CS6265: Information Security Lab

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CS6265: Info. Security Lab

- A special course: supervised, **hands-on laboratory**
- Focusing on *reverse engineering* and *binary exploitation*
- Designed for seniors and above (including InfoSec MS, fresh PhDs)
  - **Prerequisite**: OS, system programming, architecture
  - **Background**: low-level programming (e.g., C, asm)

Learning via Capture-the-flag

CTF: Cyber War Game

- Jeopardy
- Attack and defense

Topics

- Reverse engineering
- Binary exploitation
- Bug finding
- Memory forensic
- etc.

Schedule: https://tc.gts3.org/cs6265/2024-fall/cal.html

Big Picture: Course Structure

- Total 9 labs (week/bi-weekly)
- **Event 1**. In-class, 24h TKCTF Nov 22 at 3pm (Fri) - Nov 23 at 3pm (Sat)
  - CS6265-hosted CTF event plus **Prizes ($1,000)**
  - Each team prepares one challenge for other teams
- **Event 2**. NSA Codebreaker Challenge

Event 1: TKCTF (Lab 10)

Event 2: NSA Codebreaker (Lab 11)

Weekly Structure (for Lab)

- Fri : Cover a single topic/theme (e.g., stack overflow)
- Optional recitations
  - Mon/Wed 2:30pm - 3:30pm
  - Location: CODA C0906 (Underwood)
- Thu : Deadline for the current week's problem set (i.e., 10 challenges)

In-class Meeting (on Fri)

- 30 min: discus last week's challenges (you will be asked to explain)
- 30 min: cover this week's topic
- 30-60 min: **in-class tutorial (so bring your laptop!)**
- 30-60 min: TA-ing

Course Grading

- *100% Lab* (no single lab returned → F)
- No midterm/final exams
- 9 labs + 4-lab worth events = 13 labs
  - In-class CTF (2-lab worth)
  - NSA Codebreaker (2-lab worth)

Scoring in Each Lab (Game Rules)

- **10 challenges** (20pt x 10 = 200pt) + **1 in-class tutorial** (20pt) = 220pt
- Need to submit flag, write-up w/ an exploit of each challenge
- Bonus: two fastest solvers (aka, first/second bloods) → +2pt/+1pt
- Hint: each challenge has 1-2 hints → -1pt x #hints revealed
- Late policy: 50% of the original points (one extra week)

Ref. Check Submission Site!

Grading Scheme (Expected)

- Grading Scheme (expected):
  - A : Average 7+ challenges per lab (7/10 x 200pt + 20pt = **160pt+**)
  - B : Average 6+ challenges per lab (6/10 x 200pt + 20pt = **140pt+**)
  - C : Average 5+ challenges per lab (5/10 x 200pt + 20pt = **120pt+**)
  - D : Average 5- challenges per lab
  - F : Below or zero flag submitted for at least one lab.
- Expected distribution: 40%: A , 30-40%: B, 30-20%: C and below
- **If you don't turn in at least one flag for every lab, you will get an F**
- See Game Rules!

Online Competition

Class | Problems | Scoreboard | Status | Chart New api-key

lab11

Name	Points	Release	Deadline	Solved	Flag	Exploits
sandbox-ptrace	20	11-18-2016 00:00:00	12-01-2016 00:00:00	9	Submit	Submit
sandbox-seccomp	20	11-18-2016 00:00:00	12-01-2016 00:00:00	4	Submit	Submit
sandbox-ptrace2	20	11-18-2016 00:00:00	12-01-2016 00:00:00	8	Submit	Submit
srop	20	11-18-2016 00:00:00	12-01-2016 00:00:00	7	Submit	Submit
simple-aeg	20	11-18-2016 00:00:00	12-01-2016 00:00:00	3	Submit	Submit
sandbox-pin	20	11-18-2016 00:00:00	12-01-2016 00:00:00	1	Submit	Submit
kproc-zeropage	20	11-18-2016 00:00:00	12-01-2016 00:00:00	2	Submit	Submit
kproc-bufovfl	20	11-18-2016 00:00:00	12-01-2016 00:00:00	1	Submit	Submit
kproc-ret2dir	20	11-18-2016 00:00:00	12-01-2016 00:00:00	0	Submit	Submit
kproc-uaf	20	11-18-2016 00:00:00	12-01-2016 00:00:00	0	Submit	Submit

lab10

Name	Points	Release	Deadline	Solved	Flag	Exploits
dlmalloc	20	11-11-2016 00:00:00	12-01-2016 00:00:00	20	Submit	Submit
ptmalloc	20	11-11-2016 00:00:00	12-01-2016 00:00:00	14	Submit	Submit
uaf-basic	20	11-11-2016 00:00:00	12-01-2016 00:00:00	23	Submit	Submit
heap-spray	20	11-11-2016 00:00:00	12-01-2016 00:00:00	20	Submit	Submit

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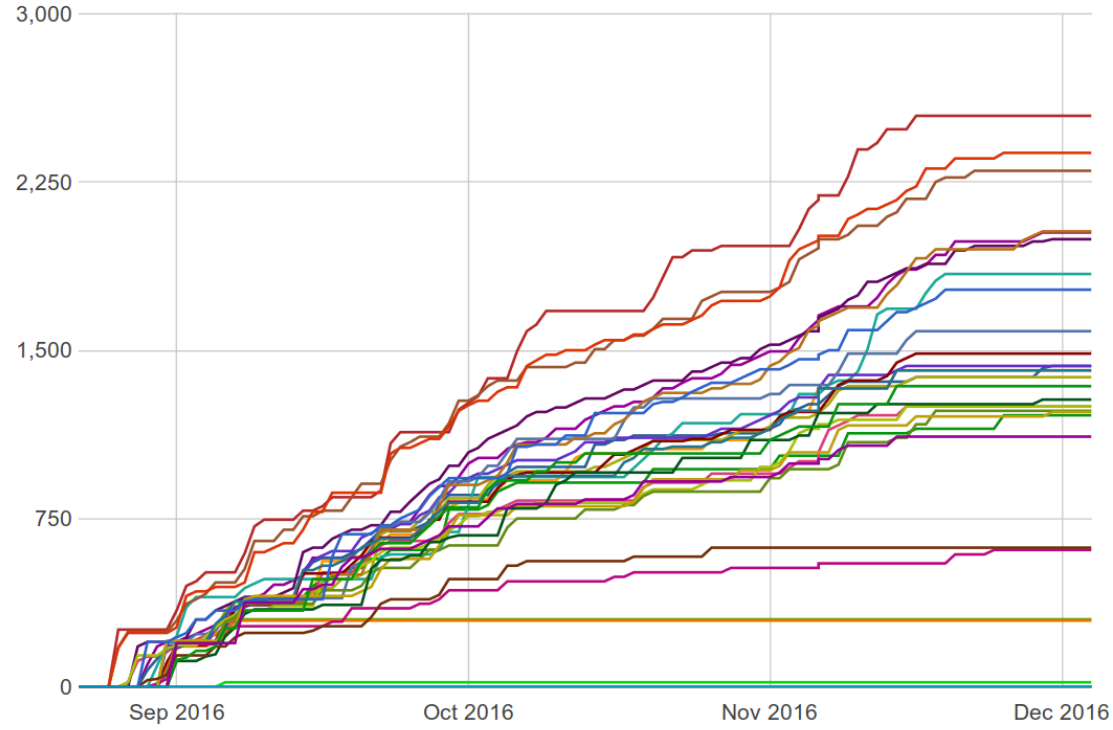
Score Charts



Tips for CS6265

- Study in group (e.g., discussion)!
- Come to the recitation (Mon/Wed)!
- Understand your time budget!
- Tackle challenges in order!
- Learn basic tools next two weeks (e.g., editor, debugger, python)!

Misconduct Policy

- Cheating vs. collaboration
- Refer GT's Academic Misconduct Policy
- ***Never ever*** use/copy other students' code/write-up
- Please ***write down names*** of your collaborators

About Course Material

- You should ***never*** share exploits/write-up online
- Once found → F (even after the semester is over)
- We are checking your submission against past years' submissions

Team

- TA: Mansour Alharthi and Chuhong Yuan
- Contact: 6265-staff@cc.gatech.edu
- Website: https://tc.gts3.org/cs6265/2024/
- Ed Discussion: https://edstem.org/us/courses/62511/discussion/

TA Rules

- Please come to the recitation (Mon/Wed 2:30-3:30pm, CODA C0906)
- Please post your questions on Ed Discussion
- Feel free to **answer other students' questions** (bonus points)?!
- Please proactively participate in the online discussion
- Contact 6265-staff@cc.gatech.edu as a last resort (slowest)!

Next Two Weeks

Monday	Tuesday	Wednesday	Thursday	Friday
Aug 19 First day of class (**No class**)	Aug 20	Aug 21	Aug 22	Aug 23 **LEC:** Warm-up: x86, Tools [slides] **TUT:** Tut01: GDB/x86 [video] **Preparation:** Read asm **Assigned:** Lab01: Bomb Lab1
Aug 26	Aug 27	Aug 28	Aug 29 **DUE:** Lab 01	Aug 30 **LEC:** Warm-up: x86_64, Shellcode, Tools [slides] **TUT:** Tut02: Pwndbg, Ghidra, Shellcode [video1], [video2], [video3] **Preparation:** Read x86_64 **Assigned:** Lab02: Bomb Lab2 / Shellcode

Today's Topics

- This week: Bomblab !
- Quick introduction to GDB
- In-class tutorial
  - Walk over x86 asm and tools
  - Be familiarized with GDB and x86 (32-bit)
  - Let's crack `crackme0x00` – `crackme0x03` binaries

Note on Flag

- Random looking bytes, but be careful. It is designed to include tons of information unique to you, so we can easily check plagiarism

```
$ cat /proc/flag
CB25682B33EF8BF23545A767562A1D5AA33C88EEACC1AE562D950CB9F1E5725D
864725DB51460902ECBD52BA4CBED86A10F3A98A35F6FB71871019702A0E9199
5BC59332C390A3C27D0EC2CE85BC13E956A6027E3171352F90467A8C12346D9A
2A26EE914B3078ED031FDB14BB6224C3D743D79A733FB49EB4E9C1F383CF810E
F6841EE935FE2DA2C57DB4804B6823884B36AE62B08848486918C120E4C2AA94
E1D3F8A6E9E2251AC39E5F37971FB07DFF839E0BC1C4E6C1D4A24E0948F8751B
25BFFE854CD84A8D8E28814398FF192CD9AD37150D83DA872E944DF1552F97DD
...
```

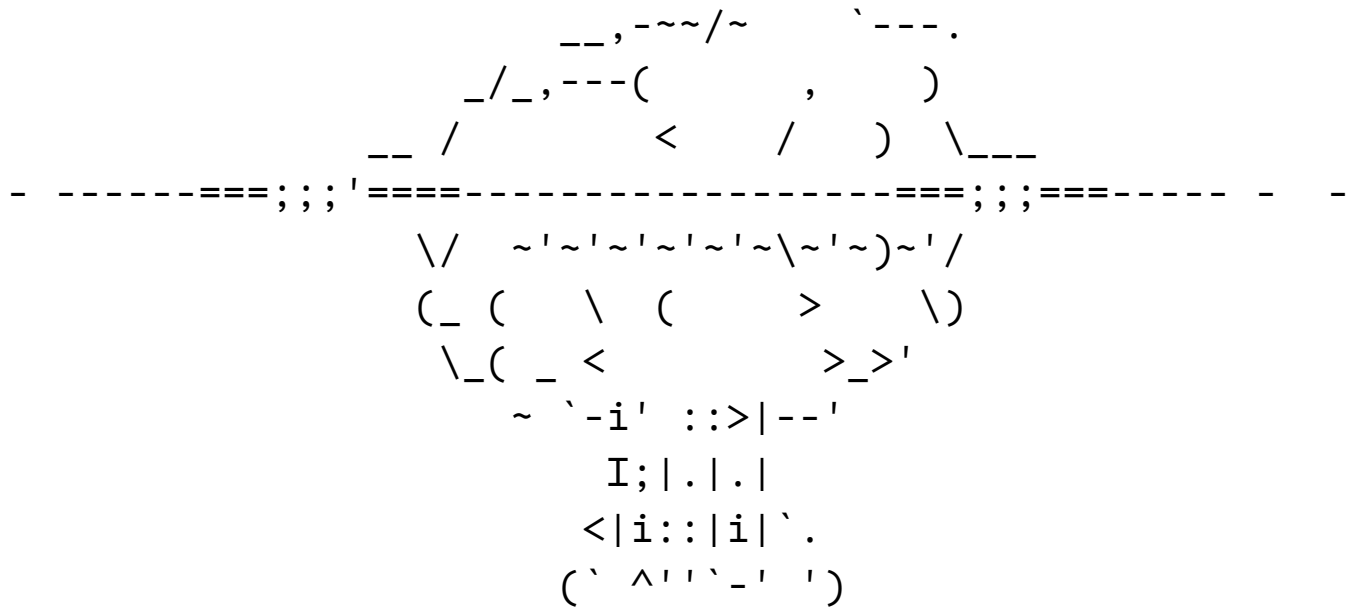
Note on Bomblab

```
$ ./bomb
Enter your api-key: <paste-your-api-key>

        ,--.!,   ____                  _      _        _
     __/   -*-  | __ )  ___  _ __ ___ | |__  | |  __ _| |__
   ,d08b.  '|`  |  _ \ / _ \| '_ ` _ \| '_ \| |/ _` | '_ \
  0088MM        | |_) | (_) | | | | | | |_) | | (_| | |_) |
   `9MMP'       |____/ \___/|_| |_| |_|_.__/|_|\__,_|_.__/
         cs6265

Welcome to my fiendish little bomb. You have N? phases with
which to blow yourself up. See you alive!
(hint: security question)
>
```

Be Cautious!



WARNING!

- **Don’t send us email to restore scores!**
- Be extra cautious about what you are typing..
- But think about how to defeat? (i.e., cheating our server?)
- **ANY** techniques are acceptable and be creative!
- **Read the binary**, check how it works internally, tinker it locally?

DEMO: GDB Summary

- run/continue
- break/tbreak/rbreak/delete
- stepi/nexti/finish
- info reg/proc/break
- backtrace/examine
- gdbinit
- python
- etc.

Pwndbg

- Use `gdb-pwndbg` in the server
- GDB Commands (left side) are enough for Lab01/02

PWNDBG CHEATSHEET

HTTPS://PWNDBG.RE/

GDB COMMANDS

file <path>
load binary file to debug

run [<args>...]
run program (with args)

starti [<args>...]
start program and stop
at its very first instruction

set args <args>...
set program arguments

break <where>
set a breakpoint

info breakpoints|threads|regs
list breakpoints/threads/register values

delete <breakpoint>
delete a breakpoint

next
go to next (source) line

step
go to next line stepping into functions

ni
go to next instruction

si
go to next instruction stepping
into functions

finish
run until current function returns

PWNDBG COMMANDS:

pwndbg [<topic>]
print info about pwndbg commands

config
show pwndbg configuration

theme
show pwndbg theme configuration

tip [--all]
print tips that are shown during startup

CONTEXT DISPLAY

context [<section>]
display context or a given context section
(regs, disasm, args, code, stack, backtrace,
expressions, ghidra, threads)

set context-sections [<sect1>] [<sect2>...]
set context to display only given sections

ctx-watch eval|execute <expression>
adds a given expression to be shown on context display

START COMMANDS

attachp <pid|name>
attach to given pid or process by part of its name

start [<args>...]
run and stop program at the first found symbol from:
main, _main, start, _start, init, _init or entry

entry [<args>...]

p2p <mapping_names> [<mapping_names>...]
pointer to pointer chain search (e.g. p2p stack
libc will look for pointers to libc on the stack)

xinfo <where>
show offsets of the specified address from
various useful locations

STACK COMMANDS

retaddr
print return addresses on the stack

canary
print the global stack canary/cookie value
and finds canaries on the stack

NAVIGATION

xuntil <where>
continue until an address or function

nextcall
continue to next call instruction

nextjmp
continue to next jump instruction

nextret
continue to next return-like instruction

stepret
step until a ret instruction is found

tls
print thread local storage address

MISC COMMANDS

distance <where1> <where2>
compute difference between two addresses

patch <where> '<instructions>...'
patch given address with given code/bytes

patch_list
list all applied patches

patch_revert <patch>
revert a patch

cymbol [...]
add, show, load, edit, or delete custom structures
in plain C (so they can be used e.g. with print command)

plist [...]
dump elements of a linked list (see help plist)

procinfo
display process information

errno [<errno value>]
print libc's errno error code string

GLIBC HEAP HACKING

heap_config
show glibc allocator hacking configuration

In-class Tutorial

- Step 1: Setup the game environment
  - https://tc.gts3.org/cs6265/2024/rules.html
- Step 2: Tutorial (in CTF servers)
  - https://tc.gts3.org/cs6265/2024/tut/tut01-warmup.html

```
$ ssh lab01@54.88.195.85
password: xxxxxxxxx

$ cat README
$ cd tut01-crackme
$ cat README
```

References

- GDB tutorial
- x86 instructions
- x86 architecture