PROGRAMMING LOGIC AND TECHNIQUES

Computing concepts

Computation = information processing

In the field of computer science, and in our specific case, the field of programming, we never create new information from nothing. Instead, we **process data** from **external sources**.

- Input from keyboards or other input devices
- Persistent data sources (databases, files on hard drives, etc…)
- Responses to requests on a network (ex: web content over the Internet)

Computation = information processing

Programs are used to process this information, display it, manipulate it, save it, etc.

Some definitions

- Non-volatile (persistent) storage
  - Hard disk drives (HDD)
  - Solid-state drives (SSD)
  - USB flash drives
  - Etc.
- Volatile (temporary) storage
  - Random access memory (RAM)

Data storage volume

Units of measure for **data:**

- Bit (= 1 binary digit)
  - What is **binary**?
- Byte (= 8 bits)
  - Equivalent term: **Octet**

Data storage volume (decimal prefixes)

Units of measure for **data** (decimal/metric prefixes):

Bit	**b** (**bit**)	(= 1 binary digit)
Byte	**B**	(= 8 bits)
Kilobyte	**kB**	(= 1000 bytes)
Megabyte	**MB**	(= 1000 kilobytes)
Gigabyte	**GB**	(= 1000 megabytes)
Terabyte	**TB**	(= 1000 gigabytes)

$$1000 = 10^3 = 10 \times 10 \times 10$$

Data storage volume (binary prefixes)

Units of measure for **data** (binary prefixes):

- Bit **b (bit)** (= 1 binary digit)
- Byte **B** (= 8 bits)
- Kibibyte **KiB** (= 1024 bytes)
- Mebibyte **MiB** (= 1024 kibibytes)
- Gibibyte **GiB** (= 1024 mebibytes)
- Tebibyte **TiB** (= 1024 gibibytes)

$$1024 = 2^{10} = 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2$$

Data storage volume (terminology)

- Unfortunately, and confusingly, decimal-prefix terms (**kilo**byte, **mega**byte, **giga**byte, etc.) are sometimes used to refer to binary multiples of 1024 (2^{10}) instead of decimal multiples of 1000 (10^3).

- For example, even though it's technically true that:
  - 1 **kilo**byte = 1 **kB** = 1000 bytes, and
  - 1 **kibi**byte = 1 **KiB** = 1024 bytes

  … "**1 kilobyte**" is nevertheless sometimes used informally to refer to **1024 bytes.**

Data storage volume (terminology)

- This is an informal usage of terminology that was common traditionally, and it continues to be used sometimes.

- However, technical international standards clearly distinguish between decimal- and binary-prefix units.

Bandwidth volume

Units of measure for **bandwidth** (rate of data transfer):

- Bits per second **bit/s** **bps**
- Kilobits per second **kbit/s** **kbps**
- Megabits per second **Mbit/s** **Mbps**
- Gigabits per second **Gbit/s** **Gbps**

Storage volume vs. Bandwidth volume

When referring to the **size** of files or other pieces of data, we generally speak in terms of **bytes** (not bits).

However, when referring to bandwidth or the **transfer rate** of data, we generally speak in terms of **bits per second** (not bytes per second).

Example:

If my internet provider offers me an internet connection with a transfer rate of 10 megabits/second, how long will it take me to download a file with a size of 100 megabytes?

Storage volume vs. bandwidth volume

How do we convert a value represented in **bits**, to the equivalent value in **bytes**?

Simply divide the **bits** value by 8 to get the **bytes** value!

(8 bits = 1 byte)

Speed (bits):	10 Mbit/s
Speed (bytes):	10 ÷ 8 = 1.25 MB/s
File size:	100 MB
Download time:	100 ÷ 1.25 = 80 seconds

Processor clock speed

The **clock speed** (clock rate, processor speed) of processors (CPUs), is calculated in **hertz**.

This is the unit of measure for **frequency**:

- Hertz **Hz** (= 1 cycle per second)
- Kilohertz **kHz** (= 1000 hertz)
- Megahertz **MHz** (= 1000 kilohertz)
- Gigahertz **GHz** (= 1000 megahertz)

In processors, this value represents the number of basic instructions per second that a processor core can execute.

1 hertz = 1 instruction per second

Processor clock speed

Therefore, if we have a single-core processor with a clock speed of 3.5 GHz, we can conclude that it is able to perform 3,500,000,000 (3.5 billion) basic instructions per second!

The main components of a computer

- Power supply unit (PSU)
- Motherboard
- Processor (central processing unit or CPU)
- Random access memory (RAM)
- Hard disk drive (HDD) and/or solid-state drive (SSD)
- Video card (graphics card)

Power supply unit

Even if all of the components are in place inside of a computer, without the **power supply unit**, the computer simply will not work.

This component is used to deliver the required electricity to the motherboard in order to run all of the components that are installed in the computer.

Motherboard

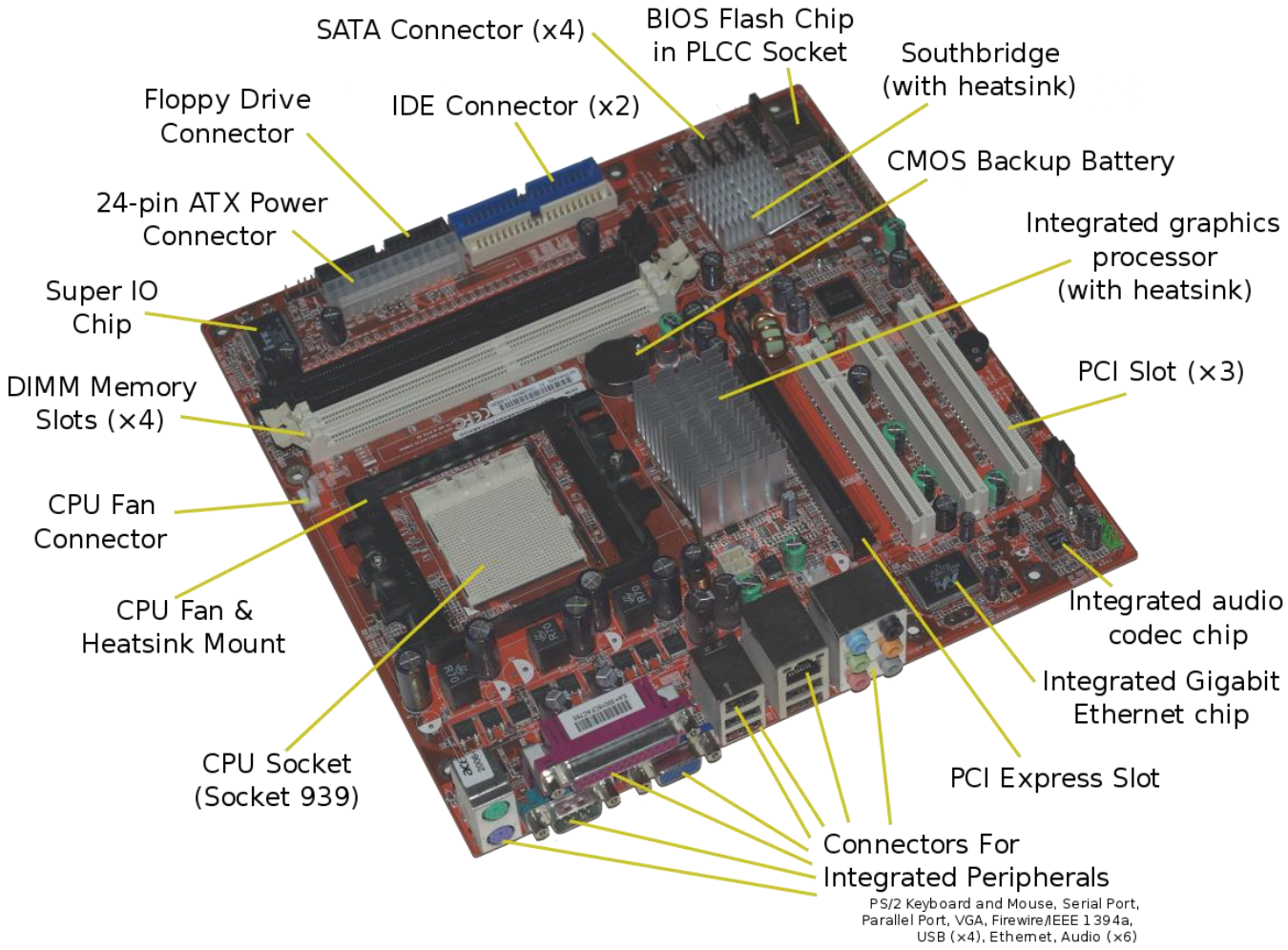
- The **motherboard,** also called the **system board** or **main circuit board**, is aptly named.
- This is the main component of your computer, the one that "holds" and connects all of the other components together – physically, first of all, because it is screwed to the inside of your PC's case.

Motherboard

- It also has **slots** for connecting dozens of different kinds of components and peripherals, in addition to the essential elements described in this presentation.

- Furthermore, at the software level it connects everything, because whenever a program sends or receives any data, the data must necessarily pass through the motherboard in its path through the hardware of the computer.

Motherboard



https://en.wikipedia.org/wiki/Motherboard

Motherboard

In the vast majority of cases, the motherboard has some integrated (built-in) **peripherals** and **connectors** that allow it to accomplish basic tasks that all computers are expected to accomplish nowadays:

- USB ports
- Network card / Ethernet port
- Sound card
- VGA/DVI/HDMI connectors
- Etc.

Processor

- The **processor** has several alternative names, such as the **microprocessor** or **CPU** (central processing unit).
- Fundamentally, its role is to process digital information, and it operates only upon **bits** (binary digits).
- In other words, it communicates in a language that consists of sequences of 0s and 1s.

Processor

- Moreover, it performs the instructions and calculations necessary for executing programs.
- The speed at which it does this is determined in part by its **clock speed**, expressed in **hertz** – or, in the case of current processors, in gigahertz (GHz).

Processor

Take, for example, an Intel processor:

Intel® Core™ i7-8565U Processor (8M Cache, up to 4.60 GHz)

- 8 MB SmartCache Cache
- 4 Cores
- 8 Threads
- 4.60 GHz Max Turbo Frequency
- U - Ultra-low power
- 8th Generation

Source : https://www.intel.ca

Cache: The **cache** is used to store repetitive sequences of instructions in memory.

Cores: This number represents the number of **physical cores,** which defines how many tasks can be performed simultaneously. 4 cores means that 4 tasks can be executed at the exact same time.

Threads: This number represents the number of **virtual/logical cores,** which defines how many tasks can be performed in parallel – but not literally at the same time. One thread can be efficiently activated when another is idle.

Gigahertz: This number represents the **clock speed**: the frequency at which basic instructions can be executed by each of the cores.

Processor

- Regarding the calculation of the number of instructions a processor can execute per clock cycle:
  - Not all CPUs with the same clock speed will be able to execute a given task in the same time, depending on the architecture of the CPU in question.
  - With the arrival of multi-core processors, it became possible for processors to execute multiple instructions per cycle!

Memory: Random access memory (RAM)

- **RAM** (random access memory) is a type of **memory** (or **primary storage**). It is used to store data and machine code that is currently being used by the processor.
- One advantage of RAM is its high access speed.
- Another advantage is that, from a given moment, all locations in RAM can be accessed in roughly the same time, unlike some other storage media, such as hard disk drives (HDDs) and compact discs (CDs).

Memory: Random access memory (RAM)

- Another feature of memory is that it is a medium of temporary storage: once a given process is terminated, the corresponding data stops being stored in memory.
- Moreover, RAM is **volatile,** which means that it requires power in order to store data. When the computer is turned off or the power is otherwise interrupted, the stored data is quickly lost.

Mass storage drives

- Data that needs to be stored persistently is saved on **mass storage drives**. That's to say, nearly everything: operating system files, software, and especially your personal data:
  - Photos, videos, music, emails, documents, etc.

- There are two main types of mass storage drives:
  - Hard disk drive (HDD)
  - Solid-state drive (SSD)

Mass storage: Hard disk drive (HDD)

- Contrary to the illustration above, the magnetic disk (**platter**) is not visible, nor is the mechanical **actuator arm** that holds the **read/write head**.
- The components are housed inside of a rectangular case, which is screwed in place inside of the PC's case.
- The higher the platter rotation speed, the higher the performance.
- There are currently hard drives running at 5400, 7200, 10000 or 15000 RPM (revolutions per minute), with the speeds of 7200 and 10000 RPM being the most widespread.

Mass storage: Solid-state drive (SSD)

- Until a few years ago, hard disk drives were indispensable to the functioning of a computer.
- However, today hard drives can be replaced by a **solid-state drive** (SSD). Solid-state drives store data just like hard drives do, but their design and their features are different.

Mass storage: Solid-state drive (SSD)

- Unlike hard disk drives, SSDs do not have mechanical arms or rotating platters. Instead, they are fabricated using only electronic components that are “solid” and remain immobile in the case.
- As a result, SSDs have multiple strengths over HDDs:
  - They are lighter and more impact-resistant, making them an attractive choice for laptops.
  - Furthermore, they are much faster, which is an asset for all types of computers, since the execution speed of all the components can be slowed down by the mechanical action of the conventional hard disk drive.

Video card

- Although very important for some uses, the **video card** (graphics card) is placed last on this list because it can be replaced by an **integrated chipset** directly on the CPU.
- When integrated into the CPU, the graphics rendering will be performed using the RAM installed on the motherboard.

Video card

- However, for some applications, especially games, a video card is indispensable.
- By taking control over the display management, processing the visual information itself, and using its own memory, the video card releases the processor from having to perform these functions.
- Moreover, by freeing up RAM, it allows other processes to have access to more resources.

Other peripherals

- Keyboard
- Mouse
- Screen
- Printer
- Scanner
- Network card
- Sound card
- Joystick
- Webcam
- Etc…