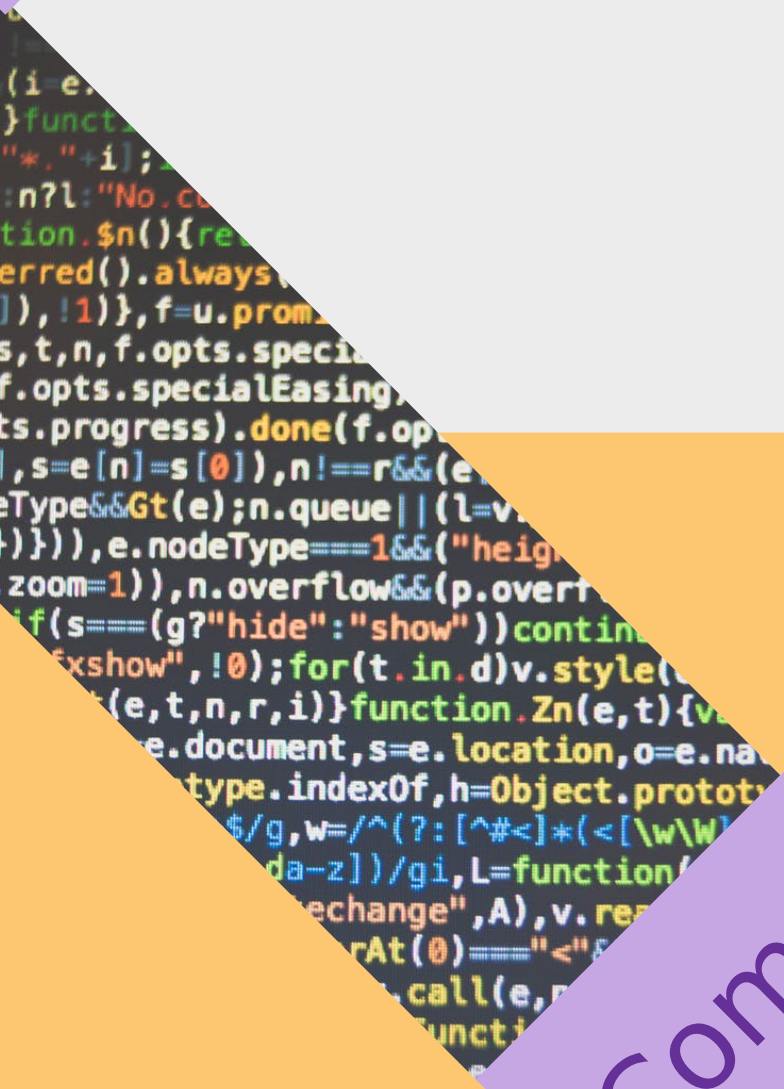
Curs 2020-2021



Computer Systems
Internal Hardware

IES Jaume II El Just
Tavernes de la Valldigna

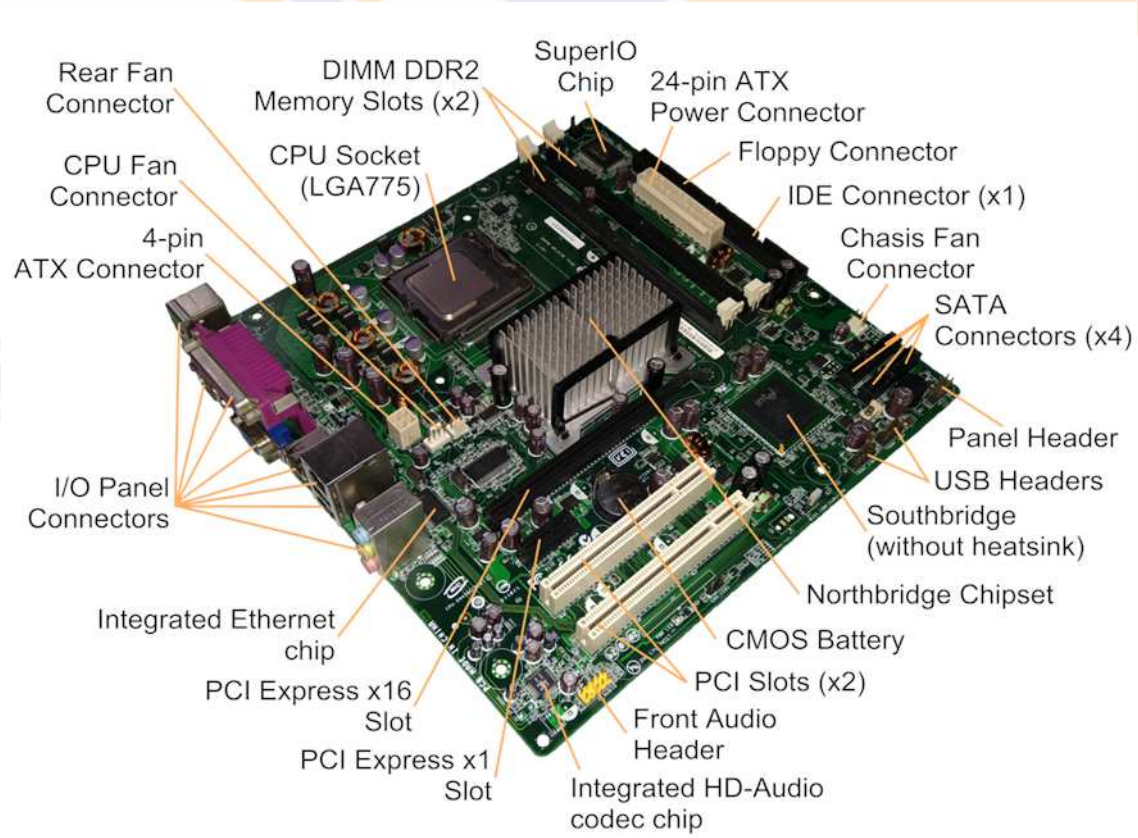
Contents

1 Motherboard

The motherboard or mainboard is a printed circuit board. Actually it is the main circuit board of the computer. On that board, the components are connected forming the computer. The motherboard has some chips integrated on it as the socket for the microprocessor, chipset, Bios, etc... or even some slots in order to connect as it has been said before, other components which formed the computer, some other devices or peripherals. The main components of the motherboard are:

- Connectors for power supply.
- Socket for connecting the microprocessor.
- RAM slots
- Chipset: integrated circuit in order to manage the transfer data issues.
- Firmware: it is a read only memory in order to execute tasks when the computer turns on. That memory is EEPROM, flash ... and it is known as BIOS.
- CMOS Battery
- External connectors in order to connect peripherals as mouse, keyboard, printer, scanner, etc... Slots: that are connectors to connectadditional boards
-

The following picture shows a mother board and its components:

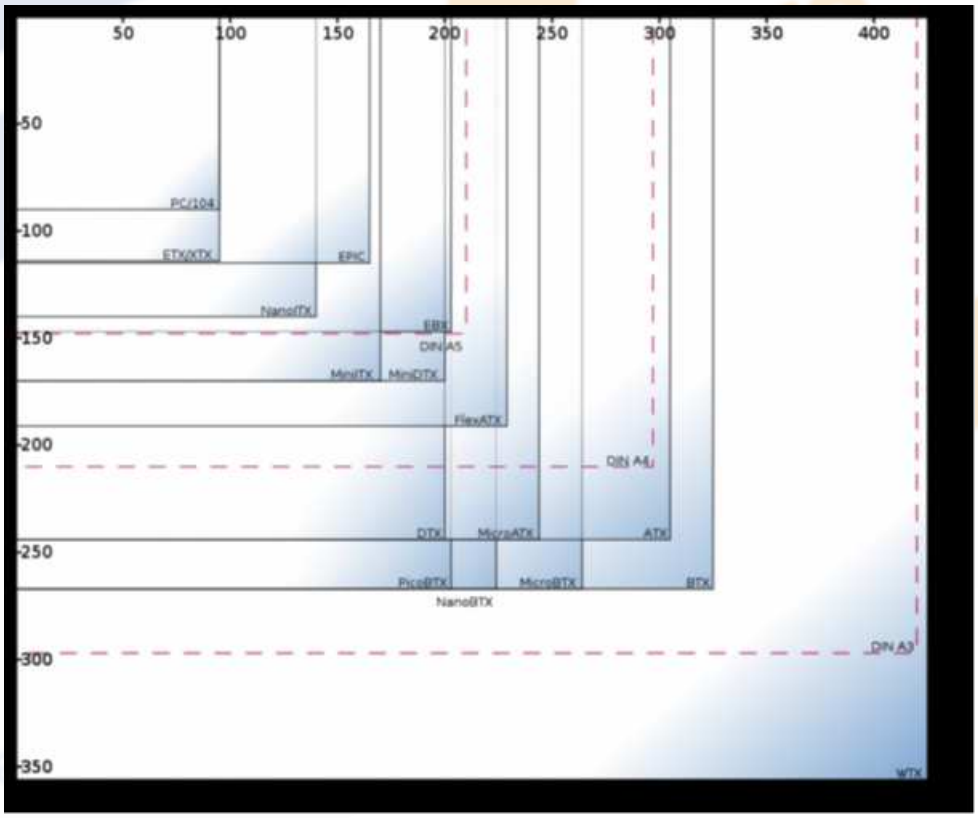


1.1 Form factor

It is needed to standardize some features of the motherboard since there are a lot of firms which are making boards, chips and other components for them. So some measures, shapes and distribution of components are agreed. The features defined by the factor form are:

- The shape of the board.
- The measurements: width and long.
- The position of the anchors
- The position of some components: slots, external connectors etc...
- The connector of the power supply.
- The electric connexion of the power supply. Voltages, how many cables are required etc...

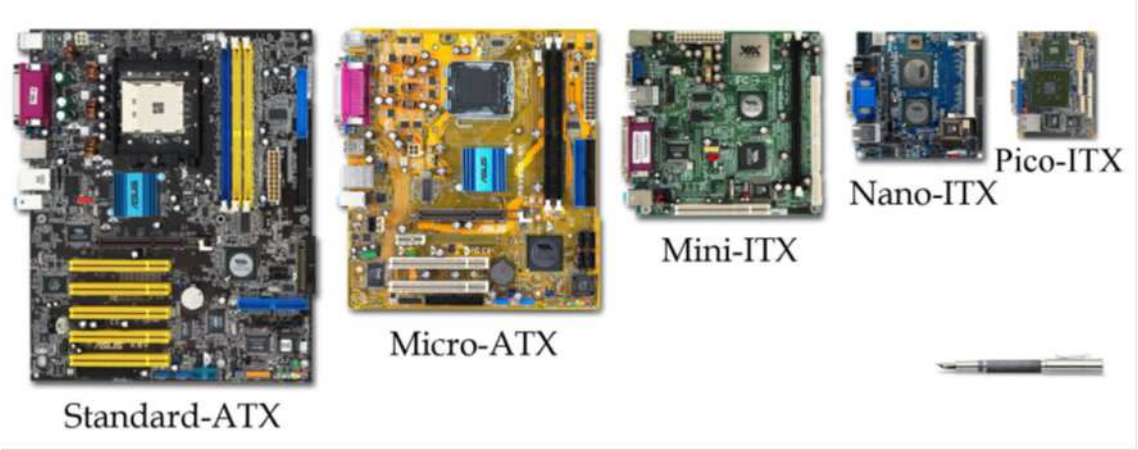
There are different factors as it can be seen in the following picture:



The most used is ATX form factor and its variants. The main features are:

- The dimensions are 305mmx244 mm(12"x9,6")
- The kind of power supply connector 24 (20+4) pins in order to avoid connexion errors.
- A connection and disconnection system of the computer through software.

There are some other variants of ATX smaller, and that it got because some of the slots of expansion are removed from the board:



1.2 BIOS

BIOS (Basic Input/output System) is firmware used to perform hardware initialization when the computer turns on. It is the first software which is executed and it shows error codes, coded series of sounds or messages on the screen when the POST (power-on self test) had recognized some necessary hardware to initialize the operating system in the computer.

BIOS is stored in a memory ROM (Read-only memory), it was programmed when the ROM was made and never could be erased and reprogrammed. Nowadays, is used FLASH or EPROM memory because BIOS can be updated. On the other hand, CMOS is other memory which stores a graphic program in order to manage some possibilities in the BIOS. CMOS need power supply in order to not lose the information (CMOS battery). When the battery runs out, settings are removed and it is necessary to set up again your configuration. Normally the BIOS chip has the name of the firm which has made the chip.

The main manufactures of BIOS are American Megatrends (AMI), AWARD and Phoenix Technologies.

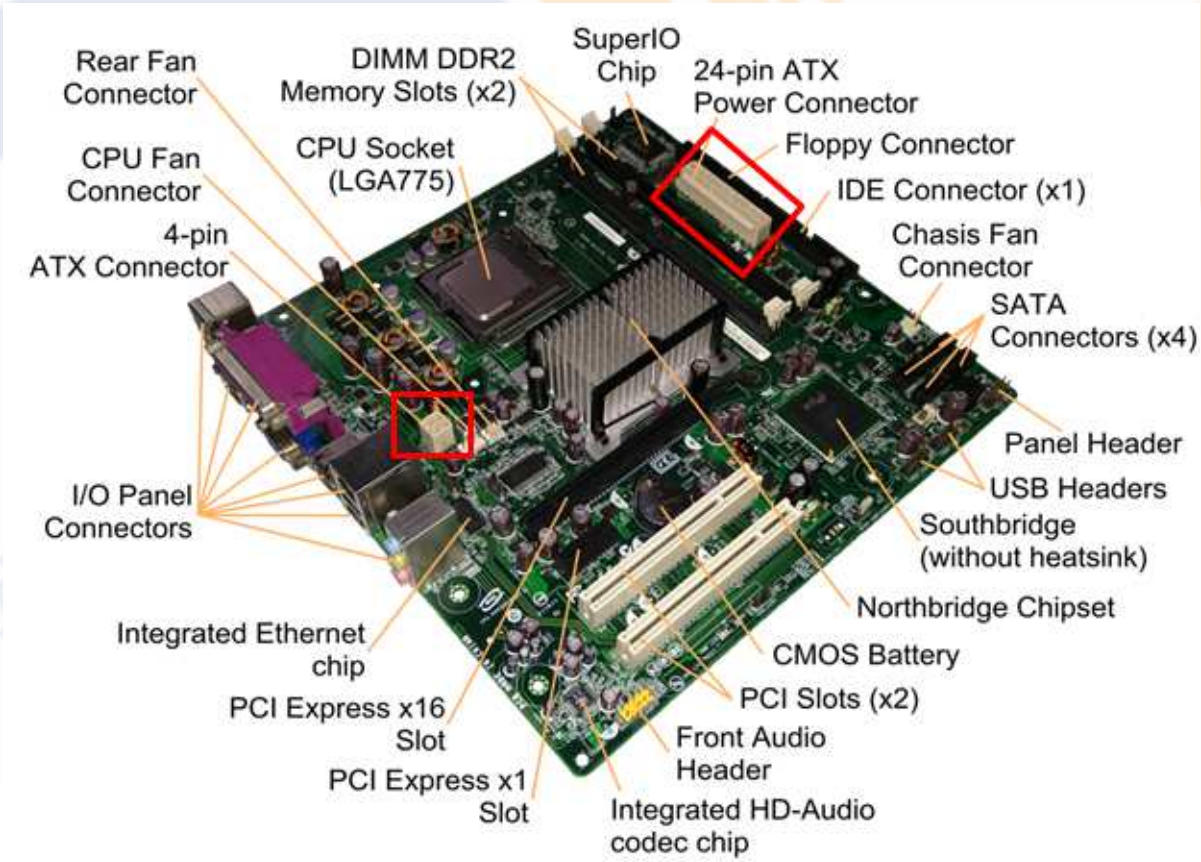
1.3 UEFI

In order to offer more and better possibilities to the users, Intel, AMD, Microsoft and some other manufactures got the agreement to promote other specification Unified Extensible Firmware Interface (UEFI). Nowadays, The majority of the computers use UEFI instead of BIOS. UEFI offers:

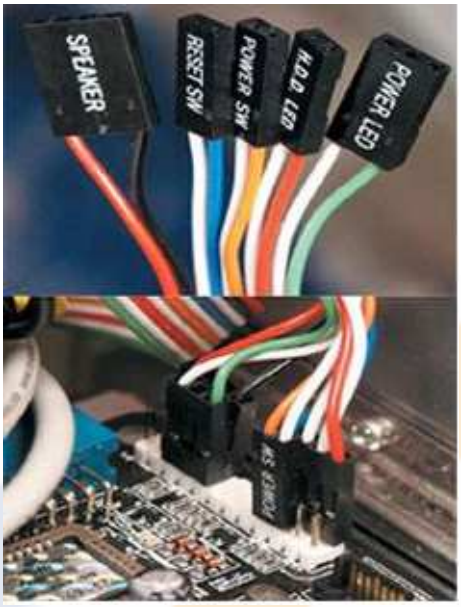
- Good and comfortable graphic interface in order to manage some configurations.
- It is possible to add some extension as tools to overclock or test software.
- Faster boot of the computer.
- Changes in the boot process
- Support for booting devices of large size.
- Secure Boot. That is a component which offers more security because avoid to install any software not signed but at the same time it avoids to install Linux in Windows 8. To solve this problems, UEFI offer the possibility to switch to Legacy mode (BIOS mode)

1.4 Internal Connectors

- **Power supply connector**: One of the most important connectors is the power supply. There are some different connectors according to the pins:
  - ATX: 20 pins
  - ATX 2: 24 pins
  - ATX 2.2: 24 +4 pins.

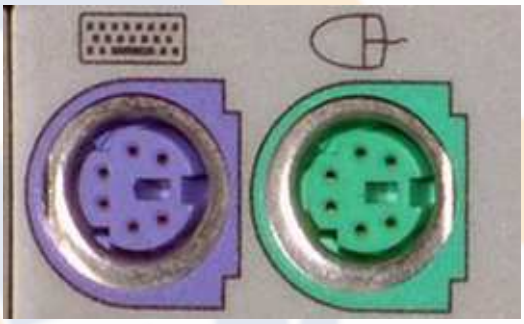


- **Front panel connector**: the front panel connector is where the connector of the hard disk drive activity lights, case speaker, reset button, power on/off button, computer power on light, and key lock, are connected to make them function smoothly.



1.5 External Connectors

- **MiniDIN**: they are two connectors to connect keyboard and mouse. One of them is green and the other is purple. Green is to connect mouse and purple is to connect the keyboard. However, it is possible and recommended to connect keyboard and mouse to USB.



- **Parallel and serial port**: there are two ports in order to send or receive data between computer components. For example: it is used to connect printer to parallel port.

- **USB (Universal Serial Bus)**: That is connector which reaches 4.8 Gb/s in the 3.0 version.

- **IEEE 1394, firewire, thunderbolt**. It is mainly used to transmit data from video cameras or photo.

1.6 Expansion Slots

The expansion slots are some ports on the board in order to connect some card to add features, benefits or simply add some card to the computer. For instance it is possible to connect graphic cards, sound or TV cards. The most used types of slots are:

- **PCI**. The speed of that slot is 133 MB/s
- **PCIe (PCI express)**: that bus as a lane full duplex and it is structured in lanes. In PCIe 1.1 each lane transport 250 MB/s., PCI e 2.0 double that rate (500MB/s) and PCIe 3.0 double the last one (1 GB/s each lane). Each slot has 1, 2, 4 or 16 lane. That is specified as x1,2,4,or 16. For example: the speed of a PCIe 3.0 slot x16 would be 1GB/s for 1 lane but this time are 16, so it would be 16 GB/s. But the transmission is in both direction because is full duplex, the final speed would be 32 GB/s
- **AMR**: slot to connect audio devices
- **CNR**: AMR +network card
- **AMR**: a small slot to connect audio devices
- **CNR**: slot in order to connect communciation devices (modem, network cards) and is also used to connect audio devices.

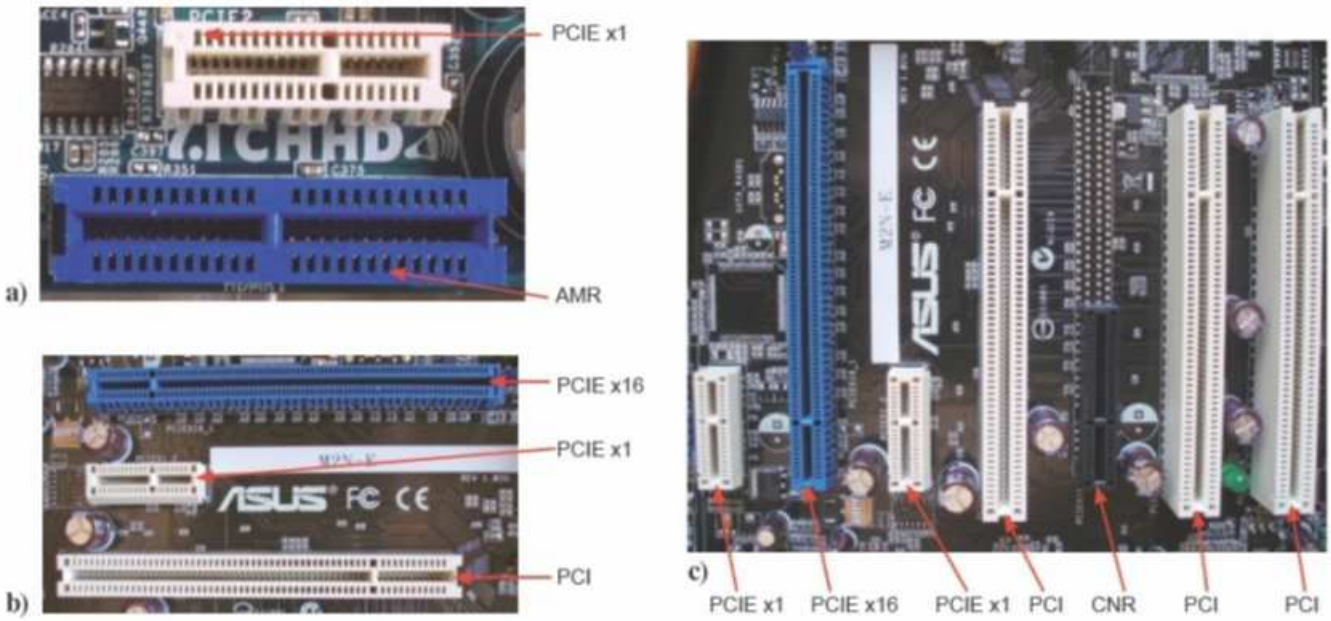
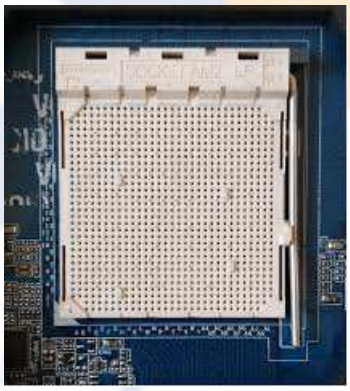


Figura 4.35. Comparación de aspecto y tamaño de las diferentes ranuras de expansión: a) PCIE x1 con AMR; b) PCIE x1 con PCIE x16 y con PCI; c) todas, donde podemos ver su tamaño relativo y posición en la placa base.

1.7 CPU Socket

It is used to place the microprocessor of the same family. It is possible to see the data sheet of the motherboard in order to make sure what microprocessor is suitable for the socket.



2 Chipset

Chipset is a set of chips which are in charge of managing the flow of data and instructions between CPU and others devices, buses, memory cache and peripherals.

A chipset has two sections (Southbridge and Northbridge). Each section is dedicated for an specific functions:

- The Southbridge, is also known as the input/output controller hub. That chip is not connected directly to the CPU and it is in charge of manage the motherboard slower connections as I/O devices, expansion slots and hard disk drives.
- The Northbridge manages the computer faster interaction requirement and communications, that is tos ay, the communications between CPU and, RAM, ROM, BIOS... and also the northbridge connects the southbridge with CPU. The northbridge is linked directly to

the CPU. There are some functions of the northbridge which are integrated inside of the CPU in some models. For instance, i3, i5 and i7 the memory controller is inside of the CPU and the northbridge used is IOH (Intel). That is a northbirdge without the memory controller.

Try it
Locate in the motherboard of the point 1 motherboard the northbridge and southbridge.

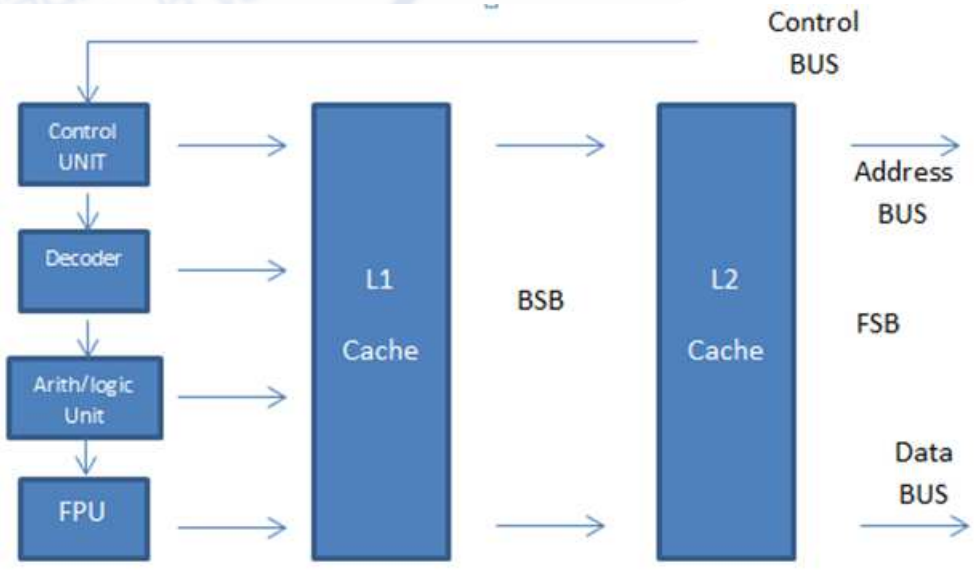
3 Processors

The processor appears in the fourth generation of the computers and it is the brain of the computer since it is in charge of decode and execute the instructions of the programs which are in the main memory. It has been said that normally, it is placed on the socket for it and normally it has a square or rectangular shape. Besides, one of its tasks manages and controls the rest of the component which form the computer and those peripherals connected to it.

As every chip, the processor is made with a transistor. The transistor is an electronic component made with silicon. The power of the CPU depends on how many transistors could be placed in a small space.

There are two kinds of processors:

- Single core: the elements of the single core are:
  - Control Unit, decoder (it is inside of the control unit) and ALU has been studied in the last unit
  - FPU (Float Point Unit) it is a coprocessor in order to do complex operations and helps the arithmetic/logic unit. The floating point is a kind of representation which allows to represent number which a high precision.
  - L1 cache and L2 cache are memory which store data in order to get them fast. The difference between both (L1 and L2) is that L1 is faster and smaller than L2. It was to do with the hierarchy of the memory studied in the last unit.
  - BSB (Back side Bus) and FSB (Front Side Bus) are the buses which link microprocessor and L2 cache and data and address bus used respectively. FSB in AMD processor is called HyperTransport.

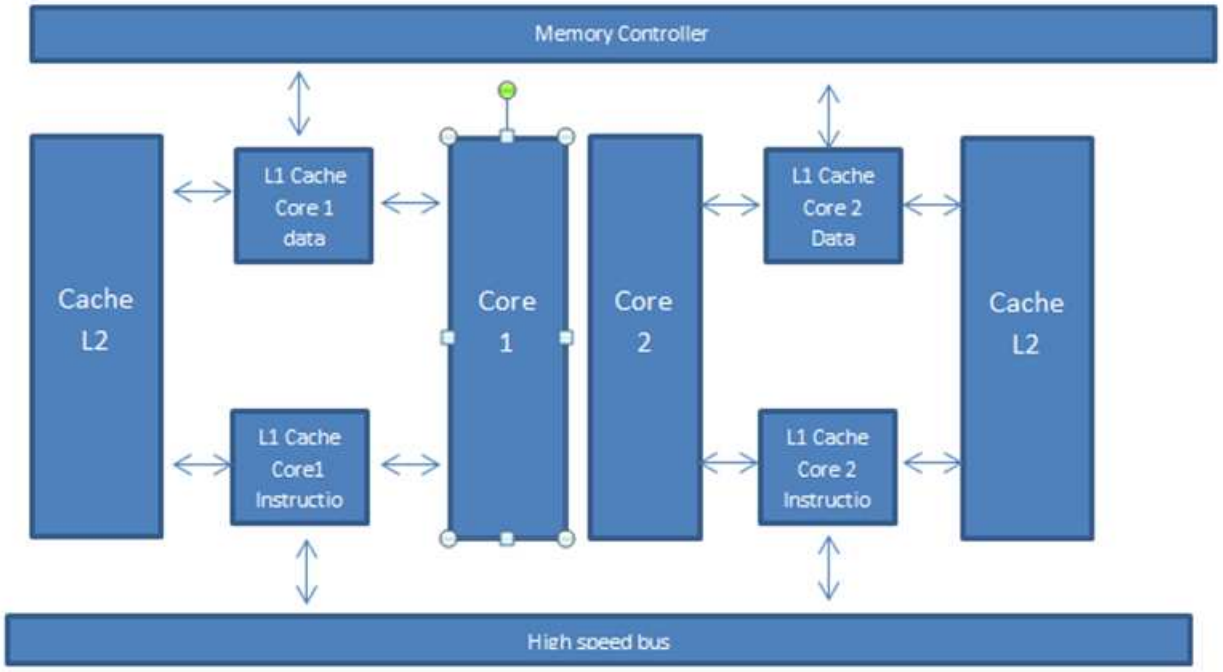


- Multi core. In spite of the fact that the speed and the performance got by processors are very high, the limits are about to be reached and one taken option was to increase the number of cores inside a microprocessor. That way it enables to execute different instructions while gaining a better performance but increasing the heat.

  The architecture is very similar to the single core but it is added:

  - Integrated memory controller: the memory controller for faster access to RAM
  - Bus transport high speed.

    The following picture is a dual core architecture.



Some features should bear in mind when it is talked about processors:

- **Frequency**: when it is talk about frequency, it refers to the frequency of the clock of the CPU and it means the amount of the instructions per second which it is able to execute. Normally it is measured in MHz or GHz, that is to say, millions or billions per second.
- **Speed**: Bus speed usually refers to the speed of the front side bus (FSB) which connects the CPU to the Northbridge. FSB speeds can range from 66 MHz to over 800 MHz. Since the CPU reaches the memory controller though the Northbridge, FSB speed can dramatically affect a computer's performance. There are some reasons that affect the speed of the bus:

  - Chips rarely work at the same speed of the CPU.
  - The number of the bits which are transmitted (since bits are transmitted in blocks).

- **Cache**: cache is the memory faster than RAM memory and it is the first memory which a data or instruction is searched before to invoke RAM memory. There are 3 levels and the order to search data or instruction is first level, second level, third level and RAM memory. Cache memory is inside of the processor:

  - Level 1: that is the fastest and smaller, normally is 128 KB per core.
  - Level 2: it is bigger than level 1 cache, 512 KB-1MB and sometimes is shared by several cores.
  - Level 3: that is shared by all of the cores and the size ranges between 2 and 8 MB. In the nomenclatures, when 64KB + 64KB appears, it indicates that is 64 KB for data and the same size for instructions. If it appears 2 x 4MB, it indicates that are 4 MB per core (if two cores).

- **Number of bits**: the type of the processor (32 or 64 bits) not only affects its overall performance but it also affects the type of software with which can be used. The difference between are:
  - A big difference between 32-bit processors and 64-bit processors is the number of calculations per second they can perform, which affects the speed at which they can complete tasks.
  - The maximum amount of RAM that is supported. 32-bits processos can support $2^{32} = 4GB$ of memory. 64-bit could support $2^{64} = 18EB$ but the limit is 44 bits, it is to say,$2^{44} = 16TB$

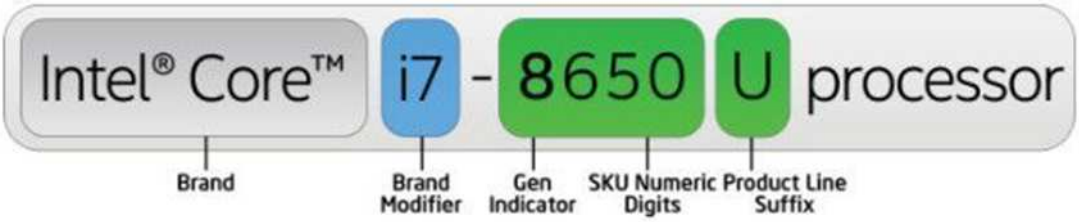
3.1 Processors Nomenclature

3.1.1 Intel

As everybody knows, Intel Corporation is one of the major processors maker in the world. The company was founded in 1968 with the name Integrated Electronics Corporation. Later the name took the three first letters of Integrated and the two first letters of Electronics, Intel.

Nowadays, Intel processors are in its tenth generation and their name gives a lot of information.

For example:



- Intel Core: it points out the architecture of the processor.
- i7: the information of the brand modifier is the family which the processor belongs.
- 8: the generation indicator points out the generation which the processor belongs. In this case, it belongs the eighth
- 650: the sku numeric Digits are an identifier and the higher number the better since more capabilities.
- U: the product line suffix, that letter is not always present. And represent a variety of processor. Each generation has its own set of letters. Letters depending on the generation

3.1.1.1 10^{th} Generation

The processors of that generation also, called Ice Lake Mobile, can have the following letters:

- U : Ultra-low power
- Y : Extremely-low power
- G7: it points out that it includes an integrated graphic card Iris Plus.

3.1.1.2 9^{th} Generation

The letters of that generation, also called Coffee Lake Refresh:

- K(Unlocked): it means that the processor of that generation with that letter, is able to be overclocked since they are unlocked as to speed and voltage. They are usually used to play.
- F: it requires an independent graphic card.

3.1.1.3 8^{th} Generation

That generation is also called Coffee Lake / Kaby Lake Refresh / Whiskey Lake The most used letters are:

- K(Unlocked): the same that the letter "K" in the last generation explained.
- U: Ultra-low power. Just for laptops

3.1.1.4 7^{th} Generation

The letters of that generation, also called: Kaby Lake/Skylake (X-series Processors)/Apollo Lake, are:

- H: High performance graphics
- HK: High performance graphics; and the processors with that letter in that generation are able to be overclocked.
- HQ: processors with 4 cores and high performance graphics
- U: Ultra-low power
- Y: Extremely-low power

3.1.1.5 6^{th} Generation

In that generation, one of the most used letter is:

- T: it offers enhanced stile of life for power.
- HK: High performance graphics; the processors with that letter in that generation are able to be overclocked.
- HQ: processors with 4 cores and high performance graphics

- U: Ultra-low power
- Y: Extremely-low power

6th generation In that generation, one of the most used letter is: • "T": it offers enhanced stile of life for power.

Some of the letters most used have been described before as K, H, HK, HQ and U.

Through the 10 generation, the nomenclature of the processors has changed. The following examples of letters have been used in the past as well:

- X:a processor that offers a maximun performance. The more performance, the more expensive.
- R:desktop processor but integrated in the motherboard.
- M:laptop processor.
- MQ: 4 cores laptop processor.
- MX: laptop processor which offfers the máximum performance.

To learn a litle bit more

You can learn more about processor of Intel in these links:

`https://en.wikipedia.org/wiki/List_of_Intel_microprocessors`
`https://en.wikipedia.org/wiki/Intel_Core#Ice_Lake_microarchitecture_(10th_generation)`

To learn a litle bit more

Specify what features have the following processors just knowing the name of them:

- Intel Core i9-9900 K
- Intel Core i7-6700 K
- Intel Core i7-7500 U
- Intel Core i7-1060G7
- Intel Core i5-8350 U
- Intel Core i3-7100T

3.1.2 AMD

Advanced Micro Devices Inc. is an American Electronics company established in California. As Intel, that company develops processors, chipset, integrated circuits, embedded processors, etc... As it has been made with Intel, it is going to try to explain the information which is possible to get from the name of the different processors of that company.

3.1.2.1 Series FX

That series of processors has four, six and eight cores but it is out-of date. Regarding nomenclature:

- The first number means the number of processors. For example AMD FX 8350, the first number, 8 means that the processor has 8 cores.
- Second number points out what kind of architecture the processor uses. The AMD FX series was created with Bulldozer architecture but later Piledriver architecture improved it. The number 3 indicates Piledriver architecture.
- Third number means the frequency process of the processor. The higher number, the higher frequency.

3.1.2.2 Athlon Series

This architecture has never got more than 4 cores and they didn't have third level cache (L3 cache). As the before series of processors, the first number points out the architecture and the second one points out the speed of the processor.

3.1.2.3 APU serie

That kind of processors, are those with integrated graphics. Regarding nomenclature:

- The first letter and number mean the number of cores:
  - A6 points out 2 cores
  - A8 and greater points out 4 cores.
- The first number means the architecture and the generation:
  - APU 6000 series are based in Piledriver
  - APU 7000 series are based in Steamroller
  - APU 8000 series are based in Excavator
  - APU 9000 series are based in Excavator v2.
- Second number means the frequency process of the processor. The higher number, the higher frequency.

  The letter k in some processor of that series means that these processors, have a multiplier in order to be able to be overclocked.

3.1.2.4 Ryzen AMD serie

The processor of that series, has a multiplier to be able to be overclocked. Besides, it offers the configurations of 4, 6 and 8 cores and some processors can manage 2 threads per core. Regarding nomenclature :

- The first number points out the number of cores:
  - Ryzen 7 has 8 cores,
  - Ryzen 5 has 6 cores except Ryzen 5 1500 and 1400 that have 4 cores and 8 threads

  - Ryzen 3 has 4 cores.

- The second number means the generation
- The third number is used to differentiate the speed. The higher number, the higher frequency.
- The X letter is used to point out higher frequency of work. For example: Ryzen 7 1700 X works with 3,4 GHz – 3.8 GHz and Ryzen 7 1700 works with 3 GHz- 3.7GHz

3.1.2.5 APU Ryzen Series

In this series, the architecture used is ZEN and GPUs Radeon RX Vega but there are 2 kinds of processors:

- Low power
- Standard version

Regarding nomenclature:

- The first number indicates the number of CPU cores and GPU cores.
- The second number indicates the generation.
- U letter indicated lower power and lower frequency than the desktop version indicates with G letter. For instance, APU ryzen 5 2400 G is the standard version for PC and APU Ryzen 5 2500 U is the same version for laptops.

3.1.2.6 AMD Threadripper

This kind of processors is those for high performance sector. And the nomenclature is the following:

- The first number indicates the generation. At the moment 2 series exist:
  - Threadripper 1000 Series
  - Threadripper 2000 Series
- The third number is some kind of scale of values which indicates the number of cores and threads. For example: Threadripper 1950 X has 16 cores and 32 threads and, on the other hand, the threadripper 1920 X has 12 cores and 24 threads.
- X letter indicates the high performance of that serie of processors.

To learn a litle bit more

You can learn more about processor of AMD in the following link:

`https://en.wikipedia.org/wiki/List_of_AMD_Ryzen_microprocessors`

To learn a litle bit more

Search information about the following AMD processors and write down the features of them:

- FX-8120
- FX-4150
- Ryzen 5 1600X
- Ryzen 3 2200G
- Ryzen Threadripper 2950X
- Athlon Pro 300GE

4 Memory

The RAM (Random Access Memory) memory is the component in charge of store programs and data temporarily, that is to say is a volatile memory. Other characteristic of that memory is that it is possible to access to any address at any time.

The RAM memory is formed by cells arranged in matrix way, normally there are several cells in the same line or address, that group of cells where a bit is stored, is called word.

But, actually the size of memory which is able to address is said by the address bus. So for example, if the address bus has 32 bits, the amount of memory which it is able to address is 2^{32} Bits, that is to say, 4,294,967,296 bytes = 4 GB.

On the other hand, the data bus is in charge of transmitted data and instruction. Nowadays processors use 64-bits which can be transmitted 8 bytes in each clock cycle.

The most important characteristics are:

- **Speed**: it is measured in Hz. Nowadays the indicated speed refers to the real bus speed. For example DDR333 means a memory which works with a 166 MHz of speed but it sends the information two times per clock cycles. So 2x166 = 333 MHz.
- **Bandwidth**: that measures the amount of data transmitted and expresses the flow rate that the memory can achieve. It is possible to know that parameter by: (Real clock speed x use of cycle x bus width x Number of channels) / 8 = bytes.

  Example

  Memory of 3200MHz in Dual channel (64 bits) with 2 transfers by cycle:
  1600 000 000 cycles x 2 x 64 x 2= 409 600 000 000 bits, 51,2 GB/s

- **Number of channels**: it depends on where the memory RAM is connected to the motherboard, the controller of the motherboard can access to two, three or even four channels simultaneously. And the bandwidth is increased. To do this it is compulsory to have a DDR2, DDR3, DDR4 identical modules.
- **RAM types**:

- DRAM (Dynamic RAM): each cell of the RAM is made of a transistor and another electronic component called capacitor. When "1" value of bit in a cell is stored, the capacitor is charged with energy (the capacitor are stores of energy). But, that capacitor need to be recharged with energy. And an electronic circuit in charge of recharging the capacitors is needed. That kind of memory is cheaper and slower than the SRAM. There are differents kinds of DRAM:
  * DDR: double use of the cycle.
  * DDR2: quadruple use of the cycle.
  * DDR3: they send 8 bits per cycle.
- SRAM (Static RAM): they are faster and more expensive than the previous one. That kind of memory doesn't need to be charged because they use another kind and powerful transistor.

4.1 SIMM modules and DIMM modules

The RAM memory is a set of printed circuits which are inserted on the board:

- SIMM (Single In Line Memory Module) . The connection pins are in the same side of the card. It needs an angle of 45 ^{o} to introduce the modules in the slot on the board.
- DIMM (Dual In Line Memory Module). That kind of module is bigger than the previous one and they have contact pins in both sides.
- SO-DIMM: that kind of memory is to laptop. They are smaller than the modules for PC.

In order to avoid electrical instability when several modules are installed on a motherboard, there are modules that in order to ensure stability have buffers or registers which can be differentiated because they have more chips with smaller size or horizontal placed. This solution prodeuces poor performance.

On the other hand, RAM memory uses some methods in order to detect and correct errors in data:

- Parity generates: the goal to this method is to have an even number of "1" in the message. To do this, a bit is added to the message. The number of "1" counted has to be even, if the number of "1" is odd, the bit added will be "1" in order to do an even number of "1". That method detects the error but it doesn't correct it.
- ECC: That method detects and fixes the error but the algorithm to do this is very complex.