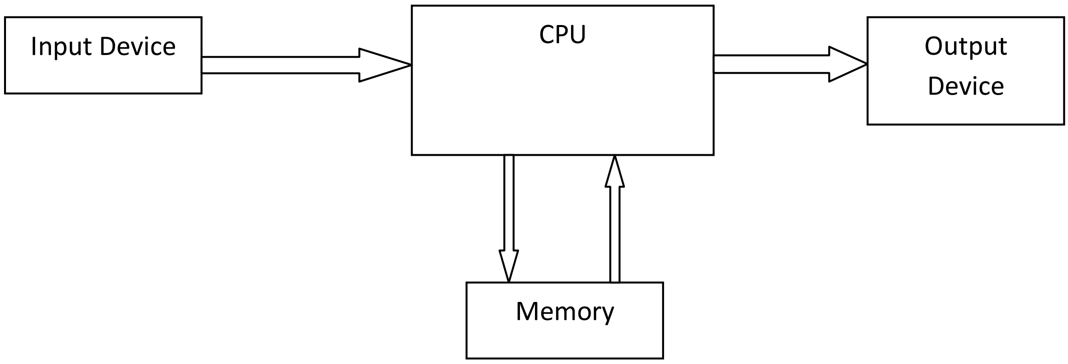
BASIC COMPUTER ORGANISATION

Basic Computer Model and different units of Computer

The model of a computer can be described by four basic units in high level abstraction. These basic units are:

- Central Processor Unit
- Input Unit
- Output Unit
- Memory Unit



Central Processor Unit [CPU]:

Central processor unit consists of two basic blocks:

- The program control unit has a set of registers and control circuit to generate control signals.
- The execution unit or data processing unit contains a set of registers for storing data and an Arithmetic and Logic Unit (ALU) for execution of arithmetic and logical operations.

In addition, CPU may have some additional registers for temporary storage of data.

B. Input Unit:

With the help of input unit data from outside can be supplied to the computer. Program or data is read into main storage from input device or secondary storage under the control of CPU input instruction.

Example of input devices: Keyboard, Mouse, Hard disk, Floppy disk, CD-ROM drive etc.

C. Output Unit:

With the help of output unit computer results can be provided to the user or it can be stored in storage device permanently for future use. Output data from main storage go to output device under the control of CPU output instructions.
Example of output devices: Printer, Monitor, Plotter, Hard Disk, Floppy Disk etc.

D. Memory Unit:

Memory unit is used to store the data and program. CPU can work with the information stored in memory unit. This memory unit is termed as primary memory or main memory module. These are basically semi conductor memories.

There are two types of semiconductor memories -

- **Volatile Memory:** RAM (Random Access Memory).
- **Non-Volatile Memory:** ROM (Read only Memory), PROM (Programmable ROM) EPROM (Erasable PROM), EEPROM (Electrically Erasable PROM).

Secondary Memory :

There is another kind of storage device, apart from primary or main memory, which is known as secondary memory. Secondary memories are non volatile memory and it is used for permanent storage of data and program.

Example of secondary memories:

- Hard Disk, Floppy Disk, Magnetic Tape ------ These are magnetic devices,
- CD-ROM ------ is optical device
- Thumb drive (or pen drive) ------ is semiconductor memory.

GENERATIONS OF COMPUTER

➢ First generation of computer

The earliest attempt to make an electronic computer using vacuum tubes appears to have been made in the late 1930s. This special purpose machine was intended for solving linear equations, but the project never completed at all.
The first successful, widely known general purpose electronic computer system was electronic numerical integrator and calculator or ENIAC.

➢ Second Generation (1956-1963)

In second generation Transistors replaced the vacuum tubes used in the first generation. The transistor was invented in 1947 but did not see widespread use in computers until the late 1950s. The transistor was far superior to the vacuum tube, allowing computers to become smaller, faster, cheaper, more energy-efficient and more reliable than their first-generation predecessors. Though the transistor still generated a great deal of heat that subjected the computer to damage, it was a vast improvement over the vacuum tube. Second-generation computers still relied on punched cards for input and printouts for output.
Second-generation computers moved from cryptic binary machine language to symbolic, or assembly, languages, which allowed programmers to specify instructions in words. High-level programming languages were also being developed at this time, such as early versions of COBOL and FORTRAN. These were also the first computers that stored their instructions in their memory, which moved from a magnetic drum to magnetic core technology.
The first computers of this generation were developed for the atomic energy industry.

➢ Third Generation (1964-1971)

The development of the integrated circuit was the hallmark of the third generation of computers. Transistors were miniaturized and placed on silicon chips, called semiconductors, which drastically increased the speed and efficiency of computers.
Instead of punched cards and printouts, users interacted with third generation computers through keyboards and monitors and interfaced with an operating system, which allowed the device to run many different applications at one time with a central program that monitored the memory. Computers for the first time became accessible to a mass audience because they were smaller and cheaper than their predecessors.

➢ Fourth Generation (1971-Present)

The microprocessor brought the fourth generation of computers, as thousands of integrated circuits were built onto a single silicon chip. What in the first generation filled an entire room could now fit in the palm of the hand. The Intel 4004 chip, developed in 1971, located all the components of the computer—from the central processing unit and memory to input/output controls—on a single chip.

In 1981 IBM introduced its first computer for the home user, and in 1984 Apple introduced the Macintosh. Microprocessors also moved out of the realm of desktop computers and into many areas of life as more and more everyday products began to use microprocessors.

As these small computers became more powerful, they could be linked together to form networks, which eventually led to the development of the Internet. Fourth generation computers also saw the development of GUIs, the mouse and handheld devices.

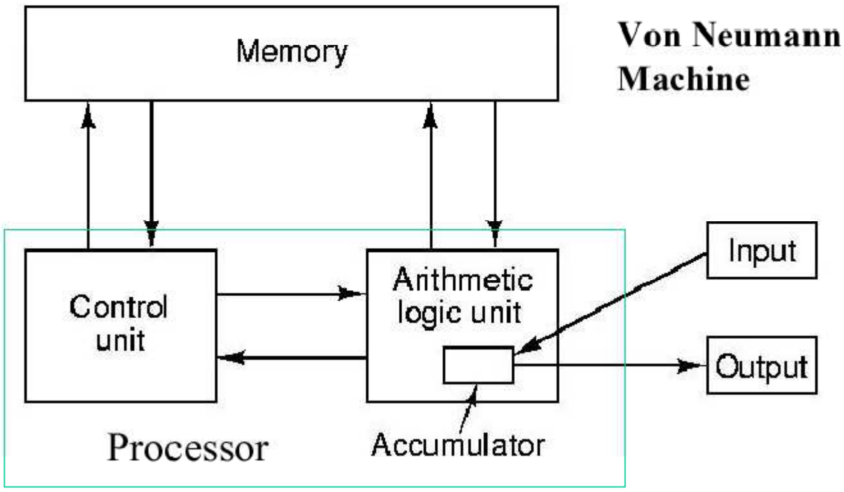
GENERATIONS OF COMPUTER (short description)

Generation no	Technologies	Hardware features	Software features	Representative computers
1st (1946-1954)	Vacuum tubes. CRT memories	Fixed-point arithmetic	Machine language, assembly language	Institute for Advanced Studies (lAS), UNIVAC (Universal Automatic Computer), ENIAC (Electronic Numerical Integrator & Calculator)
2nd(1955-I964)	Discrete transistors, ferrite cores, magnetic disks	Floating-point arithmetic	High-level languages, subroutines	IBM (International Business Machine) 7094.
3rd (1965-1974)	Integrated circuits (SSI and MSI)	Microprogramming, Pipelining. Cache memory	Multi-programming operating systems, Virtual memory	IBM 360. DEC's (Digital Equipment Corporation) PDP-8

4th (1975-1978)	LSI & VLSI circuits, Semiconductor memories	Microprocessors. Micro-computers	Real-time OS. parallel languages, RISC	Motorola's 68020. Intel's 80x 86 families.
5th (1979- till)	ULSI circuits, Optical disk	Embedded system. Massive parallelism	Multimedia Artificial Intelligence Internet	Intel's Xeon. Duo-core.

Von Neumann Architecture

The architecture, suggested by John Von Neumann, is referred to as the Von Neumann Architecture, which has similar structural blocks as the constituent units which were suggested by Charles Babbage. Neumann identified five blocks to perform operations on the data.



The blocks are namely Input block, Memory block, Output block; Arithmetic and Logic Unit block (ALU) and the Control Unit block. Traditionally ALU and Control Unit block are built together. The functions of these two blocks are complementary to each other to the extent that they are better built together. These two blocks together are referred to as the Central Processing Unit (CPU). The units work with the inherent philosophy of stored program concept given by Von Neumann.

Stored Program Concept:

The concept utilizes the memory to store all the instructions to be performed by the computer for a particular task prior to execution. The required data also are to be stored in memory at execution time. The CPU fetches one instruction from memory, decodes it and executes the same. At the end of the execution of the current instruction, it fetches the next instruction and the cycle continues till the job is finished.

The key features of Von Neumann architecture are as follows:

- The computer reads the instruction set from the outside world through the input device.
- The memory gets them through the Arithmetic and Logic Unit (ALU) and stores them within.
- The Control Unit of CPU fetches one instruction at a time from the memory to the ALU, analyses it, and fetches required data.
- ALU executes the instruction, stores result back to memory if required.
- To give an output, the content from ALU is given to output device.
- Control Unit of CPU controls all operations. It executes instructions in sequential order unless the effect of the instruction is to change the sequence of instructions.

It can be well observed that there is a single path between memory and ALU. Each instruction and operand need to be fetched from memory. Intermediate results are also needed to be stored in memory. This path between the memory and the ALU is kept busy almost every moment. Being a single path it is very critical. This path is called the bottleneck of the Von Neumann architecture. The Von Neumann machines are termed as Institute of Advanced Systems (IAS) machine or Princeton Machine by some authors. This is because the design of the system was done in Institute of Advanced Systems (IAS) at Princeton University, USA.
Very few computers have a pure Von Neumann architecture. Most computers add another step to check for interrupts, electronic events that could occur at any time. Interrupts let a computer do other things while it waits for events.

Drawback:

Von Neumann computers spend a lot of time moving data to and from the memory, and this slows the computer (this problem is called von Neumann bottleneck) so, engineers often separate the bus into two or more busses, usually one for instructions, and the other for data.

Harvard Architecture

The Harvard architecture is computer architecture with physically separate storage and signal pathways for instructions and data. The term originated from the Harvard Mark I relay-based computer, which stored instructions on punched tape (24 bits wide) and data in electro-mechanical counters. These early machines had limited data storage, entirely contained within the central processing unit, and provided no access to the instruction storage as data. Programs needed to be loaded by an operator, the processor could not boot itself.

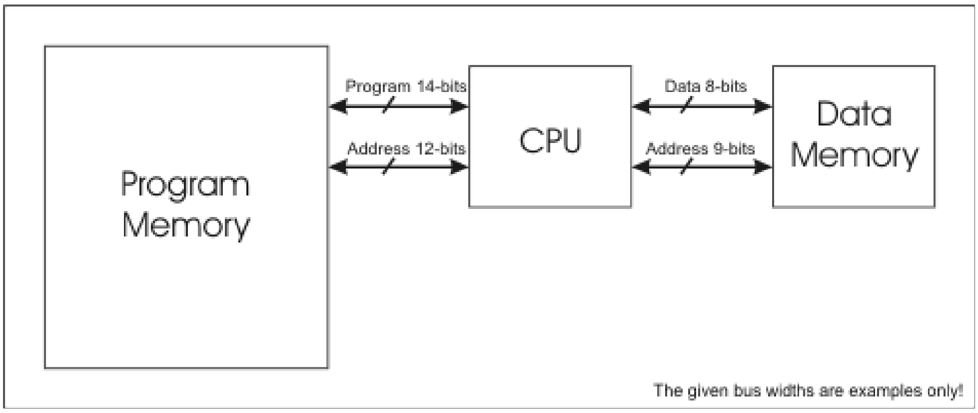


Fig: Harvard Architecture

In Harvard architecture, there is no need to make the two memories share characteristics. In particular, the word width, timing, implementation technology, and memory address structure can differ. In some systems, instructions can be stored in read-only memory while data memory generally requires read-write memory.

The Harvard architecture uses physically separate memories for their instructions and data, requiring dedicated buses for each of them. Instructions and operands can therefore be fetched simultaneously. Different program and data bus widths are possible, allowing program and data memory to be better optimized to the architectural requirements. E.g.: If the instruction format requires 14 bits then program bus and memory can be made 14-bit wide, while the data bus and data memory remain 8-bit wide.

Von-Neumann Architecture	Harvard Architecture
1. Under pure 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 bus system.	1. In a computer using the Harvard architecture, the CPU can both read an instruction and perform a data memory access at the same time, even without a cache.
2. Von-Neumann architecture is much slower as it has a single communication pathway.	2. A Harvard architecture computer is more faster for a given circuit complexity because instruction fetches and data access do not contend for a single memory pathway.
3. A Von-Neumann architecture machine does not have distinct code and data address spaces.	3. A Harvard architecture machine has distinct code and data address spaces.
4. It is not possible to have two separate memory systems for a Von-Neumann architecture.	4. It is possible to have two separate memory systems for a Harvard architecture.
5. Von Neumann architectures usually have a single unified cache, which stores both instructions and data.	5. Harvard architecture usually have a multiple cache, which stores both instructions and data separately.
6. It needs external memory all the time.	6. It may not need external memory at all.