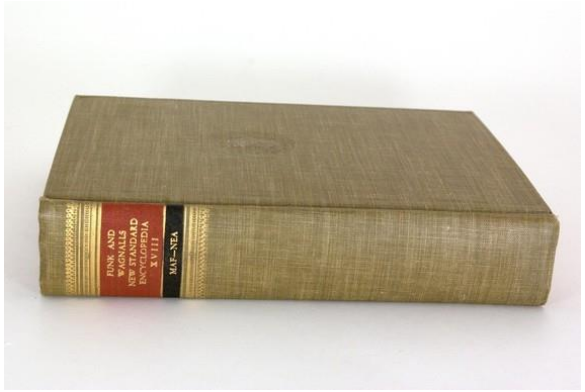
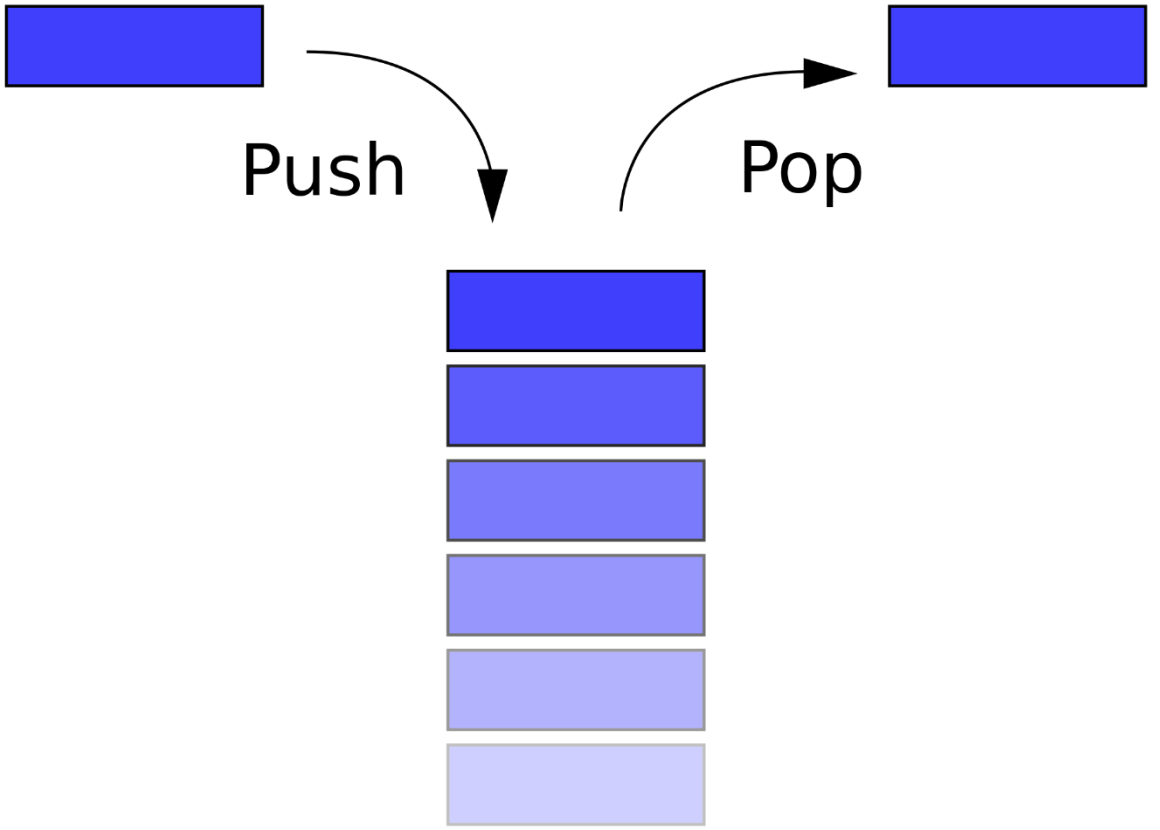
X86 Stack
Called Function POV

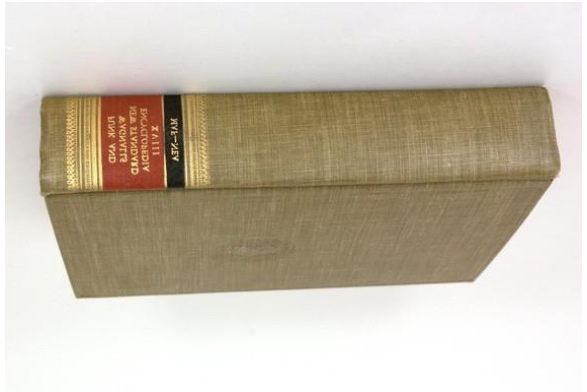
Computer Systems Section 3.7

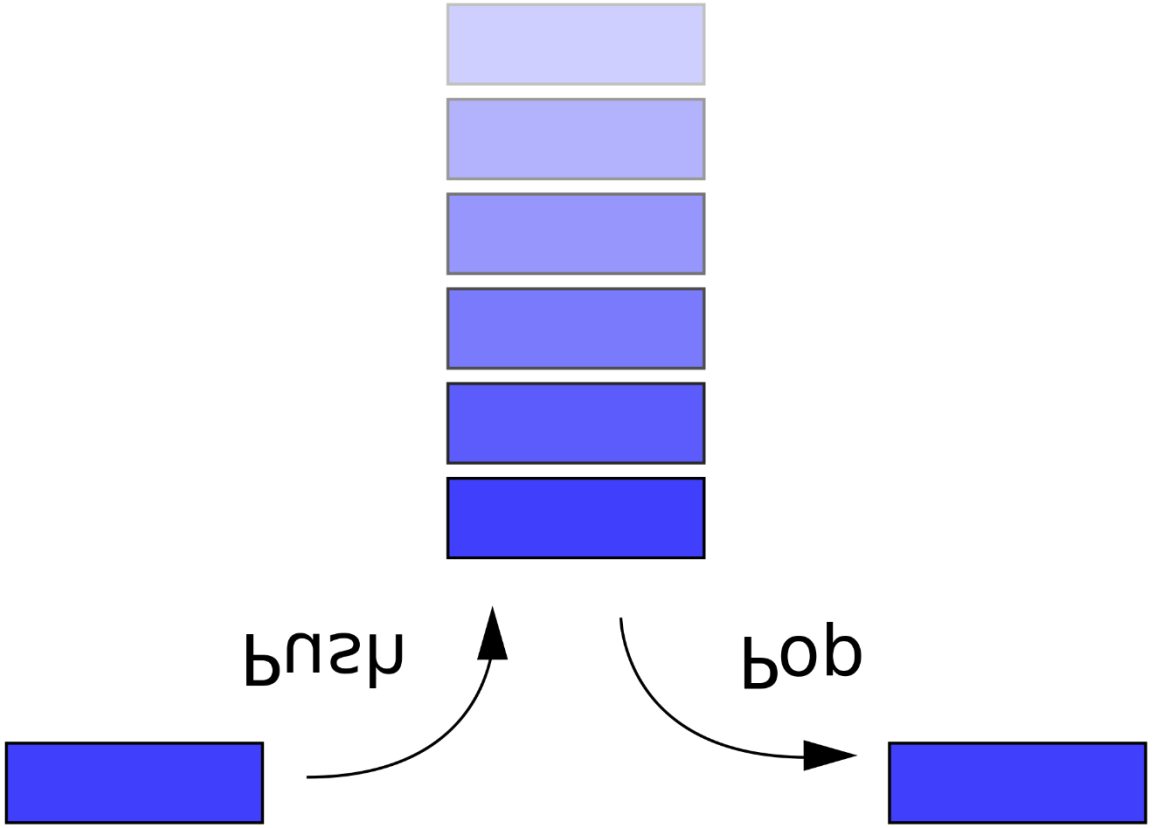
The Stack (as we learned in CS-120)





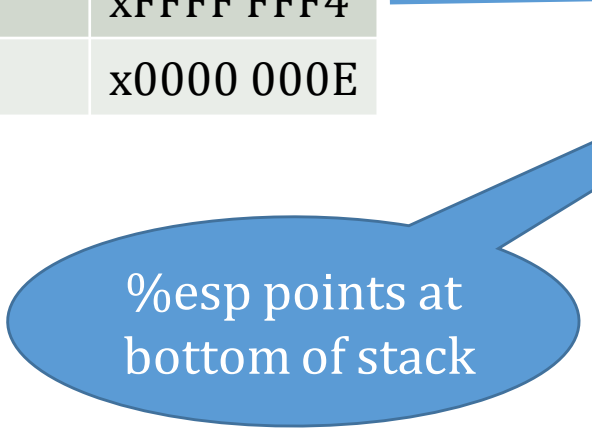
The x86 stack





x86 Stack

Reg	Value
esp	xFFFF FFF4
eax	x0000 000E



Memory	
Address	Value
xFFFF FFFC	
xFFFF FFF8	x0000 0004
xFFFF FFF4	x0000 0003
xFFFF FFF0	
xFFFF FFEC	
x0000 0004	
x0000 0000	

- Memory above %esp is in use
- Memory below %esp is available

x86 Stack

Reg	Value
esp	xFFFF FFF4
eax	x0000 000E

Memory	
Address	Value
xFFFF FFFC	
xFFFF FFF8	x0000 0004
xFFFF FFF4	x0000 0003
xFFFF FFF0	
xFFFF FFEC	
x0000 0004	
x0000 0000	

push %eax

x86 Stack

Reg	Value
esp	xFFFF FFF0
eax	x0000 000E

Memory	
Address	Value
xFFFF FFFC	
xFFFF FFF8	x0000 0004
xFFFF FFF4	x0000 0003
xFFFF FFF0	x0000 000E
xFFFF FFEC	
x0000 0004	
x0000 0000	

push %eax

subl $4,%esp
movl %eax,(%esp)

x86 Stack

Reg	Value
esp	xFFFF FFF4
eax	x0000 000E
ebx	x0000 000E

Memory	
Address	Value
xFFFF FFFC	
xFFFF FFF8	x0000 0004
xFFFF FFF4	x0000 0003
xFFFF FFF0	x0000 000E
xFFFF FFEC	
x0000 0004	
x0000 0000	

pop %ebx

movl (%esp),%ebx
addl $4,%esp

Stack Frame

Reg	Value
ebp	xFFFF FFF0
esp	xFFFF FFE0
eax	x0000 000E

What's In a Stack Frame?

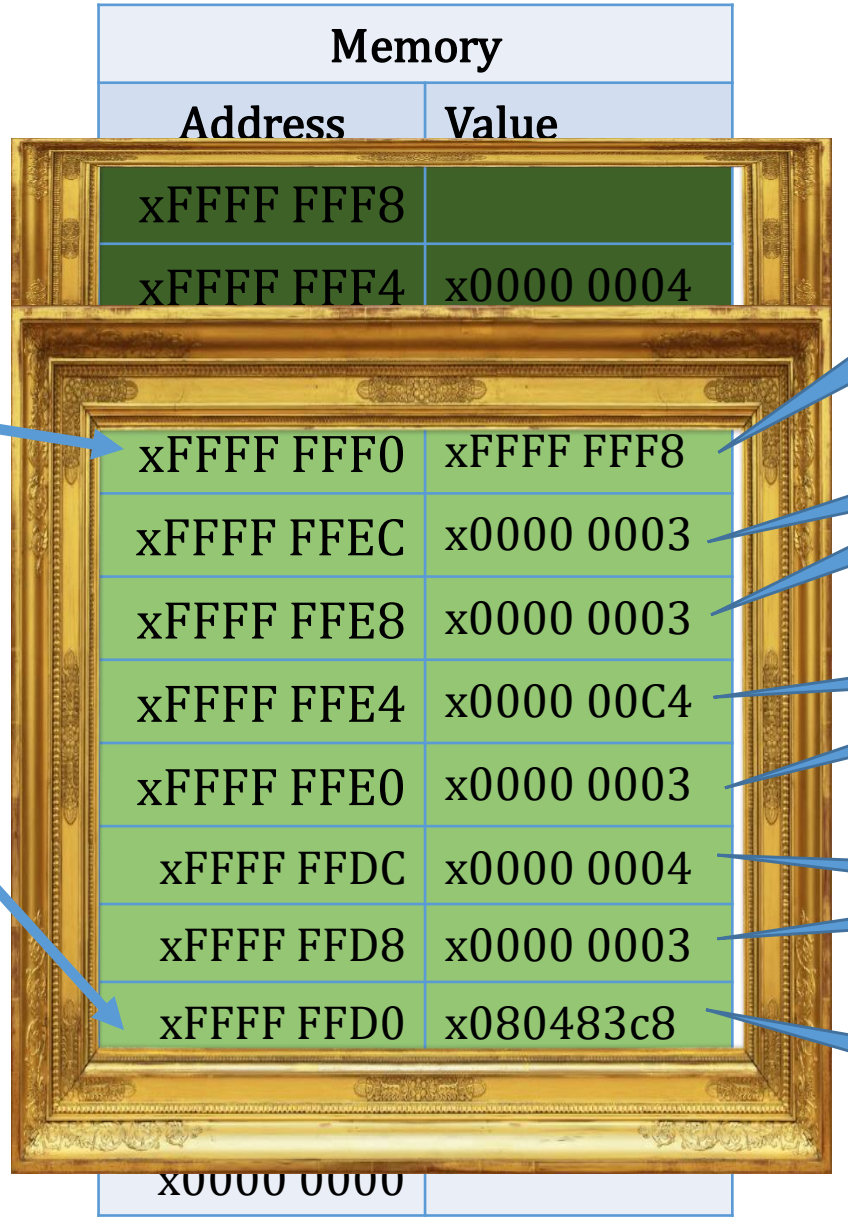
- Caller's frame info (pointer to top of caller's frame)
- Space for Local Variable Values
- Space for saved state
- Space for arguments to lower level functions
- Return address (when calling functions)

How Big is a Stack Frame?

Info	Size
Caller's frame info	4 bytes
Local Variables	? (different for each function)
Saved State	? (different for each function)
Arguments	? (depends on who is called)
Return Address	4 bytes (if needed)
Total	**4+???**

Frame Contents

Reg	Value
ebp	xFFFF FFF0
esp	xFFFF FFD0
eax	x0000 000E



Caller's base pointer

Local Variables

Saved Regs

Arguments

Return Address

Frame Offsets

Reg	Value
ebp	xFFFF FFF0
esp	xFFFF FFD0
eax	x0000 000E

	Memory	
Labels	Address	Value
8(%ebp)	xFFFF FFF8	x0000 0005
4(%ebp)	xFFFF FFF4	x0000 0004
(%ebp)	xFFFF FFF0	xFFFF FFF8
-4(%ebp)	xFFFF FFEC	x0000 0003
-8(%ebp)	xFFFF FFE8	x0000 0003
	xFFFF FFE4	x0000 00C4
	xFFFF FFE0	x0000 0003
8(%esp)	xFFFF FFDC	x0000 0004
4(%esp)	xFFFF FFD8	x0000 0003
(%esp)	xFFFF FFD0	x080483c8
		x0000 0000

Parameters

Caller's base pointer

Local Variables

Saved Regs

Arguments

Return Address

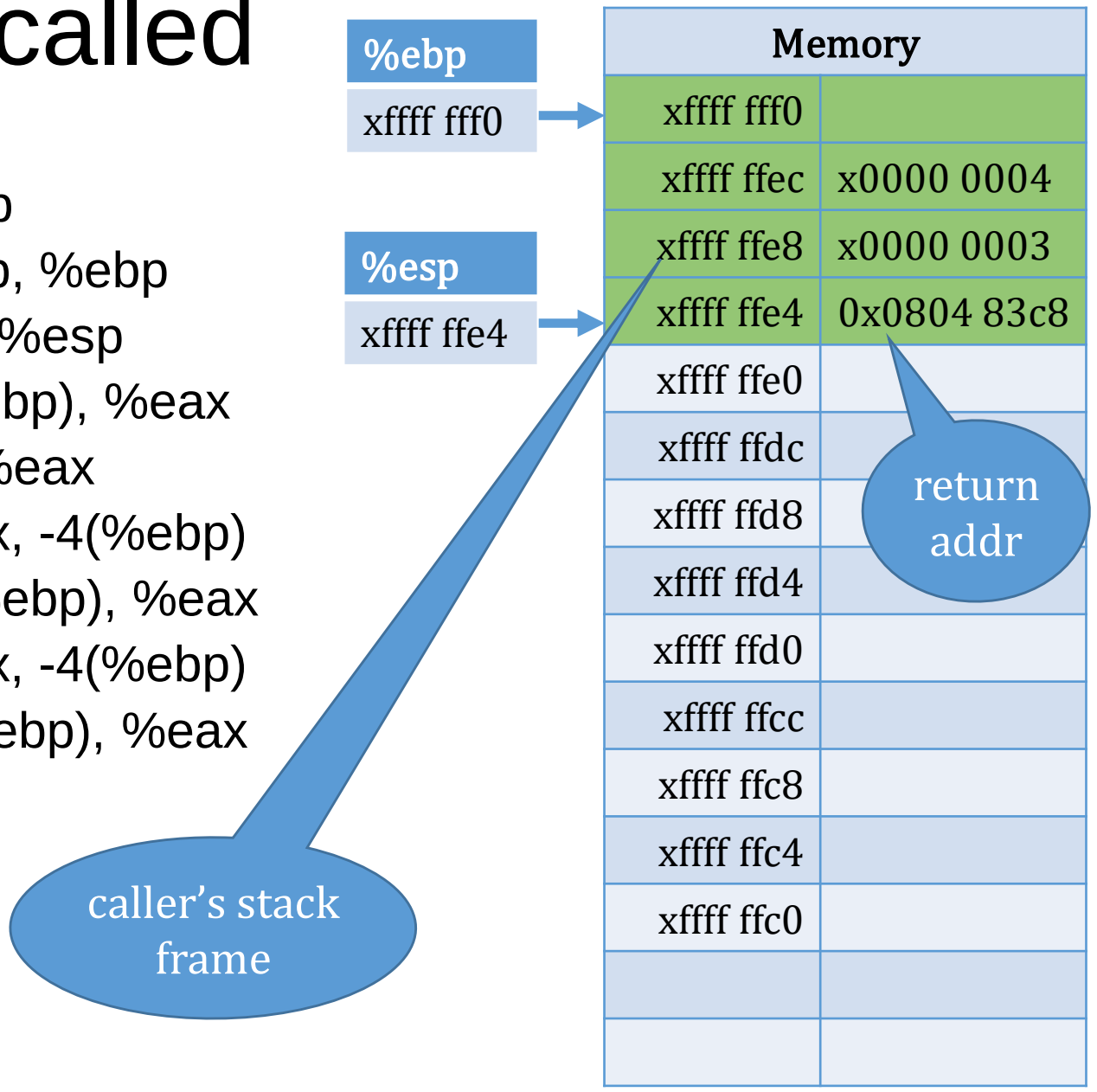
When I am called…

- My caller's stack frame is still active
- I need to save information about my callers frame
- I need to create my own stack frame

Stack when myfunc called

```
int myfunc(int a,int b) {
        int c;
        c = a + 3;
        c = c + b;
        return c;
}
```

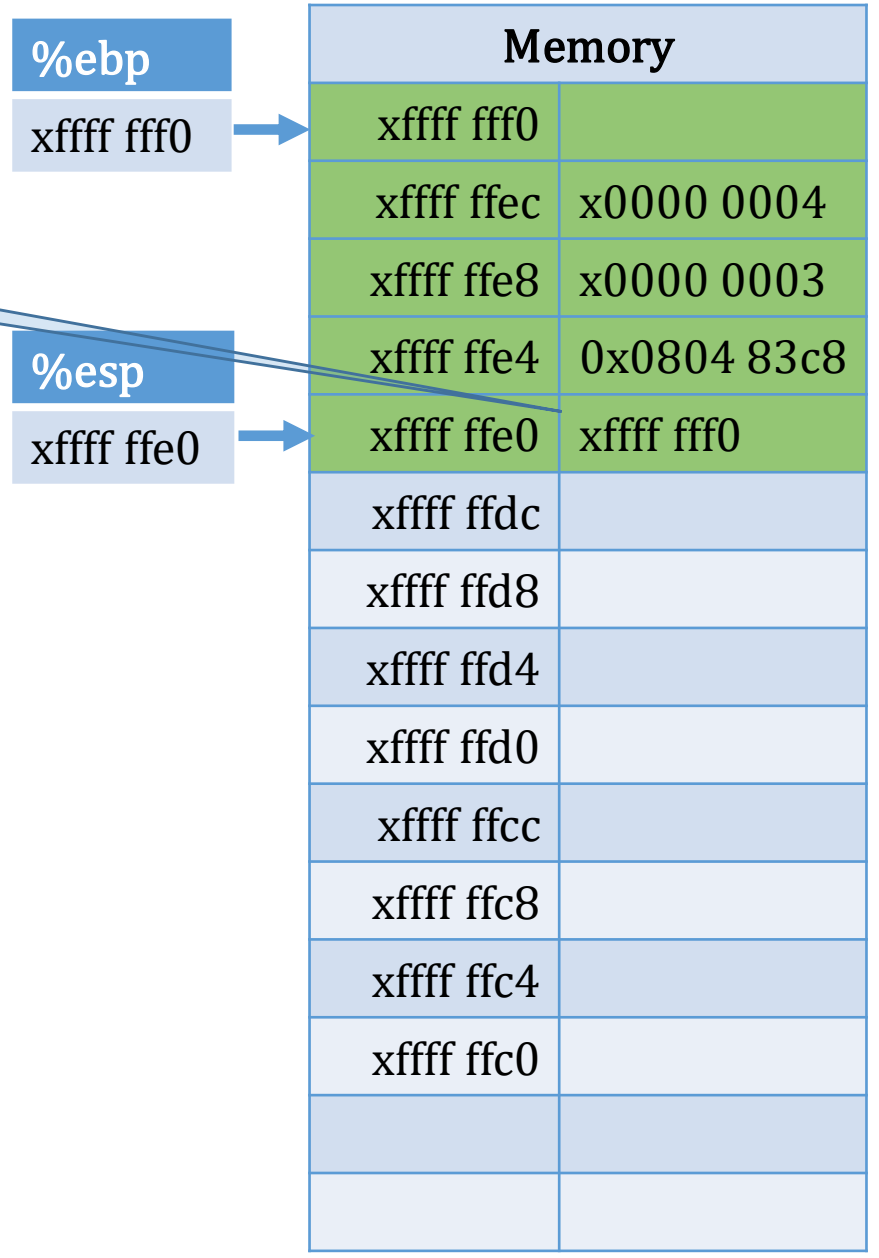
```
myfunc:
        pushl   %ebp
        movl    %esp, %ebp
        subl    $16, %esp
        movl    8(%ebp), %eax
        addl    $3, %eax
        movl    %eax, -4(%ebp)
        movl    12(%ebp), %eax
        addl    %eax, -4(%ebp)
        movl    -4(%ebp), %eax
        leave
        ret
```



Save caller's base pointer

```
int myfunc(int a,int b) {
        int c;
        c = a + 3;
        c = c + b;
        return c;
}
```

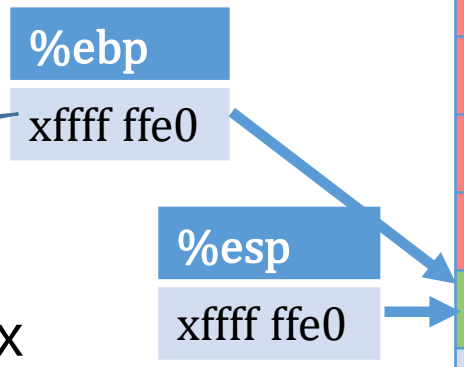
```
myfunc:
        pushl   %ebp
        movl    %esp, %ebp
        subl    $16, %esp
        movl    8(%ebp), %eax
        addl    $3, %eax
        movl    %eax, -4(%ebp)
        movl    12(%ebp), %eax
        addl    %eax, -4(%ebp)
        movl    -4(%ebp), %eax
        leave
        ret
```



Create new frame

```
int myfunc(int a,int b) {
        int c;
        c = a + 3;
        c = c + b;
        return c;
}
```

```
myfunc:
        pushl   %ebp
        movl    %esp, %ebp
        subl    $16, %esp
        movl    8(%ebp), %eax
        addl    $3, %eax
        movl    %eax, -4(%ebp)
        movl    12(%ebp), %eax
        addl    %eax, -4(%ebp)
        movl    -4(%ebp), %eax
        leave
        ret
```

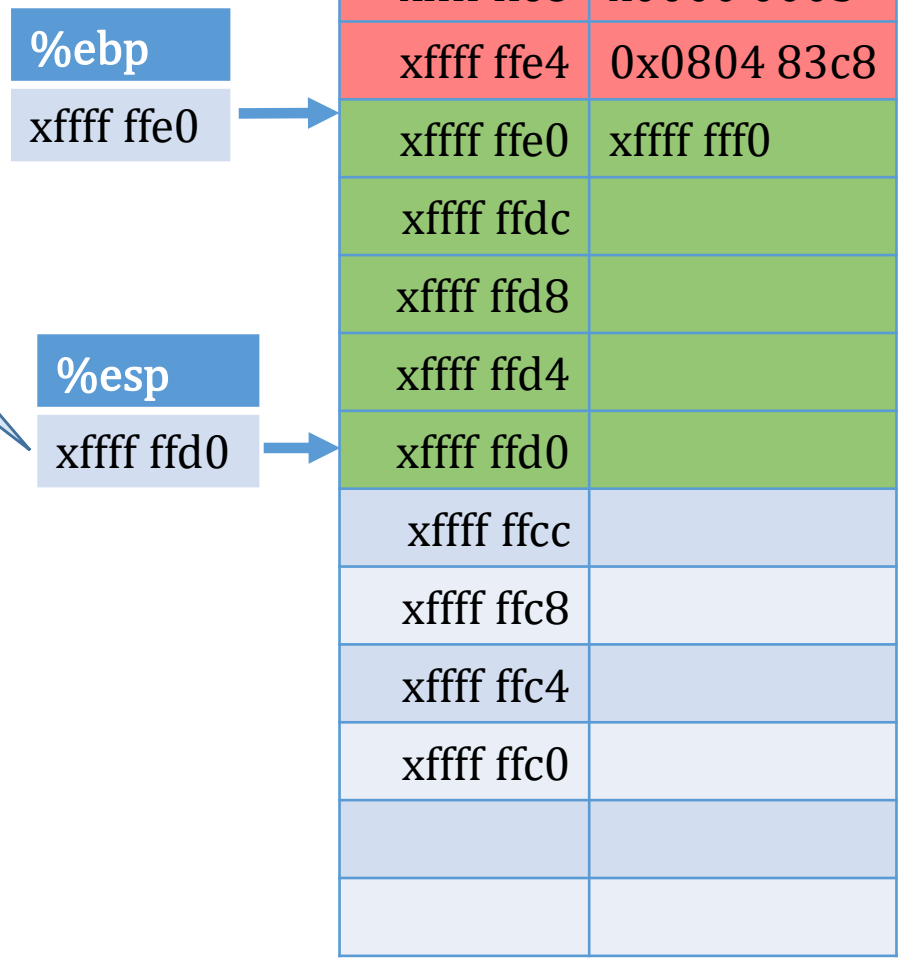


Memory	
xffff fff0	
xffff ffec	x0000 0004
xffff ffe8	x0000 0003
xffff ffe4	0x0804 83c8
xffff ffe0	xffff fff0
xffff ffdc	
xffff ffd8	
xffff ffd4	
xffff ffd0	
xffff ffcc	
xffff ffc8	
xffff ffc4	
xffff ffc0	

Create new frame (part 2)

```
int myfunc(int a,int b) {
        int c;
        c = a + 3;
        c = c + b;
        return c;
}
```

```
myfunc:
        pushl   %ebp
        movl    %esp, %ebp
        subl    $16, %esp
        movl    8(%ebp), %eax
        addl    $3, %eax
        movl    %eax, -4(%ebp)
        movl    12(%ebp), %eax
        addl    %eax, -4(%ebp)
        movl    -4(%ebp), %eax
        leave
        ret
```



Myfunc Execution here.

Save return value

```
int myfunc(int a,int b) {
        int c;
        c = a + 3;
        c = c + b;
        return c;
}
```

```
myfunc:
        pushl   %ebp
        movl    %esp, %ebp
        subl    $16, %esp
        movl    8(%ebp), %eax
        addl    $3, %eax
        movl    %eax, -4(%ebp)
        movl    12(%ebp), %eax
        addl    %eax, -4(%ebp)
        movl    -4(%ebp), %eax
        leave
        ret
```

%eax holds return value

%ebp
xffff ffe0

%esp
xffff ffd0

%eax
x0000 000a

Memory	
xffff fff0	
xffff ffec	x0000 0004
xffff ffe8	x0000 0003
xffff ffe4	0x0804 83c8
xffff ffe0	xffff fff0
xffff ffdc	x0000 000a
xffff ffd8	
xffff ffd4	
xffff ffd0	
xffff ffcc	
xffff ffc8	
xffff ffc4	
xffff ffc0	

Give up my frame

```
int myfunc(int a,int b) {
        int c;
        c = a + 3;
        c = c + b;
        return c;
}
```

```
myfunc:
        pushl   %ebp
        movl    %esp, %ebp
        subl    $16, %esp
        movl    8(%ebp), %eax
        addl    $3, %eax
        movl    %eax, -4(%ebp)
        movl    12(%ebp), %eax
        addl    %eax, -4(%ebp)
        movl    -4(%ebp), %eax
        leave
        ret
```

leave:
mov %ebp,%esp
pop %ebp

%ebp
xffff ffe0

%esp
xffff ffe0

%eax
x0000 000a

Memory	
xffff fff0	
xffff ffec	x0000 0004
xffff ffe8	x0000 0003
xffff ffe4	0x0804 83c8
xffff ffe0	xffff fff0
xffff ffdc	x0000 000a
xffff ffd8	
xffff ffd4	
xffff ffd0	
xffff ffcc	
xffff ffc8	
xffff ffc4	
xffff ffc0	

Restore Caller's Frame

```
int myfunc(int a,int b) {
        int c;
        c = a + 3;
        c = c + b;
        return c;
}
```

```
myfunc:
        pushl   %ebp
        movl    %esp, %ebp
        subl    $16, %esp
        movl    8(%ebp), %eax
        addl    $3, %eax
        movl    %eax, -4(%ebp)
        movl    12(%ebp), %eax
        addl    %eax, -4(%ebp)
        movl    -4(%ebp), %eax
        leave
        ret
```

leave:
mov %ebp,%esp
pop %ebp

%ebp
xffff fff0

%esp
xffff ffe4

%eax
x0000 000a

Memory	
xffff fff0	
xffff ffec	x0000 0004
xffff ffe8	x0000 0003
xffff ffe4	0x0804 83c8
xffff ffe0	xffff fff0
xffff ffdc	x0000 000a
xffff ffd8	
xffff ffd4	
xffff ffd0	
xffff ffcc	
xffff ffc8	
xffff ffc4	
xffff ffc0	

X86 Calling Conventions (Simple)

On Entry

- Save caller's base pointer
- Create my stack frame
- Initialize local variables

On Exit

- Save return value in %eax
- Return my stack frame
- Restore caller's stack frame

Return to caller

```
int myfunc(int a,int b) {
        int c;
        c = a + 3;
        c = c + b;
        return c;
}
```

```
myfunc:
        pushl   %ebp
        movl    %esp, %ebp
        subl    $16, %esp
        movl    8(%ebp), %eax
        addl    $3, %eax
        movl    %eax, -4(%ebp)
        movl    12(%ebp), %eax
        addl    %eax, -4(%ebp)
        movl    -4(%ebp), %eax
        leave
        ret
```