Lecture 7: ALU operations, arithmetic

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February 10, 2020

601.229 Computer Systems Fundamentals



ALU operations

- ► ALU = "Arithmetic Logic Unit"
- ► An ALU is a hardware component within the CPU that does computations (of various kinds) on data values
 - Addition/subtraction
 - ► Logical operations (shifts, bitwise and/or/negation), etc.
- ▶ So, ALU instructions are the ones that do computations on values
 - ► Typically, ALU operates only on integer values
 - CPU will typically have floating-point unit(s) for operations on FP values

lea instruction

- ▶ lea stands for "Load Effective Address"
- ► Instructions that allow a memory reference as an operand generally do an address computation
 - ► E.g., movl 12(%rdx,%rsi,4), %eax
 - ► Computed address (for source memory location) is %rdx+(%rsi×4)+12
- ► The lea instruction computes a memory address, but does *not* access a memory location
 - ► E.g., leaq 12(%rdx, %rsi, 4), %rdi
 - ► Keep in mind we're not obligated to use the computed address as an address we can just use it as an integer
- ▶ In general, lea can do integer computations of the form p + (qS) + r where S is 0, 1, 2, 4, or 8
- ▶ lea does not set condition codes (e.g., on overflow)



Addition, subtraction

- add and sub instructions add and subtract integer values
- ► Two operands, second operand modified to store the result
- ► E.g.,

```
movq $1, %r9
movq $2, %r10
addq %r9, %r10
/* %r10 now contains the value 3 */
```

- Overflow is possible!
 - ► Can detect using condition codes

Increment, decrement

- ▶ inc and dec instructions increment or decrement by 1
- ▶ One operand, can be either register or memory
- **Examples**:

```
incq %rax    /* increment %rax by 1 */
incl 4(%rbp)   /* increment 32 bit value at addr %rbp+4 */
decq %rdi    /* decrement %rdi */
```

Overflow is possible, check condition codes

Shifts

- ▶ Left shift: sal
- ► Right shift: sar (arithmetic), shr (logical)
 - ▶ sar shifts in the value of the sign bit, shr shifts in zeroes
- **Examples**:

Bitwise logical operations

- ► Two-operand logical operations: and, or, xor
- Unary logical operation: not
- Examples:

Multiplication

- ► Two forms of imul instruction
- ► Two operand: multiply operands and truncate
 - **Example:**

- ► One operand: multiply 64 bit operand and value in %rax, 128-bit result in %rdx:%rax
 - ► Signed (imulq) and unsigned (mulq) variants
 - Example:



Division