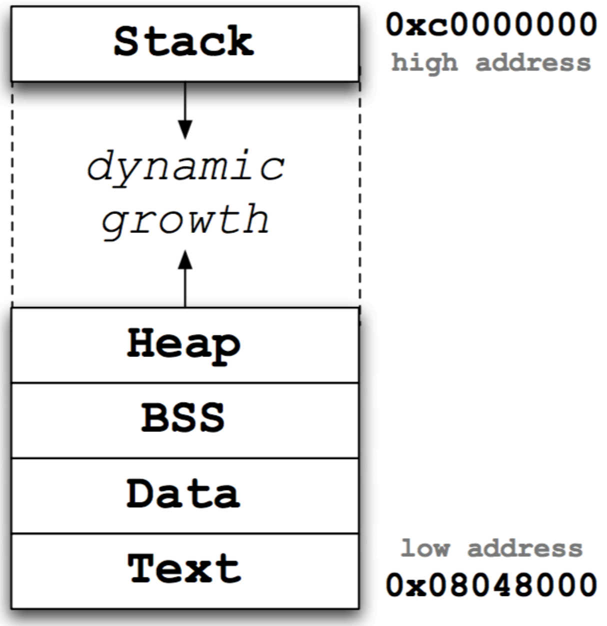
Buffer Overrun Review

Process Layout in Memory

- **Stack**
  - grows towards *decreasing* addresses.
  - is initialized at *run-time*.
- **Heap**
  - grow towards *increasing* addresses.
  - is initialized at *run-time*.
- **BSS** section
  - size fixed at *compile-time*.
  - is initialized at *run-time*.
  - was grouped into **Data** in CS61C.
- **Data** section
  - is initialized at *compile-time*.
- **Text** section
  - holds the program instructions (read-only).



IA-32 Notation

- Format : inst src dst
- registers prefixed with a ‘%’, constants with ‘$’
- (%ebx) means accessing the memory address stored in register %ebx
- l suffix on instruction indicates a “long-word” (32-bit) instruction

Important Registers

- %eax, %ebx, %ecx, %edx, %edi, %esi – general purpose registers (%eax used to store return value)
- %ebp – base pointer. Indicates start of stack frame
- %esp – stack pointer. Indicates bottom on stack
- %eip – instruction pointer. Indicates instruction to run

Common Instructions

- mov ***a***, ***b*** – copy value of ***a*** into ***b***
- push ***a*** – push ***a*** onto the stack (decrement stack, copy value over)
- pop ***a*** – pop data from stack into ***a*** (copy value over, increment stack)
- call ***func*** – push address of next instruction onto stack & transfer control to ***func***
- ret – pop return address off stack and jump to it
- leave – syntactic sugar for mov %ebp, %esp followed by pop %ebp (restores prev stack frame)

Function Structure

```
foo:
        push %ebp                   |
        mov  %esp, %ebp             |   Function prologue (creates a new stack frame)
        sub $???,  %esp             |
        …
        …                           |   Function body
        …
        leave                       |   Function epilogue (restore old stack frame &
        ret                         |   jump to return address)
```

Calling Convention

```
foo:
        …
        …
        …
        push $5
        push $1
        call bar
        add $8, %esp
        …
        …
        …
```

Example of calling bar(1,5)

Arguments pushed on stack in reverse order (last argument pushed first)

Stack restored after function call end

Extra: Caller also sometimes need to save registers, but don't worry about this too much

Let’s walk through an example!

- Terminology:
  - SFP : saved %ebp on the stack
  - OFP : old %ebp from the previous stack frame
  - RIP : return address on the stack

Function Calls

```
void foo(int a, int b, int c)
{
    int bar[2];
    char qux[3];
    bar[0] = 'A';
    qux[0] = 0x42;
}

int main(void)
{
    int i = 1;
    foo(1, 2, 3);
    return 0;
}
```

Function Calls in Assembler

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    int i = 1;
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main:
    pushl %ebp
    movl  %esp,%ebp
    subl  $4,%esp
    movl  $1,-4(%ebp)
    pushl $3
    pushl $2
    pushl $1
    call  foo
    addl  $12,%esp
    xorl  %eax,%eax
    leave
    ret
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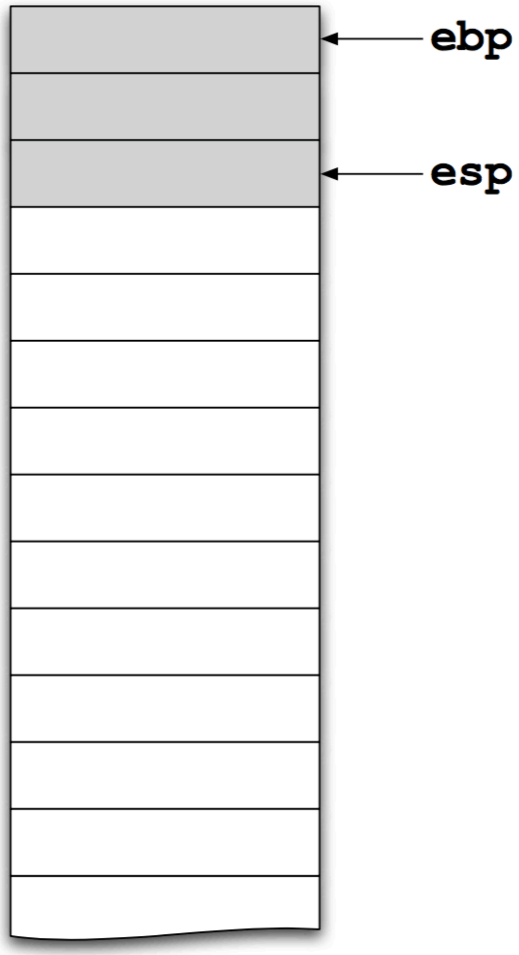

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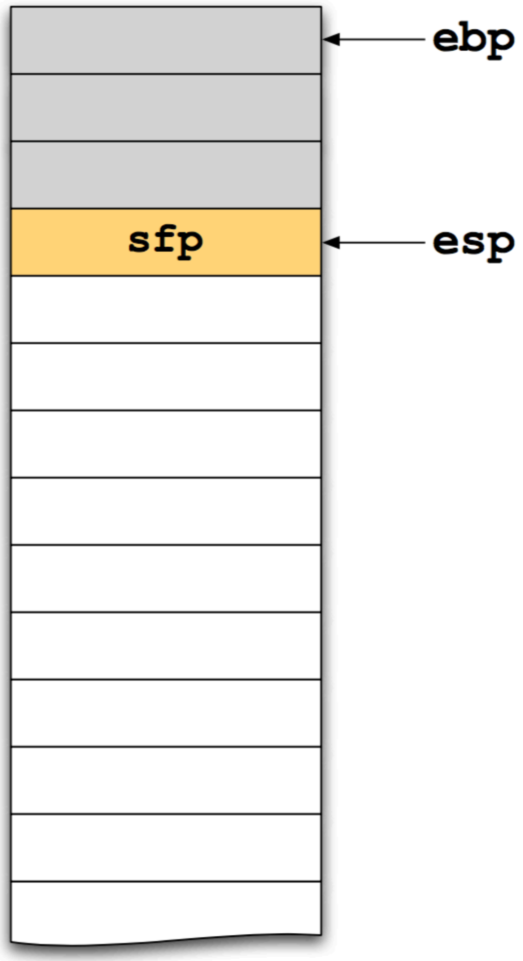

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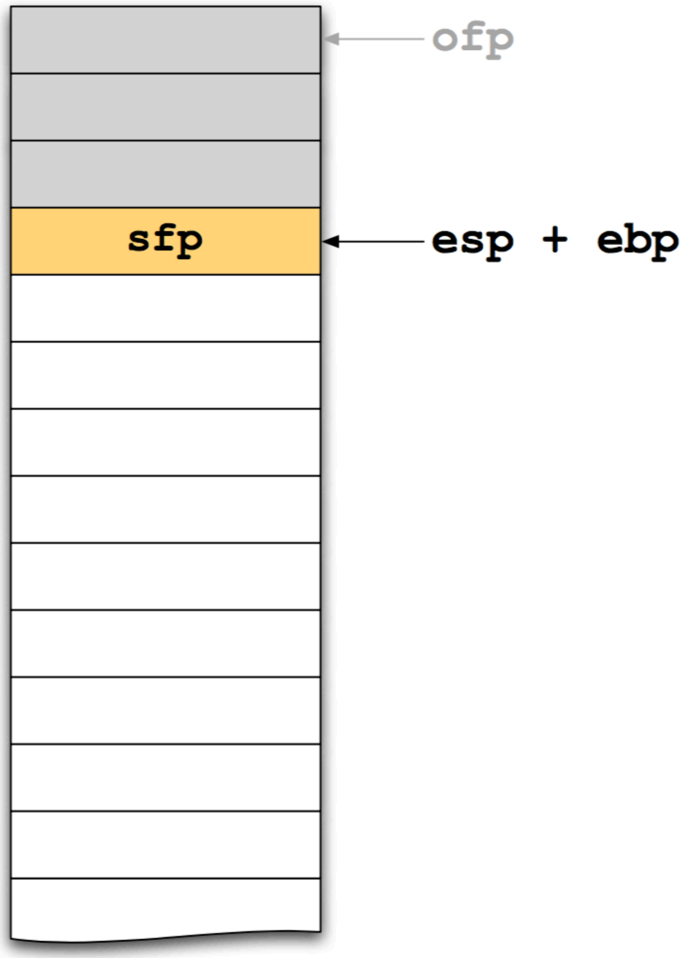

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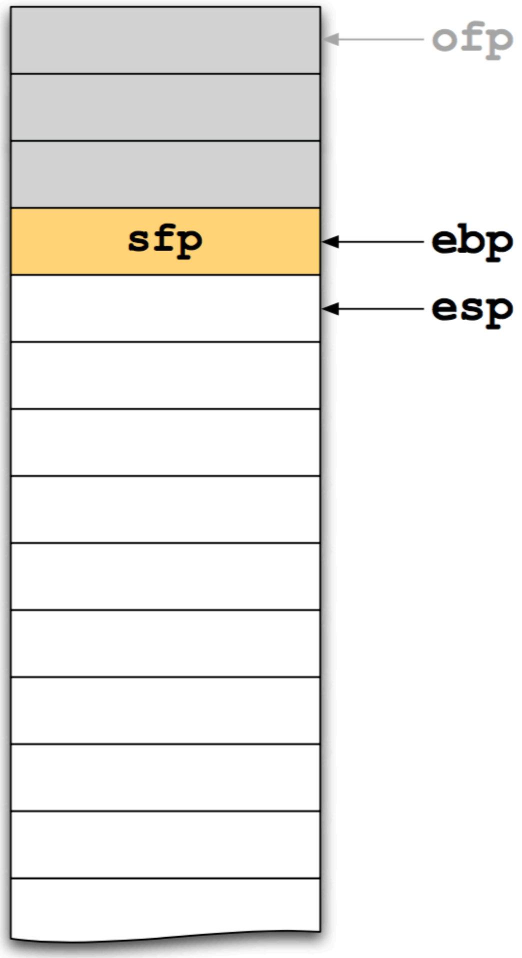

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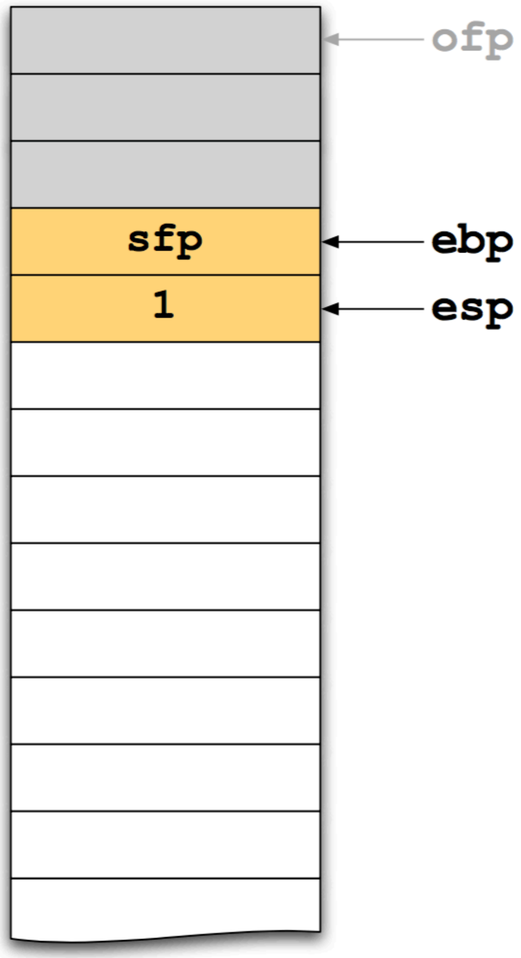

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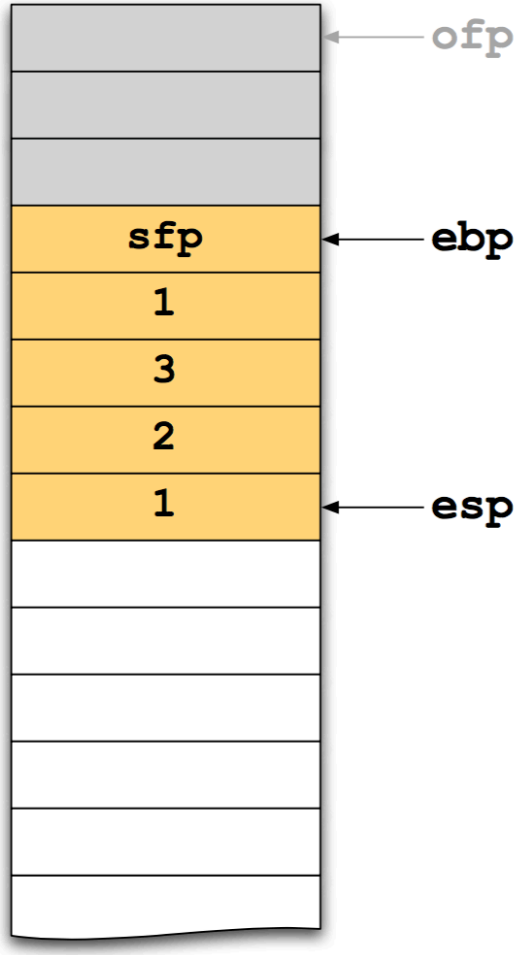

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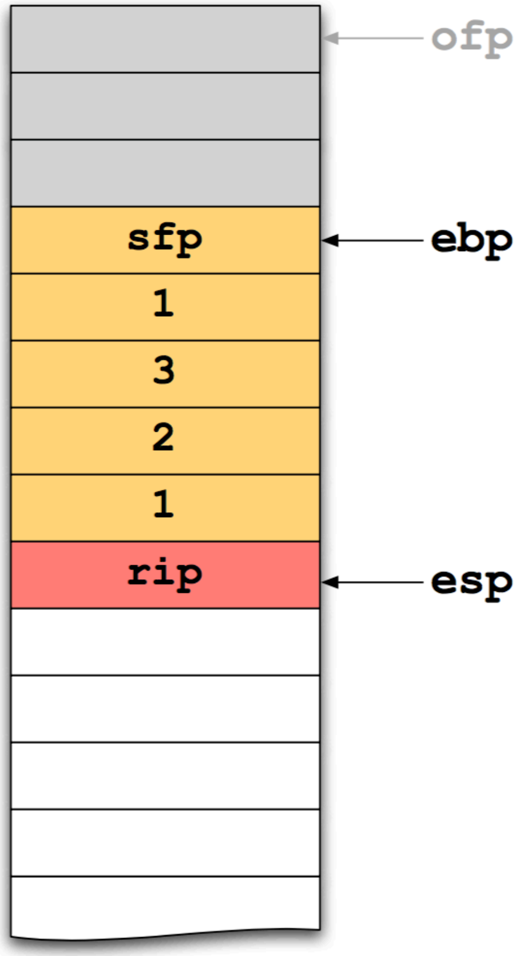

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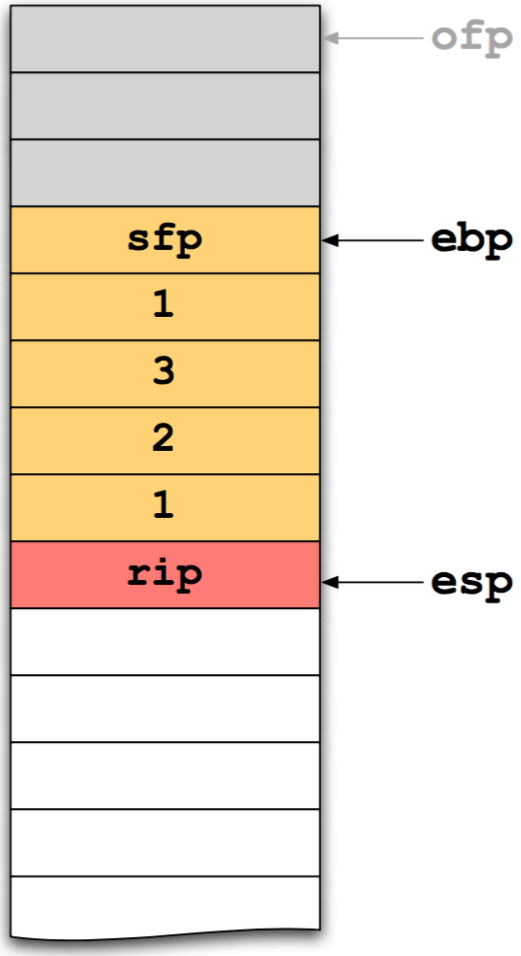

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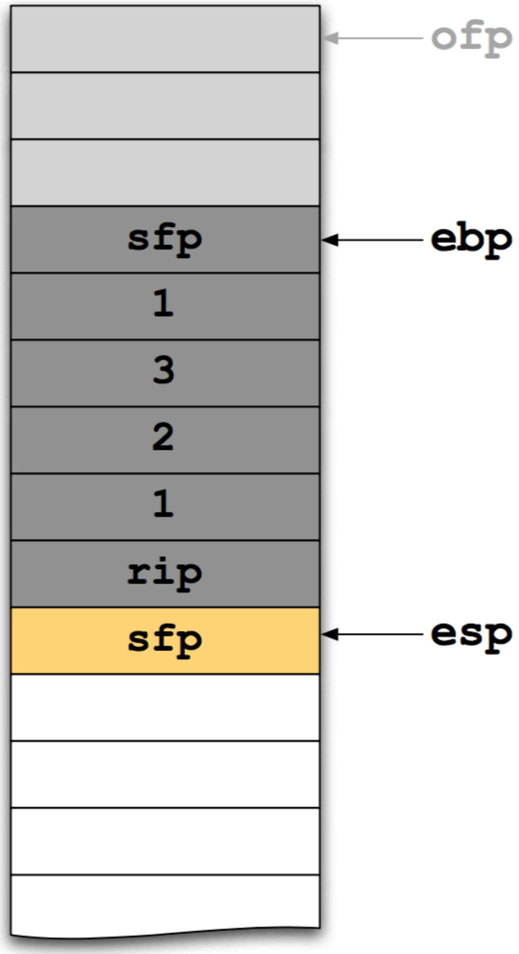

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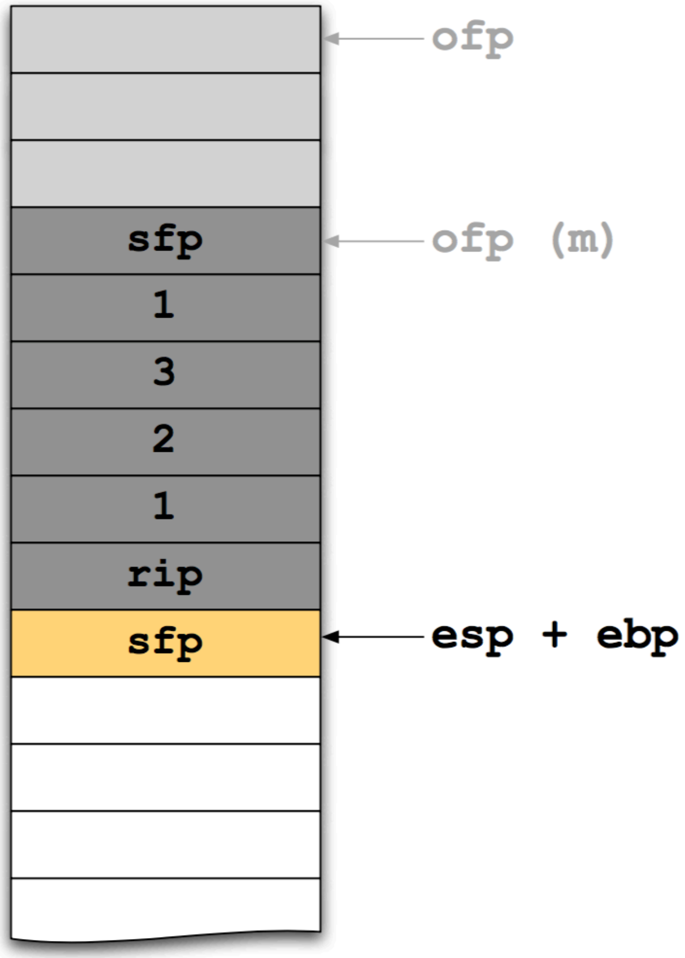

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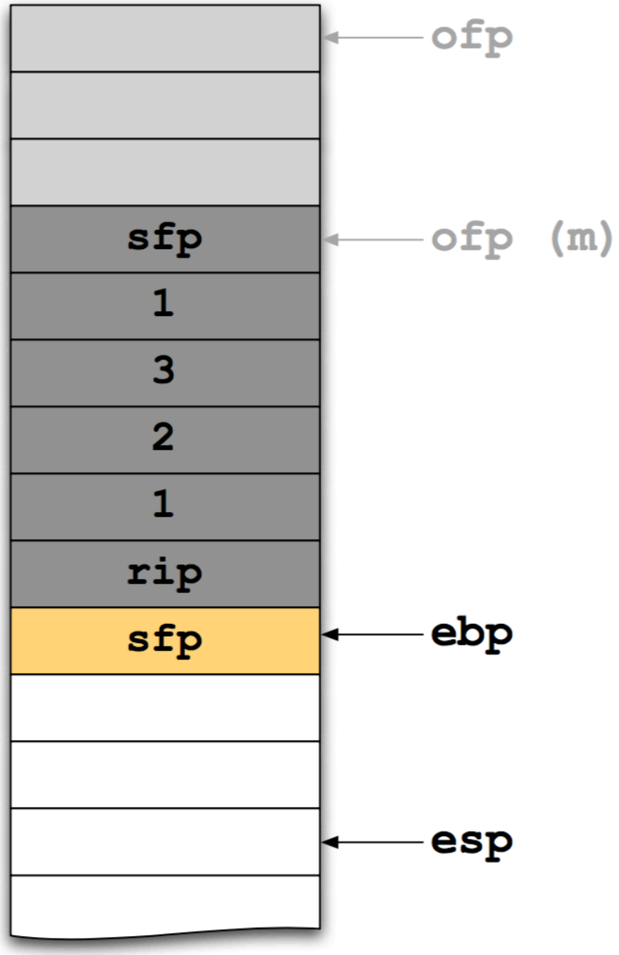

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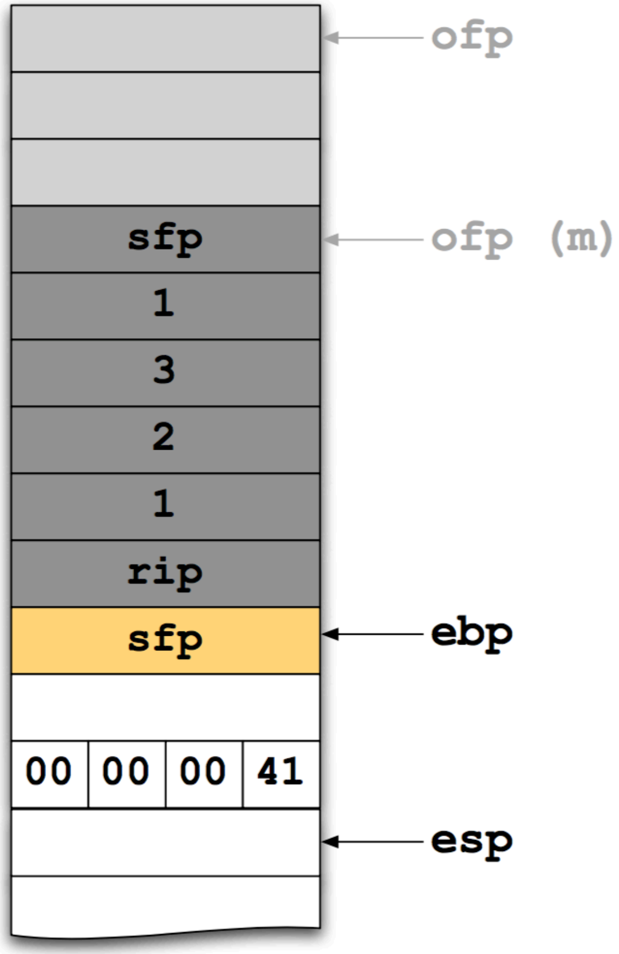

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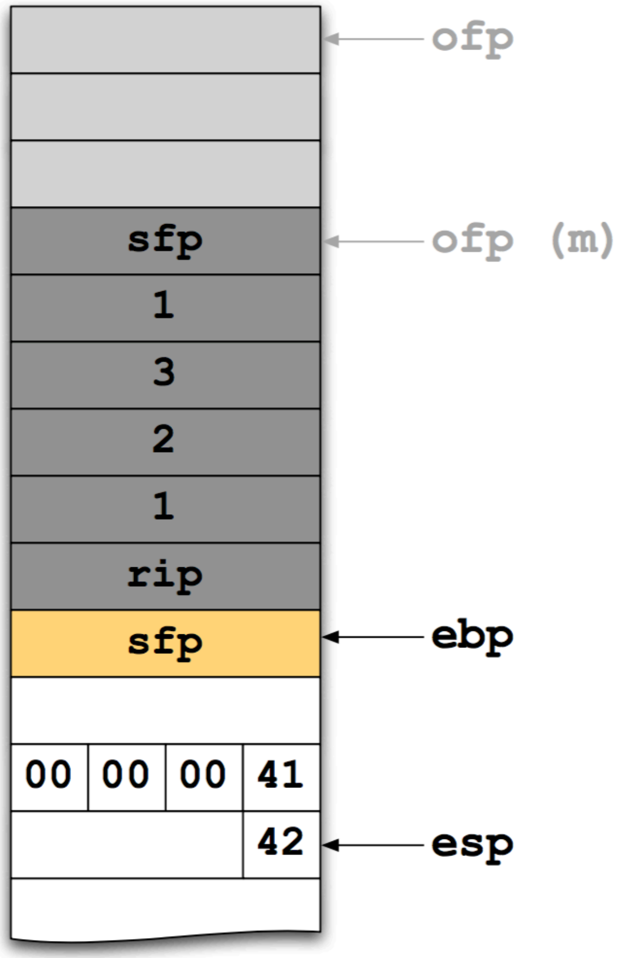

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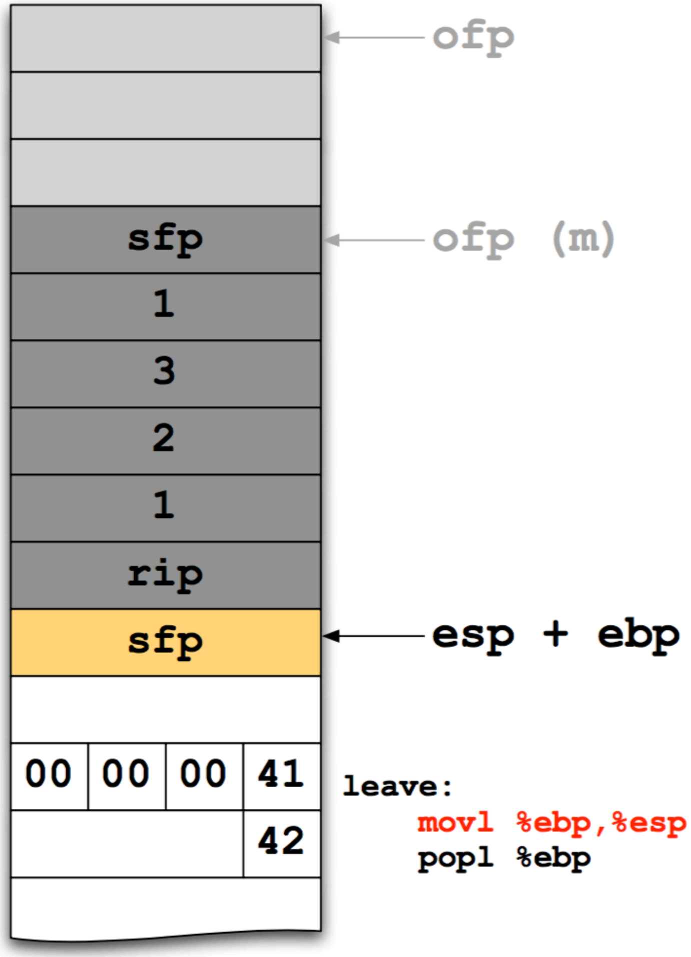

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leave:
    movl %ebp,%esp
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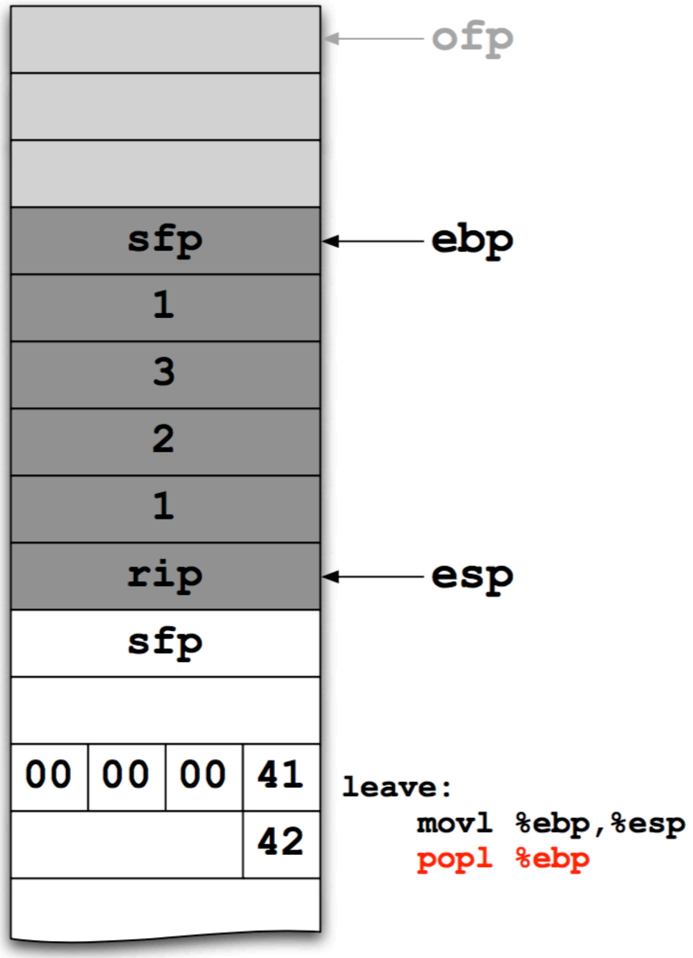

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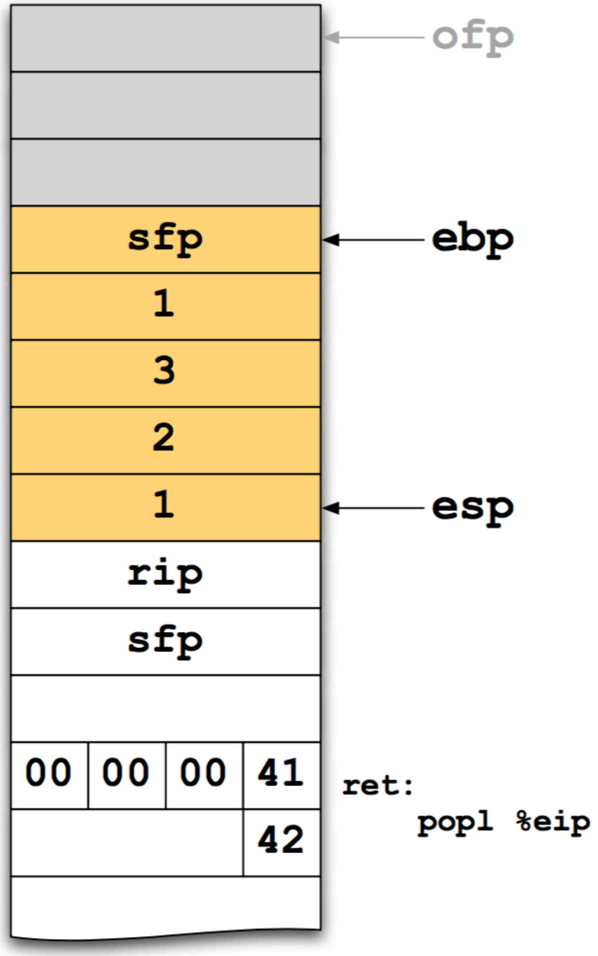

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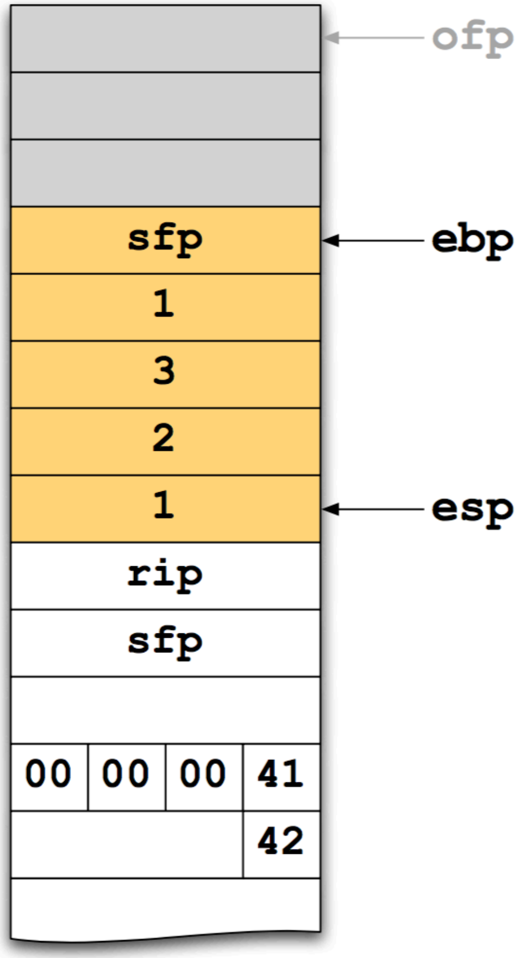

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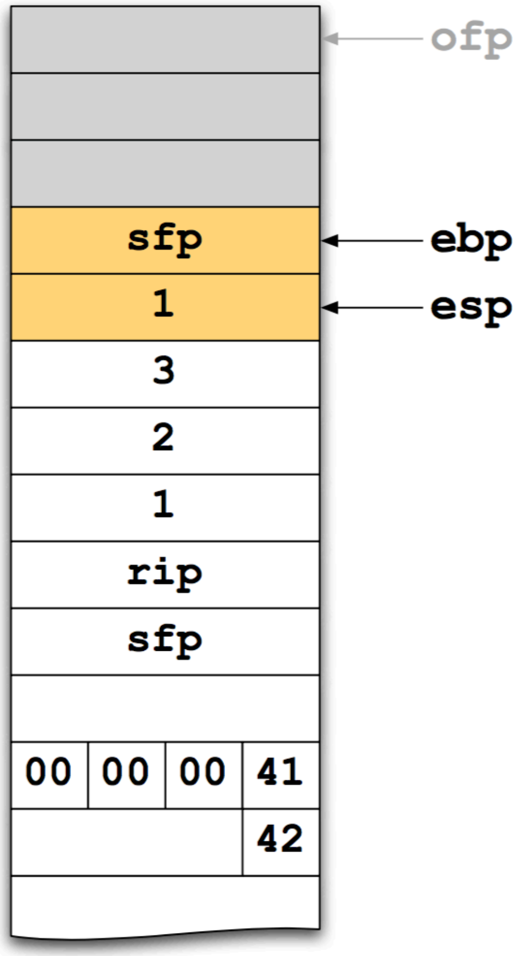

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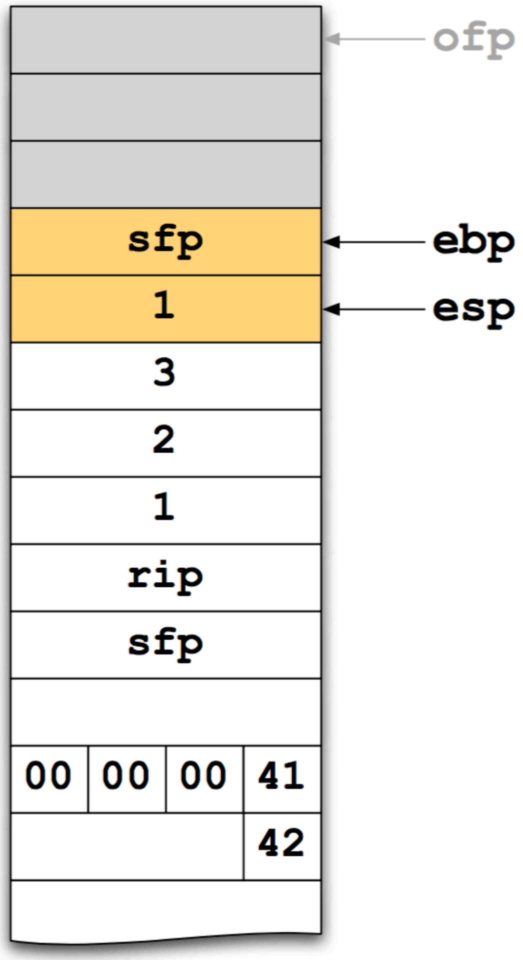

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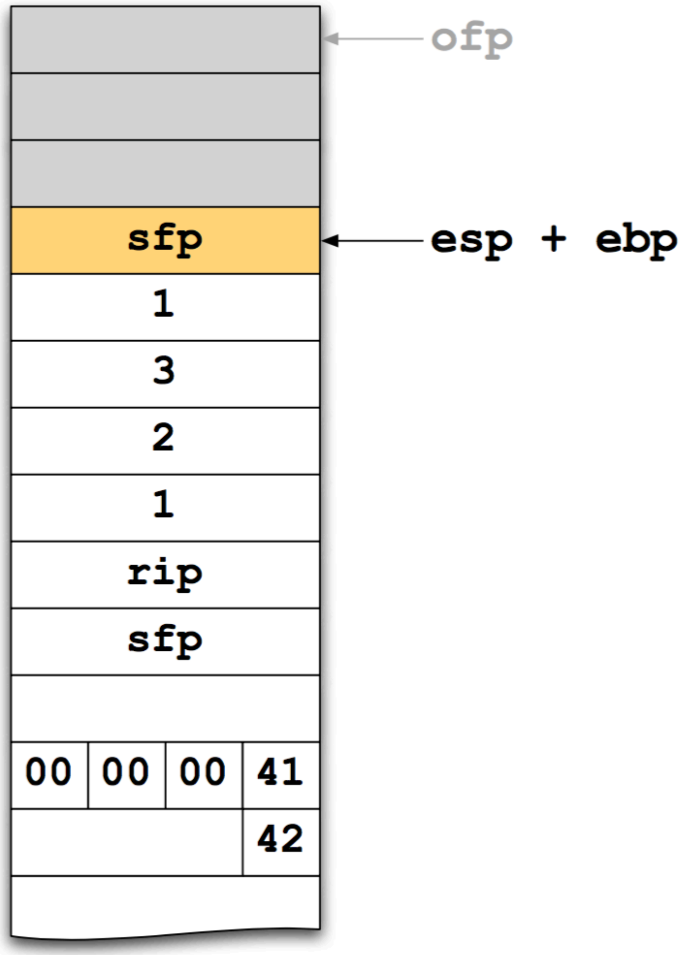

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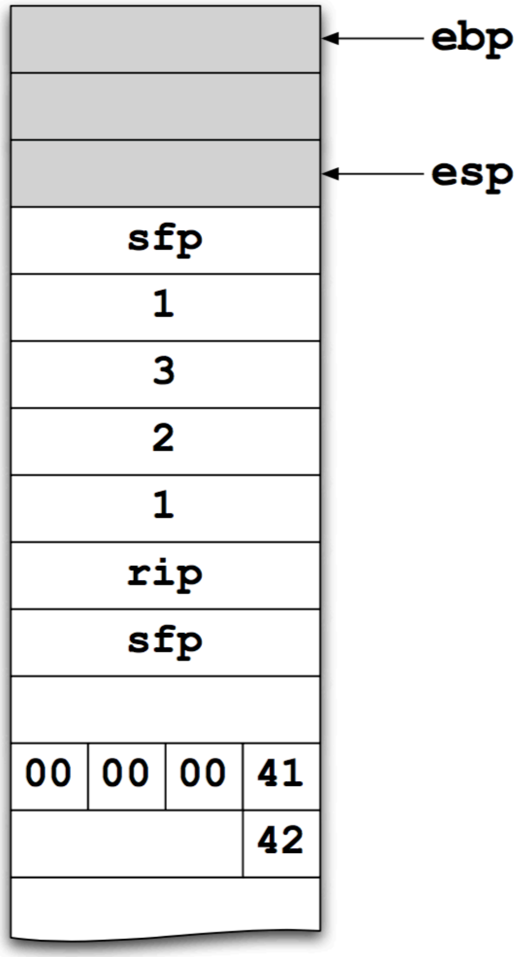

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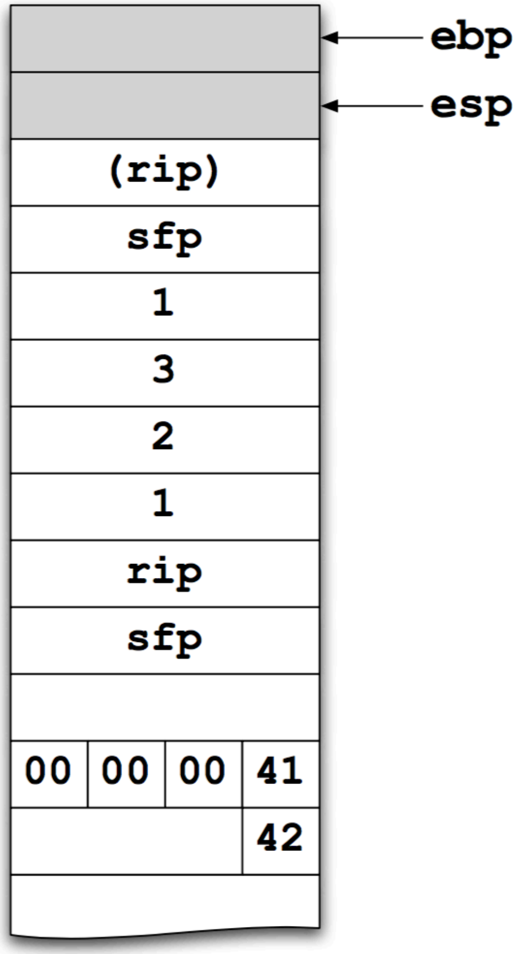
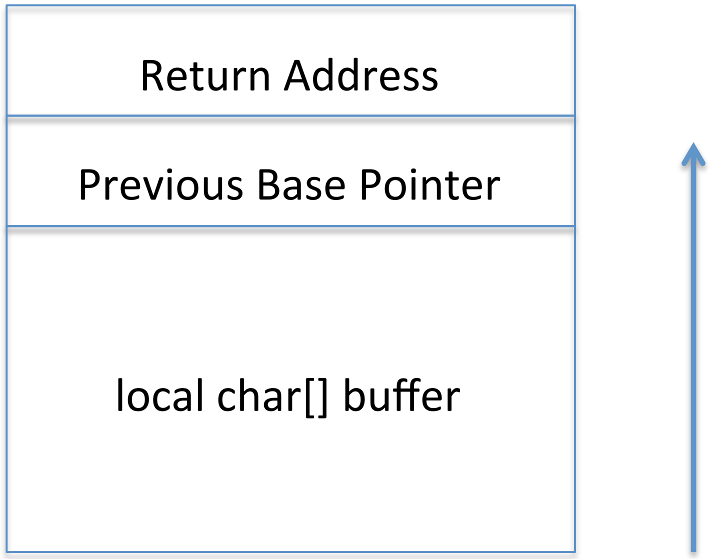


Buffer Overflow

- C is not memory safe, many functions can write past buffers
  - Ex: strcpy(), gets(), etc



Writing past length of char[] buffer
will begin to overwrite things on the stack like
previous base pointer and return address

Overwriting return address can allow program to
Jump to wherever attacker wants