Chapter 1: Introduction

1 Introduction

Computer science is one of the most important modern sciences. His subject is calculation, in the broadest sense of the term. In other words, any type of information that can be represented by a series of numbers. Such as text, DNA, images or sounds, etc.

The aim of this chapter is to introduce a few basic concepts to get you started. The chapter begins with the concept of computing, followed by a brief history of the most important stages it has gone through, and finally, some basic definitions of algorithms and their characteristics.

2 Computer science

2.1 Definition

Computer science or Informatic, which is a combination of the two words information and automatic, is the science of processing information automatically using a machine.

- **processing:** is the set of instructions (commands) or operations that the machine executes.
- **information:** Everything a machine can handle and manipulate. Such as : text, number, image, video, ... It can be divided into data and instructions.
- **machine:** The device carries out these instructions. Such as : calculator, computer, telephone, game, television, receiver (demo), and any system bearing the word digital.

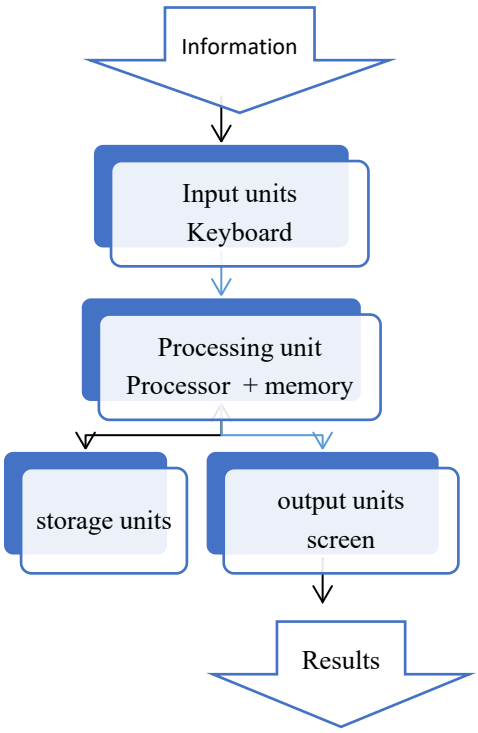
2.2 Computer

computer means any programmable device where information is input, processed, stored or output.

The computer consists of :

- **Input units**: these are the devices used to enter information into a computer. Such as: keyboard for entering numbers and text, mouse for entering movements and clicks, scanner for entering images, microphone for entering audio, and camera for video.
- **Processing unit**: It is made up of memory, the best-known of which is RAM, and the processor. The memory contains the instructions and data, and the processor executes the instructions (logical and arithmetic operations) on the data and stores the results in memory.
- **Storage units**: They are used to store and retrieve information. Such as : hard disk, floppy disk, CD or DVD, flash disk, memory card...

- **Output units**: the screen for viewing photos and videos, the printer for outputting images and text on paper, the headphones and loudspeaker for sound...



2.3 Information representation

To represent information in human language, in Arabic for example, you need 28 characters, in French 26 characters, in Chinese more than 5000 characters. But in computer language, we only need two symbols. Where the information inside the computer, i.e. the memory and processor, is processed in the form of electrical signals, and this takes just two cases, for example: the presence or absence of current. They are stored on the CD in the form of holes, and take on only two states, either the presence of a hole, or its absence. And on the hard disk in the form of magnetic charges, and take on only two states, either magnetized or unmagnetized.

Note that to represent information, we always only need two states. We can write them down as 0 and 1 (just an abstraction, they don't really exist). Machine language is therefore said to be binary. The smallest place to store information is called a bit. It contains either 0 or 1.

2.4 Important notes

- In this lesson, we're interested in number and text data only.
- Some devices can be input and output at the same time. Ex : touch screen.
- In fact, storage media are both input and output units.
- Representing data as bits with electricity or holes is only a simplification and an approximate understanding.
- All information in the computer is in the form of 0s and 1s, whether instructions, numbers, text, images, audio, video...
- There is a course called machine structure (MS) which deals with the representation of data.

3 A brief history of computing

Since time immemorial, man has invented tools and machines to help him calculate and process data. These tools are considered to be the beginnings of computing, but the real and rapid development of this science only took place after the Second World War. Computing has gone through many stages, including the

beginnings of a computer that ran on vacuum tubes. Then came the era of transistors and integrated circuits. And then the era of the Internet and the Web. Finally, the current era, which represents the age of mobility and data sharing. The following list summarizes the most important inventions, theories and events in computer science.

- **The beginnings of computing**
  - 3000 BC J.-C. The Babylonian abacus .
  - 780 Al-Khwarizmi Algebra
  - 1645 Pascaline: Pascal invents the arithmetic machine.
  - 1703 Binary arithmetic by Leibniz.
  - 1801 Jacquard synthesizes the work of his predecessors and invents the first programmable machine to knit and weave.
  - 1822 Babbage invents the first mechanical calculator designed to calculate polynomials.
  - 1847 Boolean algebra for binary arithmetic and logic.
  - 1890 First use of jacquard cards outside the textile industry. and its use in statistical studies.
- **Pioneering times**
  - 1920 Quevedo invents an electromechanical arithmetic device that is controlled by a typewriter and prints out the results.
  - 1928 Von Neumann's MinMax algorithm.
  - 1936 Alan Turing publishes an article in which he presents the Turing machine as a theoretical model for the computer.
  - 1937 Design of the first electronic calculator, Atanasov.
  - 1939 The first non-programmed ABC electronic computer.
  - 1942 The invention of an Enigma decoding machine (Germany) by Alan Turing (England), which was the reason for his victory in the Second World War.
  - 1944 Howard Aiken used perforated paper strips and vacuum tubes to calculate problems, and was the first programmable device in America.
  - 1946 The first large-scale electronic digital computer was launched under the name ENIAC.
  - 1947 The invention of the transistor.
  - 1947 Invention du langage de programmation assembleur, un langage de bas niveau.
  - 1948 Invention of the first machine corresponding to the first-generation Van Neumann architecture (instructions are stored with data in memory).
  - 1950 the Turing test.
  - 1953 The first high-level programming language.
  - 1956 IBM's first hard disk.
  - 1958 invention of integrated circuits.
  - 1958 The second generation of computers appeared after the invention of the transistor.
  - 1960 The first computer with multiple processors and parallel tasks.
  - 1962 invention of the word informatic.
  - 1963 invention of the mouse.
  - 1964 IBM completes the 360 family of minicomputers (third generation of computers).
  - 1964 BASIC programming language.
  - 1965 Moore's Law: "A CPU will double in speed every 18 months."
  - 1967 marketing of floppy disks by IBM.
  - 1969 Unix operating system development.
  - 1970 Pascal language
- **The beginnings of microcomputing**
  - 1970 The first Alto personal computer is produced in Xerox laboratories, using icons, windows, graphics and a mouse.
  - 1971 Intel 4004, the first microprocessor (4th generation)

- 1972 C language development.
- 1973 Development and marketing of Micral, the first micro-computer, by French company R2E
- 1975 Altair 8800 The first Altair Basic computer by Bill Gates and Paul Allen.
- 1975 Microsoft Corporation is founded by Bill Gates and Paul Allen.
- 1976 Creation of Apple and launch of the Apple I by Steve Jobs and Steve Wozniak.
- 1980 The invention of the compact disc (CD).
- 1981 Osborne 1 The first laptop (10.7 kg).
- 1981 The IBM PC personal computer.
- 1982 The emergence of the word Internet.
- 1983 C++.
- 1984 Apple : Macintosh edition.

- **The age of the Internet and the Web**
  - 1989 Over 100,000 computers connected to the Internet.
  - 1989 Web invention by Tim Berners-Lee.
  - 1991 Linux operating system
  - 1992 HTML.
  - 1993 Launch of the Intel Pentium processor.
  - 1995 Le DVD.
  - 1995 Windows 95.
  - 1995 Java.
  - 1996 USB.
  - 1997 A program that beat Kasparov, the best chess player in the world.
  - 1998 Creating Google.
  - 2001 Creation of Wikipedia by Jimmy Wales.
  - 2004 Creating Facebook.
- **The age of mobility and shared data**
  - 2007 the iPhone.
  - 2008 Archos is the first electronic touch tablet with GPS.
  - 2008 First use of the word MOOC (massive open online course)
  - 2009 Archos 5 IT the first Android tablet
  - 2010 Cloud Computing development.
  - 2011 Smartphone sales outstrip computer sales.
  - 2013Smart tablet sales outstrip computer sales.
  - 2015 Windows 10.
  - 2016 3D printing.
  - 2020 AMD launches a 64-core processor.
  - 2021 IBM has announced that it has etched the first chip using 2nm technology.

4 Introduction to algorithms

A computer can be compared to a human. Humans receive information through their senses. For example, 5 + 3 is information that is received through hearing if spoken or through sight if written. The human stores it in memory, and then the brain (the reasoning part) processes and calculates the result. In the previous example, the result is 8, which is stored in memory and can be communicated through speech or pointing, for example. However, if we encounter a human with senses, a brain, memory, and language, and we ask them, for example, to calculate 25 × 13 or solve a linear equation without teaching them, they would not be able to do it unless we teach them. The same applies to a computer. It alone cannot do anything unless we provide it with a solving method, known as an algorithm or software.

4.1 Definitions

Algorithm: An algorithm in mathematics and computer science is a set of sequential, detailed and completed steps required to solve a problem and achieve results, based on elementary data. In other words, it's the solution method.

It was named Algorithm after the scientist Abu Jaafar Muhammad ibn Musa al-Khwarizmi, who in the 9th century wrote the first systematic work presenting solutions to linear (first-degree) and quadratic (second-degree) equations.

The algorithm is based on three components:

- Sequence: An algorithm is a set of sequential instructions executed by the computer in a specific order.
- Selection: An algorithm may need to test certain conditions. If the result is correct, it follows a path with sequential instructions, and if it is incorrect, it follows another path of instructions.
- Loop: Sometimes, the same sequence of steps needs to be repeated multiple times.

Note: An algorithm is not a programming language but rather a set of analysis and thinking methods that a programmer must follow in order to write code correctly. It is considered the most challenging part of programming, but once you learn it properly, you can learn any programming language.

Data Structure: It is a means of storing and organizing data to facilitate their use and modification.

Program: It is an algorithm written in a programming language and can be written on a computer using any text editor. The computer cannot directly execute it until it is translated.

Application: A program that has been translated into machine language (0 and 1) and is ready to be executed by the processor. Sometimes it is also referred to as a program.

Examples

- Cooking recipe, changing a car wheel, recitation method, chess game...
- Calculation of the greatest common divisor, method for solving a quadratic equation, calculation of the derivative...
- Calculation of students' average, employees' salary, electricity bill...

4.2 Characteristics of the algorithm

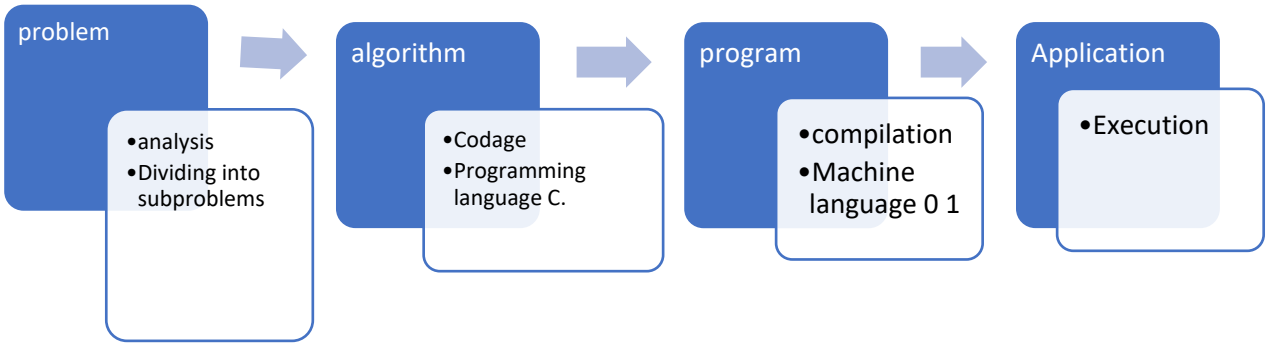
Good algorithms have a set of characteristics, the most important of which are:

- Readability: The algorithm should be understandable, even by non-computer experts.
- Precision: Each step should be clear and unambiguous. The inputs (data) and outputs (results) should be precisely defined.
- Termination: The algorithm must stop after a limited number of steps.
- Generality: The solution should be applicable to a specific type of problem. Therefore, for each problem case or dataset, the algorithm should terminate and return the correct result.
- Independence: It should be written in a way that is independent of any specific device, programming language, or operating system.
- Conciseness: It should not exceed one page, otherwise the problem should be divided into multiple sub-problems.
- The complete steps lead to the correct solution to the problem.
- Efficiency: Measured by the execution time (processor) and the amount of memory required.

Note: There are infinitely many solutions to a problem, but we choose the one that is efficient. This means selecting the solution that is fastest and does not require a large amount of memory.

4.3 Steps of solving a computer problem

The development of the program, in general, goes through the following steps:



4.3 Étapes de la résolution d'un problème en informatique

I. Analysis (to obtain the algorithm)

At the beginning, we have a problem, and to find a solution (algorithm), we perform analysis. The process goes through three steps:

1. By dividing the problem into simpler subproblems whose solutions are less complex, and in the case where the partial problem is still complex, it is further divided into even simpler problems. Solving these problems leads to the solution of the initial problem.
2. For each partial problem, the elements necessary for formulating a solution must be identified.
   - Inputs: Specify the data required for processing.
   - Outputs: Determine the expected results.
   - Intermediates: Identify any intermediate results or computations.
3. Determine the relationships that exist between these elements (between data and results), in terms of rules, formulas, mathematical equations, and processing methods.

The set of elements obtained during the analysis step, along with their relationships, are called data and instructions. Once the analysis process is complete, the instructions are arranged in their logical order of implementation. This is known as an algorithm.

Example 1

The problem: prepare an omelet.

analysis

The problem can be divided into two subproblems:

- Preparation of the mixture
- Cooking the mixture

The first subproblems is the preparation of the mixture:

- Identify the inputs: two eggs, salt - as desired, black pepper - as desired, a bowl.
- Identify the output: the omelette mixture.
- Method:
  - Bring a bowl.
  - Crack the two eggs into the bowl.
  - Sprinkle with salt and black pepper.
  - Whisk well for three minutes.

The second subproblem: cooking the mixture:

- Identify the inputs: the mixture, butter, a tablespoon, a frying pan, an oven, a large plate.
- Identify the output: omelette dish.
- Method:

- Prepare a frying pan and place it on the heat.
- Melt the butter.
- Pour the scrambled eggs.
- Leave the eggs on the heat for fifteen seconds without stirring.
- Fold the eggs from one end until they form a half-circle.
- Remove it from the heat.
- Pour it onto a large plate.

Example 2

The problem: Calculate the sum of the squares of two numbers.

Analysis:

The problem can be divided into three subproblems:

- Calculate the square of the first number.
- Calculate the square of the second number.
- Calculate the sum of the two squares.

The first subproblem:

- Identify the input: a of integer type.
- Identify the output: x of integer type.
- Relation: x = a * a.

The second subproblem:

- Identify the input: b of integer type.
- Identify the output: y of integer type.
- Relation: y = b * b.

The third subproblem:

- Identify the inputs: x and y of integer type.
- Identify the output: z of integer type.
- Relation: z = x + y.

Algorithm

Data:

Identify the inputs: a and b of integer type.

Specify the output: z of integer type.

Identify the intermediates: x and y of integer type.

Instructions:

```
x=a*a
y=b*b
z=x + y
```

II. Coding programming (to obtain the program)

After obtaining the algorithm, which is usually written in human language, the programmer chooses a programming language, such as C, and then translates the data and instructions into that language. The program is called the source code. It is a text file that can be read by a person, with a file extension specific to the language used. For example, .c for C or .cpp for C++.

III. Compilation (to obtain the application)

The program is translated and converted into codes that can be understood and executed by the computer, which means the binary language (0 and 1), a language that varies depending on the device (processor and operating system). This process is done automatically. The result is a binary file (unreadable by humans),

usually with the .exe extension in the Windows environment. This process includes a verification process for spelling mistakes (syntax errors and writing errors).

IV. execution

The processor loads the program into memory and starts executing one instruction after another. In a Windows environment, this is done by double-clicking on the application (.exe). This process involves testing and correcting semantic errors (errors in the result).

Note: In the case of interpreted languages, the process of translation and execution happens simultaneously.