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Algorithms and Data structure 1

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Chapter I

Introduction to computing

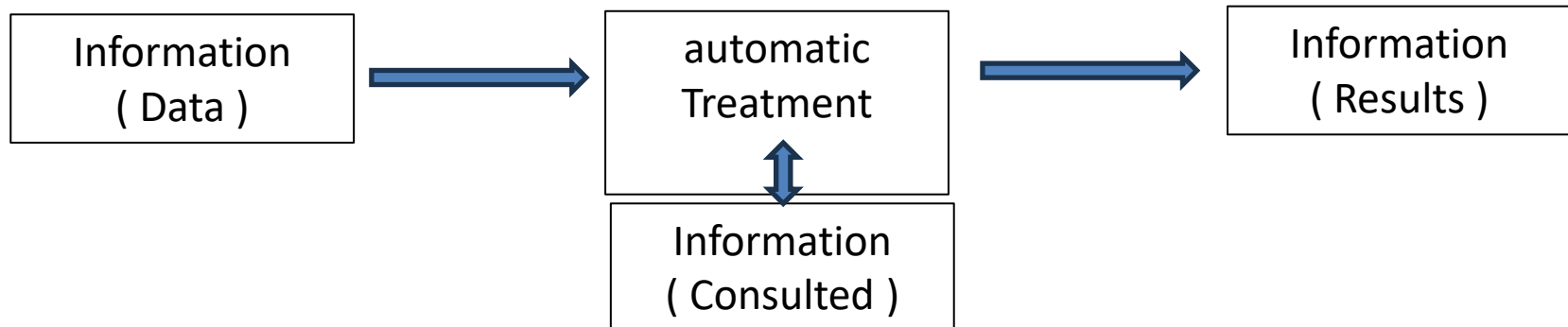
1. Definition of Computer Science : it is the science of processing information by automatic means.

- **Information**: is an element of human knowledge capable of being represented using a coding system in order to be stored, processed or communicated.

There are two types of information: data and instructions.

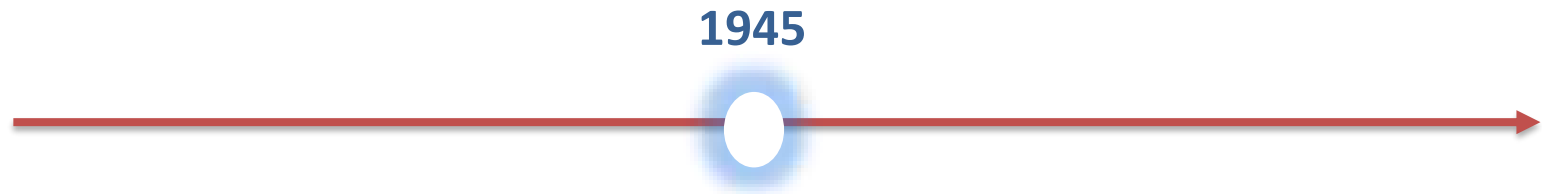
- **Data**: is a representation of information for automatic processing, such as a student's data: first name, last name, age and address.
- **Instruction**: is a form of information that allows you to describe the action that must be taken carried out (executed) by the computer.

- **Automatic information processing**: is a series of operations transforming a representation of this information into another representation that is easier to manipulate or interpret.



2. Evolution of computing and computers

2.1 History of computing:



Before 1945

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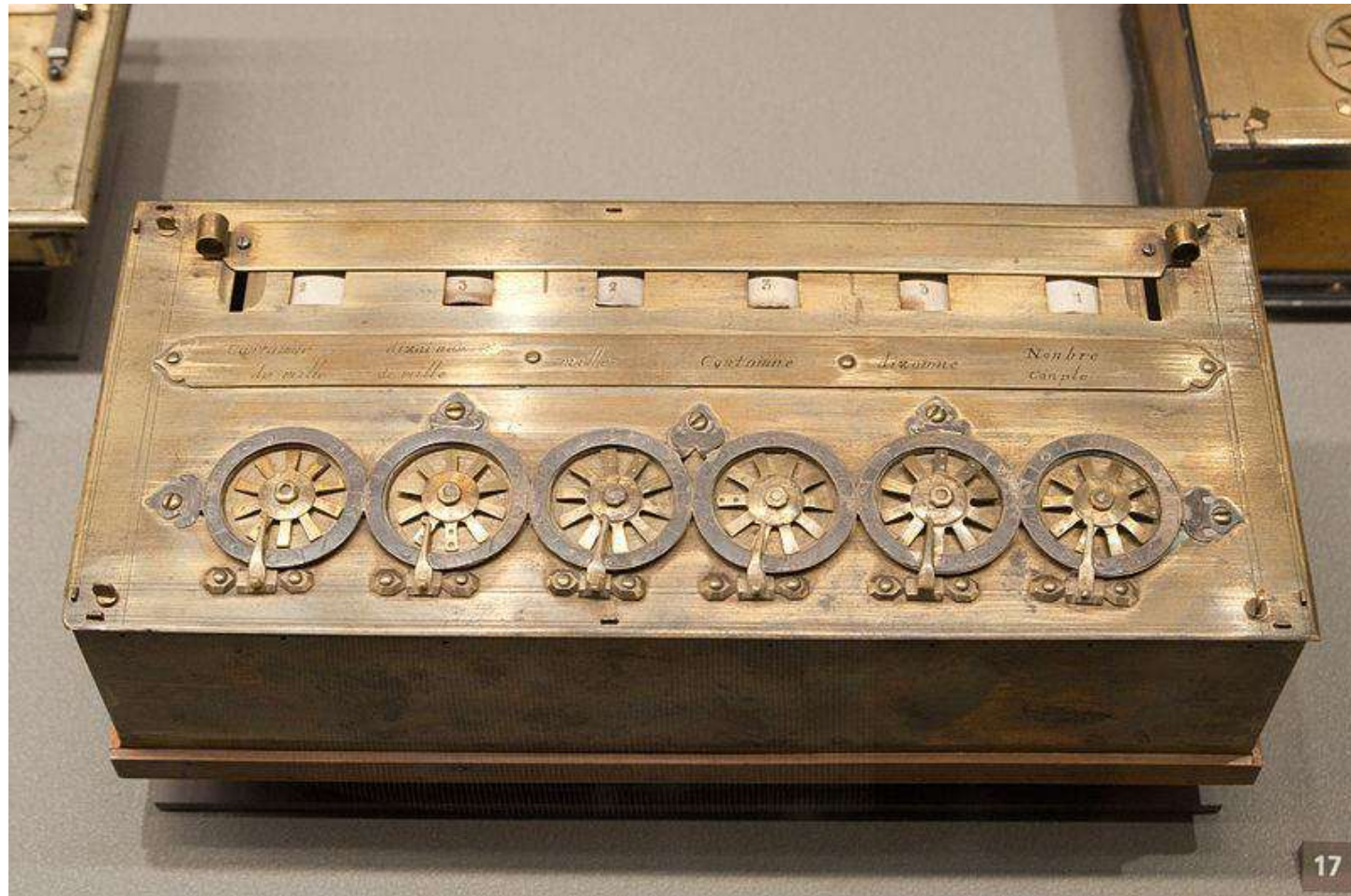
Before 1945???

- The history of computing begins with the invention of machines (before the appearance of computers) which initially corresponded to different lines of thought.

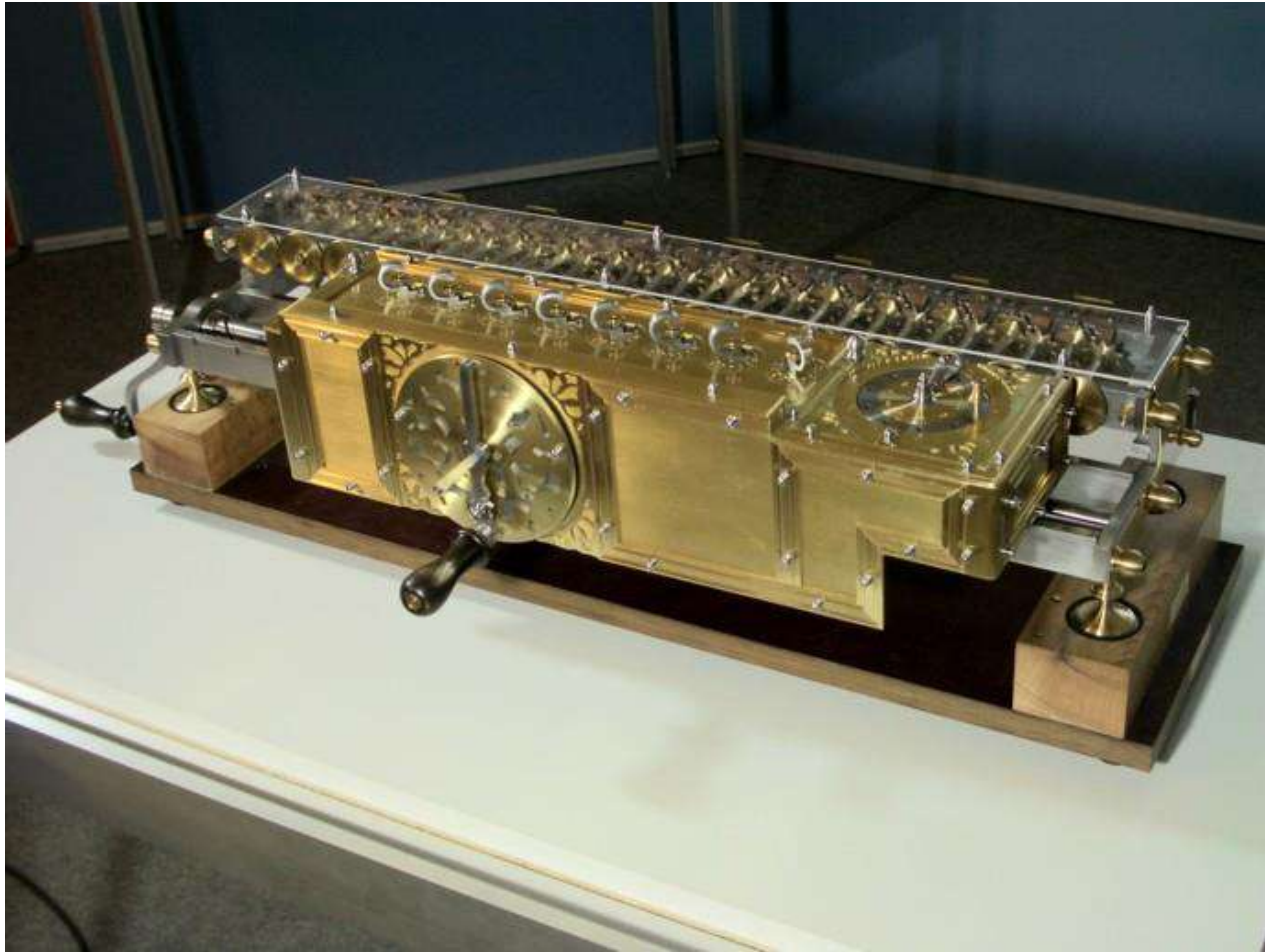
1. Calculating machines

- **Pascal's Pascaline**, 17th century: Pascal invents the Pascaline, the first calculating machine (addition and subtraction only), for his father's calculations.
- **Leibniz's multiplication machine**, 17th century.
- Leibniz improves Pascal's machine to have the four basic operations (+, -, *, /).

Pascaline



Leibniz machine



2. Automata

- Automata, astronomical clocks, military machines from the 12th century.

3. Programmable machines

- **Jacquard's** loom , 1752-1834
- Start of marketing of scientific mechanical machines (military use in general).
- Babbage invents the first programmable analytical machine. 1834

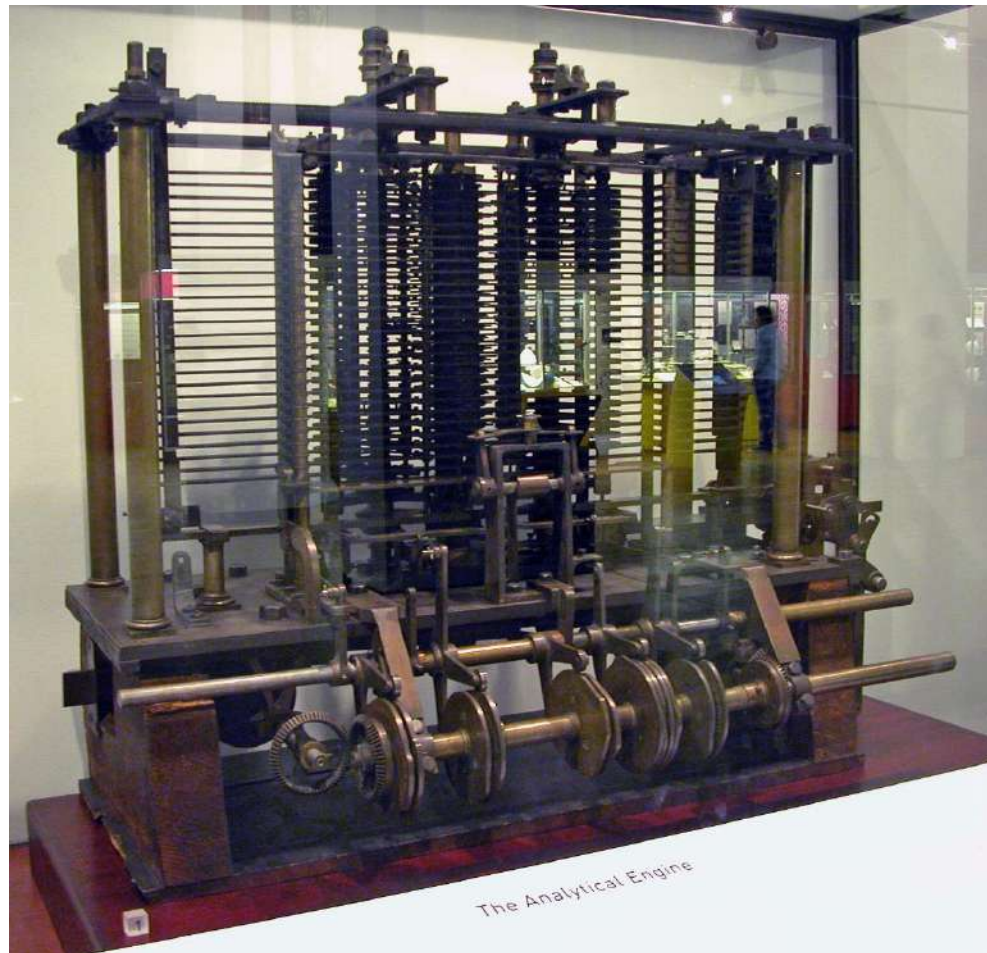
Astronomical clock



Jacquard loom



Babbage programmable analytical machine



After 1945

After 1945: the birth of the computer

- It is generally accepted that the computer era, which covers a few decades, is divided into several generations essentially marked by technological advances.
- 1. **First generation 1945 – 1954** : computers were vacuum tube machines
 - large, heavy, power-hungry.
 - very slow , unreliable,
- 2. **Second generation 1955-1965** : computers were transistor machines
 - smaller, faster, more reliable
 - development of new programming languages applications like data processing and accounting systems
- 3. **Third generation 1966-1974** : computers were integrated circuit machines
 - Reduction in size, power consumption, cost of computers
 - Use operating systems simplified their use of users
- 4. **Fourth generation from 1975-1990** : introduction of microprocessors
 - creation of PC
 - more affordable and accessible
 - Use GUI, computers easier to use for non-technical users.
- 5. **Fifth generation (1990-present)** : emergence of AI and ML systems
 - computers mobile, connected
 - use of wireless technology and social networks.

3. Information coding systems

- Today our computers, telephones and other devices can handle numbers and text as well as images, video or music...
- But **how can we represent, within a digital system,** this diversity of objects in the real or virtual world? What techniques are used to digitally represent the magnitudes that surround us?

3.1 Definitions

- **Coding Unit**
- The components constituting a computer system react, internally, to “**all or nothing**” signals.
- The two stable states thus defined are represented by the symbols “**0**” and “**1**” or by “L” (Low) and “H” (High) The numbering system adapted to the representation of such signals is **base 2**, we then speak of **binary coding**.
- The information **coding unit** is an element that can only take the values **0 or 1**; the **bit** (contraction of Binary Digit).

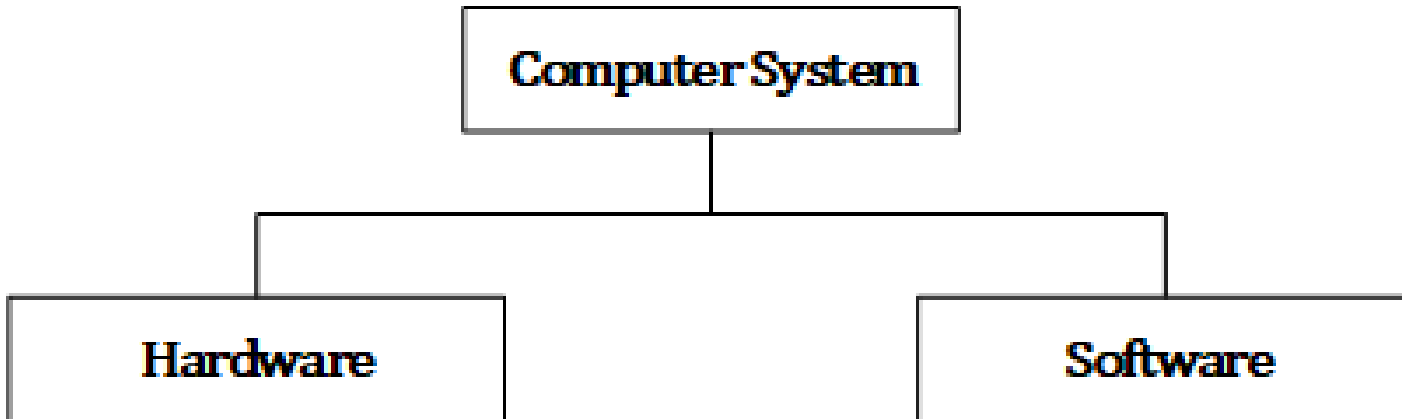
■ Transfer Unit

- For data exchanges, elementary information (bits) are manipulated in groups which thus form binary **words**.
- The size of these words is most often a multiple of **$8 = 2^3$** .
- The transfer unit used for data exchange is the 8-bit word called byte.
- A byte is a particular byte (binary digit) containing 8 bits. To facilitate manipulation, a byte can be divided into two 4-bit words called quartets: the one on the left is the most significant quartet, MSQ (Most Significant Quartet) , and the one on the right, the nibble low weight, **LSQ** (Less Significant Quartet).

Computer system

A computer system is a system composed of two distinct parts :

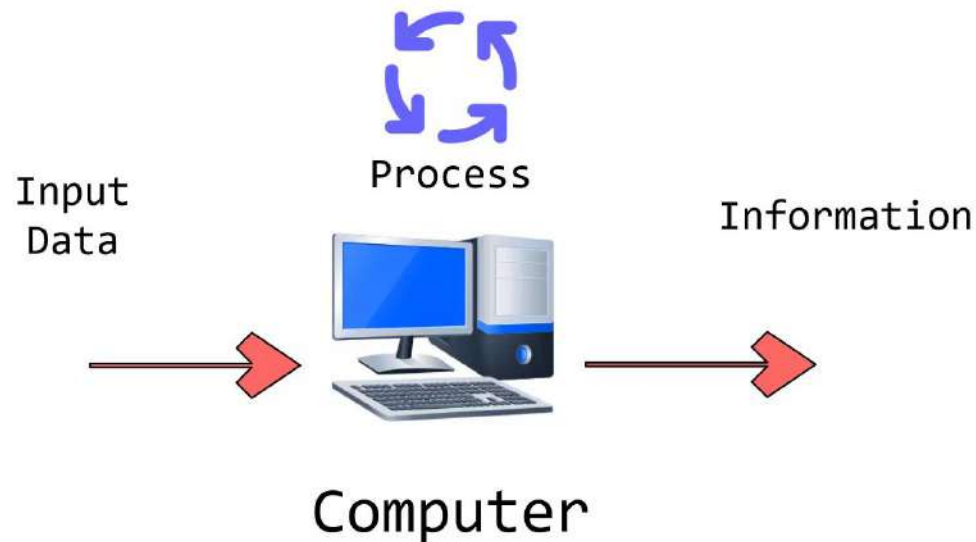
Hardware which includes the central unit as well as all the other devices connected to it and the **software** .



4. Hardware

A computer is an information processing machine.

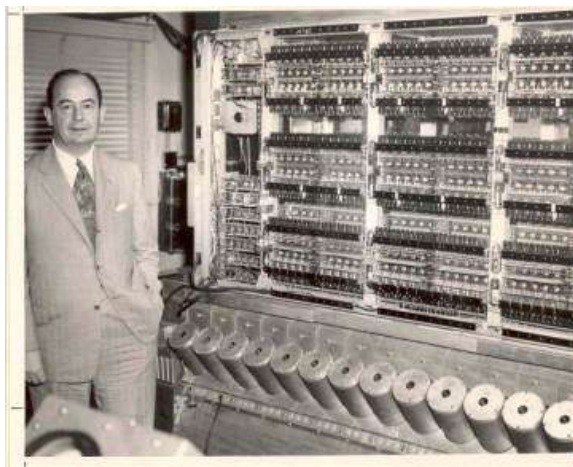
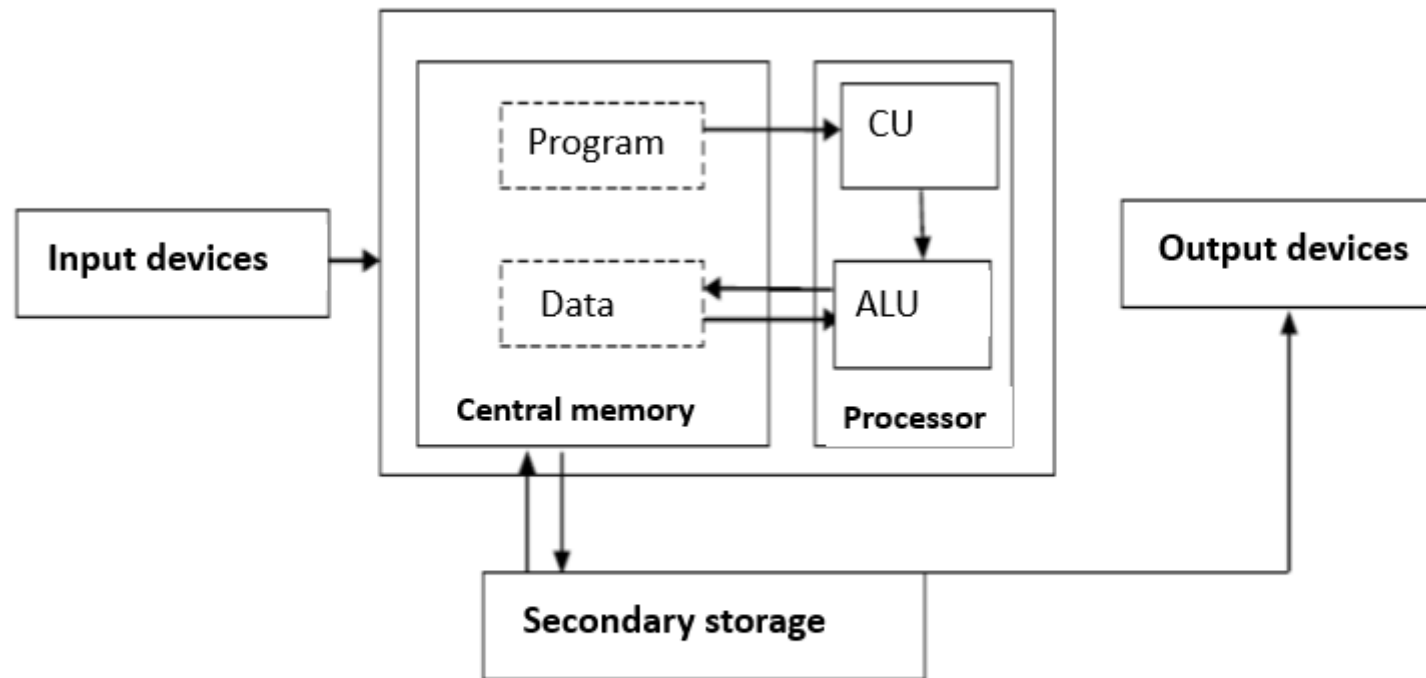
It is capable of **acquiring** information, **storing** it, **transforming** it by carrying out any type of processing, then **restoring** it in another form.



4.1 Von Neumann architecture

The architecture, called Von Neumann architecture, breaks the computer into four distinct parts:

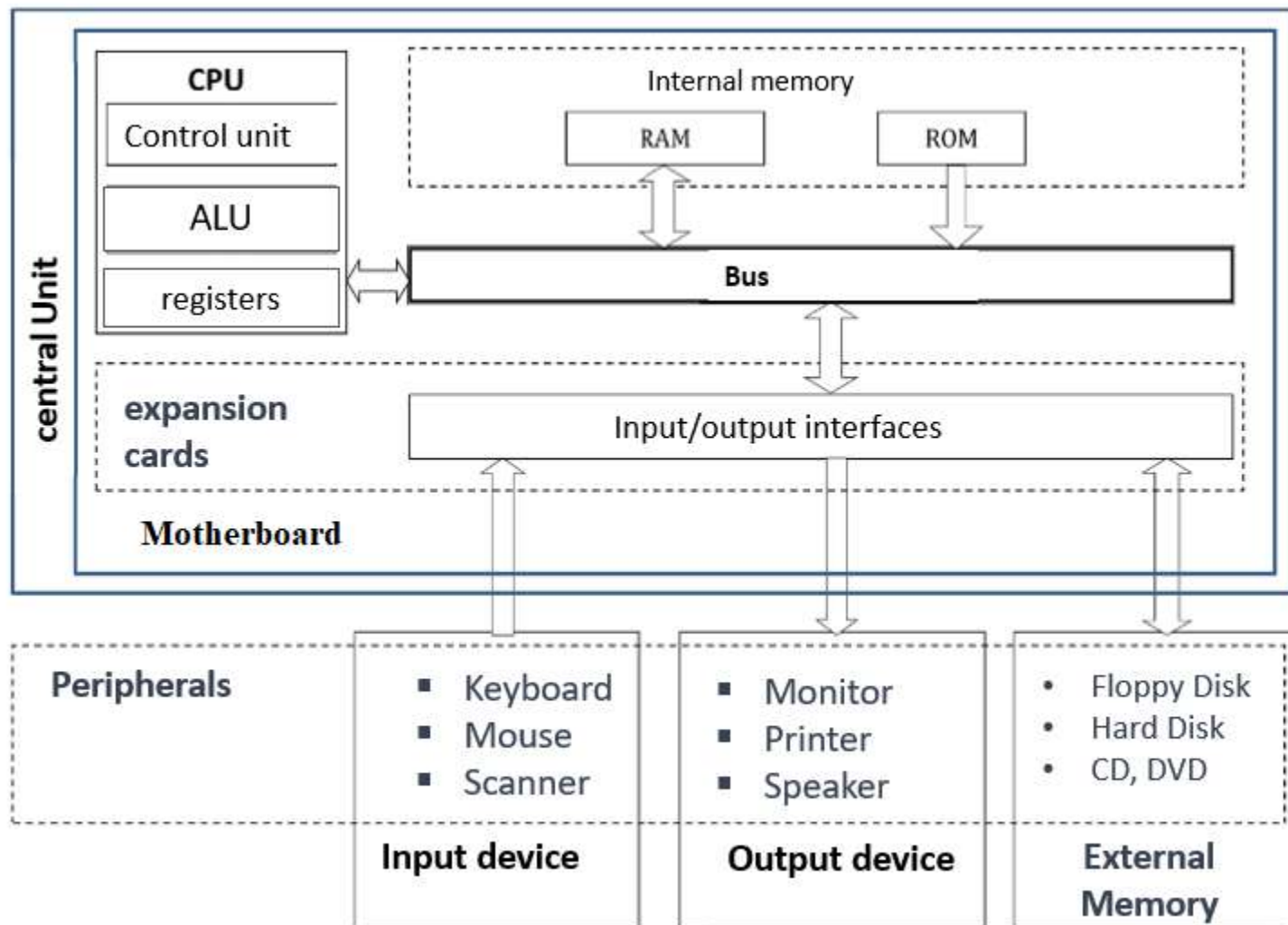
- 1 **Processor** : is made up of an arithmetic and logic unit (ALU) or processing unit: its role is to **carry out basic operations and a control unit, responsible for sequencing the operations;**
- 2 **Memory** that contains both the data and the program executed by the control unit. Memory is divided into **volatile memory or RAM** (Random Access Memory) which contains **programs** and **data** being processed, and **permanent memory or ROM** (Read Only Memory) which **stores programs and basic data** of the machine;
- 3 **Input and Output** devices, which allow communication with the outside world.



4.2 Operating principles

- The two main components of a computer are the central memory and the processor. The central memory stores information (programs and data), while the processor executes the instructions making up the programs step by step.
- For each instruction, the processor schematically performs the following operations:
 1. Read from memory (MC) the instruction to be executed;
 2. Carry out the corresponding processing;
 3. Go to the next instruction.

- The processor is divided into two parts, the control unit and the processing unit (CU and ALU respectively):
 - Control unit is responsible for reading into memory and decoding instructions
 - Processing unit, also called Arithmetic and Logic Unit (ALU), executes instructions that manipulate data.
- **CM** : is the internal **C**entral **M**emory of the microcomputer. It allows you to store programs and data.
- **CU** : is the **C**ontrol **U**nit coordinates the work between the different bodies.
- **ALU**: It is the arithmetic and logical unit. It is used to perform arithmetic and logical calculations.
- **Program**: A program is a series of elementary instructions, which will be executed in order by the processor.



Computer hardware Components

Connection interfaces (ports)

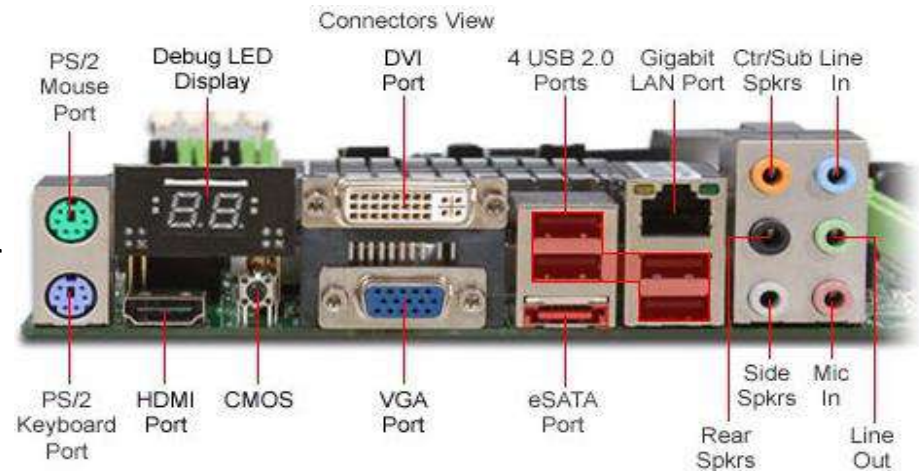
Used to connect peripherals and expansion cards to the motherboard. There are internal ports and external ports.

❑ Internal ports:

- PCI (Peripheral Component Interconnect) and PCI Express to connect all expansion cards;
- AGP to connect graphics cards;
- IDE and SATA to connect hard disk drives and CD/DVD drives;
- Floppy for connecting floppy drives.

❑ External ports:

- PS2 to connect keyboards and mice;
- VGA to connect screens, data shows, etc.;
- HDMI to connect high resolution displays
- Serial to connect measuring devices, routers, etc.;
- Parallel to connect old printers;
- LAN or (RJ45) to connect the network cable;
- eSATA to connect external hard drives;
- USB is used to connect a generic number of devices.



B. Peripherals :

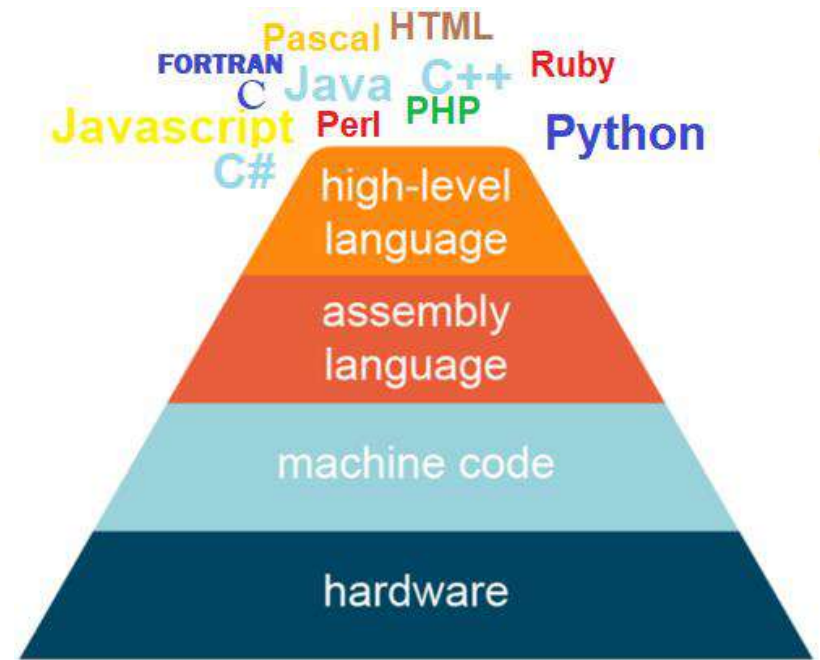
The term peripheral means any element located on the periphery of the computer which is not necessary for its operation but of which the user needs to communicate with the computer .

- **Input peripherals** : allow data transfer from outside towards the computer (keyboard, mouse, scanner, microphone, etc.).
- **Output peripherals devices** : allow transfer of computer data towards outside (screen , printer , speaker , etc.).
- **Input /output Peripherals** : allow the computer to both directions (floppy disk drive , modem, burner , ... (Examples : hard disk , floppy disk , USB key , etc.).

B - Part system (software)

C. Programming languages

- ✓ In computing, a programming language is used to produce or develop applications.
- ✓ A so-called high-level programming language is easily understandable by a human being, but not by machine. E.g. Java, C, C++, Pascal, Fortran, PHP, HTML,... etc.
- ✓ A program written in a high-level programming language is called **source code**.
- ✓ A computer (processor) only understands machine language or machine code, which is a sequence of bits.
- ✓ So, a program written in a high-level language must be translated into a language machine using a compiler or interpreter to be executed by the computer (processor).



Different Programming Languages

```
01010010001111  
0000000110101  
01000110111101
```

**Machine
language**



```
mov sec ebx  
mov six e9c  
mov rax rdx
```

**Assembly
language**



```
#include <stdio.h>  
int main() {  
    printf ("Hello World");  
    return 0; }
```

**High-level
language**



Devices

A. Display devices : These are output devices, providing a visual representation to the user, such as a monitor (screen).



- **B. Printer:** it is a device allowing printed output (on paper) of computer data.



- **C. Storage devices** : this is an input-output device capable of storing information permanently (hard disk, CD-ROM drive, DVD-ROM drive, etc.);



- **D. Acquisition peripherals** . They allow the computer to acquire specific data, such as video data, we then speak of *video acquisition* , digitized images (scanner) or sound (micro);



E. Input devices : these are peripherals capable only of sending information to the computer :

- **Mouse** : It is a pointing device. Its role is to vary the position of the cursor on the screen in order to communicate with the machine.



- **Keyboard** : This is the input element in interactive mode. It is one of the interfaces between the user and the machine. It is composed of three parts:
 - the alphanumeric part
 - The numeric keypad, which provides numbers and direction keys
 - The function keys, of variable importance, the role of each key being specified for each program



- **Modem** : This is the device used to transfer information between several computers via a wired or wireless transmission medium (telephone line, sim card)

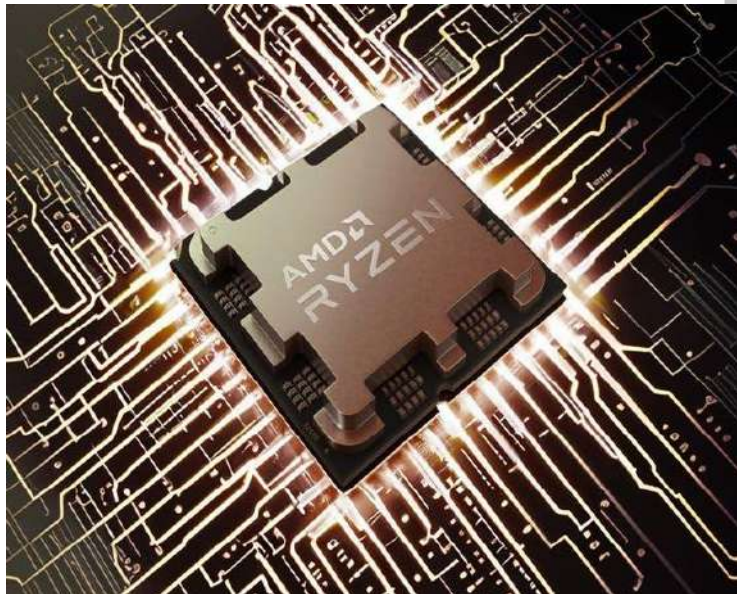


- **G. Internal components:** represent the elements that exist inside the central unit, namely: the motherboard, memories, cards (sound/graphics/network/...), readers (floppy disks/CD/DVD/memory cards, etc...

1. Motherboard : it is the main element of the computer. The motherboard is the base (support) which brings together all the essential elements of the computer.



2. Microprocessor : The computer's brain. It allows you to manipulate digital information, that is to say information encoded in binary form, and to execute instructions stored in memory.



3. Memory : Electronic component capable of permanently or temporarily storing data. There are two main categories of memories

i. Volatile memory : also called Central Memory or RAM (Random Access Memory) allows data to be temporarily stored during the execution of a program. Their contents will be lost once the power supply is interrupted.

ii. Mass memory (secondary or external) : allows permanent storage of data even if the memory is no longer electrically powered (when the computer is shut down).

- Magnetic storage devices (e.g. : Hard disk, floppy Disk, Tape, pen drive, memory card),
- Optical storage devices (e.g.: CD-ROM or DVD-ROM);
- Read Only Memories (e.g. : BIOS chip which is used for starting the computer).

Memory Storage-Device



RAM



ROM



HARD-DISK



CD



Floppy-Disk



Memory-Card



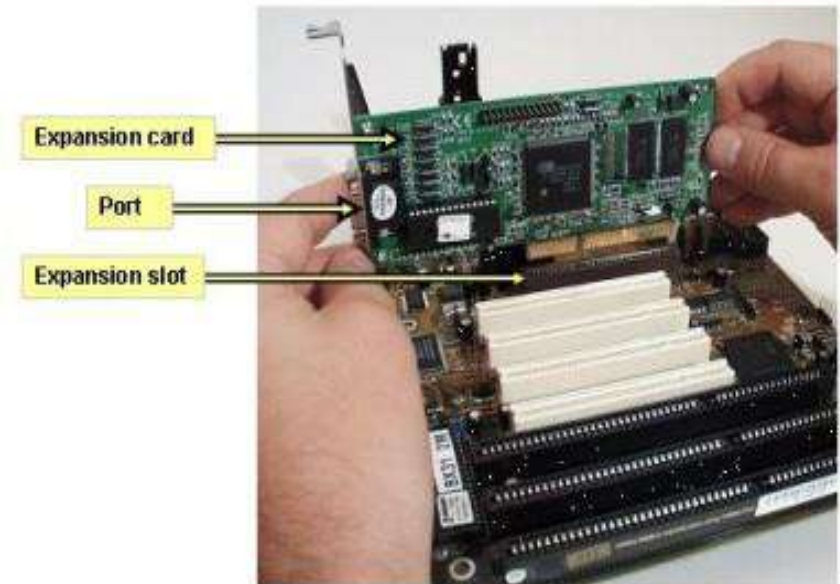
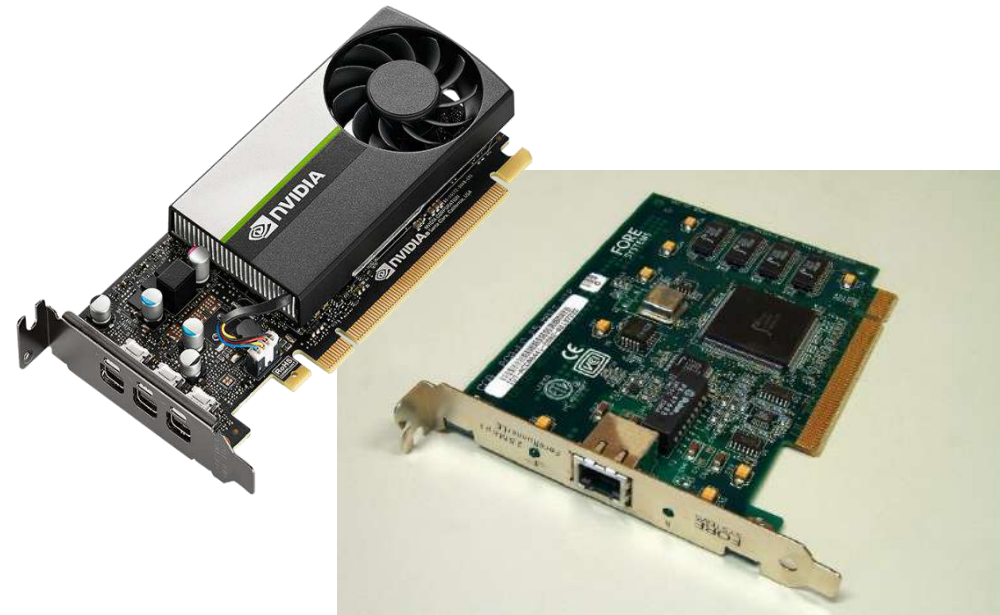
Pen-Drive



Tape

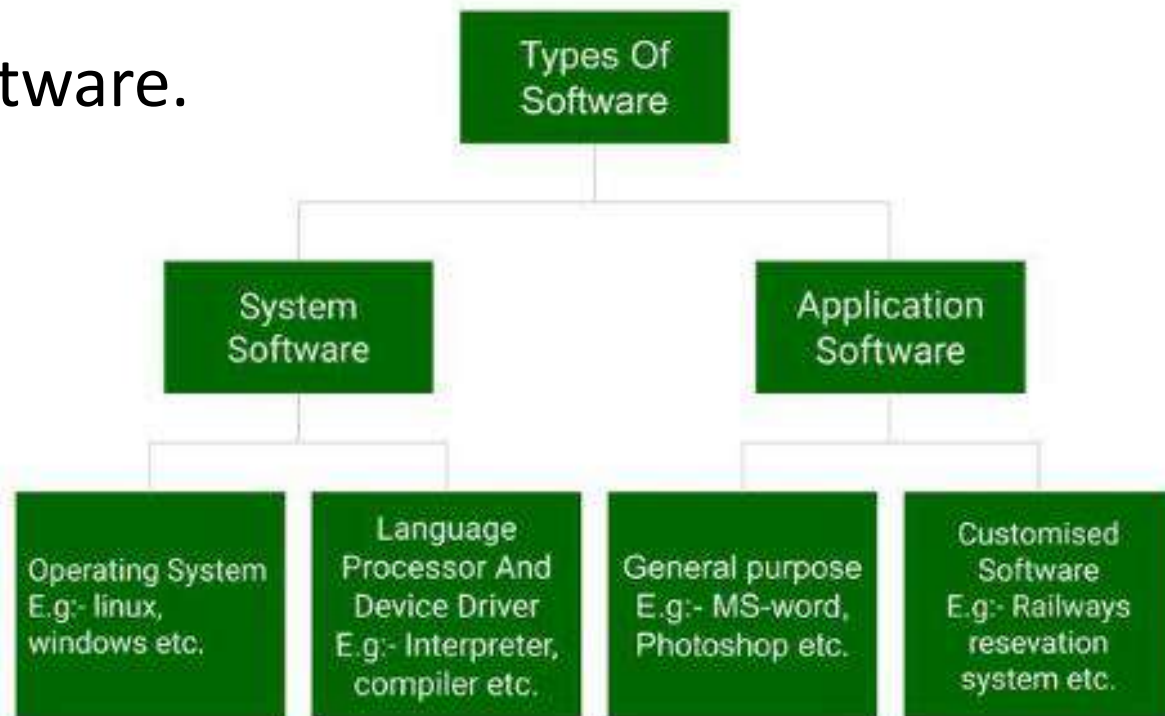
4. Expansion card

- It is a printed circuit board that can be inserted into expansion slot on computer motherboard to add new input or output functionality to a computer via expansion bus, it is also known as add-on card or accessory card e.g, : graphics card, sound, modem or network cards, ... etc.



5. Software

- A software is a set of applications which consist of a set of programs relating to the processing of information.
- There are two types of software:
 - System software
 - application software.



5.1 systems software:

- **Operating system** : is a set of programs that controls how the hardware of a computer works. An operating system provides a means of communication between the user and the computer, deals with the loading and running of applications programs and manages the transfer of data and files to and from peripheral devices. Several operating systems have been developed: Unix, MsDos, Windows, Linux, Mac OS,...



5.2 Application software

Programs that meet the needs of the human user.

They carry out very specific tasks such as word processing, calculations, programming, database management. We can cite for example:

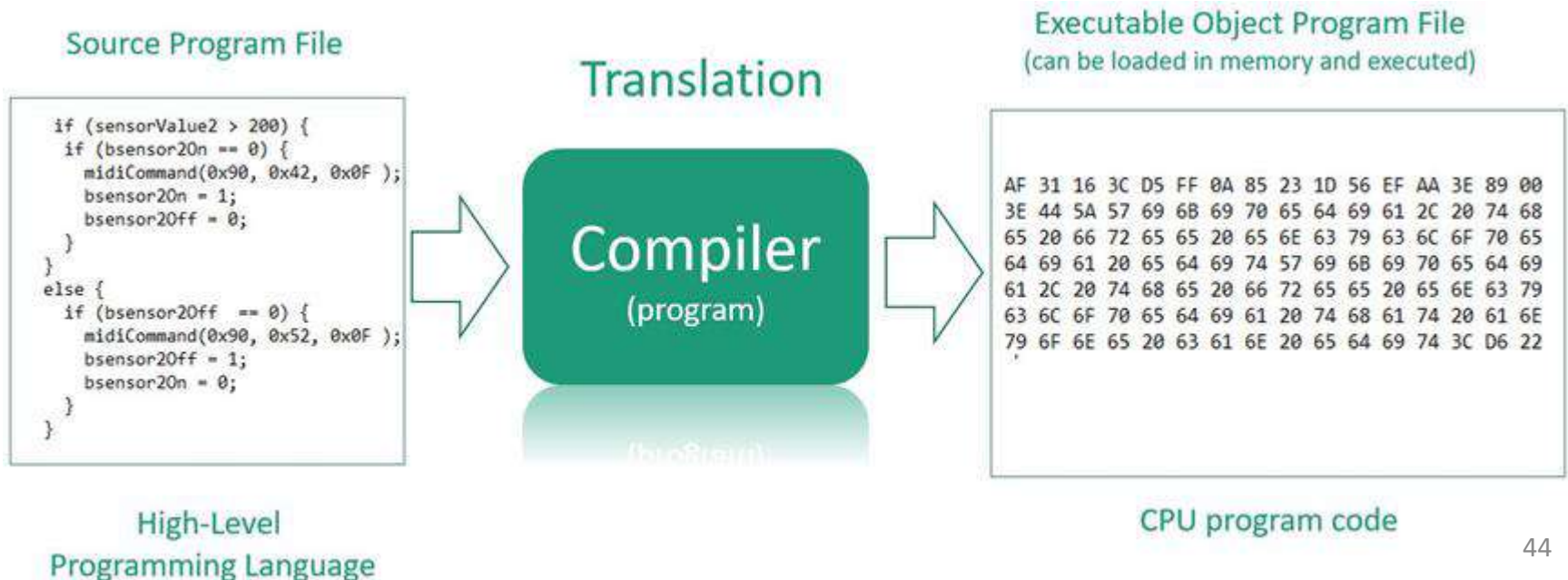
- Word processing - DTP: with layout, justification, numbering, dictionary...
- Spreadsheet: table of 2-dimensional numbers and calculations
- Database: set of files (name, address, etc.) and search by section, direct mail, etc.
- CAD (computer Aided Design), Computer drawing: clean, easy modification, archiving...
- Management: Payroll, Invoicing, Stock...
- Communication: transfer of programs by modem and telephone line, minitel server, etc.



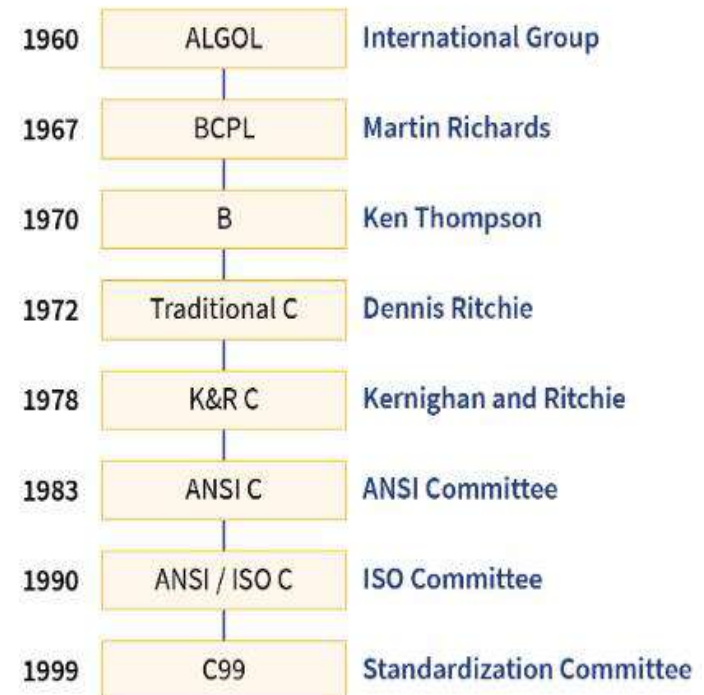
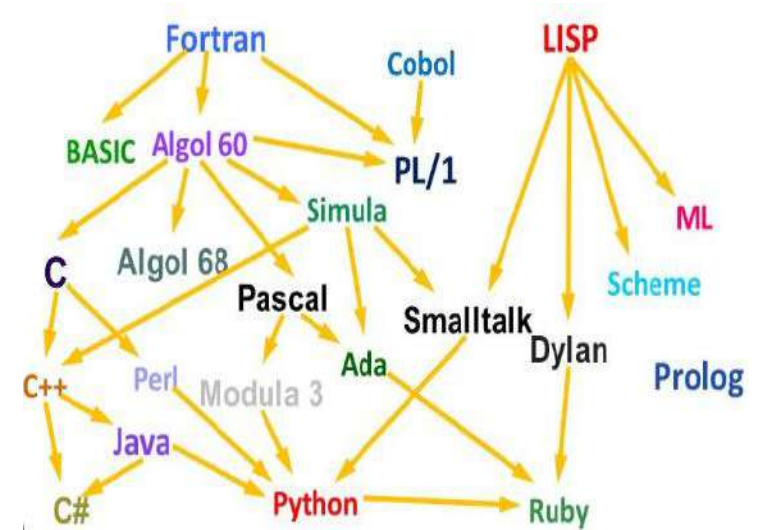
5.3 Programming languages

- In computer science, a **programming language** is a conventional notation intended to formulate algorithms and produce computer programs that apply them. Similar to a natural language, a programming language is composed of an alphabet, vocabulary, grammar rules, and meanings.
- Programming languages make it possible to describe on the one hand the structures of the data which will be manipulated by the computing device, and on the other hand to indicate how the manipulations are carried out, according to which algorithms. They serve as means of communication by which the programmer communicates with the computer, but also with other programmers; the programs are usually written, read, understood and modified by a community.

A programming language is implemented by an **automatic translator** : compiler or interpreter. A **compiler** is a computer program which first transforms source code written in a given programming language into target code which can be directly executed by a computer, namely a program in machine language or intermediate code 2, while the interpreter carries out this translation.



- Each programming language reflects a paradigm, a set of notions that guide the programmer's thinking.
- The first programming languages were created in the 1950s. Many computer science concepts were launched by a language, before be improved and extended in the following languages. Most of the time the design of a programming language has been heavily influenced by experience gained with previous languages.



Elements of the programming language

- A programming language is built from a **formal grammar**, which includes symbols and syntactic rules, to which semantic rules are associated.
- These elements are more or less complex depending on language ability. The modes of operation and definition of the complexity of a programming language are generally determined by their membership in one of the degrees of the Chomsky Hierarchy.

I. The alphabet

The alphabet of programming languages is based on common standards like ASCII, which has the letters A to Z without accents, numbers and symbols, or Unicode for most modern languages.

II. Vocabulary

The vocabulary represents the set of instructions constructed based on symbols . The instruction can be mnemonic or only symbolic as when it is represented by operation symbols such as arithmetic ("+" and "-") or Boolean operators.

III. Rules defined by a formal grammar, they govern the different ways in which language elements can be combined to obtain programs

IV. Semantics

The meaning of each of the sentences that can be constructed in the language (expressions, statements and program units).

Comparison of C language with English

