Chapter 1: Generalities and Definitions

1. Definitions

1.1. Computer Science:

This new term created in 1962 by Philippe Dreyfus represents a science based on information techniques allowing the automatic processing of information through the computing tool, 'the computer.' This field is based on two fundamental principles:

• **Hardware**: which represents the computer's hardware aspect, including design and administration.

• **Software**: which represents the intangible “the non-physical” part of a computer: software, applications, ..."

1.2. The computer:

It is an electronic machine capable of automatically processing all kinds of information (Text, Image, etc.).

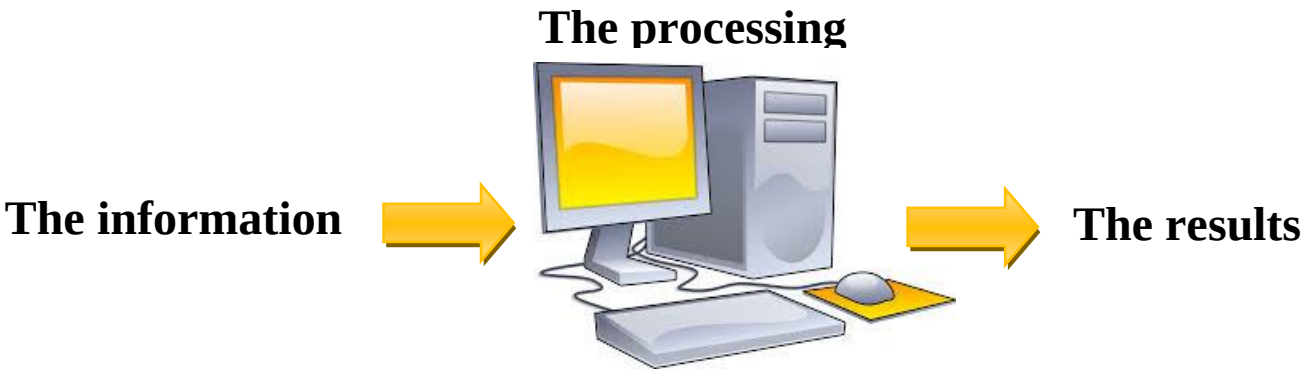

Fig1. How a computer works

1.3. The Importance and Utility of a Computer:

This computer tool allows us to accelerate the processing of large volumes of data and obtain correct, precise, and error-free calculation results within reasonable timeframes.

1.4. The Computer System:

It is the combination of programs (Software) and hardware (Hardware) necessary to meet the computer needs of a user

2. The Basic Architecture of a Computer

A machine can be called a computer when it contains at least a processor and a memory. In other words, a computer is a machine that can capture information from its environment through input devices, process this information using the processor and memory, and then react to its environment through output devices (FIG1).

A computer can take various forms, such as a laptop, a tablet, a smartphone, a personal computer (PC), a car computer, a real-time system, an embedded system, a self-driving car, and more. The following figure encompasses all the examples that have been mentioned."

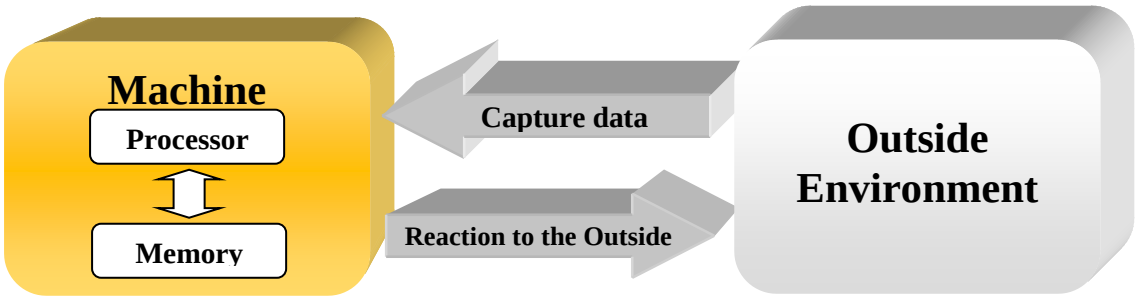

Fig2. Computer Interaction with the External Environment

For example:

Car Computer: It contains several real-time systems such as the Anti-lock Braking System (ABS)."

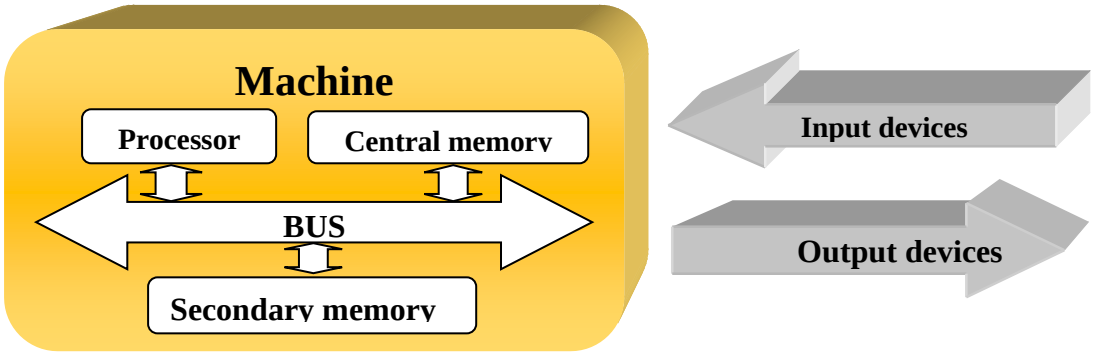

Fig3. Global Overview of a Computer

3. The Von Neumann Machine and the Harvard Machine

There are two fundamental types of structures, known as 'Von Neumann' and 'Harvard,' as presented in the following figures:

3.1. Von Neumann

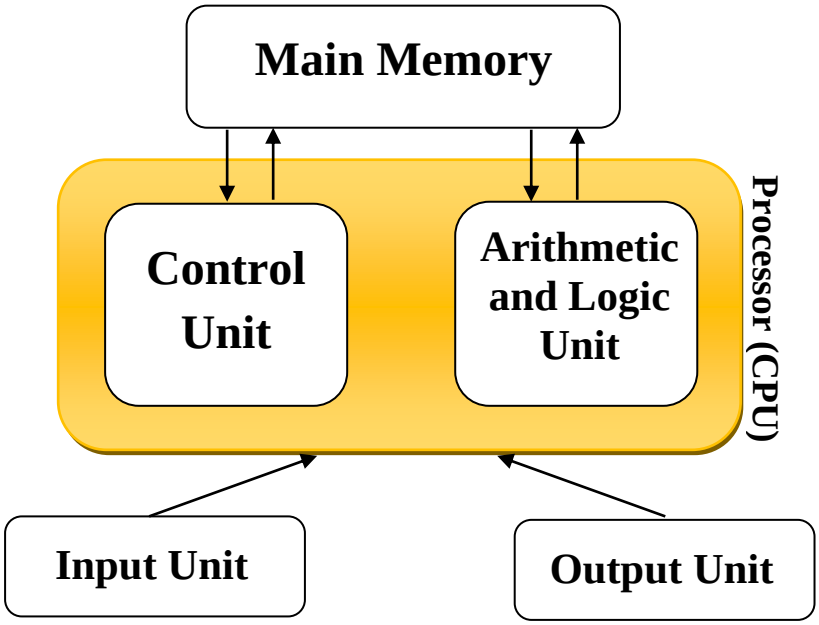

Fig3. Von Neumann Architecture

A processor based on a Von Neumann structure stores programs and data in the same memory area. An instruction contains the operation code and the operand's address. This type of microprocessor mainly incorporates two basic units:

- The Arithmetic and Logic Unit (**ALU**)
- The Control and Command Unit (**CU**)

3.2. Harvard

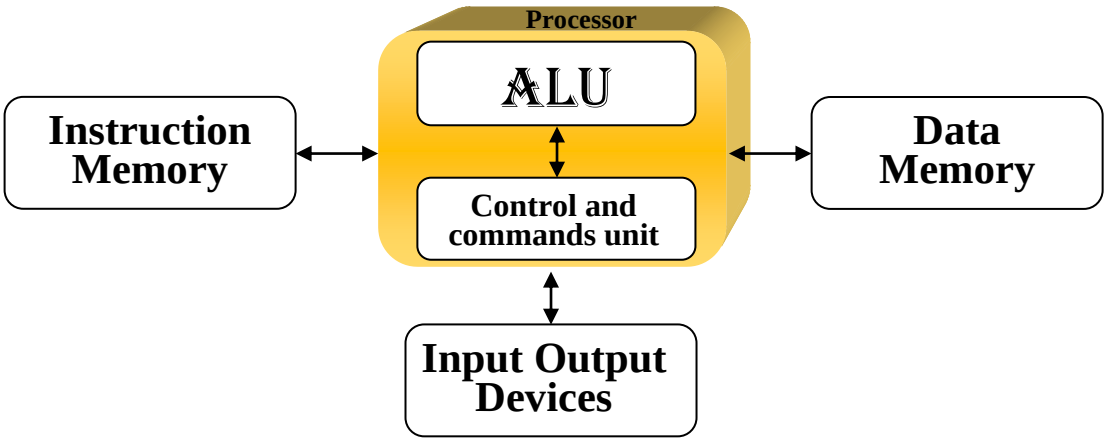

Fig4. Harvard Architecture

This structure differs from the Von Neumann architecture only in that program (instruction) and data memories are separated. Access to each of the two memories is done through a distinct path. This organization allows for the simultaneous transfer of an instruction and data, which improves performance.

3.3. The use of these structures in the real market

The architecture generally used by processors is the Von Neumann structure (examples: the Motorola 68XXX family, the Intel 80X86 family). The Harvard architecture is rather used in specialized microprocessors for real-time applications.

However, there are a few rare real-time applications with a Von Neumann structure. The reason for this is related to the higher cost of the Harvard-type structure. Indeed, it requires twice as many data and address buses.

4. Basic Components of a Computer:

4.1. The processor (CPU) :

The role of the Processor (CPU) is to execute programs (instruction blocks), and it consists of two essential units:

- Arithmetic and Logic Unit (ALU): Responsible for performing elementary operations (such as multiplication, addition, subtraction, comparison, rotation, etc.) of the processor at each clock cycle.
- Control and Command Unit (CU): Controls the operations on memory (read/write) and the operations to be performed by the ALU based on the currently executing instruction.

In order to perform operations on data and execute programs, the CU requires a workspace. This workspace is called memory.

4.2. BUS

- **Data Bus:** Facilitates the transfer of instructions to or from the processor. It is a bidirectional bus**.**

- **Address Bus:** (sometimes called memory bus) Transports memory addresses to which the processor wishes to access to read or write data. It is a unidirectional bus.

- **Control Bus (Commands Bus):** Transports commands and synchronization signals from the control unit to all hardware components. It is a bidirectional bus as it also transmits response signals from hardware elements.

4.3. Memories:

A memory is a device capable of:

- Recording information,
- Retaining it (memorizing),
- And restoring it (possibility to read or retrieve it later).

Memory can be in the processor (Registers), internal (Main Memory or RAM), or external (Secondary Memory)

4.3.1. Memory Capacity:

The capacity (size) of a memory refers to the number (quantity) of information that can be stored (memorized) in that memory.

The capacity can be expressed in:

• **Bit:** A bit is the basic element for representing information; it can only take two values: True / False (1 / 0).

- **Byte :** 1 Byte = 8 bits
- **Kilo-Byte (KB) :** 1 kilo-Byte (KB)= 1024 Bytes = 2^{10} Bytes
- **Mega-Byte (MB) :** 1 Mega-Byte (MB)= 1024 KB = 2^{20} Bytes
- **Giga-Byte (GB) :** 1 Giga-Byte (GB)=1024 MB = 2^{30} Bytes
- **Tera-Byte (TB) :** 1 Tera-Byte (TB)= 1024 GB =2^{40} Bytes

4.3.2. Memory Types:

There are different types of memories, the most used are:

a. Central Memory "Main Memory" (CM) :

- It represents the workspace of the computer and the main storage organ for information used by the processor,
- To execute a program, it must first be loaded (copied) into the main memory,
- The main memory is a volatile memory, allowing both read and write access,
- It is also known as Random Access Memory (RAM), meaning that the access time to information is independent of its location in memory,
- It is a volatile memory, which means that preserving its content requires a continuous supply of electrical power "loses its data when the power is turned off".
- Access time to main memory is faster compared to magnetic memories.

b. Read Only Memory « ROM »:

is a type of memory in a computer that is used to store data or instructions that should not be changed or modified during the normal operation of the system.

The ROM is non-volatile, meaning its content is retained even without electrical power, The best-known example is the BOOT programs.

c. Memory registers:

Memory registers are small, high-speed storage locations within the CPU (Central Processing Unit) of a computer. These registers are used to hold data temporarily during the execution of instructions. Registers are essential components of the processor because they enable fast access to data, which helps in speeding up the overall processing performance.

d. Cache Memory:

Cache memory is a special type of high-speed memory that is located close to the processor in a computer system. Its primary function is to store frequently used information by software and applications when they are active, aiming to minimize constant exchanges between the processor and the main memory.

e. Secondary Memory:

Secondary memory, also known as auxiliary storage or non-volatile memory, refers to a type of computer memory that is used for long-term data storage even when the power to the computer is turned off.

These types of memory are typically used for storing large amounts of data, such as operating system files, software applications, documents, media files, and other user data. It serves as a more permanent storage solution compared to the main memory, which is used for temporary data storage during active processing.

There are various types of secondary memory devices, including:

Hard Disk Drives (HDDs): Traditional magnetic storage devices that use rotating platters to store data.

Solid-State Drives (SSDs): Faster and more reliable storage devices that use flash memory technology.

Optical Discs: Such as CDs, DVDs, and Blu-ray discs, which are used for storing data and media.

USB Flash Drives: Portable and removable storage devices that use flash memory for data storage.

Memory Cards: Used in cameras, smartphones, and other devices for data storage.