

CS107, Lecture 21

Reverse Engineering

While you're waiting – grab a copy of the assembly reference sheet up front!

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Based on slides created by Cynthia Lee, Chris Gregg, Jerry Cain, Lisa Yan and others.

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Learning Assembly



Reference Sheet: cs107.stanford.edu/resources/x86-64-reference.pdf
See more guides on Resources page of course website!

Learning Goals

- Learn how to approach reverse engineering executables
- Understand the requirements and tasks for assign5

Lecture Plan

- **GDB / Function Call Practice:** Recursion
- **Reverse Engineering Practice:** Minivault

```
cp -r /afs/ir/class/cs107/lecture-code/lect21 .
```

Lecture Plan

- **GDB / Function Call Practice: Recursion**
- **Reverse Engineering Practice: Minivault**

```
cp -r /afs/ir/class/cs107/lecture-code/lect21 .
```

Example: Recursion

- Let's look at an example of recursion at the assembly level.
- We'll use everything we've learned about registers, the stack, function calls, parameters, and assembly instructions!
- We'll also see how helpful GDB can be when tracing through assembly.



factorial.c and factorial

`gdb tips`



<code>layout split</code>	(ctrl-x a: exit, ctrl-l: resize, refresh: refresh, layout reg/asm, focus next)	View C, assembly, and gdb (lab5)
<code>info reg</code>		Print all registers
<code>p \$eax</code>		Print register value
<code>p \$eflags</code>		Print all condition codes currently set
<code>b *0x400546</code>		Set breakpoint at assembly instruction
<code>b *0x400550 if \$eax > 98</code>		Set conditional breakpoint
<code>ni</code>		Next assembly instruction
<code>si</code>		Step into assembly instruction (will step into function calls)

gdb tips



`p/x $rdi`

Print register value in hex

`p/t $rsi`

Print register value in binary

`x $rdi`

Examine the byte stored at this address

`x/4bx $rdi`

Examine 4 bytes starting at this address

`x/4wx $rdi`

Examine 4 words (4 bytes) starting at this address

`x/1gx $rdi`

Examine 1 giant word (8 bytes) starting at this address

`finish`

Finish function, return to caller

Lecture Plan

- **GDB / Function Call Practice: Recursion**
- **Reverse Engineering Practice: Minivault**

```
cp -r /afs/ir/class/cs107/lecture-code/lect21 .
```

assign5

You are a security researcher hired to explore potential vulnerabilities and issues at Stanford Bank. **3 core parts:**

- 1. Uncovering ATM software vulnerabilities**
- 2. Demonstrating how a data leak can lead to data aggregation and uncovering of personal information**
- 3. Reverse engineering a secure program – discover 4 passwords needed to gain access to the system**

Minivault

The **minivault** program is practice for part 3, SecureVault (it doesn't share code with SecureVault but is similar reverse-engineering practice).

You must provide correct passwords for 2 stages:

```
./minivault [stage1password] [stage2password]
```

stage1 and **stage2** are 2 functions in minivault, each passed in the password for that stage. Our goal is to get both to return 1, and not 0.

Reverse Engineering Tips

- 1. Run the program live in GDB and step through.** Reading and diagramming by hand is useful, but quickly becomes infeasible with larger programs.
- 2. Break the assembly into chunks**
- 3. Use gdb to verify your hypotheses.**
- 4. Document your knowns and unknowns.** Document and re-verify conflicting assumptions.
- 5. Use compiler explorer to see what code looks like in assembly.**
- 6. Use library functions to your advantage.** If you spot a call to what looks like a library function, it's the real deal.
- 7. When tracing an unknown function, before dissecting its behavior first learn about the input/output of the function and what role it plays.**

Demo: Minivault

Respond on PollEv:
pollev.com/cs107



When, in terms of strstr's behavior, will the jump to be taken?

Nobody has responded yet.

Hang tight! Responses are coming in.

Recap

- **GDB / Function Call Practice:**
Recursion
- **Reverse Engineering Practice:**
Minivault

Lecture 21 takeaway: Reverse engineering lets us understand the behavior of a program without seeing its source code. Check out slide 12 for some summarized tips!

```
cp -r /afs/ir/class/cs107/lecture-code/lect21 .
```