Subprograms: Examples and Sample Problems

ICS312

Machine-Level and Systems Programming

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Example Stack Instructions

- Assuming that ESP=00001000h

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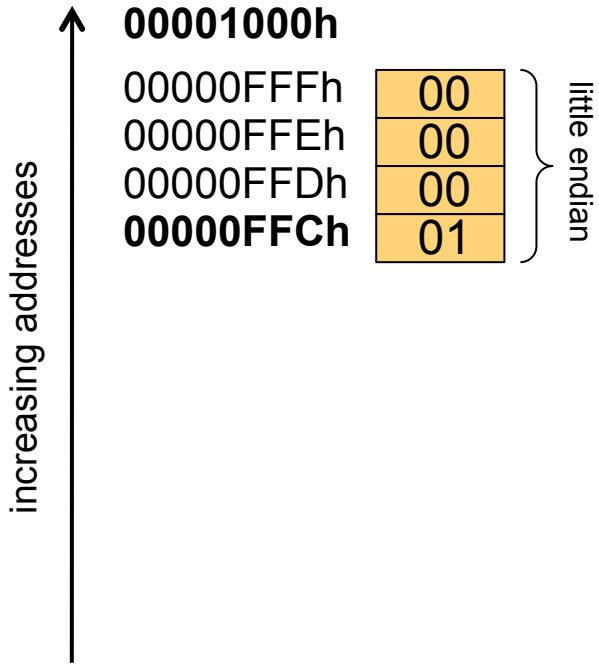
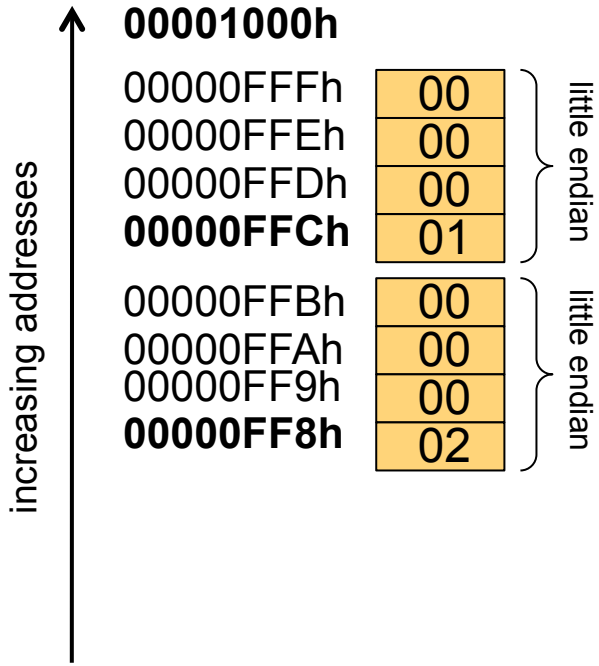
```
push    dword   1           ; ESP = 00000FFCh
```



Example Stack Instructions

- Assuming that ESP=00001000h

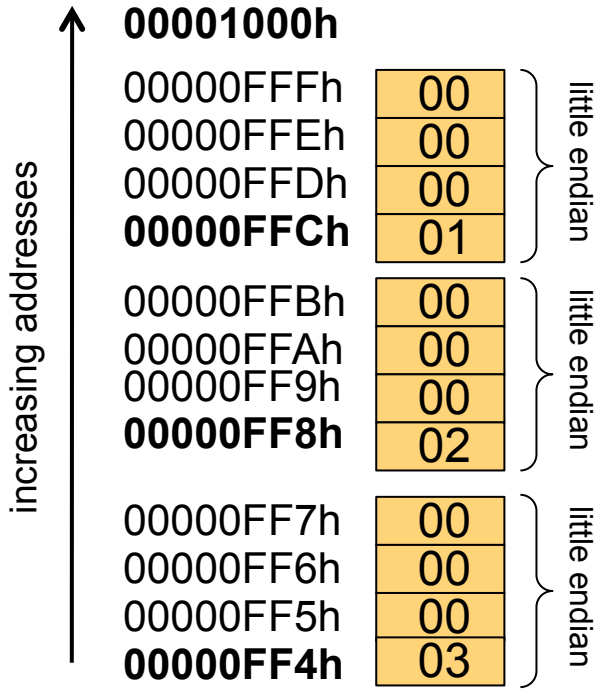
```
push    dword   1       ; ESP = 00000FFCh
push    dword   2       ; ESP = 00000FF8h
```



Example Stack Instructions

- Assuming that ESP=00001000h

```
push    dword   1       ; ESP = 00000FFCh
push    dword   2       ; ESP = 00000FF8h
push    dword   3       ; ESP = 00000FF4h
```

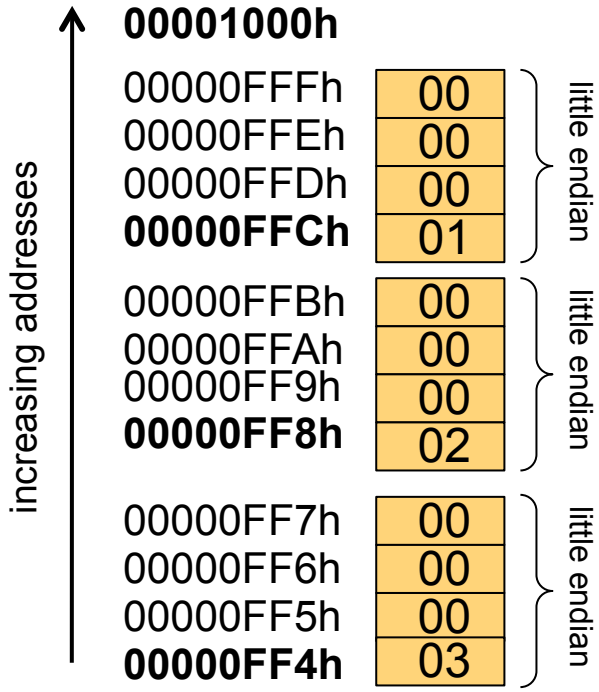


Example Stack Instructions

- Assuming that ESP=00001000h

```
push    dword   1       ; ESP = 00000FFCh
push    dword   2       ; ESP = 00000FF8h
push    dword   3       ; ESP = 00000FF4h

pop     eax             ; EAX = 3
pop     ebx             ; EBX = 2
pop     ecx             ; ECX = 1
```



A Full Example

```
L     dd  42, 43, 44, 45, 56
...
push      dword L
call      func
add       esp, 4
call      print_int
...
func:
      push      ebp
      mov       ebp, esp
      push      [ebp+8]
      push      8
      call      reference
      add       esp, 8
      add       eax, 10
      pop       ebp
      ret
reference:
      push      ebp
      mov       ebp, esp
      mov       eax, [ebp+12]
      add       eax, [ebp+8]
      mov       eax, [eax]
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```
L     dd  42, 43, 44, 45, 56
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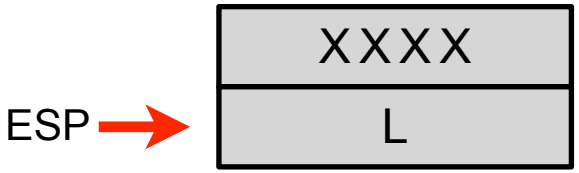
      pop       ebp
      ret
```



A Full Example

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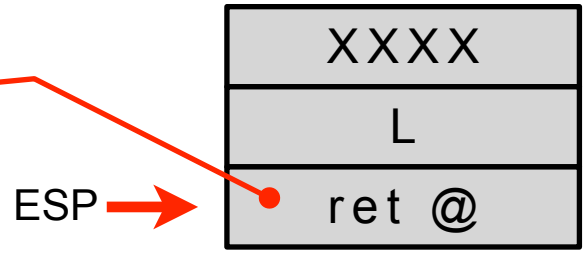
      ret
```



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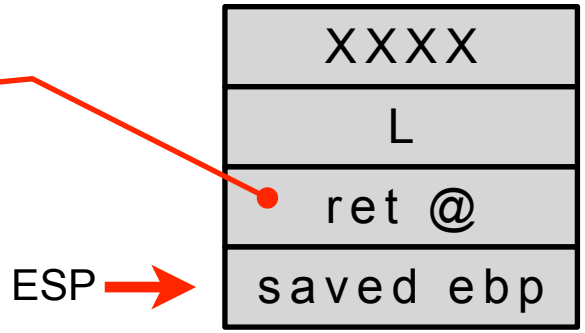
      ret
```



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```
L       dd  42, 43, 44, 45, 56
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push    dword L
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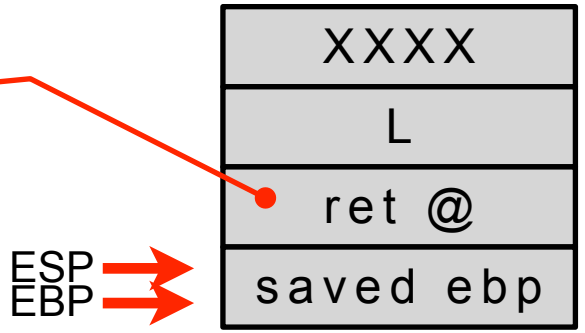

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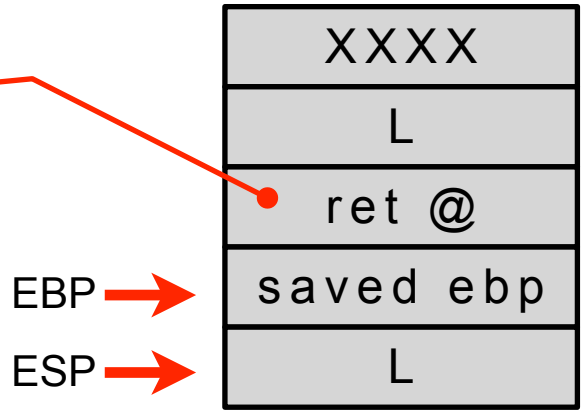

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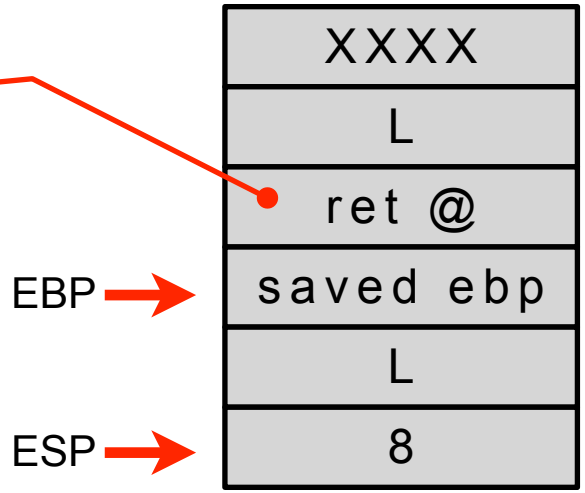

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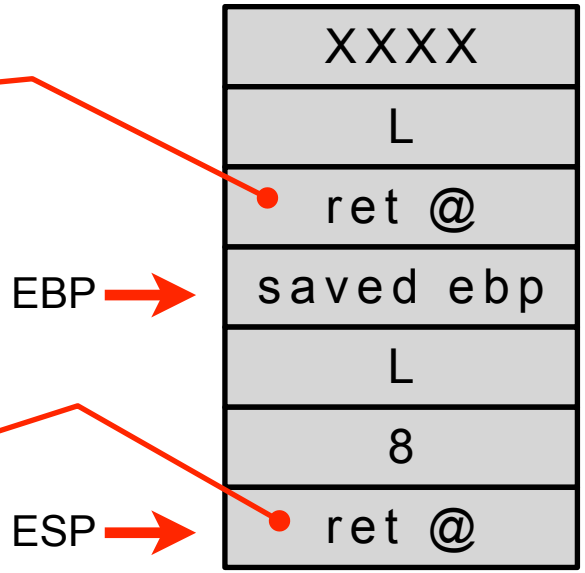

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call    func
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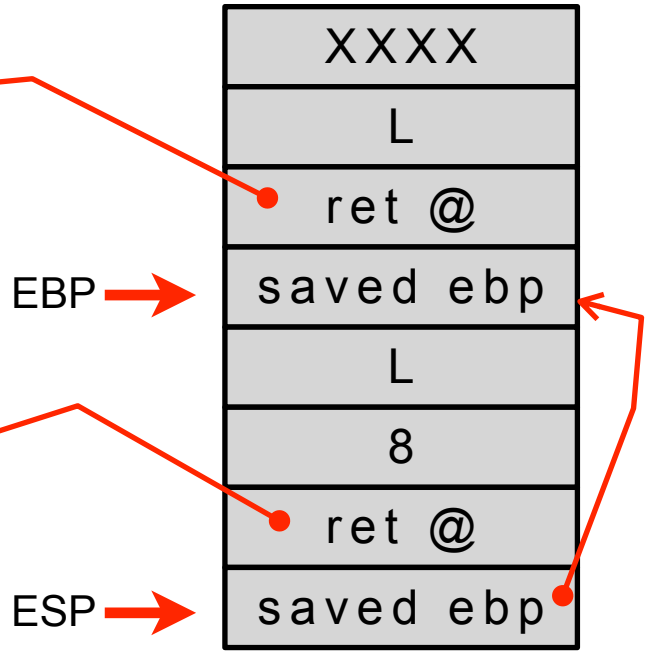

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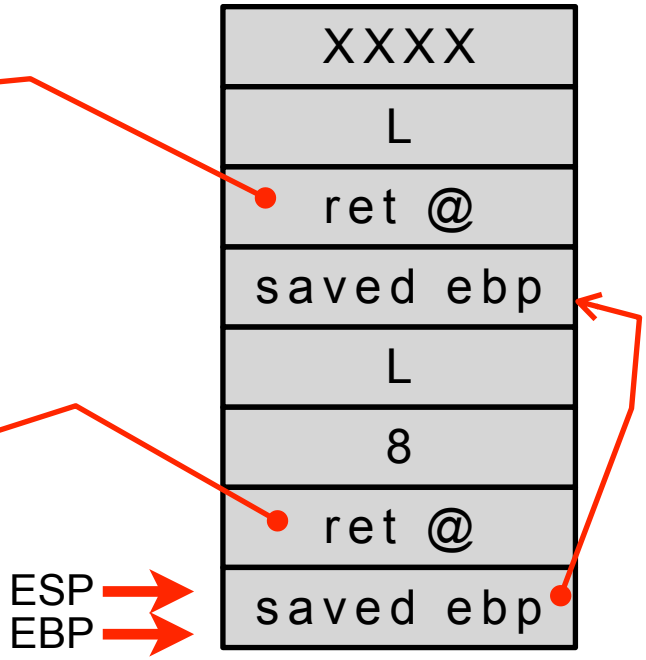

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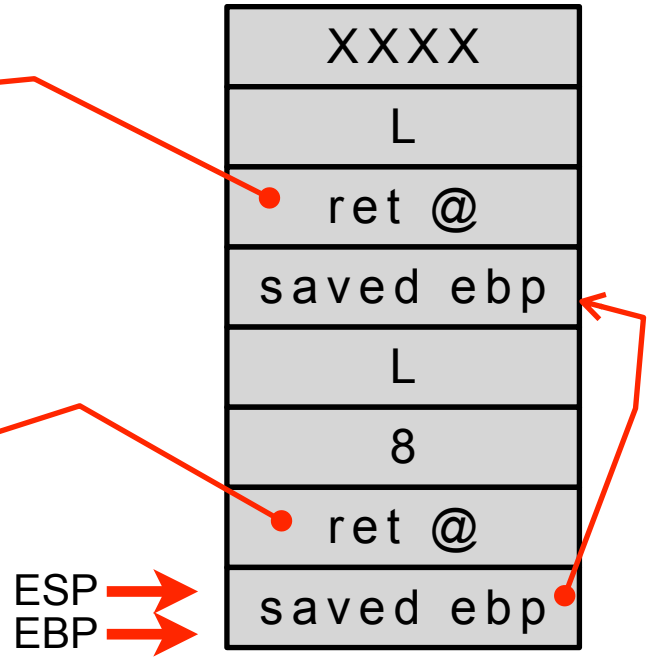

EAX = L

A Full Example

```
L     dd  42, 43, 44, 45, 56
...
push      dword L
call      func
add       esp, 4
call      print_int
...
func:
      push      ebp
      mov       ebp, esp
      push      [ebp+8]
      push      8
      call      reference
      add       esp, 8
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      mov       eax, [eax]
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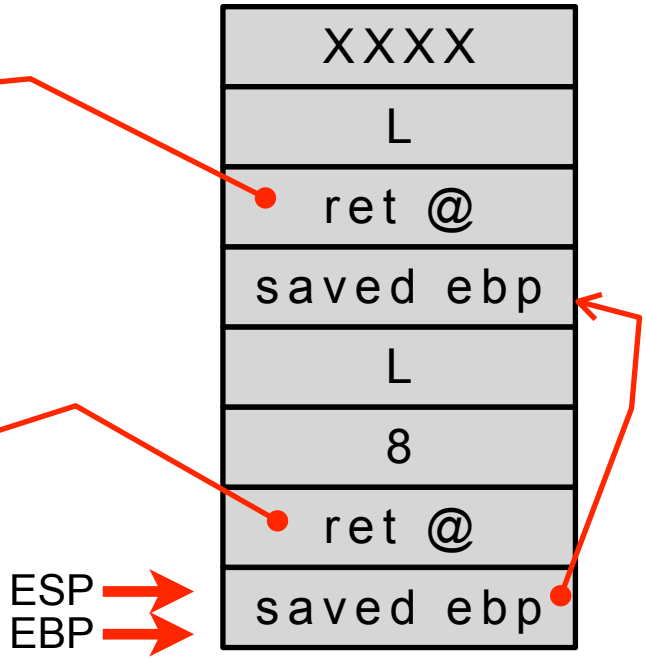

EAX = L + 8

A Full Example

```
L       dd  42, 43, 44, 45, 56
...
push    dword L
call    func
add     esp, 4
call    print_int
...
func:
        push    ebp
        mov     ebp, esp
        push    [ebp+8]
        push    8
        call    reference
        add     esp, 8
        add     eax, 10
        pop     ebp
        ret
reference:
        push    ebp
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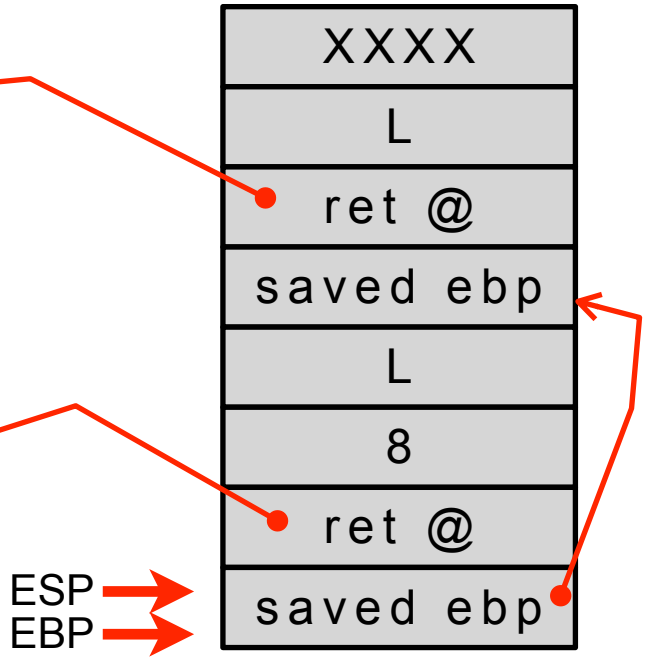
        mov     eax, [eax]
        pop     ebp
        ret
```



EAX = [L + 8] = 44

A Full Example

```
L     dd  42, 43, 44, 45, 56
...
push      dword L
call      func
add       esp, 4
call      print_int
...
func:
      push      ebp
      mov       ebp, esp
      push      [ebp+8]
      push      8
      call      reference
      add       esp, 8
      add       eax, 10
      pop       ebp
      ret
reference:
      push      ebp
      mov       ebp, esp
      mov       eax, [ebp+12]
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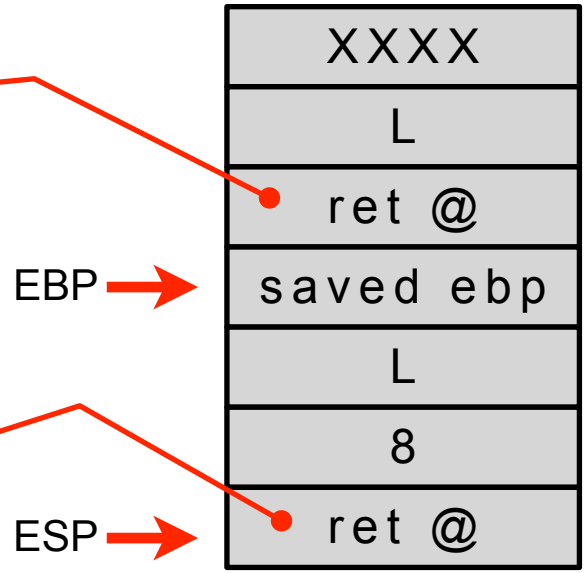
      mov       eax, [eax]
      pop       ebp
      ret
```



EAX = 44

A Full Example

```
L     dd  42, 43, 44, 45, 56
...
push      dword L
call      func
add       esp, 4
call      print_int
...
func:
      push      ebp
      mov       ebp, esp
      push      [ebp+8]
      push      8
      call      reference
      add       esp, 8
      add       eax, 10
      pop       ebp
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reference:
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      mov       eax, [ebp+12]
      add       eax, [ebp+8]
      mov       eax, [eax]
      pop       ebp
      ret
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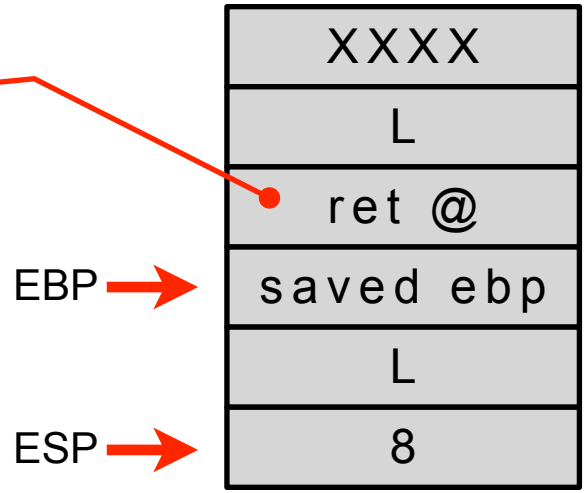

EAX = 44

A Full Example

```
L       dd  42, 43, 44, 45, 56
...
push    dword L
call    func
add     esp, 4
call    print_int
...
func:
        push    ebp
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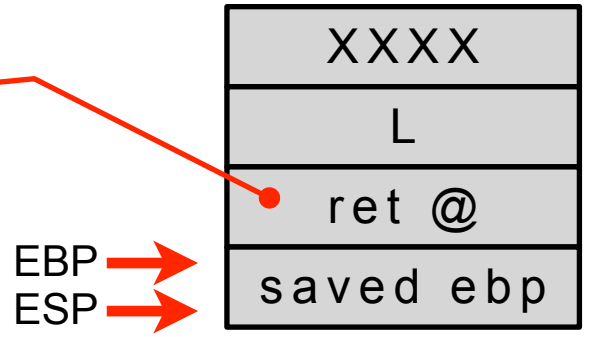

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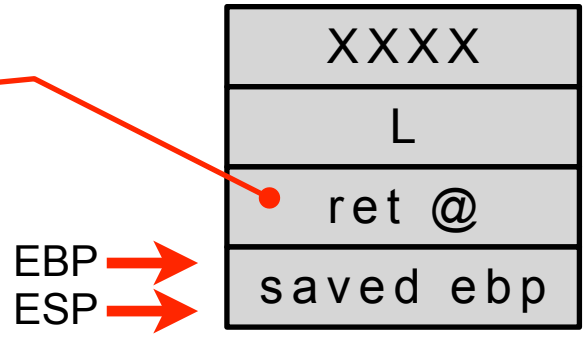

EAX = 44 + 10 = 54

A Full Example

```
L     dd  42, 43, 44, 45, 56
...
push      dword L
call      func
add       esp, 4
call      print_int
...
func:
      push      ebp
      mov       ebp, esp
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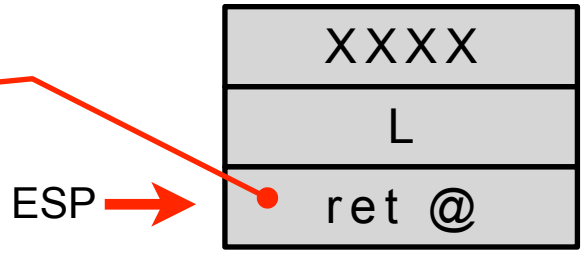

EAX = 54

A Full Example

```
L     dd  42, 43, 44, 45, 56
...
push      dword L
call      func
add       esp, 4
call      print_int
...
func:
      push      ebp
      mov       ebp, esp
      push      [ebp+8]
      push      8
      call      reference
      add       esp, 8
      add       eax, 10
      pop       ebp
      ret
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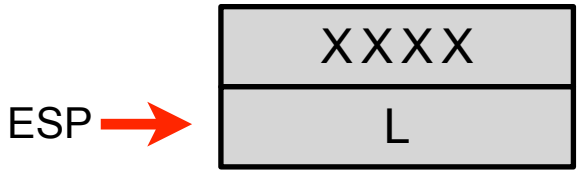

EAX = 54

A Full Example

```
L     dd  42, 43, 44, 45, 56
...
push      dword L
call      func
add       esp, 4
call      print_int
...
func:
      push      ebp
      mov       ebp, esp
      push      [ebp+8]
      push      8
      call      reference
      add       esp, 8
      add       eax, 10
      pop       ebp
      ret
reference:
      push      ebp
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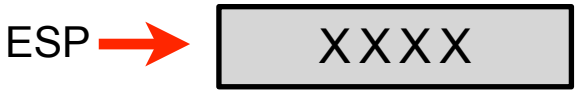

EAX = 54

A Full Example

```
L     dd  42, 43, 44, 45, 56
...
push      dword L
call      func
add       esp, 4
call      print_int
...
func:
      push      ebp
      mov       ebp, esp
      push      [ebp+8]
      push      8
      call      reference
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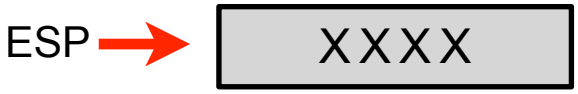

prints “54”

Practice

- What things are wrong with the following program?

```
        push    ebx
        push    30
        call    func
        add     esp, 4
        call    print_int
        call    print_nl
        . . .

func:   push    ebp
        mov     ebp, esp
        mov     eax, [ebp+8]
        add     eax, [ebp+4]
        ret
```

Practice (Solution)

- What 5 things are wrong with the following program?

```
        push    ebx
        push    dword 30
        call    func
        add     esp, 8
        call    print_int
        call    print_nl
        . . .

func:   push    ebp
        mov     ebp, esp
        mov     eax, [ebp+12]
        add     eax, [ebp+8]
        pop     ebp
        ret
```

Practice

- What does the stack look like?

```
        push    ebx
        push    dword 30
        call    func
                <----------------------------   HERE?
        add     esp, 8
        call    print_int
        call    print_nl
        . . .

func:   push    ebp
        mov     ebp, esp
                <----------------------------   HERE?
        mov     eax, [ebp+12]
        add     eax, [ebp+8]
        pop     ebp
        ret
```

Practice (Solution)

- What does the stack look like?

```
        push    ebx
        push    dword 30
        call    func
                <-------------------------
        add     esp, 8
        call    print_int
        call    print_nl
        . . .

func:   push    ebp
        mov     ebp, esp
                <-------------------------
        mov     eax, [ebp+12]
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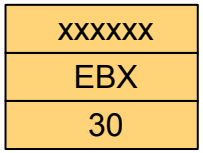
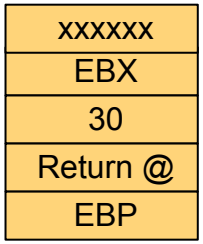
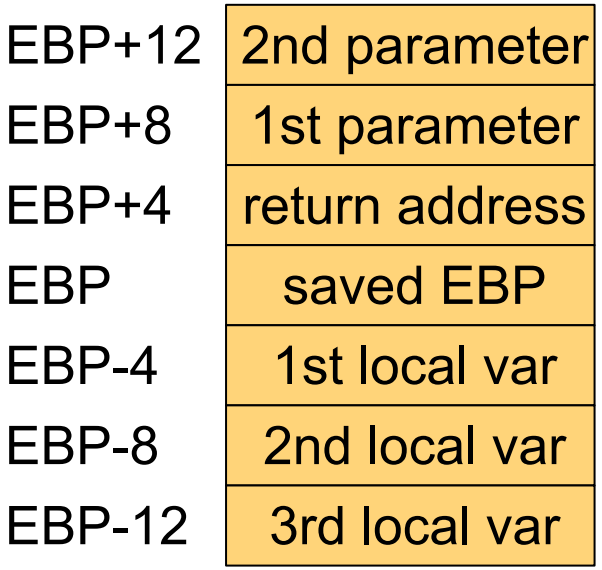
        pop     ebp
        ret
```





Local Variables Example

- Inside the body of the subprogram, parameters are referenced as:
  - [EBP+8]: 1st parameter
  - [EBP+12]: 2nd parameter
- Inside the body of the subprogram, local variables are referenced as:
  - [EBP-4]: 1st local variable
  - [EBP-8]: 2nd local variable
  - [EBP-12]: 3rd local variable



Very important you have this picture in mind; you should be able to redraw it

A Full Example

- Let's write the assembly code equivalent to the following C/Java function

```
int   f(int num) {   // computes Fibonacci numbers
      int x, sum;
      if (num == 0) return 0;
      if (num == 1) return 1;
      x = f(num-1);
      sum = x + f(num-2)
      return sum;
}
```

- Let's write a "straight" translation, without optimizing variables away, just for demonstration purposes

A Full Example (main program)

```
%include "asm_io.inc"

segment .data
        msg1            db      "Enter n: ", 0
        msg2            db      "The result is: ", 0

        . . . ; declaration of asm_main and setup

        mov         eax, msg1           ; eax = address of msg1
        call        print_string        ; print msg1
        call        read_int            ; get an integer from the keyboard (in EAX)
        push        eax                 ; put the integer on the stack (parameter #1)
        call        f                   ; call f
        pop         ebx                 ; remove the parameter from the stack
        mov         ebx, eax            ; save the value returned by f
        mov         eax, msg2           ; eax = address of msg2
        call        print_string        ; print msg2
        mov         eax, ebx            ; eax = sum
        call        print_int           ; print the sum
        call        print_nl            ; print a new line

        . . . ; clean up
```

A Full Example (function f)

```
;       FUNCTION: f
;       Takes one parameter:  an integer
;       eax = return value
segment .text
f:      enter  8,0          ; num in [ebp+8]
                            ; local var x in [ebp-4],
                            ; local var sum in [ebp-8]
        push    ebx         ; save ebx
        push    ecx         ; save ecx
        push    edx         ; save edx

        mov     eax, [ebp+8]            ; eax = num
        sub     eax, 2                  ; eax -= 2
        jns     next        ; if not <0, goto next
        add     eax, 2                  ; eax += 2
        jmp     end
next:
        mov     eax, [ebp+8]    ; eax = num
        add     eax, -1         ; eax -= 1
        push    eax             ; put (num -1) on stack
        call    f               ; call f (recursively)
        add     esp, 4          ; remove (num-1) from stack
        mov     [ebp-4], eax    ; put the returned value in x
        mov     eax, [ebp+8]    ; eax = num
        add     eax, -2         ; eax -= 2
        push    eax             ; put (num -2) on stack
        call    f               ; call f (recursively),
                                ; the return value is in eax
        add     esp, 4      ; remove (num-1) from stack
        add     eax, [ebp-4]    ; eax += x

end:
        pop     edx         ; restore ebx
        pop     ecx         ; restore ecx
        pop     ebx         ; restore edx
        leave               ; clean up the stack
        ret                 ; return
```