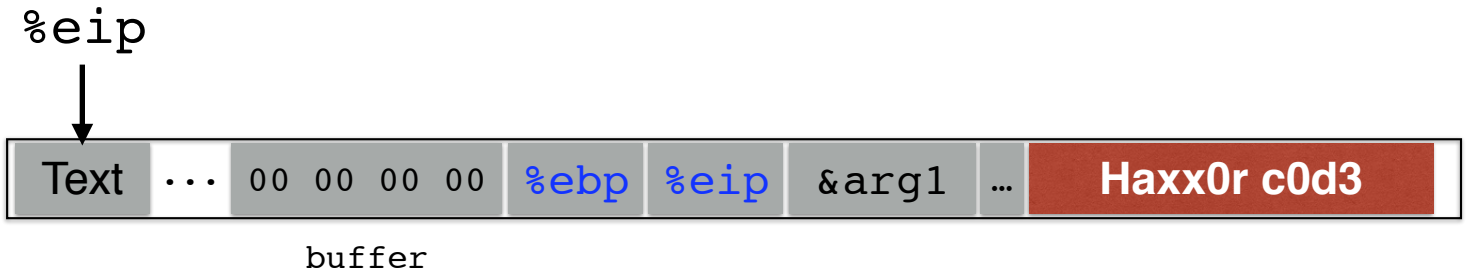
Code injection

Code Injection: Main idea

```
void func(char *arg1)
{
    char buffer[4];
    sprintf(buffer, arg1);
    ...
}
```



(1) Load my own code into memory

(2) Somehow get `%eip` to point to it

Challenge 1
Loading code into memory

- It **must be the machine code** instructions (i.e., already compiled and ready to run)
- We have to be careful in how we construct it:
  - It **can't contain** any **all-zero bytes**
    - Otherwise, sprintf / gets / scanf / … will stop copying
    - How could you write assembly to never contain a full zero byte?
  - It **can't use the loader** (we're injecting)

What code to run?

- Goal: **general-purpose shell**
  - Command-line prompt that gives attacker **general access to the system**
- The code to launch a shell is called **shellcode**

Shellcode

```
#include <stdio.h>
int main( ) {
   char *name[2];
   name[0] = “/bin/sh”;
   name[1] = NULL;
   execve(name[0], name, NULL);
}
```

Assembly

```
xorl %eax, %eax
pushl %eax
pushl $0x68732f2f
pushl $0x6e69622f
movl %esp,%ebx
pushl %eax
...
```

```
“\x31\xc0”
“\x50”
“\x68””//sh”
“\x68””/bin”
“\x89\xe3”
“\x50”
...
```

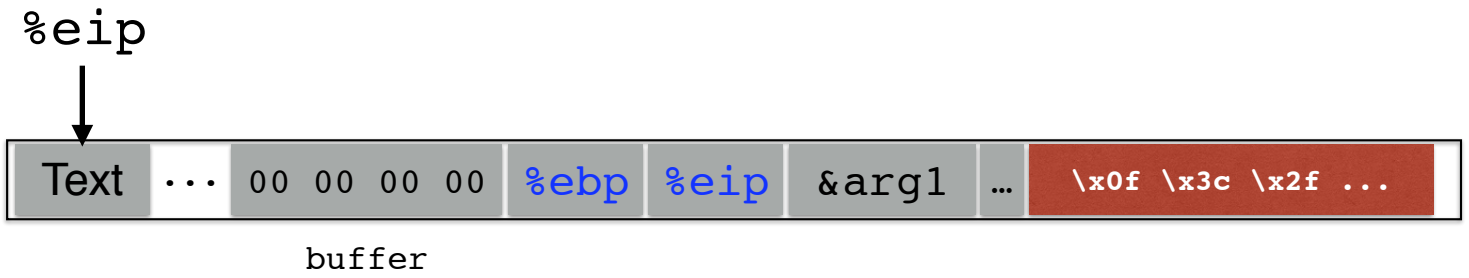
Machine code

(Part of) your input

Challenge 2

Getting injected code to run

- We can't insert a "jump into my code" instruction
- We don't know precisely where our code is



Recall

Memory layout summary

Calling function:

1. Push arguments onto the stack (in reverse)
2. Push the return address, i.e., the address of the instruction you want run after control returns to you
3. Jump to the function's address

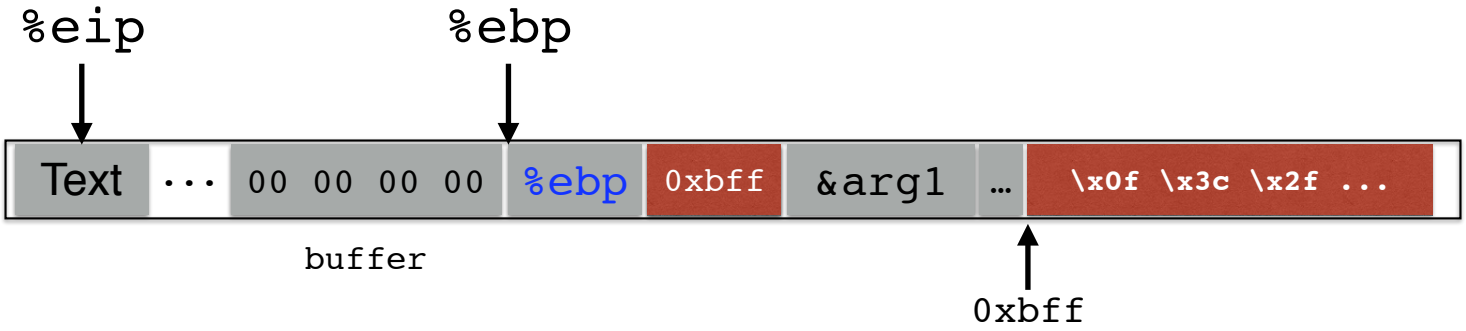
Called function:

4. Push the old frame pointer onto the stack (%ebp)
5. Set frame pointer (%ebp) to where the end of the stack is right now (%esp)
6. Push local variables onto the stack

Returning function:

7. Reset the previous stack frame: %esp = %ebp, %ebp = (%ebp)
8. **Jump back to return address**: %eip = 4(%esp)

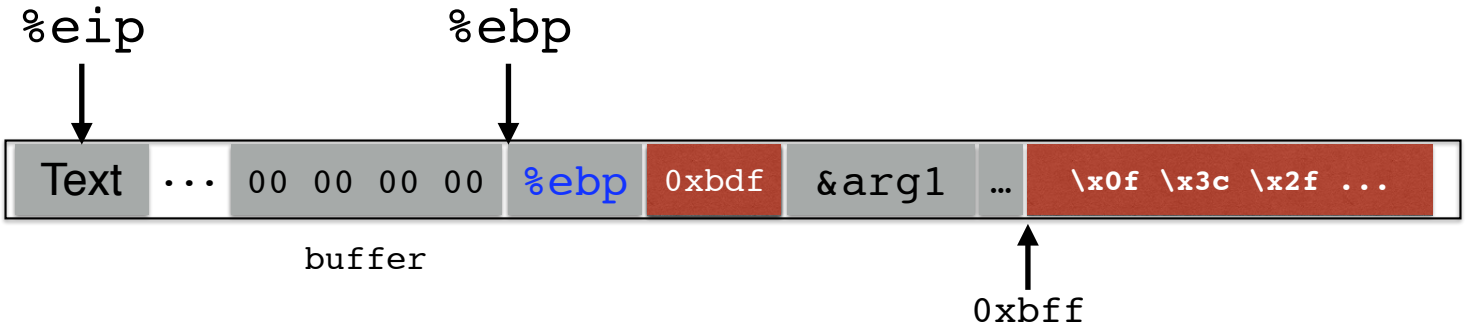
Hijacking the saved `%eip`



But how do we know the address?

Hijacking the saved `%eip`

What if we are wrong?



This is most likely data, so the CPU will panic (Invalid Instruction)

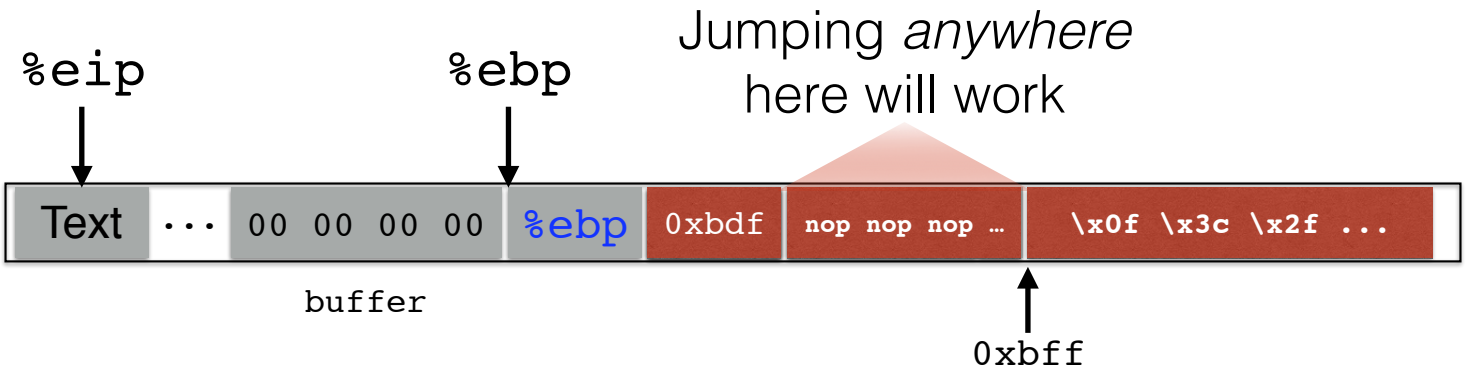
Challenge 3

Finding the return address

- If we don't have access to the code, we don't know how far the buffer is from the saved `%ebp`
- One approach: just try a lot of different values!
  - Worst case scenario: it's a 32 (or 64) bit memory space, which means 2^{32} (2^{64}) possible answers
- Without address randomization (discussed later):
  - The **stack always starts** from the same **fixed address**
  - The stack will grow, but usually it **doesn't grow very deeply** (unless the code is heavily recursive)

Improving our chances: `nop` sleds

`nop` is a single-byte instruction
(just moves to the next instruction)



Now we improve our chances
of guessing by a factor of #nops

Putting it all together

But it has to be *something*;
we have to start writing wherever
the input to **`gets`**/etc. begins.