CSE 351

buffer overflows and lab 3

Buffer overflows

- C performs no bounds-checking on array accesses
  - This makes it fast but also unsafe

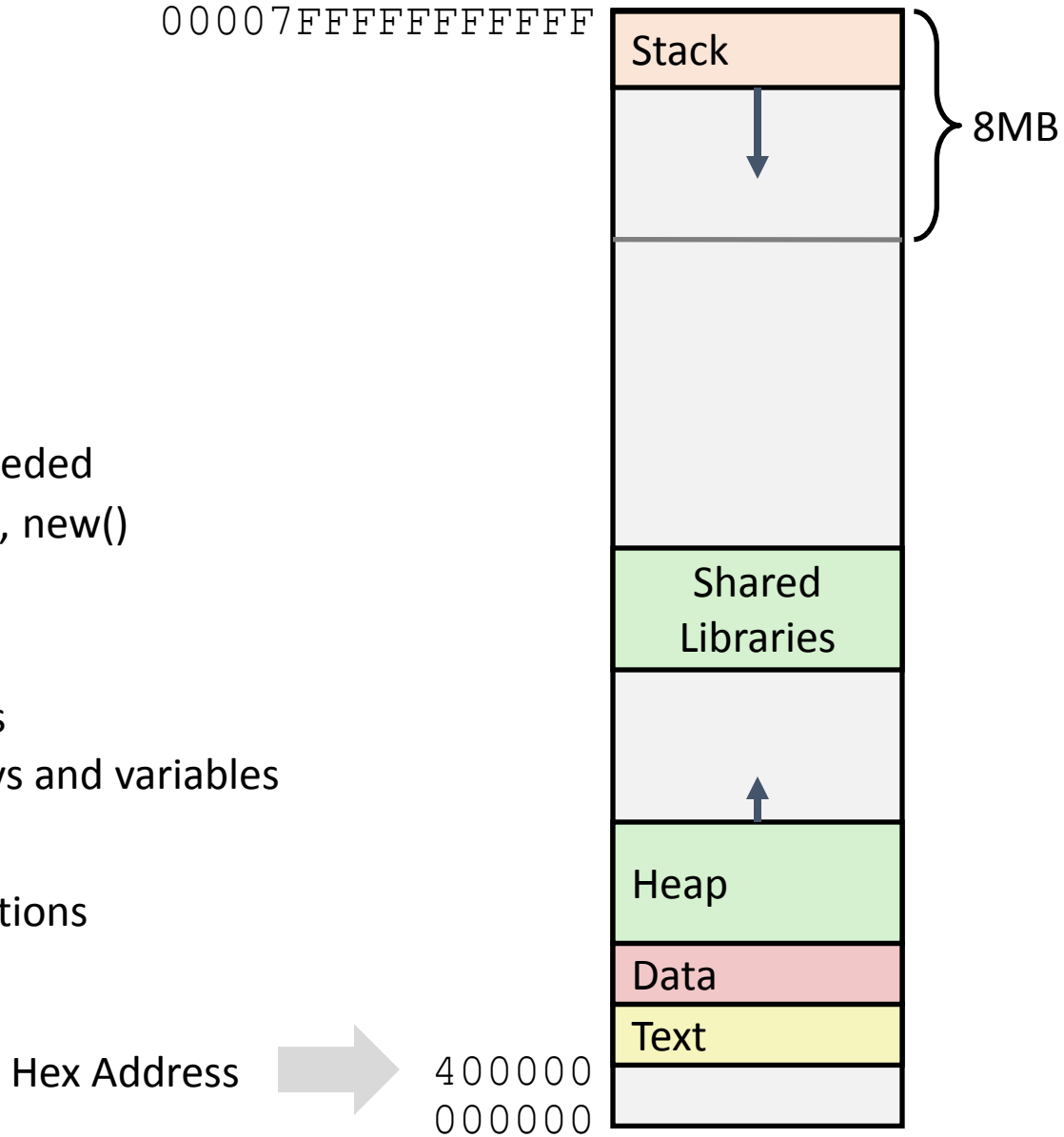
- For example: `int arr[10]; arr[15] = 3;`
  - No compiler warning, just memory corruption

- What symptoms are there when programs write past the end of arrays?
  - Hint: we saw an example of this in lab 0

x86-64 Linux Memory Layout

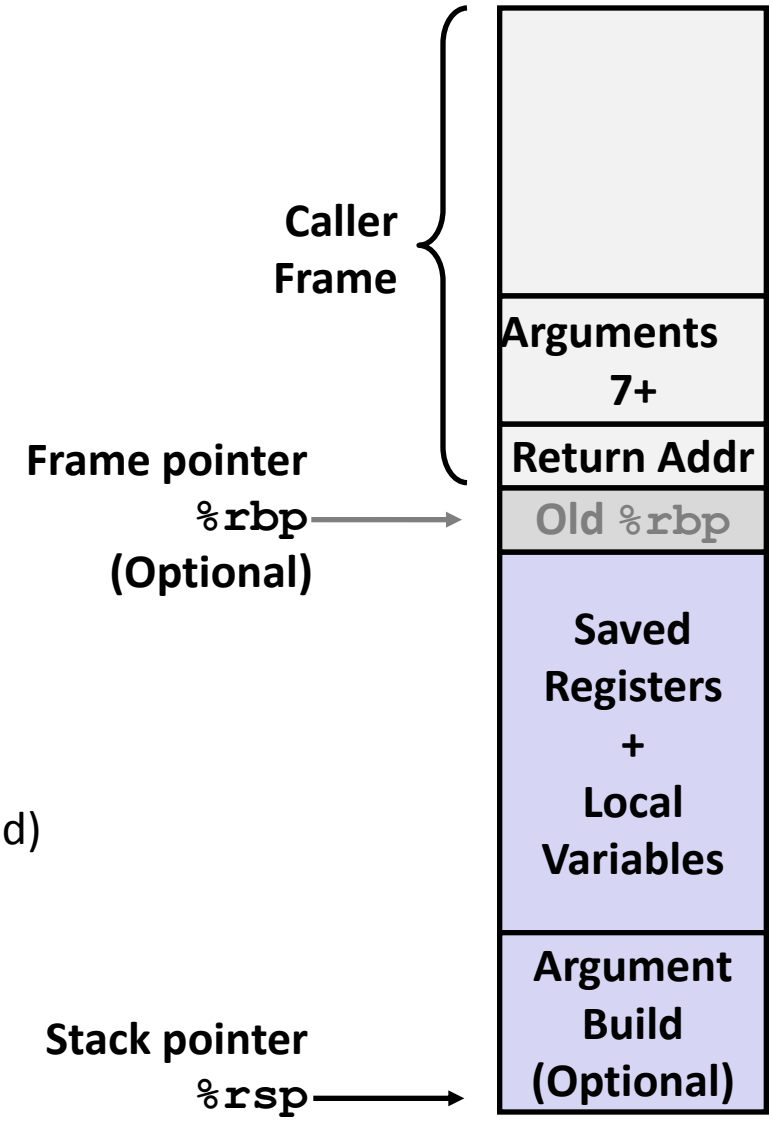
not drawn to scale

- Stack
  - Runtime stack (8MB limit)
  - E. g., local variables
- Heap
  - Dynamically allocated as needed
  - When call malloc(), calloc(), new()
- Data
  - Statically allocated data
    - Read-only: string literals
    - Read/write: global arrays and variables
- Text / Shared Libraries
  - Executable machine instructions
  - Read-only



Reminder: x86-64/Linux Stack Frame

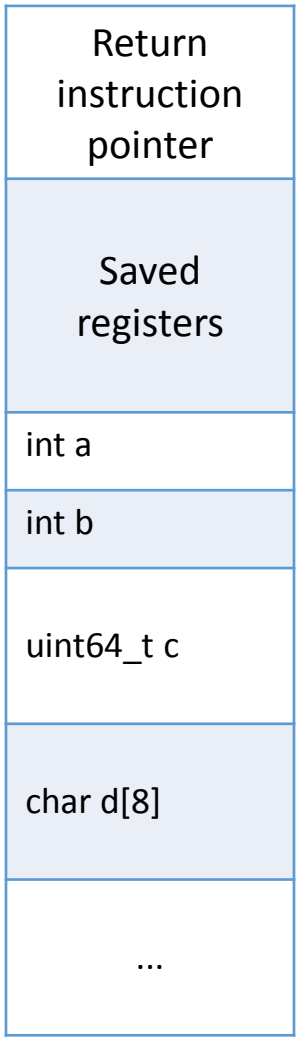
- Caller's Stack Frame
  - Arguments (if > 6 args) for this call
  - Return address
    - Pushed by **`call`** instruction
- Current/ Callee Stack Frame
  - Old frame pointer (optional)
  - Saved register context (when reusing registers)
  - Local variables (If can't be kept in registers)
  - "Argument build" area (If callee needs to call another function - parameters for function about to call, if needed)



Stack layout

- Note that the top of the diagram represents higher addresses, and the bottom is lower addresses

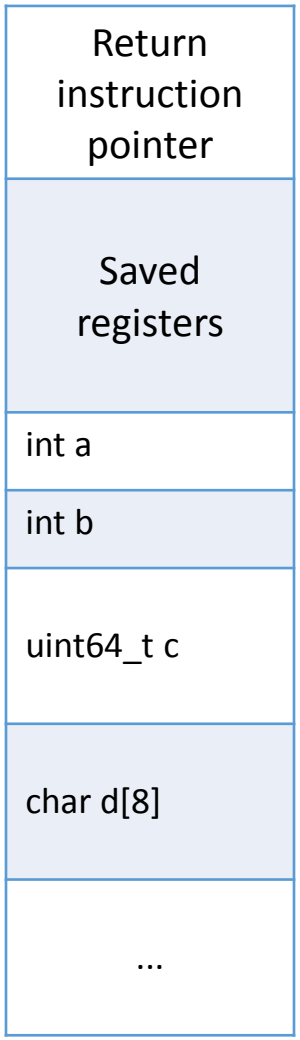
- To which memory does `d[10]` refer in this example?



Buffer overflow attacks

- In buffer overflow *attacks*, malicious users pass values to attempt to overwrite important parts of the stack or heap

- For example, an attacker could overwrite the return instruction pointer with the address of a malicious block of code



Protecting against overflows

- `fgets(char* s, int size, FILE* stream)`
  - Takes a size parameter and will only read that many bytes from the given input stream

- `strncpy(char* dest, const char* src, size_t n)`
  - Will copy at most `n` bytes from `src` to `dest`

Protecting against overflows

- Stack canaries
  - Use a random integer before return instruction pointer and see if its been tampered with.

- Data execution prevention
  - Mark some parts of the memory (notably the stack) as non-executable.

Lab 3: Intro

- Lab 3 is meant to teach you how buffer overflow attacks work

- The stages of this lab require different types of attacks to achieve certain goals

Lab 3: Buffer overflow exploits

- The exploitable function in lab 3 is called `Gets` (capital 'G')
  - It is called from the `getbuf` function

- `getbuf` allocates a small array and reads user input into it via `Gets`.

- If the user input is too long, then certain values on the stack within the `getbuf` function will be overwritten...

Lab 3: Buffer Overflow

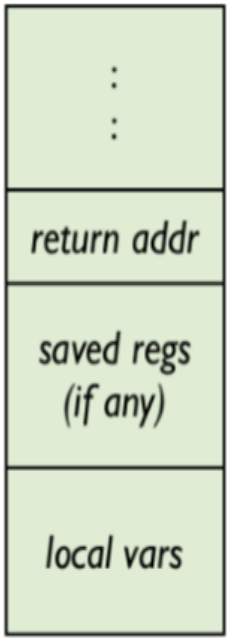
This has a buffer overflow

```
int getbuf() {
  char buf[36];
  Gets(buf);
  return 1;
}
```

Why?

- `Gets()` doesn't check the length of the buffer

The Stack in getbuf()



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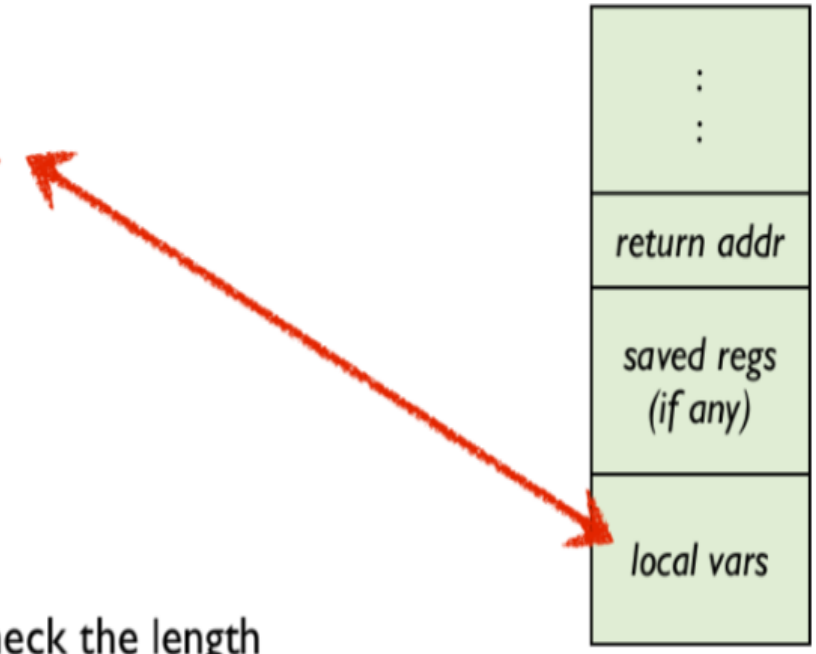

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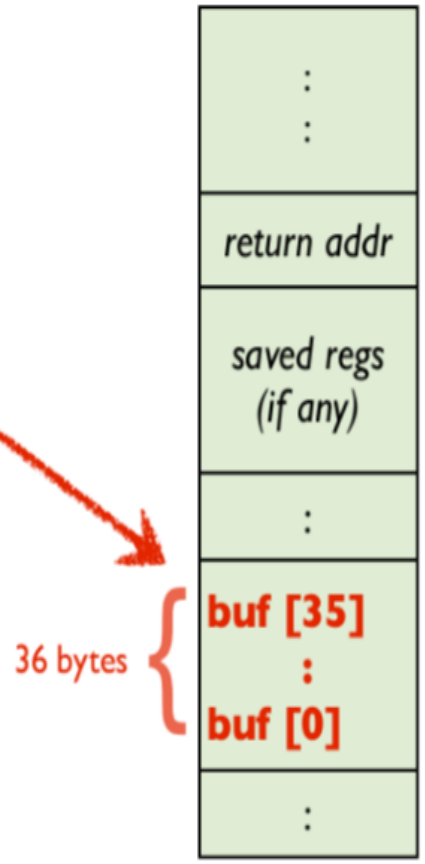

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Level 0: Call `smoke()`

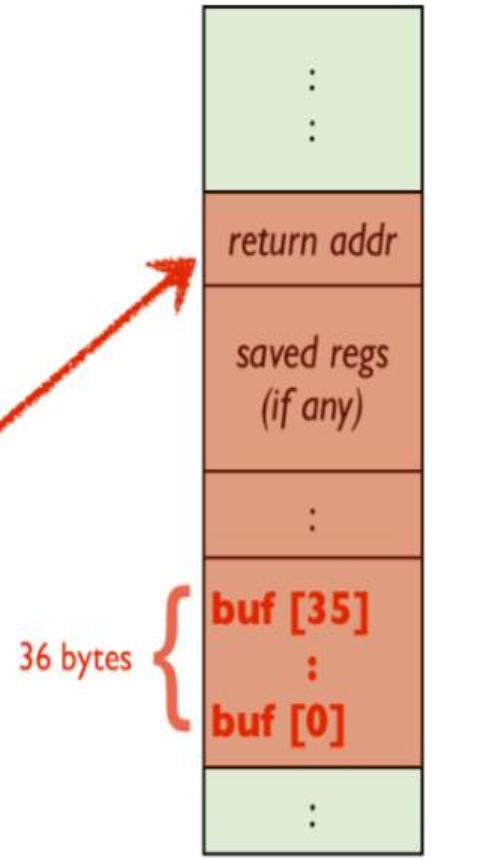
Goal: call the smoke() function from getbuf()

```
int getbuf() {
  char buf[36];
  Gets(buf);
  return 1;
}
```

How?

- overwrite the return address so we "return" to smoke()

The Stack in getbuf()



Lab 3: Understand the tools

- `sendstring` – Use to generate your malicious strings
  - Takes a list of space-separated hex values and formats them in raw bytes suited for exploits
- `gdb` – You will use this a lot to inspect your code
  - `set args –u <username>`
    - Set the argument to the program
  - `x/40wx ($rsp – 40)`
    - Show the 40 bytes above rsp
    - Change `w` to `g` to check the value in 8 byte chunks.
  - `b *(&getbuf + 12)`
    - Create a breakpoint at 12 bytes away after the start of getbuf
- `bufbomb – u [UW_NetID]` – Everyone's lab is different
  - Your username alters the lab slightly

Level 0 walkthrough

- **Goal:** Make `getbuf()` jump to a function called `smoke()`

- **How?** Overwrite the return address with your own
  - Write past the end of the buffer to do this