

Remember Back To The Lightbot

# Instruction Execution is ... So Simple Even A Computer Can Do It

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# Computers ...

- Deterministically execute instructions to process information
  - “Deterministically” means that when a computer chooses the next instruction to perform it is required by its construction to execute a specific instruction based only on the program and input it is given**

**Computers have no free will and they are not cruel**

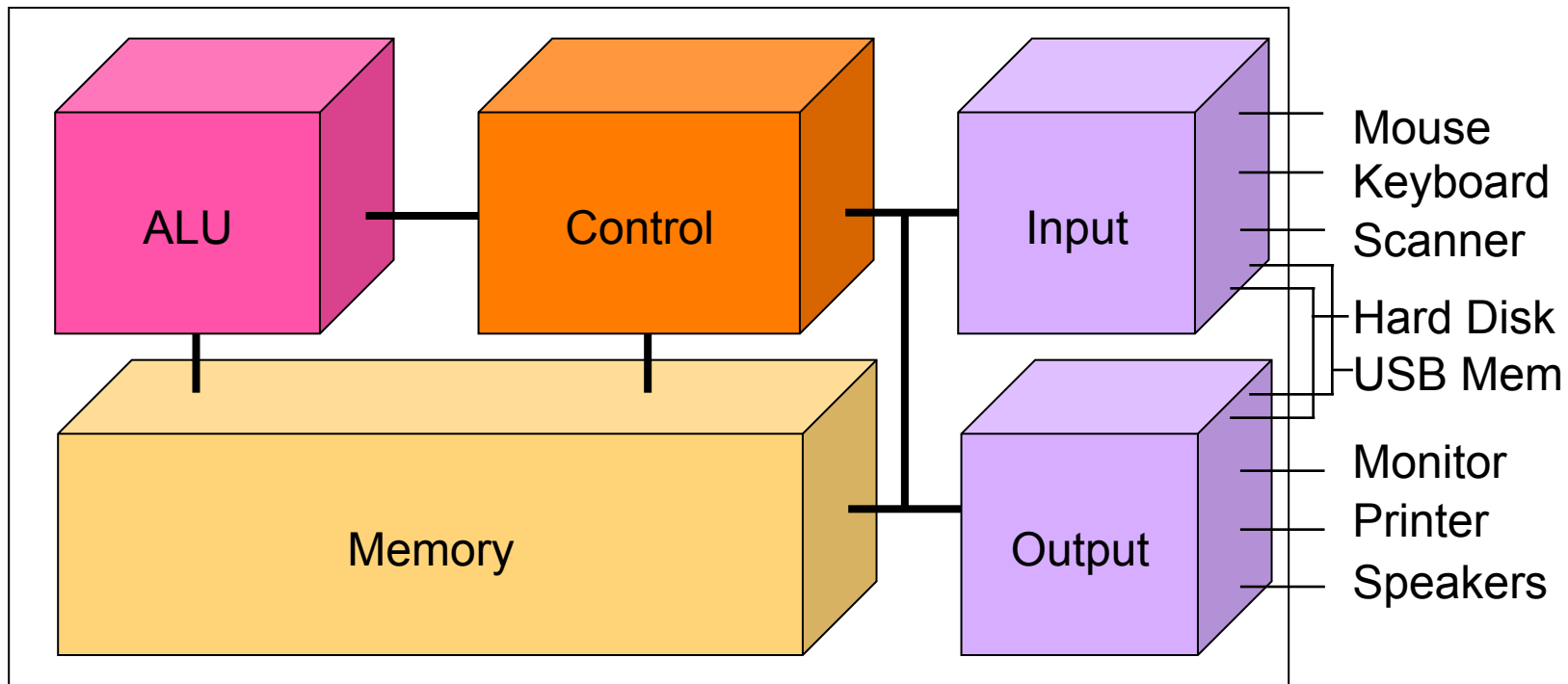
# Fetch/Execute Cycle

- Computer = instruction execution engine
  - The **fetch/execute cycle** is the process that executes instructions

Instruction Fetch (IF)  
Instruction Decode (ID)  
Data Fetch (DF)  
Instruction Execution (EX)  
Result Return (RR)

- The computer internal parts implement this cycle

# Anatomy of a Computer: The CPU

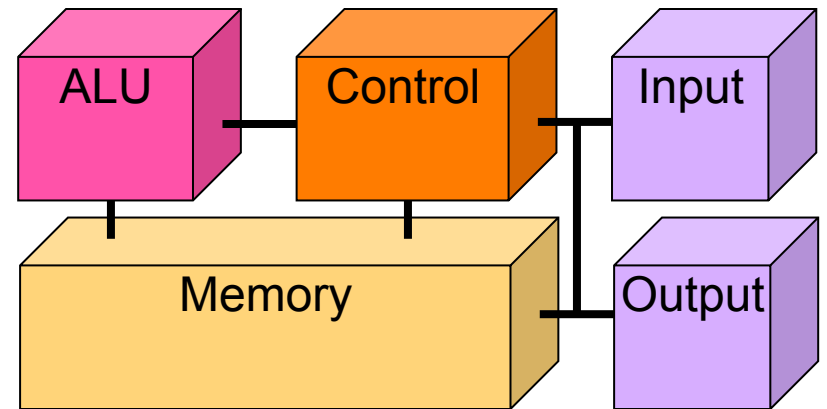


The Hard Disk (or Flash Memory) is the  $\alpha$ -device

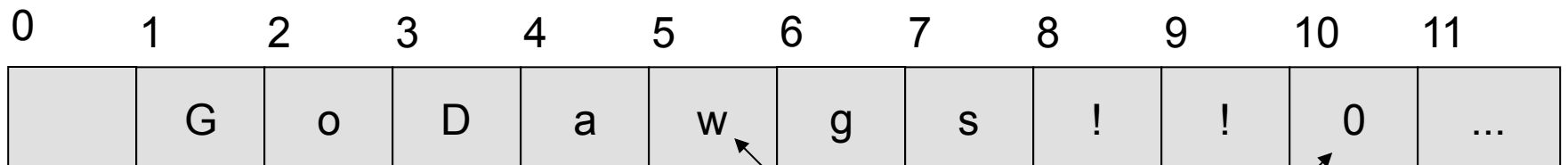


# Memory ...

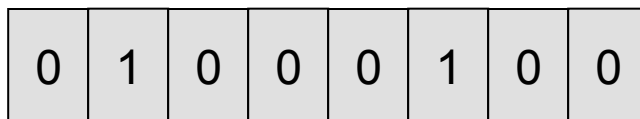
- Programs and their data must be in the memory while they are running



Byte Addresses ...



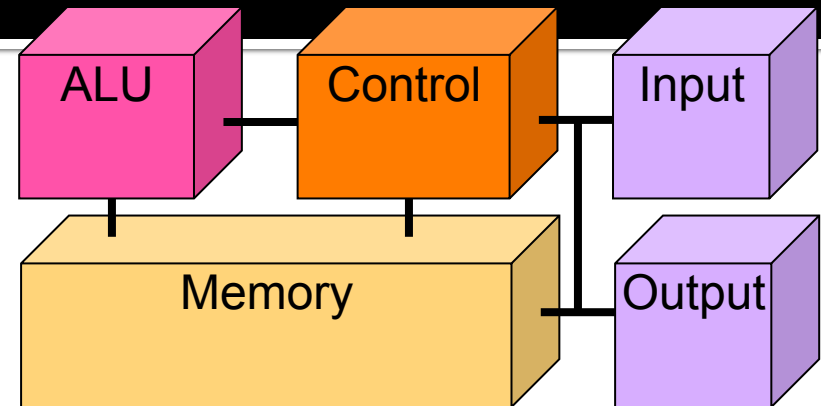
memory contents



**Groups of four bytes are a word**

# Control

- Fetch/Execute cycle is hardwired in computer's control; it's the "engine"



The instructions have the form  
ADDB 20, 10, 16

Put in memory location 20 the contents of memory location 10 + contents of memory location 16

10	11	12	13	14	15	16	17	18	19	20	21
6						12				18	...

# Indirect Data Reference

- Instructions tell *where* the data is, not *what* the data is ... contents change

One instruction has many effects

ADDB 20, 10, 16

10	11	12	13	14	15	16	17	18	19	20	21
8						7				15	...

# Indirect Data Reference

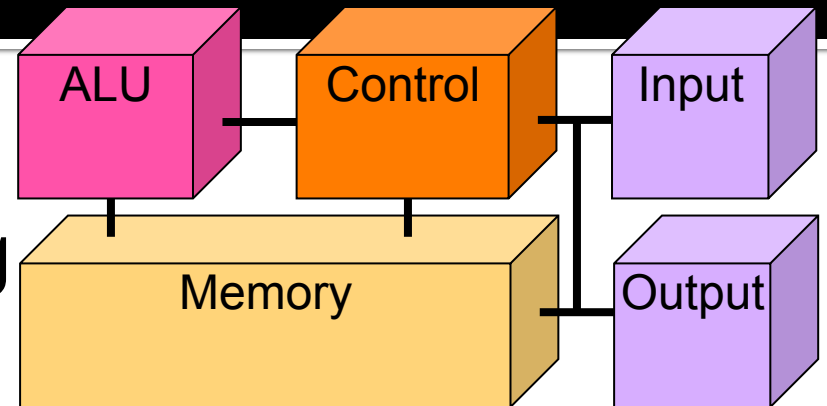
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ADDB 20, 10, 16

10	11	12	13	14	15	16	17	18	19	20	21
8						7				15	...
10	11	12	13	14	15	16	17	18	19	20	21
60						-55				5	...

# ALU

- Arithmetic/Logic Unit does the actual computing



Each type of data has its own separate instructions

ADDB : add bytes

ADDBU : add bytes unsigned

ADDH : add half words

ADDHU : add halves unsigned

ADD : add words

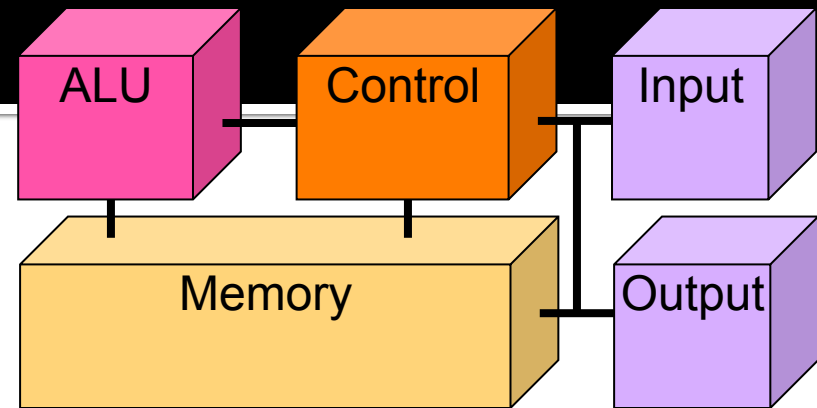
ADDU : add words unsigned

ADDS : add short decimal numbers

ADDD : add long decimal numbers

**Most computers have only about a 100-150 instructions hard wired**

# Input/Output

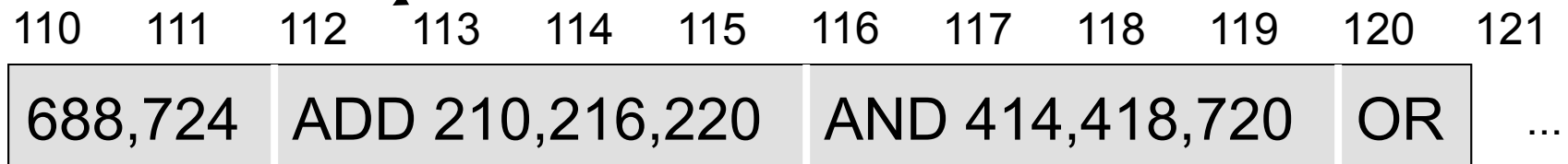


- Input units bring data to memory from outside world; output units send data to outside world from memory
  - Most peripheral devices are “dumb” meaning that the processor assists in their operation
  - Disks are *memory* devices because they can output information and input it back again

# The PC's PC

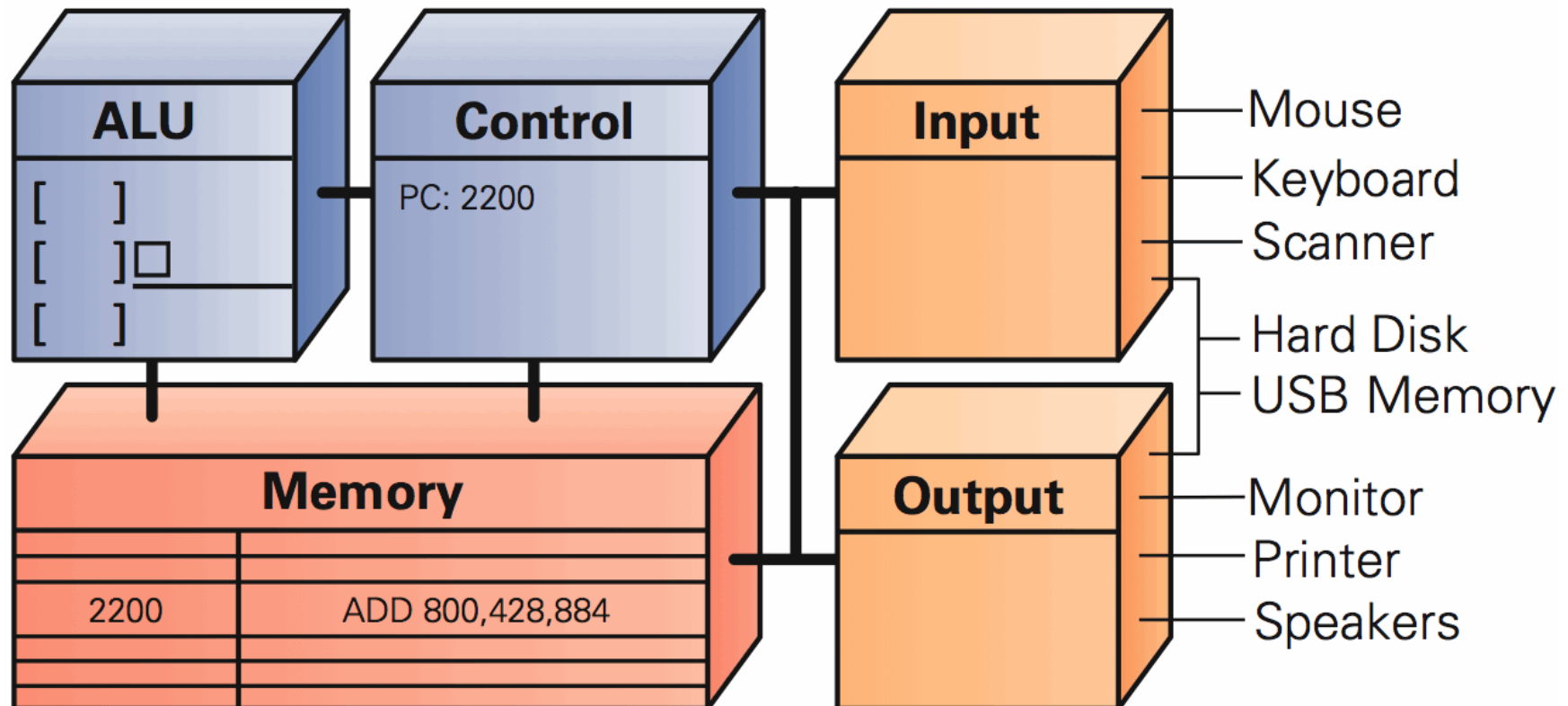
- The program counter (PC) tells where the next instruction comes from
  - Instructions are a word long, so add 4 to the PC to find the next instruction

Program Counter: 112



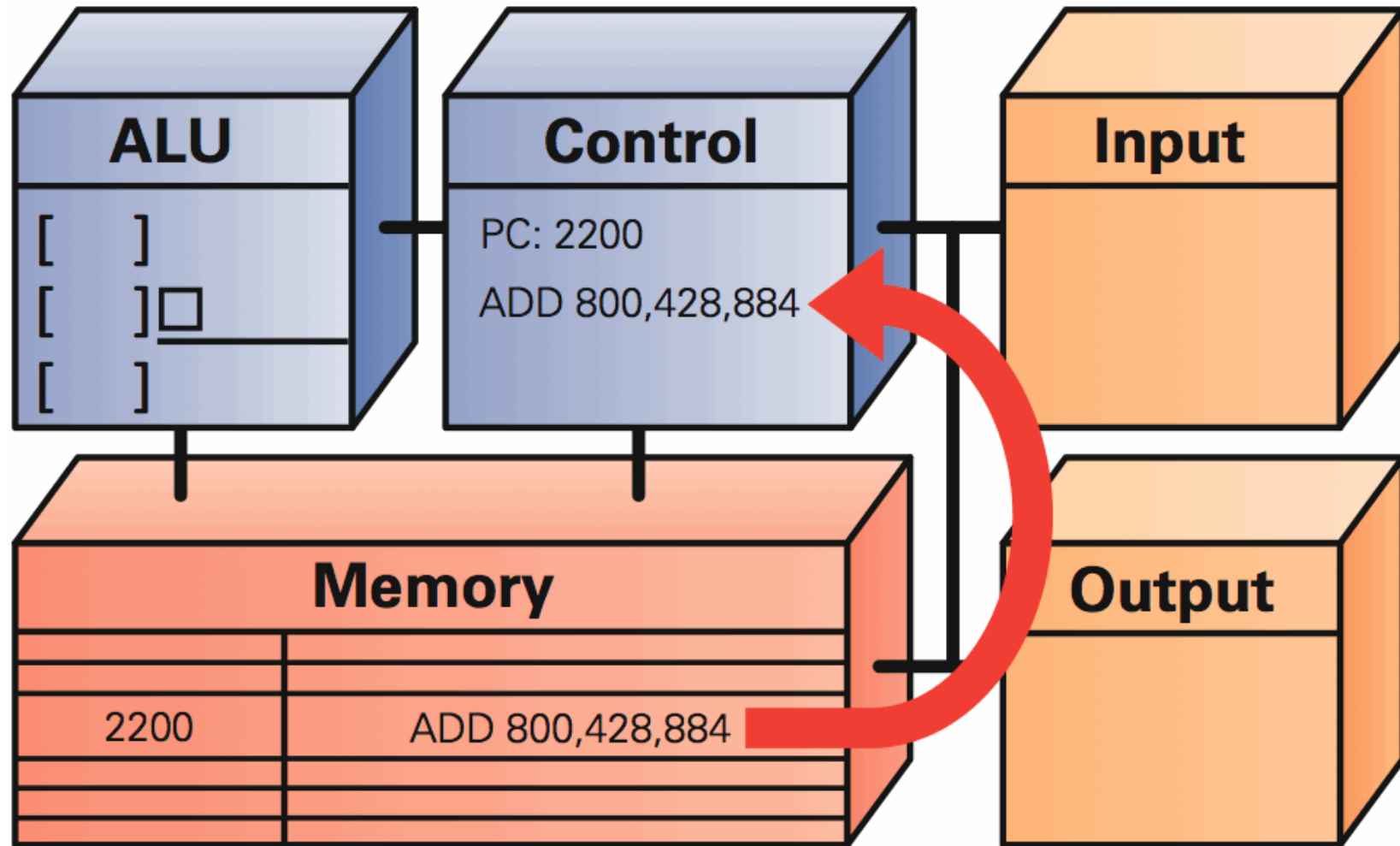
# Instruction Execution: The Setup

Run Instruction: 2200: Add 800, 428, 884

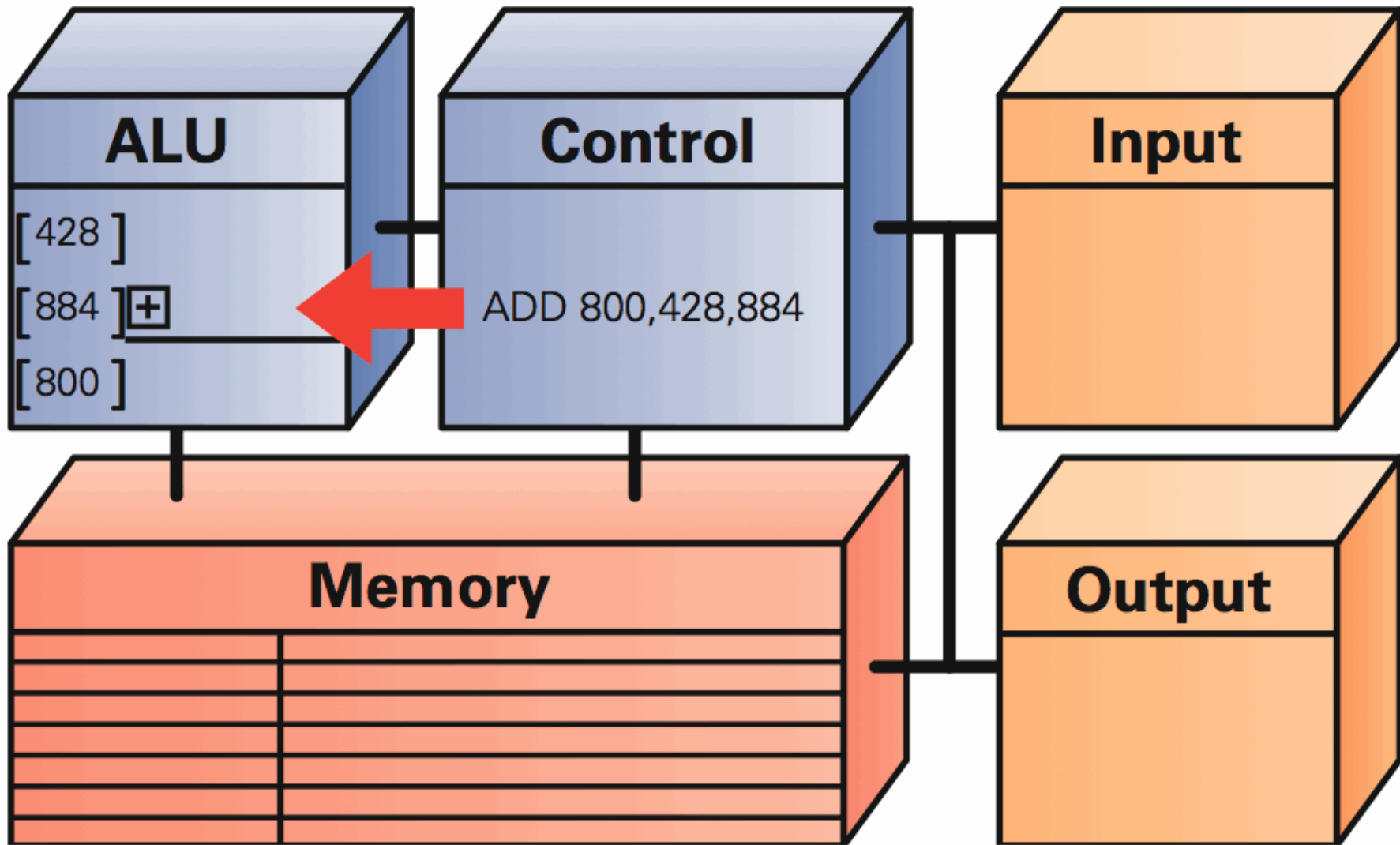




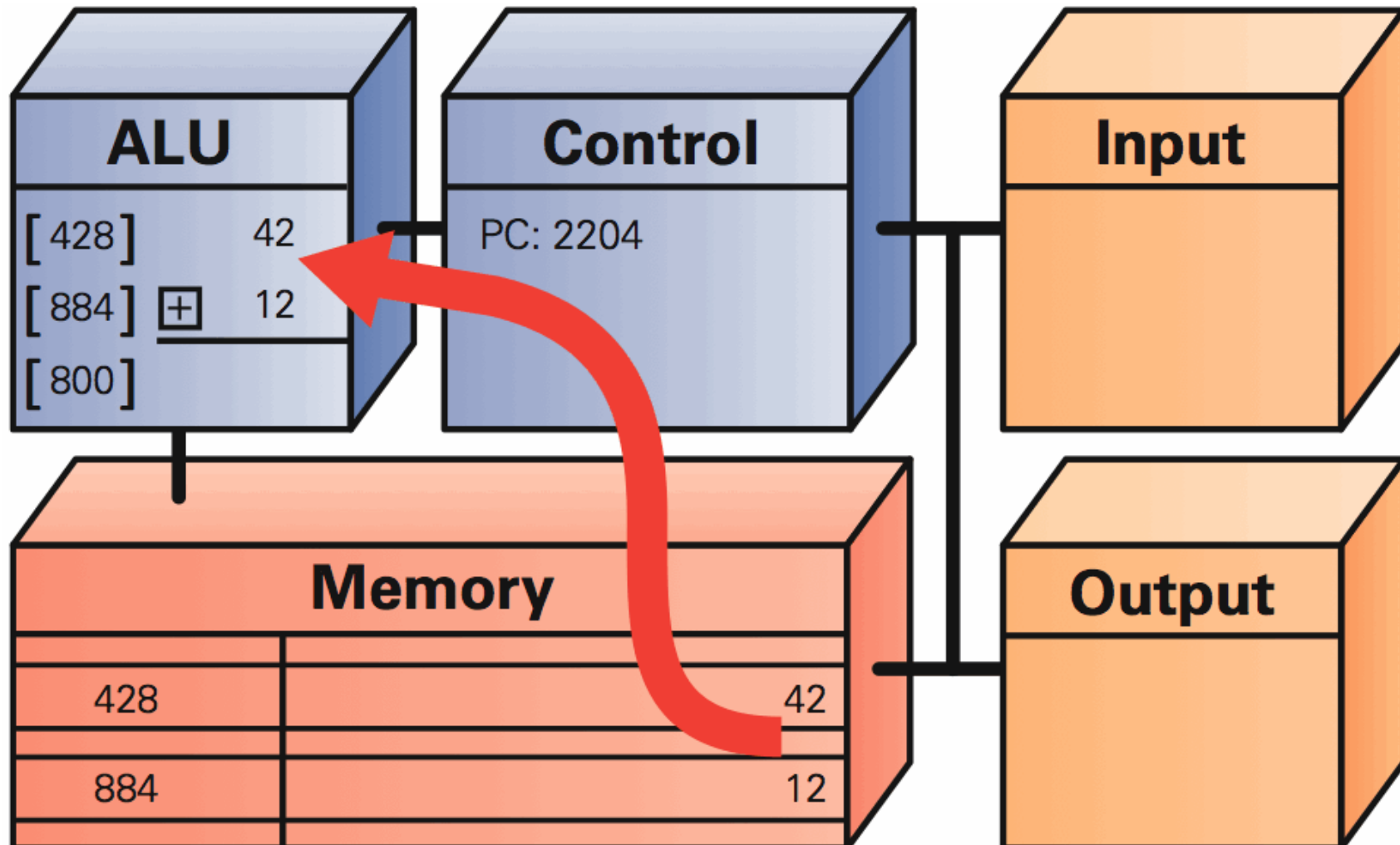
# Instruction Fetch: Get Some Work



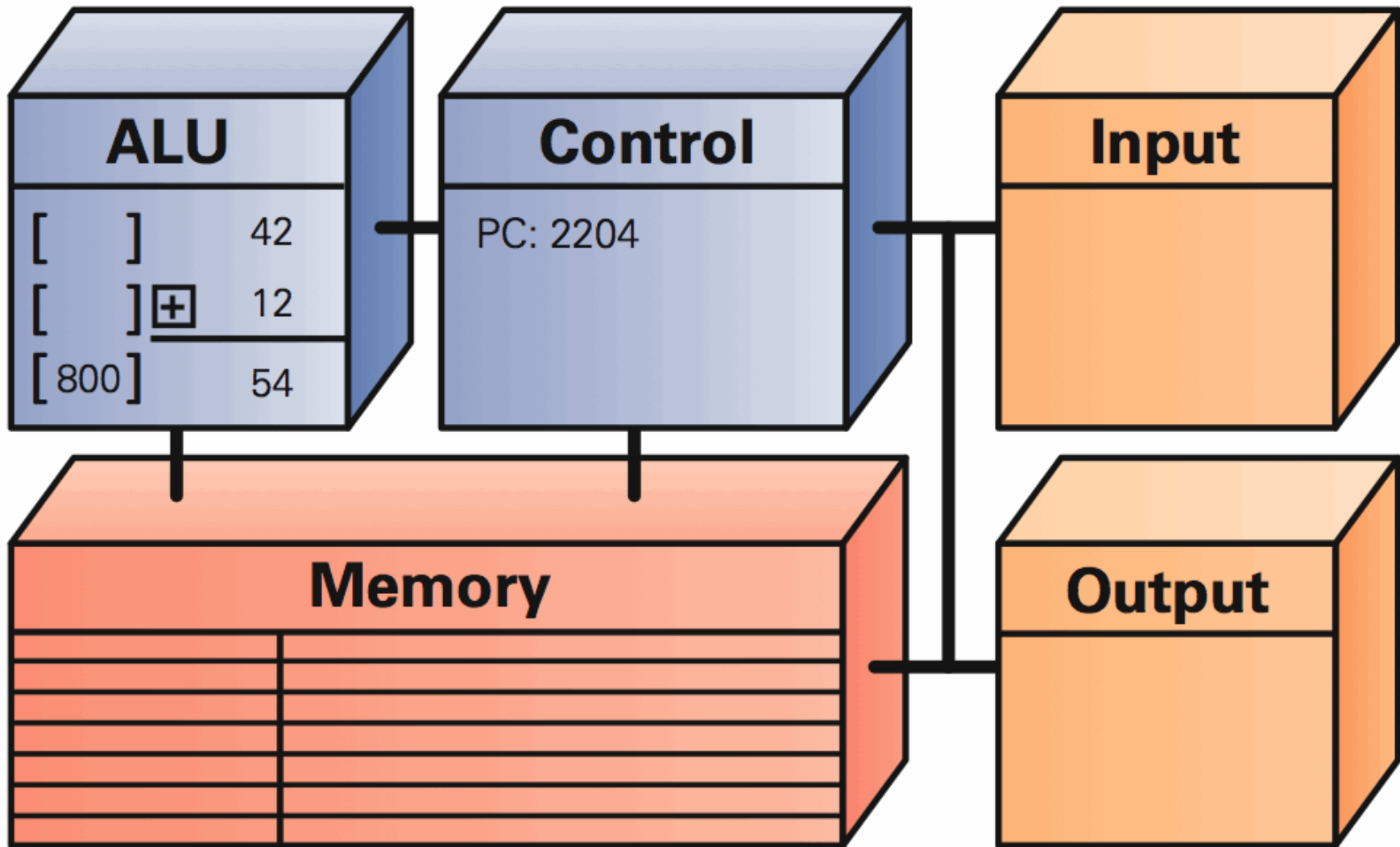
# Instruction Decode: What To Do?



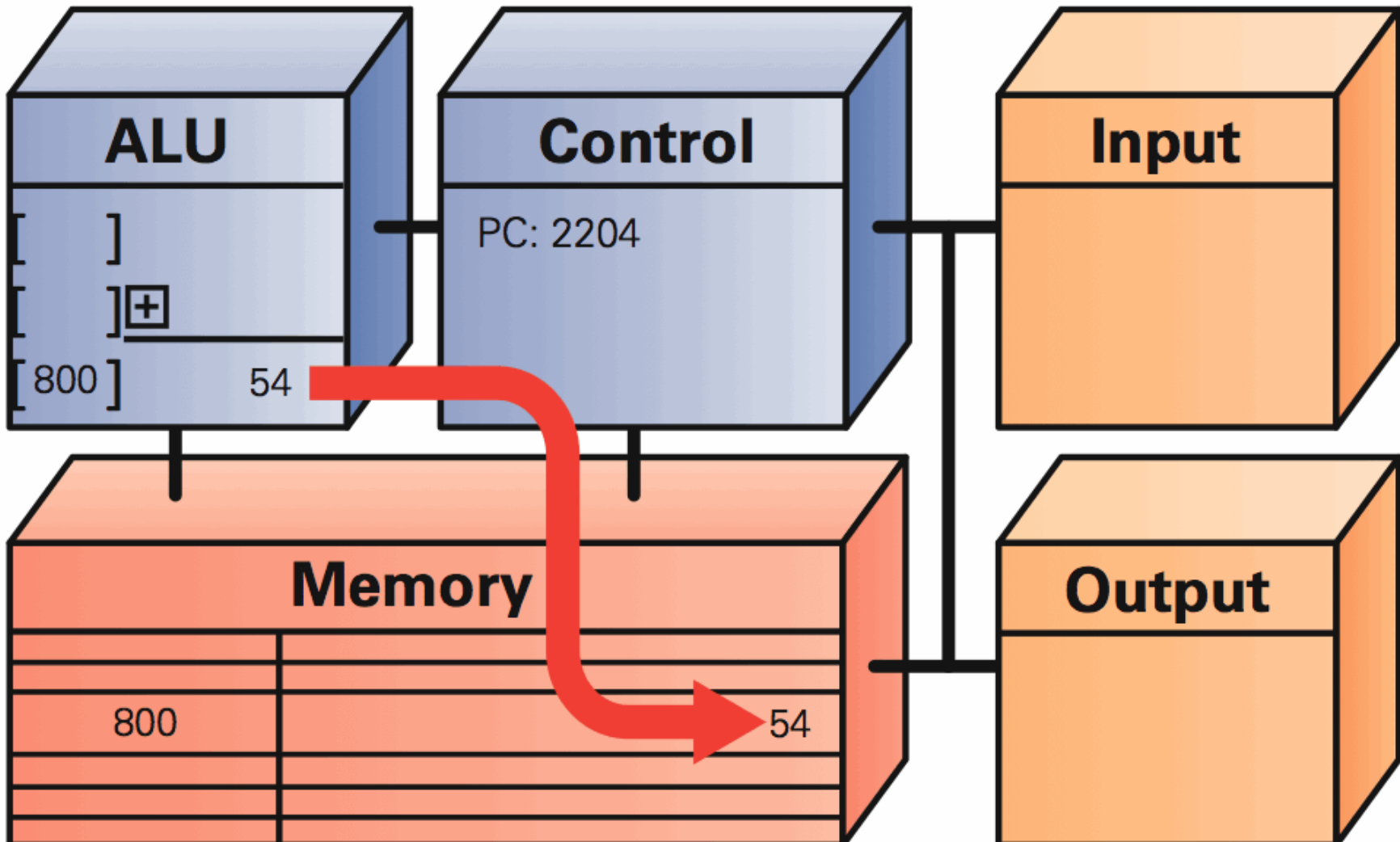
# Data Fetch: What's The Input



# Instruction Execution: Just Do It



# Result Return: Put It Away 4 Future

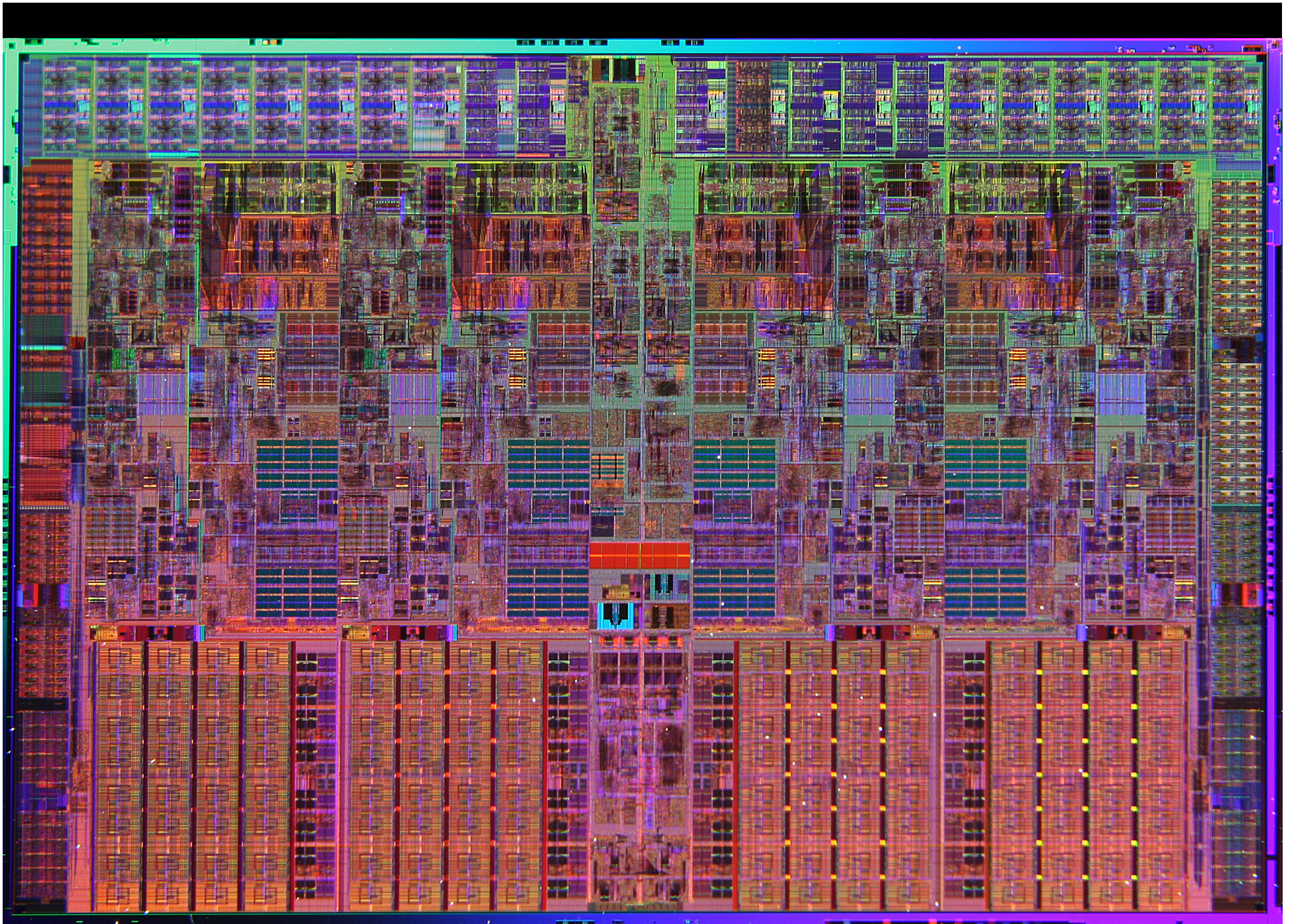


# Clocks Run The Engine

- The rate a computer “spins around” the Fetch/Execute cycle is controlled by its clock
  - Current clocks run 2-3 GHz
  - In principle, the computer should do one instruction per cycle, but often it fails to
  - Modern processors try to do more than one instruction per cycle, and often succeed

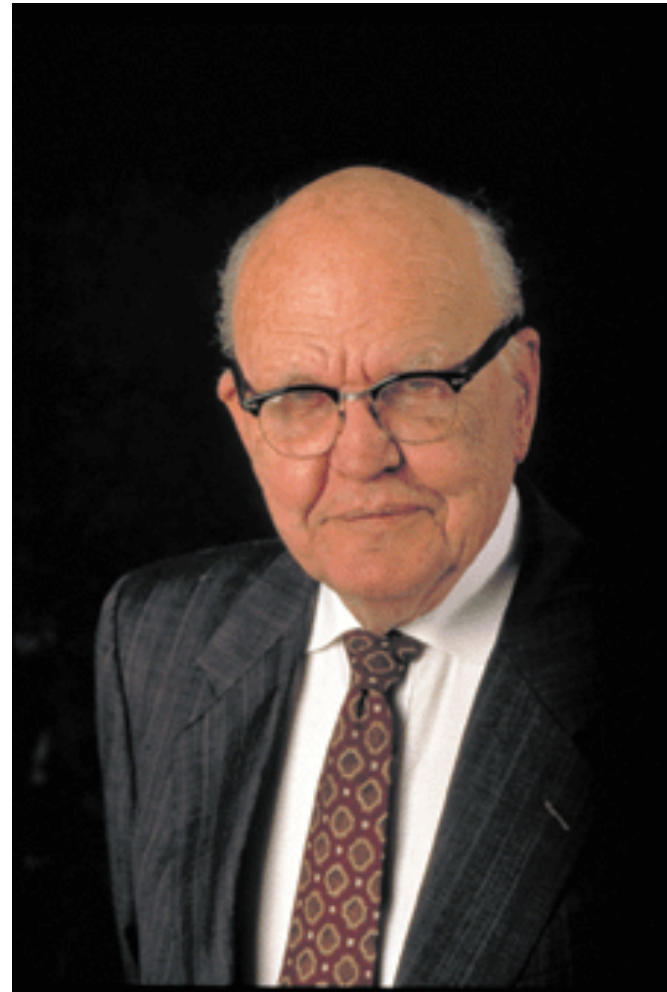
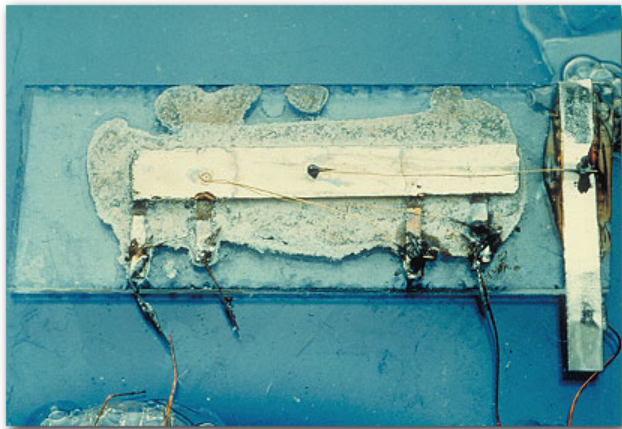
**Clock rate is not a good indicator of speed**







# Jack Kilby, Mr. Integrated Circuits



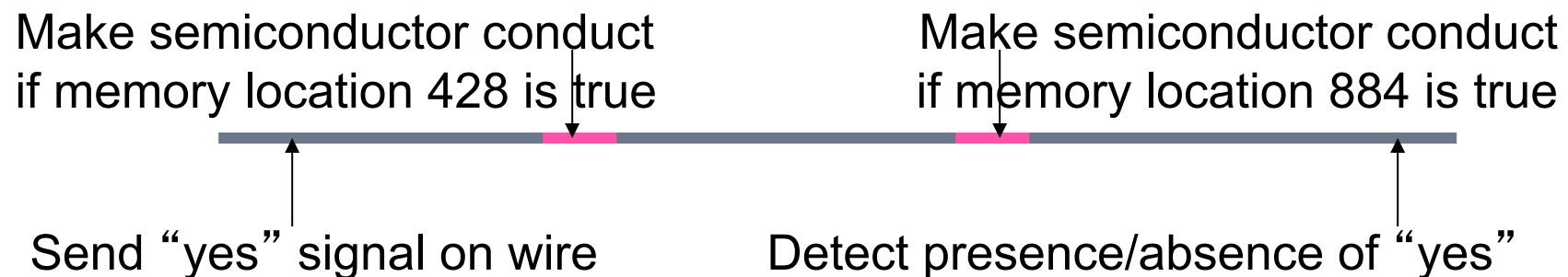


# Semiconductors

- Silicon, a semiconductor -- sometimes it conducts and sometimes it doesn't
  - It's possible to control when semiconductors do and don't conduct

Compute by controlling conducting

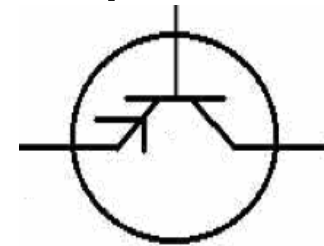
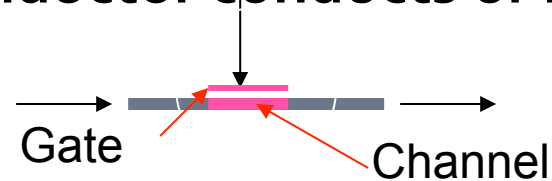
Ex.: AND 428, 884, 800



# Field Effect

- Charged objects are familiar -- use a nylon comb on a dry day

- A charged field can control whether
- a semiconductor conducts or not



A transistor  
has 3 wires

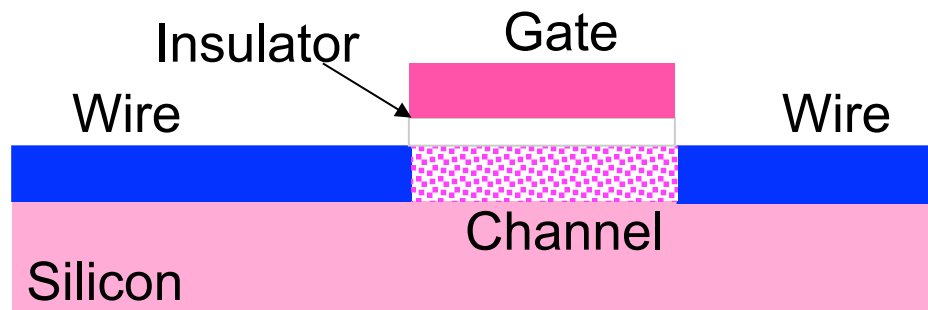


The charge of the control wire (gate) is key

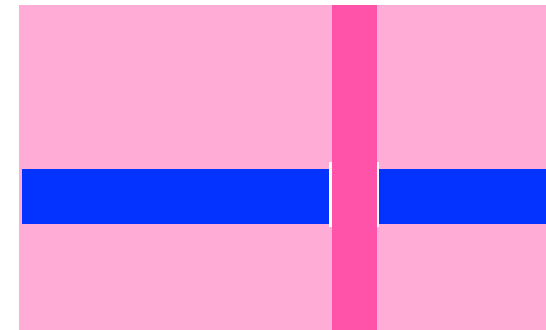
- Neutral gate, channel doesn't conduct
- Charged gate, channel conducts

# MOS Transistors

- The field-effect idea is implemented in metal-oxide-semiconductor transistors
- Schematic in Si

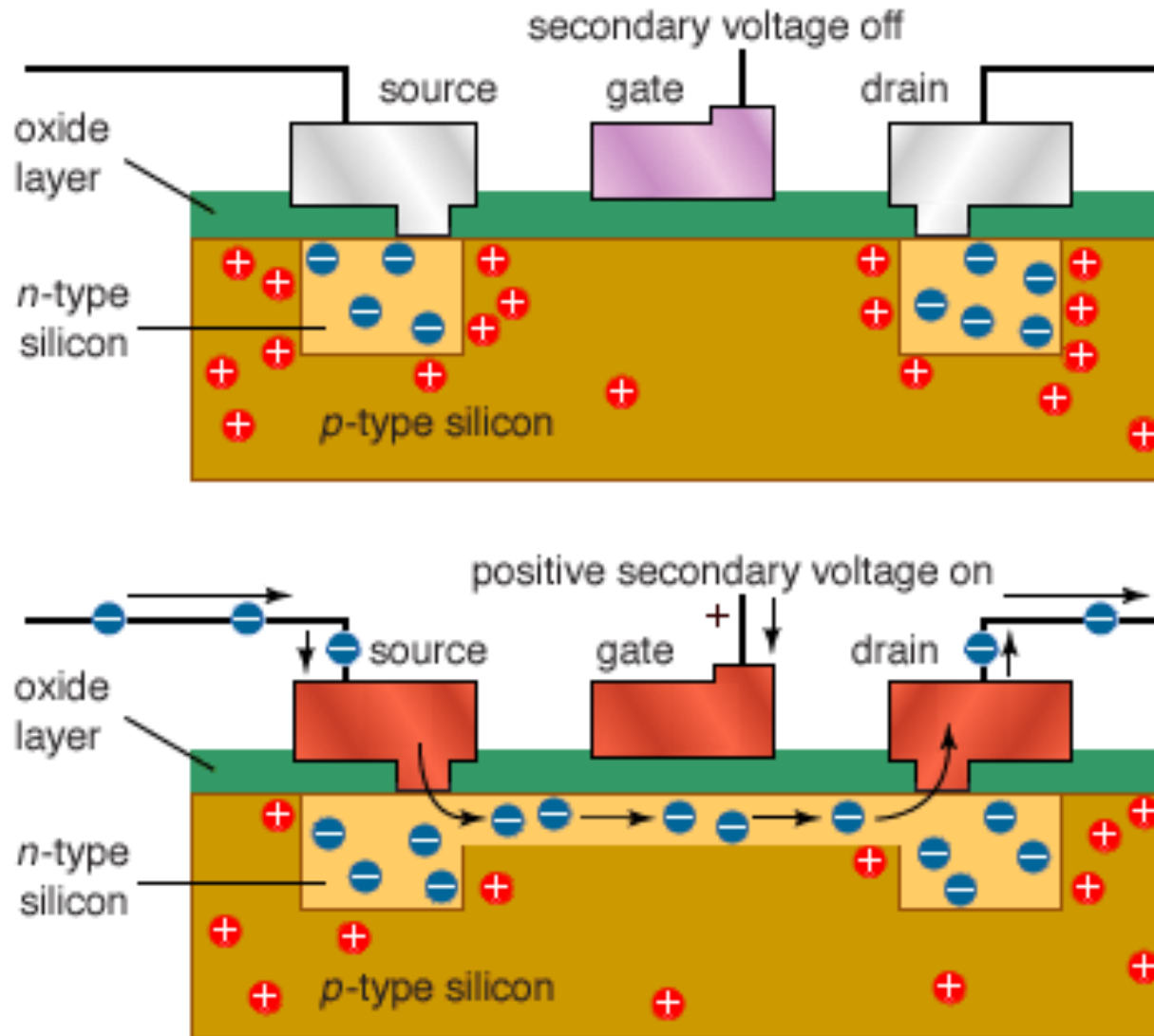


Slice across chip, look end on



From Above

# nMOS Transistor



# Fabrication ...

- Check it out ...
  - [http://umumble.com/blogs/company\\_intel/385/](http://umumble.com/blogs/company_intel/385/)

# Summary

- Fetch/execute cycle runs instructions
  - 5 steps to interpret machine instructions
  - Programs must be in the memory
  - Data is moved in and out of memory

**Instructions, data are represented in binary**