OS 1/16

Reagan Shirk

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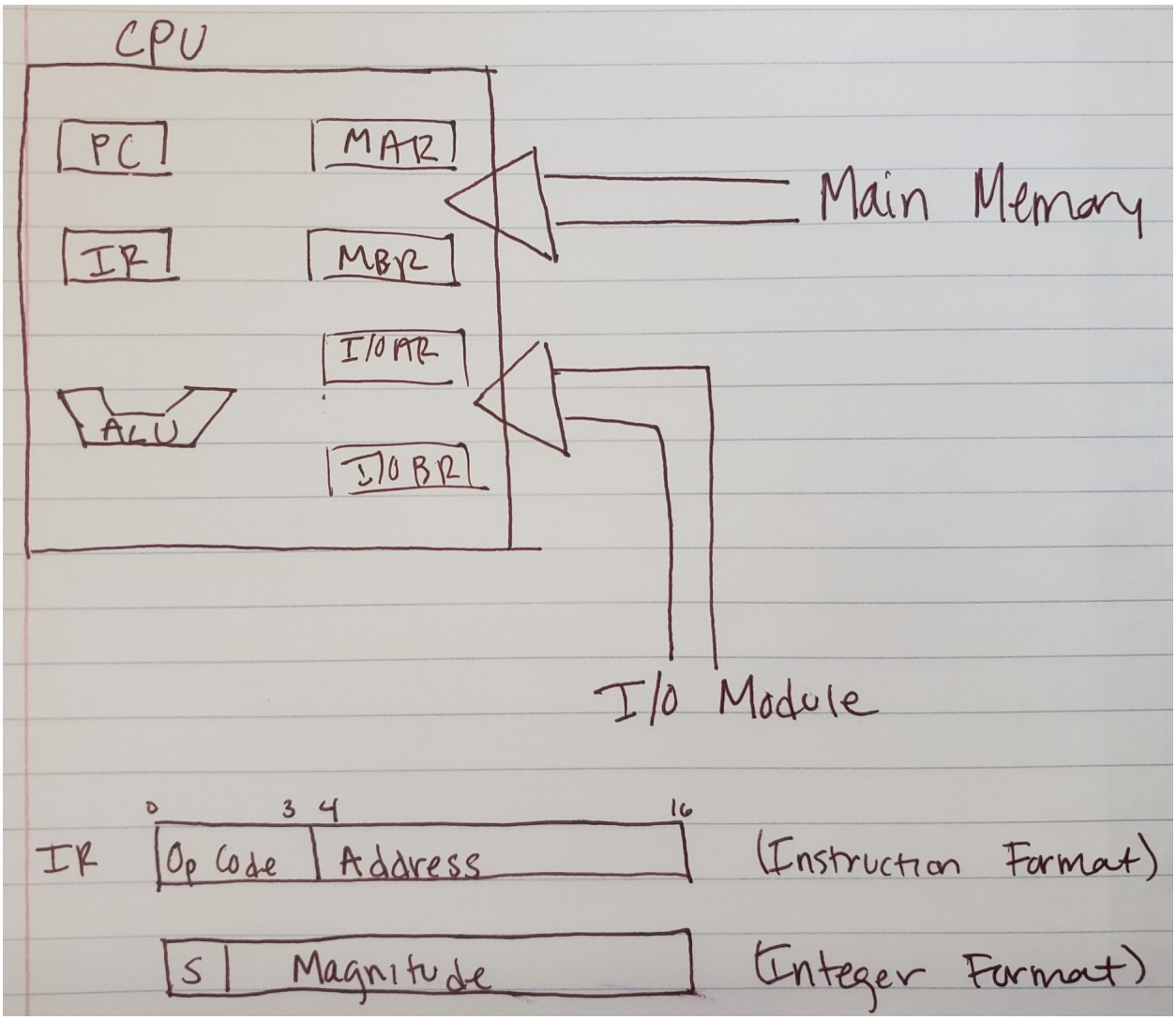
Computer Organization

- We should know all of the basic elements of a computer
  - Processor
    - like the brain, controls the operations of the computer
    - performs data processing functions
    - nickname: CPU
  - Main memory
    - Stores data and programs
    - volatile (not permanent, lost after shutdown)
    - nickname: real memory
  - I/O modules
    - monitor
    - keyboard
    - mouse
    - microphone
    - camera
    - storage
    - communication
  - System bus
    - provides communication for all components

CPU



- PC: program counter
  - Keeps track of which instruction you're on; has pointer to next instruction
- IR: instruction register
  - The instruction pointed to by the PC is loaded into the IR
- ALU: Arithmetic logic unit
  - does math- arithmetic based on the instruction
- MAR: memory address register
- MBR: memory buffer register
- I/O address register
- I/O buffer register
- These are called processors mainly because of the ALU thing, each machine has multiple
- Microprocessor
  - General purpose processor on a single chip
- GPU: Graphics Processing Unit
  - What makes a GPU different?
    - Instead of having large system with memory on the outside, they have SIMD
  - SIMD: Single instruction multiple data

    - A grid where each cell in the grid has a piece of data associated with it, you can execute one instruction for each piece of data
    - Allows for one instruction to be sent out across multiple pieces of data, similar to parallel programming
    - ++MatrixMath is relavent here somehow...?
  - DSP: Digital Signal Processing
    - On the rave in 90's telecom business
    - Allows small streaming operations specialized for a chip
    - Seen in digital cameras, motems, any type of speech translator/synthesis, encryption stuff
  - 2016 TPU: Tensor Processing Unit
    - Grant's two cents: have some level of competence in machine learning and linear algebra for a successful career
    - tensor: n-dimensional matrix (matrix is a 2 dimensional tensor)
    - TPUs are similar to GPUs but they're optimized for bulk processing operations and matrix multiplication
  - SoC: System on a Chip
    - You have *everything* one one chip
      - CPU, GPU, memory, I/O, cache (maybe not all of these but most)

Instructions

- Stages in a program:
  - Fetch: retreive next instruction, contains a start command
  - Execute: processor executes, contains a halt command
- Steps:
  - The processor fetches an instruction from memory, and at that moment:
  - PC counter is incremented
  - Fetched instruction is loaded onto the IR
    - processor-memory
    - processor I/O
    - data processing
    - control
- Quick aside:
  - $10011_2 = 19_{10}$
  - 0 & 1 = 0
  - 0 & 0 = 0
  - 1 & 0 = 0
  - 1 & 1 = 1
  - 0 or 0 = 0
  - 0 or 1 = 1
  - 1 or 0 = 1
  - 1 or 1 = 1
  - 0 xor 0 = 0
  - 0 xor 1 = 1
  - 1 xor 0 = 1
  - 1 xor 1 = 0
  - $2^1 = 2$
  - $2^{10} = 1024 = 1K$
  - $2^{20} = 1048576$
  - $2^{30} = 1$ billion something, G
  - $2^{40} = \mathrm{T}$
  - $2^{12} = 4096 = 2^2 \times 2^{10} = 4K$
  - We should know all powers of 2 up through 2^{10} as well as the ones listed above

- Working Instruction Set Examples
  - What is the format of an instruction in the IR?
    - *I have a drawing of this I'll try to remember to add*
  - In the integer format, what does the S mean?
    - It is the sign of the integer (+/-)
      - 1 is negative, 0 is positive
    - If you have an IR with [1|0|1|1], the sign is negative and the magnitude is 3
  - Least significant bit is always the one all the way to the left (in a picture)
  - 1's and 2's complements: what's the difference?
    - -1 in 1's complement: 1110
    - -1 in 2's complement: 1111
    - *Need to make sure we know 1's and 2's complements*
  - Remember: we have the program counter (PC), instruction register (IR), and accumulator (AC)
  - Operations:
    - 0001 → load from AC
    - 0010 → store AC memory
    - 0101 → add AC from memory
  - Memory:
    - 300: 1|9|4|0
    - 301: 5|9|4|1
    - 302: 2|9|4|1
    - 940: 0|0|0|3
    - 941: 0|0|0|2
  - How do we run the computer?
    - PC = 300, we need a fetch operation
      - We take the value of memory slot 300 and load it into the IR
      - IR = 1940
    - PC = 301, look at instruction register to find instruction from OpCode, in this case we need to lead from accumulator
      - AC = 0003
      - 0003 was taken from memory slot 940 but I don't think I understand why, I took comp org a year ago and I was bad at it then too
      - Fetch 301 from memory after the execute
      - IR = 5941
    - PC = 302, look at instruction register to find instruction from OpCode, we need to add AC from memory
      - Last three digits of IR are 941, so we go to that spot in memory and add it to what is in the accumulator
      - AC = 0003, 941 = 0002, together = 0005
      - AC = 0005
    - PC = 303
      - IR = 2941, store AC in memory
      - Store 0005 in 941