ISA + Arrays

CS 2130: Computer Systems and Organization 1

September 23, 2022

Announcements

- Homework 3 due Monday at 11pm on Gradescope
  - Please remember that homeworks are **individual** assignments if not stated otherwise on the assignment
  - Your code should be space-separated bytes as hex values
- Exam 1 next Friday (in class)
  - For SDAC accommodations, please schedule a time with their testing center

High-level Instructions

In general, 3 kinds of instructions

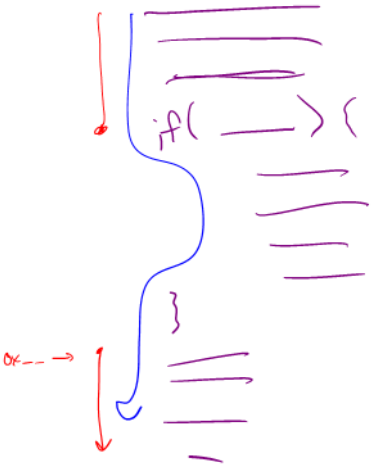
- **moves** - move values around without doing “work”
- **math** - broadly doing “work”
- **jumps** - jump to a new place in the code

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

Example 3-bit icode

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

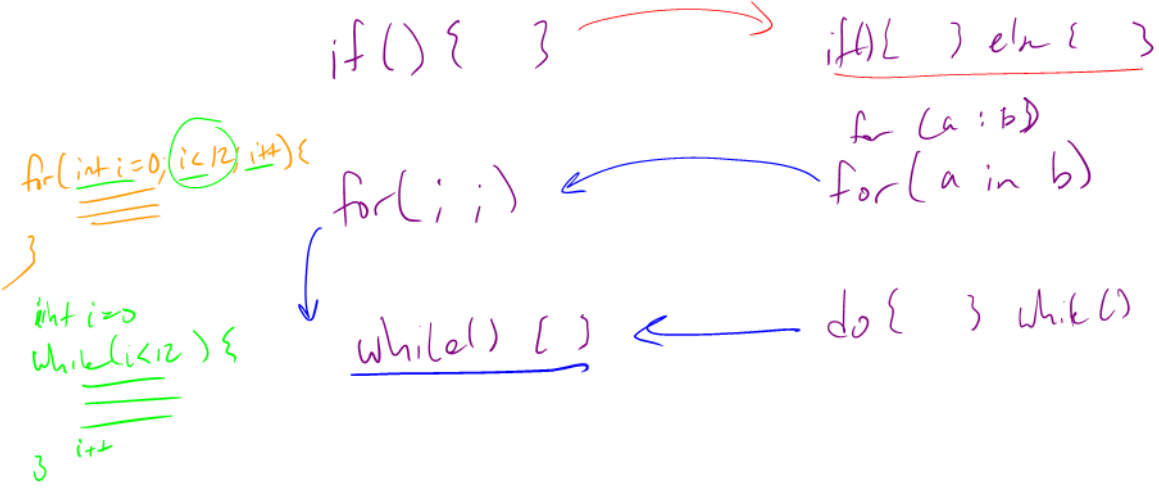
We can now write any* program!

- 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)

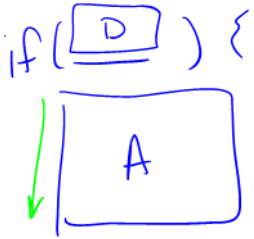
*we do have some limitations, since we can only represent 8-bit values and some operations may be tedious.

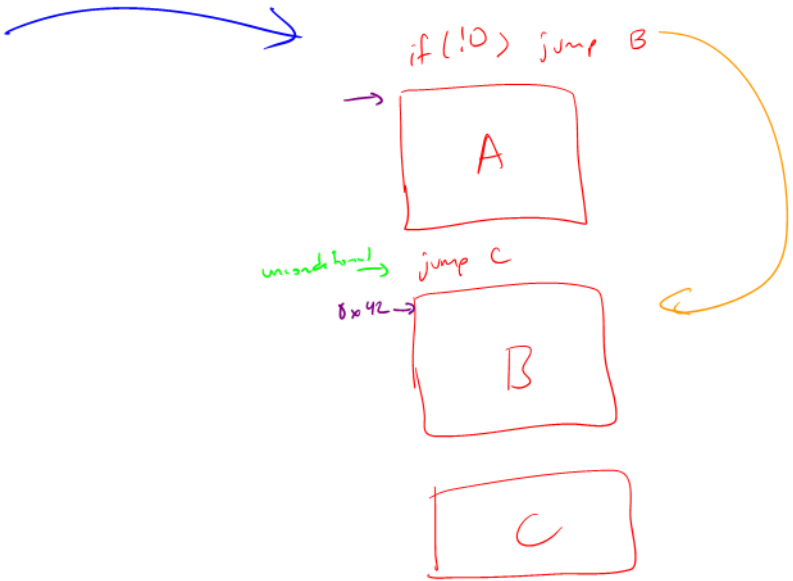
Our code to this machine code

How do we turn our control constructs into jump statements?

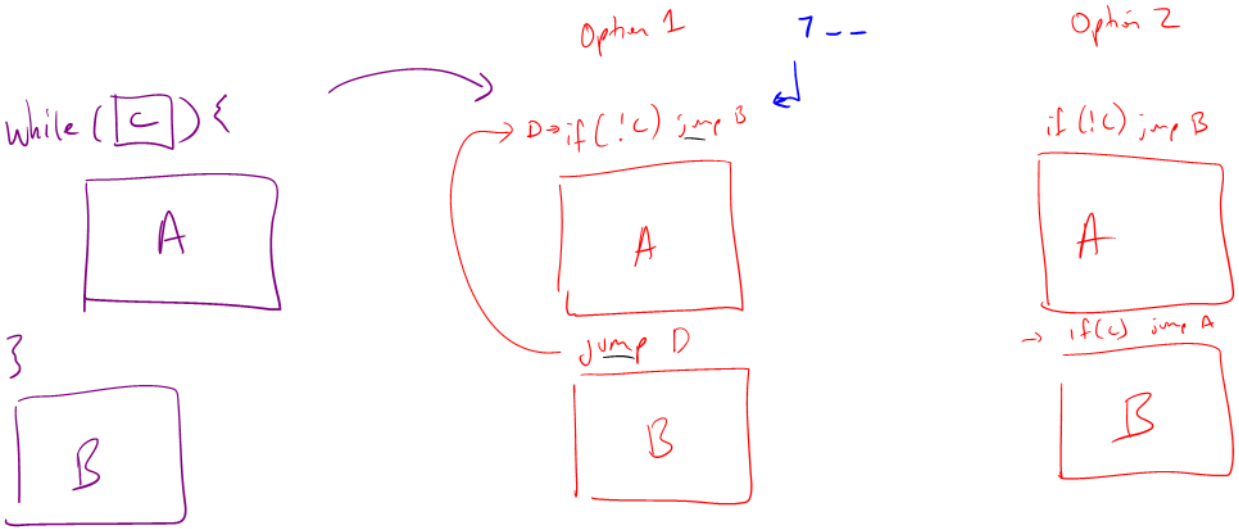


if/else to jump

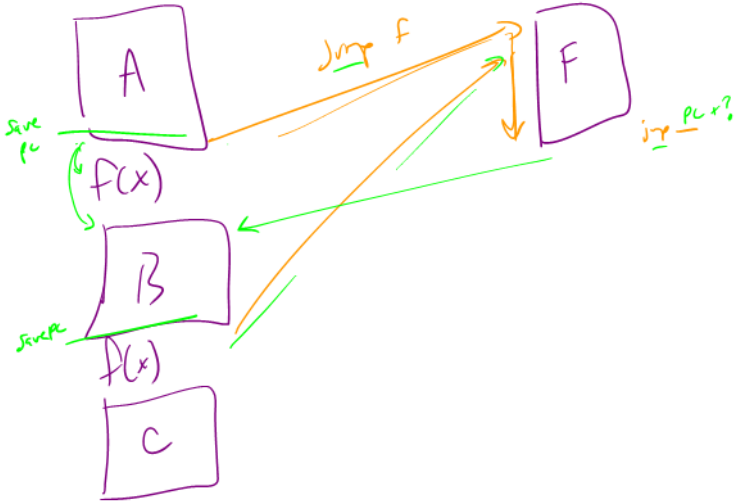




while to jump



Function Calls

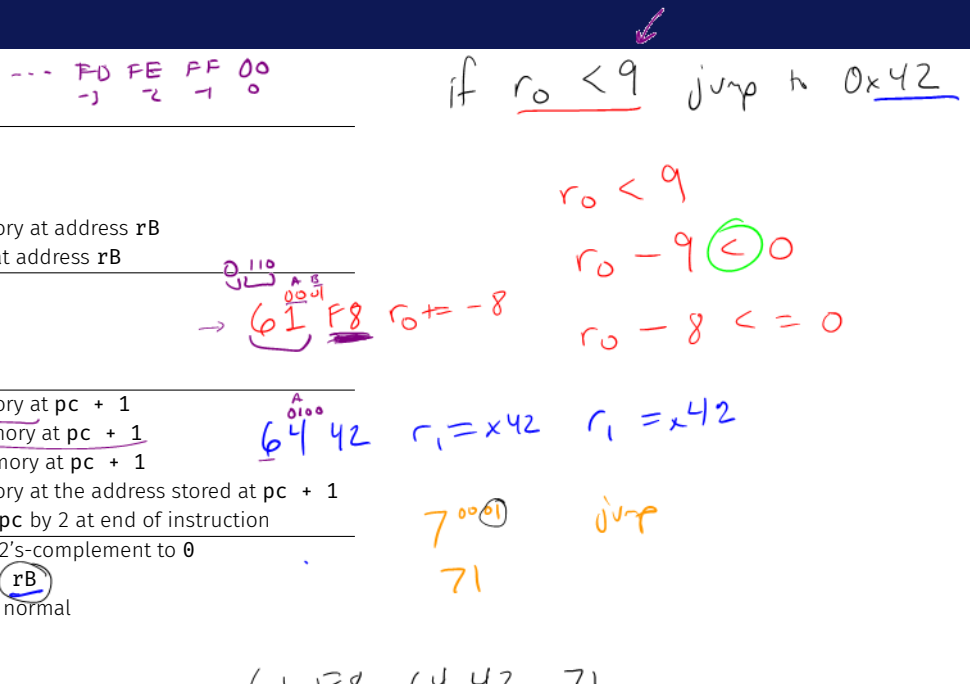


Encoding Instructions

Example 3: `if r0 < 9 jump to 0x42`

Instructions

icode	b	meaning
0		`rA = rB`
1		`rA += rB`
2		`rA &= rB`
3		`rA` = read from memory at address `rB`
4		write `rA` to memory at address `rB`
5	0	`rA = ~rA`
	1	`rA = -rA`
	2	`rA = !rA`
	3	`rA = pc`
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



Questions on Multiply

Memory

What kinds of things do we put in memory?

- Code: binary code like instructions in our example ISA
  - Intel/AMD compatible: x86_64
  - Apple Mx and Ax, ARM: ARM
  - And others!
- Variables: we may have more variables that will fit in registers
- Data Structures: organized data, collection of data
  - Arrays, lists, heaps, stacks, queues, ...

Dealing with Variables and Memory

What if we have many variables? Compute: `x += y`