More x86-64, Assembly Lab

Condition Codes

- `cmpq op2, op1` # computes result = op1 - op2, discards result, sets condition codes
- `testq op2, op1` # computes result = op1 & op2, discards result, sets condition codes

- Condition Codes - ***ZF*** *(zero flag),* ***SF*** *(sign flag),* ***OF*** *(overflow flag, signed), and* ***CF*** *(carry flag, unsigned)*

https://web.stanford.edu/class/archive/cs/cs107/cs107.1212/guide/x86-64.html

Using Condition Codes: Jumping

Don't worry too much about these!

- `j*` Instructions
  - Jumps to *target* (an address) based on condition codes

Instruction	Condition	Description
jmp *target*	`1`	Unconditional
je *target*	`ZF`	Equal / Zero
jne *target*	`~ZF`	Not Equal / Not Zero
js *target*	`SF`	Negative
jns *target*	`~SF`	Nonnegative
jg *target*	`~(SF^OF)&~ZF`	Greater (Signed)
jge *target*	`~(SF^OF)`	Greater or Equal (Signed)
jl *target*	`(SF^OF)`	Less (Signed)
jle *target*	`(SF^OF)|ZF`	Less or Equal (Signed)
ja *target*	`~CF&~ZF`	Above (unsigned ">")
jb *target*	`CF`	Below (unsigned "<")

- `set*` Instructions
  - Set low-order byte of `dst` to 0x00 or 0x01 based on condition codes
  - Does not alter remaining 7 bytes

Instruction	Condition	Description
sete *dst*	`ZF`	Equal / Zero
setne *dst*	`~ZF`	Not Equal / Not Zero
sets *dst*	`SF`	Negative
setns *dst*	`~SF`	Nonnegative
setg *dst*	`~(SF^OF)&~ZF`	Greater (Signed)
setge *dst*	`~(SF^OF)`	Greater or Equal (Signed)
setl *dst*	`(SF^OF)`	Less (Signed)
setle *dst*	`(SF^OF)|ZF`	Less or Equal (Signed)
seta *dst*	`~CF&~ZF`	Above (unsigned “>”)
setb *dst*	`CF`	Below (unsigned “<”)

Exercise 1

```
int compound(int x, int y)
{
  ____________
     return 1;
  else
    return 2;
}
```

```
compound:
        cmpl $-48, %edi
        jl .L3
        movl $1, %eax
        ret
.L3:
        movl    $2, %eax
        ret
```

Exercise 1

```
int compound(int x, int y)
{
  if(x > -49)
      return 1;
  else
    return 2;
}
```

```
compound:
        cmpl $-48, %edi
        jl .L3
        movl $1, %eax
        ret
.L3:
        movl    $2, %eax
        ret
```

Exercise 2

```
…
…
movl $0xABCD, %eax
movl $0x1BCD, %edi
cmpl %edi, %eax
setg %al
…
…
```

- What is the final value of %al?
  - 0000 0001
- What is the final value of %eax?
  - 0xAB**01**

Exercise 3

```
int compound(int x, int y, int *z)
{
    if(_____){
        if (_____){
            x = _____;
        }
        else if(_____){
            y = _____;
        }
        else{
            y = _____;
        }
    }
    return x + y;
}
```

```
compound:
        cmpl    %esi, %edi
        jle     .L2
        cmpl    $5, %esi
        jle     .L3
        addl    $3, %edi
.L2:
        leal    (%rdi,%rsi), %eax
        ret
.L3:
        cmpl    %esi, 4(%rdx)
        je      .L4
        addl    %edi, %esi
        jmp     .L2
.L4:
        addl    $5, %esi
        jmp     .L2
```

Exercise 3

```
int compound(int x, int y, int *z)
{
    if(x > y){
        if (y > 5){
            x = x + 3;
        }
        else if(y != *(z+1)){
            y = y + x;
        }
        else{
            y = y + 5;
        }
    }
    return x + y;
}
```

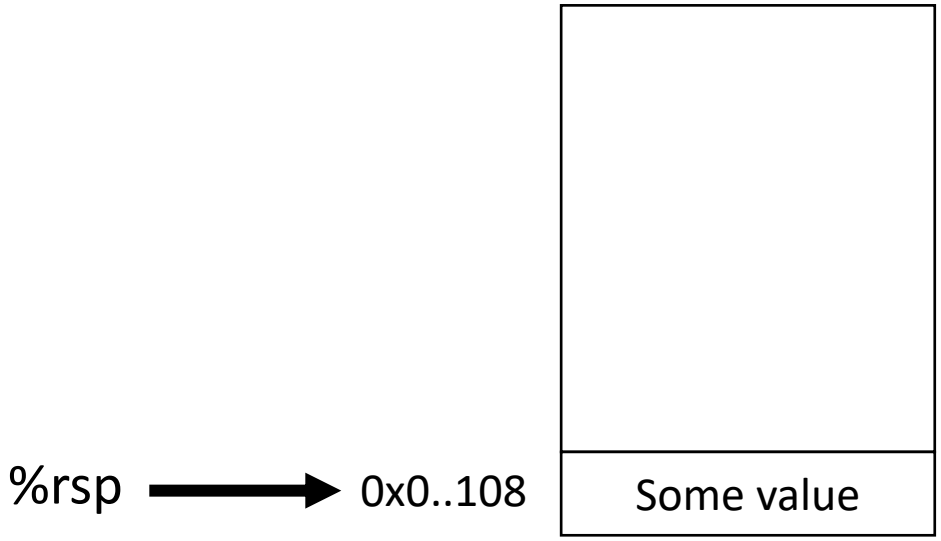
```
compound:
        cmpl    %esi, %edi
        jle     .L2
        cmpl    $5, %esi
        jle     .L3
        addl    $3, %edi
.L2:
        leal    (%rdi,%rsi), %eax
        ret
.L3:
        cmpl    %esi, 4(%rdx)
        je      .L4
        addl    %edi, %esi
        jmp     .L2
.L4:
        addl    $5, %esi
        jmp     .L2
```

Push and Pop to Memory stack

```
pushq %rbp
```

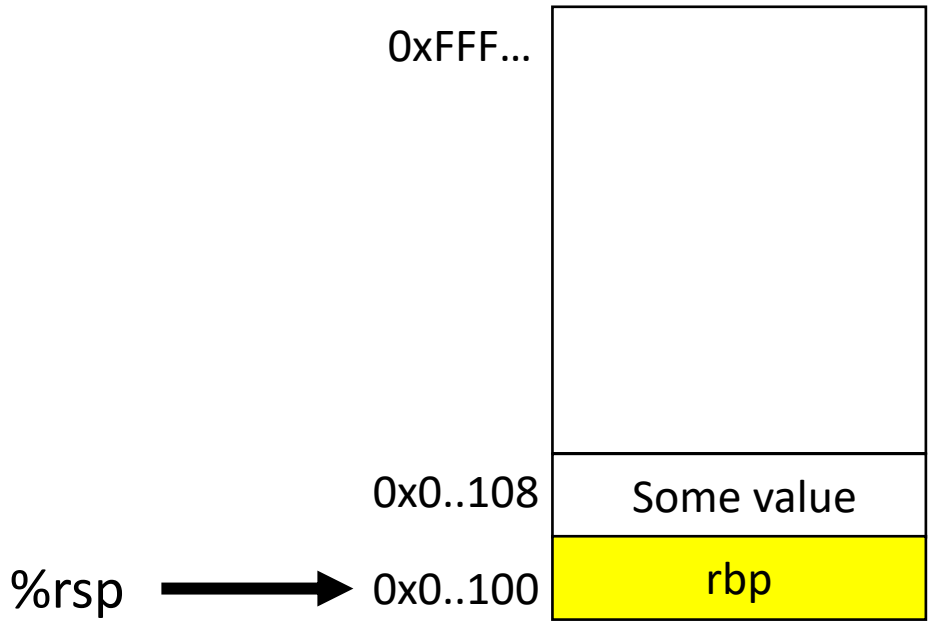
…

…



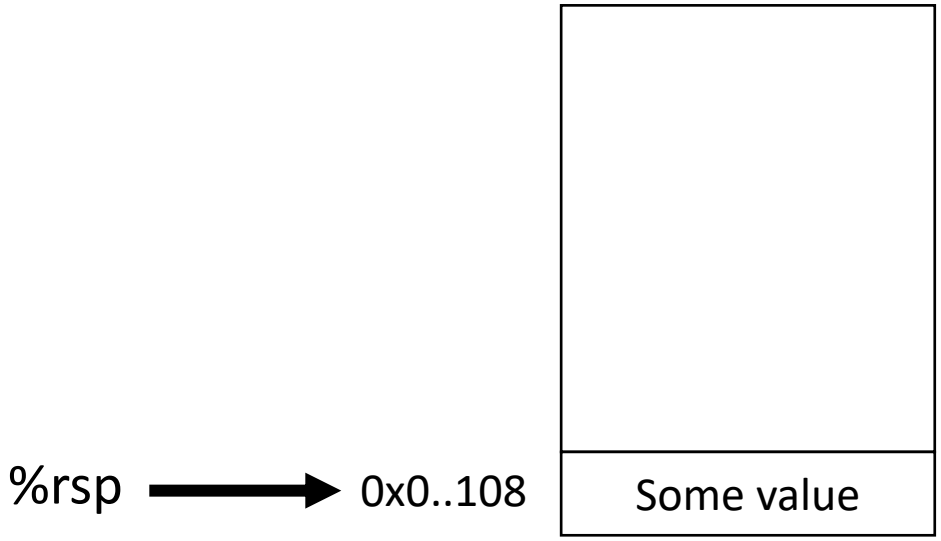
Push and Pop to Memory stack

```
pushq %rbp
…
…
pop %rbp
```



Push and Pop to Memory stack

```
pushq %rbp
…
…
pop %rbp
```



echo:

24 bytes (decimal)

```
000000000040069c <echo>:
  40069c:  48 83 ec 18           sub    $0x18,%rsp
  4006a0:  48 89 e7              mov    %rsp,%rdi
  4006a3:  e8 a5 ff ff ff        callq  40064d <gets>
  4006a8:  48 89 e7              mov    %rsp,%rdi
  4006ab:  e8 50 fe ff ff        callq  400500 <puts@plt>
  4006b0:  48 83 c4 18           add    $0x18,%rsp
  4006b4:  c3                    retq
```

After echo() finishes execution, the return address 4006c3 is popped from the stack

call_echo:

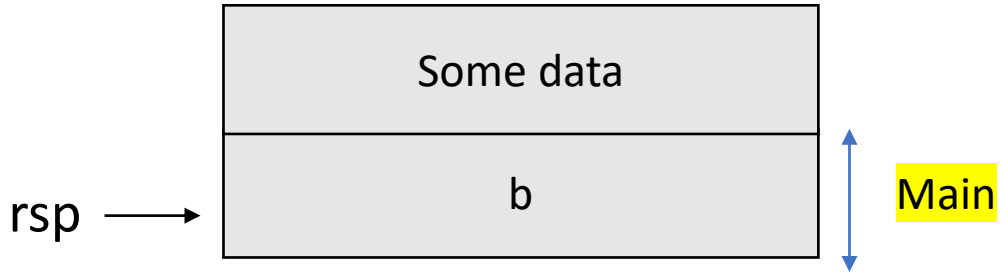
return address

```
  4006b5:  48 83 ec 08           sub    $0x8,%rsp
  4006b9:  b8 00 00 00 00        mov    $0x0,%eax
  4006be:  e8 d9 ff ff ff        callq  40069c <echo>
  4006c3:  48 83 c4 08           add    $0x8,%rsp
  4006c7:  c3                    retq
```

call to function echo() pushes the return address 4006c3 to the stack

Functions and Memory Stack

```
int add(int x, int y)
{  return x+y;
}
int double_sum(int x, int y){
return 2*add(x,y);
}
int main() {
int b = double_sum(10, 20);
return 0;
}
```



Functions and Memory Stack

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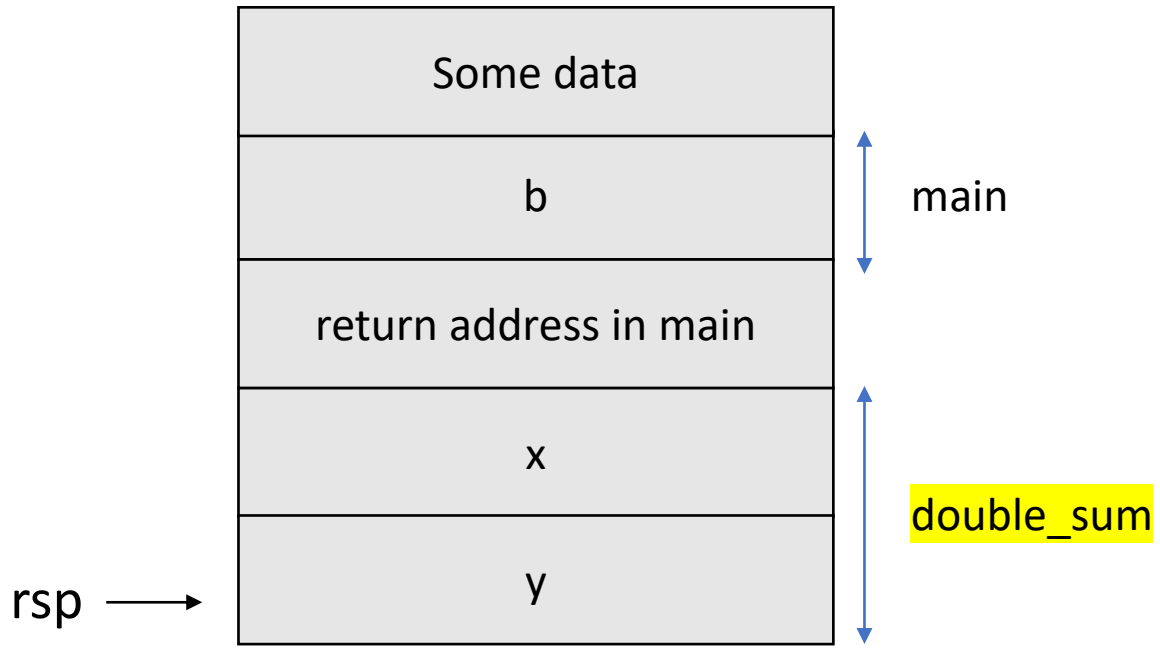

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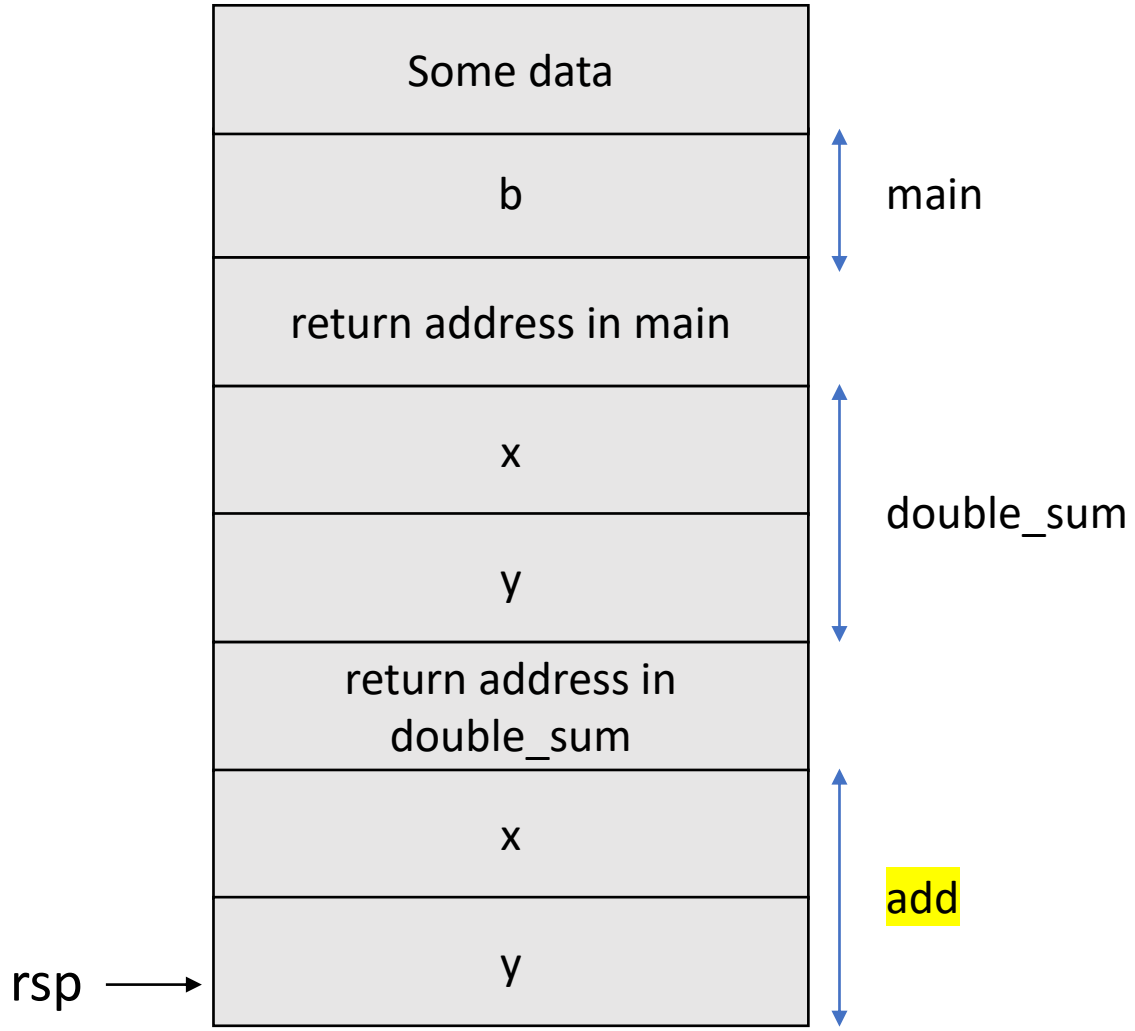

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return 0;
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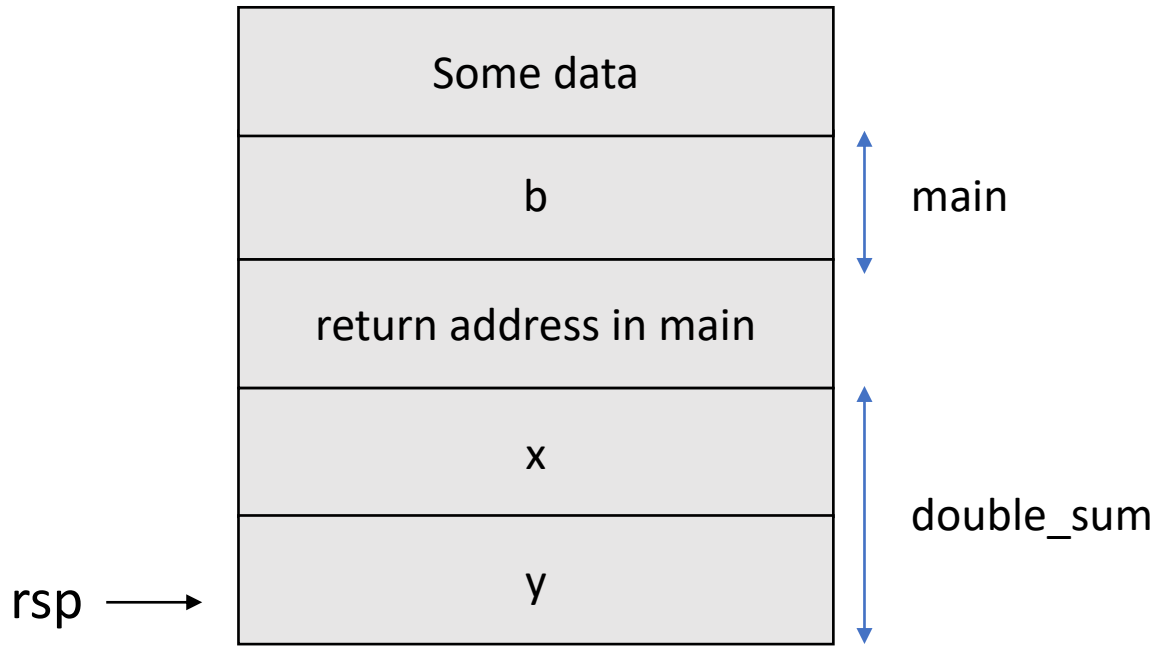
```



Functions and Memory Stack

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}
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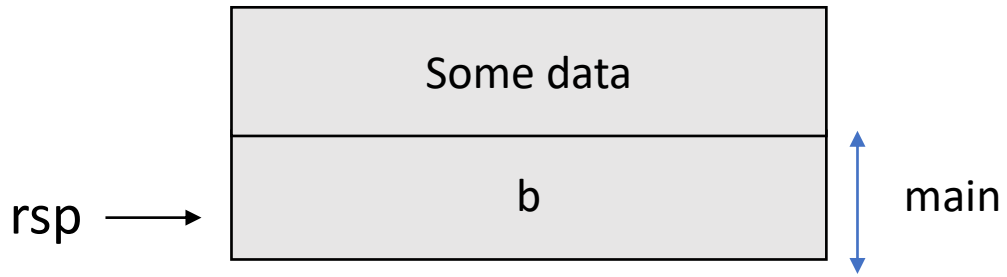

Functions and Memory Stack


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int double_sum(int x, int y){
return 2*add(x,y);
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int main() {
int b = double_sum(10, 20);
return 0;
}
```

Reverse Engineering a x86 code to C code - I

```
.LFBO
    pushq   %rbp
    movq    %rsp,%rbp
    movl    %edi,-4(%rbp)
    movl    %esi,-8(%rbp)
    movl    -4(%rbp),%eax
    cmpl    -8(%rbp),%eax
    jg      .L2
    movl    -8(%rbp),%eax
    jmp     .L3
.L2:
    movl    -4(%rbp),%eax
.L3:
    popq    %rbp
    ret
```

Step 1

```
int LFBO (int edi, int esi)
{
    rbp = rsp
    [rbp - 4] = edi
    [rbp - 8] = esi
    eax = [rbp - 4]
    if (eax > [rbp - 8]) goto L2
    eax = [rbp - 8]
    goto L3
L2:
    eax = [rbp - 4]
L3:
    return eax
}
```

https://stackoverflow.com/questions/28490124/reverse-engineer-assembly-code-to-c-code

Reverse Engineering a x86 code to C code - I

```
int LFBO (int edi, int esi)
{
    rbp = rsp
    [rbp - 4] = edi
    [rbp - 8] = esi
    eax = [rbp - 4]
    if (eax > [rbp - 8]) goto L2
    eax = [rbp - 8]
    goto L3
L2:
    eax = [rbp - 4]
L3:
    return eax
}
```

Step 2

```
int LFBO (int edi, int esi)
{
    int eax;

    eax = edi;
    if (eax > esi) goto L2;
    eax = esi;
    goto L3;
L2:
    eax = edi;
L3:
    return eax;
}
```

https://stackoverflow.com/questions/28490124/reverse-engineer-assembly-code-to-c-code

Reverse Engineering a x86 code to C code - I

```
int LFBO (int edi, int esi)
{
    int eax;

    eax = edi;
    if (eax > esi) goto L2;
    eax = esi;
    goto L3;
L2:
    eax = edi;
L3:
    return eax;
}
```

Step 3

```
int LFBO (int edi, int esi)
{
    if (edi <= esi) {
        return esi;
    }
    else {
        return edi;
    }
}
```

https://stackoverflow.com/questions/28490124/reverse-engineer-assembly-code-to-c-code

Reverse Engineering a x86 code to C code - I

```
int LFBO (int edi, int esi)
{
    if (edi <= esi) {
        return esi;
    }
    else {
        return edi;
    }
}
```

Step 4

```
int LFBO (int x, int y)
{
    if (x <= y) {
        return y;
    }
    else {
        return x;
    }
}
```

Step 5

```
int LFBO (int x, int y)
{
    return (x > y) ? x : y;
}
```

https://stackoverflow.com/questions/28490124/reverse-engineer-assembly-code-to-c-code

Reverse Engineer the following x86-64 code to C code

```
0000000000001129 <add>:
    1129:       f3 0f 1e fa             endbr64
    112d:       55                      push   %rbp
    112e:       48 89 e5                mov    %rsp,%rbp
    1131:       89 7d ec                mov    %edi,-0x14(%rbp)
    1134:       89 75 e8                mov    %esi,-0x18(%rbp)
    1137:       c7 45 fc 00 00 00 00    movl   $0x0,-0x4(%rbp)
    113e:       eb 0e                   jmp    114e <add+0x25>
    1140:       83 7d ec 64             cmpl   $0x64,-0x14(%rbp)
    1144:       7e 04                   jle    114a <add+0x21>
    1146:       83 6d ec 0a             subl   $0xa,-0x14(%rbp)
    114a:       83 45 fc 01             addl   $0x1,-0x4(%rbp)
    114e:       83 7d fc 09             cmpl   $0x9,-0x4(%rbp)
    1152:       7e ec                   jle    1140 <add+0x17>
    1154:       8b 45 ec                mov    -0x14(%rbp),%eax
    1157:       5d                      pop    %rbp
    1158:       c3                      retq
```

Pseudocode 1

```
add (int edi, int esi)
{       rbp = rsp
        [rbp-0x14]= edi
        [rbp-0x18]= esi
        [rbp -0x4] = 0
        goto L1
        L3:if [rbp-0x14]<=$0x64
                goto L2
        [rbp-0x14]-= 0xa
        L2:[rbp -0x4] +=1
        L1:if [rbp -0x4] <=0x9
                goto L3
        eax = [rbp-0x14]
}
```

Pseudocode 1

```
add (int edi, int esi)
{       rbp = rsp
        [rbp-0x14]= edi
        [rbp-0x18]= esi
        [rbp -0x4] = 0
        goto L1
L3:     if [rbp-0x14]<=$0x64
                goto L2
        [rbp-0x14]-= 0xa
L2:     [rbp -0x4] +=1
L1:     if [rbp -0x4] <=0x9
                goto L3
        eax = [rbp-0x14]
}
```

Pseudocode 2

```
add(int edi, int esi)
{
        i = 0
        while i <= 0x9
        {
                if edi > 0x64
                        edi -= 0xa

                i ++
        }
        return edi
}
```

Pseudocode 2

```
add(int edi, int esi)
{
      i = 0
      while i <= 0x9{
            if edi > 0x64
                  edi -= 0xa


            i ++


      }
      return edi
}
```

C code

```
add (int x, int y)
{
      int i = 0;
      while (i <= 9){
            if (x > 100)
                  x -= 10;
            i ++;
      }
      return x;
}
```

Assembly Lab

- Refer to the Panopto video