CS354: Machine Organization and Programming

Lecture 15
Wednesday the October 07th 2015

Section 2
Instructor: Leo Arulraj
© 2015 Karen Smoler Miller

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. . .

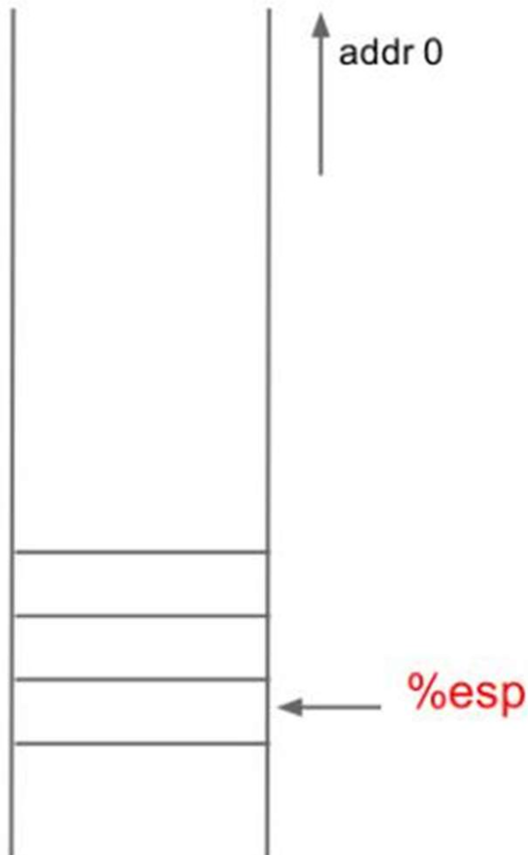
(what the compiler must be able to implement)

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

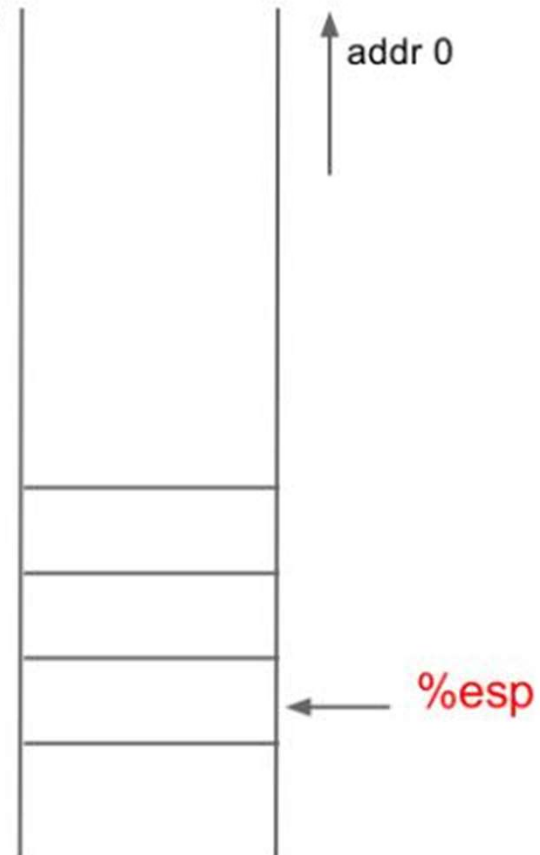
this is such a common operation that the x86 architecture supports it with a single instruction

```
call fcn
```

does the equivalent of

```
push %eip
jmp fcn
```

PC



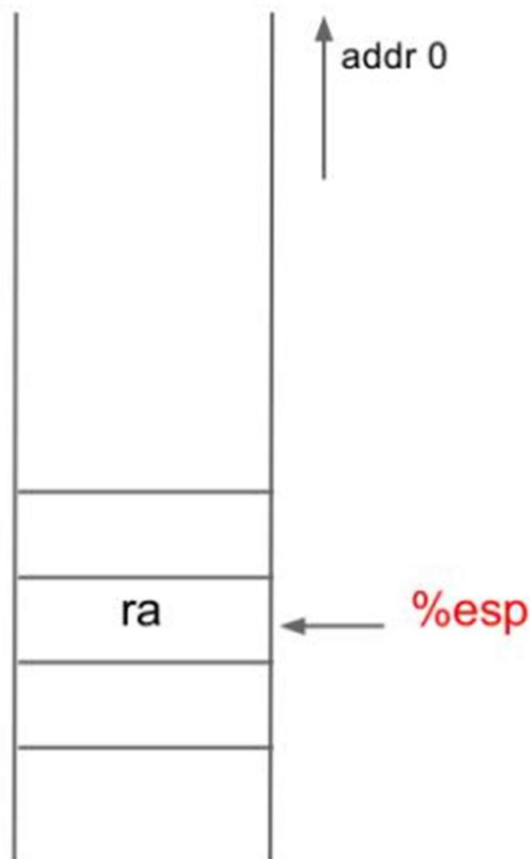
2. return

use the return address pushed onto the stack

```
ret
```

does the equivalent of

```
popl %eip
```

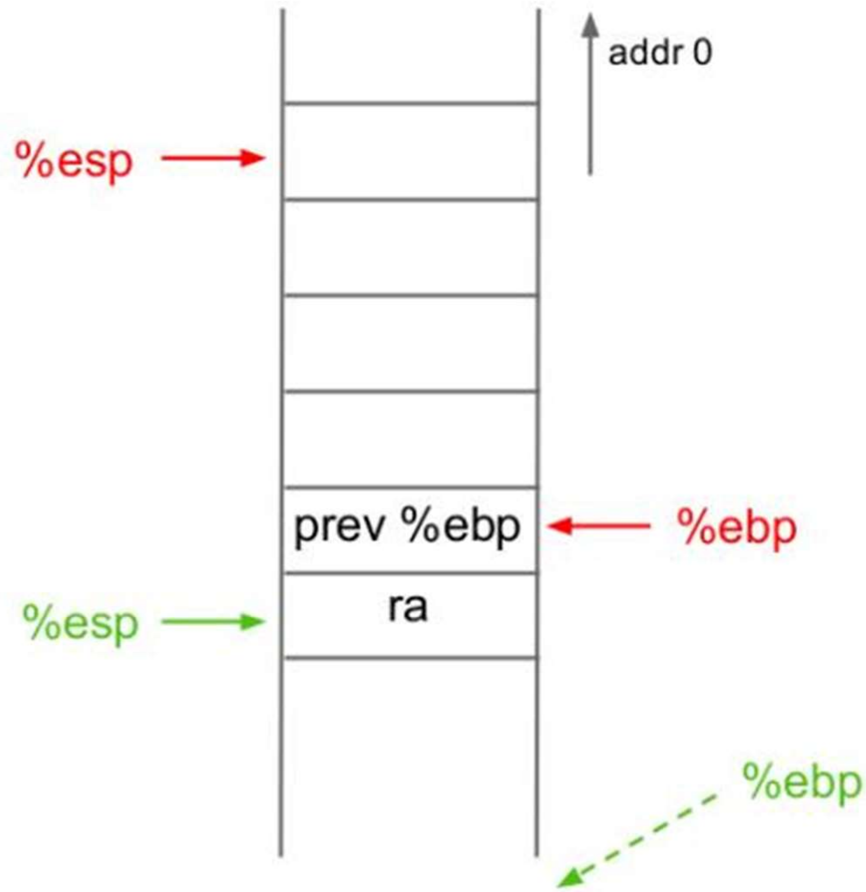


3. incorporate AR

For example, assume we need AR space for 3 ints.

gcc on x86 allocates AR space in multiples of 16 bytes.

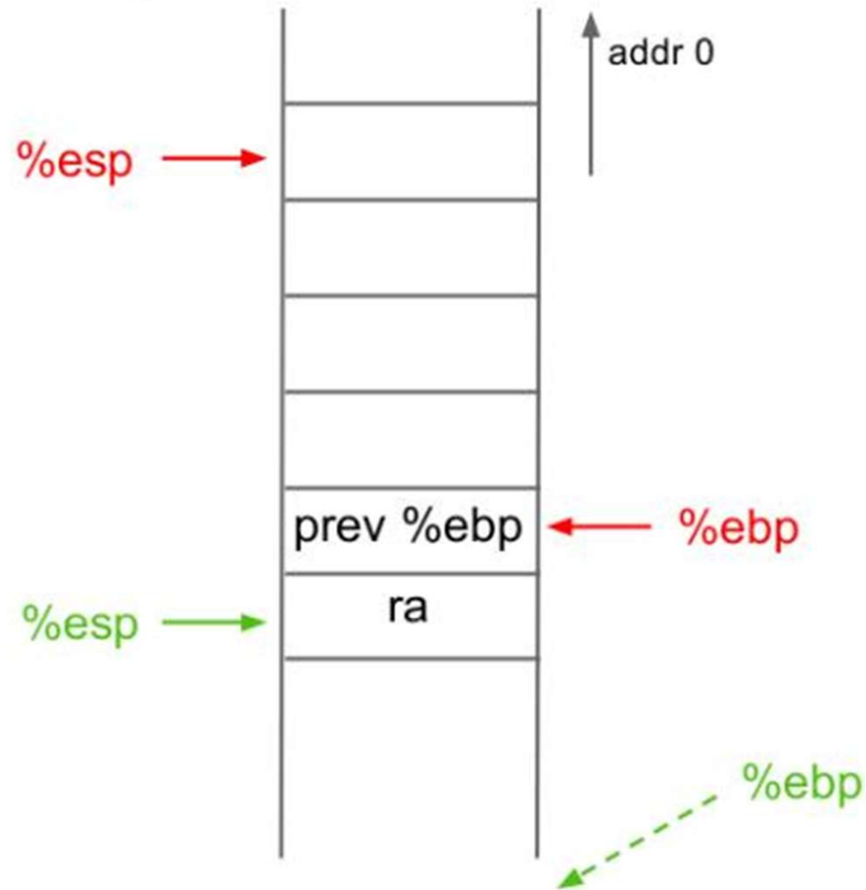
Before fcn starts, but after the `call` instruction



After fcn **prologue**

prologue code

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

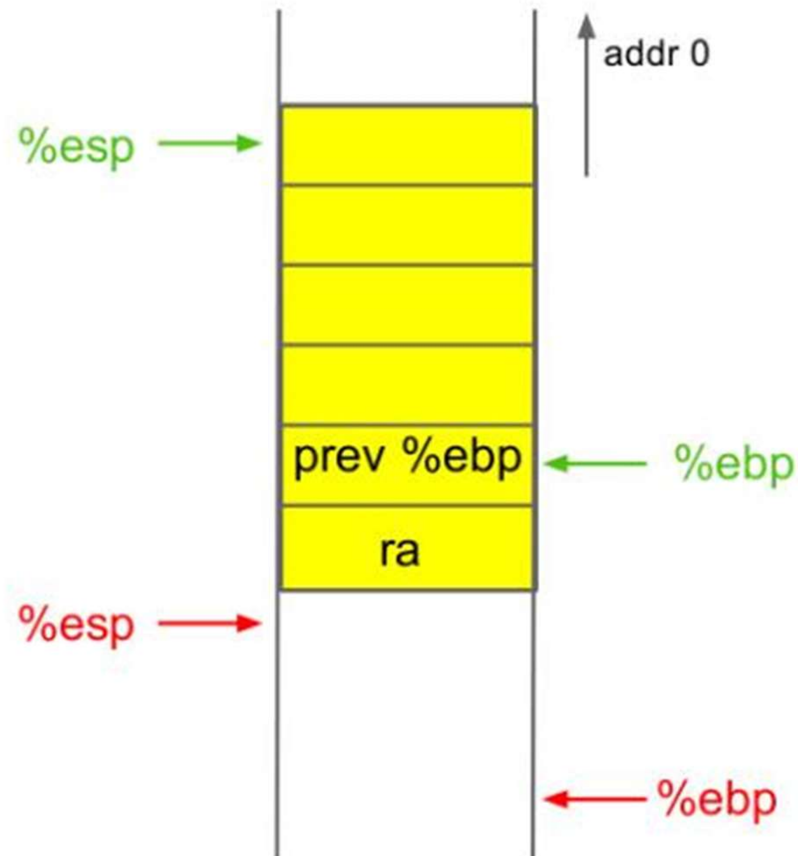


Before fcn starts, but after the `call` instruction

After fcn **prologue**

epilogue code

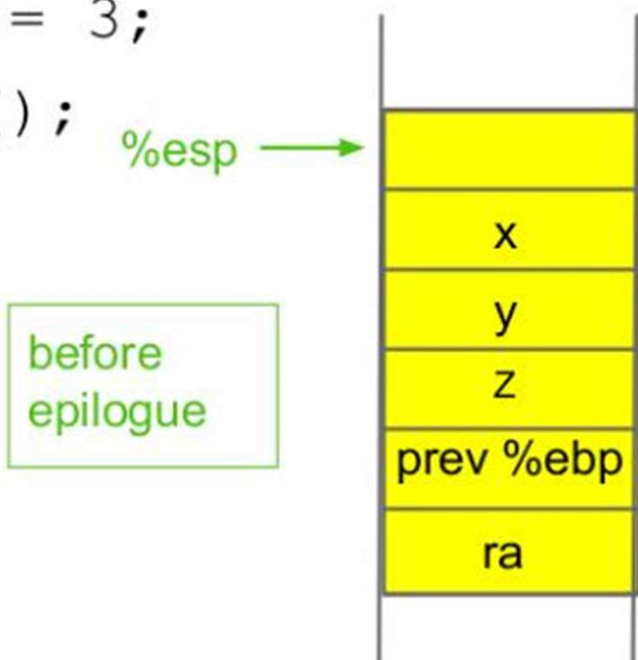
```
leave      does  movl %ebp, %esp
                 popl %ebp

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
```



%ebp

4. return value

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

```
int b() {                   b:




    c();                        call  c
    return 4;                   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, (%esp)
       movl  $2, 4(%esp)
       movl  $3, 8(%esp)
       call  a

       leave
       ret
```

A view of the stack taken from the CSAPP textbook