

## A Programmable System

- Program consist of n series of “instructions”
  - o Changing the instructions changes the behavior of the machine
- In a von Neumann architecture, instructions & data share the same memory
  - o Most programmable systems are von Neumann
- An instruction is a group of bits that encodes a particular operation
  - o It contains the “opcode” or operation code” which specifies that operation
  - o Eg add, load, multiply, branch
- A full description of the instructions is the “instruction set architecture” ISA
- Along with the opcode “the operands” are specified in the instruction
  - o Give register/value/addresses/etc. needed by instruction

## The Control Circuit

- The control circuit must first “fetch” the instruction
  - o IE read from memory, using the address in the program counter (PC)
- The instruction must then be “decoded”
  - o The instruction (opcode & operands) must be used to decide how to direct the datapath
- Last stage: execute
- Single cycle hardware control
- The decoder is a combinational circuit that has the instruction as input & output control signals for the datapath.
  - o Can include operands in output too
  - o Some signals will also control the PC (for branching)
  - o The control & datapath will finish the instruction one cycle
    - Another fetch will happen in the next cycle
  - o We are limited to operations that can be completed in a single cycle. (IE one ASM block)
    - Typical things like add, increment, shift, gate load, store, etc
    - To do more complex operations, we need to slow down the clock
- Multiple cycle control
  - o Can spend several cycles working on a single instruction
  - o This adds complexity to the control circuit
    - In each cycle, we will either execute part f an instruction or tech the next op.
    - Will need some register to store information between cycles
    - Will need an “instruction register” IR to hold the instruction

## Single Cycle control

The parts of n single-cycle units must look like this:

PC→(address)→ memory→ (instruction) → instruction decoder

“memory could be the same one that’s accessible to the data path (von Neumann)P could be separate “instruction memory”

instruction decoder outputs are control signals to datapath