Computer and Network Security

Lecture 01:
Overview & Mindset

COMP-5370/6370

Computer & Network Security

Security is an **enormous** field with many specializations, sub-fields, and communities.

- This is an **intro course** focused on exposure to the topics and gaining experience applying security-centric ideas.
- If you want to see how far the rabbit hole goes, there are follow-on courses.

Security Vocabulary is HARD

Security
Privacy
Resilience
Information Assurance
Risk Management
C---r + *any of above*

- Everyone has a specific definition for every word
  - Not all definitions agree
- Definitions change frequently and new words are constantly added to vocabulary

CompSci Security Vocab

"Attack"

Intentional exploitation for attacker's gain and victim's loss

"Bug"

Something that fails in unintended ways

"Weakness"

Bug that may be able to harm S&P

"Vulnerability"

Weakness which can be intentionally triggered

"Exploit"

Way to leverage a vulnerability

Security Mindset

A way of thinking about scenarios in order to identify and mitigate possible failures.

- Come in many form and applicable outside of computers/networks

Failures Come in Many Forms

- Tacoma Narrows
  - Design Failure
  - Natural Forces

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- Hard Rock Hotel
  - Process Failure
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Failures Come in Many Forms

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  - Natural Forces
- Hard Rock Hotel
  - Process Failure
  - Unintentional Actor
- World Trade Center
  - Intentional Failure
  - Intentional Actor
- Therac-25
  - Implementation Failure

Security Mindset

A way of thinking about scenarios in order to identify and mitigate possible failures.

- Come in many form and applicable outside of computers/networks
- Have to think like an attacker

Adversary

- Intelligent Actor
  - Person, Group, or Organization
- Have own:
  - Capabilities
  - Motivations
  - Intentions
- Are **NOT** restricted by expectations

Security Mindset

A way of thinking about scenarios in order to identify and mitigate possible failures.

- Come in many form and applicable outside of computers/networks
- Have to think like an attacker
  - Comprehend abilities and behavior patterns
  - Understand how search for/exploit weaknesses

Thinking Like an Attacker

- What is the **easiest/simplest** way to win?
  - “weakest link”, “low-hanging fruit”

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  - What are the creator’s expectations?
  - Who else does the creator rely on?

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- What are the **explicit assumptions** built into the system?
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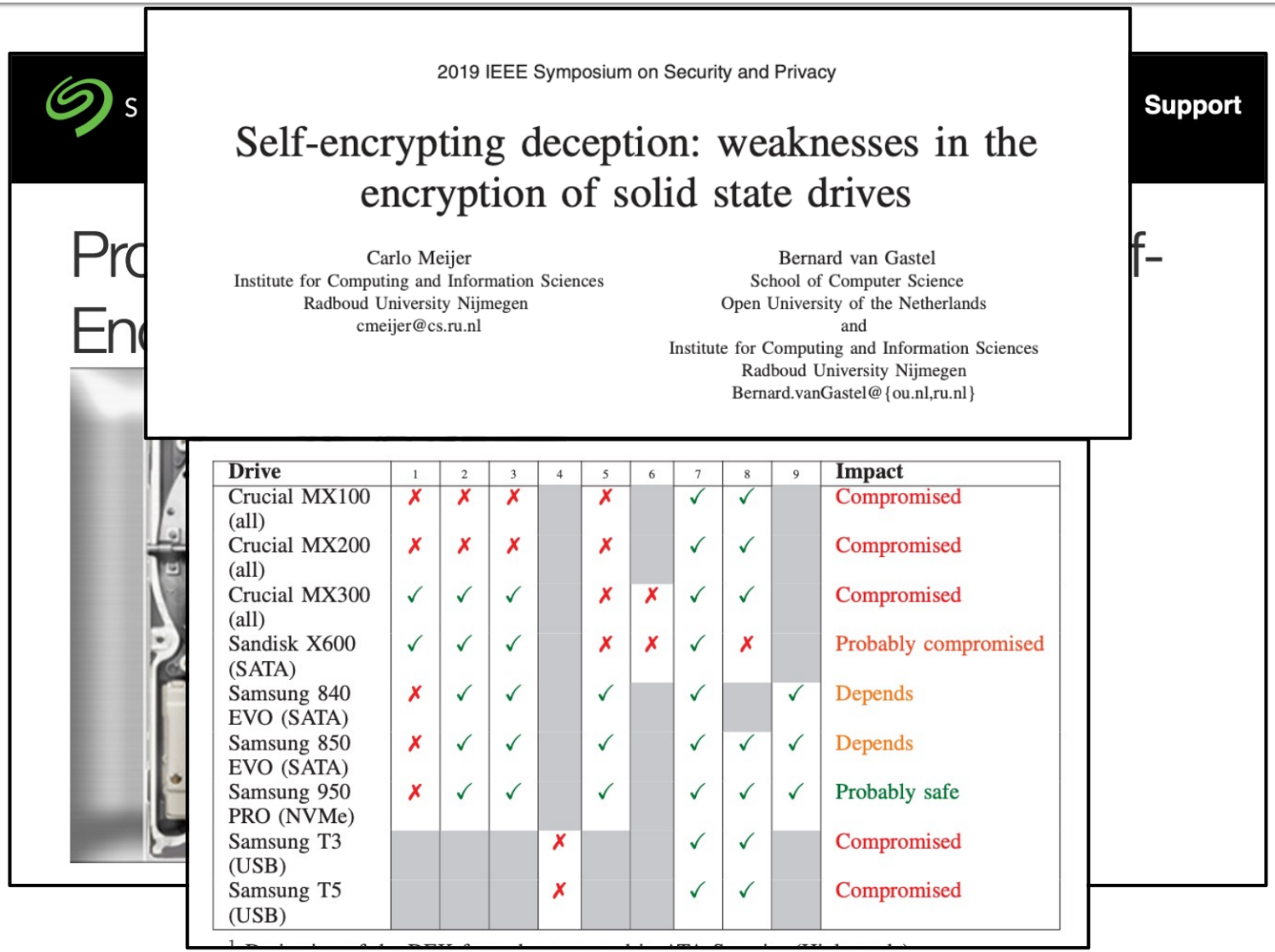
  - Who else does the creator rely on?
- What are the **implicit assumptions** which the aren’t always true/strong?
  - “outside the box” solutions

Thinking Like an Attacker

- What are the **implicit assumptions** which the aren't always true/strong?

Security Assumptions



2019 IEEE Symposium on Security and Privacy

Self-encrypting deception: weaknesses in the encryption of solid state drives

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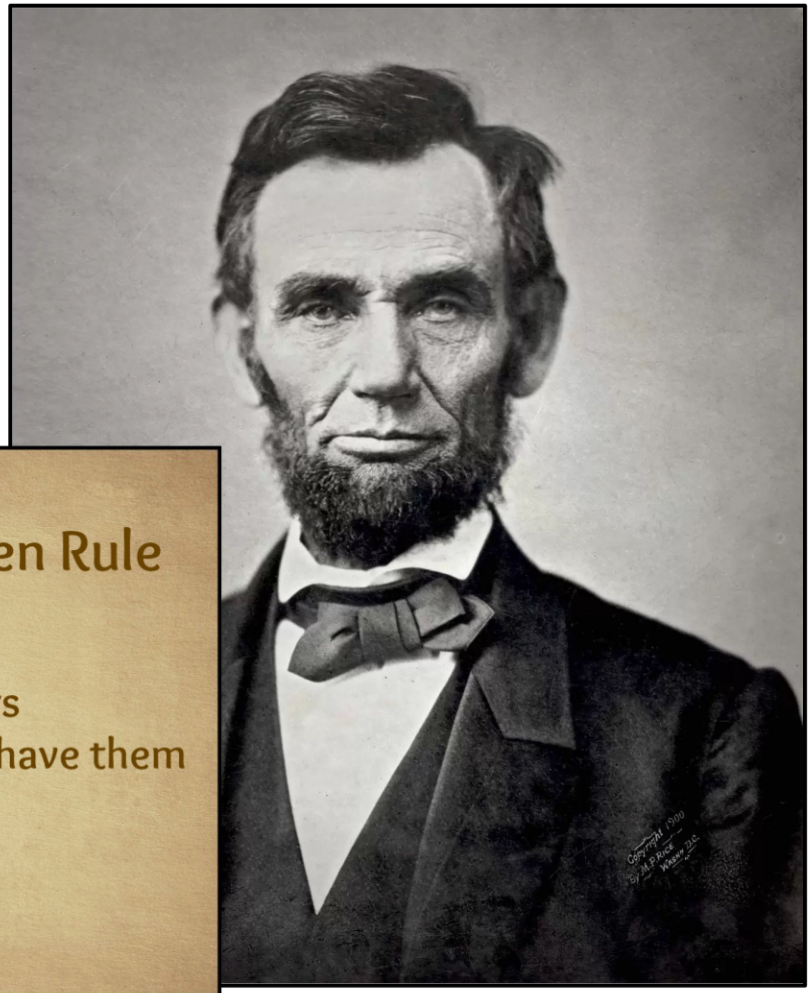
School of Computer Science
Open University of the Netherlands
and
Institute for Computing and Information Sciences
Radboud University Nijmegen
Bernard.vanGastel@{ou.nl,ru.nl}

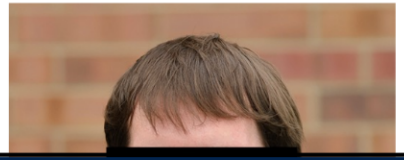
Drive	1	2	3	4	5	6	7	8	9	Impact
Crucial MX100 (all)	✗	✗	✗		✗		✓	✓		Compromised
Crucial MX200 (all)	✗	✗	✗		✗		✓	✓		Compromised
Crucial MX300 (all)	✓	✓	✓		✗	✗	✓	✓		Compromised
Sandisk X600 (SATA)	✓	✓	✓		✗	✗	✓	✗		Probably compromised
Samsung 840 EVO (SATA)	✗	✓	✓		✓		✓		✓	Depends
Samsung 850 EVO (SATA)	✗	✓	✓		✓		✓	✓	✓	Depends
Samsung 950 PRO (NVMe)	✗	✓	✓		✓		✓	✓	✓	Probably safe
Samsung T3 (USB)				✗			✓	✓		Compromised
Samsung T5 (USB)				✗			✓	✓		Compromised

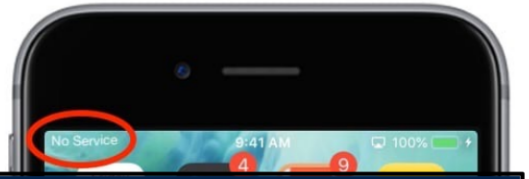
Role-Playing as "Bad Guys"



Role-Playing as "Bad Guys"

Scenario





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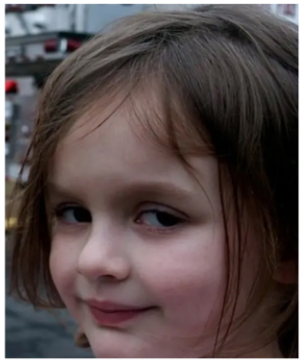
Published: March 12, 2020

Thinking Like an Attacker

Your Turn to be Her →



- What is the **easiest/simplest** way to win?
- What are the **explicit assumptions** built into the system?
- What are the **implicit assumptions** which the aren't always true/strong?

As an Attacker:

- What is the simplest way to gain access?

Attacker: Low-Hanging Fruit

- Lock-Picking
  - “high-skill manipulation”

Attacker: Low-Hanging Fruit

- Hammer beats door
  - “brute force attack”

Attacker: Low-Hanging Fruit

- Get-in and stay-in
  - “time of check, time of use vulnerability”

Attacker: Low-Hanging Fruit

- Trick someone into giving you access
  - “social engineering”

As an Attacker:

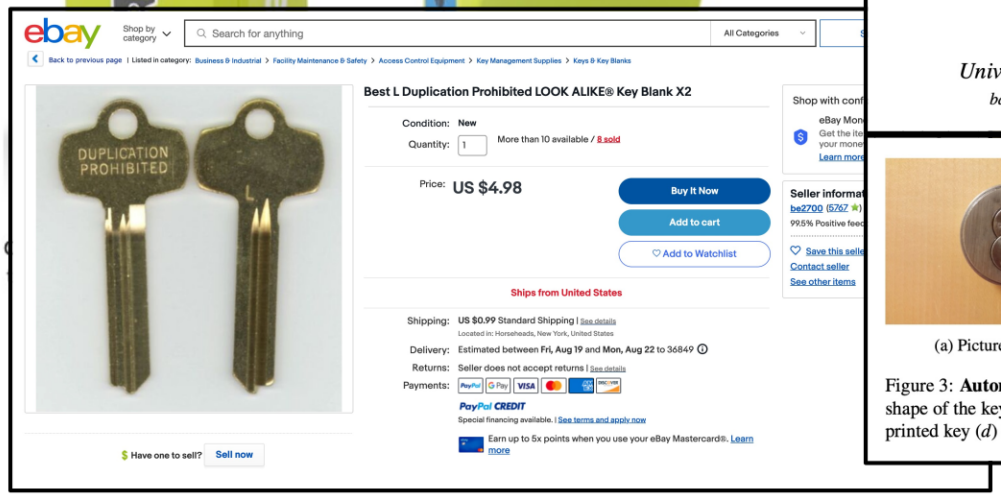
- What is the simplest way to gain access?
- What is assumed about the system?

Attacker: Breaking Assumptions

- Find an unlocked window
  - *Doors aren't the only way people enter and exit the building*

Attacker: Breaking Assumptions

- Duplicate a key
  - *Only authorized people will ever posses keys*



Replication Prohibited: Attacking Restricted Keyways with 3D Printing

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(a) Picture of lock (b) Keyway detection (c) Model generation (d) 3D printing

Figure 3: **Automatic key blank generation** — Our tool takes an image of a lock (*a*), automatically detects the outline shape of the keyway (*b*), and produces a 3D model of a blank (*c*) that fits in the keyway. A MakerBot Replicator 2 3D printed key (*d*) produced using the generated key blank model is illustrated.

As an Attacker:

- What is the simplest way to gain access?
- What is assumed about the system?
- What did defender not think about?

Attacker: Getting Creative

- Locate door with different properties
  - *Attackers can't fly but also aren't limited to the ground-floor*

Attacker: Getting Creative

- Obtain “unobtainium”

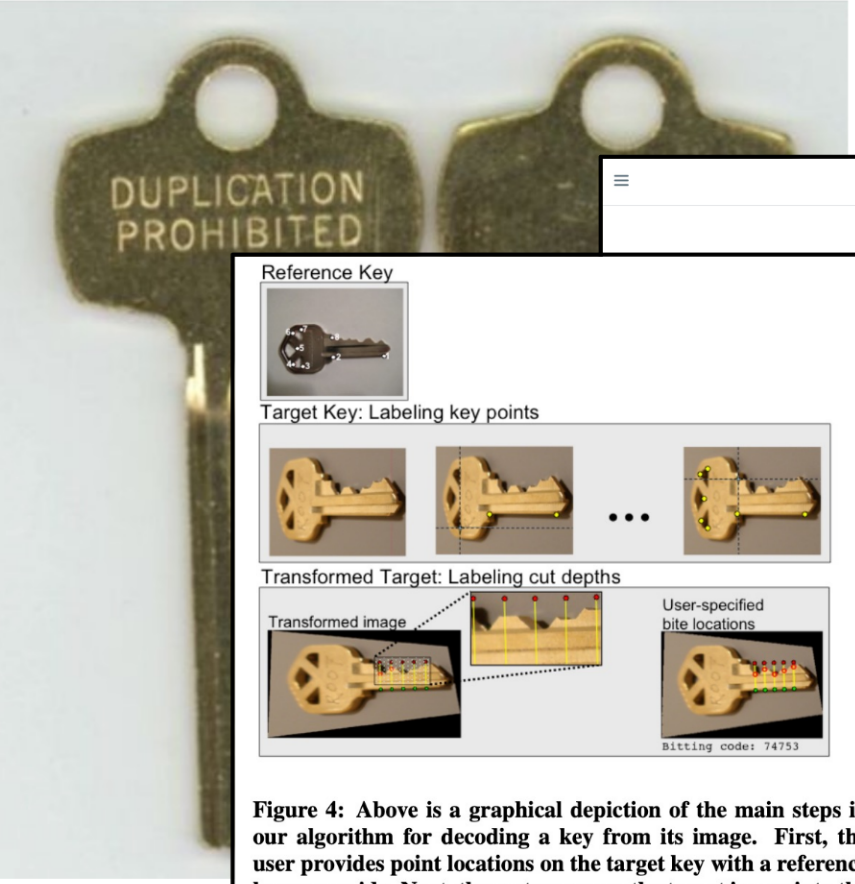

Figure 4: Above is a graphical depiction of the main steps in our algorithm for decoding a key from its image. First, the user provides point locations on the target key with a reference key as a guide. Next, the system warps the target image into the pose of the reference key and overlays markings of where the bite codes are to be found. Finally, the user specifies where the cut falls along each line and the bit depths are decoded by the system into a bitting code.

Reconsidering Physical Key Secrecy: Teleduplication via Optical Decoding

Benjamin Laxton, Kai Wang and Stefan Savage
Department of Computer Science & Engineering
University of California, San Diego
La Jolla, California, USA

Figure 9: Our proof-of-concept telephoto experiment. The key image, captured at a distance of 195 feet, was correctly decoded as 74753.

Security Mindset

A way of thinking about scenarios in order to identify and mitigate possible failures.

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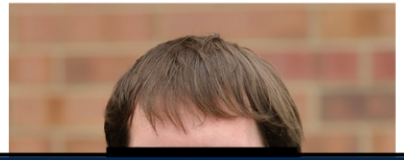
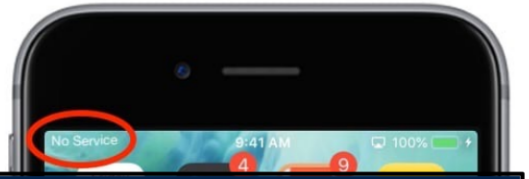
  - Understand how search for/exploit weaknesses
- Have to think like a defender
  - Identify what is being protected against who
  - Analyze/Evaluate cost-benefit trade-offs

Thinking Like a Defender

- What **assets** are you trying to protect?
  - What about those assets is important?
- Who are you trying to **defend against**? Who are you willing to **let succeed**?
  - Nothing is ever 100% secure against all actors
- What will you **trade** for improved security?
  - Costs: time, energy, complexity, etc.

Scenario





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Defender Complications

Your Turn

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  - What about those assets is important?
- Who are you trying to **defend against**? Who are you willing to **let succeed**?
  - Nothing is ever 100% secure against all actors
- What will you **trade** for improved security?
  - Costs: time, energy, complexity, etc.

Option 1: Do Nothing

Bama: 28 Notre Dame: 0

"Maybe Alabama doesn't come back in the 2nd half"
- Halftime Interview of 2012 national championship

- Give up
- Hope that attackers don't notice your vulnerabilities
- Claim bad people shouldn't be doing bad things

Option 2: Complete Overhaul

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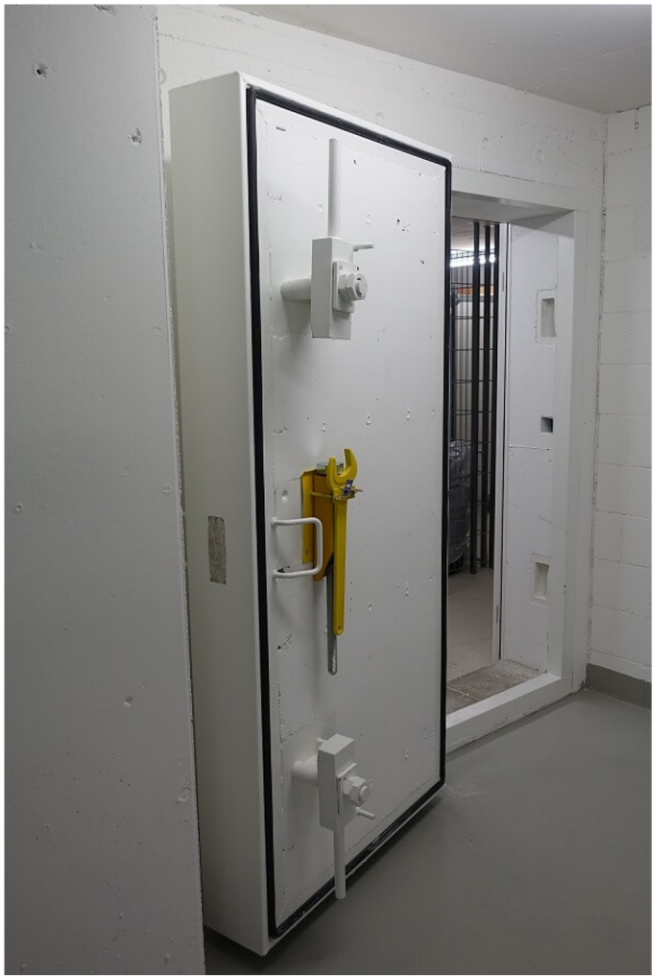
- Re-organize to limit the attack surface

Option 2: Complete Overhaul



- Re-organize to limit the attack surface
- Restrict entrance and exit to single location

Option 2: Complete Overhaul

- Re-organize to limit the attack surface
- Restrict entrance and exit to single location
- Increase attackers' risk of negative outcomes

Option 3: Intentionally Designed Defenses

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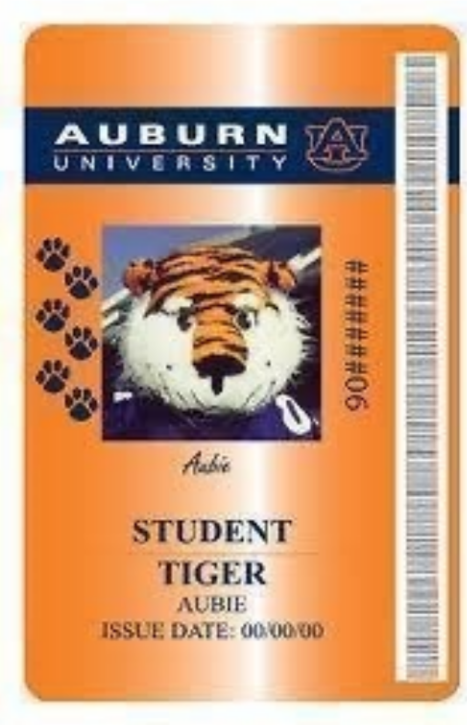
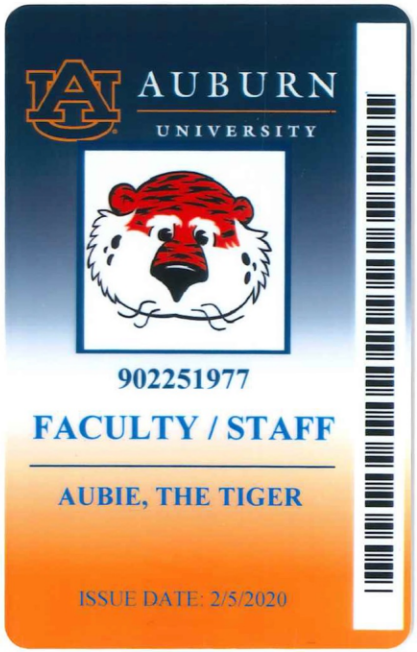
- Tiered physical boundaries

Option 3: Intentionally Designed Defenses





- Tiered physical boundaries
- Tiered access permissions

Option 3: Intentionally Designed Defenses

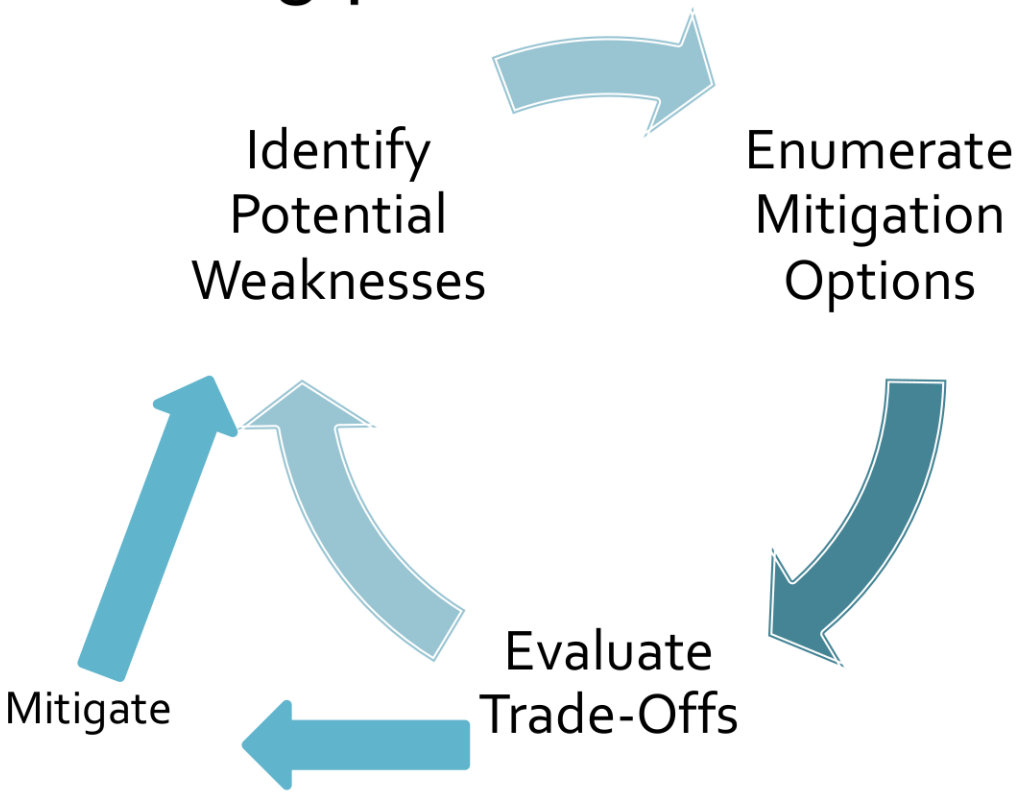
- Tiered physical boundaries
- Tiered access permissions
- Rely on non-experts to make rational decisions

Building Secure Solutions

- Security is the outcome of a **process** and is not a *product* by itself
  - It is extremely hard to add-to design later
  - Is an on-going effort throughout the lifecycle

Threat Modeling

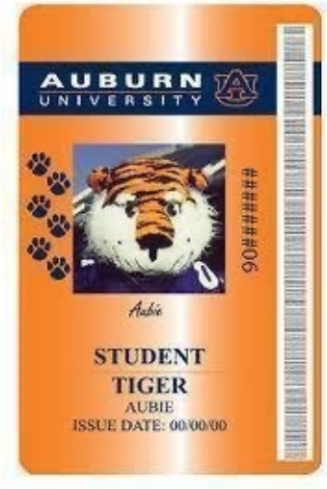
A systematic approach to analyzing and understanding potential weaknesses.

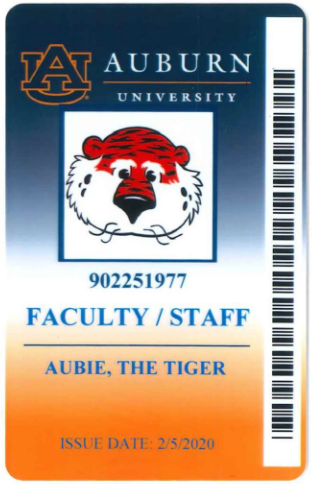


During Planning

- Create a system that is defendable

During Operation





- Create a system that is defendable
- Maintain the mechanisms for defending it

During Un-Wanted Events

REPORT YOUR LOST TIGER CARD

Students

If you cannot locate your student Tiger Card, you should immediately take one of the following actions to deactivate and protect your card. Once you have located your Tiger Card, you can easily reactivate your card the same way the card was deactivated:

1. Activate/deactivate your Tiger Card online.
   - You will need to login using your Auburn University student credentials (abc1234).
   - Once logged in, select "I Lost/Found My Card" under the "Quick Links" menu.
2. Activate/deactivate your cards through the mobile Tiger Card App.
3. Report your card as lost/found in person by coming by the Tiger Card office (Monday-Friday 7:30 a.m.- 4:30 p.m.)
4. Report your card as lost/found by phone at (334) 844-4507 (Monday-Friday 7:30 a.m.- 4:30 p.m.)

Faculty/Staff

For information on reporting a lost **Faculty/Staff** ID, please visit ID Card Services (Onboarding Center) or contact them at 334-844-1763. ID Card Services (Onboarding Center) is located at 1530 East Glenn Avenue.

Last updated: August 13, 2021

BACK TO TOP

- Create a system that is defendable
- Maintain the mechanisms for defending it
- Train and educate non-experts

Keeping Systems Defendable

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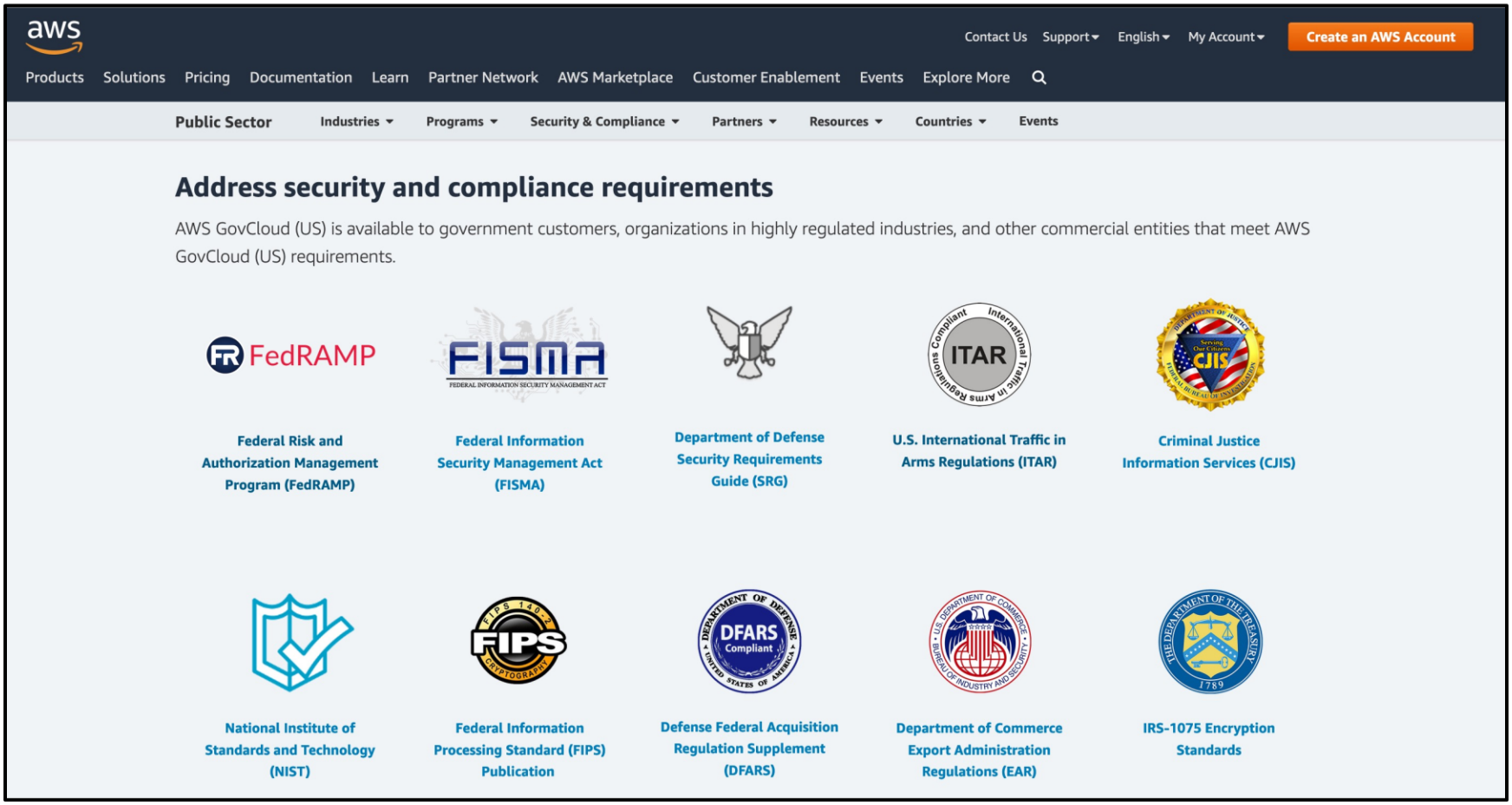
- Create a system that is defendable
- Maintain the mechanisms for defending it
- Train and educate non-experts
- **Make safe easy and unsafe hard/obvious**

Building Secure Solutions

- Security is the outcome of a **process** and is not a *product* by itself
  - It is extremely hard to add-to design later
  - Is an on-going effort throughout the lifecycle
- Security is **not a checkbox** to hit on the way to releasing a product
  - “HIPAA Compliant” =!= safe/secure/private
  - “Used cipher X” =!= “Used cipher X correctly”

Certified != Secure



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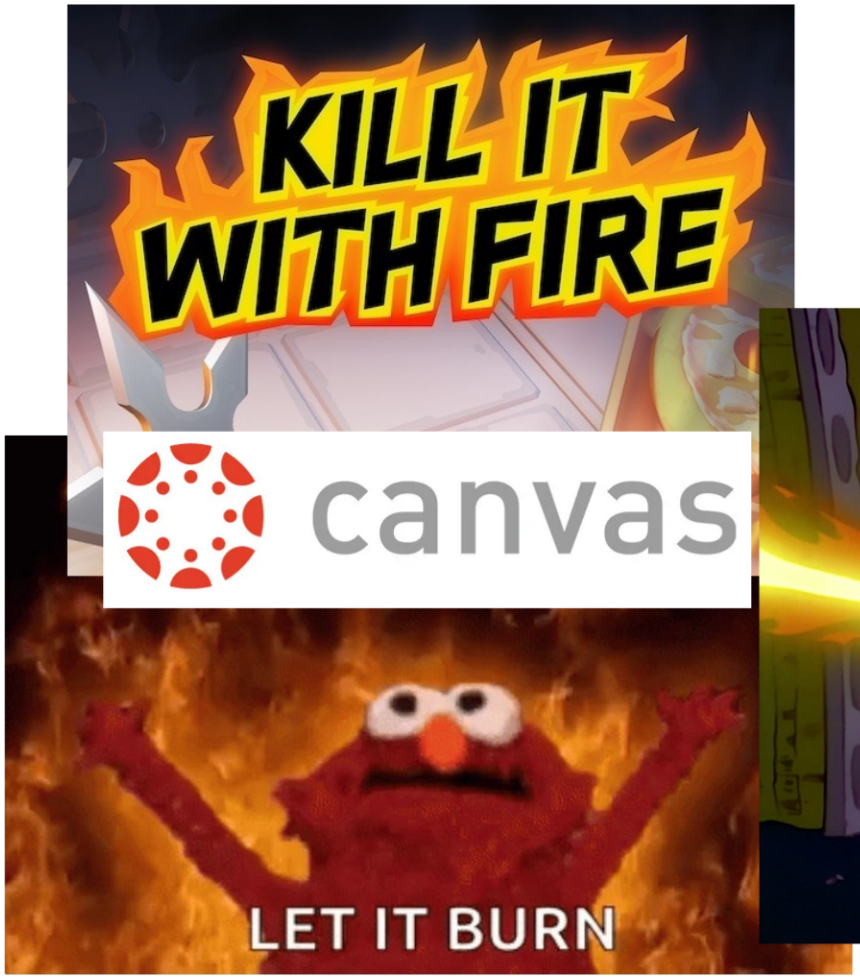
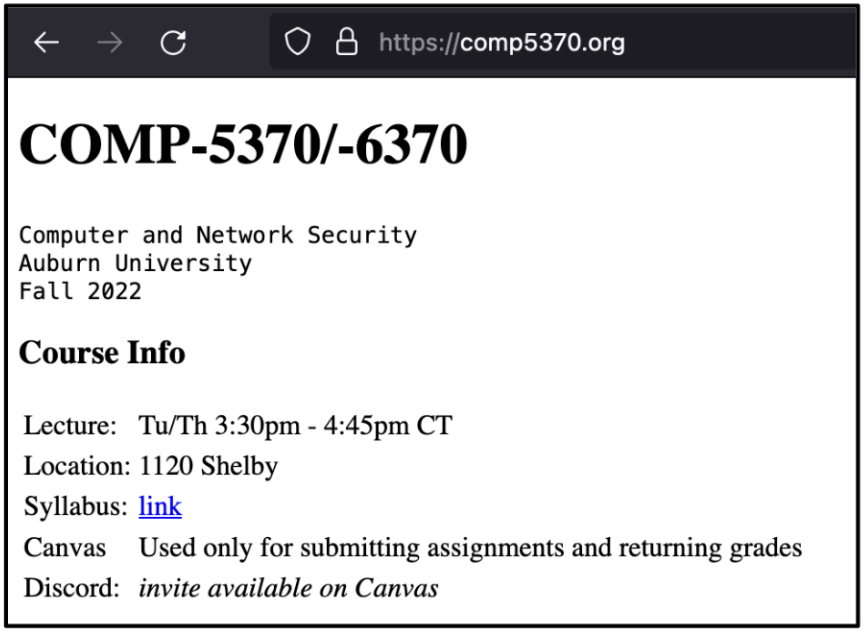
Things to Look Forward To

- Concepts & Ideas
  - “Security Mindset”
  - Randomness
- Applied Crypto
  - Encryption/Hashing
  - Key Exchanges
- Network Security
  - Good/Bad Protocols
  - Web attacks/defenses
- Host/App Security
  - Malware, botnets, etc
  - Binary exploitation
- Real-World Application
  - Privacy Protections
  - C---r Issues



- Canvas is ***the DEVIL***
  - Only for submitting and getting grades

Course Website



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- https://comp5370.org
  - Syllabus
  - Slides
  - Assignments
  - …

Grading Overview

- Projects (3x)
  - Project 1 is 2 parts for a total of 10%
- In-Class Exams (2x)
- Midterm (1x)
- Final (1x)

Grading

- **3x Course Projects (each)** — 10%
- **Final Exam** — 25%
- **2x In-Class Exams (each)** — 12.5%
- **Midterm Exam** — 20%

Calculating Your Course Grade With your returned scores as a percentile value (i.e. 0% – 100%), fill-in the below formula:

$$0.10 \times project_1 + 0.10 \times project_2 + 0.10 \times project_3 + 0.125 \times exam_1 + 0.125 \times exam_2 + 0.20 \times midterm + 0.25 \times final$$

Course Textbook

- There is **no textbook** for this course b/c…

The Internet is *OUR* Textbook

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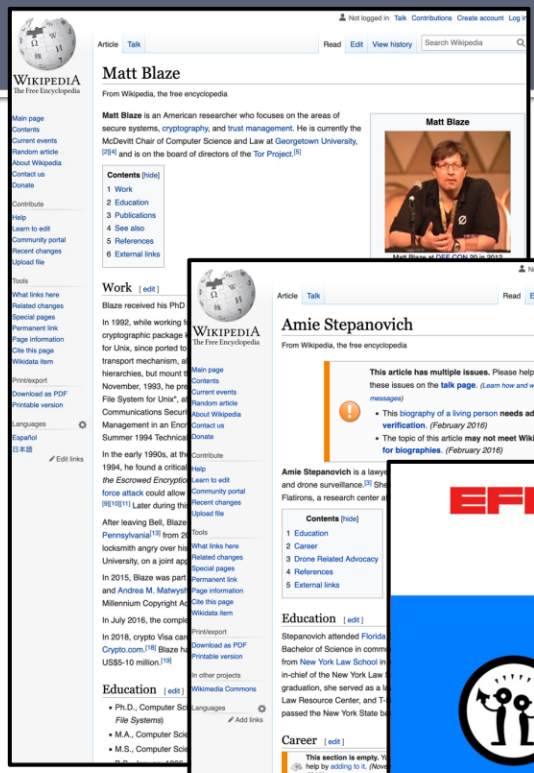

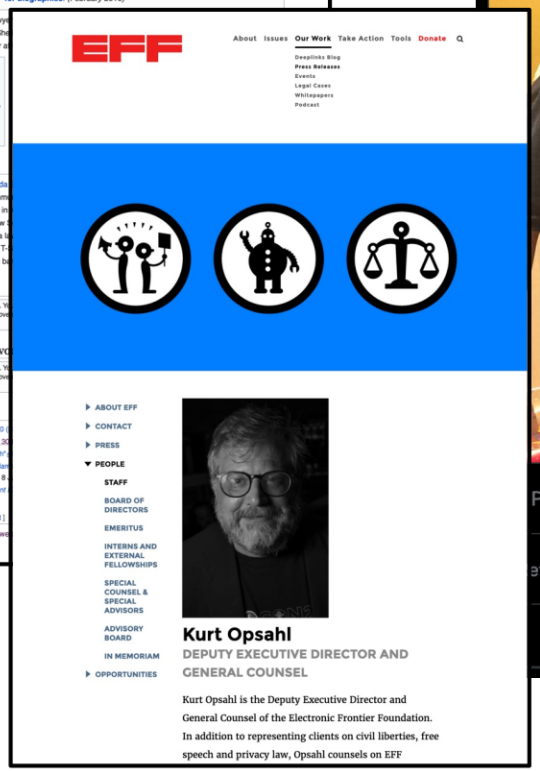

The Internet is *OUR* Textbook

Theorem 19.18. *The AND protocol (P, V) is a Sigma protocol for the relation $\mathcal{R}_{\text{AND}}$ defined in (19.22). If (P_0, V_0) and (P_1, V_1) provide knowledge soundness, then so does (P, V). If (P_0, V_0) and (P_1, V_1) are special HVZK, then so is (P, V).*

Proof sketch. Correctness is clear.

For knowledge soundness, if (P_0, V_0) has extractor Ext_0 and (P_1, V_1) has extractor Ext_1, then the extractor for (P, V) is

$$Ext\Big((y_0, y_1), ((t_0, t_1), c, (z_0, z_1)),\ ((t_0, t_1), c', (z_0', z_1') \Big) :=$$
$$\Big(Ext_0(y_0, (t_0, c, z_0), (t_0, c', z_0')),\ Ext_1(y_1, (t_1, c, z_1), (t_1, c', z_1'))\Big).$$

For special HVZK, if (P_0, V_0) has simulator Sim_0 and (P_1, V_1) has simulator Sim_1, then the simulator for (P, V) is

$$Sim((y_0, y_1), c) := ((t_0, t_1), (z_0, z_1)),$$

where

$$(t_0, z_0) \xleftarrow{\text{R}} Sim_0(y_0, c) \quad \text{and} \quad (t_1, z_1) \xleftarrow{\text{R}} Sim_1(y_1, c).$$

A Graduate Course in Applied Cryptography
Dan Boneh and Victor Shoup
https://toc.cryptobook.us/

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Attacker: Getting Creative

- Obtain “unobtainium”

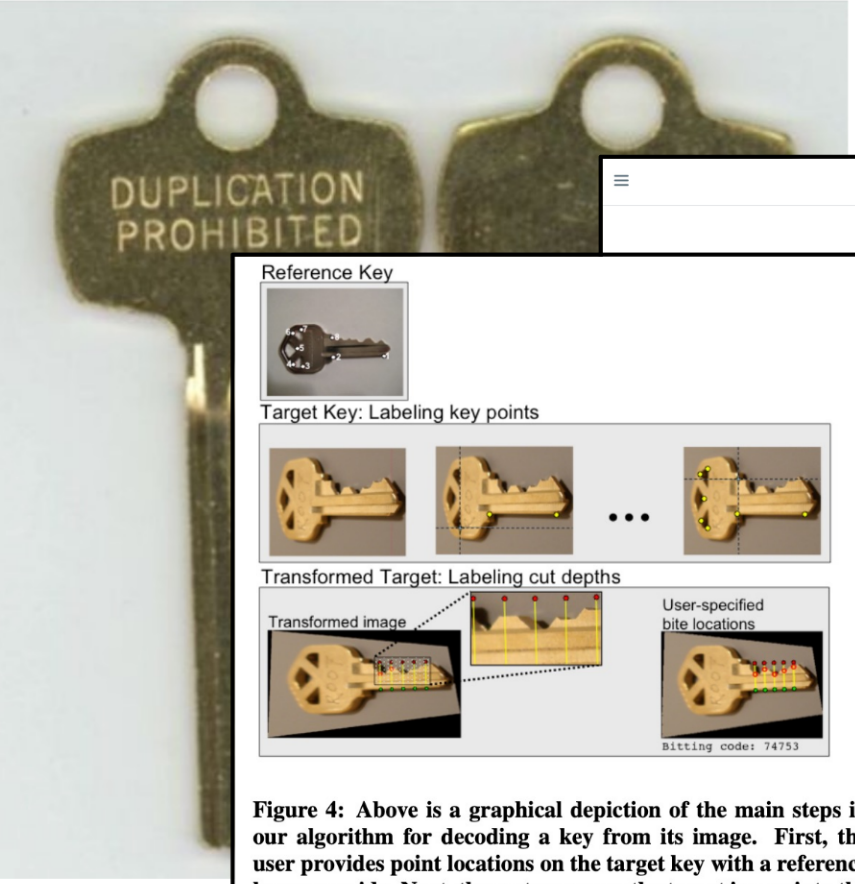

Figure 4: Above is a graphical depiction of the main steps in our algorithm for decoding a key from its image. First, the user provides point locations on the target key with a reference key as a guide. Next, the system warps the target image into the pose of the reference key and overlays markings of where the bite codes are to be found. Finally, the user specifies where the cut falls along each line and the bit depths are decoded by the system into a bitting code.

Reconsidering Physical Key Secrecy: Teleduplication via Optical Decoding

Benjamin Laxton, Kai Wang and Stefan Savage
Department of Computer Science & Engineering
University of California, San Diego
La Jolla, California, USA

Figure 9: Our proof-of-concept telephoto experiment. The key image, captured at a distance of 195 feet, was correctly decoded as 74753.

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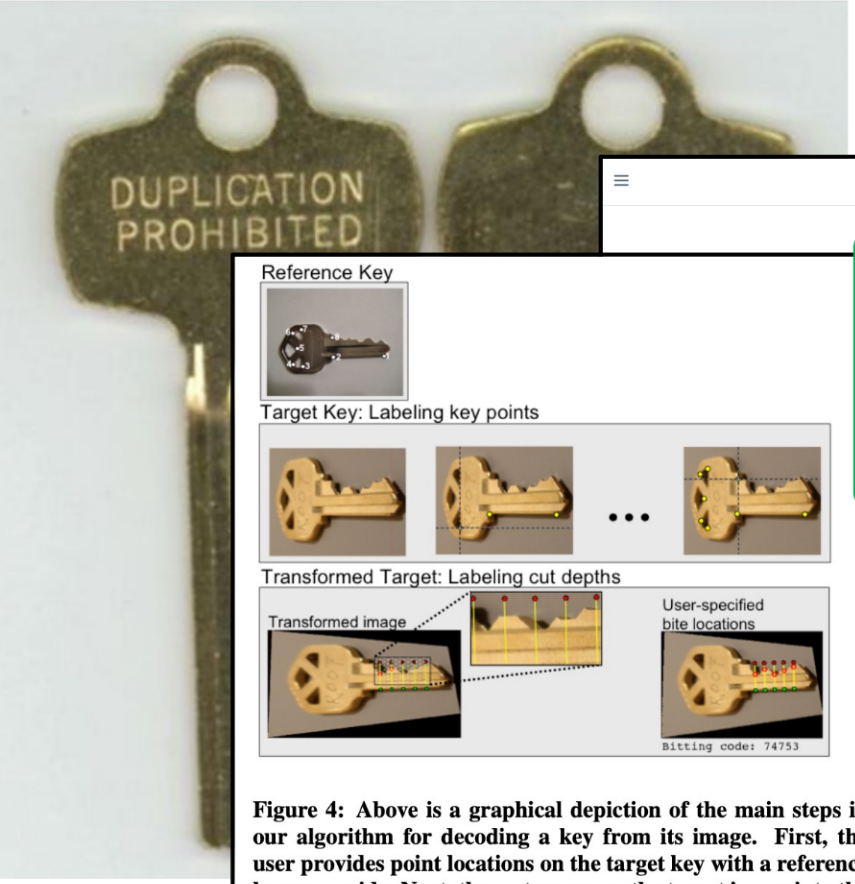

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- Everything else is out-of-scope
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1) DO NOT COMMIT CRIMES

2) Respect others' security & privacy

Have Questions?

- In-person interaction usually solves problems immediately
  - Office hours in syllabus and on website
  - After-class, open-door, etc. (instructor-only)
  - If the office-phone rings, I pick it up
- Email is a valid but highly-latent channel
  - Might answer in next lecture
  - Might take couple of days to get to your email

Course TA

- Ginny Genge
- Office Hours:
  - Mo 1-2
  - We 4-5
  - 2168 Brown-Koppel

Code Counts in CS

Errors in Submission Students should be aware that all projects will be graded in an auto-grader style workflow (i.e. automated and/or mechanical actions to test submission). If a compilation/interpretation error is encountered (i.e. syntax error, tabs vs. spaces in Python, etc.) the submitted source code **will not** be examined nor debugged and **a grade of zero (0) will be given**. The environment in which your projects will be graded will be clearly defined in each assignment and non-running projects will be eligible for a regrade as discussed below.

Regrade Requests While obvious grading errors* can be handled immediately by bringing them the instructor's attention, students are welcome to request an assignment/project/exam be regraded in its entirety by contacting the TA. All regrade requests must follow the requirements of:

1. Clearly state that a regrade is being requested.
2. Clearly state the fundamental misunderstanding that caused the original submission to be deducted points.
3. Clearly state the changes that were made to remediate that fundamental misunderstanding.
4. Contain no extraneous changes that are not related to that fundamental misunderstanding.
5. Be made within seven (7) days of the assignment being returned.
6. Be requested over email.

Students should be aware that points will be deducted based on the original submission's fundamental misunderstanding and depending on the circumstances, this may result in a grade of zero (0). The instructor has the final authority on A) whether a regrade will be conducted based on the request and B) to what degree the fundamental misunderstanding will be penalized.

Late Assignments Hurt

Late Assignments Any assignment submitted after the deadline must be sent via e-mail to the TA. Late assignments will lose 10 percentage points per hour† based on the timestamp in the email received. **"Late-days" are not available to students in the Fall 2024 iteration of this course.** In the case of extenuating circumstances, the student *must* contact the instructor at the earliest reasonable opportunity. The Excused Absence policy will be applied but exceptions may be made at the instructor's discretion.

- 10% deduction per hour
  - 1 Day = 24 hours
  - 100% - 240% = **-140%**

You do not have late days

Grading Overview

- Projects (3x)
  - Project 1 is 2 parts for a total of 10%
- In-Class Exams (2x)
- Midterm (1x)
- Final (1x)

Grading

- **3x Course Projects (each)** — 10%
- **Final Exam** — 25%
- **2x In-Class Exams (each)** — 12.5%
- **Midterm Exam** — 20%

Calculating Your Course Grade With your returned scores as a percentile value (i.e. 0% – 100%), fill-in the below formula:

$$0.10 \times project_1 + 0.10 \times project_2 + 0.10 \times project_3 + 0.125 \times exam_1 + 0.125 \times exam_2 + 0.20 \times midterm + 0.25 \times final$$

Project 1-A

- Released tomorrow and due in 2 weeks
- Use the Security Mindset while building a straight-forward, custom data format parser
- Does **not** require large amount of code but **does** require a large amount of thinking

CTF This Weekend

- "Capture the Flag" challenges
- Register via link in your email
  - $30 registration but meals + snacks/drinks provided

Computer and Network Security

Lecture 01:
Overview & Mindset

COMP-5370/6370