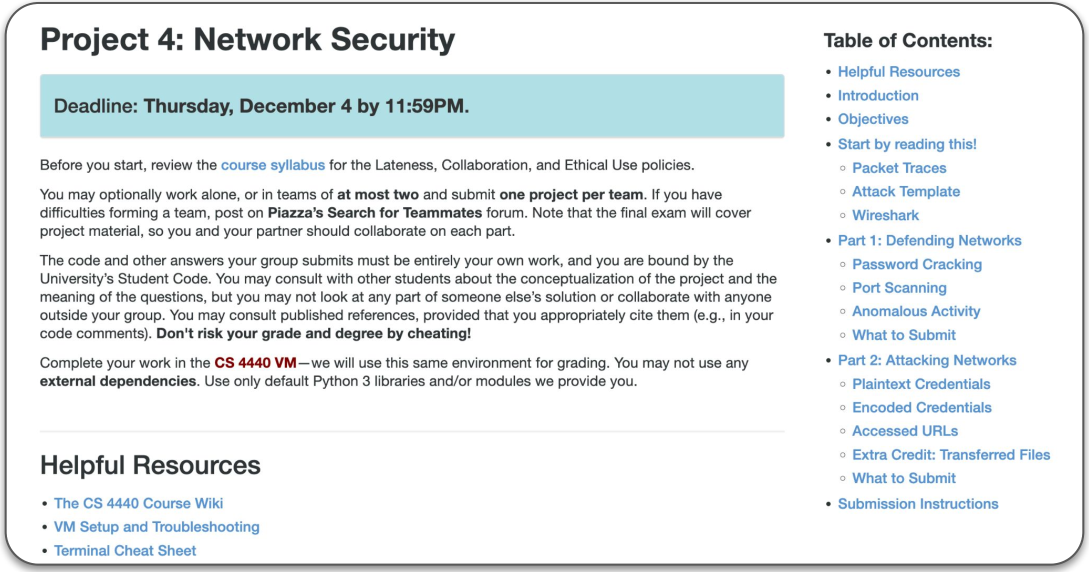
Week 14: Lecture A

What’s Next? Life After CS 4440

Tuesday, December 2, 2025

Announcements

- **Project 4: NetSec** released
  - **Deadline: Thursday** by 11:59PM



Project 4: Network Security

Deadline: **Thursday, December 4 by 11:59PM.**

Before you start, review the course syllabus for the Lateness, Collaboration, and Ethical Use policies.

You may optionally work alone, or in teams of **at most two** and submit **one project per team**. If you have difficulties forming a team, post on **Piazza's Search for Teammates** forum. Note that the final exam will cover project material, so you and your partner should collaborate on each part.

The code and other answers your group submits must be entirely your own work, and you are bound by the University's Student Code. You may consult with other students about the conceptualization of the project and the meaning of the questions, but you may not look at any part of someone else's solution or collaborate with anyone outside your group. You may consult published references, provided that you appropriately cite them (e.g., in your code comments). **Don't risk your grade and degree by cheating!**

Complete your work in the **CS 4440 VM**—we will use this same environment for grading. You may not use any **external dependencies**. Use only default Python 3 libraries and/or modules we provide you.

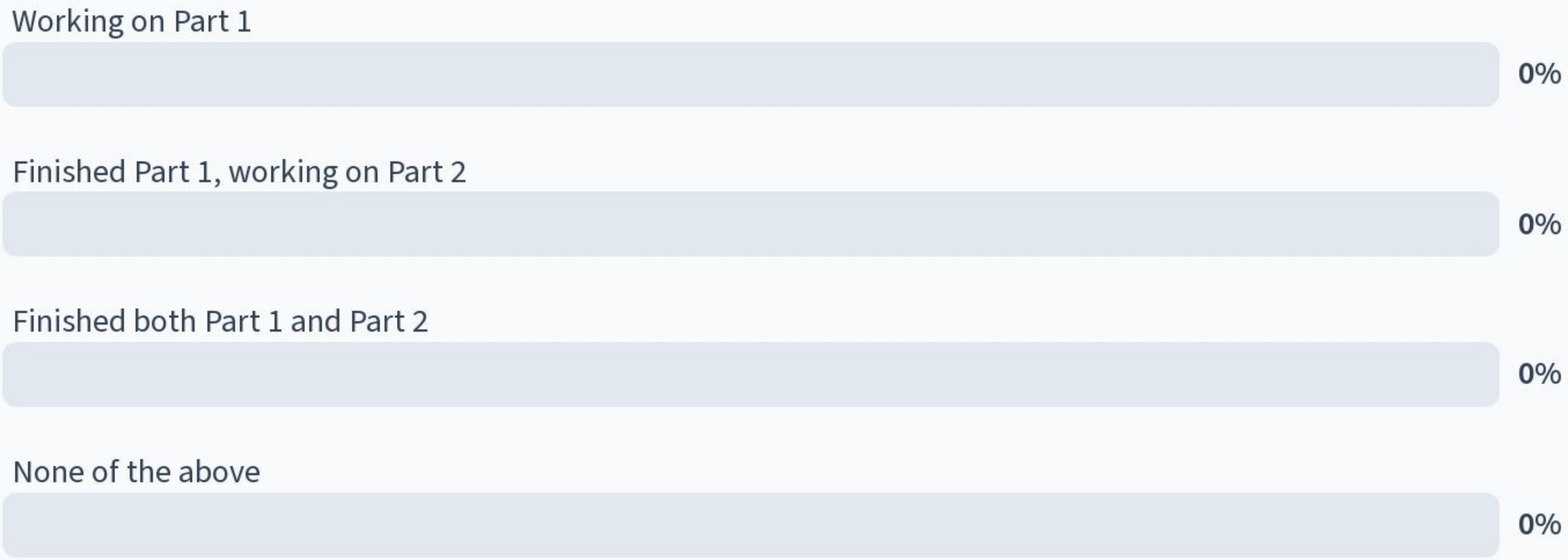
Helpful Resources

- The CS 4440 Course Wiki
- VM Setup and Troubleshooting
- Terminal Cheat Sheet

Table of Contents:

- Helpful Resources
- Introduction
- Objectives
- Start by reading this!
  - Packet Traces
  - Attack Template
  - Wireshark
- Part 1: Defending Networks
  - Password Cracking
  - Port Scanning
  - Anomalous Activity
  - What to Submit
- Part 2: Attacking Networks
  - Plaintext Credentials
  - Encoded Credentials
  - Accessed URLs
  - Extra Credit: Transferred Files
  - What to Submit
- Submission Instructions

Project 4 Progress



Working on Part 1 0%

Finished Part 1, working on Part 2 0%

Finished both Part 1 and Part 2 0%

None of the above 0%

Start the presentation to see live content. For screen share software, share the entire screen. Get help at **pollev.com/app**

Final Exam

- **Save the date:** **1–3PM** on **Wednesday, December 10**
  - **CDA accommodations:** schedule exam via CDA Portal

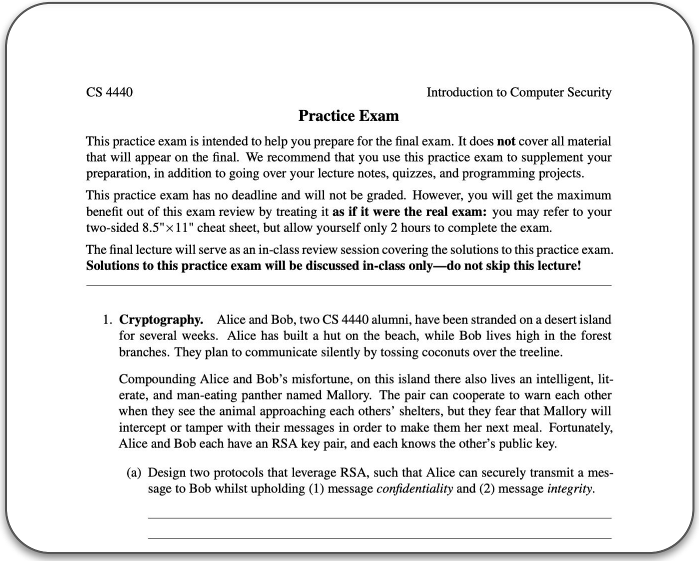
- **High-level details** (more to come):
  - One exam covering all course material
  - Similar to project/quiz/lecture exercises

- **Cheat Sheet**
  - **One 8.5”x11” paper** with handwritten/typed notes on **both** sides
  - **Suggestion:** Don’t just use someone else’s—you’ll learn better making **your own**!
  - **Suggestion:** Don’t just paste lecture slides—you’ll learn better by **writing/typing** it!

Practice Exam

- **Practice Exam** released
  - See **Assignments** page on the CS 4440 website

- **Final lecture** will serve as a **review session**
  - Solutions discussed **in-class only**—don't skip!



CS 4440 Introduction to Computer Security

Practice Exam

This practice exam is intended to help you prepare for the final exam. It does **not** cover all material that will appear on the final. We recommend that you use this practice exam to supplement your preparation, in addition to going over your lecture notes, quizzes, and programming projects.

This practice exam has no deadline and will not be graded. However, you will get the maximum benefit out of this exam review by treating it **as if it were the real exam:** you may refer to your two-sided 8.5"×11" cheat sheet, but allow yourself only 2 hours to complete the exam.

The final lecture will serve as an in-class review session covering the solutions to this practice exam. **Solutions to this practice exam will be discussed in-class only—do not skip this lecture!**

1. **Cryptography.** Alice and Bob, two CS 4440 alumni, have been stranded on a desert island for several weeks. Alice has built a hut on the beach, while Bob lives high in the forest branches. They plan to communicate silently by tossing coconuts over the treeline.

   Compounding Alice and Bob's misfortune, on this island there also lives an intelligent, literate, and man-eating panther named Mallory. The pair can cooperate to warn each other when they see the animal approaching each others' shelters, but they fear that Mallory will intercept or tamper with their messages in order to make them her next meal. Fortunately, Alice and Bob each have an RSA key pair, and each knows the other's public key.

   (a) Design two protocols that leverage RSA, such that Alice can securely transmit a message to Bob whilst upholding (1) message *confidentiality* and (2) message *integrity*.

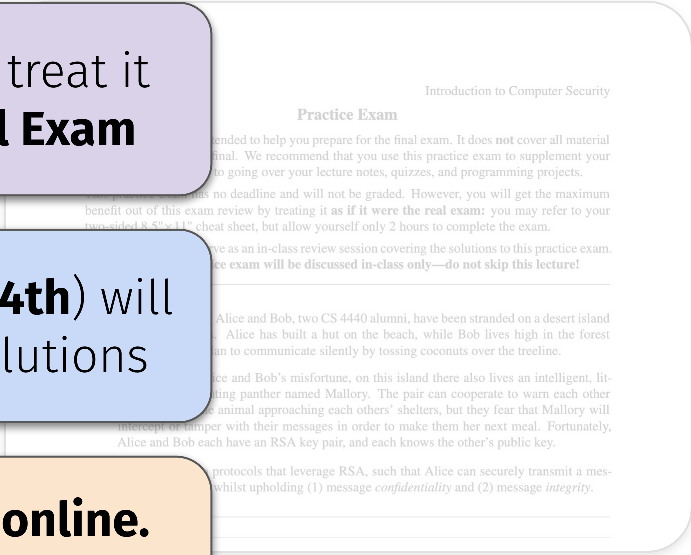
Practice Exam

- **Practice Exam re**
  - See **Assignmen**
- **Final lecture** will serve as a **review session**
  - Solutions discu

To get the most out of this, treat it just **as you would the Final Exam**

Last lecture (**Thursday, Dec. 4th**) will go over the exam review solutions

Solutions won't be posted online.
(Reminder: attendance/participation makes up **5%** of your course grade)



Introduction to Computer Security

Practice Exam

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End-of-semester Course Evals

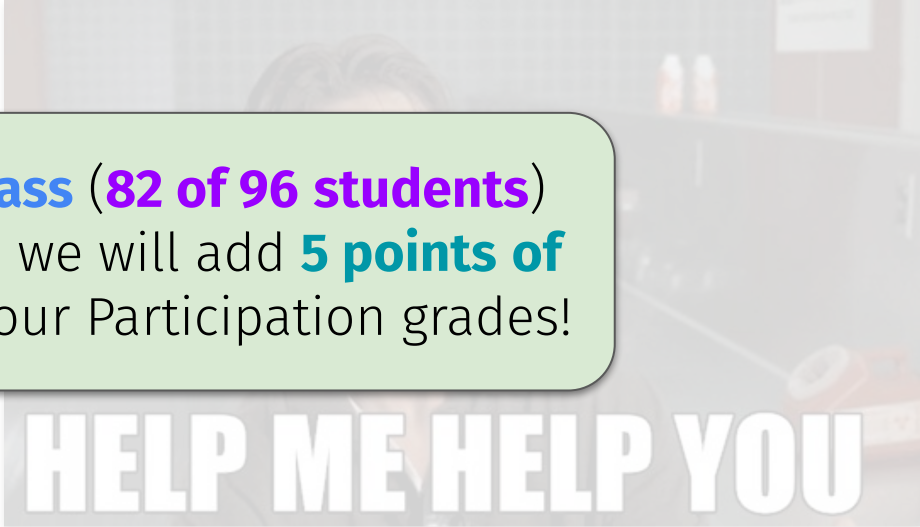
- **I want your feedback!**
  - 3rd time teaching this course 😃
  - **Help me improve the class!**

- Due by **December 15th**
  - https://scf.utah.edu
  - **Please please please!**

End-of-semester Course Evals

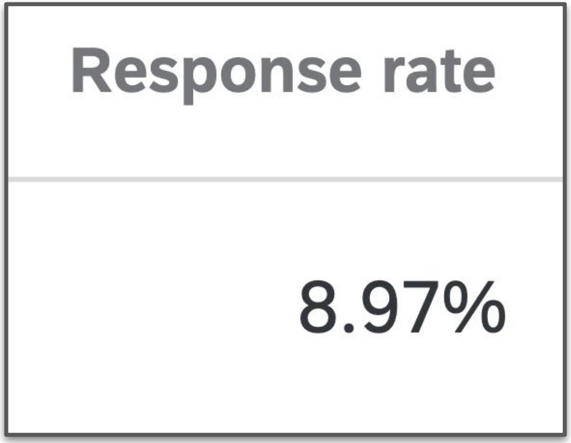
- **I want your feedback!**
  - 3rd time teaching this course 😃
  - **Help me improve the class!**

- Due by **Dece**
  - https://sc
  - **Please pl**

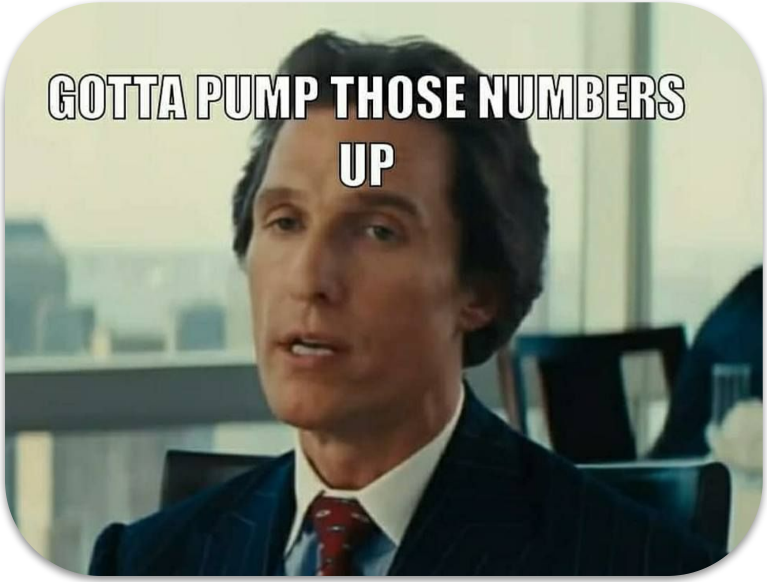


If 85% of the class (**82 of 96 students**) submits an eval, we will add **5 points of extra credit** to your Participation grades!

End-of-semester Course Evals



Response rate
8.97%



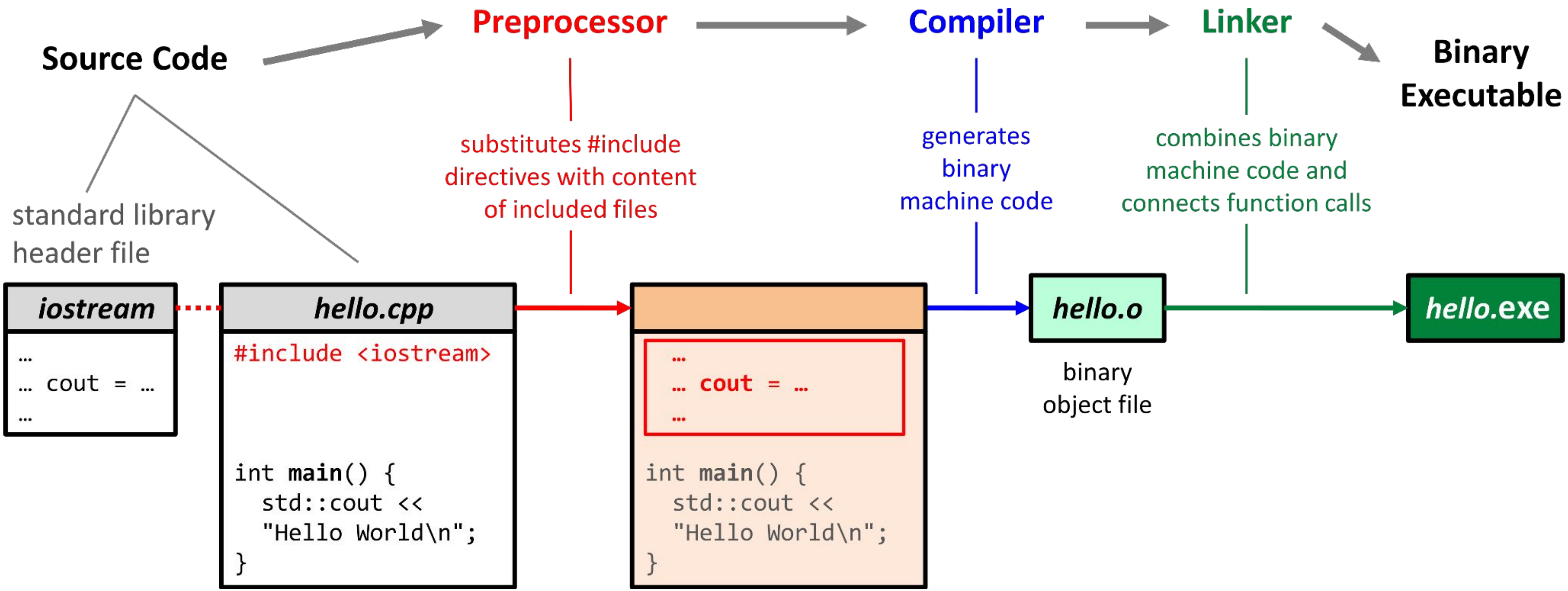
End-of-semester Course Evals

Questions?

Last time on CS 4440...

Binary Reverse Engineering
Instruction Recovery
Control Flow Analysis
Structure Recovery
RE Challenges

Recap: the Compilation Process



Source Code → Preprocessor → Compiler → Linker → Binary Executable

standard library header file

Preprocessor: substitutes #include directives with content of included files

Compiler: generates binary machine code

Linker: combines binary machine code and connects function calls

iostream

```
…
… cout = …
…
```

hello.cpp

```
#include <iostream>



int main() {
  std::cout <<
  "Hello World\n";
}
```

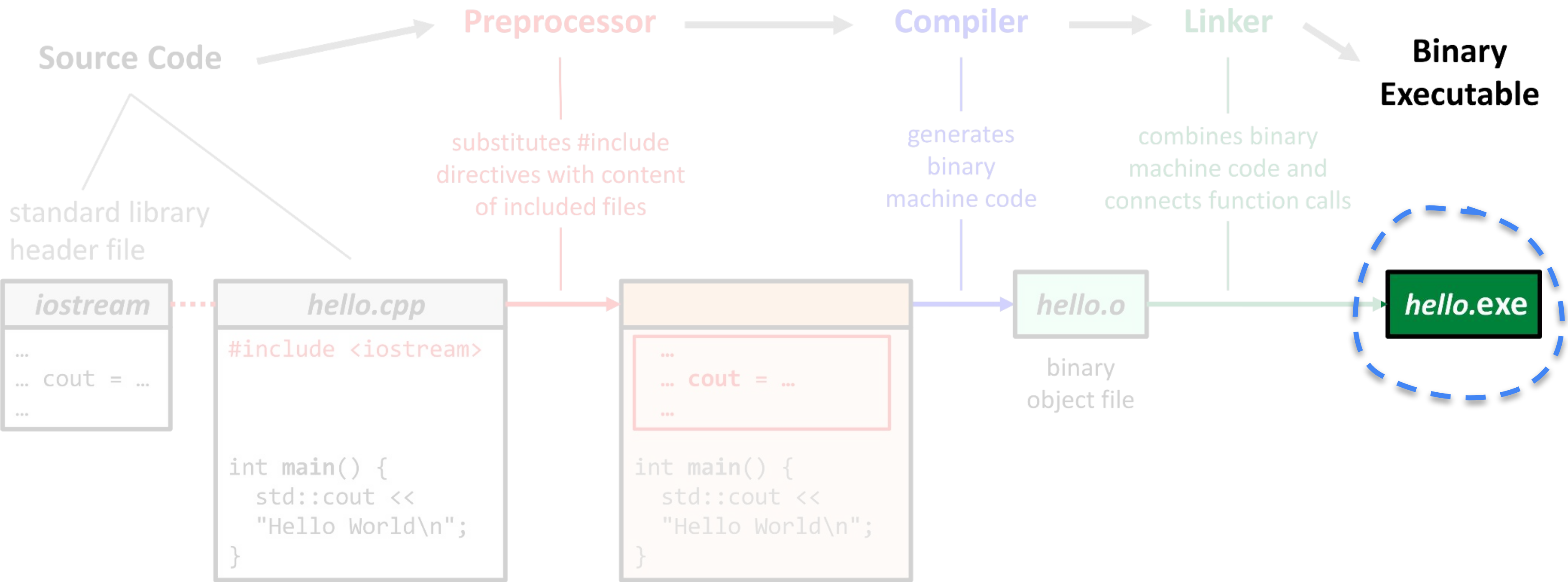
```
…
… cout = …
…

int main() {
  std::cout <<
  "Hello World\n";
}
```

hello.o

binary object file

hello.exe

Recap: the Compilation Process



Closed-source Software

- **It's everywhere!**

skype
Office
NVIDIA
Dropbox
Outlook
Windows
iOS
macOS
cisco
ORACLE
Solaris
PlayStation
NETGEAR

Closed-source Software

- It's everywhere!

Commercialized applications and libraries

Freely-distributed **proprietary software**

Legacy software whose source code is lost

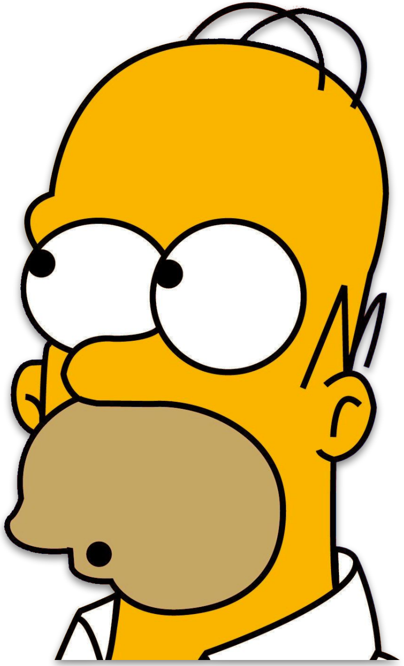
Reverse Engineering (RE)

- **What is RE?**

> “A process or method through which one attempts to **understand** through deductive reasoning how a previously made **device**, **process**, **system**, or piece of **software** accomplishes a task with **very little (if any) insight** into exactly how it does so.”

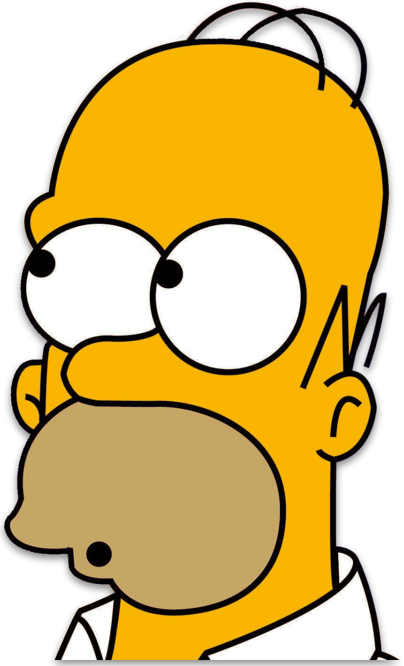
Three Pillars of RE

1. ???



Three Pillars of RE

1. **Instruction Recovery**



Pillar #1: Instruction Recovery

- **Goal: ???**

Pillar #1: Instruction Recovery

- **Goal:** translate bytes into **logical instructions**
  - Called instruction **decoding**
  - Analogous to what CPU does
  - General output: **disassembly**

Instruction stream

```
B8 22 11 00 FF 01 CA 31 F6 53 8B 5C 24
04 8D 34 48 39 C3 72 EB C3
```

Read bytes from input executable

Machine code bytes

```
B8 22 11 00 FF
01 CA
31 F6
53
8B 5C 24 04
8D 34 48
39 C3
72 EB
C3
```

Group bytes

Assembly language statements

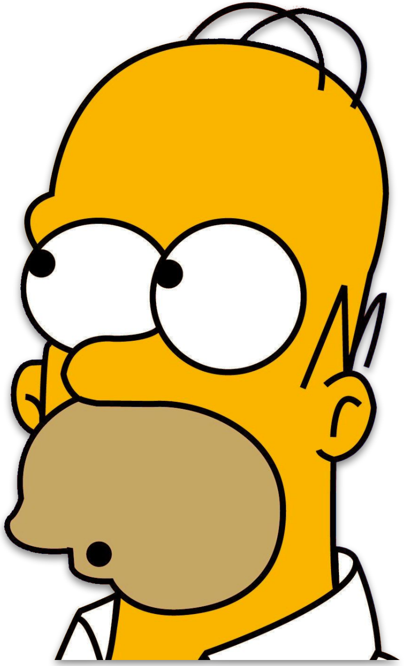
```
foo:
movl $0xFF001122, %eax
addl %ecx, %edx
xorl %esi, %esi
pushl %ebx
movl 4(%esp), %ebx
leal (%eax,%ecx,2), %esi
cmpl %eax, %ebx
jnae foo
retl
```

Decode instructions

Three Pillars of RE

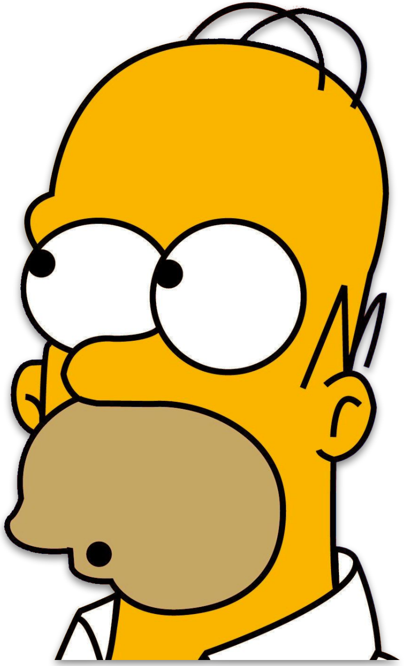
1. **Instruction Recovery**
   - Decode bytes to instructions
   - Disambiguate code from data

2. **???**



Three Pillars of RE

1. **Instruction Recovery**
   - Decode bytes to instructions
   - Disambiguate code from data
2. **Control Flow Recovery**
   - Intra-procedural execution flow
   - Inter-procedural execution flow



Pillar #2: Control Flow Recovery

- Direct Edges
  - ???

Pillar #2: Control Flow Recovery

- **Direct Edges**
  - Jump/call a function
- **Indirect Edges**
  - **???**

```
jmp 0x4001AB3
```

Target is pre-set **statically**

Pillar #2: Control Flow Recovery

- **Direct Edges**
  - Jump/call a function
- **Indirect Edges**
  - Transfer to a register
  - Function pointers
  - Switch-case tables
- **“Pseudo” Edges**
  - ???

```
jmp 0x4001AB3
```

Target is pre-set **statically**

```
call %eax; where?
```

Target found at **runtime**

Pillar #2: Control Flow Recovery

- **Direct Edges**
  - Jump/call a function
- **Indirect Edges**
  - Transfer to a register
  - Function pointers
  - Switch-case tables
- **“Pseudo” Edges**
  - Post-call returns
- **Tail Calls**
  - ???

```
jmp 0x4001AB3
```

Target is pre-set **statically**

```
call %eax;
```
where?

Target found at **runtime**

```
ret;
```
goes where?

Necessary to recover **all paths**

Pillar #2: Control Flow Recovery

- **Direct Edges**
  - Jump/call a function
- **Indirect Edges**
  - Transfer to a register
  - Function pointers
  - Switch-case tables
- **“Pseudo” Edges**
  - Post-call returns
- **Tail Calls**
  - Call at function’s end

```
jmp 0x4001AB3
```

```
call %eax; where?
```

```
ret; goes where?
```

```
jmp &foo; call?
```

Target is pre-set **statically**

Target found at **runtime**

Necessary to recover **all paths**

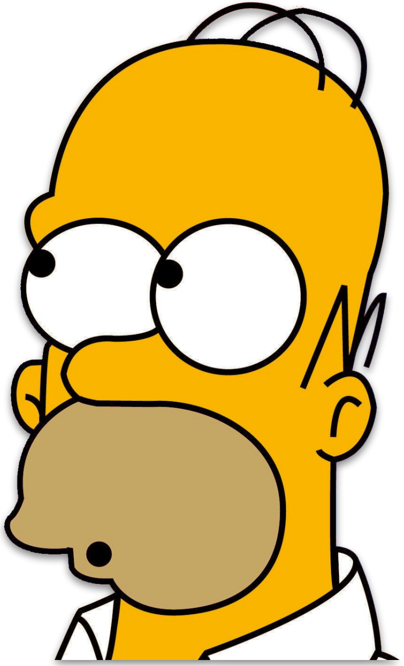
Expressed as **jumps**, not calls

Three Pillars of RE

1. **Instruction Recovery**
   - Decode bytes to instructions
   - Disambiguate code from data

2. **Control Flow Recovery**
   - Intra-procedural execution flow
   - Inter-procedural execution flow

3. **???**

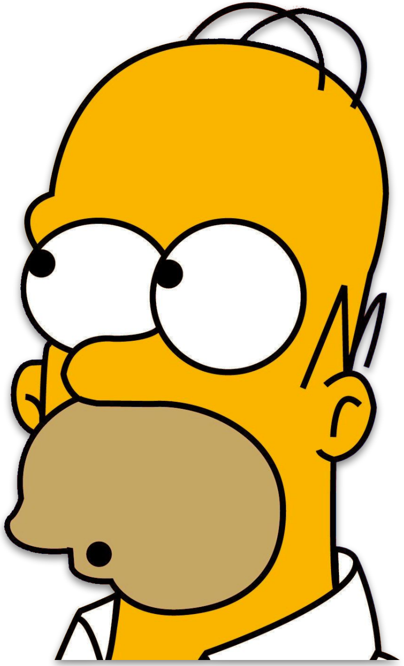


Three Pillars of RE

1. **Instruction Recovery**
   - Decode bytes to instructions
   - Disambiguate code from data

2. **Control Flow Recovery**
   - Intra-procedural execution flow
   - Inter-procedural execution flow

3. **Program Structure Recovery**
   - Identify program basic blocks
   - Higher-level constructs (e.g., loops)



Pillar #3: Structure Recovery

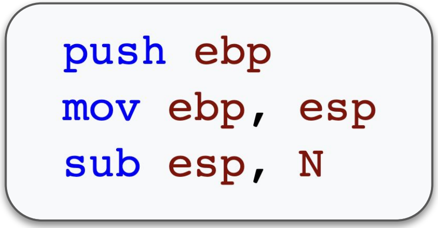
- Largely **heuristic**-based
  - Construct-specific rules

- **Functions:**
  - **Start:**
    - **???**

Pillar #3: Structure Recovery

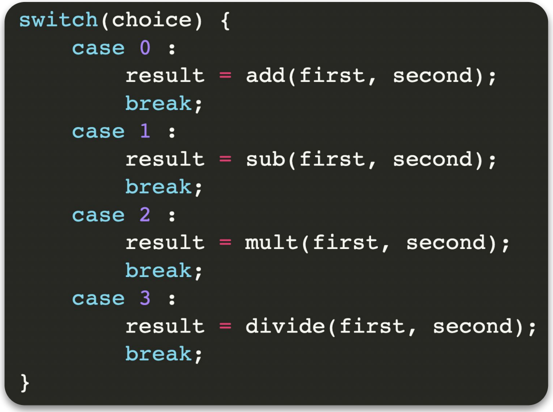
- Largely **heuristic**-based
  - Construct-specific rules

- **Functions:**
  - **Start:**
    - Target of a `call`
    - Target of a tail call
    - A known prologue
    - A dispatch table entry
  - **End:**
    - **???**



```
push ebp
mov ebp, esp
sub esp, N
```

Prologue



```
switch(choice) {
    case 0 :
        result = add(first, second);
        break;
    case 1 :
        result = sub(first, second);
        break;
    case 2 :
        result = mult(first, second);
        break;
    case 3 :
        result = divide(first, second);
        break;
}
```

C-level Switch Table

Pillar #3: Structure Recovery

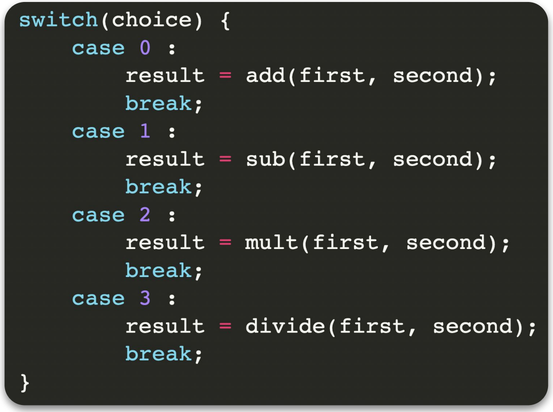
- Largely **heuristic**-based
  - Construct-specific rules
- **Functions:**
  - **Start:**
    - Target of a `call`
    - Target of a tail call
    - A known prologue
    - A dispatch table entry
  - **End:**
    - Location of a `ret`
    - Location of a tail call
    - A known epilogue

```
push ebp
mov ebp, esp
sub esp, N
```

Prologue

```
mov esp, ebp
pop ebp
ret
```

Epilogue



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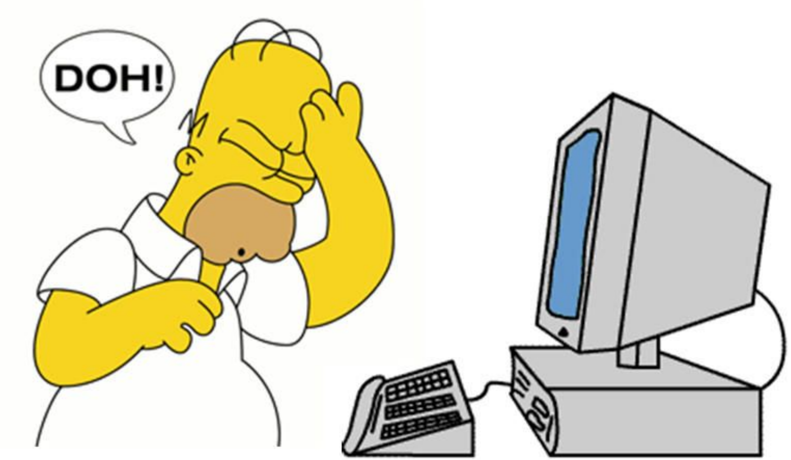
C-level Switch Table

Challenges to RE

- ???

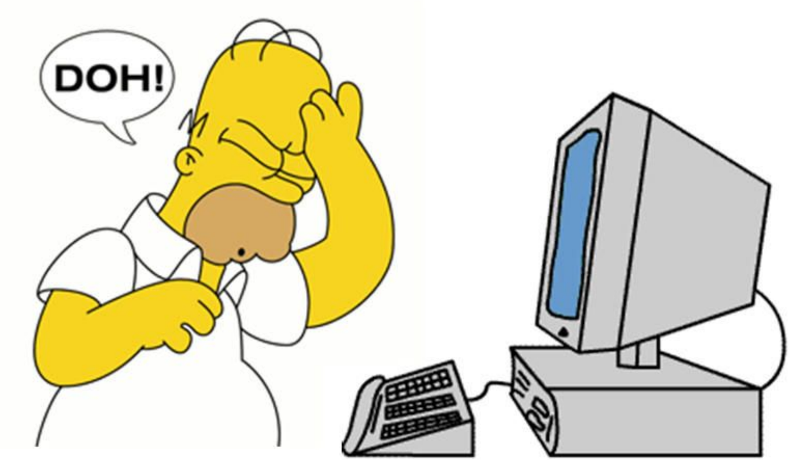


Challenges to RE

- **Compiler Craziness**
  - Data-in-code
  - Optimizations

- **Haphazard Heuristics**
  - Weird/esoteric patterns
  - E.g., all jump table variants

- **Obtuse Obfuscations**
  - Control-flow flattening
  - Opaque predicates



Questions?

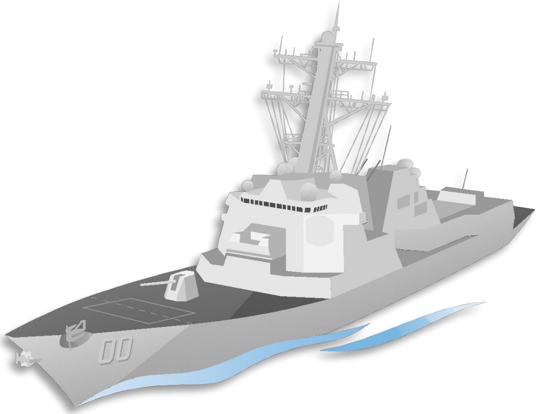
This time on CS 4440…

The Security Ecosystem
Bug Bounty Programs
Capture-the-Flag
Career Paths

Our world depends on software…

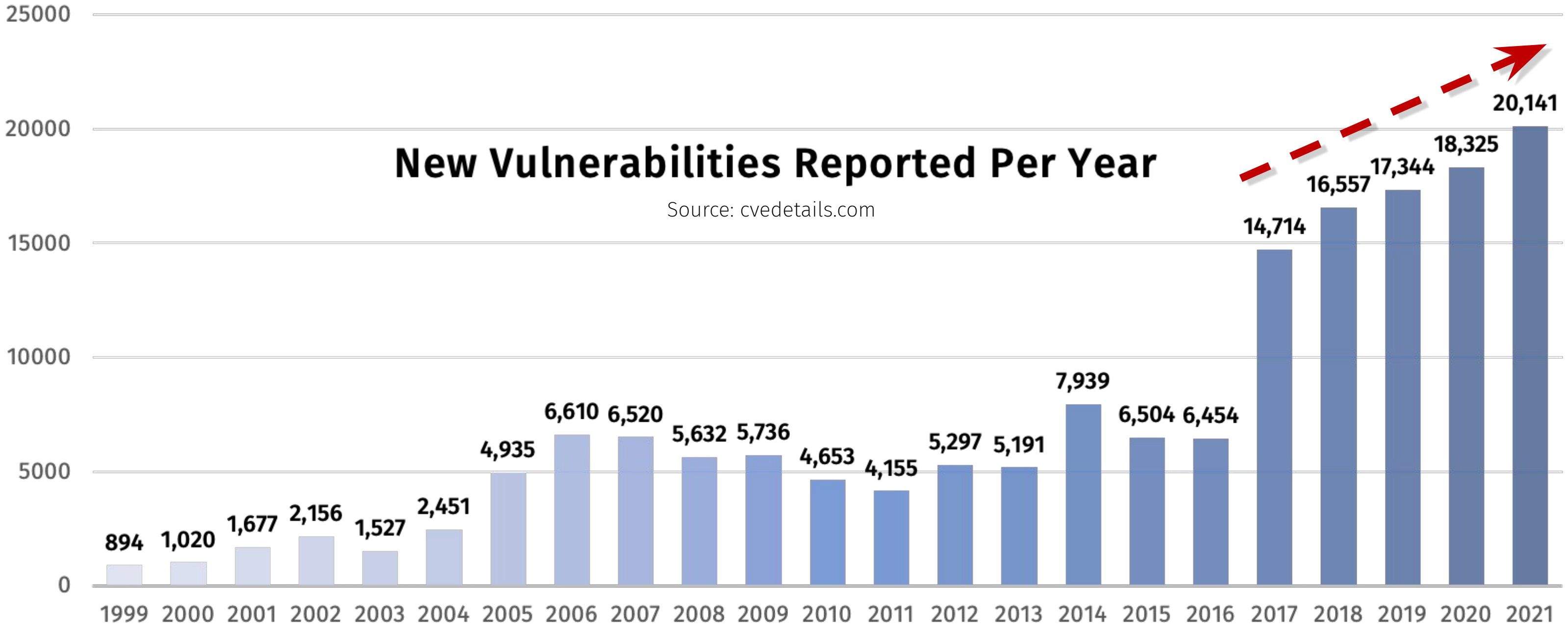
Personal Technology

Infrastructure & Industry



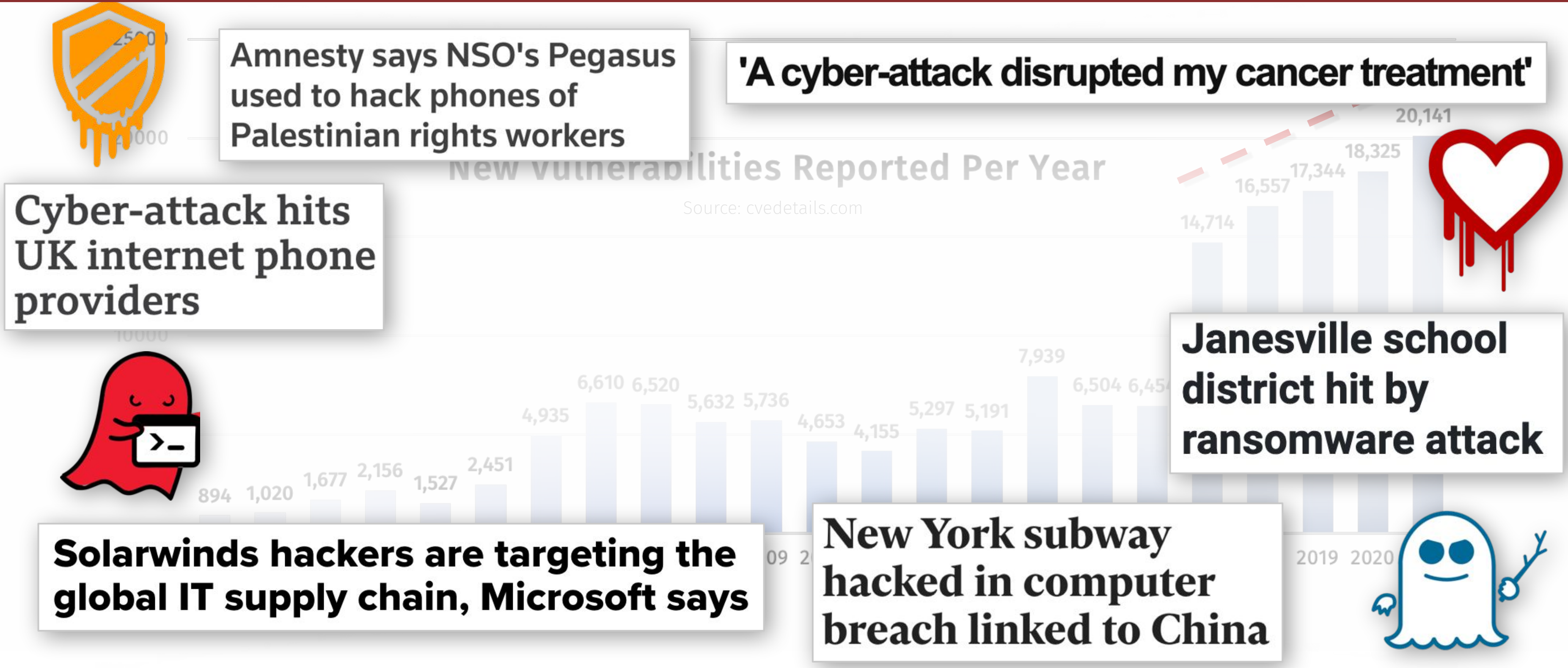
Military and Government

… and software security is a *nightmare*


New Vulnerabilities Reported Per Year

Source: cvedetails.com

… and software security is a *nightmare*



Source: cvedetails.com

Amnesty says NSO's Pegasus used to hack phones of Palestinian rights workers

'A cyber-attack disrupted my cancer treatment'

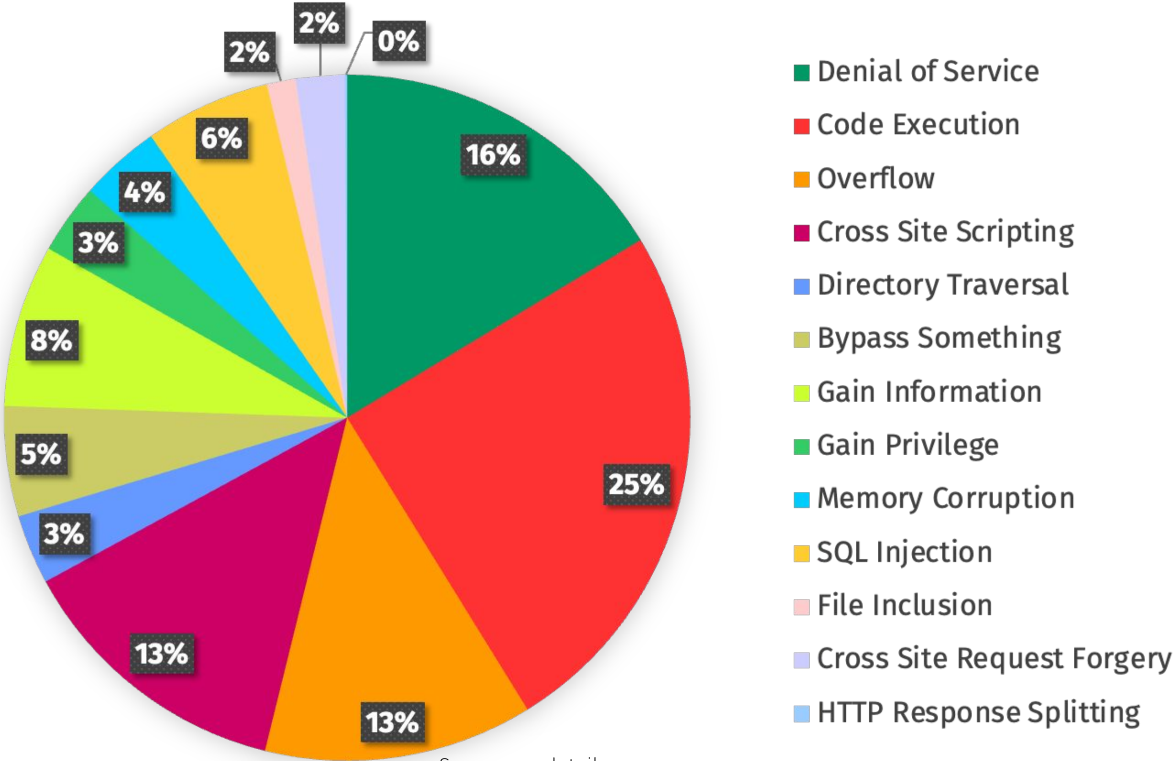
Cyber-attack hits UK internet phone providers

Janesville school district hit by ransomware attack

Solarwinds hackers are targeting the global IT supply chain, Microsoft says

New York subway hacked in computer breach linked to China

Software Security Vulnerabilities



Source: cvedetails.com

Attacks are getting more sophisticated…

1997
Function ptr hijacking

1997
Ret-2-Libc attacks

1996
Stack overflows

1972
First known overflows

1998
Heap overflows

1998
StackGuard bypasses

1999
Format strings

2002
Integer overflows

2007
Heap grooming

2005
Ret oriented programming

2005
Hardware DEP bypasses

2002
ASLR bypasses

2007
Null pointer dereference

2007
Double frees

2009
Heap spraying

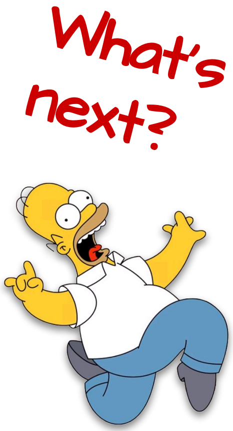
2010
JIT spraying

2021
Zero-click exploits

2016
Data oriented programming

2014
Call oriented programming

2011
Jmp oriented programming



Attacks are getting more sophisticated…

Who will be at the frontlines of stopping the next attack?

199 Functio hijacking

1997 Ret-2-Libc attacks

1996 Stack overflows

1972 First known overflows

overflows

1998 StackGuard byp es

99 rmat ings

2002 Integer overflows

grooming

2005 Ret oriented programming

05 rd re D byp

2002 ASLR bypasses

dereference

2007 Double frees

2009 Heap spr

exploits

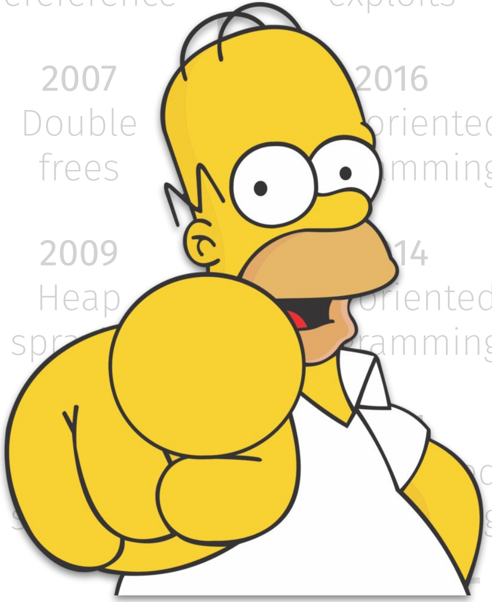
2016 oriented mming

14 oriented ramming

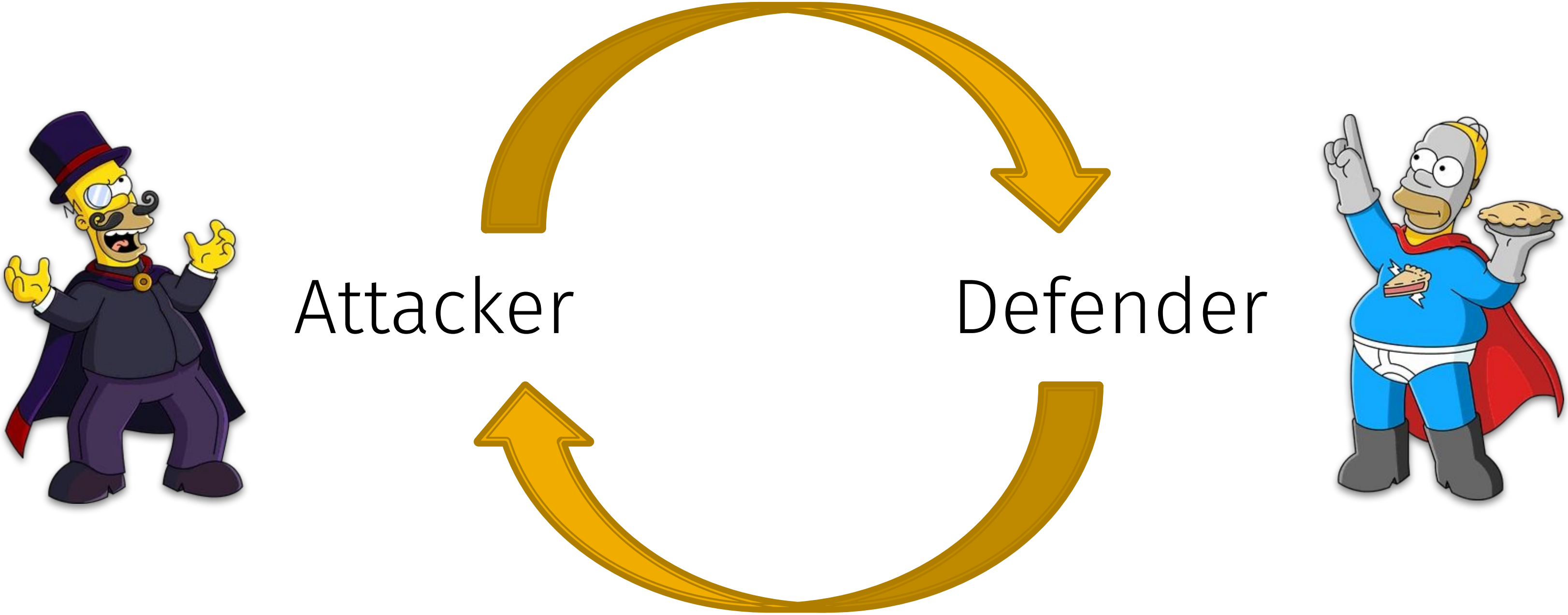
d g

What's next?

YOU!



Choose your side!



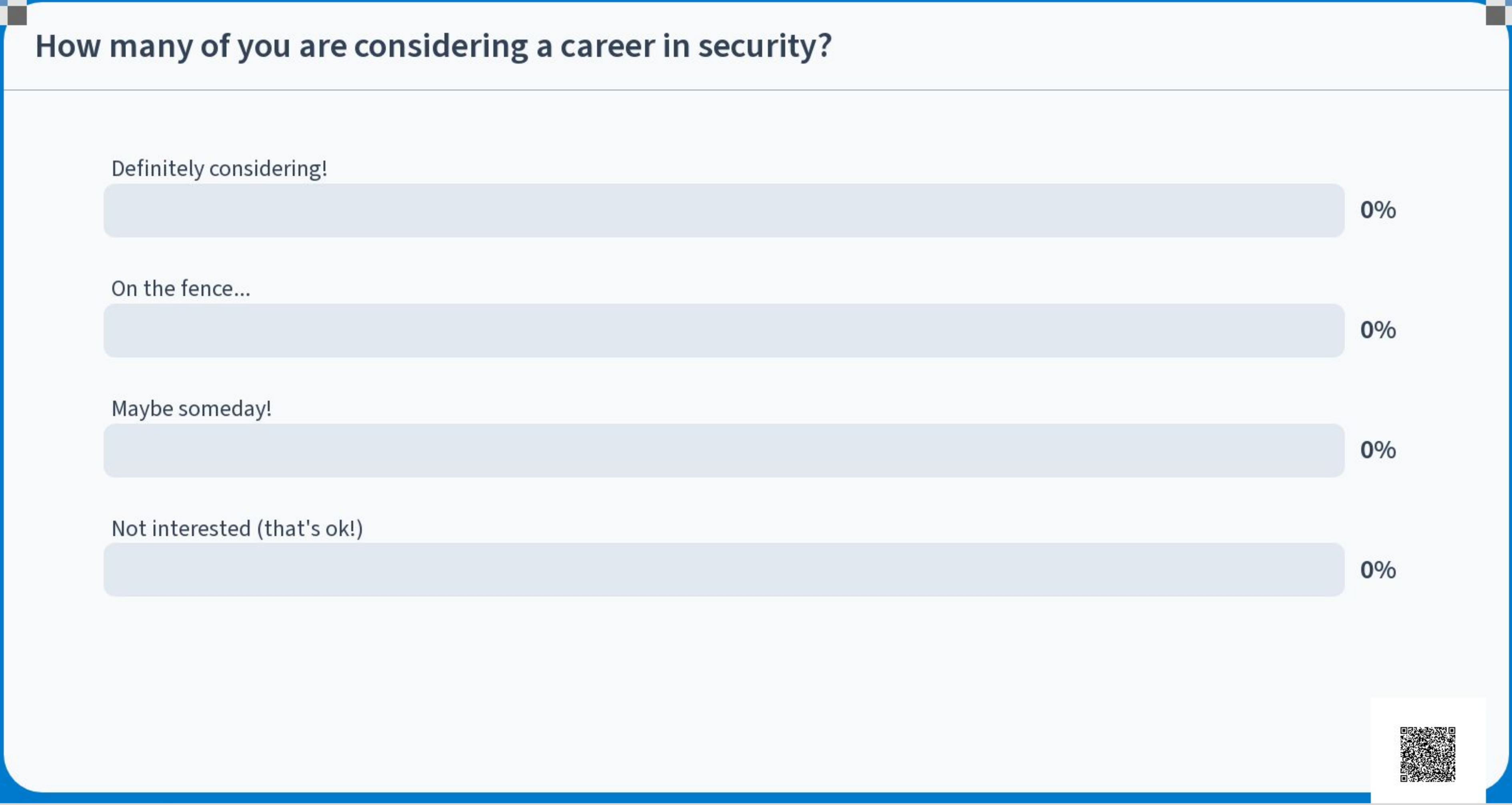
Attacker

Defender

Laws and Ethics

- **If you perform attacks, do so ethically!**
  - Federal/state laws criminalize computer intrusion, wiretapping, or other abuse
  - Computer Fraud and Abuse Act (CFAA)
  - You can be sued or go to jail

- **Ethical attacker scenarios:**
  - Career as a **Penetration Tester**
  - **CTF competitions** (join **UTAHSEC** too!)
  - Become a **Security Researcher**



How many of you are considering a career in security?

Definitely considering! 0%

On the fence... 0%

Maybe someday! 0%

Not interested (that's ok!) 0%

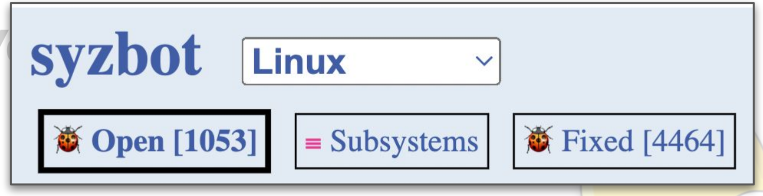
Bug Bounties

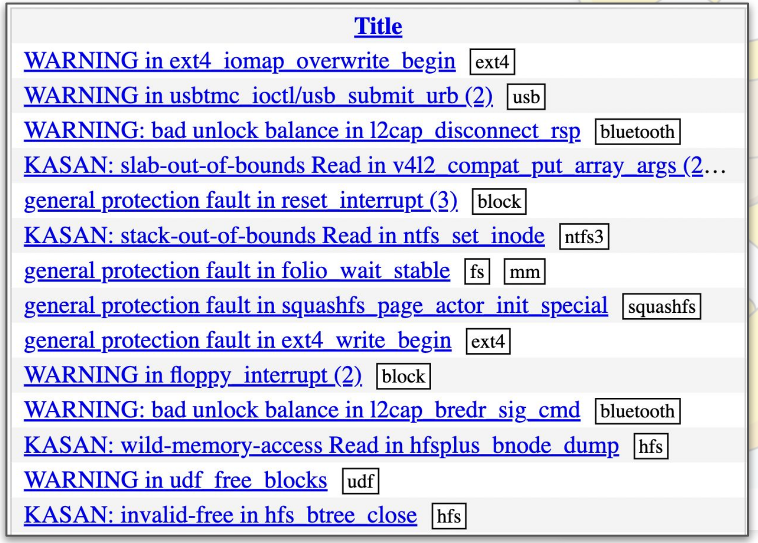
Why find and report bugs?

- **You want to save the world**

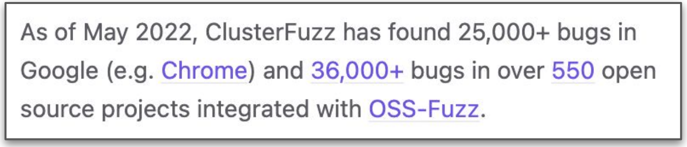
Why find and report bugs?

- Y

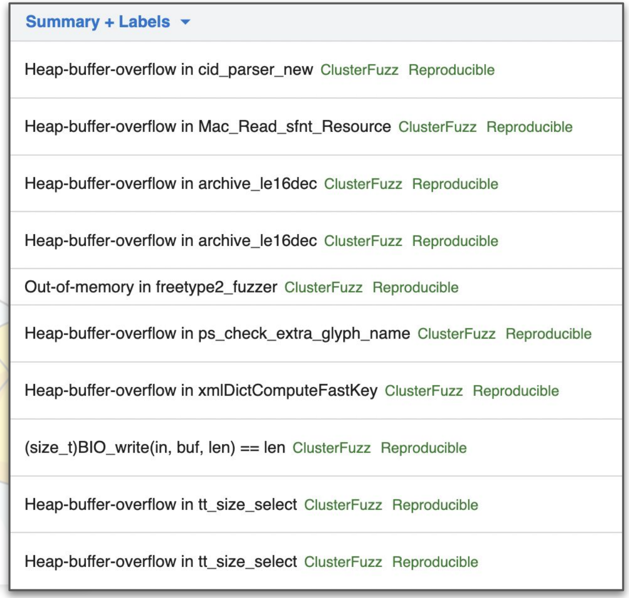




Title
WARNING in ext4_iomap_overwrite_begin ext4
WARNING in usbtmc_ioctl/usb_submit_urb (2) usb
WARNING: bad unlock balance in l2cap_disconnect_rsp bluetooth
KASAN: slab-out-of-bounds Read in v4l2_compat_put_array_args (2…
general protection fault in reset_interrupt (3) block
KASAN: stack-out-of-bounds Read in ntfs_set_inode ntfs3
general protection fault in folio_wait_stable fs mm
general protection fault in squashfs_page_actor_init_special squashfs
general protection fault in ext4_write_begin ext4
WARNING in floppy_interrupt (2) block
WARNING: bad unlock balance in l2cap_bredr_sig_cmd bluetooth
KASAN: wild-memory-access Read in hfsplus_bnode_dump hfs
WARNING in udf_free_blocks udf
KASAN: invalid-free in hfs_btree_close hfs



As of May 2022, ClusterFuzz has found 25,000+ bugs in Google (e.g. Chrome) and 36,000+ bugs in over 550 open source projects integrated with OSS-Fuzz.



Summary + Labels

Heap-buffer-overflow in cid_parser_new ClusterFuzz Reproducible

Heap-buffer-overflow in Mac_Read_sfnt_Resource ClusterFuzz Reproducible

Heap-buffer-overflow in archive_le16dec ClusterFuzz Reproducible

Heap-buffer-overflow in archive_le16dec ClusterFuzz Reproducible

Out-of-memory in freetype2_fuzzer ClusterFuzz Reproducible

Heap-buffer-overflow in ps_check_extra_glyph_name ClusterFuzz Reproducible

Heap-buffer-overflow in xmlDictComputeFastKey ClusterFuzz Reproducible

(size_t)BIO_write(in, buf, len) == len ClusterFuzz Reproducible

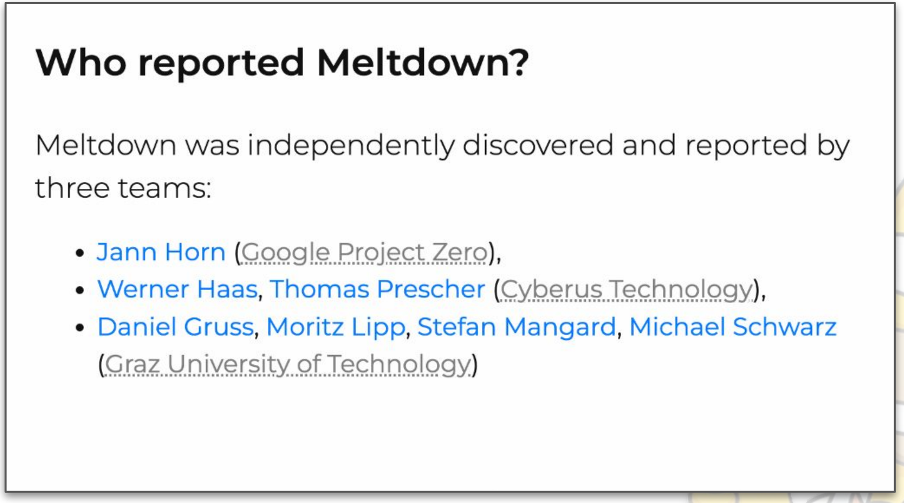
Heap-buffer-overflow in tt_size_select ClusterFuzz Reproducible

Heap-buffer-overflow in tt_size_select ClusterFuzz Reproducible

Why *else* find and report bugs?

- **You want the notoriety of finding a new bug**

Why *else* find and report bugs?

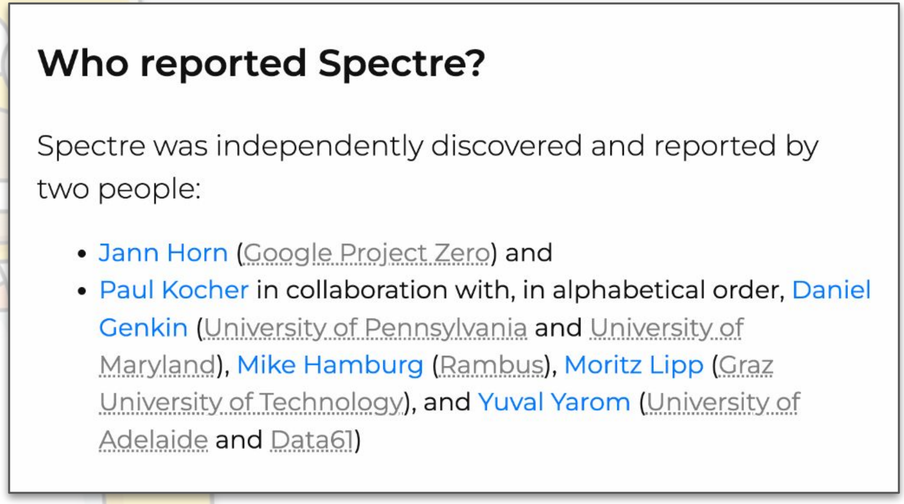


Who reported Meltdown?

Meltdown was independently discovered and reported by three teams:

- Jann Horn (Google Project Zero),
- Werner Haas, Thomas Prescher (Cyberus Technology),
- Daniel Gruss, Moritz Lipp, Stefan Mangard, Michael Schwarz (Graz University of Technology)

new bug



Who reported Spectre?

Spectre was independently discovered and reported by two people:

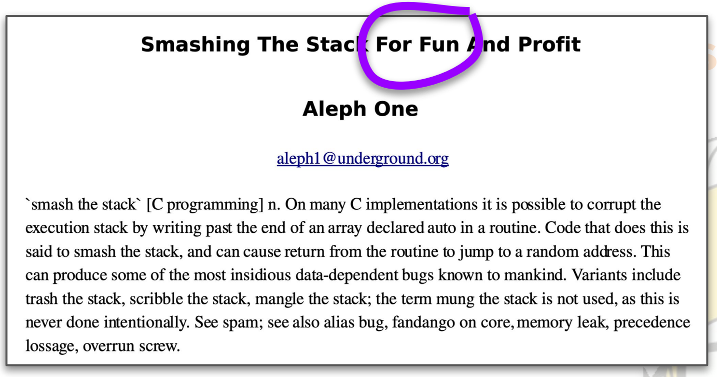
- Jann Horn (Google Project Zero) and
- Paul Kocher in collaboration with, in alphabetical order, Daniel Genkin (University of Pennsylvania and University of Maryland), Mike Hamburg (Rambus), Moritz Lipp (Graz University of Technology), and Yuval Yarom (University of Adelaide and Data61)

Why *else* find and report bugs?

- You love the thrill of breaking stuff

Why *else* find and report bugs?

- stuff

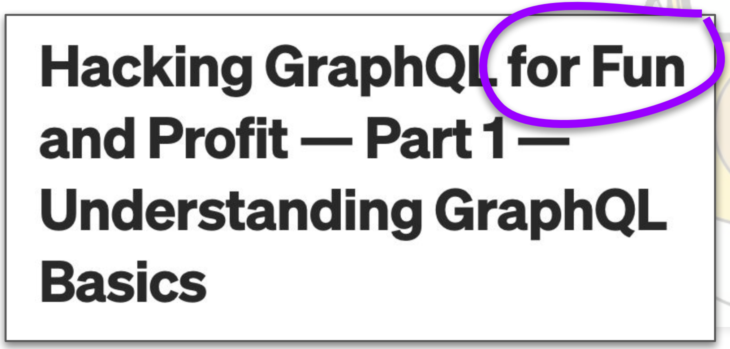


Smashing The Stack For Fun And Profit

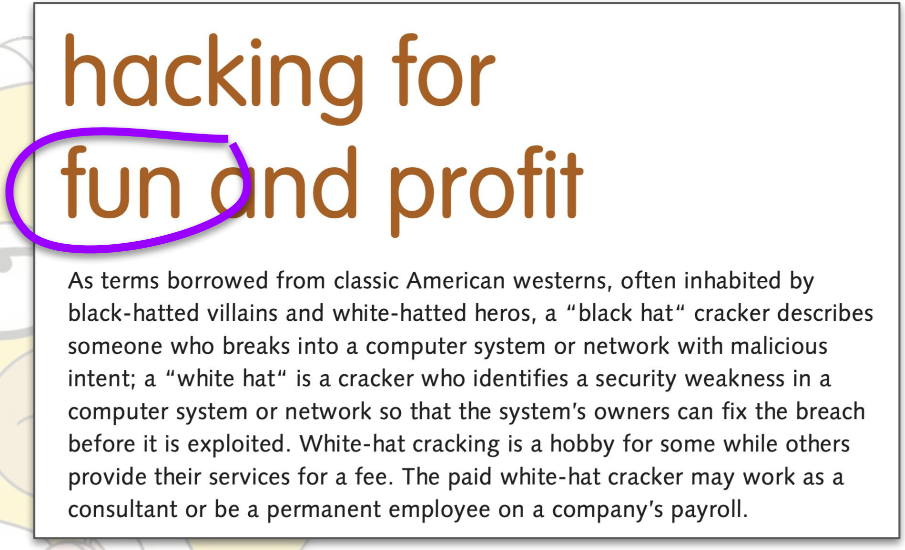
Aleph One

aleph1@underground.org

`smash the stack` [C programming] n. On many C implementations it is possible to corrupt the execution stack by writing past the end of an array declared auto in a routine. Code that does this is said to smash the stack, and can cause return from the routine to jump to a random address. This can produce some of the most insidious data-dependent bugs known to mankind. Variants include trash the stack, scribble the stack, mangle the stack; the term mung the stack is not used, as this is never done intentionally. See spam; see also alias bug, fandango on core, memory leak, precedence lossage, overrun screw.



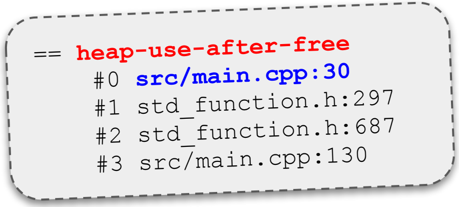
Hacking GraphQL for Fun and Profit — Part 1 — Understanding GraphQL Basics



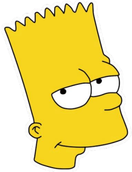
hacking for fun and profit

As terms borrowed from classic American westerns, often inhabited by black-hatted villains and white-hatted heros, a “black hat“ cracker describes someone who breaks into a computer system or network with malicious intent; a “white hat“ is a cracker who identifies a security weakness in a computer system or network so that the system's owners can fix the breach before it is exploited. White-hat cracking is a hobby for some while others provide their services for a fee. The paid white-hat cracker may work as a consultant or be a permanent employee on a company's payroll.

Disclosing Bugs Responsibly



```
== heap-use-after-free
     #0 src/main.cpp:30
     #1 std_function.h:297
     #2 std_function.h:687
     #3 src/main.cpp:130
```



Disclosing Bugs Responsibly

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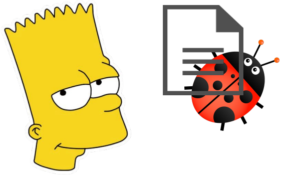
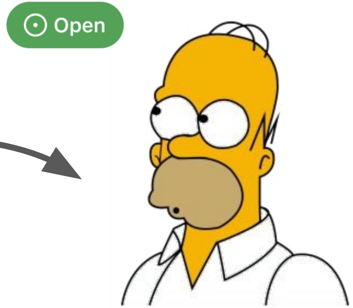
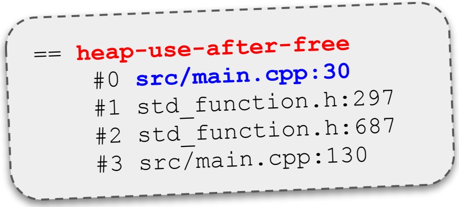




Disclosing Bugs Responsibly



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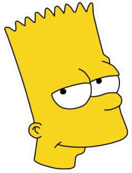
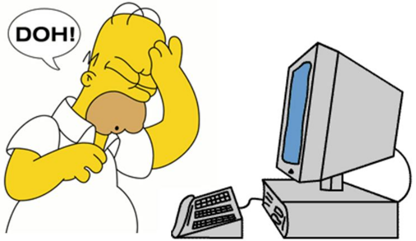
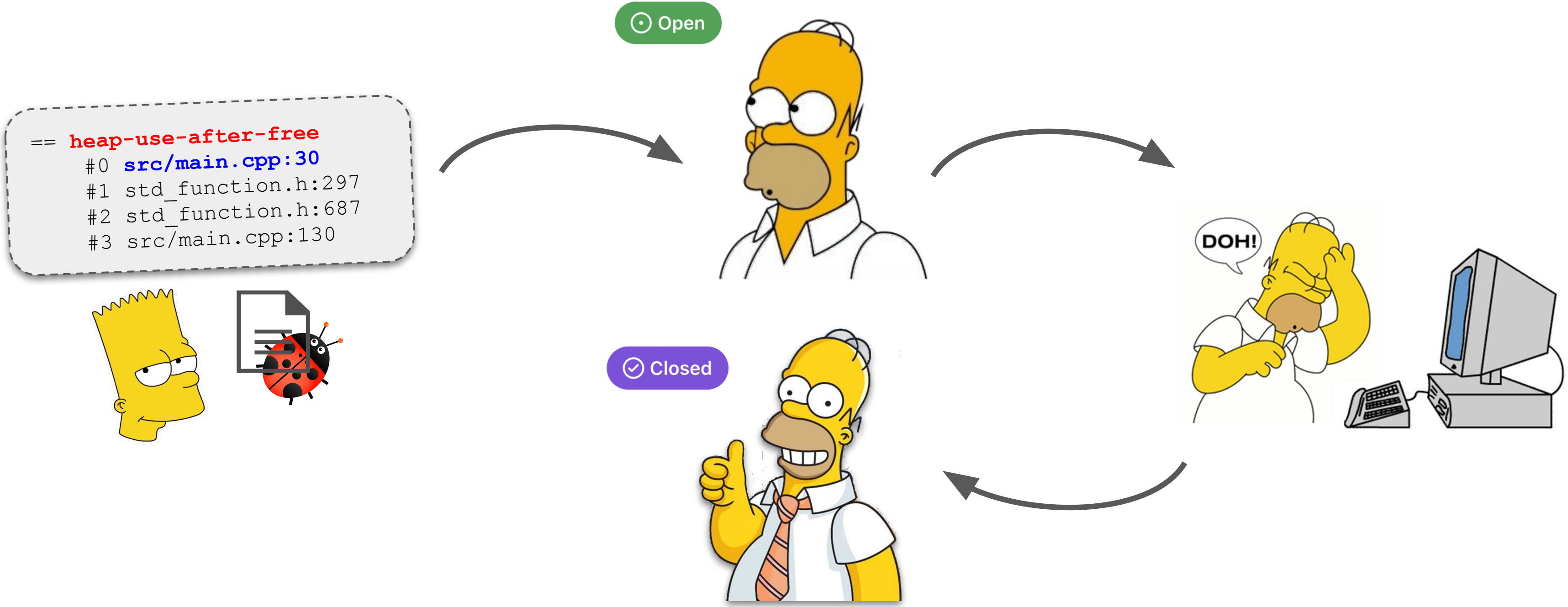


⊙ Open



Disclosing Bugs Responsibly



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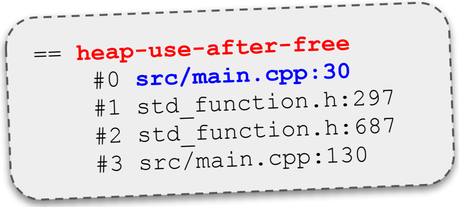
Disclosing Bugs Responsibly



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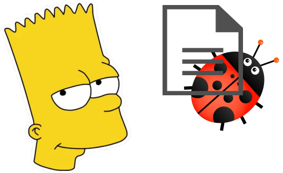
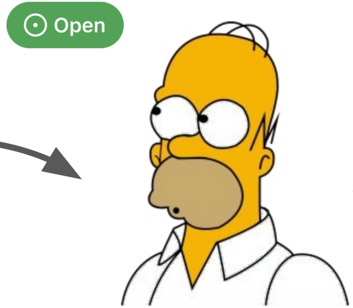
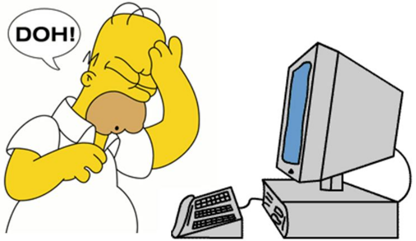
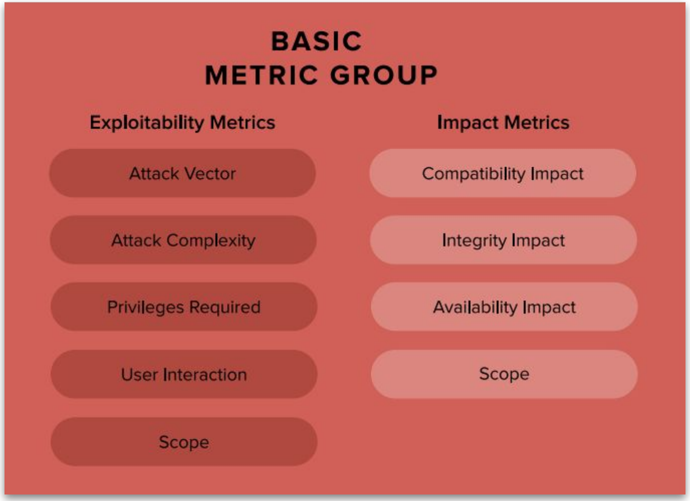






What developers love…

- **Proof-of-concept test cases**
  - Devs need to reproduce your bug
  - Perform their own severity analysis
    - Limited time and resources
    - Fix most severe ones first
    - E.g., MS Patch Tuesday
  - Help them improve their test suites



BASIC
METRIC GROUP

Exploitability Metrics

- Attack Vector
- Attack Complexity
- Privileges Required
- User Interaction
- Scope

Impact Metrics

- Compatibility Impact
- Integrity Impact
- Availability Impact
- Scope

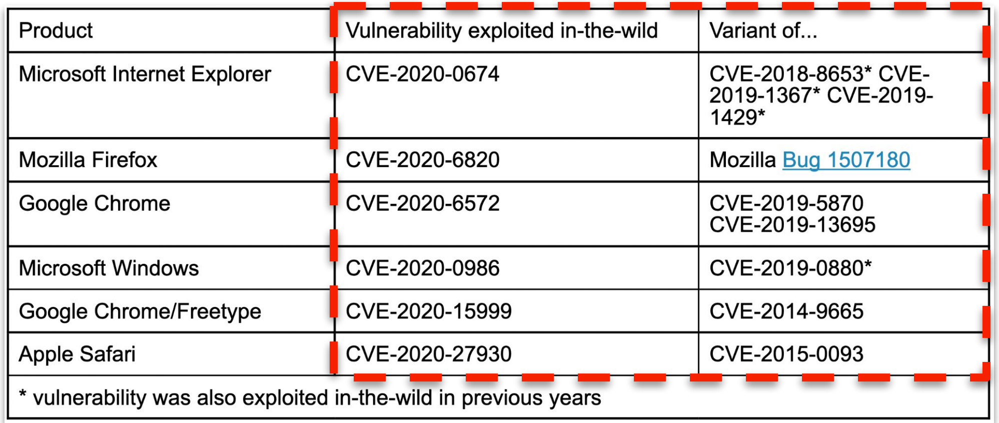
What developers love...

- **Actionable insights**
  - ***Basic:*** build information
    - E.g., compiler, version, OS, etc.
    - Only report bugs in the latest version!
  - ***Good*:** crashing source lines, PoCs
  - ***Better:*** root cause analysis
    - E.g., *Missing a check on chunk X*
    - You'll need to get your hands dirty
  - ***Best*:** proposed patches
    - May be a back-and-forth battle

Come on you guys! You're dereferencing a null pointer. It's right there!

What developers love...

- **Follow-up testing**
  - Initial fixes may be incomplete
  - Re-run your fancy fuzzer
  - **Open-source your fancy fuzzer**



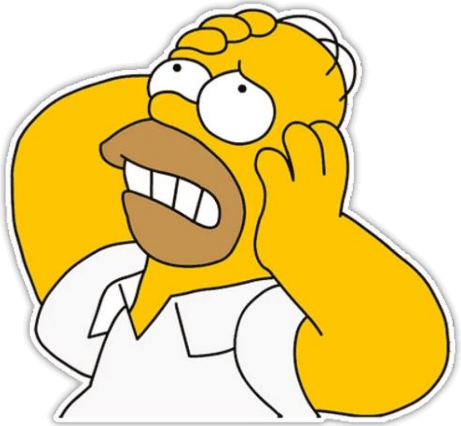
Product	Vulnerability exploited in-the-wild	Variant of...
Microsoft Internet Explorer	CVE-2020-0674	CVE-2018-8653* CVE-2019-1367* CVE-2019-1429*
Mozilla Firefox	CVE-2020-6820	Mozilla Bug 1507180
Google Chrome	CVE-2020-6572	CVE-2019-5870 CVE-2019-13695
Microsoft Windows	CVE-2020-0986	CVE-2019-0880*
Google Chrome/Freetype	CVE-2020-15999	CVE-2014-9665
Apple Safari	CVE-2020-27930	CVE-2015-0093

* vulnerability was also exploited in-the-wild in previous years

Source: Deja Vulnerability by Google Project Zero

What developers *hate*…

- **Little (or unhelpful) information**
  - No PoC test cases or stack traces
  - Bugs on obsolete versions
    - E.g., *I installed this via apt-get*
  - Spamming tons of bug reports
    - Duplicate bug reports
    - Already-reported bugs



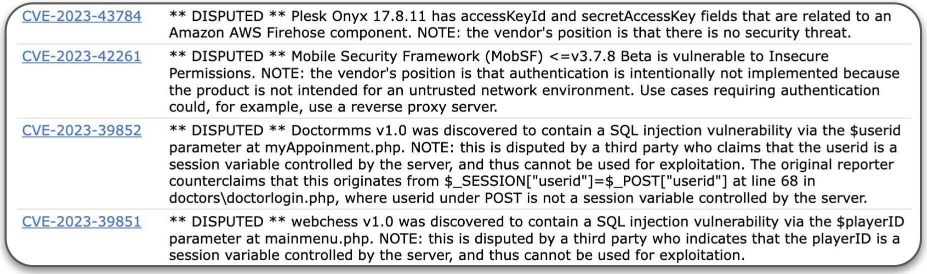
What developers *hate*...

- **Selfish resumé padding**
  - Requesting CVE assignment without first asking them
    - Common in academic papers
    - Reviewers are partially to blame

What developers *hate*...

- **Selfish resumé padding**
  - Requesting CVE assignment without first asking them
    - Common in academic papers
    - Reviewers are partially to blame

  - **Developers can (and do) dispute CVEs**



CVE-2023-43784	** DISPUTED ** Plesk Onyx 17.8.11 has accessKeyId and secretAccessKey fields that are related to an Amazon AWS Firehose component. NOTE: the vendor's position is that there is no security threat.
CVE-2023-42261	** DISPUTED ** Mobile Security Framework (MobSF) <=v3.7.8 Beta is vulnerable to Insecure Permissions. NOTE: the vendor's position is that authentication is intentionally not implemented because the product is not intended for an untrusted network environment. Use cases requiring authentication could, for example, use a reverse proxy server.
CVE-2023-39852	** DISPUTED ** Doctormms v1.0 was discovered to contain a SQL injection vulnerability via the $userid parameter at myAppoinment.php. NOTE: this is disputed by a third party who claims that the userid is a session variable controlled by the server, and thus cannot be used for exploitation. The original reporter counterclaims that this originates from $_SESSION["userid"]=$_POST["userid"] at line 68 in doctors\doctorlogin.php, where userid under POST is not a session variable controlled by the server.
CVE-2023-39851	** DISPUTED ** webchess v1.0 was discovered to contain a SQL injection vulnerability via the $playerID parameter at mainmenu.php. NOTE: this is disputed by a third party who indicates that the playerID is a session variable controlled by the server, and thus cannot be used for exploitation.

What developers *hate*...

- **Weaponizing and selling an exploit**
  - A huge underground economy
    - Nation-state actors
    - Cyber-criminal gangs

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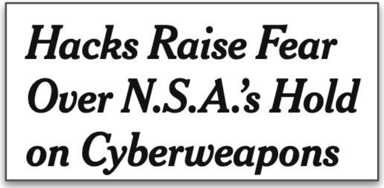
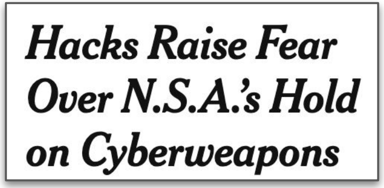
  - **Don’t do this**
    - Likely to end up in bad hands regardless of who brokered it


Hacks Raise Fear Over N.S.A.’s Hold on Cyberweapons

What developers *hate*...

- **Weaponizing and selling an exploit**
  - A huge underground economy
    - Nation-state actors
    - Cyber-criminal gangs
  - **Don’t do this**
    - Likely to end up in bad hands regardless of who brokered it
    - Authoritarian regimes use these all the time for **evil acts**
    - You are very likely causing people to get hurt **(or worse)**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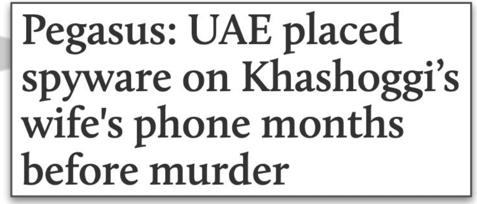
Pegasus: UAE placed spyware on Khashoggi’s wife's phone months before murder

Practice saying NO!

- **Weaponizing and selling an exploit**
  - A huge underground economy
    - Nation-state actors
    - Cyber-criminal gangs
  - **Don't**
    - end up in bad hands of who brokered it
    - an regimes use these e for **evil acts**
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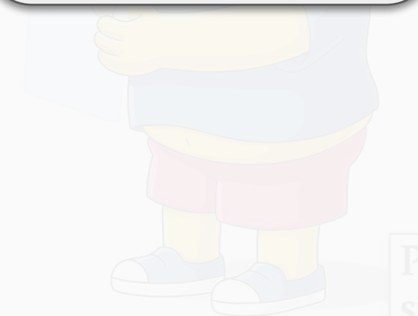

Ha ar O old o ons

Pegasu ced spyware o hoggi's wife's pho ths before mu

I have a… *lucrative*… proposition for you regarding the 0-day bug you've found…

Practice saying NO!

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Ha ar
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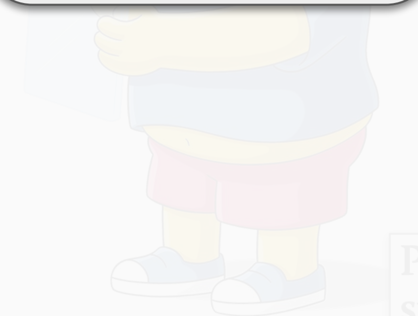
NO!



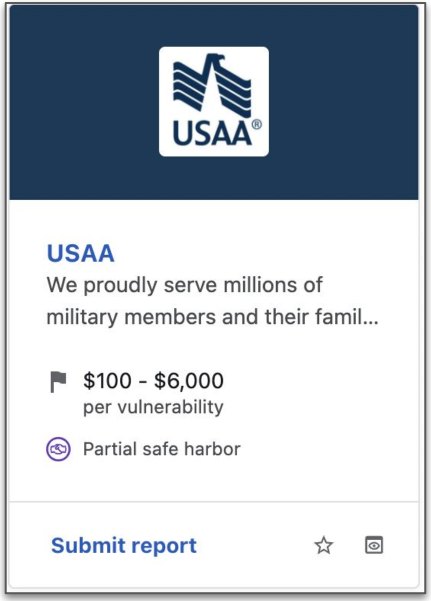
I have a… *lucrative*… proposition for you regarding the 0-day bug you've found…

Why *else* find and report bugs?

- **You want that money!**

Bug Bounties

- **Get paid to find bugs!**

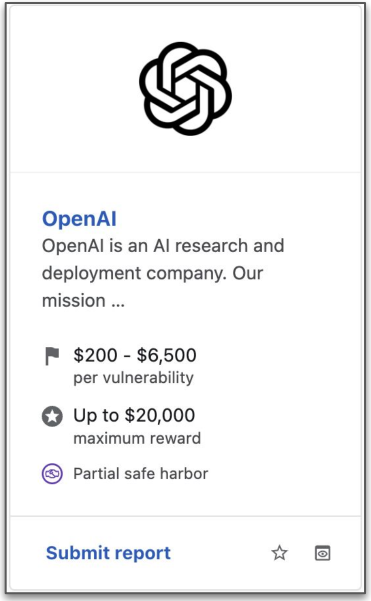


USAA

We proudly serve millions of military members and their famil...

$100 - $6,000
per vulnerability

Partial safe harbor



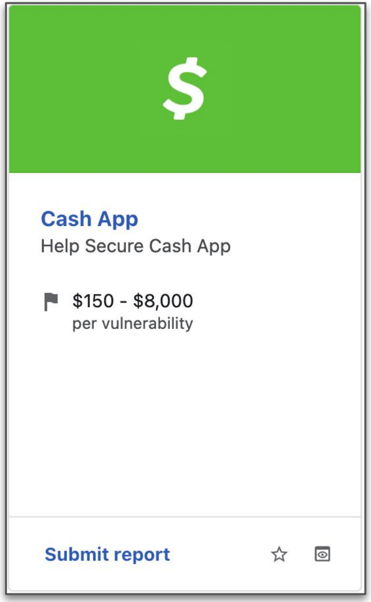
OpenAI

OpenAI is an AI research and deployment company. Our mission ...

$200 - $6,500
per vulnerability

Up to $20,000
maximum reward

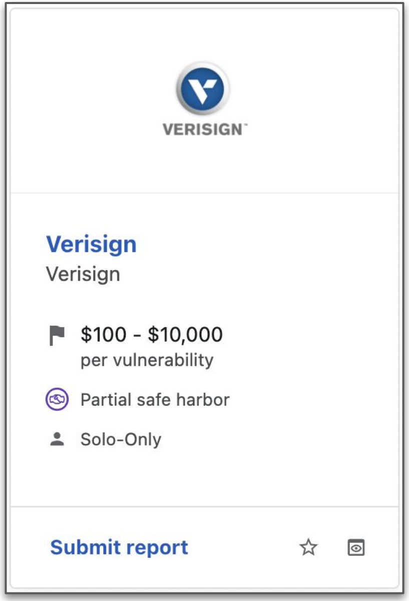
Partial safe harbor



Cash App

Help Secure Cash App

$150 - $8,000
per vulnerability



Verisign

Verisign

$100 - $10,000
per vulnerability

Partial safe harbor

Solo-Only

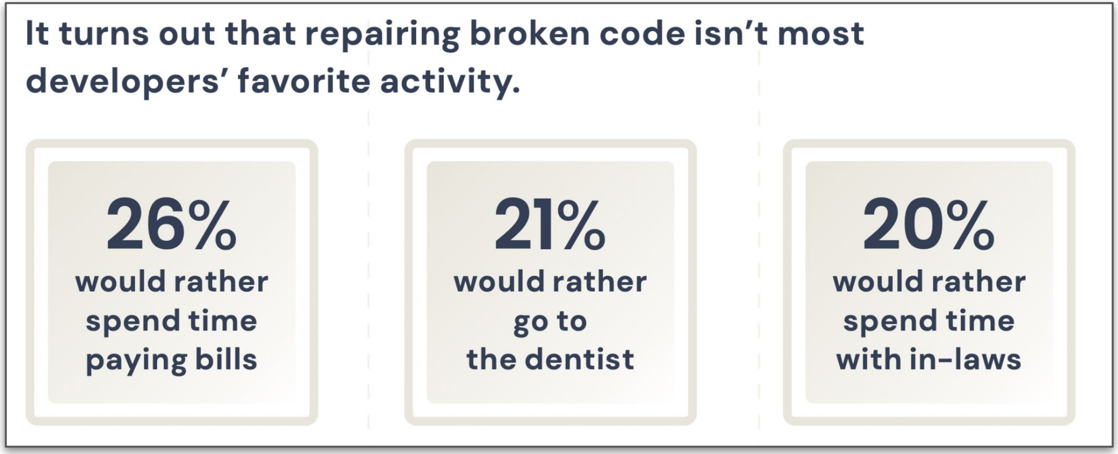
Bug Bounty Programs

- **Where programs are advertised:**
  - BugCrowd: https://bugcrowd.com/
  - HackerOne: https://www.hackerone.com/

- **Not all bugs receive a bounty!**
  - Must be reproducible by devs
  - Higher-severity = more **$$$**
  - Adjudication up to the dev

Developers are people, too

- Data suggests that fixing bugs is a really tough job



It turns out that repairing broken code isn't most developers' favorite activity.

26% would rather spend time paying bills

21% would rather go to the dentist

20% would rather spend time with in-laws

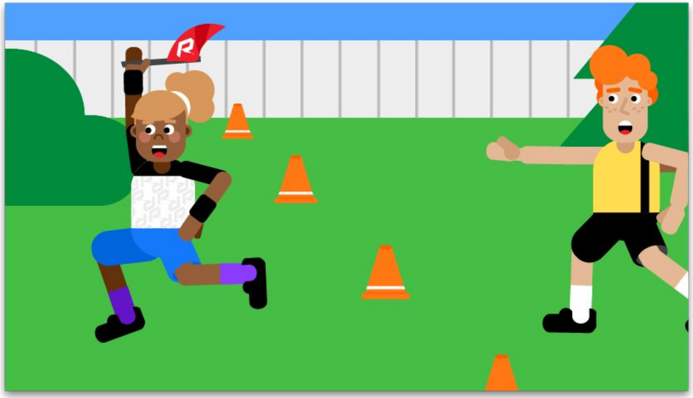
- **Treat developers with courtesy, respect, and patience**

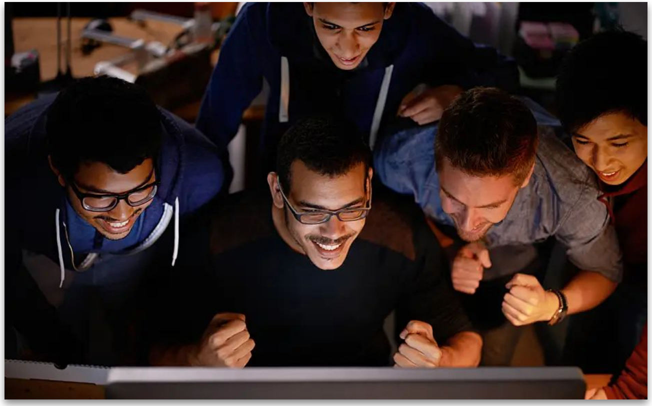
Source: https://content.rollbar.com/hubfs/State-of-Software-Code-Report.pdf

Capture-the-Flag (CTF)

What is CTF?

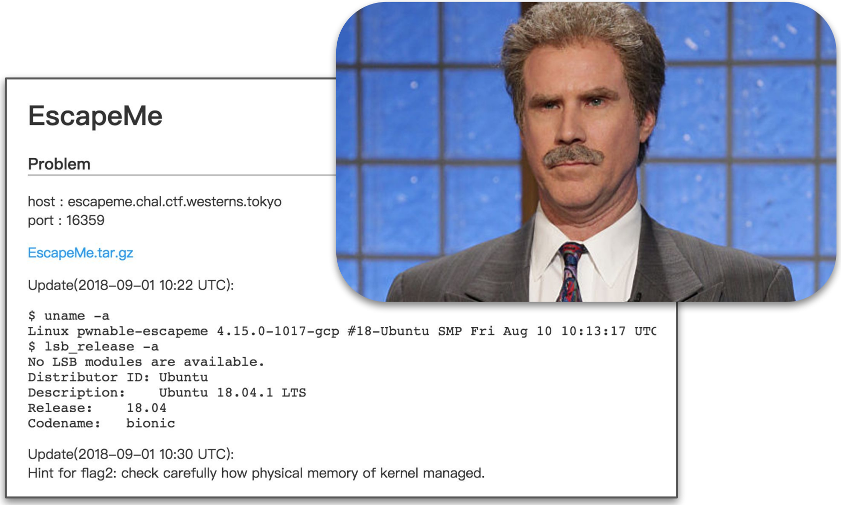
- **CTF = “Capture the Flag”**
  - Competitive cybersecurity events
  - For educational purposes, prizes, etc.
  - **Takes skill to win!**





Styles of CTF: Jeopardy

- **Jeopardy:** solve the most challenges to win
  - **Score the most points** in allotted time



EscapeMe

Problem

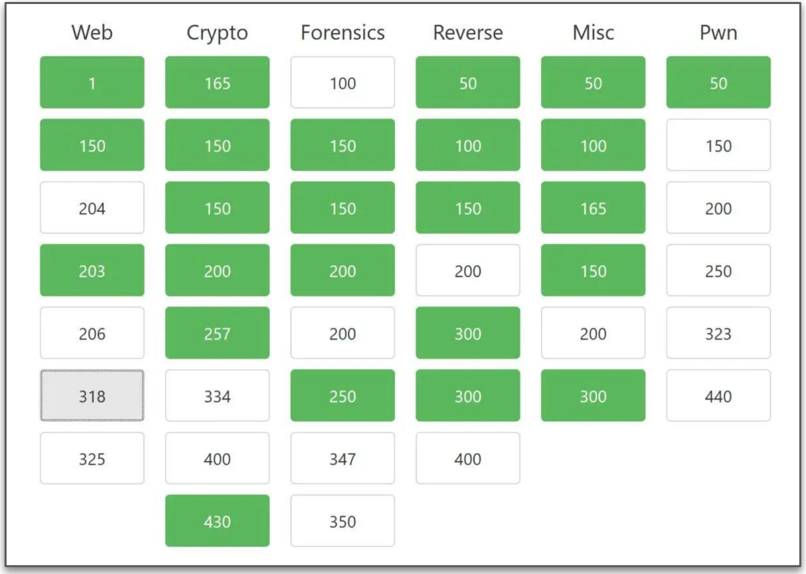
host : escapeme.chal.ctf.westerns.tokyo
port : 16359

EscapeMe.tar.gz

Update(2018-09-01 10:22 UTC):

```
$ uname -a
Linux pwnable-escapeme 4.15.0-1017-gcp #18-Ubuntu SMP Fri Aug 10 10:13:17 UTC
$ lsb_release -a
No LSB modules are available.
Distributor ID: Ubuntu
Description:    Ubuntu 18.04.1 LTS
Release:    18.04
Codename:   bionic
```

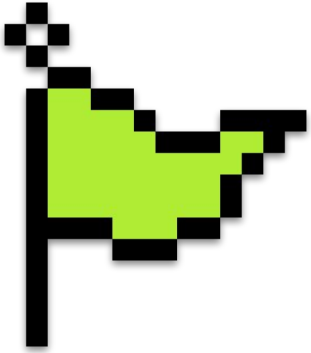
Update(2018-09-01 10:30 UTC):
Hint for flag2: check carefully how physical memory of kernel managed.



Web	Crypto	Forensics	Reverse	Misc	Pwn
1	165	100	50	50	50
150	150	150	100	100	150
204	150	150	150	165	200
203	200	200	200	150	250
206	257	200	300	200	323
318	334	250	300	300	440
325	400	347	400		
	430	350			

Jeopardy Scoring

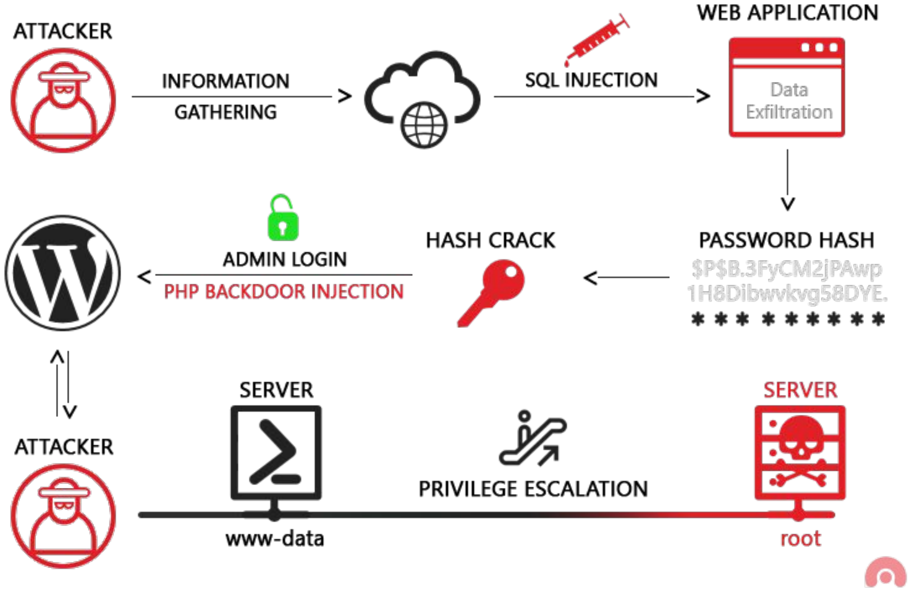
- Maximum points in the beginning
  - Incentivizes **"first blood"** (i.e., first to solve)
  - **Score decreases as more solve it**
    - Harder challenges weighted higher
    - Easier challenges weighted lower
  - **Submit the flag (when you find it)!**
    - Usually an obvious string
    - E.g., `ucc{b3_r34dy_f0r_$pr1ng23}`



STALLONE
This time he's fighting for his life.
FIRST BLOOD
SYLVESTER STALLONE FIRST BLOOD RICHARD CRENNA

Jeopardy Challenges

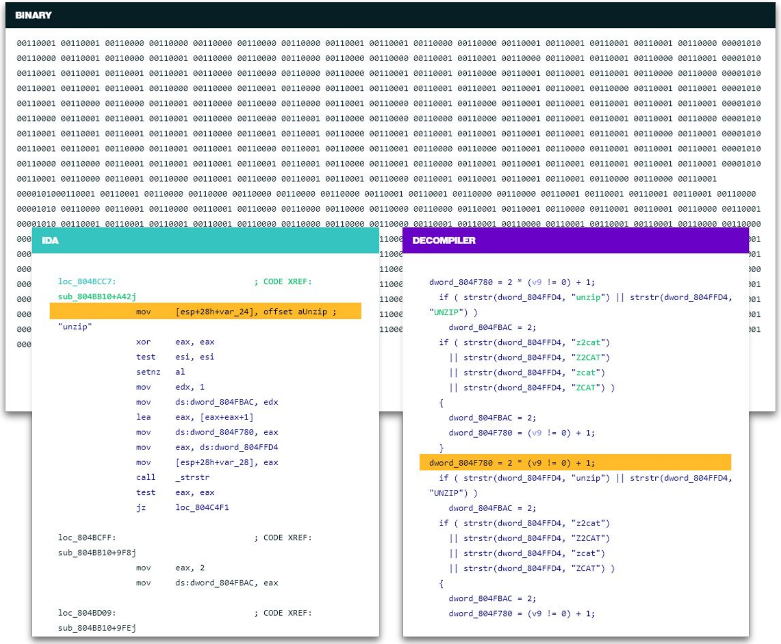
- **Web:** web security
  - **Examples:**
    - SQL injection
    - Cross-site scripting
    - Request forger
    - Password cracking
    - ...
  - Find the flag!



Jeopardy Challenges

- **RE:** reverse engineering
  - Figure out what this weird binary executable does
    - Then find the flag!

  - **Examples:**
    - Windows EXEs
    - Linux ELFs
    - iOS/Android apps
    - Weird/esoteric formats
      - Xbox game files
      - …



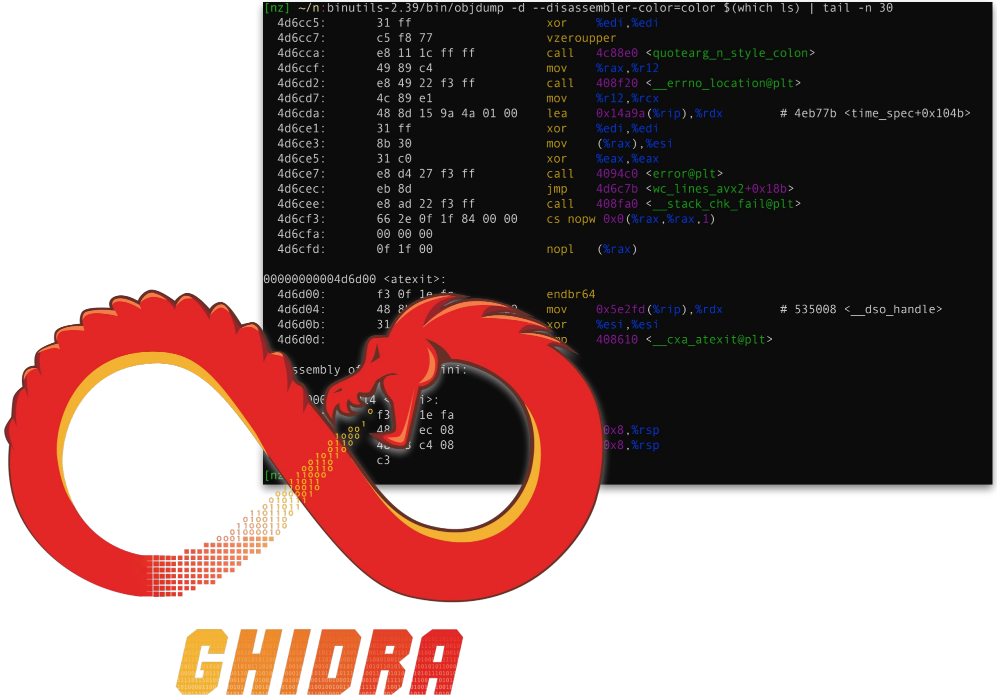
```
00110001 00110001 00110000 00110000 00110000 00110000 00110000 00110001 00110001 00110000 00110000 00110001 00110001 00110001 00110001 00110000 00001010
00110000 00110001 00110000 00110001 00110000 00110000 00110000 00110000 00110000 00110001 00110001 00110000 00110001 00110001 00110000 00110001 00001010
00110001 00110001 00110001 00110001 00110000 00110000 00110000 00110000 00110001 00110001 00110000 00110001 00110001 00110001 00110000 00110000 00001010
00110001 00110001 00110001 00110000 00110000 00110001 00110000 00110001 00110001 00110001 00110001 00110001 00110001 00110000 00110001 00110001 00001010
00110001 00110000 00110000 00110001 00110000 00110000 00110000 00110001 00110000 00110001 00110000 00110001 00110001 00110001 00110001 00110001 00001010
00110000 00110001 00110001 00110001 00110000 00110000 00110001 00110000 00110000 00110000 00110000 00110001 00110001 00110001 00110001 00110000 00001010
00110001 00110001 00110001 00110001 00110000 00110001 00110001 00110000 00110001 00110001 00110001 00110001 00110001 00110001 00110000 00110001 00001010
00110001 00110001 00110000 00110001 00110001 00110000 00110001 00110000 00110001 00110000 00110000 00110001 00110000 00110001 00110001 00110001 00001010
00110000 00110000 00110001 00110001 00110001 00110001 00110001 00110000 00110001 00110000 00110001 00110001 00110001 00110001 00110001 00110001 00001010
00110001 00110000 00110001 00110000 00110001 00110000 00110001 00110001 00110000 00110001 00110001 00110001 00110001 00110000 00110000 00110001
0000101000110001 00110001 00110000 00110000 00110000 00110000 00110000 00110001 00110001 00110000 00110000 00110001 00110001 00110001 00110001 00110000
00001010 00110000 00110001 00110000 00110001 00110000 00110000 00110000 00110000 00110000 00110001 00110001 00110000 00110001 00110001 00110000 00110001
00001010 00110001 00110001 00110001 00110001 00110000 00110000 00110000 00110000 00110001 00110001 00110000 00110001 00110001 00110001 00110000 00110000
```

```
loc_804BCC7:                              ; CODE XREF:
sub_804BB10+A42j
                mov     [esp+28h+var_24], offset aUnzip ;
"unzip"
                xor     eax, eax
                test    esi, esi
                setnz   al
                mov     edx, 1
                mov     ds:dword_804FBAC, edx
                lea     eax, [eax+eax+1]
                mov     ds:dword_804F780, eax
                mov     eax, ds:dword_804FFD4
                mov     [esp+28h+var_28], eax
                call    _strstr
                test    eax, eax
                jz      loc_804C4F1

loc_804BCFF:                              ; CODE XREF:
sub_804BB10+9F8j
                mov     eax, 2
                mov     ds:dword_804FBAC, eax

loc_804BD09:                              ; CODE XREF:
sub_804BB10+9FEj
```

```
dword_804F780 = 2 * (v9 != 0) + 1;
  if ( strstr(dword_804FFD4, "unzip") || strstr(dword_804FFD4,
"UNZIP") )
    dword_804FBAC = 2;
  if ( strstr(dword_804FFD4, "z2cat")
    || strstr(dword_804FFD4, "Z2CAT")
    || strstr(dword_804FFD4, "zcat")
    || strstr(dword_804FFD4, "ZCAT") )
  {
    dword_804FBAC = 2;
    dword_804F780 = (v9 != 0) + 1;
  }
dword_804F780 = 2 * (v9 != 0) + 1;
  if ( strstr(dword_804FFD4, "unzip") || strstr(dword_804FFD4,
"UNZIP") )
    dword_804FBAC = 2;
  if ( strstr(dword_804FFD4, "z2cat")
    || strstr(dword_804FFD4, "Z2CAT")
    || strstr(dword_804FFD4, "zcat")
    || strstr(dword_804FFD4, "ZCAT") )
  {
    dword_804FBAC = 2;
    dword_804F780 = (v9 != 0) + 1;
```

Jeopardy Challenges

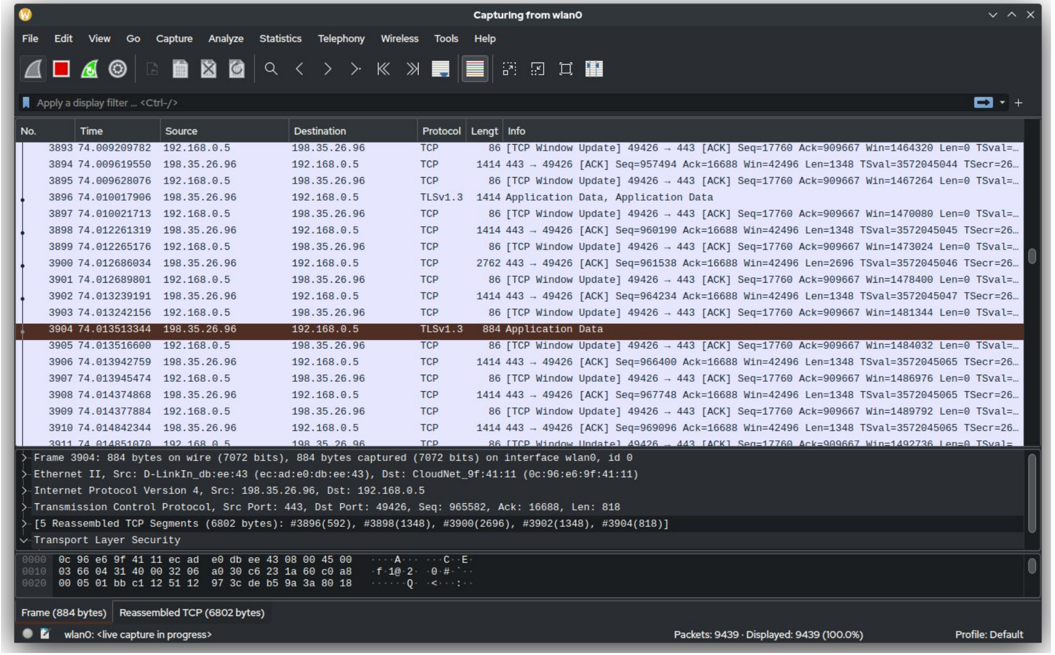
- **RE:** reverse engineering
  - Figure out what this weird binary executable does
    - Then find the flag!
  - **Tools of the trade:**
    - Decompilers
      - IDA Pro, Ghidra
    - Disassemblers
      - Objdump, angr
    - Custom tools!



```
[nz] ~/n:binutils-2.39/bin/objdump -d --disassembler-color=color $(which ls) | tail -n 30
  4d6cc5:       31 ff                   xor    %edi,%edi
  4d6cc7:       c5 f8 77                vzeroupper
  4d6cca:       e8 11 1c ff ff          call   4c88e0 <quotearg_n_style_colon>
  4d6ccf:       49 89 c4                mov    %rax,%r12
  4d6cd2:       e8 49 22 f3 ff          call   408f20 <__errno_location@plt>
  4d6cd7:       4c 89 e1                mov    %r12,%rcx
  4d6cda:       48 8d 15 9a 4a 01 00    lea    0x14a9a(%rip),%rdx        # 4eb77b <time_spec+0x104b>
  4d6ce1:       31 ff                   xor    %edi,%edi
  4d6ce3:       8b 30                   mov    (%rax),%esi
  4d6ce5:       31 c0                   xor    %eax,%eax
  4d6ce7:       e8 d4 27 f3 ff          call   4094c0 <error@plt>
  4d6cec:       eb 8d                   jmp    4d6c7b <wc_lines_avx2+0x18b>
  4d6cee:       e8 ad 22 f3 ff          call   408fa0 <__stack_chk_fail@plt>
  4d6cf3:       66 2e 0f 1f 84 00 00    cs nopw 0x0(%rax,%rax,1)
  4d6cfa:       00 00 00
  4d6cfd:       0f 1f 00                nopl   (%rax)

00000000004d6d00 <atexit>:
  4d6d00:       f3 0f 1e f              endbr64
  4d6d04:       48 8                    mov    0x5e2fd(%rip),%rdx        # 535008 <__dso_handle>
  4d6d0b:       31                      xor    %esi,%esi
  4d6d0d:                                 p    408610 <__cxa_atexit@plt>

 ssembly of      ini:

   00(    t4 <    i>:
                f3      1e fa
                48      ec 08                  0x8,%rsp
                4       c4 08                  0x8,%rsp
                c3
[n
```

Jeopardy Challenges

- **Net:** network security
  - Analyze network traffic
    - Then find the flag!
  - **Tools of the trade:**
    - Wireshark
    - Others?



```
No.  Time        Source        Destination   Protocol Lengt Info
3893 74.009209782 192.168.0.5  198.35.26.96  TCP        86 [TCP Window Update] 49426 → 443 [ACK] Seq=17760 Ack=909667 Win=1464320 Len=0 TSval=…
3894 74.009619550 198.35.26.96 192.168.0.5   TCP      1414 443 → 49426 [ACK] Seq=957494 Ack=16688 Win=42496 Len=1348 TSval=3572045044 TSecr=26…
3895 74.009628076 192.168.0.5  198.35.26.96  TCP        86 [TCP Window Update] 49426 → 443 [ACK] Seq=17760 Ack=909667 Win=1467264 Len=0 TSval=…
3896 74.010017906 198.35.26.96 192.168.0.5   TLSv1.3  1414 Application Data, Application Data
3897 74.010021713 192.168.0.5  198.35.26.96  TCP        86 [TCP Window Update] 49426 → 443 [ACK] Seq=17760 Ack=909667 Win=1470080 Len=0 TSval=…
3898 74.012261319 198.35.26.96 192.168.0.5   TCP      1414 443 → 49426 [ACK] Seq=960190 Ack=16688 Win=42496 Len=1348 TSval=3572045045 TSecr=26…
3899 74.012265176 192.168.0.5  198.35.26.96  TCP        86 [TCP Window Update] 49426 → 443 [ACK] Seq=17760 Ack=909667 Win=1473024 Len=0 TSval=…
3900 74.012686034 198.35.26.96 192.168.0.5   TCP      2762 443 → 49426 [ACK] Seq=961538 Ack=16688 Win=42496 Len=2696 TSval=3572045046 TSecr=26…
3901 74.012689801 192.168.0.5  198.35.26.96  TCP        86 [TCP Window Update] 49426 → 443 [ACK] Seq=17760 Ack=909667 Win=1478400 Len=0 TSval=…
3902 74.013239191 198.35.26.96 192.168.0.5   TCP      1414 443 → 49426 [ACK] Seq=964234 Ack=16688 Win=42496 Len=1348 TSval=3572045047 TSecr=26…
3903 74.013242156 192.168.0.5  198.35.26.96  TCP        86 [TCP Window Update] 49426 → 443 [ACK] Seq=17760 Ack=909667 Win=1481344 Len=0 TSval=…
3904 74.013513344 198.35.26.96 192.168.0.5   TLSv1.3   884 Application Data
3905 74.013516600 192.168.0.5  198.35.26.96  TCP        86 [TCP Window Update] 49426 → 443 [ACK] Seq=17760 Ack=909667 Win=1484032 Len=0 TSval=…
3906 74.013942759 198.35.26.96 192.168.0.5   TCP      1414 443 → 49426 [ACK] Seq=966400 Ack=16688 Win=42496 Len=1348 TSval=3572045065 TSecr=26…
3907 74.013945474 192.168.0.5  198.35.26.96  TCP        86 [TCP Window Update] 49426 → 443 [ACK] Seq=17760 Ack=909667 Win=1486976 Len=0 TSval=…
3908 74.014374868 198.35.26.96 192.168.0.5   TCP      1414 443 → 49426 [ACK] Seq=967748 Ack=16688 Win=42496 Len=1348 TSval=3572045065 TSecr=26…
3909 74.014377884 192.168.0.5  198.35.26.96  TCP        86 [TCP Window Update] 49426 → 443 [ACK] Seq=17760 Ack=909667 Win=1489792 Len=0 TSval=…
3910 74.014842344 198.35.26.96 192.168.0.5   TCP      1414 443 → 49426 [ACK] Seq=969096 Ack=16688 Win=42496 Len=1348 TSval=3572045065 TSecr=26…
3911 74.014851070 192.168.0.5  198.35.26.96  TCP        86 [TCP Window Update] 49426 → 443 [ACK] Seq=17760 Ack=909667 Win=1492736 Len=0 TSval=…
```

```
> Frame 3904: 884 bytes on wire (7072 bits), 884 bytes captured (7072 bits) on interface wlan0, id 0
> Ethernet II, Src: D-LinkIn_db:ee:43 (ec:ad:e0:db:ee:43), Dst: CloudNet_9f:41:11 (0c:96:e6:9f:41:11)
> Internet Protocol Version 4, Src: 198.35.26.96, Dst: 192.168.0.5
> Transmission Control Protocol, Src Port: 443, Dst Port: 49426, Seq: 965582, Ack: 16688, Len: 818
> [5 Reassembled TCP Segments (6802 bytes): #3896(592), #3898(1348), #3900(2696), #3902(1348), #3904(818)]
v Transport Layer Security
```

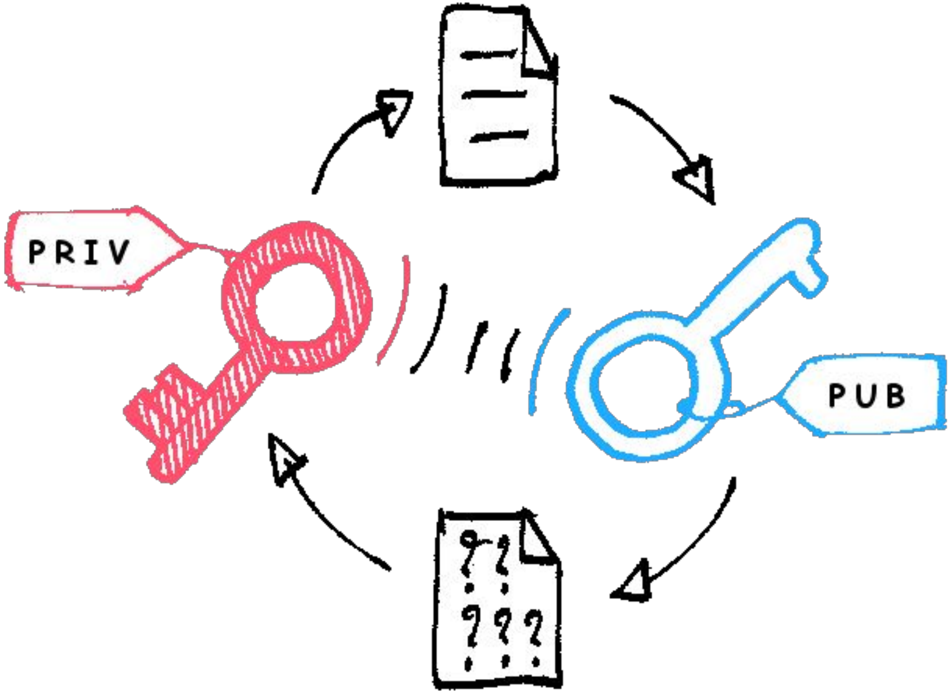
```
0000  0c 96 e6 9f 41 11 ec ad  e0 db ee 43 08 00 45 00   ····A··· ···C··E·
0010  03 66 04 31 40 00 32 06  a0 30 c6 23 1a 60 c0 a8   ·f·1@·2· ·0·#·`··
0020  00 05 01 bb c1 12 51 12  97 3c de b5 9a 3a 80 18   ······Q· ·<···:··
```

Frame (884 bytes) | Reassembled TCP (6802 bytes)

wlan0: <live capture in progress> Packets: 9439 · Displayed: 9439 (100.0%) Profile: Default

Jeopardy Challenges

- **Crypto:** cryptography
  - Undo this crypto, find the flag!
  - **Examples:**
    - Ciphers
    - Public-key crypto
    - Signature forgery
    - …
  - **Tools of the trade:**
    - Usually hand-coded stuff
    - Lots of math!!!

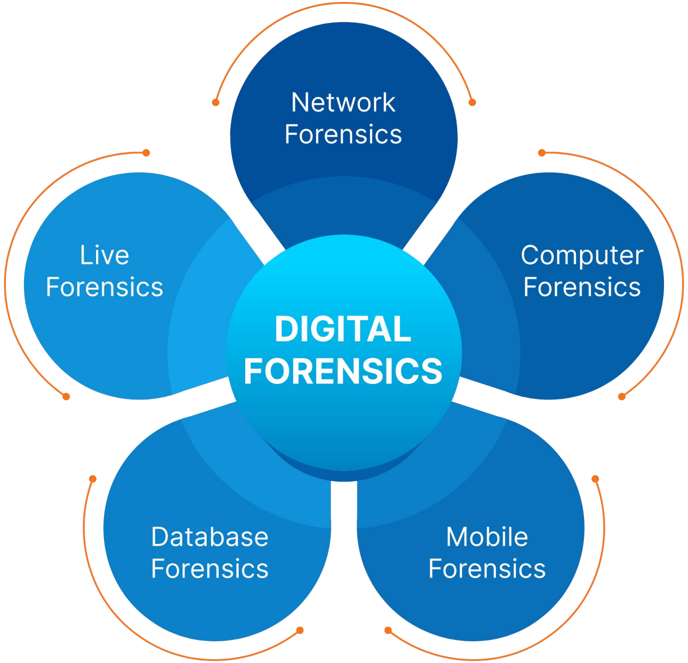


Jeopardy Challenges

- **Forensics:** digital forensics
  - Find the hidden flag
  - Mimics digital CSI investigations

  - **Examples:**
    - File system dumps
    - Memory dumps

  - **Tools of the trade:**
    - The Sleuth Kit
    - …

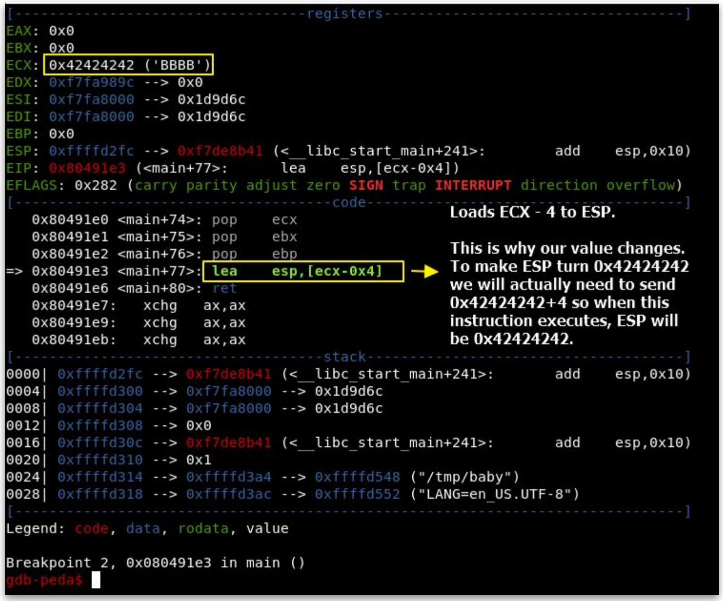


Jeopardy Challenges

- **Pwn:** exploitation
  - Find the program's bug
  - Figure out how to exploit (***pwn***) it!

  - **Examples:**
    - Stack/heap overflows
    - Spawning a root shell
    - Control-flow redirection

  - **Tools of the trade:**
    - Debuggers (GDB), RE tools
    - **CS 4440 Project 2** provides a great intro to exploitation



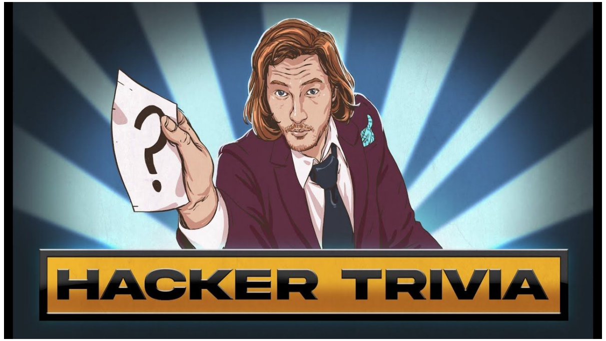
```
[----------------------------------registers-----------------------------------]
EAX: 0x0
EBX: 0x0
ECX: 0x42424242 ('BBBB')
EDX: 0xf7fa989c --> 0x0
ESI: 0xf7fa8000 --> 0x1d9d6c
EDI: 0xf7fa8000 --> 0x1d9d6c
EBP: 0x0
ESP: 0xffffd2fc --> 0xf7de8b41 (<__libc_start_main+241>:       add    esp,0x10)
EIP: 0x80491e3 (<main+77>:      lea    esp,[ecx-0x4])
EFLAGS: 0x282 (carry parity adjust zero SIGN trap INTERRUPT direction overflow)
[-------------------------------------code-------------------------------------]
   0x80491e0 <main+74>: pop    ecx
   0x80491e1 <main+75>: pop    ebx
   0x80491e2 <main+76>: pop    ebp
=> 0x80491e3 <main+77>: lea    esp,[ecx-0x4]
   0x80491e6 <main+80>: ret
   0x80491e7:   xchg   ax,ax
   0x80491e9:   xchg   ax,ax
   0x80491eb:   xchg   ax,ax
[------------------------------------stack-------------------------------------]
0000| 0xffffd2fc --> 0xf7de8b41 (<__libc_start_main+241>:       add    esp,0x10)
0004| 0xffffd300 --> 0xf7fa8000 --> 0x1d9d6c
0008| 0xffffd304 --> 0xf7fa8000 --> 0x1d9d6c
0012| 0xffffd308 --> 0x0
0016| 0xffffd30c --> 0xf7de8b41 (<__libc_start_main+241>:       add    esp,0x10)
0020| 0xffffd310 --> 0x1
0024| 0xffffd314 --> 0xffffd3a4 --> 0xffffd548 ("/tmp/baby")
0028| 0xffffd318 --> 0xffffd3ac --> 0xffffd552 ("LANG=en_US.UTF-8")
[------------------------------------------------------------------------------]
Legend: code, data, rodata, value

Breakpoint 2, 0x080491e3 in main ()
gdb-peda$
```

Loads ECX - 4 to ESP.

This is why our value changes. To make ESP turn 0x42424242 we will actually need to send 0x42424242+4 so when this instruction executes, ESP will be 0x42424242.

Jeopardy Challenges

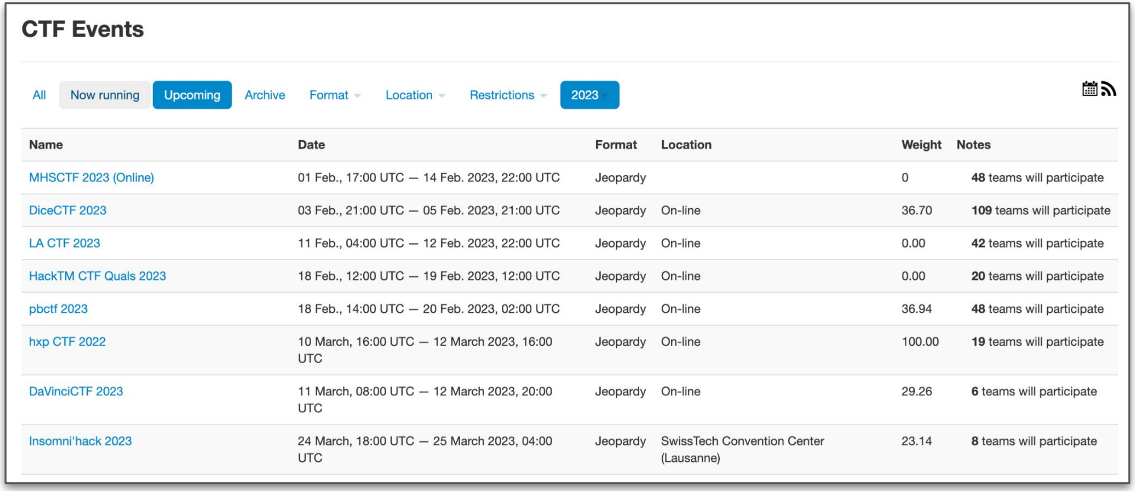
- **Misc/Trivia:** random questions
  - Hackers ***love*** their trivia
  - Usually the flag isn't obvious
    - You might have to type it out
  - **Examples:**
    - Old hacker movies
    - Mr. Robot ARG
  - **Tools of the trade:**
    - Google, YouTube, etc.



Competitions

- Events happen **all the time**
  - See CTFTime.org
- Competition **weight:**
  - How much the event counts to “rankings”
- Team limits:
  - Many have no limits
  - Others cap at **n** players

CTF TIME

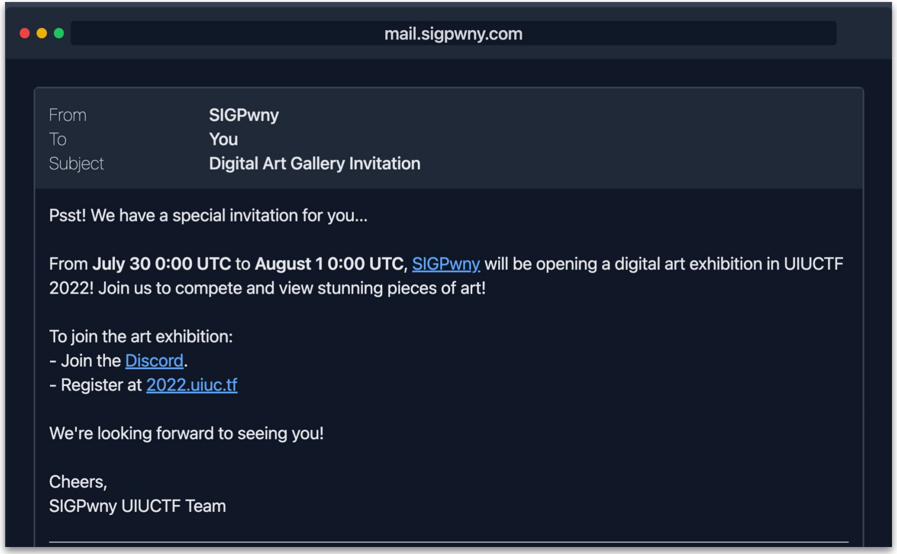


CTF Events

Name	Date	Format	Location	Weight	Notes
MHSCTF 2023 (Online)	01 Feb., 17:00 UTC — 14 Feb. 2023, 22:00 UTC	Jeopardy		0	**48** teams will participate
DiceCTF 2023	03 Feb., 21:00 UTC — 05 Feb. 2023, 21:00 UTC	Jeopardy	On-line	36.70	**109** teams will participate
LA CTF 2023	11 Feb., 04:00 UTC — 12 Feb. 2023, 22:00 UTC	Jeopardy	On-line	0.00	**42** teams will participate
HackTM CTF Quals 2023	18 Feb., 12:00 UTC — 19 Feb. 2023, 12:00 UTC	Jeopardy	On-line	0.00	**20** teams will participate
pbctf 2023	18 Feb., 14:00 UTC — 20 Feb. 2023, 02:00 UTC	Jeopardy	On-line	36.94	**48** teams will participate
hxp CTF 2022	10 March, 16:00 UTC — 12 March 2023, 16:00 UTC	Jeopardy	On-line	100.00	**19** teams will participate
DaVinciCTF 2023	11 March, 08:00 UTC — 12 March 2023, 20:00 UTC	Jeopardy	On-line	29.26	**6** teams will participate
Insomni'hack 2023	24 March, 18:00 UTC — 25 March 2023, 04:00 UTC	Jeopardy	SwissTech Convention Center (Lausanne)	23.14	**8** teams will participate

Competitions

- **Many schools host their own**
  - RPI
  - Purdue
  - OSU
  - UIUC
  - CMU
  - …
  - **University of Utah!!!** (eventually)
- Who creates and hosts challenges?
  - The event organizers!



From SIGPwny
To You
Subject Digital Art Gallery Invitation

Psst! We have a special invitation for you...

From **July 30 0:00 UTC** to **August 1 0:00 UTC**, SIGPwny will be opening a digital art exhibition in UIUCTF 2022! Join us to compete and view stunning pieces of art!

To join the art exhibition:
- Join the Discord.
- Register at 2022.uiuc.tf

We're looking forward to seeing you!

Cheers,
SIGPwny UIUCTF Team

Competitions

- **DEFCON CTF Finals**
  - The **Super Bowl** of CTF
    - Happens in Vegas during DEFCON hacker conference
  - Only top CTF teams invited
    - Win qualifier tournaments
  - **Our goal is to make it (and win)!**

How do I get good at CTF?

- **Attend UtahSec meetings**
  - **“Let’s solve this CTF challenge”** will be a frequent meeting topic
- **Read challenge write-ups**
  - Detailed solutions
- **Practice practice practice!**
  - Join the team and come learn!
- **Take CS 4440:** Intro to Security
  - An overview of many CTF-style topics

Careers in Cybersecurity

So you’ve taken CS 4440… what now?

- **Do you find cybersecurity interesting?**
  - If so, consider a **career** in cybersecurity!

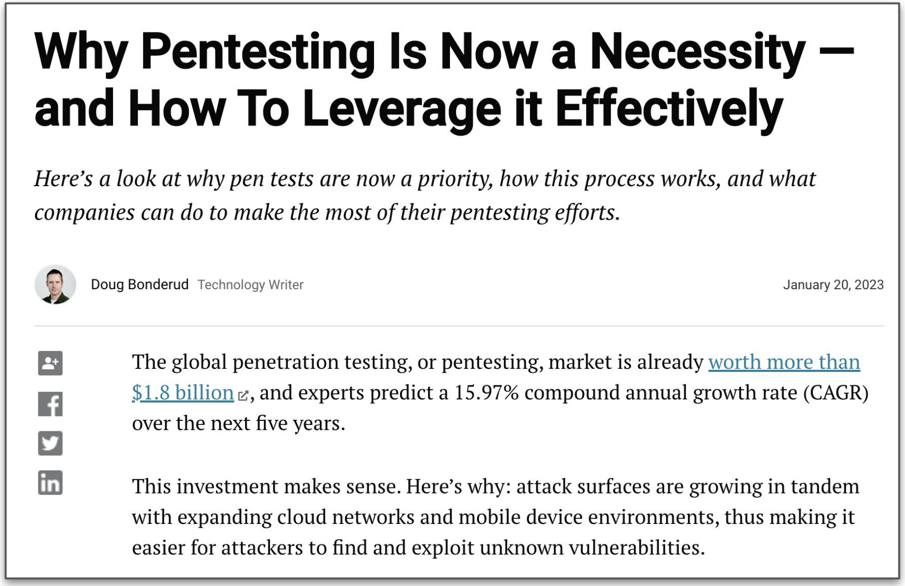
So you've taken CS 4440... what now?

- **Do you find cybersecurity interesting?**
  - If so, consider a **career** in cybersecurity!

- **Some possible career paths:**
  - The **Ethical Hacker**
  - The **Practitioner**
  - The **Researcher**

Careers in Cybersecurity: The Ethical Hacker

What is Pen-Testing?



Why Pentesting Is Now a Necessity — and How To Leverage it Effectively

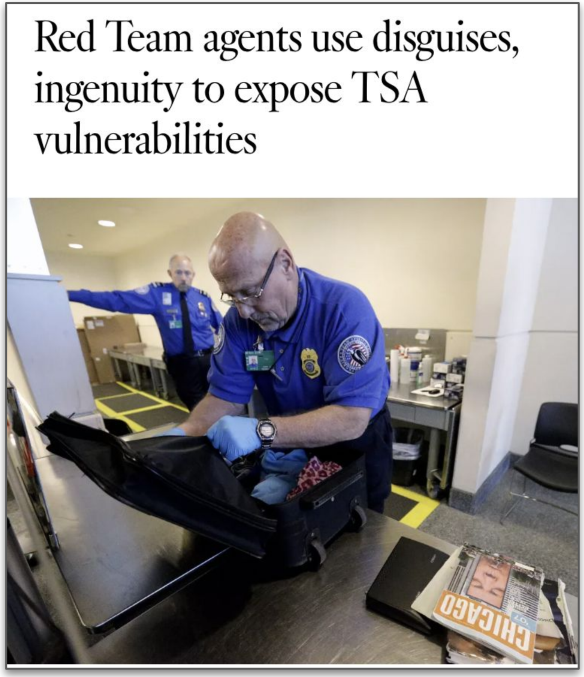
Here's a look at why pen tests are now a priority, how this process works, and what companies can do to make the most of their pentesting efforts.

Doug Bonderud Technology Writer

January 20, 2023

The global penetration testing, or pentesting, market is already worth more than $1.8 billion, and experts predict a 15.97% compound annual growth rate (CAGR) over the next five years.

This investment makes sense. Here's why: attack surfaces are growing in tandem with expanding cloud networks and mobile device environments, thus making it easier for attackers to find and exploit unknown vulnerabilities.



Red Team agents use disguises, ingenuity to expose TSA vulnerabilities

What is Pen-Testing?

- **Basically, a company hires you to hack them**

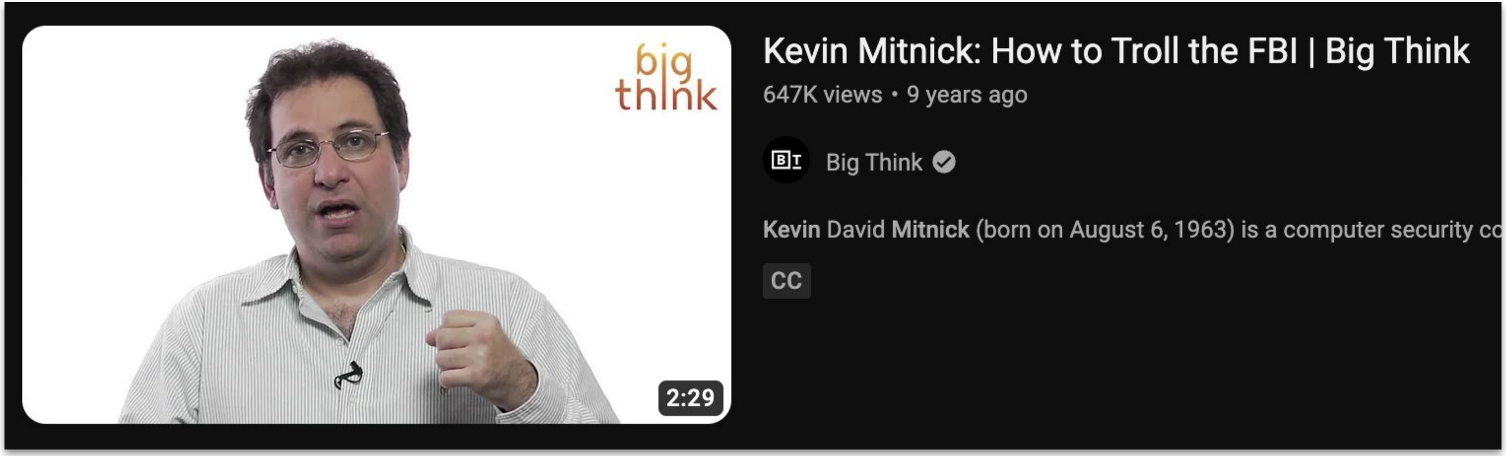
What is Pen-Testing?

- **Basically, a company hires you to hack them**
  - Test their **physical** security
    - Pick the locks on their front entrance
    - Trick employees into letting you inside
  - Test their **web and network** security
    - Impersonate the CEO in a phishing email
  - Test their **application** security
    - Exploit a widely-known-yet-unpatched bug

Becoming a Pen-Tester

- **Figure out your security niche(s)!**
  - **What topics interest you the most?**
    - Physical
    - Forensics
    - Application
    - Web / Network
    - Communications
    - Open-src Intelligence
  - **Master your niche and apply!**
    - Internships are great to start
    - Be ready to learn on the job!

Learn from the Pros



Kevin Mitnick: How to Troll the FBI | Big Think

647K views • 9 years ago

Big Think

Kevin David Mitnick (born on August 6, 1963) is a computer security co

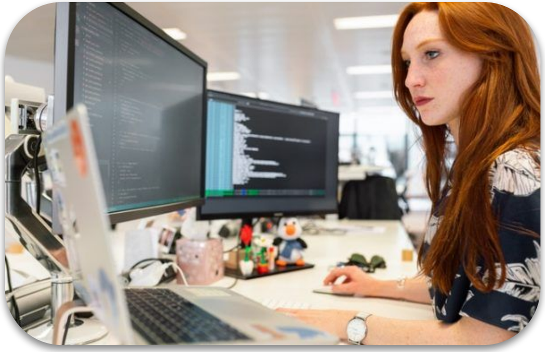
Ethical Hacking

- **Other ways to ethically hack:**
  - Participate in bug bounties
  - Submit third-party bug reports
  - Work to improve security tools

Careers in Cybersecurity:
The Practitioner

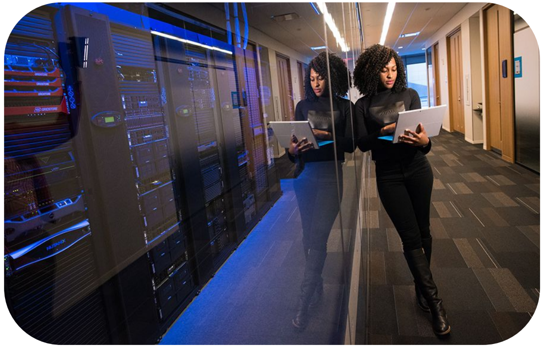
Cybersecurity Practitioners

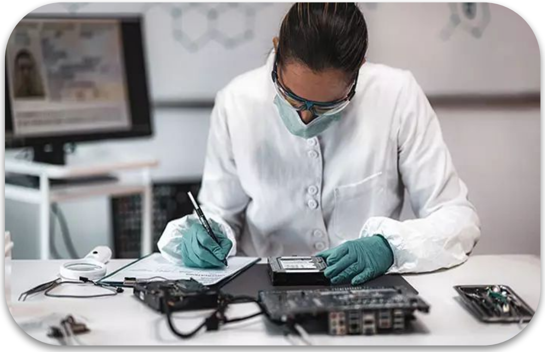
Security Operations Specialist



Software & Hardware Tester

Information Technology Manager





Computer Forensic Technician

Becoming a Security Practitioner

- **Education**
  - **CS 4440**—security fundamentals
  - Many **trade-school** programs too
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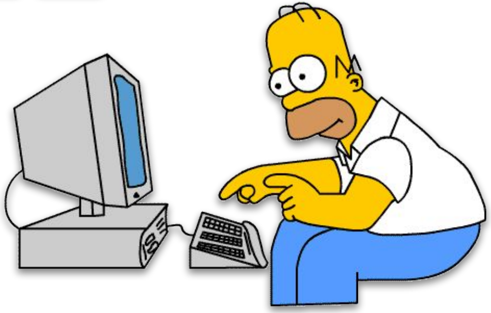
- **Tools & techniques of the trade**
  - E.g., for testing—**fuzzing**
  - E.g., for forensics—**SleuthKit**
  - E.g., for netsec—**WireShark**/**Snort**



Careers in Cybersecurity:
The Researcher

What is research?

"**Creative** and **systematic** work undertaken to increase the stock of **knowledge**"

- **Examples:**
  - New **techniques** that improve bug-finding capabilities
  - New **attacks** that exploit microarchitectural leakage
  - New **methodologies** to evaluate fuzzer's effectiveness
  - **And an infinite wealth more!**

Research Labs

Industrial Labs

TRAIL OF BITS

P0 ZERO

Binarly

galois

National Labs/FFRDCs

MIT LINCOLN LABORATORY

INL Idaho National Laboratory

Lawrence Livermore National Laboratory

Academic Labs

FuTURES^3 LAB
FUTURE TECHNOLOGY FOR USABLE, RELIABLE, & EFFICIENT SECURITY OF SOFTWARE & SYSTEMS
SCHOOL OF COMPUTING | THE UNIVERSITY OF UTAH | SALT LAKE CITY

SSG UTAH SOFTWARE SECURITY GROUP
SCHOOL OF COMPUTING | THE UNIVERSITY OF UTAH

How can I get a career in research?

1. Become an **enthusiast**
   - Find your favorite topic(s)
   - Get involved in research!
     - University labs
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2. Go to grad school and **get a PhD**
   - Your job will be conducting research
     - The “worker bees” of labs

What is a PhD?

- **“Doctorate of Philosophy”**—proof that you can **conduct** and **lead** research

This →

Also this ←

Why get a PhD?

- **What you get out of it:**
  - A fancy piece of paper
  - A prefix to your name ;)
  - Author **cutting-edge** work
  - **Expertise** in some topic

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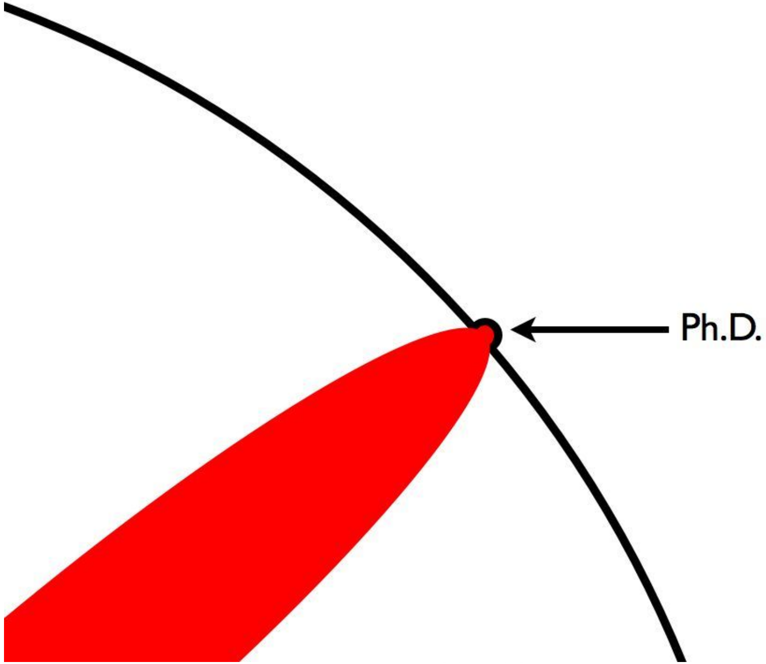
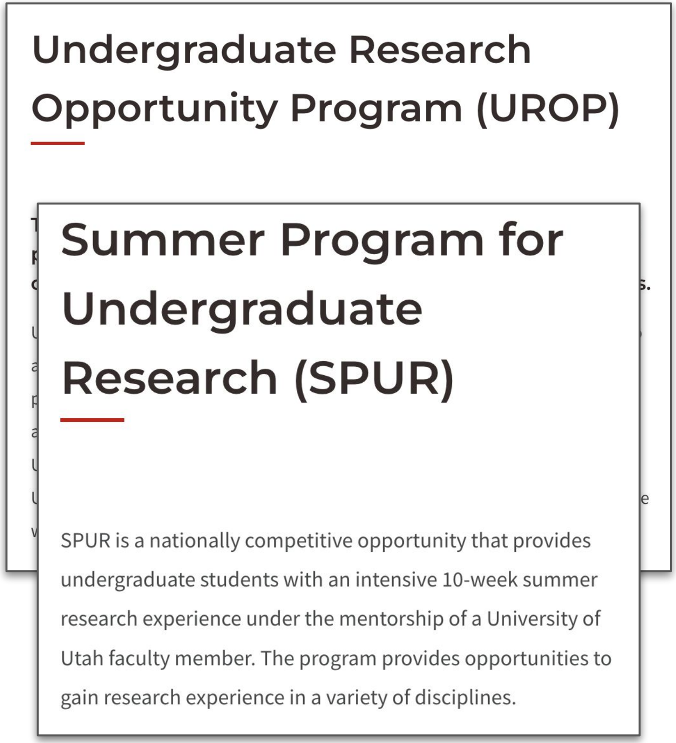
- **Circle = all knowledge**
  - **Blue** = grade school
  - **Green** = high school
  - **Pink** = your Bachelor's
  - **Red** = your Master's



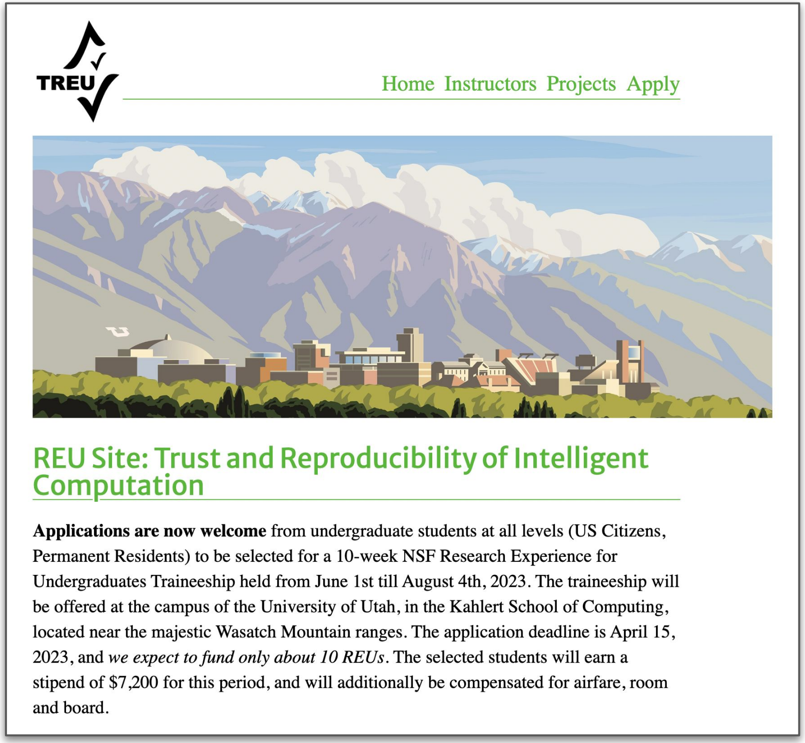
Undergrads can do research too!



Undergraduate Research Opportunity Program (UROP)

Summer Program for Undergraduate Research (SPUR)

SPUR is a nationally competitive opportunity that provides undergraduate students with an intensive 10-week summer research experience under the mentorship of a University of Utah faculty member. The program provides opportunities to gain research experience in a variety of disciplines.



REU Site: Trust and Reproducibility of Intelligent Computation

Applications are now welcome from undergraduate students at all levels (US Citizens, Permanent Residents) to be selected for a 10-week NSF Research Experience for Undergraduates Traineeship held from June 1st till August 4th, 2023. The traineeship will be offered at the campus of the University of Utah, in the Kahlert School of Computing, located near the majestic Wasatch Mountain ranges. The application deadline is April 15, 2023, and *we expect to fund only about 10 REUs*. The selected students will earn a stipend of $7,200 for this period, and will additionally be compensated for airfare, room and board.

Security/Privacy Research @ UofU

Sneha Kasera
Networks

Sameer Patil
Human Factors

Mu Zhang
Mobile / IoT

Jun Xu
Software / Systems

Anton Burtsev
Kernels

Stefan Nagy
Software / Systems

Pratik Soni
Cryptography

Luis Garcia
CPS / Drones

Guanhong Tao
ML / AI Security

Questions?

Next time on CS 4440...

Course Wrap-Up

Exam Review—show up!