CS 24: Introduction to Computing Systems

x86-64 Reference

mov and lea Instructions

x86-64		C Pseudocode
mov %src, %dst	↔	%dst = %src
mov %src, $x(%dst)	↔	*(%dst + $x) = %src
mov $x(%src), %dst	↔	%dst = *(%src + $x)
mov $src, $x(%dst)	↔	*(%dst + $x) = $src
mov $x(%b, %i, $s), %dst	↔	%dst = *(%b + %i*$s + $x)
lea $x(%b, %i, $s), %dst	↔	%dst = %b + %i*$s + $x

Arithmetic Instructions

x86-64		C Pseudocode
add %src, %dst	↔	%dst += %src
sub %src, %dst	↔	%dst -= %src
imul %src, %dst	↔	%dst *= %src
idiv %denom	↔	%rax = (%rdx:%rax) / (%denom)
		%rdx = (%rdx:%rax) % (%denom)
xor %src, %dst	↔	%dst ^= %src
and %src, %dst	↔	%dst &= %src
or %src, %dst	↔	%dst |= %src
shl $by, %dst	↔	%dst <<= $by
shr $by, %dst	↔	%dst = ((unsigned) %dst) >> $by
sar $by, %dst	↔	%dst = ((signed) %dst) >> $by
sar %dst	↔	%dst = ((signed) %dst) >> 1

"Cast" Instructions

x86-64		C Pseudocode
movzbl (%src),%dst	↔	%dst = (uint32_t)*(uint8_t*)%src
movzwl (%src),%dst	↔	%dst = (uint32_t)*(uint16_t*)%src
movsbq (%src),%dst	↔	%dst = (int64_t)*(int8_t*)%src
movslq (%src),%dst	↔	%dst = (int64_t)*(int32_t*)%src
cltq	↔	%rax = (int64_t)%eax
cqto	↔	%rdx:%rax = (int128_t)%rax

Stack Instructions

x86-64		C Pseudocode
push %src	↔	%rsp -= sizeof(%src); *(%rsp) = %src
pop %dst	↔	%dst = *(%rsp); %rsp += sizeof(%dst)
ret	↔	%rip = *(%rsp); %rsp += 8
repz ret	↔	%rip = *(%rsp); %rsp += 8
call *addr*	↔	%rsp -= 8; *(%rsp) = %rip + $0x5; %rip = *addr*

Control Flow

The processor has a special register that contains “flags” which **`test`** sets.

`test` `%r1, %r2`

- `ZF` set to result of `(%r1 & %r2) == 0`
- `SF` set to result of `(%r1 & %r2) < 0`

The processor has a special register that contains “flags” which **`cmp`** sets.

`cmp` `%r1, %r2`

- `ZF` set to result of `(%r2 - %r1) == 0`
- `SF` set to result of `(%r2 - %r1) < 0`
- `CF` set to result of “there is an *unsigned* carry out when computing `%r2 - %r1`”
- `OF` set to result of “there is a *signed* overflow when computing `%r2 - %r1`”

The processor has a special register that contains “flags” which *arithmetic instructions* implicitly set.

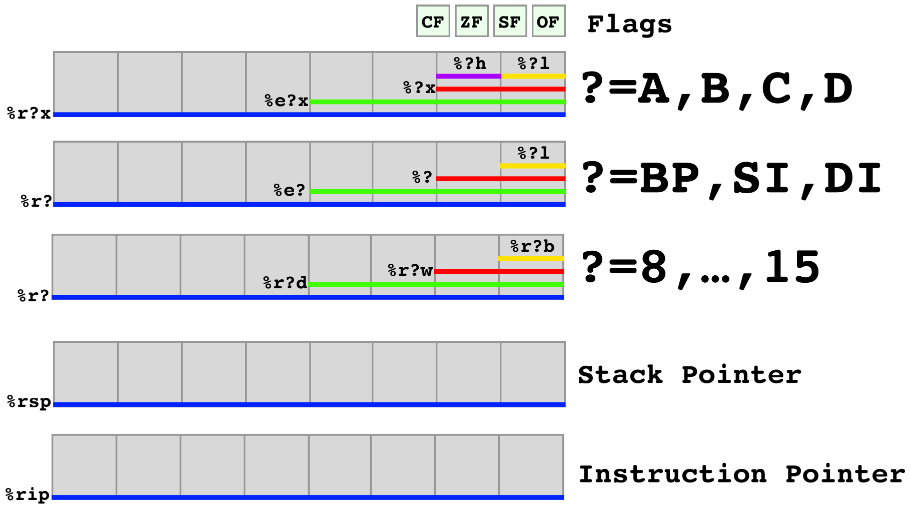
`add` `%r1, %r2`

- `ZF` set to result of `(%r2 + %r1) == 0`
- `SF` set to result of `(%r2 + %r1) < 0`
- `CF` set to result of “there is an *unsigned* carry out when computing `%r2 + %r1`”
- `OF` set to result of “there is a *signed* overflow when computing `%r2 + %r1`”

Suffix		Flag To Check		What It Means
___e	↔	`ZF`	↔	Zero
___ne	↔	`~ZF`	↔	Not Zero
___s	↔	`SF`	↔	Negative
___ns	↔	`~SF`	↔	Non-negative
___g	↔	`~(SF ^ OF) & ~ZF`	↔	Greater (signed)
___ge	↔	`~(SF ^ OF)`	↔	Greater or Equal (signed)
___l	↔	`(SF ^ OF)`	↔	Less (signed)
___le	↔	`(SF ^ OF) | ZF`	↔	Less or Equal (signed)
___a	↔	`~CF & ~ZF`	↔	Above (unsigned)
___b	↔	`CF`	↔	Below (unsigned)

x86-64		C Pseudocode
set___ `%r`	↔	`%r = FLAG`
cmov___ `%src, %dst`	↔	`%dst = %src` **`if`** `FLAG`
j___ *addr*	↔	`%rip =` *addr* **`if`** `FLAG`
jmp *addr*	↔	`%rip =` *addr*

Registers and x86-64 System V ABI



CF ZF SF OF Flags

%r?x %e?x %?x %?h %?l

?=A,B,C,D

%r? %e? %? %?l

?=BP,SI,DI

%r? %r?d %r?w %r?b

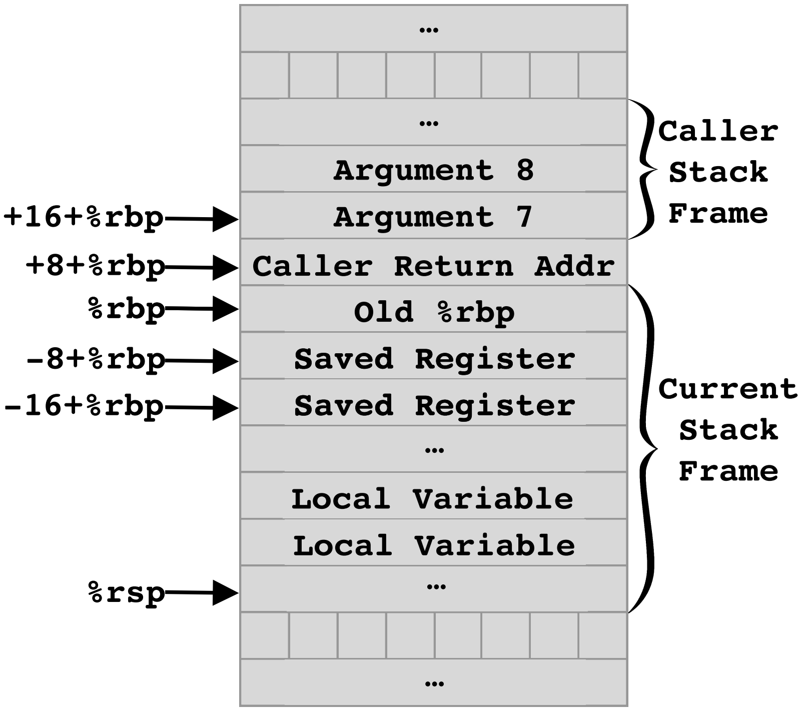
?=8,…,15

%rsp Stack Pointer

%rip Instruction Pointer

Return:	%rax
Arguments:	%rdi, %rsi, %rdx, %rcx, %r8, %r9
Caller-saved:	Arguments, %r10, %r11
Callee-saved:	%rbx, %rbp, %r12, %r13, %r14, %r15

Stack and x86-64 System V ABI



…

…

Argument 8

+16+%rbp Argument 7

+8+%rbp Caller Return Addr

%rbp Old %rbp

-8+%rbp Saved Register

-16+%rbp Saved Register

…

Local Variable

Local Variable

%rsp …

…

Caller Stack Frame

Current Stack Frame