15-213 Recitation 8: Midterm Review

Your TAs

Monday, March 2nd, 2020 (15-213, 18-213)

Wednesday, March 4th, 2020 (18-613)

Midterm Exam This Week

- **3 hours + 30 minutes for regrade requests**
- **Bring your ID!**
- **1 double-sided page of notes (in English)**
  - No preworked problems from prior exams
- **7 questions**

- **Report to the room**
  - Log in to the exam server using your andrew id
  - Present your CMU ID and cheat sheet to TA, who will then give you access to the server
  - Bring your notes sheet and some writing utensil!

Midterm Topics

- Arrays
- Cache
- Bit Operations
- Floating Point
- Stack
- Structs
- Assembly

Floating Point

- Given a floating point representation S EEE FFFF where S = significant bit, E = exponent bits, F = fraction bits, convert these to their proper decimal values

- **1 000 0000**
- **0 000 1111**
- **0 101 0110**
- **1 111 1111**

For normalized numbers:

M = 1.xxxx

E = exp - bias

For denormalized numbers:

M = 0.xxxx

E = 1 - bias

Bias = 2^(k-1)-1

$$v = (-1)^s M 2^E$$

$$E = exp - Bias$$

Floating Point

- Given a floating point representation S EEE FFFF where S = significant bit, E = exponent bits, F = fraction bits, convert these to their proper decimal values
- **1 000 0000: -0 (all zeroes, but sig bit = 1)**
- **0 000 1111: 15/64**
- **0 101 0110: 11/2**
- **1 111 1111: NaN**

Stack Manipulation

- **We execute:**

```
mov $0x15213, %rax
pushq %rax
```

- **For each of the following instructions, determine if they will result in the value 0x15213 being placed in %rcx?**

```
1) mov (%rsp), %rcx
2) mov 0x8(%rsp), %rcx
3) mov %rsp, %rcx
4) popq %rcx
```

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3) mov %rsp, %rcx
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```

Stack is memory

- **We execute:**

```
mov $0x15213, %rax
pushq %rax
popq %rax
```

- **If we now execute: `mov -0x8(%rsp), %rcx`**
  what value is in %rcx?
  1) 0x0 / NULL
  2) Seg fault
  3) Unknown
  4) 0x15213

Stack is memory

- **We execute:**

```
mov $0x15213, %rax
pushq %rax
popq %rax
```

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  what value is in %rcx?
  1) 0x0 / NULL
  2) Seg fault
  3) Unknown
  4) 0x15213

x86-64 Calling Convention

- What does the calling convention govern?
  1) How large each type is.
  2) How to pass arguments to a function.
  3) The alignment of fields in a struct.
  4) When registers can be used by a function.
  5) Whether a function can call itself.

x86-64 Calling Convention

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  4) When registers can be used by a function.
  5) Whether a function can call itself.

Register Usage

- The calling convention gives meaning to every register, describe the following 9 registers:

%rax
%rbx
%rcx
%rdx
%rsi
%rdi
%r8
%r9
%rbp

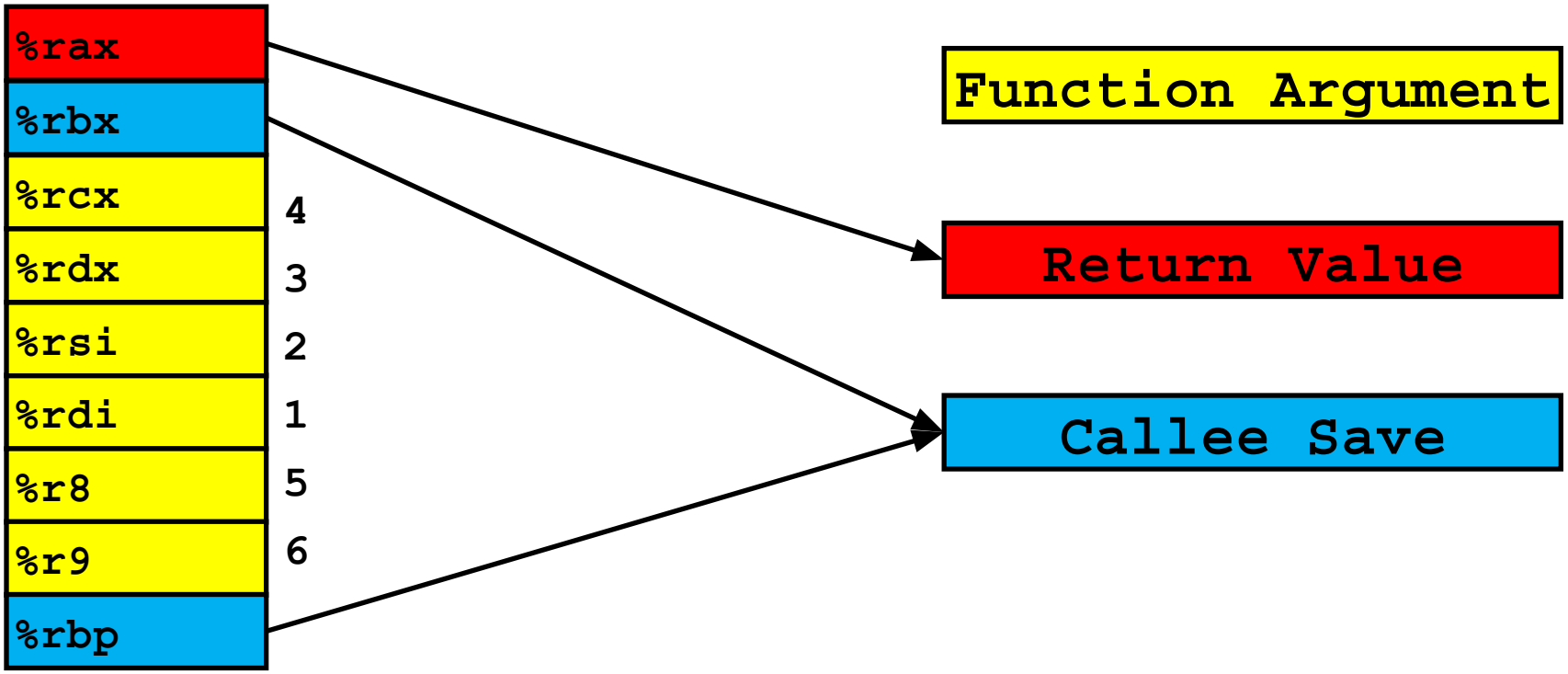
Function Argument

Return Value

Callee Save

Register Usage

- The calling convention gives meaning to every register, describe the following 9 registers:



Register Usage

- **Which line is the first violation of the calling convention?**

```
mov $0x15213, %rax
push %rax
mov 0x10(%rsp), %rcx
mov %rbx, %rax
pop %rdx
push %rax
pop %rbx
mov %rcx, %rbx
```

Register Usage

- **Which line is the first violation of the calling convention?**

Note: this is a function that was called (callee function)

```
mov $0x15213, %rax
push %rax
mov 0x10(%rsp), %rcx
mov %rbx, %rax
pop %rdx
push %rax
pop %rbx
mov %rcx, %rbx
```

Until this point, the callee has preserved the callee-save value.

Sometimes arguments are implicit

How many arguments does "rsr" take?

What do you think this function is doing? (Hint: its recursive)

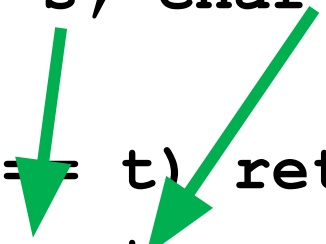
(Note, %sil is the low 8 bits of %rsi)

```
0x0400596 <+0>:     cmp    %sil,(%rdi,%rdx,1)
0x040059a <+4>:     je     0x4005ae <rsr+24>
0x040059c <+6>:     sub    $0x8,%rsp
0x04005a0 <+10>:    sub    $0x1,%rdx
0x04005a4 <+14>:    callq  0x400596 <rsr>
0x04005a9 <+19>:    add    $0x8,%rsp
0x04005ad <+23>:    retq
0x04005ae <+24>:    mov    %edx,%eax
0x04005b0 <+26>:    retq
```

Arguments can already be "correct"

- rsr does not modify s and t, so the arguments in those registers are always correct

```
int rsr(char* s, char t, size_t pos)
{
  if (s[pos] == t) return pos;
  return rsr(s, t, pos - 1);
}
```



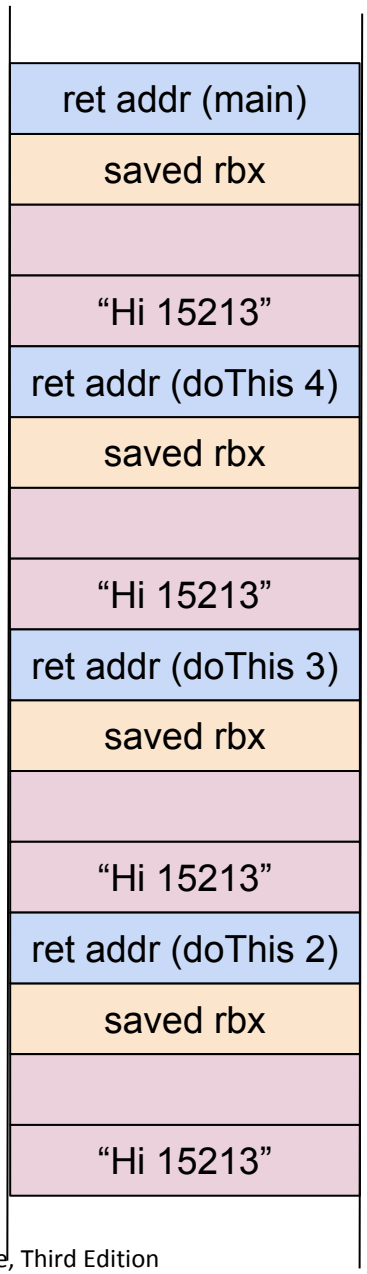
Recursive calls

- **Describe the stack after doThis(4) returns.**

```
void doThis(int count)
{
    char buf[8];
    strncpy(buf, "Hi 15213", sizeof(buf));
    if (count > 0) doThis(count - 1);
}
```

```
    push %rbx
    sub $0x10, %rsp
    mov    %edi,%ebx
    movabs $0x3331323531206948,%rax
    mov    %rax,(%rsp)
    ...
```

Recursive Calls



Struct Alignment

Char: 1 byte

Short: 2 byte

Int, Float: 4 bytes

Long, Double, Pointer: 8 bytes

```
struct foo {
    int *a;
    char b;
    char c;
    int d;
    short e;
    char buf[4];
};
```

How would this be represented? Discuss!

Struct Alignment

```
struct foo {
    int *a;
    char b;
    char c;
    int d;
    short e;
    char buf[4];
};
```

a	a	a	a	a	a	a	a
b	c	-	-	d	d	d	d
e	e	buf	buf	buf	buf	-	-

Struct Alignment

Char: 1 byte

Short: 2 byte

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```
struct foo {
    int *a;
    char b;
    char c;
    int d;
    short e;
    char buf[4];
};
```

```
struct bar {
    char g;
    int h;
    struct foo f;
    };
```

Now how do we represent bar?

Struct Alignment

```
struct foo {
    int *a;
    char b;
    char c;
    int d;
    short e;
    char buf[4];
};
```

```
struct bar {
    char g;
    int h;
    struct foo f;
    };
```

g	-	-	-	h	h	h	h
f.a	f.a	f.a	f.a	f.a	f.a	f.a	f.a
f.b	f.c	-	-	f.d	f.d	f.d	f.d
f.e	f.e	f.buf	f.buf	f.buf	f.buf	-	-