Von Neumann Architecture

Historically, there have been two types of computers: those that have a very defined function and cannot be programmed, such as calculators, and those that can be programmed (these can be configured to perform a variety of activities, and they store applications).

The contemporary computer is built on John von Neumann's concept of stored programs. Programs and data are kept in a distinct storage unit called memories in this stored-program approach, and they handle the same. A computer developed with this design would be considerably easier to reprogram, thanks to this unique notion.

Here is the basic structure:

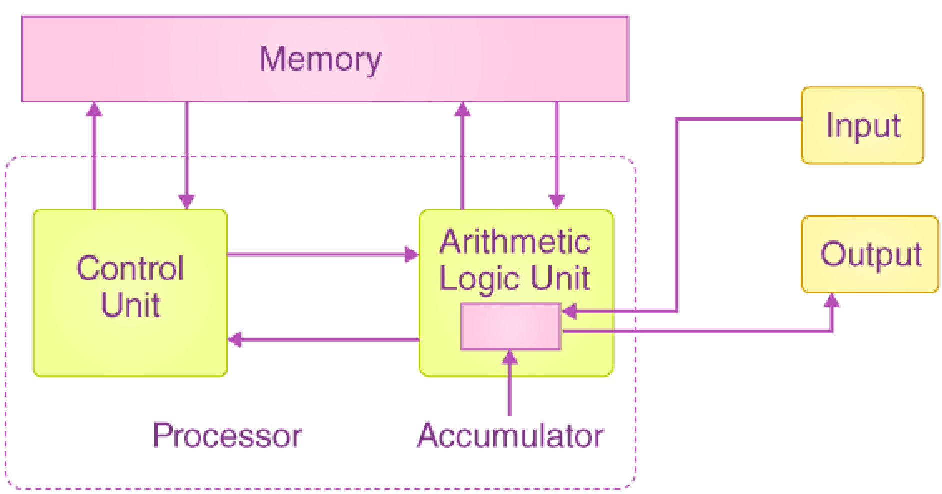

Figure 1: Von Neumann Basic Structure

It's also known as an IAS computer, and it's made up of three fundamental components:

- The CPU or Central Processing Unit
- The Main Memory Unit (most important part of the system)

- The I/O Device or the Input/Output Device

Let's take a closer look at their components in detail.

1. **CPU (Central Processing Unit)**

The control unit, main memory, and arithmetic-logic unit make up the central processing unit (CPU), which is the most important portion of any digital computer system. The CPU is the computer's brain, including all of the circuitry required to process input, store data, and generate output. The CPU is always following computer program instructions that instruct it on which information to process as well as how to process it. We couldn't run applications on a computer without a CPU.

- CU (Control Unit)

It is responsible for all processor control signals. It governs how data moves throughout the system, directs all input and output flow, and gets code for instructions.

- ALU (Arithmetic and Logic Unit)

The arithmetic logic unit (ALU) is the portion of the CPU that handles all of the CPU's computations, such as addition, subtraction, and comparisons. Also, Logical operations, arithmetic operations, and bit shifting operations are all performed by it.

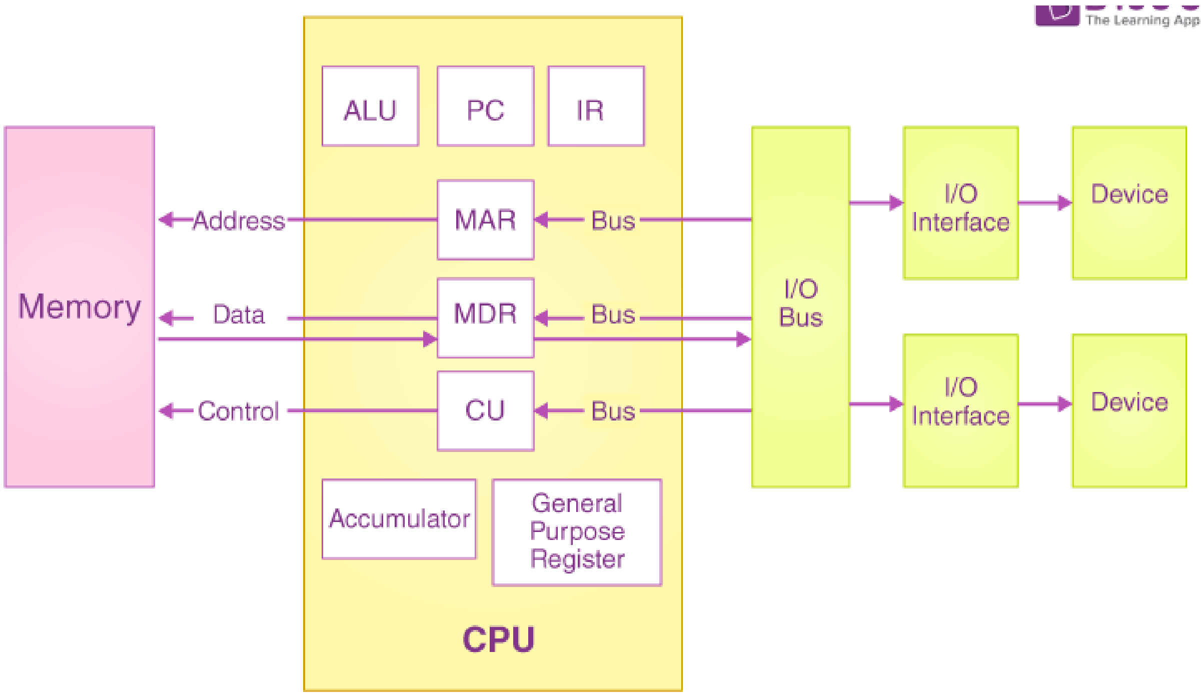

Figure 2: Basic CPU Structure of ALU

2. Registers (Main Memory Unit)

Registers are a sort of computer memory that is used to accept, store, and transport data and instructions that are used by the CPU right away. Processor registers is the term used to define the registers that the CPU uses. Registers are highly fast computer memory that are used to efficiently execute programs and operations in computer architecture.

- **Accumulator:** It stores the results of the calculations that the ALU makes.
- **Program Counter:** The PC keeps track of the location of the memory of the next instructions that are to be dealt with. Then this next address is passed by the PC and passes to the Memory Address Register (MAR).

- **Memory Address Register:** MAR stores the memory locations of those instructions that are either to be fetched from the memory or to be stored in the memory.

- **Memory Data Register:** MDR stores the instructions that are fetched from the memory or any information that is to be transferred to and stored in the memory.

- **Current Instruction Register:** CIR stores the recently fetched instructions while it waits for coding and execution.

- **Instruction Buffer Register:** The instruction that isn't to be immediately executed is placed in the IBR or instruction buffer register.

3. **I/O Devices**

Under the control of CPU input instructions, the program or the data is read into the main memory from the secondary storage or the input device. The data from a computer is output using output devices. If any results are evaluated by a computer and saved in it, you can present them to a user via output devices.

Buses

Data is sent from one portion of a computer to another via buses, which connect all key internal components to the memory and CPU. They are of the following types:

- **Control Bus:** It receives control commands from the CPU, as well as status signals from other devices, and uses them to control and coordinate all of the computer's actions.

- **Address Bus:** It communicates between memory and the processor the data address (not the actual data).

- **Data Bus:** It relays information between the memory unit, I/O devices, and the processor.

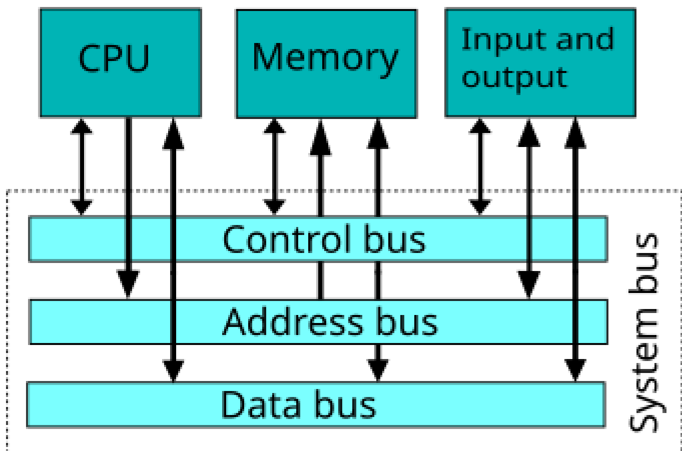

Figure 4: System bus

Von Neumann Bottleneck

Whenever we try to improve performance, we can't ignore the fact that orders can only be carried out one at a time and in a specific order. Both of these considerations limit the CPU's capabilities. The 'Von Neumann bottleneck' is a term used to describe this situation. We can give a Von Neumann processor more cache, RAM, or quicker components, but if original increases in CPU performance are to be produced, a thorough examination of the CPU configuration is required.

This architecture is critical, as it is employed in our personal computers and even supercomputers.