X86_64

CS 2130: Computer Systems and Organization 1

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Announcements

- Homework 5 **due Monday at 11:59pm** on Gradescope

hello.s example

Instructions

(short acronyms for what we want to do, like mov, add, and, or, xor, neg)

Instructions have different versions depending on number of bits to use

- `movq` - 64-bit move (similar for addq, subq)
  - q = quad word

The instruction followed by how wide of the thing we want to do.

- `movl` - 32-bit move
  - l = long
- There are encodings for shorter things, but we will mostly see 32- and 64-bit

More powerful than our ISA

Instructions can move/operate between memory and register

- `movq %rax, %rcx` - register to register
  - Remember our icode 0
- `movq (%rax), %rcx` - memory to register
  - Remember our icode 3
- `movq %rax, (%rcx)` - register to memory
  - Remember our icode 4
- `movq $21, %rax` - Immediate to register
  - Remember our icode 6 (b=0)

Note: *at most one memory address per instruction*

We cannot do memory to memory calculations.

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Other Instructions

Other instructions work the same way

src dest

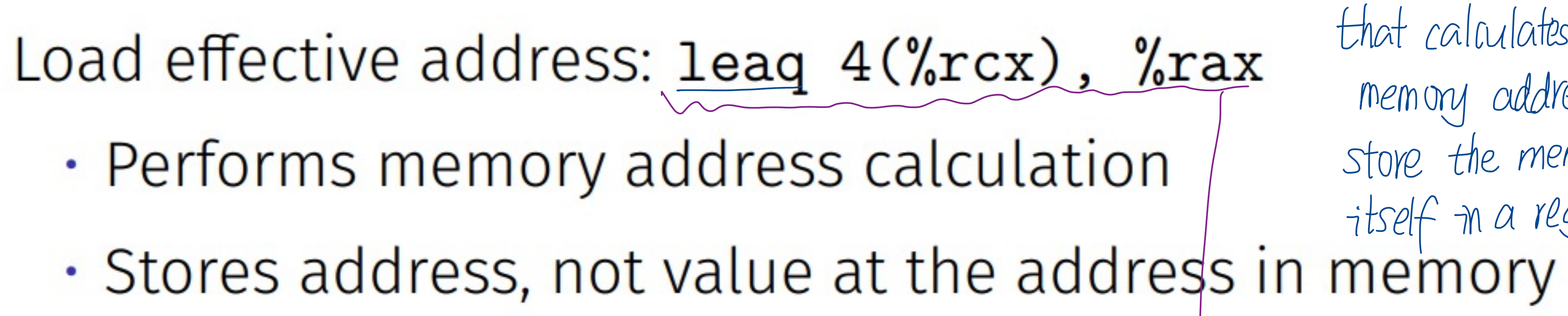
- **`addq %rax, %rcx`** — rcx += rax
- **`subq (%rbx), %rax`** — rax -= M[rbx]

  going to memory and get the value
- xor, and, and others work the same way!
- Assembly has virtually no 3-argument instructions
  - All will be modifying something (i.e., **+=**, **&=**, …)

    modify one of the inputs directly, doesn't have a seperate output.

Load Effective Address

I'm not going to the memory; "lea" is a special instruction that calculates the memory address and store the memory address itself in a register.



Load effective address: `leaq 4(%rcx), %rax`

- Performs memory address calculation
- Stores address, not value at the address in memory

%rax = %rcx + 4.

Jumps

`jmp foo`

- Unconditional jump to **foo**
- **foo** is a label or memory address
- Need **jmp*** to use register value (jump to a value in a register)

Conditional jumps

						unsigned			
jl,	**jle,**	**je,**	**jne,**	**jg,**	**jge,**	**ja,**	**jb,**	**js,**	**jo**
<	<=	==	!=	>	>=	above	below	If the signed bit is set.	If there's a overflow

Unlike our Toy ISA, these do not compare given register to 0

Jumps

We jump based on the result of some special registers called condition codes.

Condition codes - 4 1-bit registers set by every math operation, `cmp`, and `test`

- Result for the operation compared to 0 (if no overflow)
- Example:

```
addq $-5, %rax
// ...code that doesn't set condition codes...
je foo
```

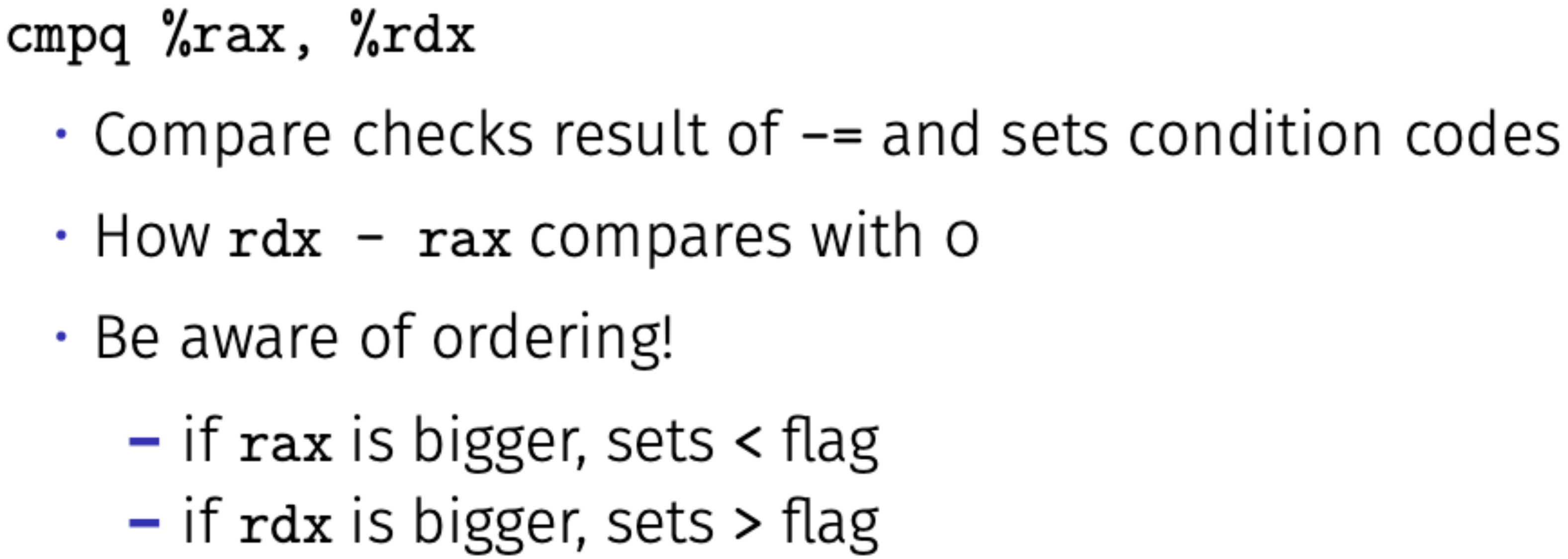
They don't have to be back to back.

→ You can do something like move things around.

jump will be based on the most recent thing that set the condition code.

  - Sets condition codes from doing math (subtract 5 from rax)
  - Tells whether result was positive, negative, 0, if there was overflow, ...
  - Then jump if the result of operation should have been = 0

Jumps: compare…



`cmpq %rax, %rdx`

- Compare checks result of -= and sets condition codes
- How `rdx - rax` compares with 0
- Be aware of ordering!
  - if `rax` is bigger, sets < flag
  - if `rdx` is bigger, sets > flag

Jumps: … and test

`testq %rax, %rdx`

- Sets the condition codes based on **`rdx & rax`**
- Less common

Neither save their result, just set condition codes!

test could be used to check if a register has 0 in it.

```
testq %rax, %rax
je  zero_case     //if rax==0
jne nonzero_case  //if rax!=0
```

Example: Loops

```
while (i < 10)
    i += 1
```

```
top: ← lable
    // check !condition, jump out
    if(i>=10) goto end
        i+=1;
    // jump back to condition
    go to top;
end : ← lable
```

```
main: ——————→ lable
      movq $0, %rax        // we set rax=0 for int i=0;

loop:
      cmp $10, %rax        // rax-10 = ?   { if rax<10, we got negtive, then do
                                           {     loop body.
      jge after                            { if rax >=10, we got positive or 0,
                                           {     then jump out the loop.
      addq $1, %rax
      jmp loop

after:
      retq        // return with a "q" because we're working with a 64
                  bit thing. (pop a 8-byte address and jump back to caller)
```

Function Calls: Calling Conventions

`callq myfun`

- Push return address, then jump to myfun
- Convention: Store arguments in registers and stack before call
  - First 6 arguments (in order): `rdi`, `rsi`, `rdx`, `rcx`, `r8`, `r9`
  - If more arguments, pushed onto stack (last to first)

`retq`

- Pop return address from stack and jump back
- Convention: store return value in `rax` before calling `retq`

This is similar to our Toy ISA's function calls in homework 4

More conventions, check readings.

Calling Conventions: Registers

The function I'm running currently and the function that I call are both sharing the same registers.

Why? Caller and callee share the same registers.

Calling conventions - recommendations for making function calls

- Where to put arguments/parameters for the function call?
- Where to put return value? in `rax` before calling `retq`
- What happens to values in the registers?
  - **Callee-save** - The function should ensure the values in these registers are unchanged when the function returns

    ① push the old values before calling ② pop the values before returning.
    - `rbx, rsp, rbp, r12, r13, r14, r15`
  - **Caller-save** - Before making a function call, save the value, since the function may change it