# CS 211

- www.cs.rutgers.edu/~morbius/cs211
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- office hours: Wednesdays 8:00-9:00 pm, Hill 403
- Bryant and O'Hallaron. Computer Systems: A Programmer's Perspective, 2nd edition. Addison-Wesley, 2011
- Kernighan and Ritchie. The C Programming Language, 2nd Edition, Prentice Hall, 1988.
- 3 weeks to do each programming assignment

# Main Components

- CPU
  - ALU - Arithmetic Logic Unit
    - Hard wired to do things such as adding and subtracting
    - logical
      - Or, And, Exclusive Or
    - Comparison
      - Result of the comparison from a condition code
    - Control Flow instructions
      - Changes what we execute next
    - Character operations
      - Move Bytes, compare bytes, interrupt
  - Fetch and execute cycle
    - CPU is "fetching" (finding) and then "executing" (running) these programs
    - Starting
      - Some hardwired architecture specific to start up, puts a value (address) in the program counter
      - These are our instructions (such as running an operating system)
      - First is the fetch cycle
        1. Get the instruction
        2. Decode the instruction
        3. Input operands to the instruction
        4. Execute the instruction, do the operation
        5. Put the output into the output operands
        6. Change counter to next instruction unless there is a branch or jump (go to another instruction)
        7. Repeat
  - registers - fastest memory
  - PC - Program Counter, a register that contains the address that points to the next instruction to execute
  - Control unit that controls and organizes each component
- Memory
  - AKA Core Memory - now transistorized, instead of magnetic cores

  - Random Access Memory RAM - read/write, getting to any part is constant time
    - No need to read previous memory
  - Address - specify a hex number to show our location in memory, it is how we read and write things
  - Main memory is volatile
    - volatile - turning off machine, what is in memory goes away
    - Instructions are held here
    - along with real data
  - Tradeoff
    - Large memory inexpensively, but is slow in terms of access
    - slow compared to reading and writing from CPU
    - however registers are the most expensive

- Bus
  - Memory, CPU are all connected by the bus
- I/O devices
  - how it communicates to outside
    - Human Interfaces
      - Mouse, keyboard, screen, etc
    - Storage
      - Disks, flash drives are not volatile
    - Networking Cards
      - NIC - network interface card
    - Graphics Cards
- Program
  - is data, there is some electronically coded set of instructions of what to do (program)
  - The hardware will recognize these, and then go and do things in a coherent fashion
  - The bit patterns of these instructions, is specific to a type of hardware
  - Instructions as data are what makes programs possible
    - they are programs writing programs
    - assemblers are machine specific
    - compilers are machine independent
    - Given the right set, computers can do things not intended

### Von Neumann Model

- Modern computer originated in 1936 with Alan Turin (Hypothetical)
- Von Neumann was involved in the Manhattan Project
- This brought him into collaboration of the program paper
- **A stored program computer in which a CPU and memory are connected by a bus**

**Von Neumann Bottleneck**

**Can only do one operation at a time, such as search or copy or execute**

### A successor - Harvard Architecture

- Better performance because separate busses - one for instructions and one for data

## Programming meets hardware

- High level programs let us do more, and are easier to deal with
- In Practice:
  - Move data through a bridge to and from memory, to and from bus to and from human interfaces
- The Operating System
  - The app runs with the OS, not on the OS (The OS is not a layer)
  - Apps typically run on the hardware, and will switch over to the OS when needs help

### Moore's Law

- Gordon Moore was an Intel Engineer
- Observation about improvements
- Processor speed doubles every 18 months
- Memory capacity doubles every 2 years
- Disk capacity doubles every year
- If performance increases but memory can't keep up then it is determined speed of the memory
  - CPU speeds have gotten faster but memroy cant keep up