Toy Instruction Set Architecture

CS 2130: Computer Systems and Organization 1
February 13, 2026

Announcements

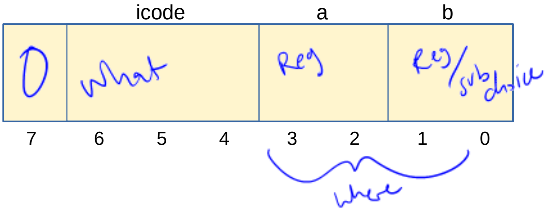
Feb 23

- Homework 3 due Monday on Gradescope
- Midterm 1 next Friday (February 20, 2026) in class
  - Written, closed notes
  - If you have SDAC, please schedule ASAP
- Review session in class next Wednesday

Encoding Instructions

Encoding of Instructions

- 3-bit icode (which operation to perform)
  - Numeric mapping from icode to operation
- Which registers to use (2 bits each)
- Reserved bit for future expansion



High-level Instructions

In general, 3 kinds of instructions

- **moves** - move values around without doing “work”
- **math** - broadly doing “work”
- **jumps** - jump to a new place in the code

Moves

icode	b	action
0		`rA = rB`
3	3	`rA = pc`
4		`rA` = read from memory at address `rB`
5		write `rA` to memory at address `rB`
6	0	`rA` = read from memory at `pc + 1`
	3	`rA` = read from memory at the address stored at `pc + 1`

Math

Broadly doing work

icode	b	meaning
1		`rA &= rB`
2		`rA += rB`
3	0	`rA = ~rA`
	1	`rA = !rA`
	2	`rA = -rA`
6	1	`rA` &= read from memory at `pc + 1`
	2	`rA` += read from memory at `pc + 1`

Note: We can implement other operations using these things!

Encoding Instructions

Example 2: `M[0x`~~82~~1A`] += r3`
Read memory at address `0x`~~82~~1A, add `r3`, write back to memory at same address

Instructions

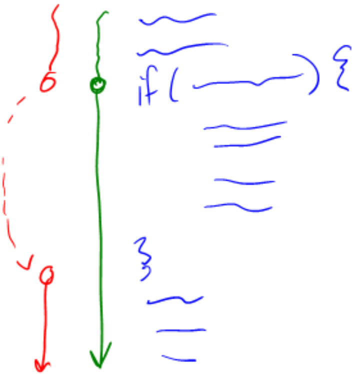
icode	b	meaning
0		`rA = rB`
1		`rA &= rB`
2		`rA += rB`
3	0	`rA = ~rA`
	1	`rA = !rA`
	2	`rA = -rA`
	3	`rA = pc`
4		`rA` = read from memory at address `rB`
5		write `rA` to memory at address `rB`
6	0	`rA` = read from memory at `pc + 1`
	1	`rA &=` read from memory at `pc + 1`
	2	`rA +=` read from memory at `pc + 1`
	3	`rA` = read from memory at the address stored at `pc + 1`
		For icode 6, increase `pc` by 2 at end of instruction
7		Compare `rA` as 8-bit 2's-complement to `0` if `rA <= 0` set `pc = rB` else increment `pc` as normal

Jumps

- Moves and math are large portion of our code
- We also need **control constructs**
  - Change what we are going to do next
  - `if`, `while`, `for`, functions, ...
- Jumps provide mechanism to perform these control constructs
- We jump by assigning a new value to the program counter `PC`

Jumps

For example, consider an `if`



Jumps

icode	meaning
7	Compare `rA` as 8-bit 2's-complement to `0` if `rA <= 0` set `pc = rB` else increment `pc` as normal

Instruction icode 7 provides a **conditional** jump

- Real code will also provide an **unconditional** jump, but a conditional jump is sufficient

Writing Code

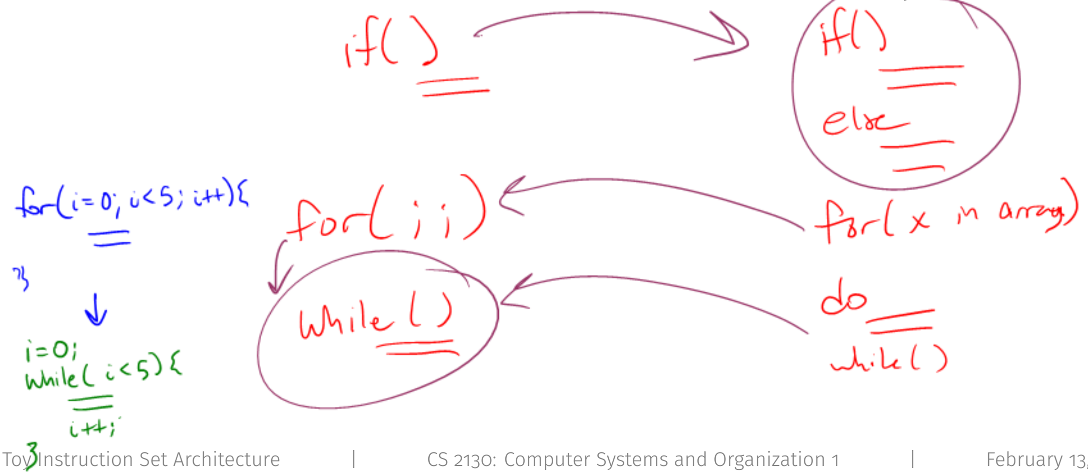
We can now write any* program!

- When you run code, it is being turned into instructions like ours
- Modern computers use a larger pool of instructions than we have (we will get there)

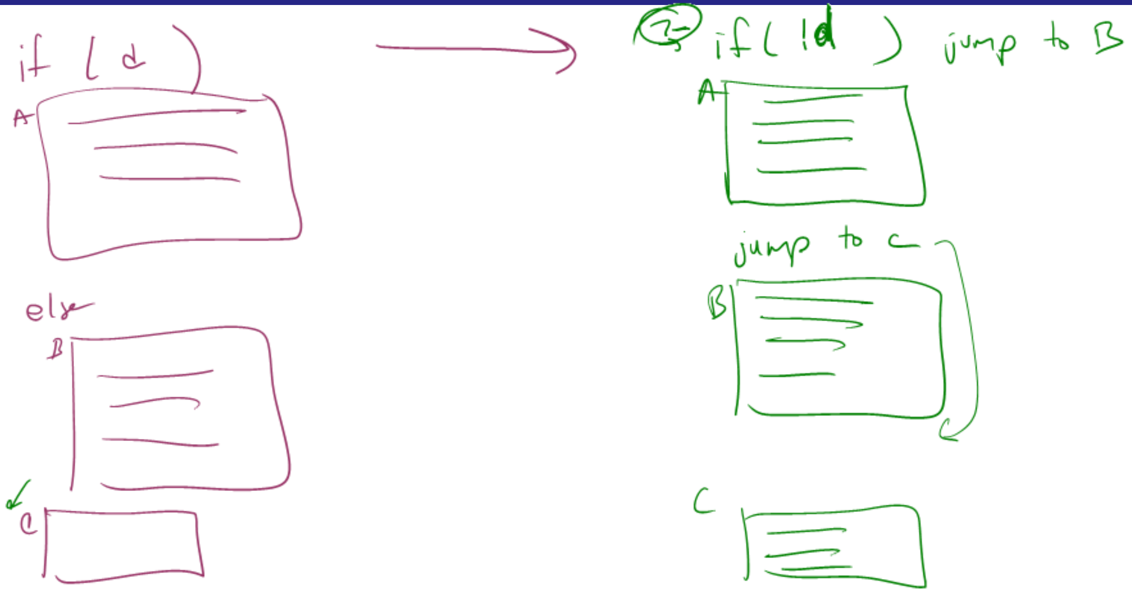
*we do have some limitations, since we can only represent 8-bit values and some operations may be tedious.

Our code to this machine code

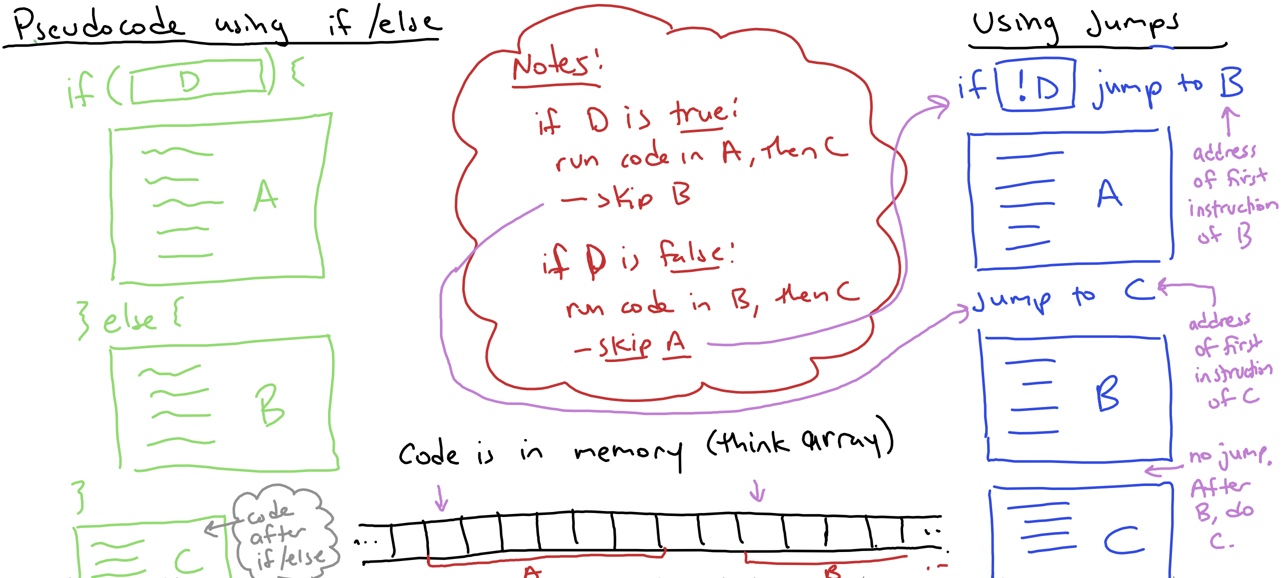
How do we turn our control constructs into jump statements?



if/else to jump



if/else to jump



while to jump