bit level manipulations

- binary: get more precision over n-ary or smth
- and (&), or (|), not (~), xor (^)
- shifts
  - `x << y`
    - throw away extra bits at left
    - fill with 0s on right
  - `x >> y`
    - throw away extra bits at right
    - logical shift: fill with 0s on left
    - arithmetic shift: replicate sign bit on left
    - *undefined*: shift amtn < 0 or $\geq$ word size
- logical &&, `||`, `!`
  - views 0 as false, nonzero as true
  - returns 0 or 1

integers

- limits
  - `UMax` $= 2^w - 1$
  - `TMin` $= -2^{w-1}$
  - `TMax` $= 2^{w-1} - 1$
- `-x = ~x + 1` in twos complement
  - but if `x = Tmin` (most negative two's complement), you get back `Tmin`

casting integers

- constants are signed ints by default
  - specify `10U` for unsigned or `24L` for long
  - source of mistakes: make sure to, eg, `1ULL << 36`
- signed ⟷ unsigned: maintain bit pattern
  - may add/substract 2^w (`0b1000` is 8 unsigned, -8 signed.)
  - casting to larger? sign extend.
  - casting to smaller? drop significant bits.
- mix of signed and unsigned in expression (eg ==)? implicitly casted and evaled in unsigned.

byte order

…	0x100	0x101	0x110	0x111	…
…	01	23	45	67	…

Table 1: big endian

…	0x100	0x101	0x110	0x111	…
…	67	45	23	01	…

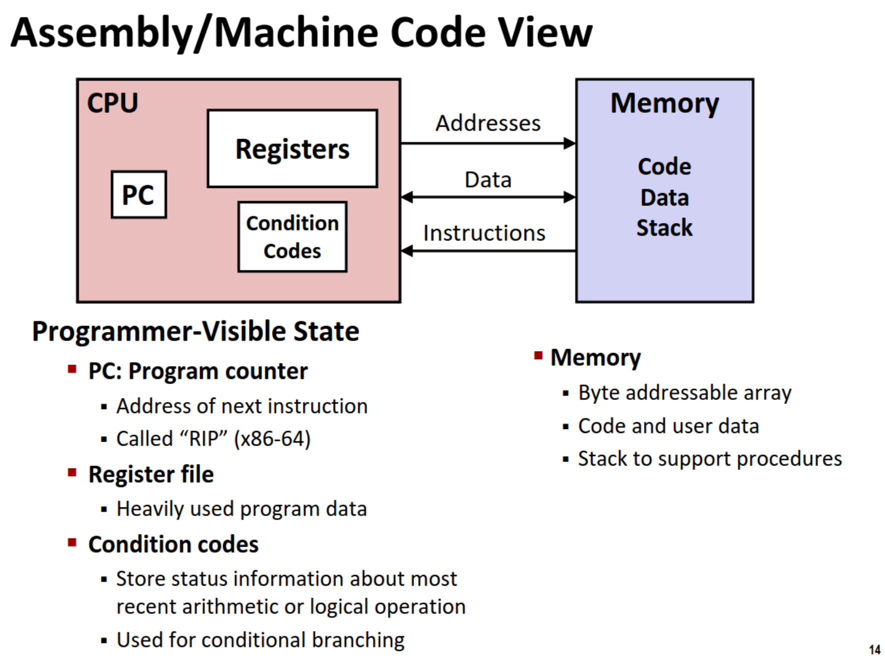
Table 2: little endian

history

- intel x86 processors
  - a Complex Instruction Set Computer (CISC), lots of instructions
  - Reduced: (RISC) can be fastish but esp good for low power
- architecture: processor design spec?? needed to know how to write assembly/machine code??

- microarchitecture: implementation of architecture
- machine code: byte-level programs processors exec.
- assembly code: text readable machine code

assembly/machine code view



Assembly/Machine Code View

CPU

PC

Registers

Condition Codes

Addresses

Data

Instructions

Memory

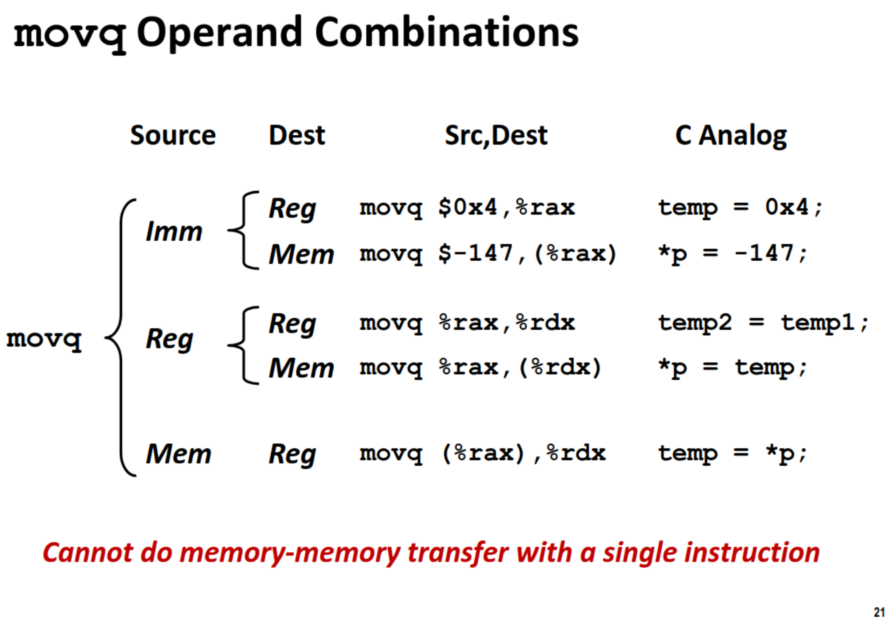
Code
Data
Stack

Programmer-Visible State

- **PC: Program counter**
  - Address of next instruction
  - Called "RIP" (x86-64)
- **Register file**
  - Heavily used program data
- **Condition codes**
  - Store status information about most recent arithmetic or logical operation
  - Used for conditional branching

- **Memory**
  - Byte addressable array
  - Code and user data
  - Stack to support procedures

- integer registers: prof: "compiler %rsp 64 bit, %esp 32 bit, compiler will spit out whichever is smaller and fits your data so b careful." also stuff like "%eax vs %ax vs %ah/%al"



movq Operand Combinations

	Source	Dest	Src,Dest	C Analog
movq	*Imm*	*Reg*	`movq $0x4,%rax`	`temp = 0x4;`
		Mem	`movq $-147,(%rax)`	`*p = -147;`
	Reg	*Reg*	`movq %rax,%rdx`	`temp2 = temp1;`
		Mem	`movq %rax,(%rdx)`	`*p = temp;`
	Mem	*Reg*	`movq (%rax),%rdx`	`temp = *p;`

Cannot do memory-memory transfer with a single instruction

- lea instruction
  - intended to calculate pointer to obj: eg array elem
  - compiler authors end up using it to do arithmetic
  - doesn't touch condition codes

- which registers are pointers?
  - %rsp (top of stack pointer) %rip (current instruction/program counter pointer) always pointers
  - pointers near stack pointer or program counter pointer *probably* also pointers.
  - `mov (%rsi), %rsi`: register used as pointer? value is probably pointer.
    - `(%rsi, %rbx)` one of these is a pointer, don't know which
    - `(%rsi, %rbx, 2)` rsi is a pointer, not rbx (why?)
    - `0x400570(, %rbx, 2)` 0x is pointer, not rbx (why?) (assume blank `,` is 0)
    - `lea (anything), %rax` idk bro
- control flow
  - lots of GOTOs. c0vm moment
- condition codes (status of recent tests): `CF, ZF, SF, OF`
  - set as side effect of arithmetic
  - Carry Flag: set if carry from unsigned overflow (or borrowing a 1 to make 0x0 - 0x1 work)
  - Zero Flag: get a 0
  - Sign Flag: t < 0
  - Overflow Flag: signed overflow
  - in GDB as eflags register (a flag isn't showing up? is set to 0.)
  - compare instruction (`cmp`)
    - computes `b-a` without setting `b`, unlike `sub`
    - used for `if` statments
  - `test` instruction
    - computes `b&a` (like `and`) wihtout setting `b`
    - used to compare `%rX` to 0 (`test %rX %rX`)
    - used to check if 1-bits are same in two registers, like normal & usage
  - `j...` instructions: jump to differnt parts depending on condition codes
    - `jmp, je, jne, jg, jge, etc`
  - `set...` these exist ig