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

Instructions have different versions depending on number of bits to use

- `movq` - 64-bit move
  - `q` = quad word
- `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

Other Instructions

Other instructions work the same way

- `addq %rax, %rcx` — rcx += rax
- `subq (%rbx), %rax` — rax -= M[rbx]
- xor, and, and others work the same way!
- Assembly has virtually no 3-argument instructions
  - All will be modifying something (i.e., +=, &=, ...)

Load Effective Address

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

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

Jumps

`jmp foo`

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

Conditional jumps

- `jl`, `jle`, `je`, `jne`, `jg`, `jge`, `ja`, `jb`, `js`, `jo`

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

Jumps

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
```

  - 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!

Example: Loops

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

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

Calling Conventions: 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
    - `rbx`, `rsp`, `rbp`, `r12`, `r13`, `r14`, `r15`
  - **Caller-save** - Before making a function call, save the value, since the function may change it

Example: Functions

```
f(x,y):
    ...
    ...
    return 4



...
z = f(2,5)
```

The Stack

```
pushq %rax
popq %rdx
```

```
 .globl  main
main:
    pushq   %rbp

    # Set some example values in registers
    movq    $0x42, %rax
    movq    $0x15, %rbx
    movl    $4, %esi

    # Push 64-bit rax, then 16-bit si
    pushq   %rax
    pushw   %si

    # Pop -- oops!
    popq    %rdi
    popw    %si

    # Return 0 (all is well)
    xorq    %rax, %rax
    popq    %rbp
    retq
```

Most Common Instructions

- `mov` - =
- `lea` - load effective address
- `call` - push PC and jump to address
- `add` - +=
- `cmp` - set flags as if performing subtract
- `jmp` - unconditional jump
- `test` - set flags as if performing &
- `je` - jump iff flags indicate == 0
- `pop` - pop value from stack
- `push` - push value onto stack
- `ret` - pop PC from the stack

Debugger

Debugger - step through code!

- You will be using this for lab 7
- Experience seeing results of these instructions step-by-step
- **Please read the x86-64 summary reading before lab!**