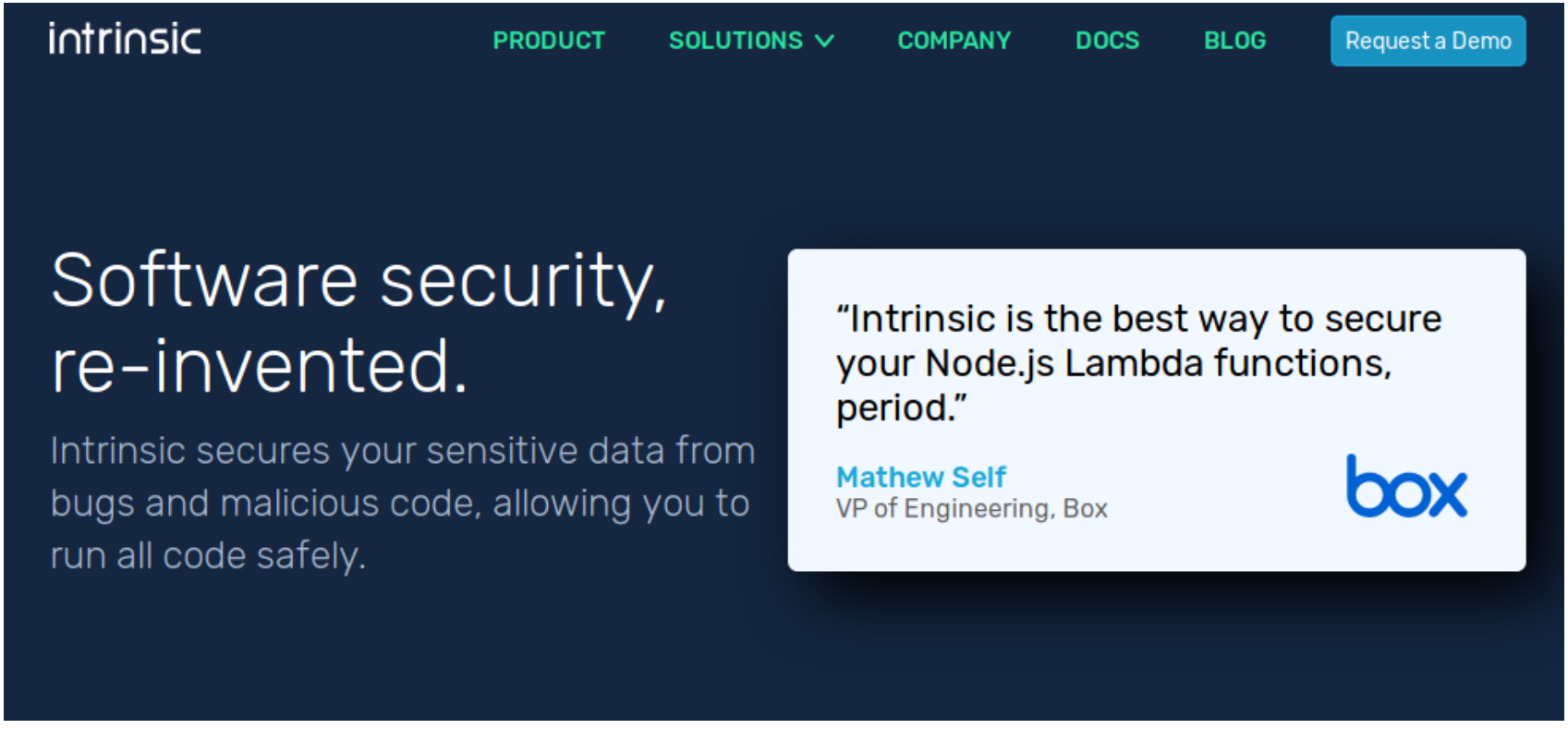
# My work: Web security


MOTHERBOARD
TECH BY VICE

## Old School 'Sniffing' Attacks Can Still Reveal Your Browsing History

The way that major browsers store history and structure links leaves them vulnerable to old school ‘sniffing’ attacks, according to new research from the University of California San Diego.

# My work: Web security



# Topics Covered

- The Security Mindset
  - Principles, threat modeling…
- Application Security
  - Defensive programming, memory protection, sandboxing, virtual machines, buffer overflows, malware
- Web Security
  - Web architecture, web attacks, web defenses
- Network Security
  - IP, TCP, routing, network protocols, network attacks, network defenses
- Cryptography
  - Public and private-key cryptography, authentication, secure channels, 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
- Technical skills
  - How to protect yourself
  - How to manage and defend systems
  - How to design and program secure systems

# Course Goals

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- Technical skills
  - How to protect yourself
  - How to manage and defend systems
  - How to design and program secure systems
- Learn to be a security-conscious citizen
- Learn to be a `leet h4x0r`, but an ethical one!

# Course Mechanics

40% Six projects

- Assignments will be due at 2pm on Wednesdays.

25% Midterm in class on Feb 10 (or 12)

```
if midterm > 0
   then max(midterm, final)
   else 0
```

35% Final: Monday (finals week, March 16) 7pm-10pm

$\leq$ 10% Participation

# Course Policies

**Early policy:**

- Can turn in assigments 3 days early to get 10% of your grade extra credit.
- No late days.

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No cheating!

- UC San Diego policy:
  `http://academicintegrity.ucsd.edu`
- If you are not sure if something is cheating, ask!
- We will report *all* suspected cheating cases to academic integrity

# Resources

- No official textbook. Optional books:
  - *Security Engineering* by Ross Anderson
  - *Hacking: The Art of Exploitation* by Jon Erikon

- Assignments and references will be available on the course web site:

  `https://cse127.programming.systems`

  Collaborative course note wiki on website.

- HW 1 will be up Wednesday. It is due **Wednesday 01/15**.

- Questions? Post to Piazza.

  `https://piazza.com/ucsd/winter2020/cse127`

# Ethics

We will be discussing and implementing real-world attacks.

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

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

- Ethics requires you to refrain from doing harm.
- Always respect privacy and property rights.
- There are many legitimate hacking challenges (CTFs).

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

Whoever intentionally accesses a computer without authorization or exceeds authorized access, and thereby obtains information from any protected computer...

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

# What is security?

# What’s the difference?

# What's the difference?

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

** An intelligence that actively tries to cause the system to misbehave.*

# The Security Mindset

- Thinking like an attacker
  - Understand techniques for circumventing security.
  - Look for ways security can break, not reasons 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"

# Thinking like an attacker

- Look for weakest links
- Identify assumptions that security depends on.
  Are they false?
- Think outside the box.
  Not constrained by system designer's worldview.

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

Breaking into the CSE building.

# Exercise

Getting accepted to UCSD.

What other security systems do you interact with?

# Thinking like a Defender

- Security policy
  - What assets 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

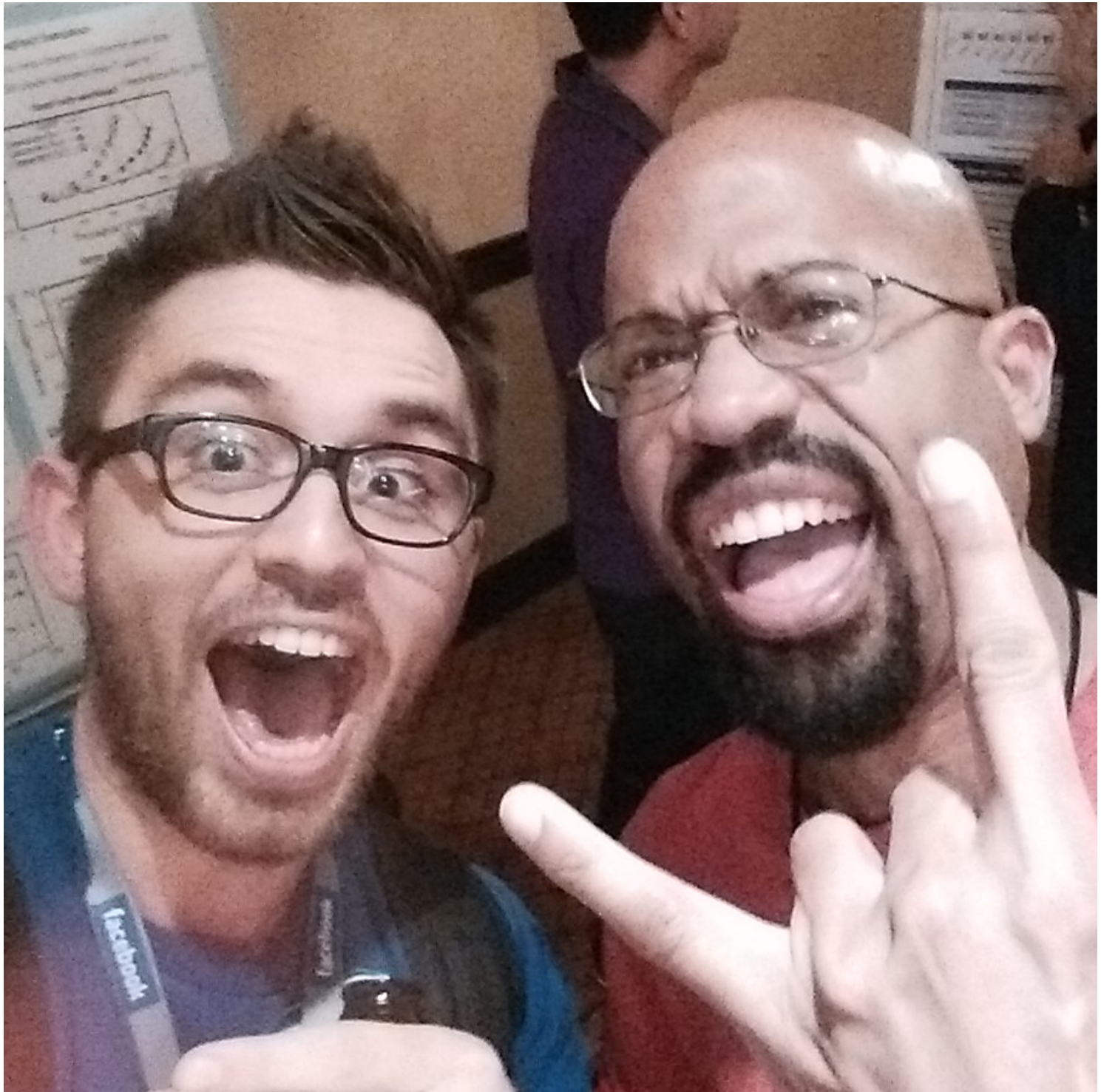
- Who are our adversaries?
  - Motives?
  - Capabilities?
- What kinds of attacks do we need to prevent? (Think like the attacker!)
- Limits: Kinds of attacks we should ignore?

# 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?<br>Fake your own death, move into a submarine?<br>YOU'RE STILL GONNA BE MOSSAD'ED UPON |

Figure 1: Threat models

James Mickens "This World of Ours"


facebook

Google

# 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

# Podesta emails

From Wikipedia, the free encyclopedia

In March 2016, the personal Gmail account of John Podesta, a former White House chief of staff and chair of Hillary Clinton's 2016 U.S. presidential campaign, was compromised in a data breach accomplished via a spear-phishing attack, and some of his emails, many of which were work-related, were hacked. Cybersecurity researchers as well as the United States government attributed responsibility for the breach to the Russian cyber spying group Fancy Bear, allegedly two units of a Russian military intelligence agency.[1]

Some or all of the **Podesta emails** were subsequently obtained by WikiLeaks, which published over 20,000 pages of emails, allegedly from Podesta, in October and November 2016.[2] Podesta and the Clinton campaign have declined to authenticate the emails.[3] Cybersecurity experts interviewed by PolitiFact believe the majority of emails are probably unaltered, while stating it is possible that the hackers inserted at least some doctored or fabricated emails. The article then attests that the Clinton campaign, however, has yet to produce any evidence that any specific emails in the latest leak were fraudulent.[4] A subsequent investigation by U.S. intelligence agencies also reported that the files obtained by WikiLeaks during the U.S. election contained no "evident forgeries".[5]

# 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?

**Donald J. Trump** ✔ @realDonaldTrump · 2h

Only reason the hacking of the poorly defended DNC is discussed is that the loss by the Dems was so big that they are totally embarrassed!

8,852 5,672 20.5K

**Donald J. Trump** ✔ @realDonaldTrump · 2h

Intelligence stated very strongly there was absolutely no evidence that hacking affected the election results. Voting machines not touched!

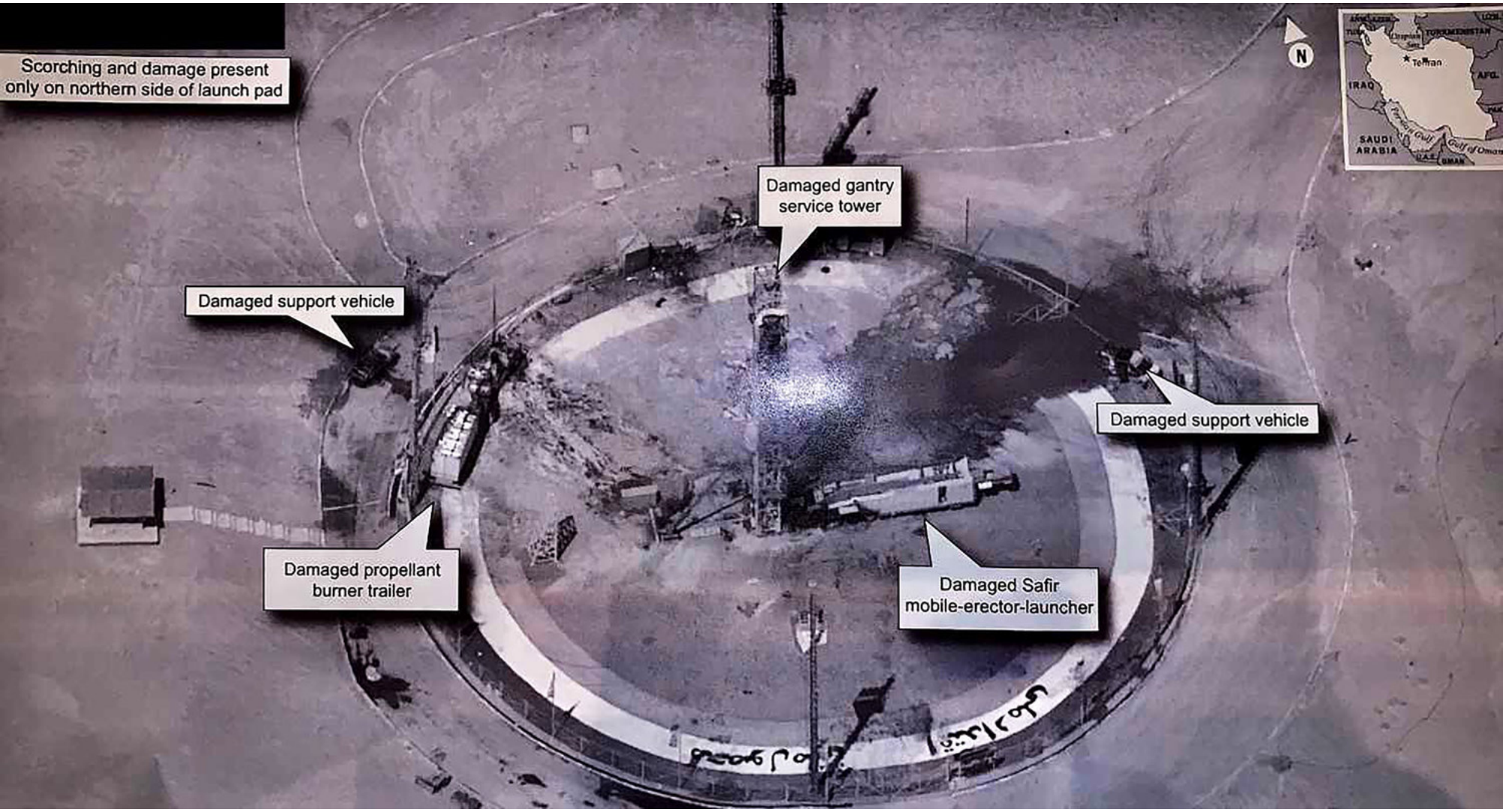
6,118 6,154 18.9K

**Donald J. Trump** ✔ @realDonaldTrump · 10h

Gross negligence by the Democratic National Committee allowed hacking to take place.The Republican National Committee had strong defense!

# Countermeasures

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


Scorching and damage present only on northern side of launch pad
Damaged gantry service tower
Damaged support vehicle
Damaged support vehicle
Damaged propellant burner trailer
Damaged Safir mobile-erector-launcher
N
Tehran
IRAQ
SAUDI ARABIA
TURKMENISTAN
AFG.
UAE
OMAN

# 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 accept a software update?

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

# Exercise

## Protecting the CSE bear?

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

# Secure Design

- Common mistake:
  Trying to convince yourself that the system is secure
- Better approach:
  Identify the *weaknesses* of your design and focus on correcting them
- Secure design is a **process**
  Must be practiced continuously; can't be retrofitted

# 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

- Complexity vs. security?

## Security Principles

- Defense-in-depth
- Diversity
- Maintainability

# Exercise

Preventing cheating on an exam?

# Exercise

Preventing you from stealing my password?

Next lecture: Buffer overflows!