

# CS354: Machine Organization and Programming

Lecture 15  
Wednesday the October 07<sup>th</sup> 2015

Section 2  
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## Class Announcements

1. How was Midterm1? Easy, Hard?
2. Any suggestions for Midterm2?

## Lecture Overview

1. Intro to Functions and Stacks
2. Instructions used for Function Calls

What we need to know how to do . . .  
(what the compiler must be able to implement)

1. call
2. return
3. AR and local variables
4. return value
5. parameters

**Function Implementation (x86-specific)**

**Important Note:** In the following slides for this lecture the stack is represented as growing upwards with lower addresses at the top and higher addresses at the bottom. This is the opposite of what we have seen and will see in this course. double words are pushed and popped

dedicated register `%esp` contains address of item currently at top of stack (TOS)

**THE STACK**

```

pushl *
  does  %esp <- %esp - 4
        movl *, (%esp)

popl *
  does  movl (%esp), *
        %esp <- %esp + 4
    
```

**THE STACK**

**1. call**

- remember the return address
- go to fcn

this is such a common operation that the x86 architecture supports it with a single instruction

```
call fcn
```

does the equivalent of

```
push %eip ← PC
jmp fcn
```

**2. return**

use the return address pushed onto the stack

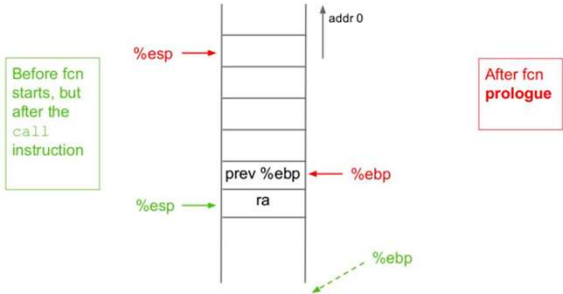
```
ret
```

does the equivalent of

```
popl %eip
```

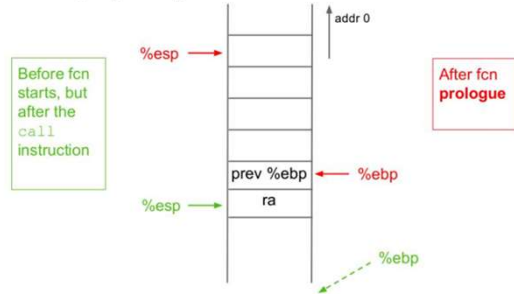
### 3. incorporate AR

For example, assume we need AR space for 3 ints.  
gcc on x86 allocates AR space in multiples of 16 bytes.



#### prologue code

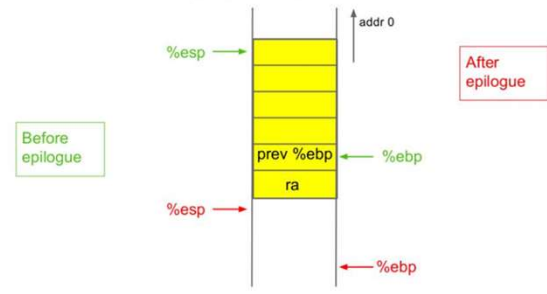
```
pushl %ebp
movl %esp, %ebp
subl $16, %esp
```



#### epilogue code

```
leave does movl %ebp, %esp
popl %ebp

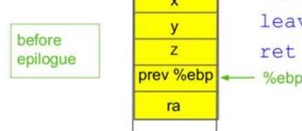
ret does popl %eip
```



### Put local variables into AR:

```
void b() {
    int x, y, z;
    x = 1;
    y = 2;
    z = 3;
    c();
}

b: pushl %ebp prologue
   movl %esp, %ebp
   subl $16, %esp
   movl $1, -12(%ebp)
   movl $2, -8(%ebp)
   movl $3, -4(%ebp)
   call c
   leave epilogue
   ret
```



#### 4. return value

On x86, return value goes in %eax (by convention)

```

int b() {
    b:
    c();
    return 4;
}
    call c
    movl $4, %eax
    leave
    ret
    
```

#### 5. parameters

No room in registers on the x86, so parameters go onto the stack.

Caller allocates space and places copies (for call by value). Child retrieves and uses copies.

```

main () {
    a( 1, 2, 3 );
}
    main:  pushl %ebp
           movl %esp, %ebp
           subl $12, %esp
           movl $1, 4(%esp)
           movl $2, 8(%esp)
           movl $3, 12(%esp)
           call a
           leave
           ret
    
```

