Computer System

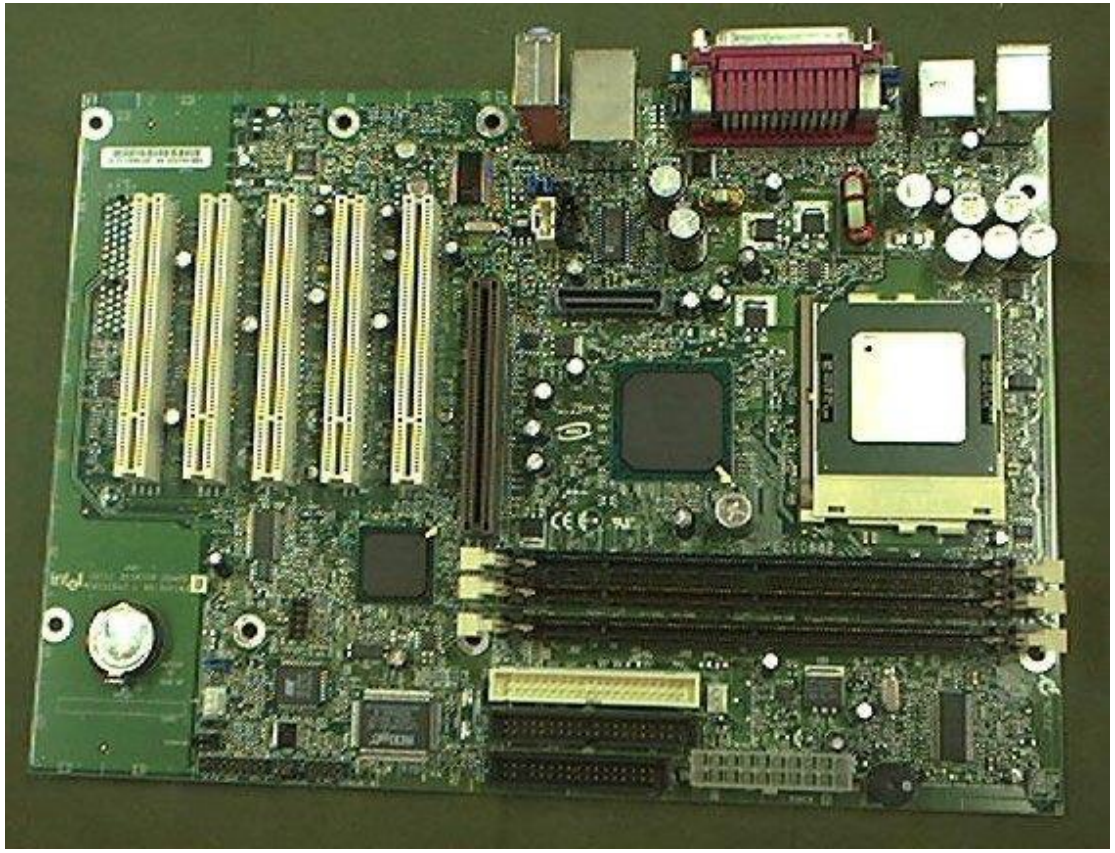
Computer System -Overview

Outlines:

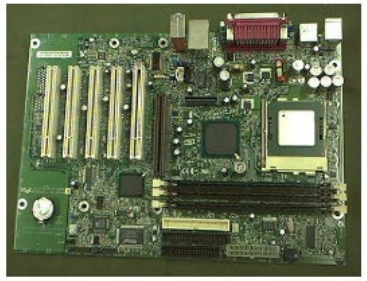
- Introduction to computer system and architecture
- Historical development
- Model
- Instruction cycle

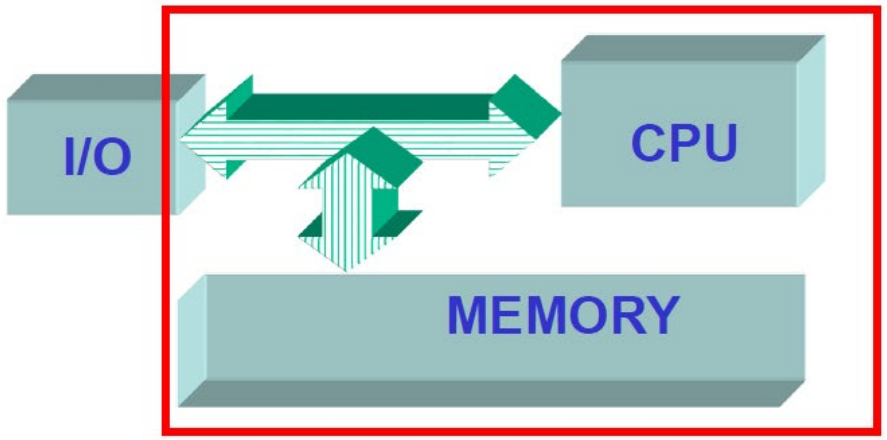
Computer System Components: High Level View

Computer System: Motherboard Level

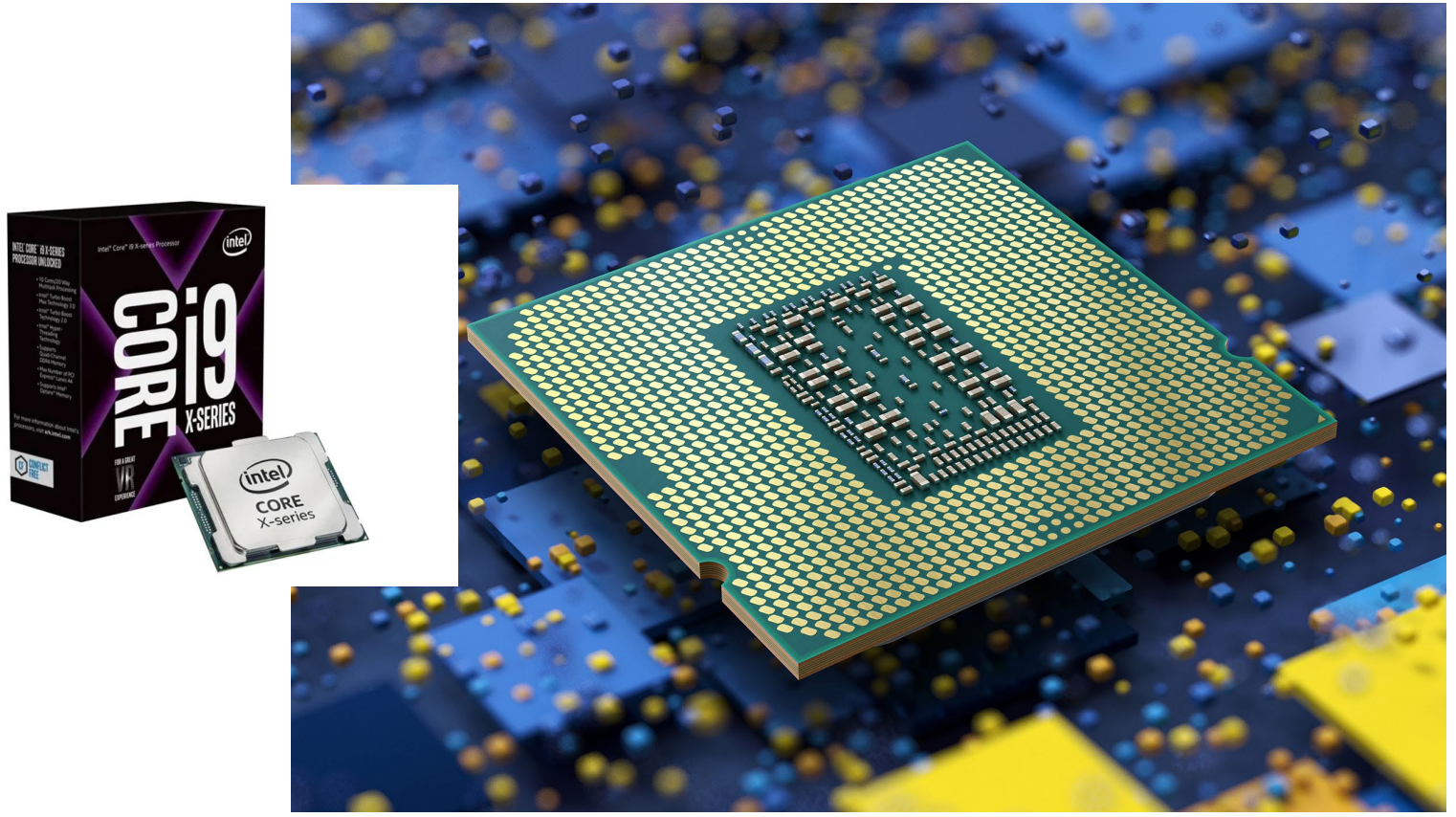


Computer Components: Interconnection



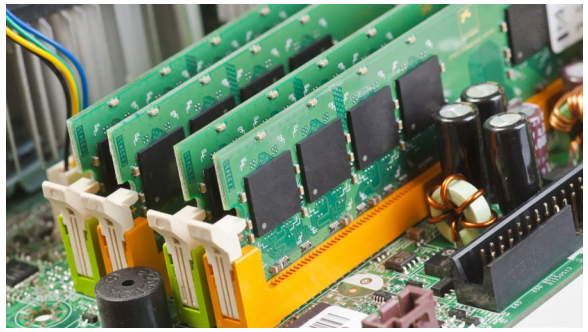


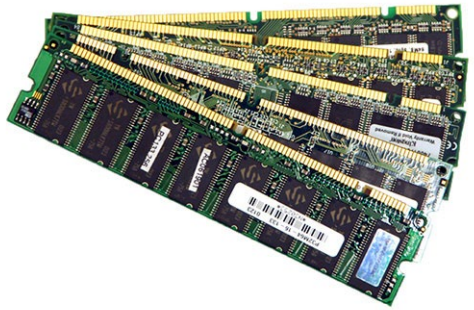
CPU



CPU Organization

Memory





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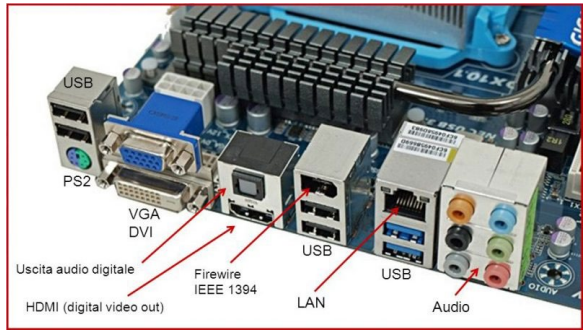
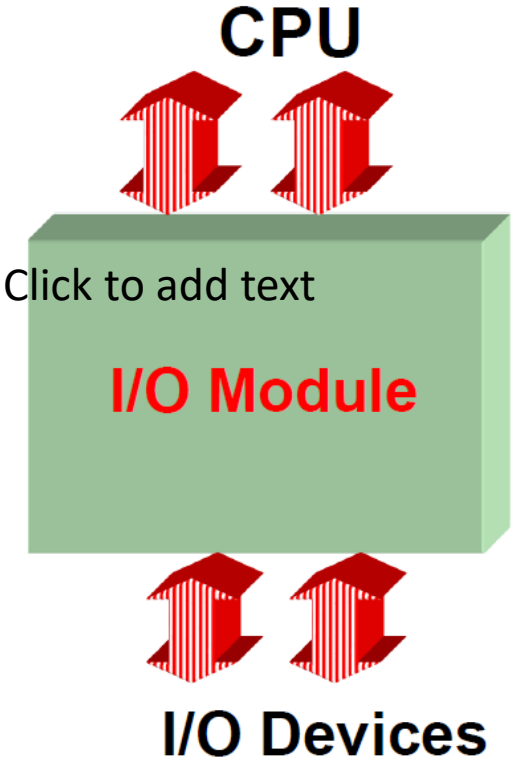
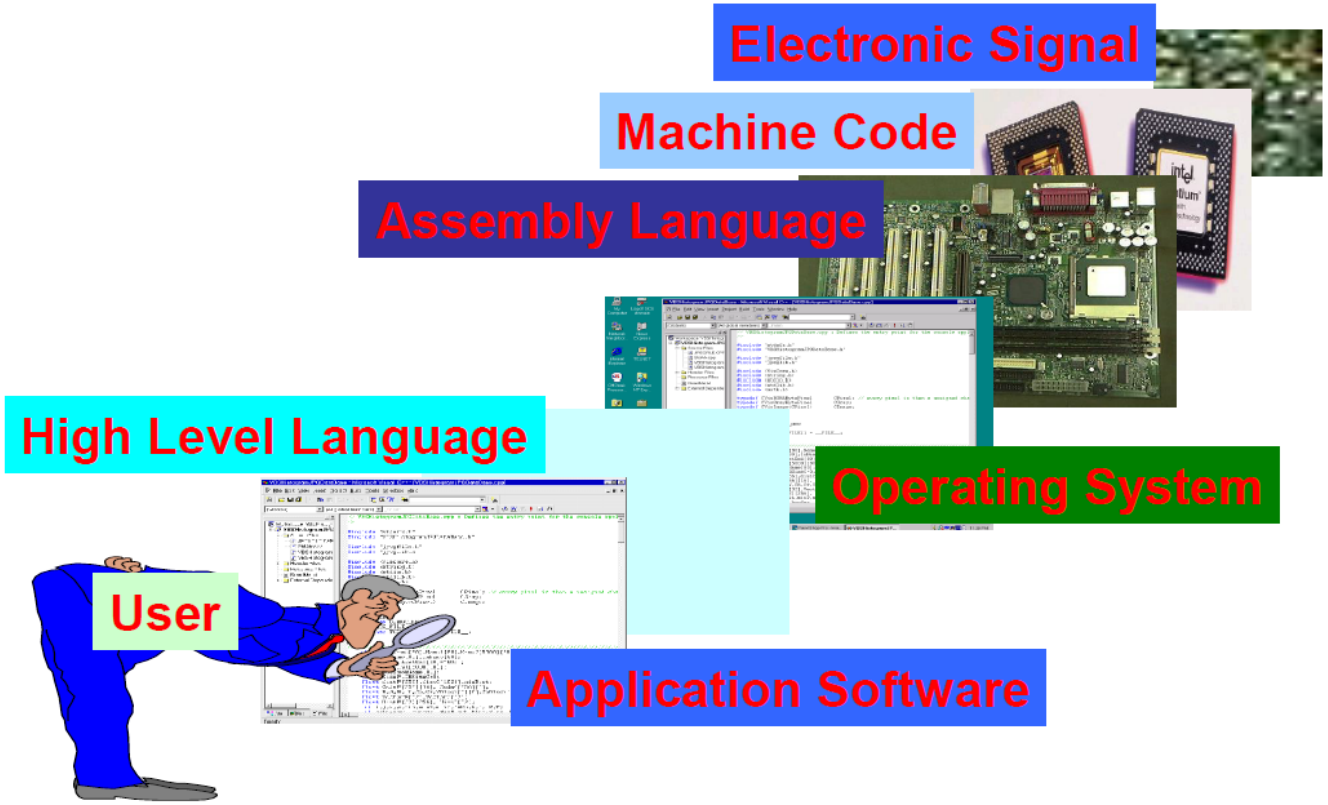
Input/Output





Computer System Hierarchy



A Brief History of Computers

The first Generation -Vacuum Tubes (1945 -1955)

ENIAC (1943 -1946)

Intended for calculating range tables of aiming artillery

Consisted of 18000 tubes, 1500 relays, weight 30 tons, consumed 140 KW

Decimal machine

Each digit represented by a ring of 10 vacuum tubes.

Programmed with multi-position switches and jumper cables.

A Brief History of Computers

John von Neumann (1945 -1952)

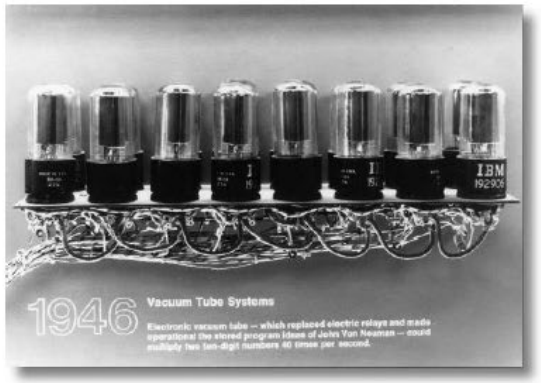
Originally a member of the ENIAC development team.

First to use binary arithmetic

Architecture consists of : Memory, ALU, Program control, Input, Output

Stored-program concept -main memory store both data and instructions

A Brief History of Computers



Vacuum Tubes

ENIAC

A Brief History of Computers

The Second Generation -Transistors (1955 -1965)

Transistors

Transistor was invented in 1948 at Bell Labs

DEC PDP-1, first affordable microcomputer ($120k), performance half that of

IBM 7090 (the fastest computer in the world at that time, which cost millions)

PDP-8, cheap ($16,000), the first to use single bus

A Brief History of Computers

CDC 6600 (1964)

An order of magnitude faster than the mighty IBM 7094

First highly parallelized machine (up to 10 instructions in parallel)

Burroughs B5000

First to emphasize software and high level programming languages (Algol 60)

A Brief History of Computers

The Third Generation -Integrated Circuits (1965 -1980)

IBM System/360

Family of machines with same assembly language

Designed for both scientific and commercial computing

DEC PDP-11

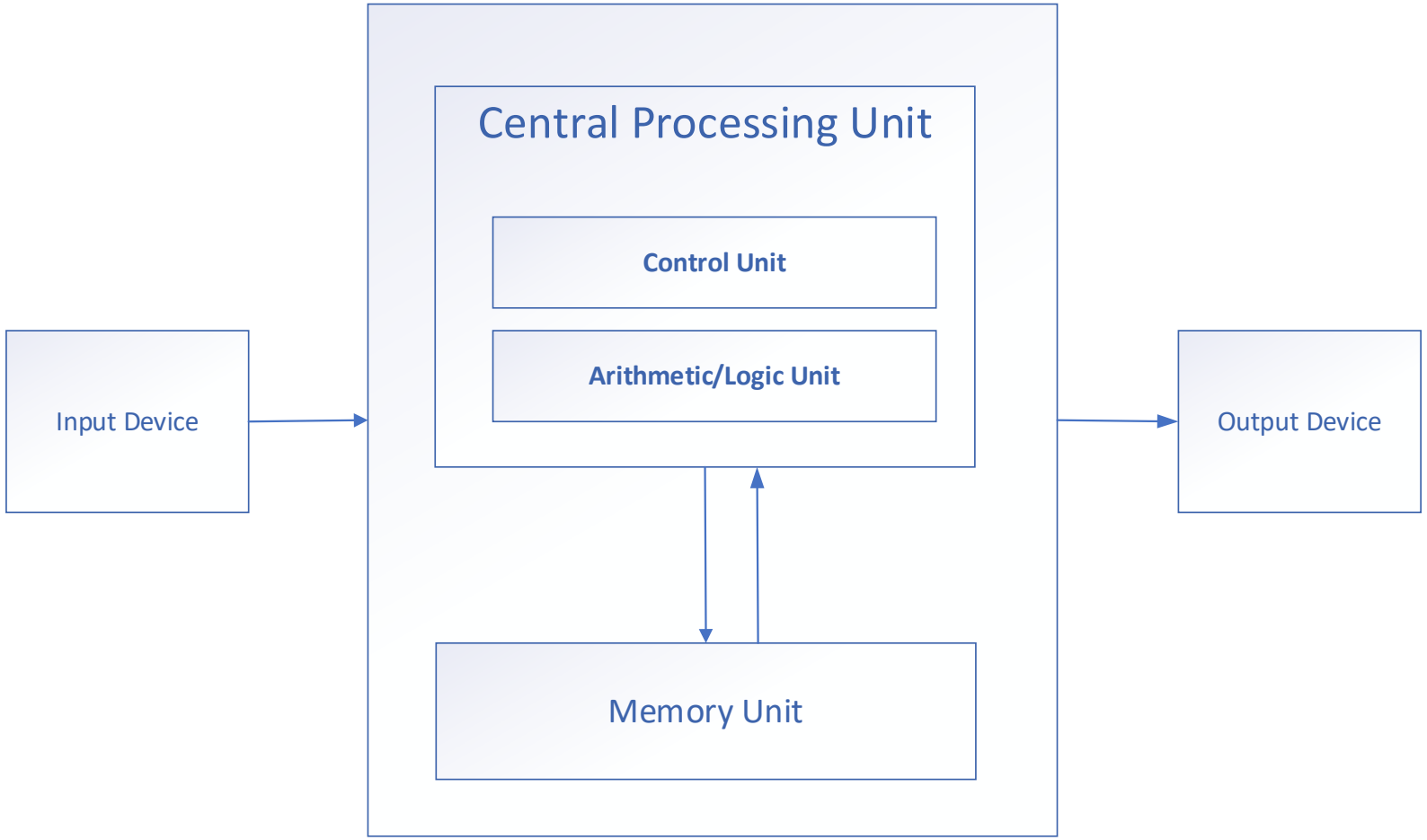
Very popular with universities, maintained DEC's lead in microcomputer market

The Fourth Generation -VLSI (1980 -?)

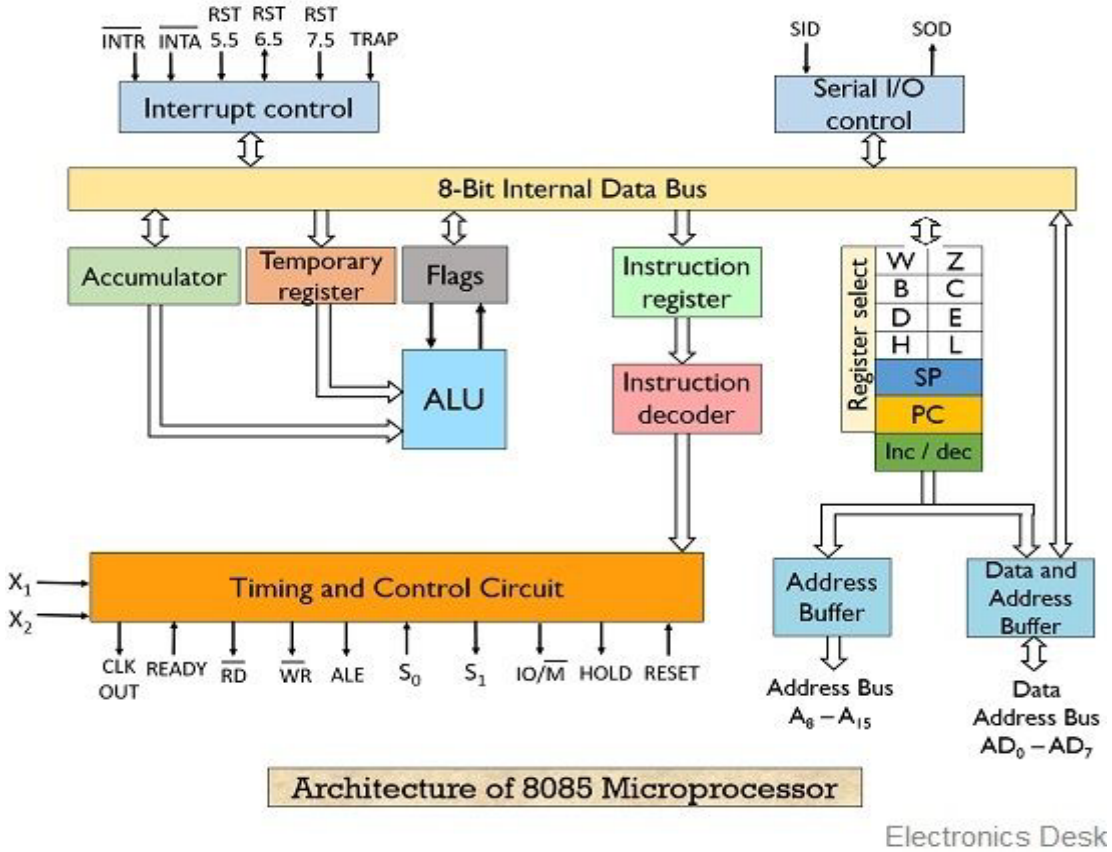
Lead to PC revolution

High performance, low cost

Von Neumann Architecture



Intel 8085 Microprocessor



https://electronicsdesk.com/8085-microprocessor.html

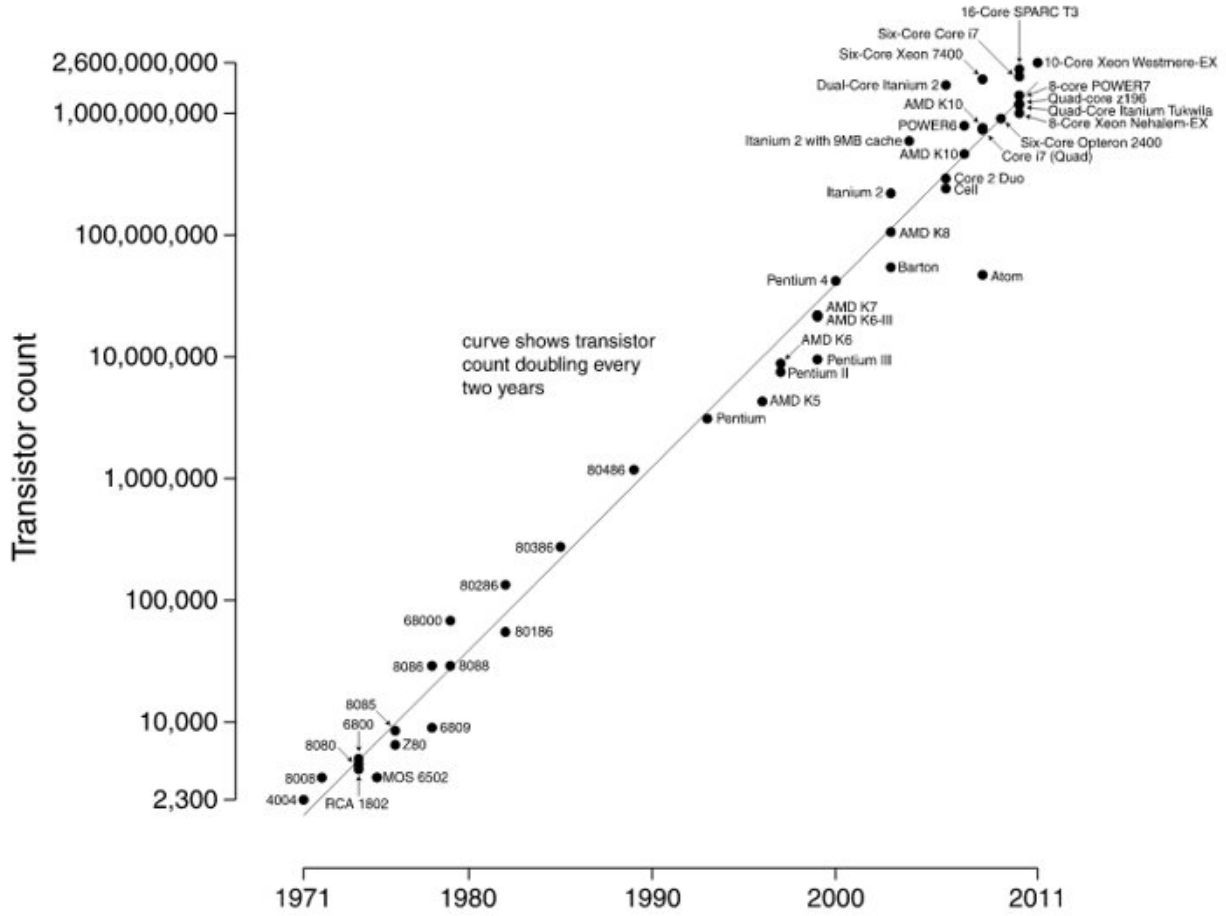
Moore’s Law

- Transistor density on a microprocessor will double every 18 to 24 months
- Computer will double in power roughly every two years, but cost only half as much
- CPUs from between 1972 and 2012, and that predicted by Moore's Law which may be stated mathematically as:

$$n_i = n_0 2^{(y_i - y_0)/T_2}$$

n_0 is the number of transistors in some reference year, y_0, and $T_2 = 2$ is the number of years taken to double this number.

Moore’s Law


Transistor count
2,600,000,000
1,000,000,000
100,000,000
10,000,000
1,000,000
100,000
10,000
2,300
1971
1980
1990
2000
2011
curve shows transistor count doubling every two years
16-Core SPARC T3
Six-Core Core i7
Six-Core Xeon 7400
10-Core Xeon Westmere-EX
Dual-Core Itanium 2
8-core POWER7
Quad-core z196
AMD K10
Quad-Core Itanium Tukwila
POWER6
8-Core Xeon Nehalem-EX
Itanium 2 with 9MB cache
Six-Core Opteron 2400
AMD K10
Core i7 (Quad)
Core 2 Duo
Itanium 2
Cell
AMD K8
Barton
Atom
Pentium 4
AMD K7
AMD K6-III
AMD K6
Pentium III
Pentium II
AMD K5
Pentium
80486
80386
80286
68000
80186
8086
8088
8085
6800
6809
8080
Z80
8008
MOS 6502
4004
RCA 1802

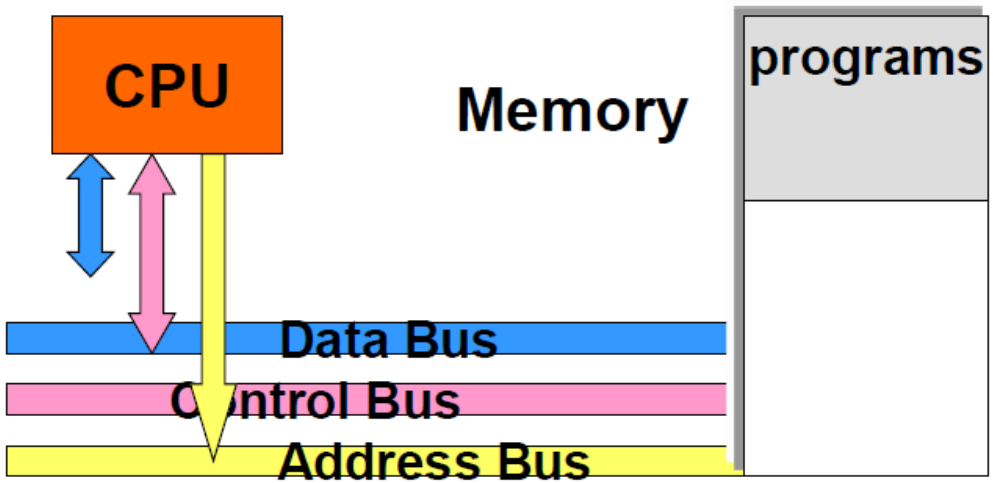
How Does a Computer Work?

Hardware needs software

Software is a program that consists of a series of instructions (and data) for performing some designated tasks.

CPU runs a program by executing the instructions one by one.

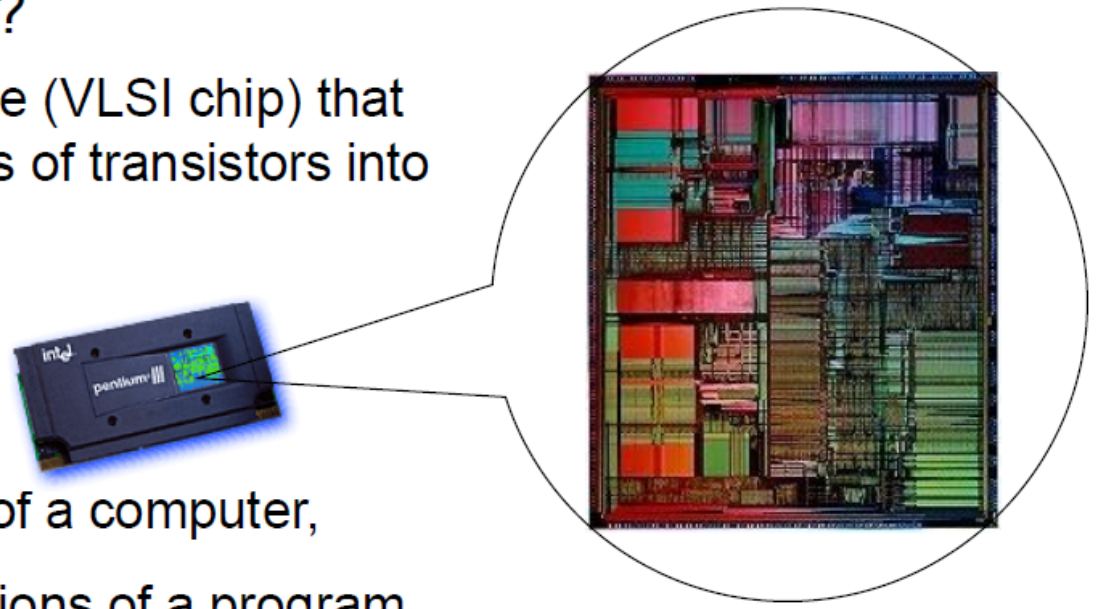
A program is stored in the main memory when it is executed.



Central Processing Unit (CPU)

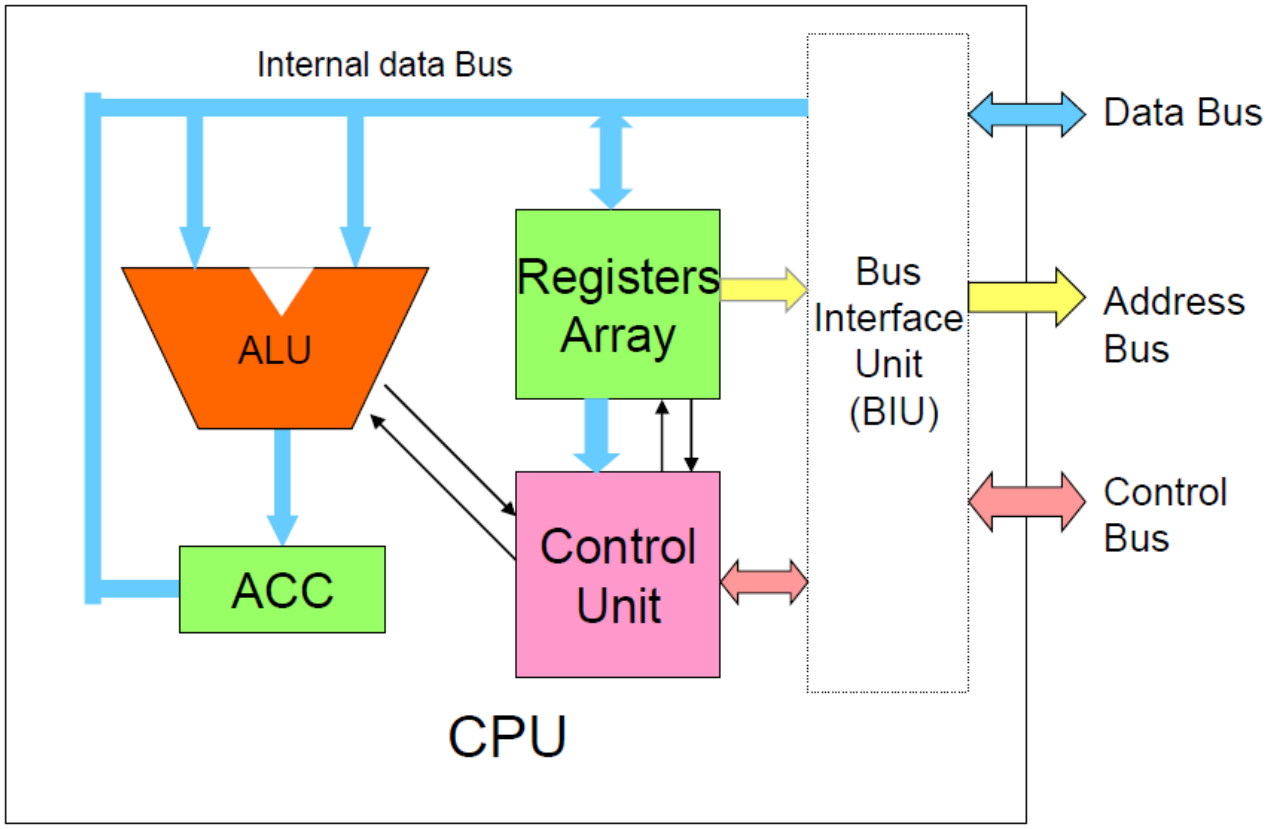
What is a CPU?

A hardware device (VLSI chip) that integrates millions of transistors into a silicon chip.



- Lies at the heart of a computer,
- Executes instructions of a program,
- Controls all operations accordingly.

CPU Architecture



Arithmetic Logic Unit (ALU)

Arithmetic Logic Unit (ALU): primarily constructed by logic gates (full adders)

It performs

–Basic arithmetic calculations:

e.g. adding(+), subtracting(-), multiplying(x) and dividing(/).

–Logic operations:

e.g. OR, AND, NOT, (Left or Right) Shift, etc.

ALU gets control signals from the Control Unit to carry out instructions one by one.

Control Unit

One of the most important parts in a CPU.

Consists of decoding, timing and control logic circuits.

Main functions:

–To decode instructions,

–To create control signals,

which tell the ALU and the Registers how to operate, what to operate on, and what to do

with the result.

–To make sure everything happens in the right place at the right time, with a clock.

Registers

A mini-storage area built with flip-flops inside CPU

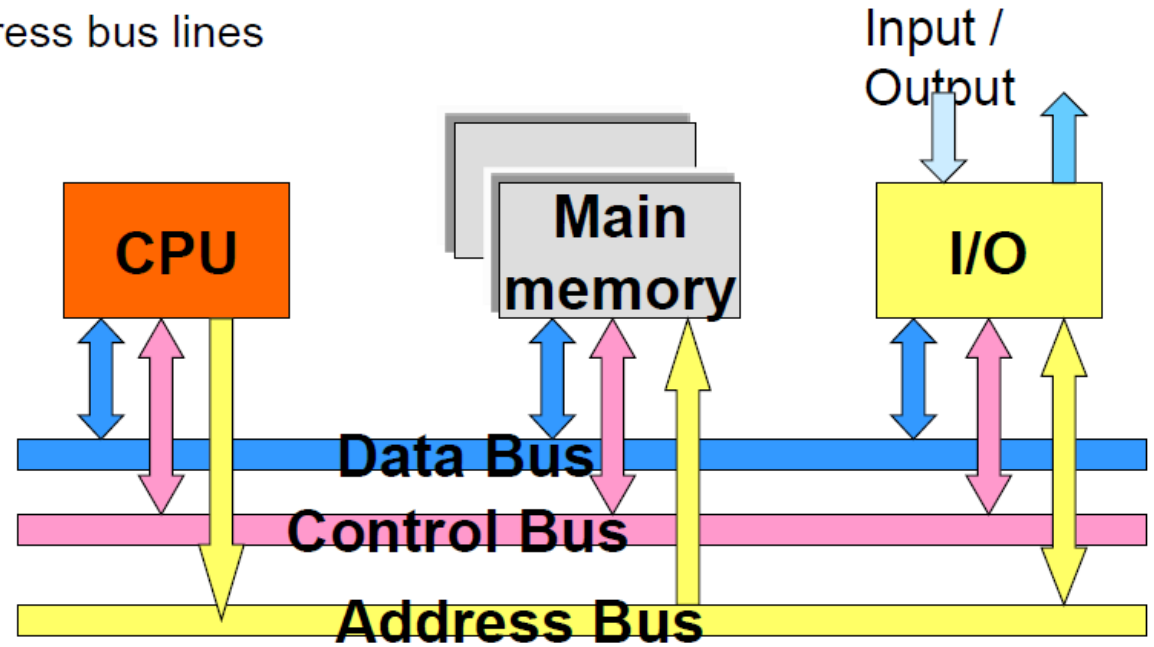
- PC (Program Counter): Holds address of instruction being executed.
- IR (Instruction Register): Holds instruction while it's decoded/executed.
- ACC (Accumulator): Result of ALU operations
- MBR (Memory Buffer Register): Temporarily holds the instruction/data fetched from the memory unit.
- MAR (Memory Address Register): holds address.

ALU can retrieve information (instruction or data) quickly.

System BUS Structure

System bus consists of 3 functional groups of lines:

- Data bus lines
- Control bus lines
- Address bus lines



Data Bus

Bi-directional path for transmitting data between the CPU and memory, and peripherals.

Width of data bus: number of bits can be transferred at a time

–E.g. 8, 16, 32, or 64 lines, each for one-bit binary data,

The width of data bus is one key factors in determining overall system performance.

Address Bus

A ‘road’ for conveying addresses to memory or input/ output devices.

The number of address lines, or width, determines maximum capacity of addresses a CPU can access to,

i.e. N lines: 2^N addressable memory (and I/O) units, e.g.

8 address lines: 2^8 = 256 addresses from 00000000 to

11111111.

Control Bus

Carries signals to control the activities of data/instruction transfers (read or write), or input/output devices.

The number of control bus lines varies, each is designed to perform a specific control task, e.g.

RD: Read signal

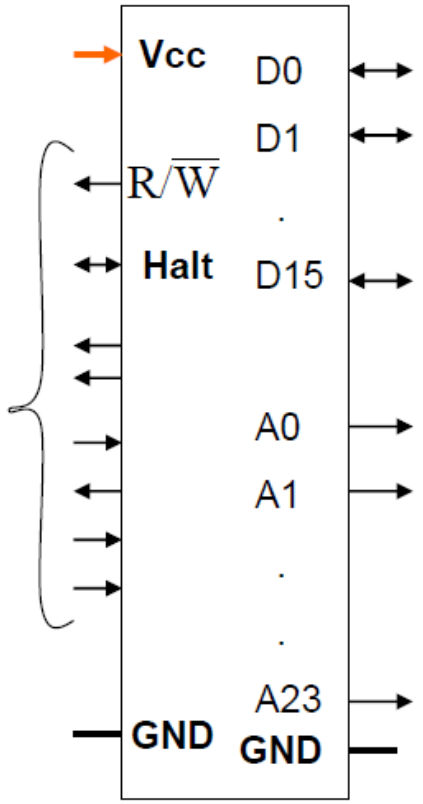
WR: Write signal

CLK: system clock signal

RESET: reset control signal

M68000 CPU chip

- **64 connection pins**
  - 16-bit Data Bus (32-bit internal).
  - 24-bit address bus (for 16 MB).
  - 21 control pins, e.g. $R/\overline{W}$, Halt, etc.
  - 3 pins for power supply: Vcc, GNDx2.



Instruction Execution

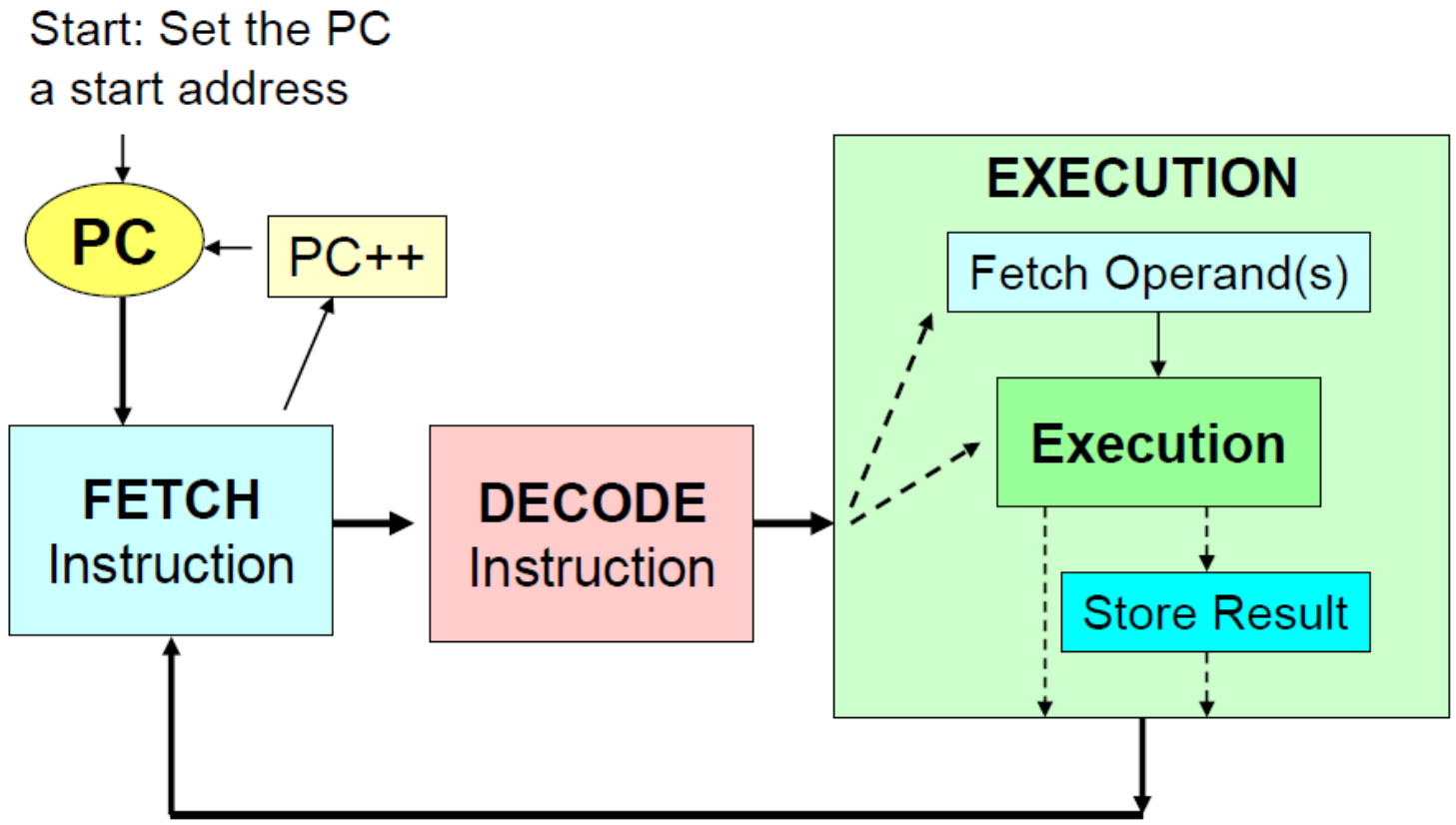
CPU performs Fetch/Decode/Execute cycle:

- Fetch instruction from primary memory
- Increment Program Counter
- Decode
- Execute instruction
- Write result to memory
- REPEAT!

Fetch Time depends on access time of memory and activity on Bus

Decode/Execute Time depends on type of instruction

Instruction Execution Cycle



Summary

Most of modern computer systems are based on von Neumann architecture

Computer components: CPU, Memory and I/O devices

BUS (Control bus, data bus and address bus) links computer components together

CPU (Centre Processing Unit):the brain of a computer.

- Consists of: ALU (Arithmetic and Logic Unit), Registers, Control Unit, Internal bus and Bus Interface Unit.

CPU instruction cycle includes:

Fetch > Decode > Execute.