Computer Organization

Hardware: refers to the physical components of a computer. These are the parts that you can see, feel and hear. Examples are the CPU, the keyboard, the monitor, memory, cables, mouse , printer and power supply.

Software: refers to the programs that control the computer and make it function.

Problem Statement
- stated using "natural language"
- may be ambiguous , imprecise

Algorithm
- step-by-step procedure , guaranteed to finish
- definiteness, effective computability, finiteness

Program: is a set of instructions that the computer obeys. Computer programs can be extremely long and complex sets of instructions. It is quite common for computer programs to be tens of thousands of lines long. The application programs that you use on your PC for word processing and spreadsheets are in fact even longer.

  - express the algorithm using a computer language
  - high-level language, low-level language

Computer architecture

The architecture of a computer is the general layout of its components, the principle features of these components, and how they are connected together.

CPU - Architecture

- The CPU may be located on a single chip or may be broken into several chips. The various component of the CPU connecting the CPU to the remainder of the computer is called the external buses. The set of chips containing the control bus, control memory; arithmetic/logic unit and registers are called *microprocessor session.*

Example is Intel® processor chip

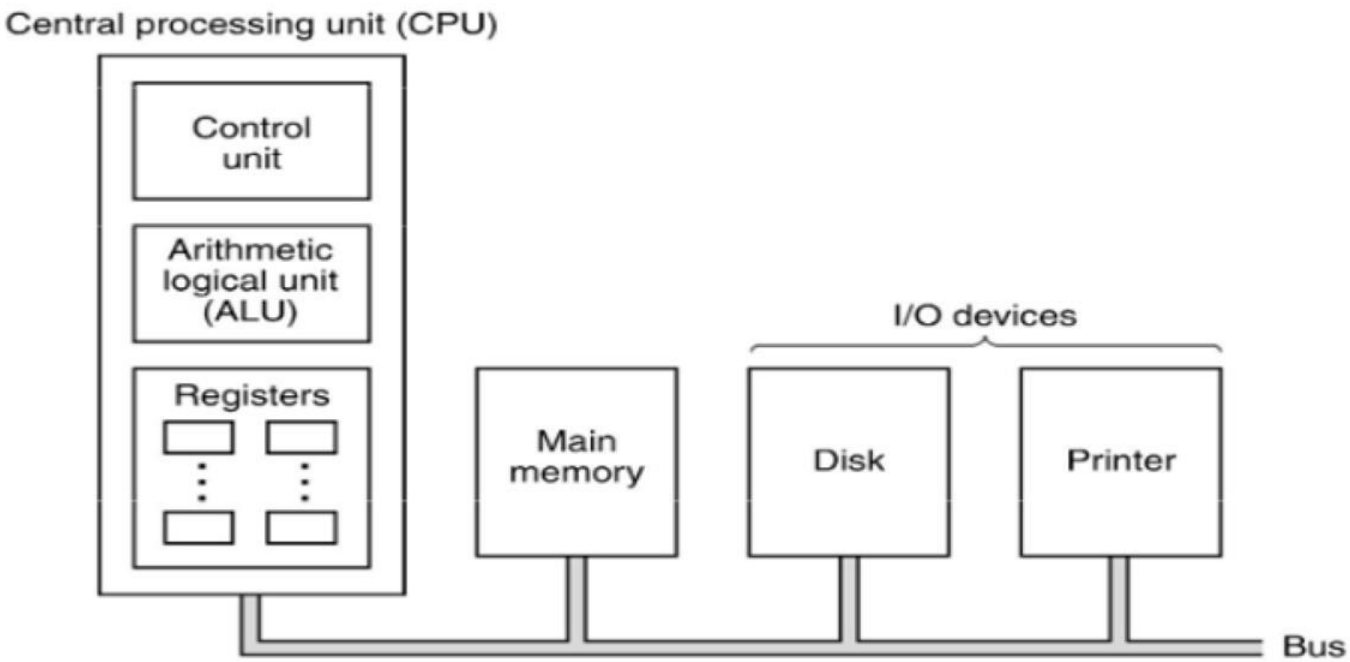
Central Processing Unit

It is the brain of the computer; it actually performs all the calculations carried by the machine. Processor speed is the speed at which the processor executes its instructions or commands. This speed is measured in millions of cycles per second, or megahertz (MHz). Original CPUs had a speed of 4.77 MHz, while systems at the time of this writing are running around 1.5 GHz. Although processor speed is not the only factor affecting performance, in general, the larger the MHz the faster the system.

It consists of a single **control unit**, the **arithmetic and logic unit (ALU)** and memory **(registers, cache, RAM and ROM)** as well as various temporary buffers and other logic.

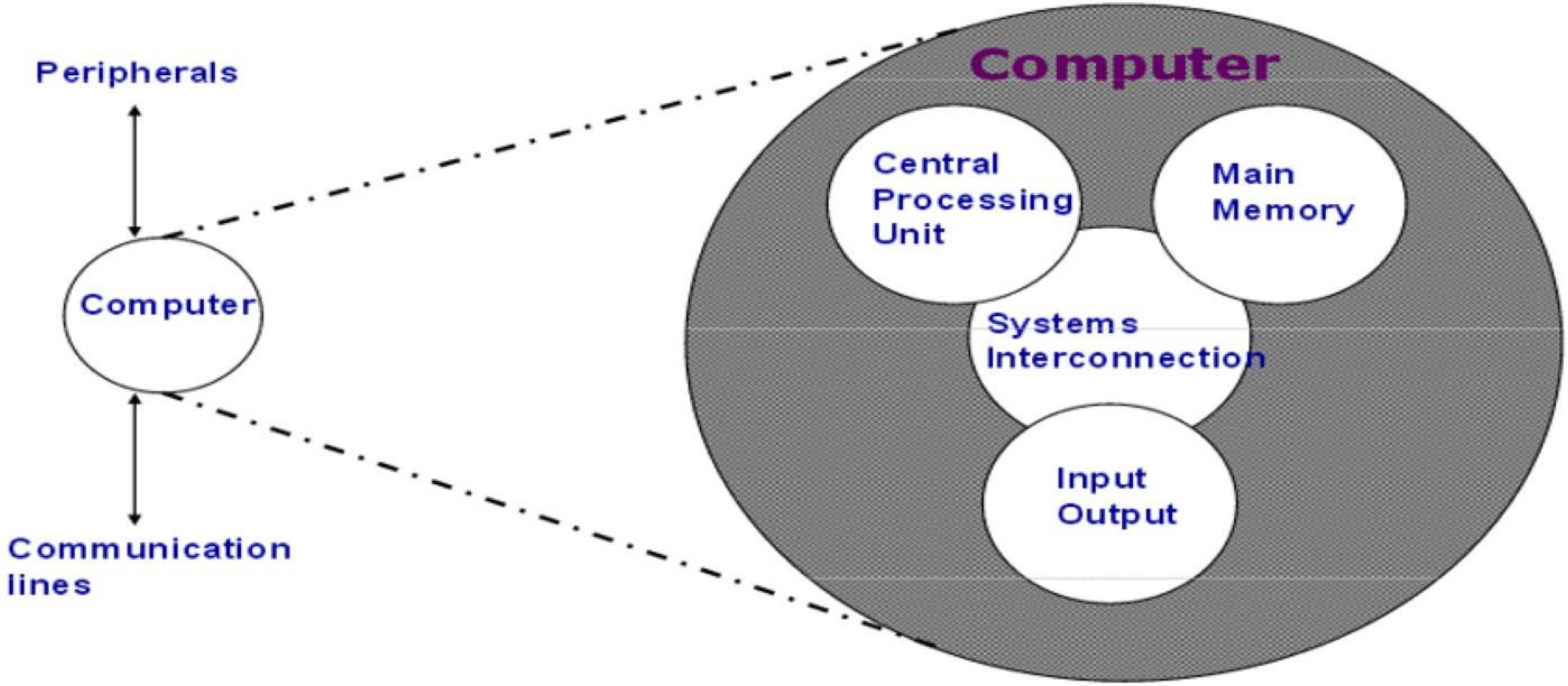
The function of the CPU is to execute programs stored in the main memory by fetching instructions, examining them, and executing them one after the other.

Central Processing Unit (CPU) based CO

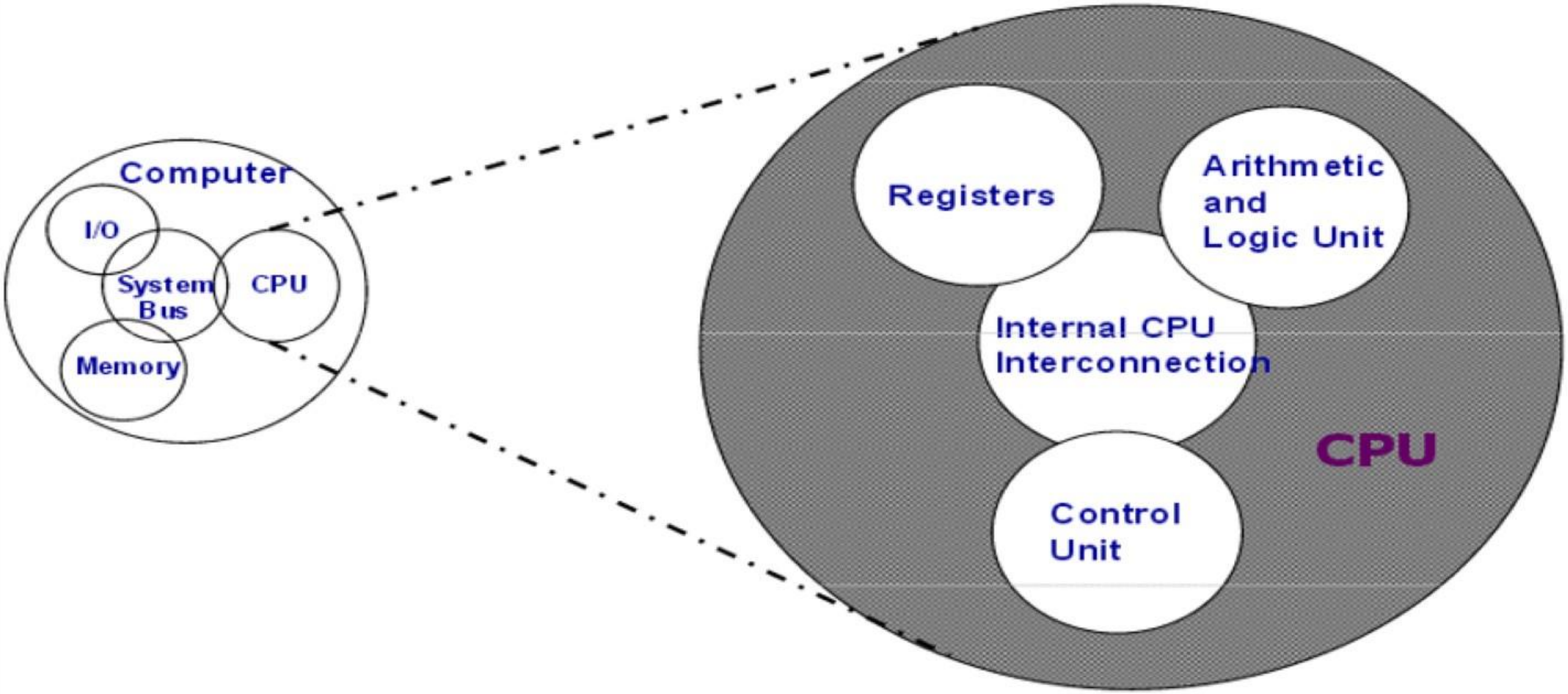


The organization of a simple computer with one CPU and two I/O devices

Structure - Top Level



Structure - The CPU



CPU - Control Unit

part of a CPU responsible for performing the machine cycle (fetch, decode, execute, store). The control unit fetches instructions from memory and decodes them to produce signals which control the other part of the computer. This may cause it to transfer data between memory and ALU or to activate peripherals to perform input or output.

Note:

These instructions are in a language called **machine code.** **Machine code** is a pattern of ones and zeros. The control unit also has the task of getting the data needed by the instructions and returning the results of the processing after the instruction has been executed.

Control unit contains the following registers:

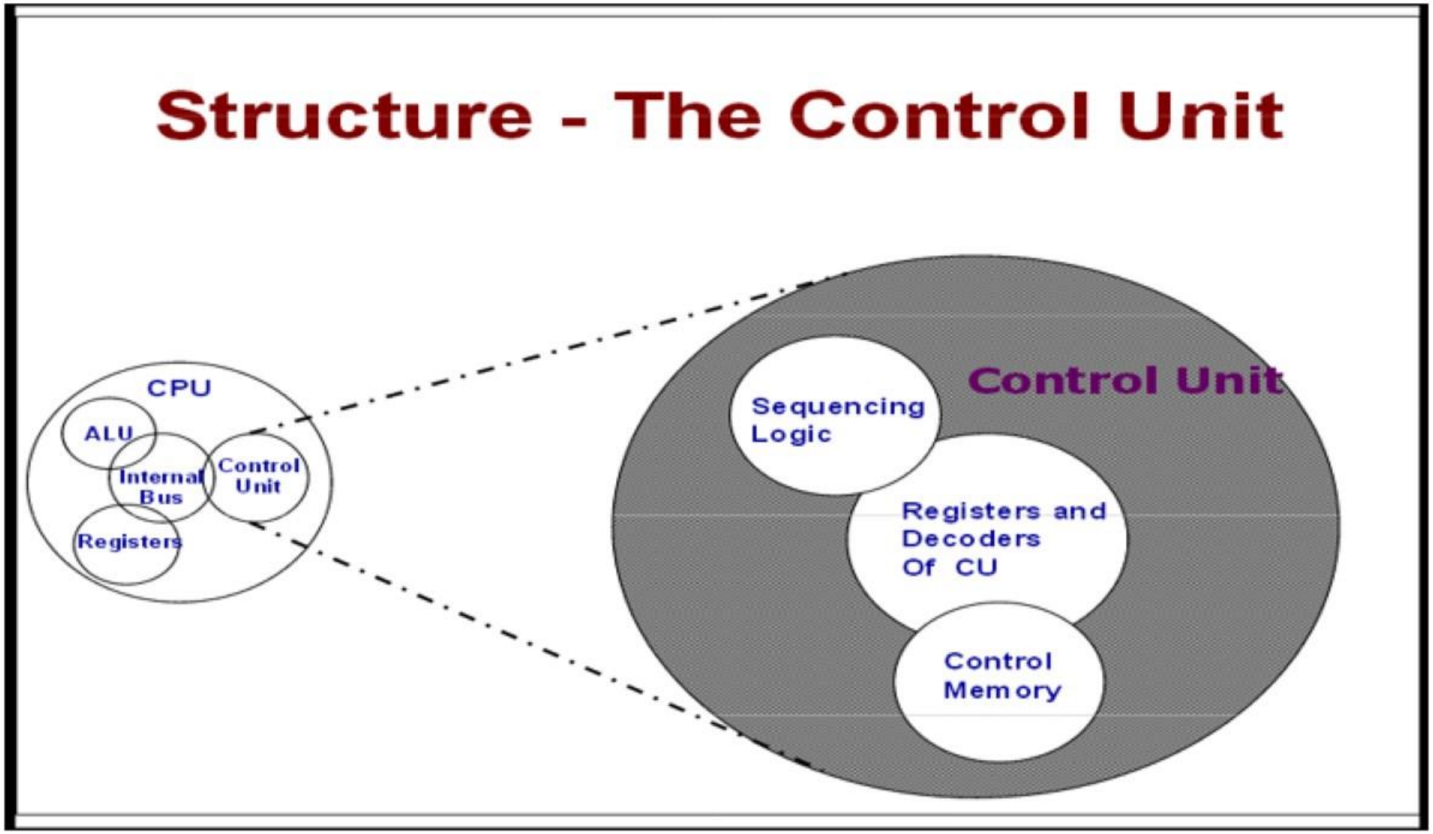
1. **Program counter (PC):** this register contains the address of the next instruction to be executed. The PC is automatically incremented after each instruction is fetched to point to the following instruction.

2. **Instruction register (IR):** this register receives the instruction as it is brought in from the main memory and hold it while it is decoded and executed.

3. **Flag register:** this register used to indicate the current state of the CPU and the important characteristics of the results of the previous instruction (e.g. zero, sign, carry,...etc.).

4. **Stack pointer (SP):** it is used for temporary storing important information while subroutines or service routines are being executed. Most stacks are Last In First Out (LIFO) stack that is the last information put onto the stack is the first to be retrieved from the stack. The top of the stack is the last information put onto the stack. The **stack pointer** points to the top of the stack.

After execution of one instruction has been completed, the address of the next instruction is obtained from the PC the next instruction is brought in from the memory and placed in the IR. The control unit then directs its execution. At the same time the control unit sets the PC to the address of the next instruction. This address is determined by the type of the current instruction and by the current contents of the status register.



CPU - Registers

The CPU also contains a small high speed memory which is used to store temporary results and control information. It is also the number of bits that the CPU can work at one time. This memory consists of a number of registers, each performing a specific function.

Registers give a processor quicker access to data, and the more registers a processor has, the more data it can get to. A processor with 16-bit registers would have 16 containers to store information used by the system. A processor with 32-bit registers would have double the amount of containers that it would use to store information.

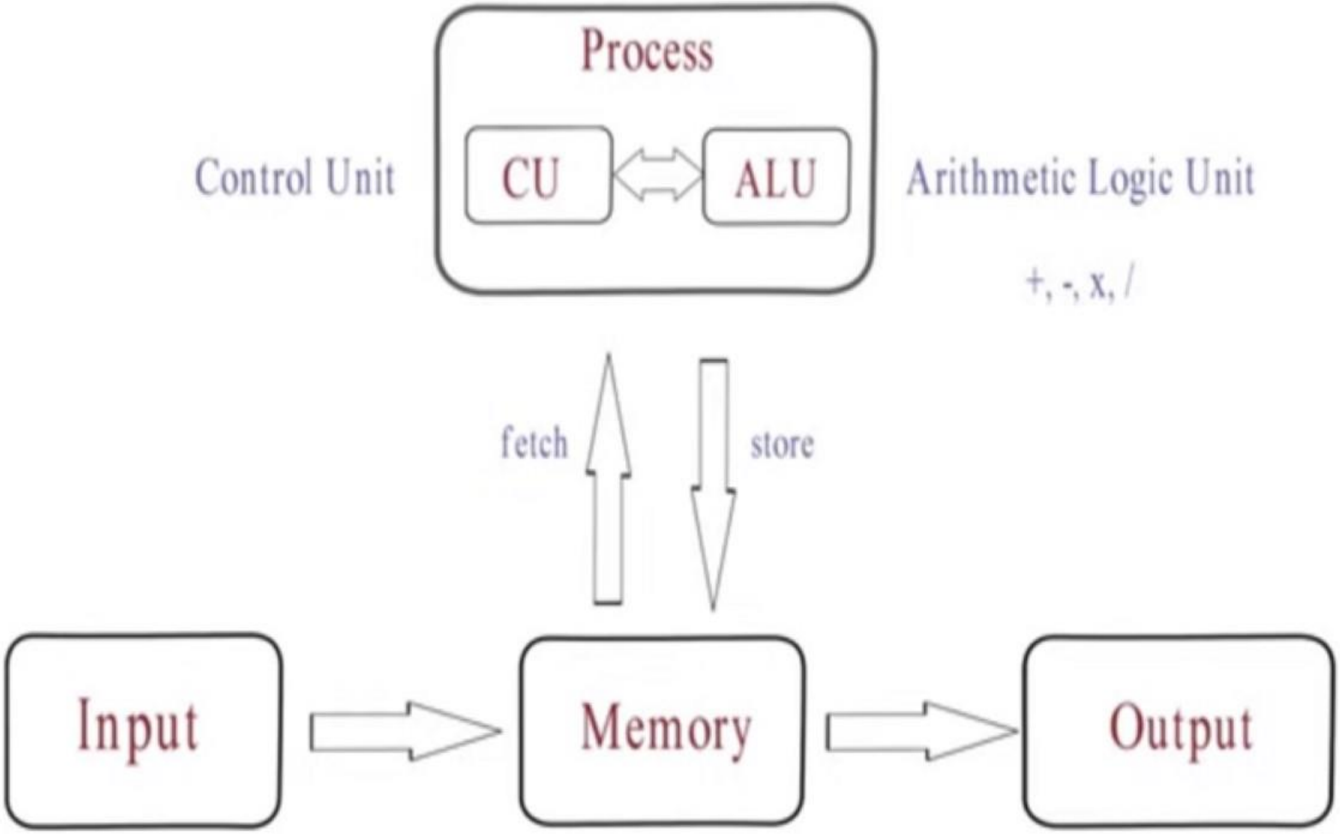
All CPUs contain a certain number of registers, which fall into one or both of the following categories:

- **Accumulators or arithmetic register**: serve the purpose of holding data used in calculations.
- **Address Registers**: are used for storing the memory location of data or instructions to be used by a program.

CPU - ALU

The arithmetic/logical unit (ALU): is responsible for performing arithmetic and logical operations and comparisons of data.

- It performs arithmetic operations on integer (whole number) and real (with a decimal point) operands.
- It stores the results in the place indicated by the instruction. It also modified the appropriate flag bits



Von Neumann Architecture

❒ Modern computer architecture is accredited to John Von Neumann

A **von Neumann machine** is a model created by **John von Neumann** for a computing machine that uses a single storage structure to hold both the set of inst1ructions (how to perform the computation) and the data required or generated by the computation. Most modern computers use this von Neumann architecture. Computers using this architecture are said to be "von Neumann machines."

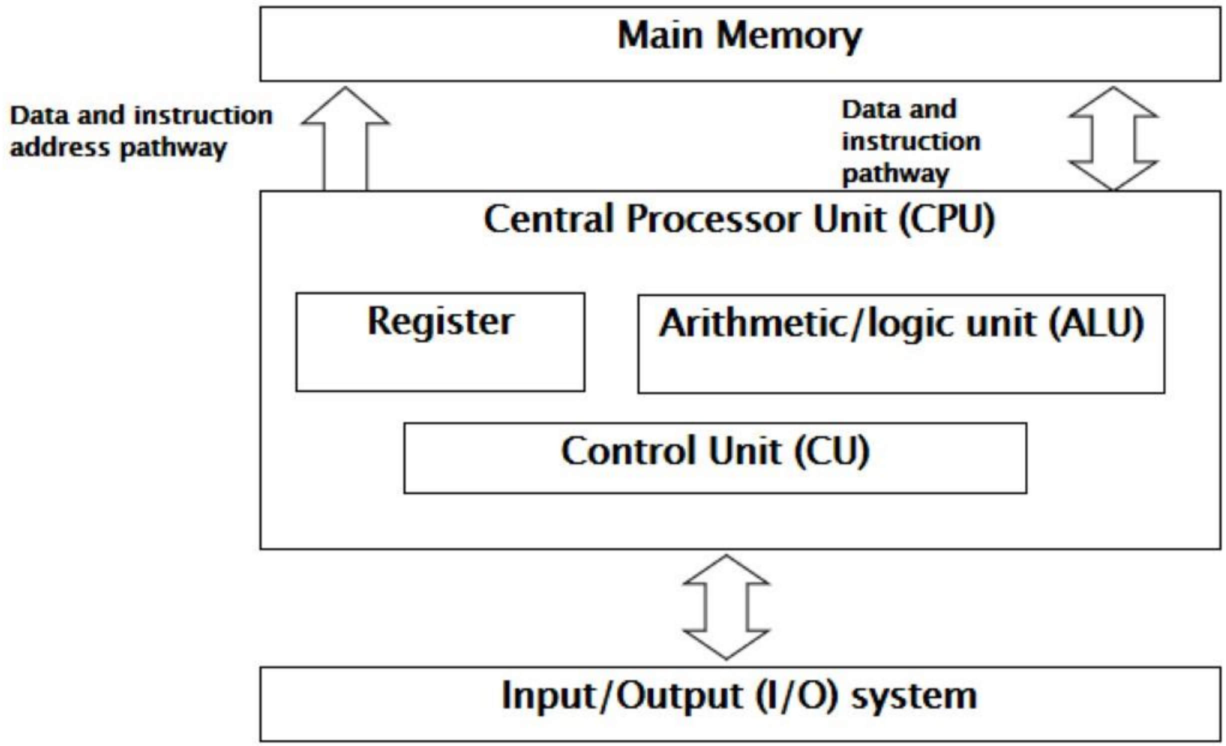
Von-Neumann machine has three basic hardware subsystems

Central Processing Unit (CPU)
Main memory
input/output (I/O)

The main memory holds the program that controls the computer's operation and the computer that can manipulate. It carries out the instructions sequentially. The CPU executes one program at a time.

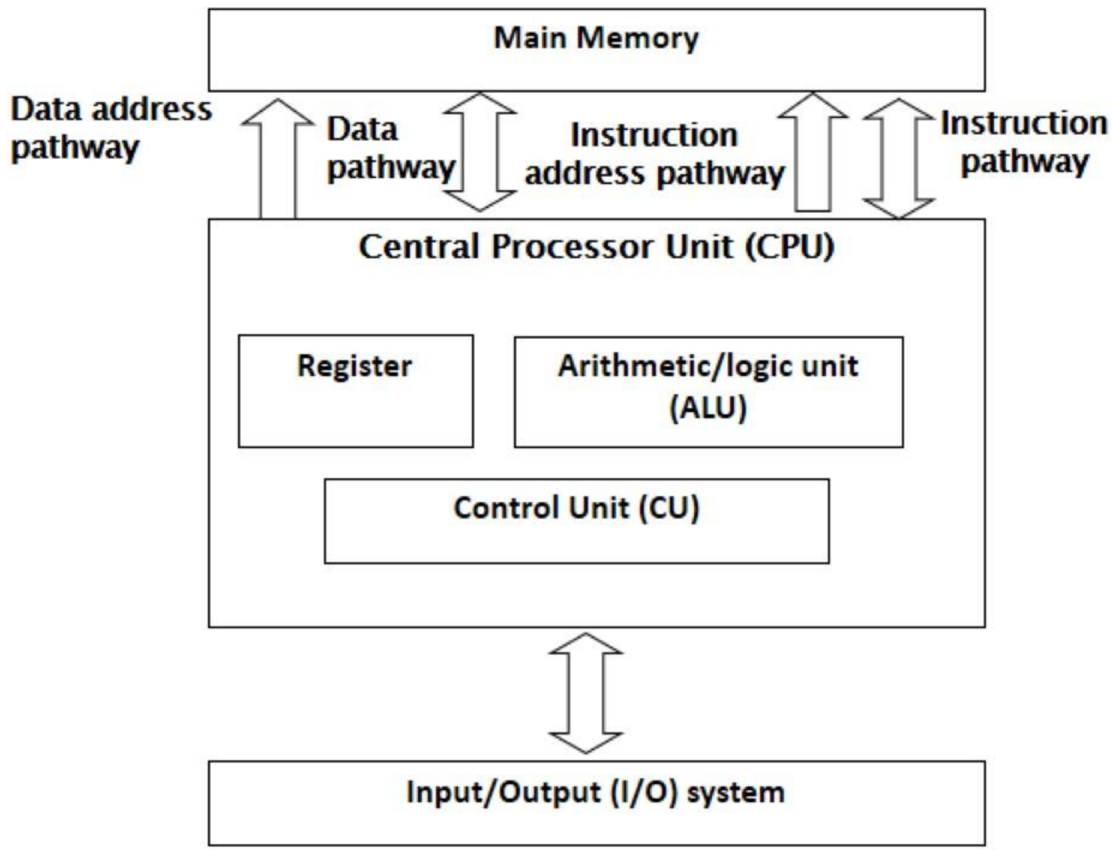
Conventional Von-Neumann machines provide one pathway for address and a second pathway for data & instructions.

Conventional Von-Neumann Machine



In a computer with Von-Neumann architecture, the CPU can be either reading an instruction or reading/writing data from/to the memory. Both cannot occur at the same time since the instructions and data use the same singal pathways and memory.

The term Harvard architecture is a class of Von Neumann machines similar to conventional Von-Neumann computers except that they provide independent pathway for data address, data, instruction address, & instruction.



Harvard architecture

In a computer with Harvard architecture, the CPU can read both an instruction and data from memory at the same time. A computer with Harvard architecture can be faster because it is able to fetch the next instruction at the same time it completes the current instruction. Speed is gained at the expense of more complex electrical circuitry.