Recitation 8: Midterm Review

15-213: Introduction to Computer Systems
Oct 14, 2019

Instructor:

Your TA(s)

Midterm Exam This Week

- **3 hours + 1 hour 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**
  - TA will verify your notes and ID
  - TAs will give you your exam server password
  - Login via Andrew, then navigate to exam server and use special exam password

Midterm Topics

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

Stack Review

- **In the following questions, treat them like the exam**
  - Can you answer them from memory?
  - Write down your answer
  - Talk to your neighbor, do you agree?

- **Discuss:**

  What is the stack used for?

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:**

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mov $0x15213, %rax
pushq %rax
popq %rax
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  1) 0x0 / NULL
  2) Seg fault
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  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.

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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

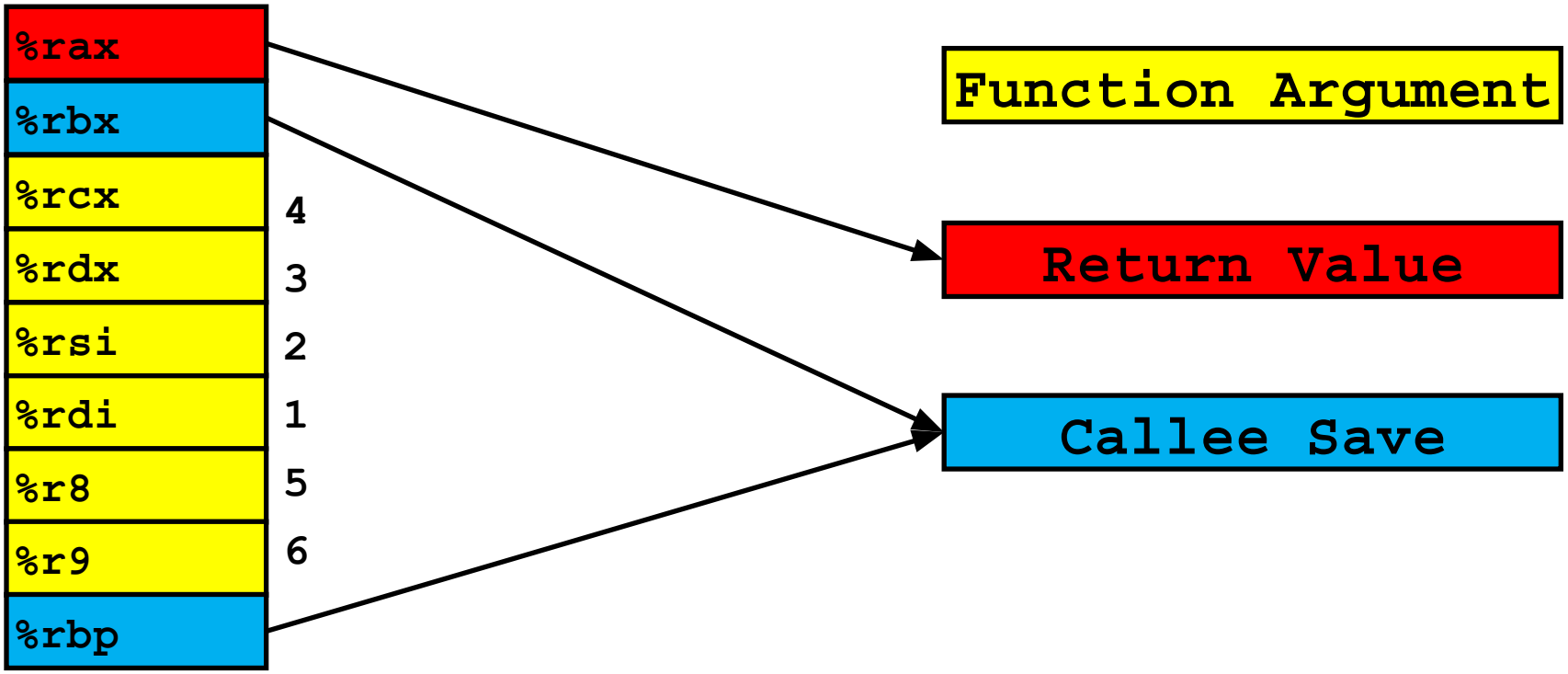
Function Argument

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?

```
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?

How many registers are changed before the function call?

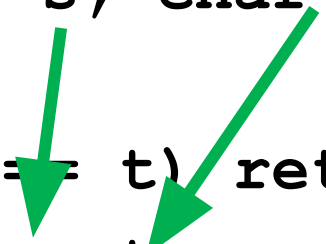
(Note, %sil is the low 8 bits of %rsi)

```
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);
}
```



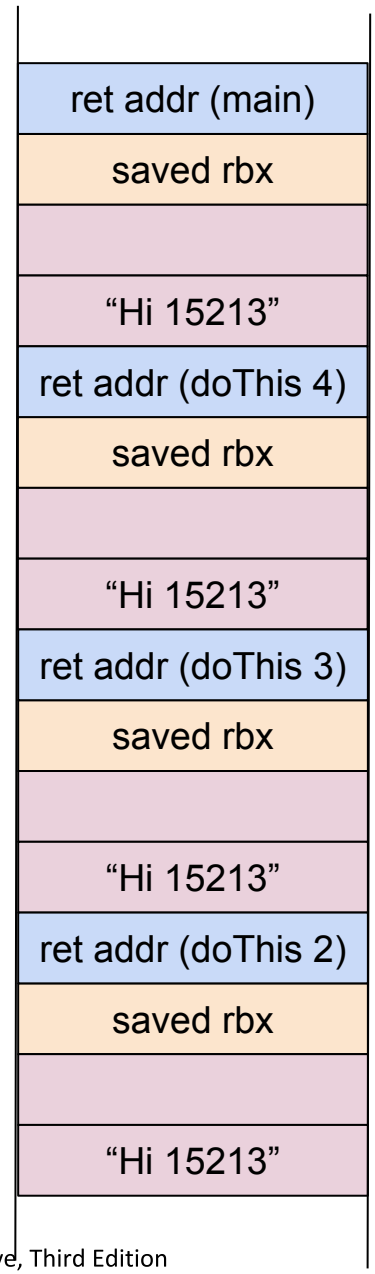
Recursive calls

- **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 *p;
    char b;
    char c;
    int x;
    short y;
    char[4] buf;
};
```

How would this be represented?

Struct Alignment

```
struct foo {
    int *p;
    char b;
    char c;
    int x;
    short y;
    char[4] buf;
};
```

p	p	p	p	p	p	p	p
b	c	-	-	x	x	x	x
y	y	buf	buf	buf	buf	-	-

Struct Alignment

Char: 1 byte

Short: 2 byte

Int, Float: 4 bytes

Long, Double, Pointer: 8 bytes

```
struct foo {
    int *p;
    char b;
    char c;
    int x;
    short y;
    char[4] buf;
};
```

```
struct bar {
    char a;
    int b;
    struct foo c;
};
```

Now how do we represent bar?

Struct Alignment

```
struct foo {
    int *p;
    char b;
    char c;
    int x;
    short y;
    char[4] buf;
};
```

```
struct bar {
    char a;
    int b;
    struct foo c;
};
```

a	-	-	-	b	b	b	b
c	c	c	c	c	c	c	c
c	c	c	c	c	c	c	c
c	c	c	c	c	c	c	c