1. Introduction to memories

Most computers are built according to the Von Neumann model, which focuses on memory. The programs that carry out the processing are stored in memory. In this chapter, we look at the different types of memory and how each is part of the memory hierarchy.

1.1 Memories

Définition 1.1 (A memory:) A memory is a device for storing information.

Définition 1.2 (The bit:) The bit: this is the smallest information storage element in memory.

Définition 1.3 (Byte:) Byte: a byte is a group of eight bits.

Définition 1.4 (Word:) **Word:** A word is a group of bits corresponding to the addressable unit of information.

1.1.1 Memory characteristics

Several important criteria characterize memories:

- **Memory capacity**: indicates the amount of information a memory can store. In general, this capacity can be expressed in bits, bytes, or more rarely in words. Given the large values of capacities, multiples of these units are commonly used: kilobit, megabit, kilobyte, megabyte, etc. (see Table 1.2).
- **Memory access time**: measures the time required to perform an operation. It is an important criterion for all types of memory.
- **Operation mode (writable or not):** read-only memory (ROM) or random-access memory (RAM).

- **Memory bandwidth:** This criterion is expressed as the product of the data bus width and the memory frequency.
- **Volatility**: represents the length of time during which information is available in memory. Magnetic memories are non-volatile: information is retained even after the power supply is turned off.
- **Size**: Physical memories take up increasingly smaller space, allowing for greater integration. This is an important factor in the development of computing.
- **Cost**: is a very important criterion in the development of computing. Electronic memories have a relatively high storage cost, which means their capacities are correspondingly lower.
- **Cycle time**: this is the minimum duration between two successive accesses.
- **Information access moden**: Random or Sequential.
- **Storage medium.**

Traditional definitions do not comply with the standards used for other units. Normally, a kilobit (symbol kb, with a lowercase "k") equals 1,000 bits, and a kilobyte (symbol kB) corresponds to 1,000 bytes. To avoid confusion, the IEC (International Electrotechnical Commission) defined binary prefixes in 1998, as illustrated in Table 1.1. The Linux system follows the IEC notation (see Figure 1.1).

Table 1.1: Binary prefixes (IEC prefixes)

Nom	**Symbol**	2^{10a} = Factor	**a**
kibi	Ki	2^{10}= 1 024	1
mebi	Mi	2^{20} = 1 048 576	2
gibi	Gi	2^{30} = 1 073 741 824	3
tebi	Ti	2^{40} = 1 099 511 627 776	4
pebi	Pi	2^{50} = 1 125 899 906 842 624	5
exbi	Ei	2^{60} = 1 152 921 504 606 846 976	6
zebi	Zi	2^{70} = 1 180 591 620 717 411 303 424	7
yobi	Yi	2^{80} = 1 208 925 819 614 629 174 706 176	8

Table 1.2: Decimal prefixes (SI prefixes)

Name	**Symbol**	10^{3a} = **Factor**	a
kilo	k	10^{3} = 1 000	1
mega	M	10^{6}= 1 000 000	2
giga	G	10^{9} = 1 000 000 000	3
tera	T	10^{12} = 1 000 000 000 000	4
peta	P	10^{15} = 1 000 000 000 000 000	5
exa	E	10^{18}= 1 000 000 000 000 000 000	6
zetta	Z	10^{21} = 1 000 000 000 000 000 000 000	7
yotta	Y	10^{24} = 1 000 000 000 000 000 000 000 000	8

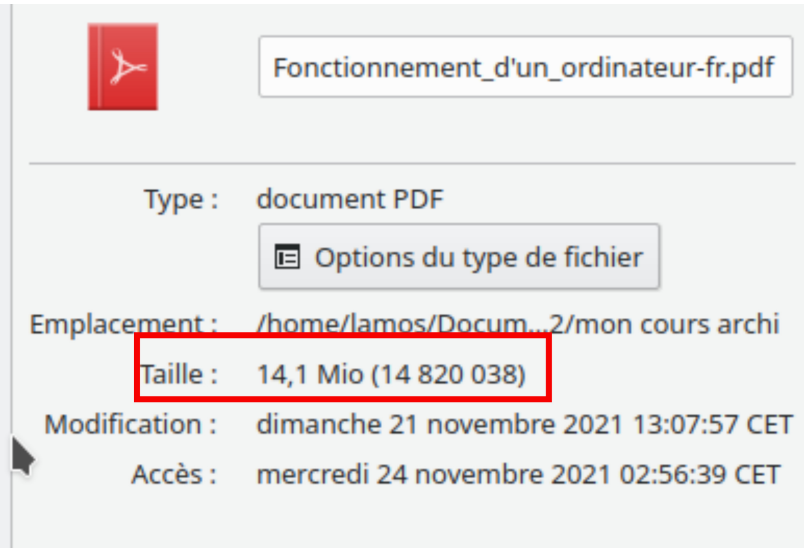


Figure 1.1: IEC Notation

1.2 Categories of memory

The memory hierarchy can be classified into two main categories:

1. **Working memories**: they are semiconductor-based. They are active during program execution. They also form two classes:

   - **Random-access memory (RAM)**: this includes, first and foremost, the internal registers within the processor, which are typically word-sized, the cache memory, and the main memory.
   - **Read-only memory (ROM)**: these are memories that contain a resident program. These memories are accessed at the computer's startup by the processor to execute the resident program, for example, to load the operating system kernel into the main memory from the hard drive."

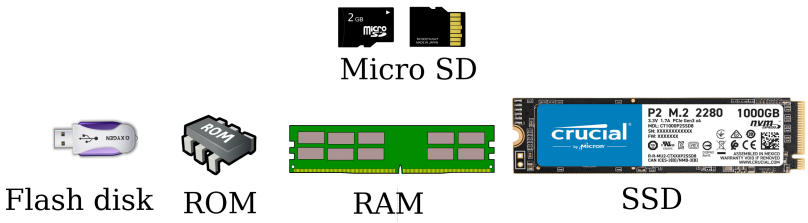
2. **Storage memories:** these are mass memories. They are used to permanently store large quantities of information (programmes and data).

1.3 Classification of memories according to the storage medium

Memories can be classified into three categories based on the technology used:

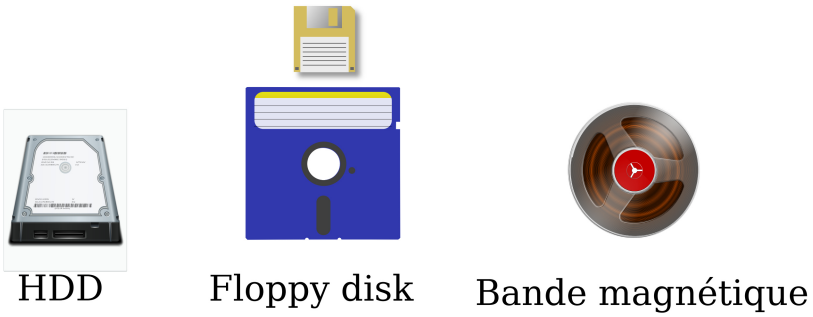
- Semiconductor memory (main memory, ROM, PROM, etc.): very fast but of limited size.

Figure 1.2: Semiconductor memories



- Magnetic memory (hard disk, floppy disk, etc.): less fast but stores a very large volume of information.

Figure 1.3: Magnetic memories



- Optical memories (DVD, CDROM,..)

Figure 1.4: Optical memories

DVD/CD