

x86-64 Integer Registers

%rax	%eax
%rbx	%ebx
%rcx	%ecx
%rdx	%edx
%rsi	%esi
%rdi	%edi
%rsp	%esp
%rbp	%ebp

%r8	%r8d
%r9	%r9d
%r10	%r10d
%r11	%r11d
%r12	%r12d
%r13	%r13d
%r14	%r14d
%r15	%r15d

- Can reference low-order 4 bytes (also low-order 1 & 2 bytes)

Complete Memory Addressing Modes

■ Most General Form

D(Rb,Ri,S)

Mem[Reg[Rb]+S*Reg[Ri]+ D]

- D: Constant “displacement” 1, 2, or 4 bytes
- Rb: Base register: Any of 16 integer registers
- Ri: Index register: Any, except for `%rsp`
- S: Scale: 1, 2, 4, or 8 (*why these numbers?*)

■ Special Cases

(Rb,Ri)

Mem[Reg[Rb]+Reg[Ri]]

D(Rb,Ri)

Mem[Reg[Rb]+Reg[Ri]+D]

(Rb,Ri,S)

Mem[Reg[Rb]+S*Reg[Ri]]

Address Computation Instruction

■ `leaq Src, Dst`

- *Src* is address mode expression
- Set *Dst* to address denoted by expression

■ Uses

- Computing addresses without a memory reference
 - E.g., translation of `p = &x[i];`
- Computing arithmetic expressions of the form $x + k*y$
 - $k = 1, 2, 4, \text{ or } 8$

■ Example

```
long m12(long x)
{
    return x*12;
}
```

Converted to ASM by compiler:

```
leaq (%rdi,%rdi,2), %rax # t <- x+x*2
salq $2, %rax           # return t<<2
```

Some Arithmetic Operations

■ Two Operand Instructions:

Format *Computation*

<code>addq</code>	<i>Src, Dest</i>	$\text{Dest} = \text{Dest} + \text{Src}$
<code>subq</code>	<i>Src, Dest</i>	$\text{Dest} = \text{Dest} - \text{Src}$
<code>imulq</code>	<i>Src, Dest</i>	$\text{Dest} = \text{Dest} * \text{Src}$
<code>salq</code>	<i>Src, Dest</i>	$\text{Dest} = \text{Dest} \ll \text{Src}$
<code>sarq</code>	<i>Src, Dest</i>	$\text{Dest} = \text{Dest} \gg \text{Src}$
<code>shrq</code>	<i>Src, Dest</i>	$\text{Dest} = \text{Dest} \gg \text{Src}$
<code>xorq</code>	<i>Src, Dest</i>	$\text{Dest} = \text{Dest} \wedge \text{Src}$
<code>andq</code>	<i>Src, Dest</i>	$\text{Dest} = \text{Dest} \& \text{Src}$
<code>orq</code>	<i>Src, Dest</i>	$\text{Dest} = \text{Dest} \text{Src}$

Also called `shlq`

Arithmetic

Logical

■ Watch out for argument order!

■ No distinction between signed and unsigned int (why?)

Some Arithmetic Operations

■ One Operand Instructions

`incq` *Dest* $Dest = Dest + 1$

`decq` *Dest* $Dest = Dest - 1$

`negq` *Dest* $Dest = - Dest$

`notq` *Dest* $Dest = \sim Dest$

■ See book for more instructions

Condition Codes (Explicit Setting: Compare)

■ Explicit Setting by Compare Instruction

- `cmpq Src2, Src1`
- `cmpq b, a` like computing `a-b` without setting destination
- **CF set** if carry out from most significant bit (used for unsigned comparisons)
- **ZF set** if `a == b`
- **SF set** if `(a-b) < 0` (as signed)
- **OF set** if two's-complement (signed) overflow
`(a>0 && b<0 && (a-b)<0) || (a<0 && b>0 && (a-b)>0)`

Condition Codes (Explicit Setting: Test)

■ Explicit Setting by Test instruction

- `testq Src2, Src1`
 - `testq b, a` like computing `a&b` without setting destination
- Sets condition codes based on value of *Src1* & *Src2*
- Useful to have one of the operands be a mask
- **ZF set** when `a&b == 0`
- **SF set** when `a&b < 0`

Jumping

■ jX Instructions

- Jump to different part of code depending on condition codes

jX	Condition	Description
jmp	1	Unconditional
je	ZF	Equal / Zero
jne	$\sim ZF$	Not Equal / Not Zero
js	SF	Negative
jns	$\sim SF$	Nonnegative
jg	$\sim (SF \wedge OF) \ \& \ \sim ZF$	Greater (Signed)
jge	$\sim (SF \wedge OF)$	Greater or Equal (Signed)
jl	$(SF \wedge OF)$	Less (Signed)
jle	$(SF \wedge OF) \mid ZF$	Less or Equal (Signed)
ja	$\sim CF \ \& \ \sim ZF$	Above (unsigned)
jb	CF	Below (unsigned)

x86-64 Linux Register Usage #1

■ **%rax**

- Return value
- Also caller-saved
- Can be modified by procedure

■ **%rdi, ..., %r9**

- Arguments
- Also caller-saved
- Can be modified by procedure

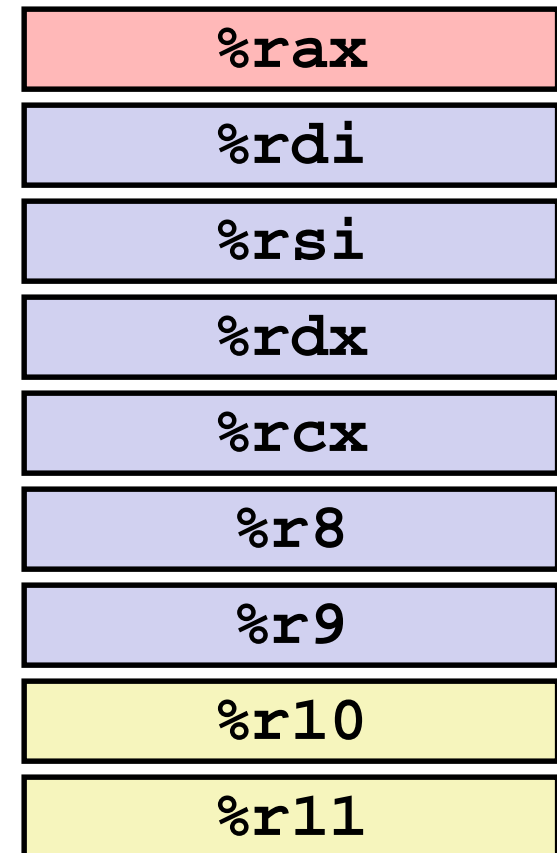
■ **%r10, %r11**

- Caller-saved
- Can be modified by procedure

Return value

Arguments

Caller-saved
temporaries



x86-64 Linux Register Usage #2

■ **%rbx, %r12, %r13, %r14**

- Callee-saved
- Callee must save & restore

■ **%rbp**

- Callee-saved
- Callee must save & restore
- May be used as frame pointer
- Can mix & match

■ **%rsp**

- Special form of callee save
- Restored to original value upon exit from procedure

