Computer systems and hardware

UNIT 1: USE OF MICROCOMPUTING SYSTEMS. FIRST PART

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2. Computers architecture
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1. Computers and history

There were some pioneers before computers:

- Abacus: The first instrument used to calculate.
- Pascal's calculator (also known as the arithmetic machine or Pascaline): Invented in year 1642. It was only used to perform addition and subtraction.
- Leibniz Wheel: Invented in 1671. It can also be used to perform multiplication and division
- Charles Babbage: Invented in year 1837. Analytical engine, considered as the first design for a general-purpose computer.
- Ada Lovelace: S. XIX. She developed the code (first computer program) for Charles Babbage's famous analytical engine.

2. Computers architecture

- Architecture is a set of rules and methods that describes the functionality, organization, and implementation of computer systems.
- Alan Touring developed a theoretical computing machine during World War II.
- Based on the Turing machine model, Von Neumann designed the first stored-program computer.

2.1. Von Neumann architecture

- The von-Neumann architecture defines five functional units for a digital computer
  - ✓ Central Process Unit (CPU)
  - ✓ Memory
  - ✓ Input/output Unit (I/O).
  - ✓ Buses
  - ✓ Peripheral devices.

- Today, in a modular computer system these units are part of the physical components.

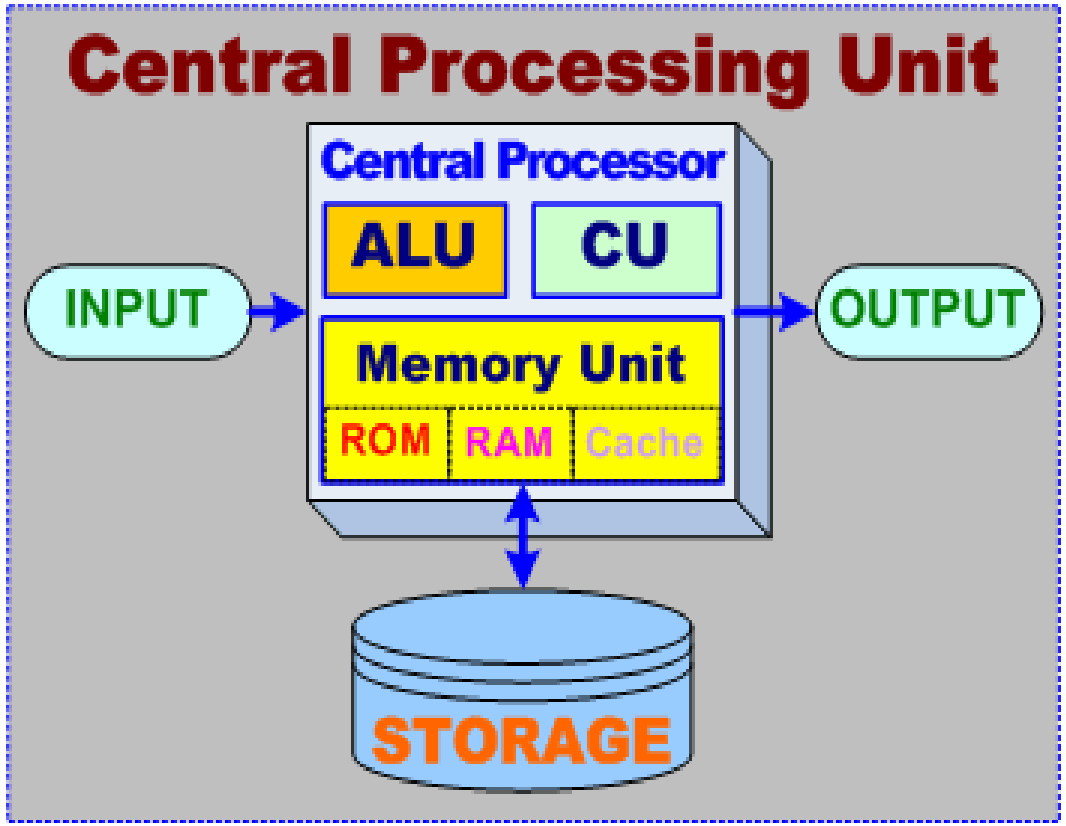
2.1.1. CPU

- A central processing unit (CPU) is the electronic circuitry within a computer that controls all the system and carries out the instructions of a computer program.
- It processes data from memory or peripheral devices.
- On large machines, the CPU requires one or more printed circuit boards.
- On personal computers and small workstations, the CPU is housed in a single chip called a microprocessor.
- Since the 1970's, the microprocessor class of CPUs has almost completely overtaken all other CPU implementations.

2.1.1. CPU

- The typical components of a CPU include the following:
  - ✓ The arithmetic logic unit (ALU), which performs arithmetic and logical operations.
  - ✓ The control unit (CU), which extracts instructions from memory and decodes and executes them, calling on the ALU when necessary.
  - ✓ Registers: They are temporary storage areas for instructions or data.
  - ✓ Internal bus: Also known system bus, connects all the internal components of a computer, such as CPU and memory, to the motherboard. It allows to exchange data, information and control signals between CU, ALU and registers.

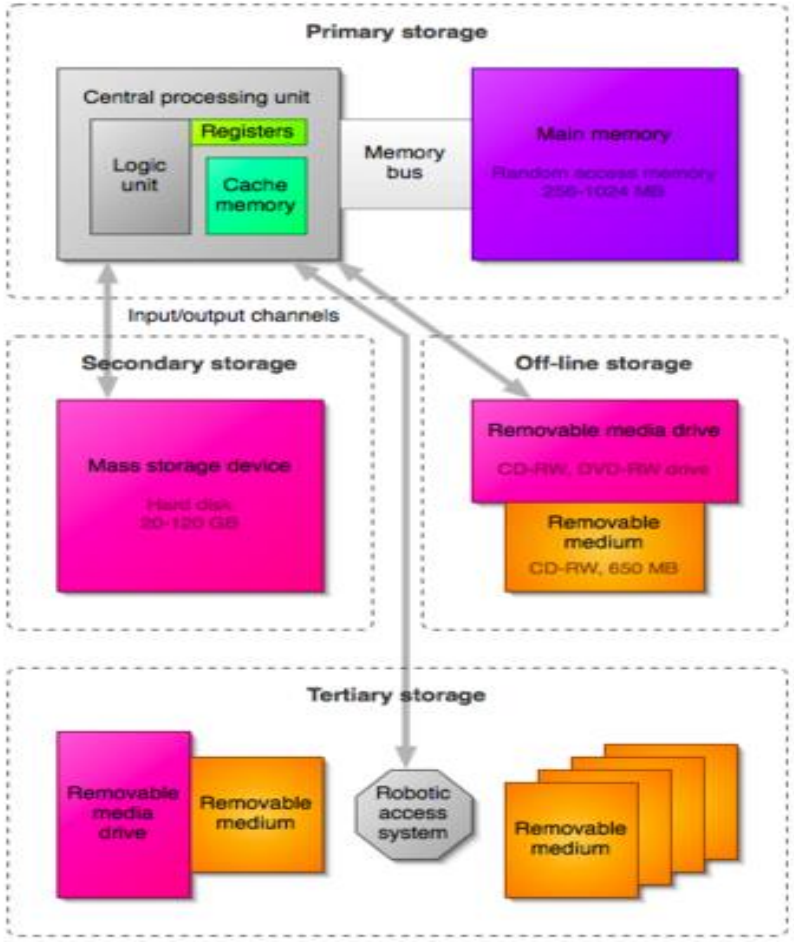
2.1.1. CPU


Central Processing Unit
Central Processor
ALU
CU
INPUT
OUTPUT
Memory Unit
ROM
RAM
Cache
STORAGE

2.1.2. Memory

- A storage device is any hardware capable of holding information either temporarily or permanently.
- There are different types of storage devices used with computers. The memory hierarchy in computer storage separates each of its levels based on response time. Smaller hardware is faster, but faster hardware is more expensive and low-capacity.
- There are four major storage levels:
  - ✓ Internal: Processor registers and cache.
  - ✓ Main: the system RAM and controller cards.
  - ✓ On-line mass storage and secondary storage: Hard disks. Terabytes in size. Computer data storage on a medium or a device that is under the control of a processing unit.
  - ✓ Off-line bulk storage, tertiary and off-line storage: Big data and servers. Up to Exabyte in size. The medium is recorded, usually in a secondary or tertiary storage device, and then physically removed or disconnected.

2.1.2. Memory


Primary storage
Central processing unit
Registers
Logic unit
Cache memory
Memory bus
Main memory
Input/output channels
Secondary storage
Mass storage device
Off-line storage
Removable media drive
Removable medium
CD-RW, 650 MB
Tertiary storage
Removable media drive
Removable medium
Robotic access system
Removable medium

2.1.2. Memory

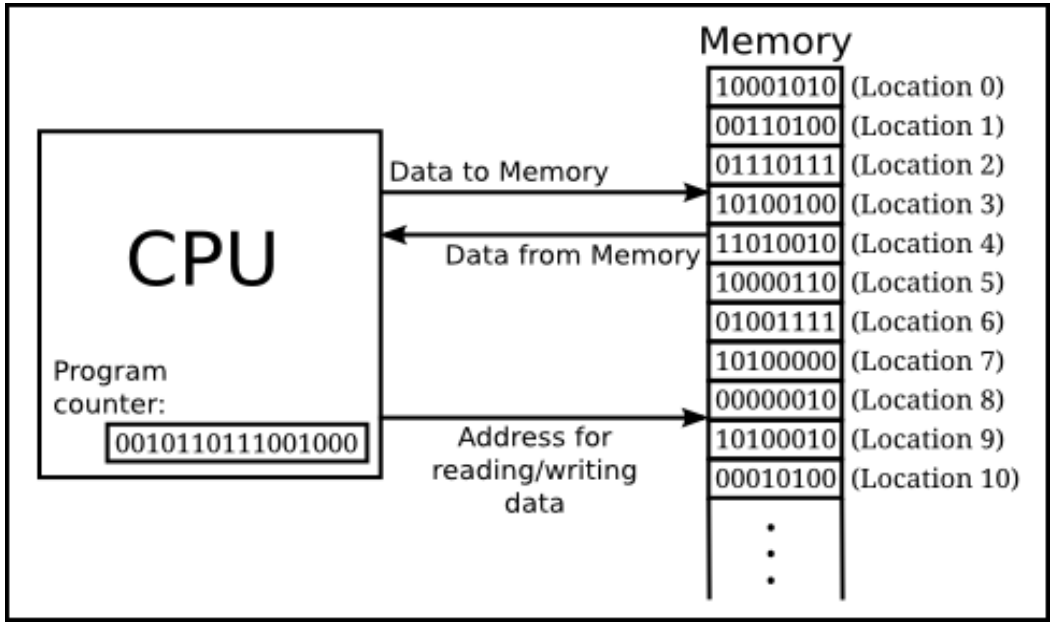
- In the Von Neumann architecture, memory refers to the computer hardware devices involved to store programs and its instructions.
- This memory, which is called random-access memory (RAM) or “main memory”, operates at a high speed. It is distinct from storage that provides slow-to-access program and data storage but offers higher capacities.
- If needed, contents of the computer memory can be transferred to secondary storage, through a memory management technique called "virtual memory".
- Anyway, the term "memory", meaning "main memory” is often associated with an addressable semiconductor memory.

2.1.2. Memory

- A digital computer's memory consists of many locations, cells, or positions, each having a physical address and a code that the CPU can use to access it.
- A computer program uses memory addresses to execute the machine code, store and retrieve data.
- In early computers, logical and physical addresses corresponded, but since the introduction of virtual memory most application programs do not have knowledge of physical addresses.
- Instead, they address logical addresses, or virtual addresses, using the computer's memory management unit and operating system memory mapping; see below.

2.1.2. Memory

- The memory has two important registers:
  - ✓ Memory Address Register (MAR): Stores the memory address from which data will be fetched to the CPU or the address to which data will be sent and stored.
  - ✓ Memory Data Register (MDR): Contains the data to be stored in the computer storage (e.g. RAM), or the data after a fetch from the computer storage.



2.1.3. I/O Unit

- Input/output or I/O is the communication between an information processing system, such as a computer, and the outside world, possibly a human or another information processing system.
- Inputs are the signals or data received by the system and outputs are the signals or data sent from it.
- I/O units abstract peripherals and allow the processor to centralize operations with these devices.

2.1.4. Buses

- Buses are electrical wires that transfer data between components inside a computer.
- There are two main types:
  - ✓ Internal buses: The internal bus connects all the internal components of a computer, such as CPU and memory, to the motherboard.
  - ✓ External buses: The external bus, or expansion bus, is made up of the electronic pathways that connect the different external devices (such as printer, keyboard etc.) to the computer.
- Buses have different measurement parameters. The most useful is bandwidth, which refers to the total amount of data that can be transferred on the bus in a given unit of time. Using the highway analogy, if the bus width is the number of lanes, and the bus speed is how fast the cars are driving, then the bandwidth is the product of these two and reflects the amount of traffic that the channel can convey per second.
- Further information: https://zappedia.com/external-data-bus/

2.1.5. Peripheral devices

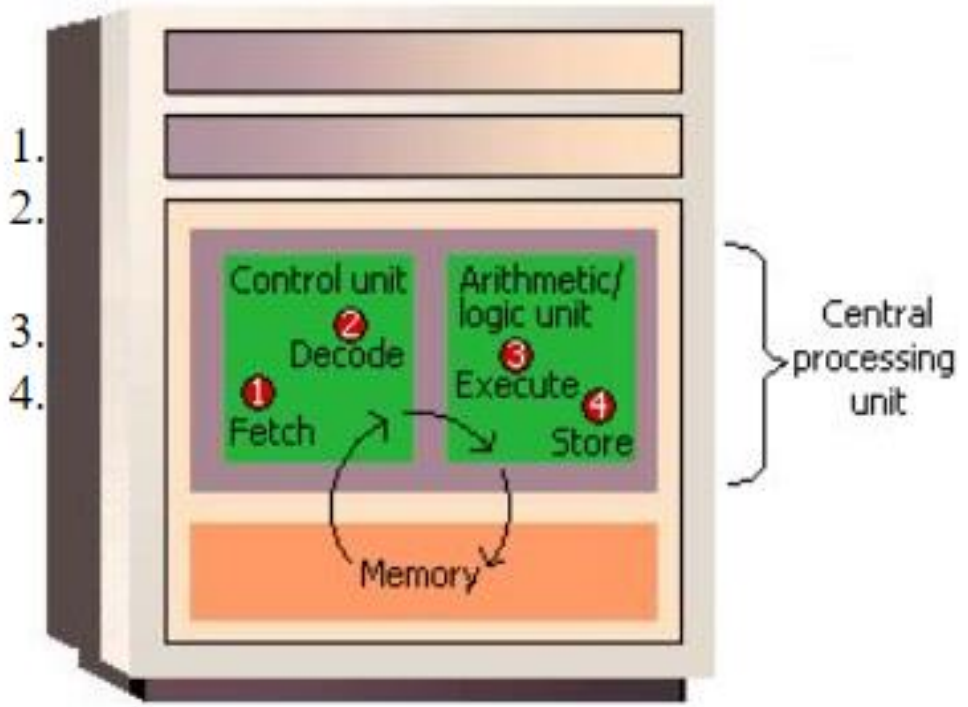
- Any device which transfers information to or from the CPU/memory combo, for example by reading data from a disk drive, is considered a peripheral
- They are used to put information into and get information out of the computer.
- There are three different types of peripherals:
  - ✓ Input devices: They interact with or send data from the user to the computer (mice, keyboards, etc.),
  - ✓ Output devices: They provide output to the user from the computer (monitors, printers, etc.),
  - ✓ Input/output devices: They perform both functions. Touchscreens are an example that combines different devices into a single hardware component that can be used both as an input and output device.

2.2. How a computer executes program instructions

- The instruction cycle (sometimes called a fetch–decode–execute cycle) is the process by which a computer retrieves a program instruction from its memory, determines what actions the instruction dictates, and carries out those actions.
- Before an instruction can be executed, program instructions and data must be placed into memory from an input device or a secondary storage device. Once the necessary data and instruction are in memory, the central processing unit performs the following four steps for each instruction:
  1. The control unit fetches (gets) the instruction from memory.
  2. The control unit decodes the instruction (decides what it means) and directs that the necessary data be moved from memory to the arithmetic/logic unit. These first two steps together are called instruction time, or I-time.
  3. The arithmetic/logic unit executes the arithmetic or logical instruction. That is, the ALU is given control and performs the actual operation on the data.
  4. The arithmetic/logic unit stores the result of this operation in memory or in a register. Steps 3 and 4 together are called execution time, or E-time

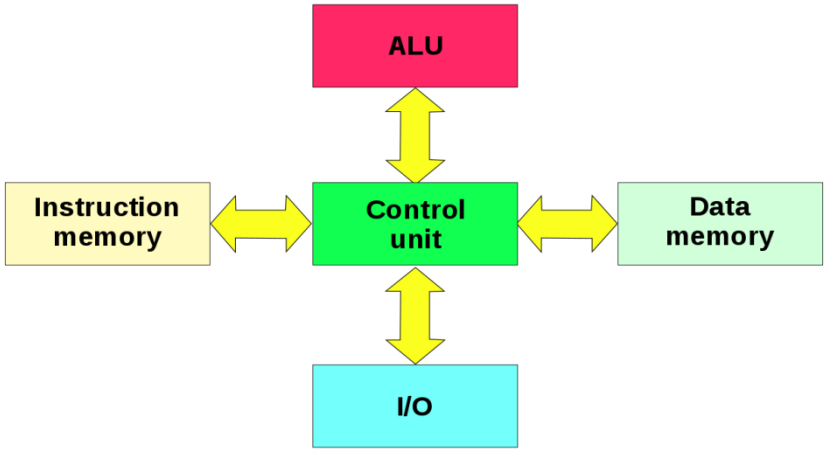
2.2. How a computer executes program instructions

- The control unit eventually directs memory to release the result to an output device or a secondary storage device.



2.3. Harvard architecture

- The Harvard architecture is a computer architecture with separate two memories: for instructions and data.
- Under pure von Neumann architecture, the CPU can be either reading an instruction or reading/writing data from/to the memory. Both cannot occur at the same time since the instructions and data use the same bus system. In a computer using the Harvard architecture, the CPU can both read an instruction and perform a data memory access at the same time.



3. Computer systems

- In computer science, we define computer system as a group of components that interact to produce information. These components are:
  - ✓ Hardware: The term hardware refers to machinery. This category includes the computer itself, which is often referred to as the central processing unit (CPU), and all of its support equipment. Among the support, equipment is input and output devices, storage devices and communications devices.
  - ✓ Software: The term software refers to computer programs and the manuals (if any) that support them.
  - ✓ People: Every system needs people if it is to be useful. This includes not only the users, but those who operate and service the computers, those who maintain the data, and those who support the network of computers

4. Hardware

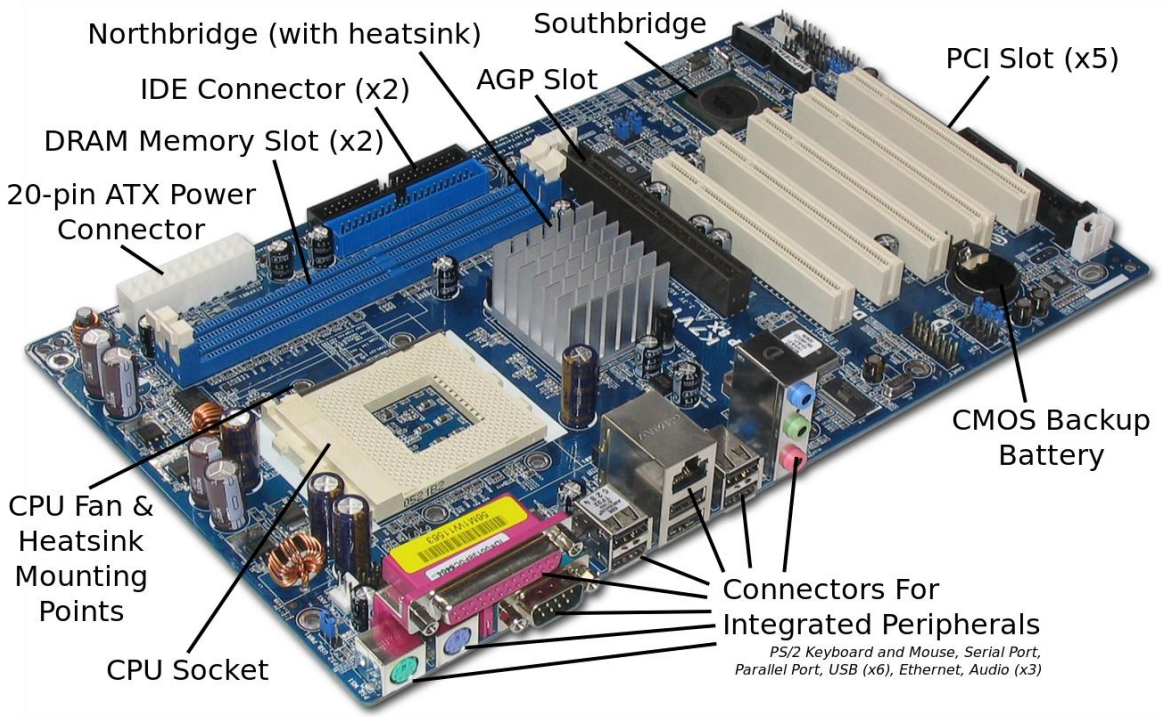
- Let’s study some of the different components to assemble a computer.

4.1. Motherboard

- A motherboard is the main printed circuit board (PCB) found in general purpose microcomputers and other expandable systems.
- It holds and allows communication between many of the crucial electronic components of a system, such as the central processing unit (CPU) and memory, and provides connectors for other peripherals
- The motherboard of a computer is typically located in the bottom of the computer housing

4.1. Motherboard

- Classical motherboard with Northbridge and Southbridge



4.1. Motherboard

- A current motherboard with PCH.

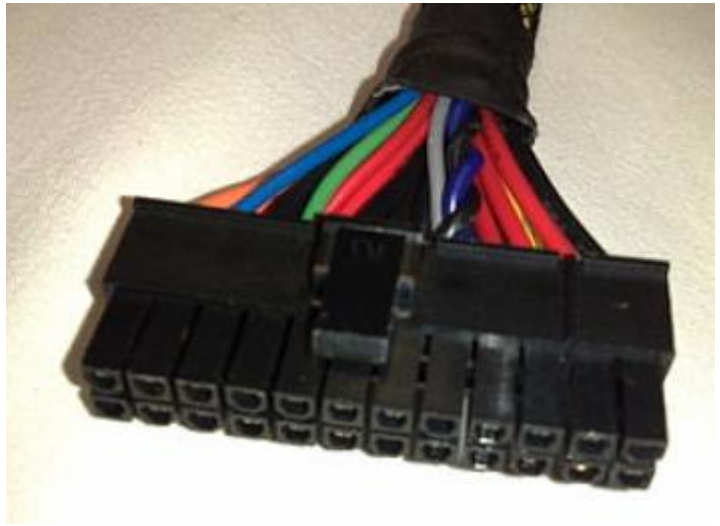
4.2. Form factor

- Motherboards are produced in a variety of sizes and shapes called computer form factor, some of which are specific to individual computer manufacturers.
- It usually determines the dimensions, power supply type, location of mounting holes, number of ports on the back panel. In the table below, you can compare the dimensions of the motherboard, depending the form factor.

AT (Obsolete)	305 × 279–330 mm
Baby-AT (Obsolete)	216 × 254–330 mm
ATX	305 × 244 mm
microATX	244 × 244 mm
Mini-ATX	150 × 150 mm
FlexATX	228.6 × 190.5 mm max.
Mini-ITX	170 × 170 mm max.
Nano-ITX	120 × 120 mm
Pico-ITX	100 × 72 mm max.

4.2. Form factor

- The most popular form factor is called ATX (Advanced Technology eXtended) due to the distribution of wires and refrigeration.
- Originally, the motherboard was powered by one 20-pin connector. An ATX power supply provides a number of peripheral power connectors and (in modern systems) two connectors for the motherboard: a 4-pin auxiliary connector providing additional power to the CPU and a main 24-pin power supply connector.

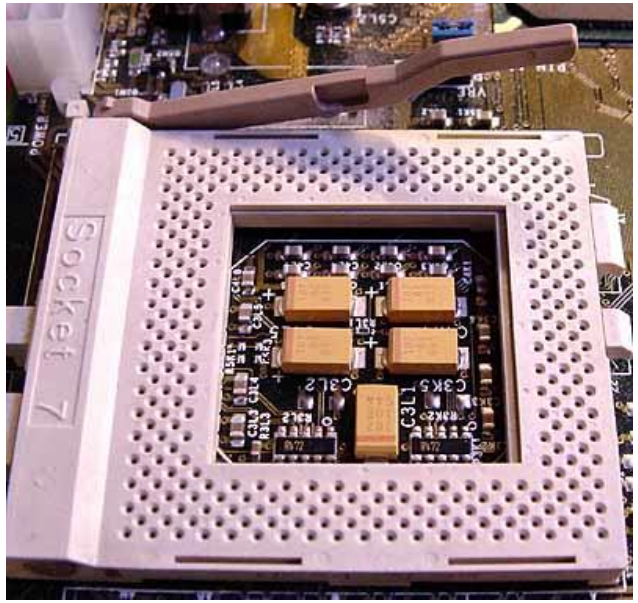


4.3. Sockets

- A CPU socket is a connector which allows for placing and replacing the microprocessor without soldering. The most common socket types are as follows:
  - ✓ PGA: A pin grid array (PGA) is square or rectangular. The CPU itself has the pins that insert into the socket. The arrangement of pins on the CPU must correspond to the slots on the socket; if not, the CPU will not connect properly to the board. Pins are easy to damage.

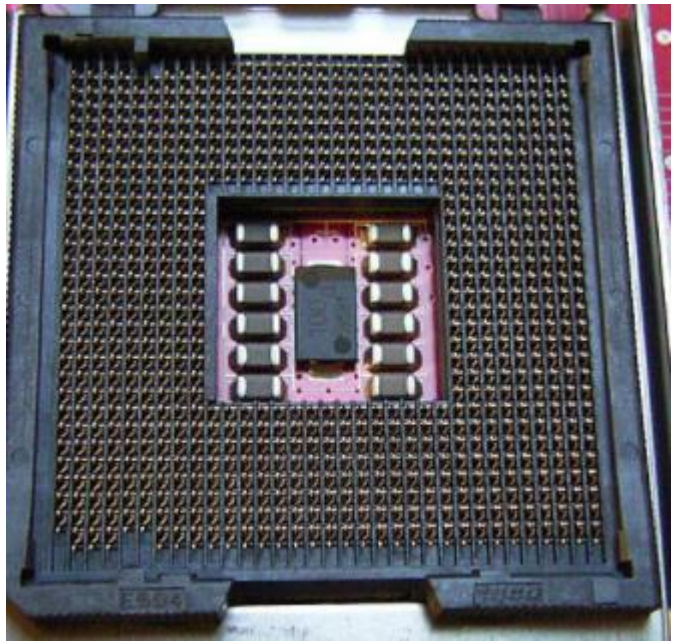
4.3. Sockets

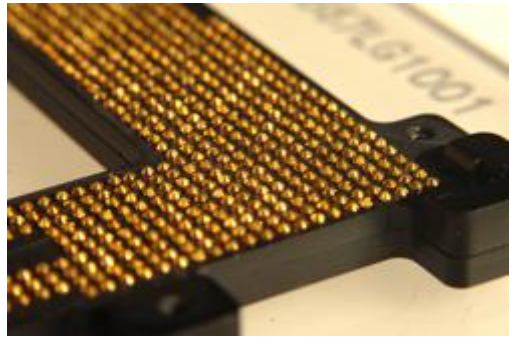
- ✓ ZIF: Zero insertion force (ZIF) is an extension of a PGA socket with pins on the CPU. It requires very little force for insertion (by using a lever or slider on the side). However, because of its lower insertion force than a conventional socket, they are likely to produce less reliable connections.



4.3. Sockets

- ✓ LGA: The land grid array (LGA) is a packaging technology with a rectangular grid of contacts on the underside of a package. Instead of having the pins connected to the CPU, they are connected to the socket itself while the CPU has slots with connectors. It can include a lever like ZIF.



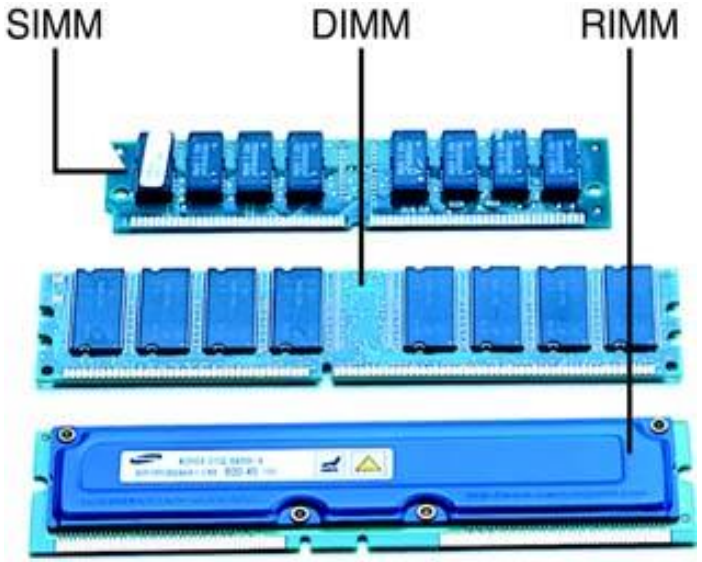


4.3. Sockets

- **Which socket is PGA and LGA?**
- **Why don’t these sockets belong to ZIF family?**

4.4. Memory slots and RAM

- A memory slot, memory socket, or RAM slot is what allows computer memory (RAM) to be inserted into the computer.
- Memory are vertical slots, typically numbering three or four, which usually are located at the upper-right corner of the motherboard. They determine the type of memory module used with the computer, which should be compatible with the motherboard.
- Types of memory modules are related to slots and include:

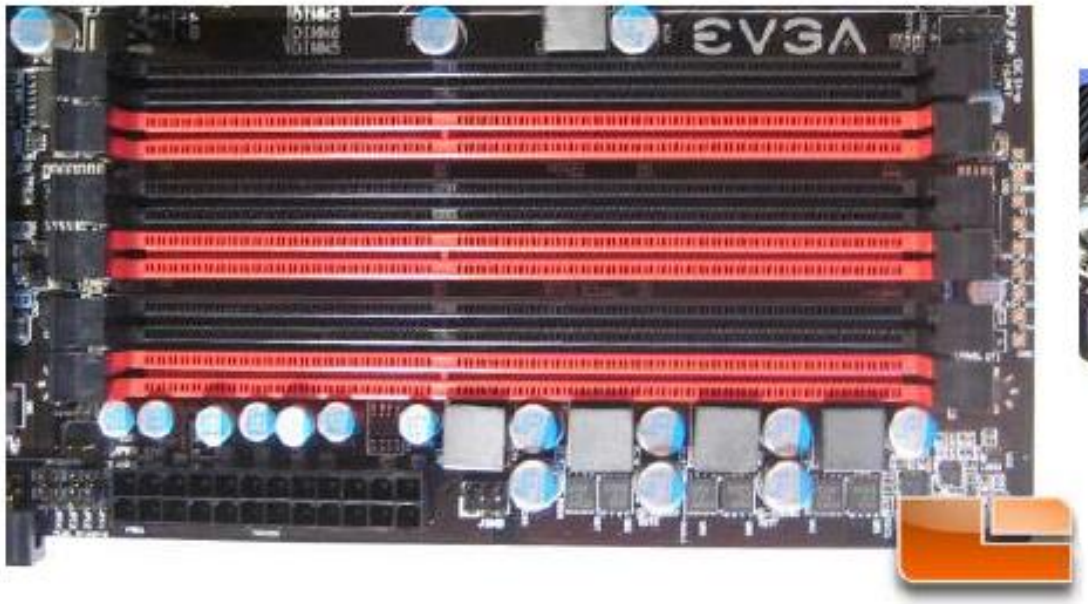


4.4. Memory slots and RAM

- Before studying in detail memory modules and slots, let's understand the **most important RAM implementations**.
  - ✓ Dynamic RAM (DRAM) is a classic form of RAM and has since been replaced by SDRAM. DRAM stores data electrically in a storage cell and refreshes the storage cell every few milliseconds. **(obsolete)**
  - ✓ FPM Memory (FPM RAM) is a type of Dynamic RAM (DRAM) that is short for **F**ast **P**age **M**ode RAM. Its access memory is faster because it just sends out one row address for locations near each other. **(obsolete)**
  - ✓ Extended Data-Out RAM (EDO RAM) is faster than DRAM. EDO RAM has also been replaced by SDRAM. EDO RAM is an improvement on DRAM because it has advanced timing features. EDO extends the amount of time data is stored and has a reduced refresh rate, which improves performance **(obsolete)**
  - ✓ Synchronous DRAM (SDRAM) replaced DRAM, FPM, and EDO. SDRAM is an improvement because it synchronizes data transfer between the CPU and memory. SDRAM allows the CPU to process data while another process is being queued.
  - ✓ Double Data Rate SDRAM (DDR SDRAM). DDR stands for double data rate, which means the chip reads or writes two words of data per clock cycle.
  - ✓ Rambus Dynamic Random Access Memory (RDRAM) was developed by Rambus and first became available to computers in 1999. Typical SDRAM can transfer data at speeds up to 133 MHz, while standard RDRAM can work over 1 GHz. Most boards cannot fully benefit from this speed, so RDRAM is typically used for video memory on graphics accelerator cards.

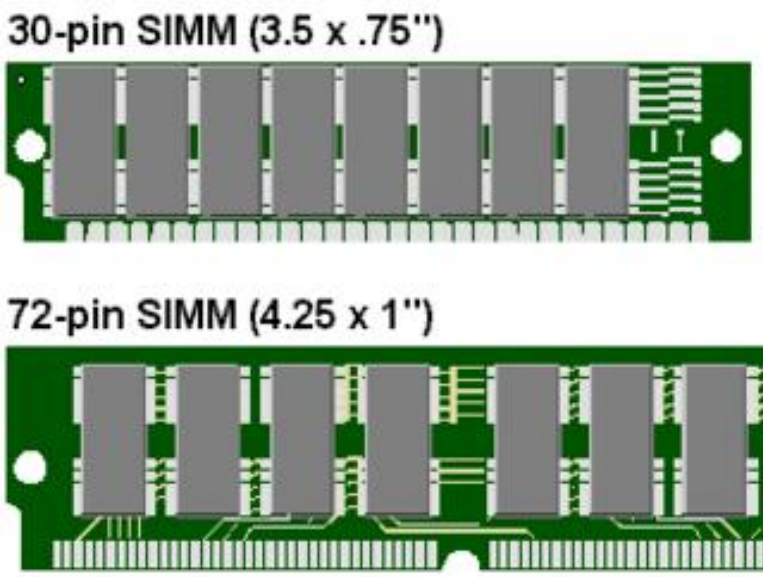
4.4. Memory slots and RAM

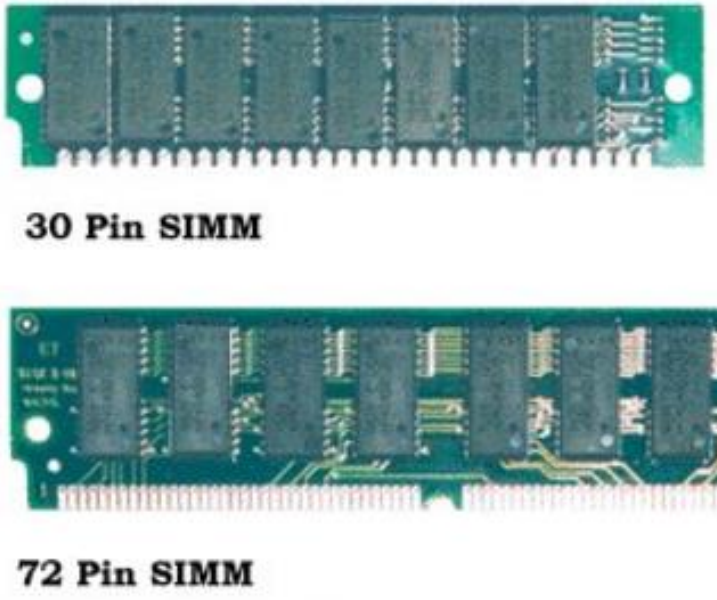
- Distinguishing characteristics of computer memory modules include voltage, capacity, speed (i.e., bit rate), and form factor. Now, let's review different types of modules, which is strictly related to slots.



4.4. Memory slots and RAM (SIMM)

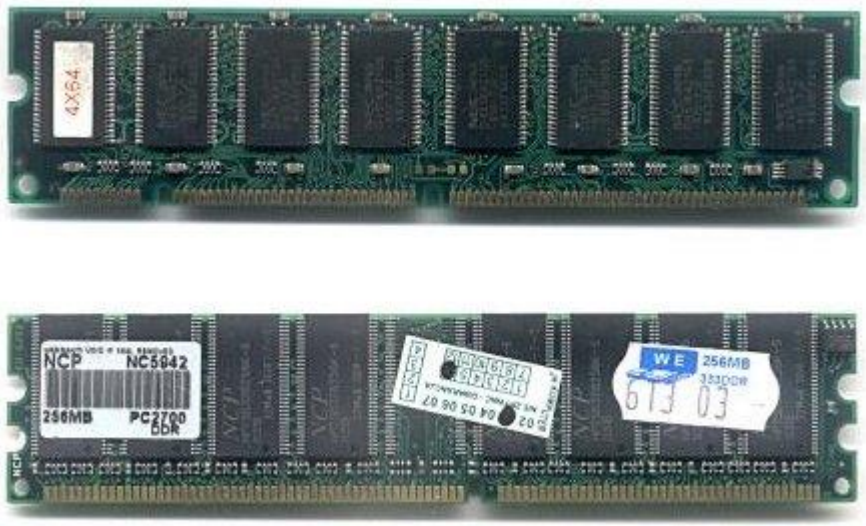
- **SIMM** means “Single Inline Memory Modules” is a memory module with 30 or 72 pins. SIMMs can be found in older machines. SIMMs with 30 pins can support 16-bit transfer rates, whereas 72 pins can support 32-bit transfer rates. SIMM has a single line of connectors and connectors on each side of the board are the same





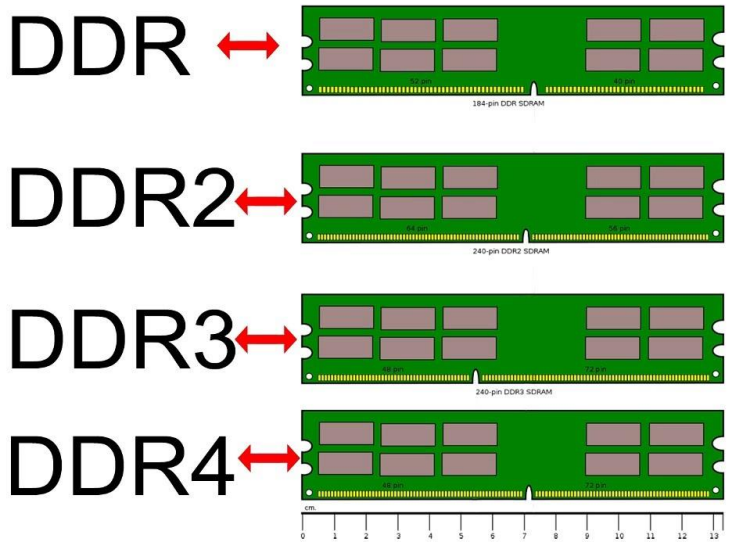
4.4. Memory slots and RAM (DIMM)

- **DIMM** means “Dual Inline Memory Modules” and they have a double line of contacts. While the contacts on SIMMs on both sides are redundant, DIMMs have separate electrical contacts on each side of the module. This way, SIMMs have a 32-bit data path, while standard DIMMs have a 64-bit data path. Common types of DIMMs include the following:
  - ✓ 168-pin DIMM, used for SDR SDRAM (in the first picture)
  - ✓ 184-pin DIMM, used for DDR SDRAM (in the second picture)



4.4. Memory slots and RAM (DIMM)

- ✓ DDR2: The bus clocked at twice the speed of the memory cells in DDR, so four words of data can be transferred per memory cell cycle. Use a 240-pin DIMM
- ✓ DDR3: DDR2 RAM provides 4 data transfers per cycle, while DDR3 increases the number to 8. Use a 240-pin DIMM
- ✓ DDR4: Include higher module density and lower voltage requirements, coupled with higher data rate transfer speeds, over its predecessor DDR4. Use a 288-pin DIMM

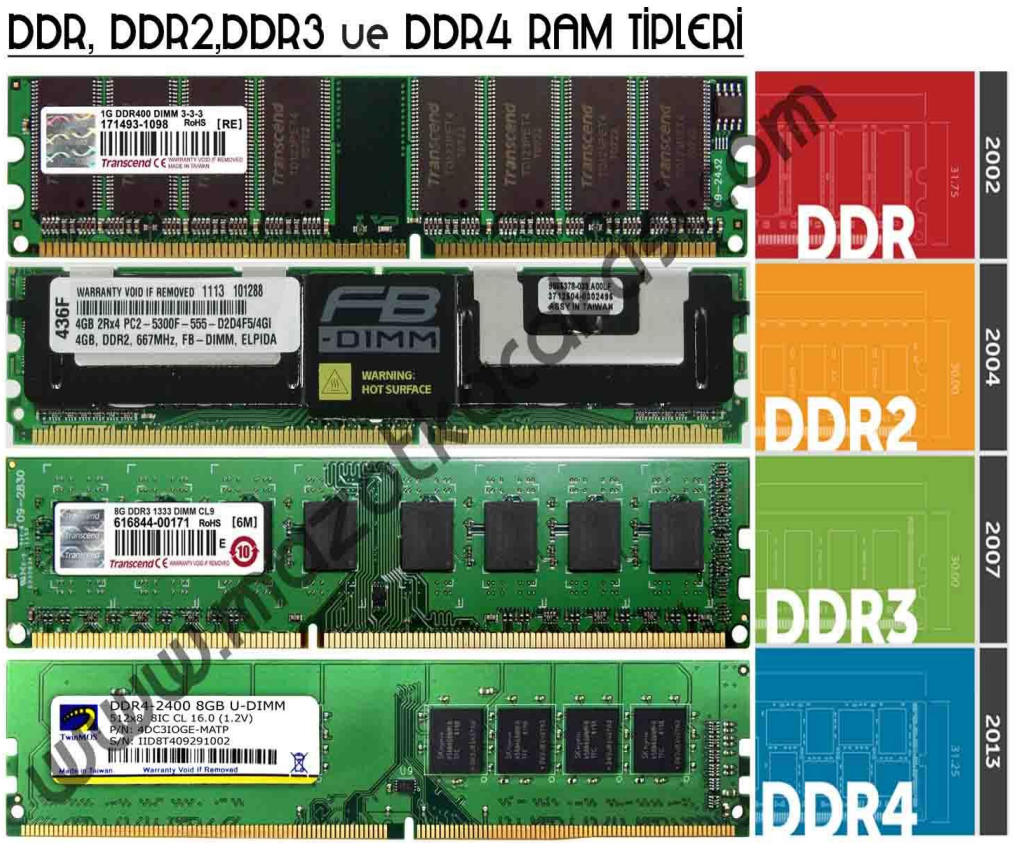


4.4. Memory slots and RAM (DIMM)

- **Comparison**

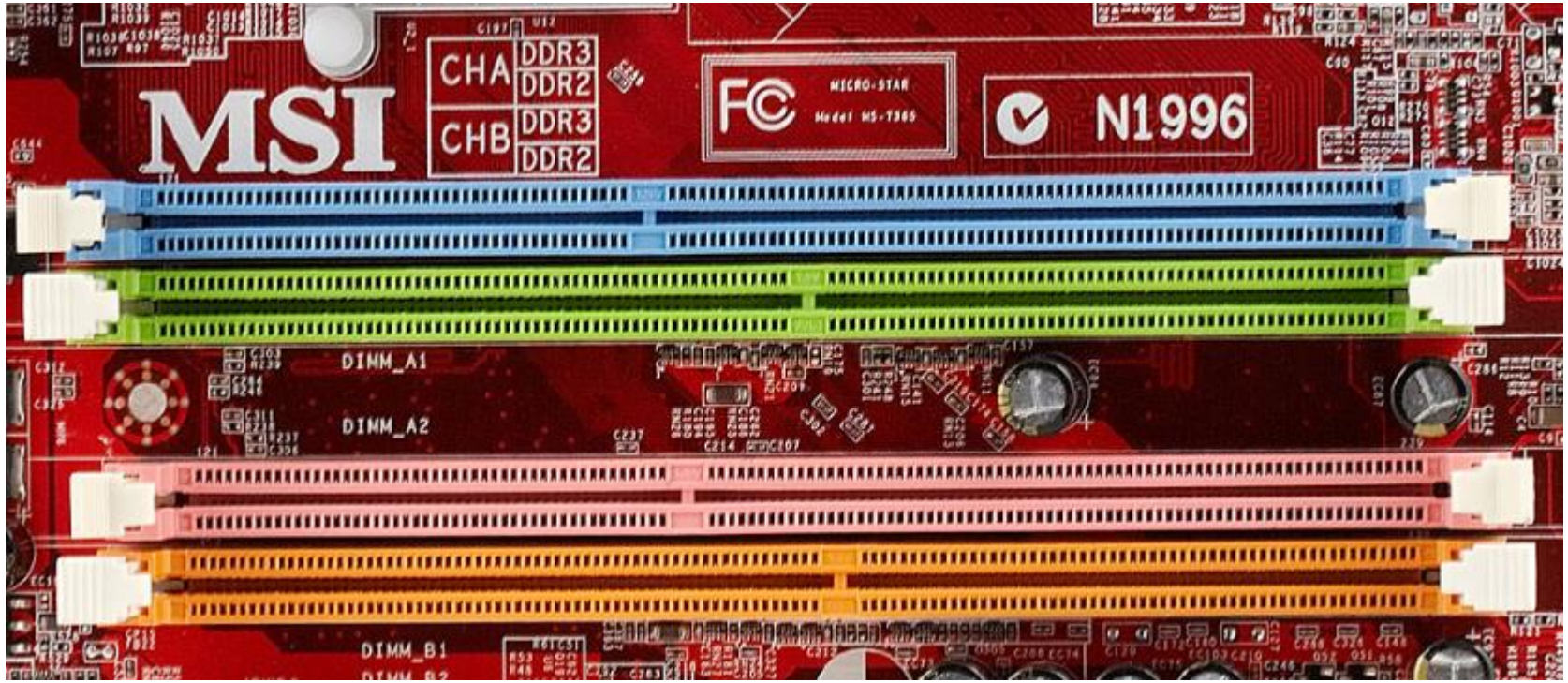
DDR SDRAM Standard	Internal rate (MHz)	Bus clock (MHz)	Prefetch	Data rate (MT/s)	Transfer rate (GB/s)	Voltage (V)
SDRAM	100-166	100-166	1n	100-166	0.8-1.3	3.3
DDR	133-200	133-200	2n	266-400	2.1-3.2	2.5/2.6
DDR2	133-200	266-400	4n	533-800	4.2-6.4	1.8
DDR3	133-200	533-800	8n	1066-1600	8.5-14.9	1.35/1.5
DDR4	133-200	1066-1600	8n	2133-3200	17-21.3	1.2

- <u>DDR, DDR2, DDR3 and DDR4 are not compatible.</u>
- Dynamic memories store data inside an array of tiny capacitors. DDR memories transfer two bits of data per clock cycle from the memory array to the memory internal I/O buffer. This is called 2-bit prefetch. On DDR2 this internal datapath was increased to four bits, and on DDR3 it was raised again to eight bits, etc.



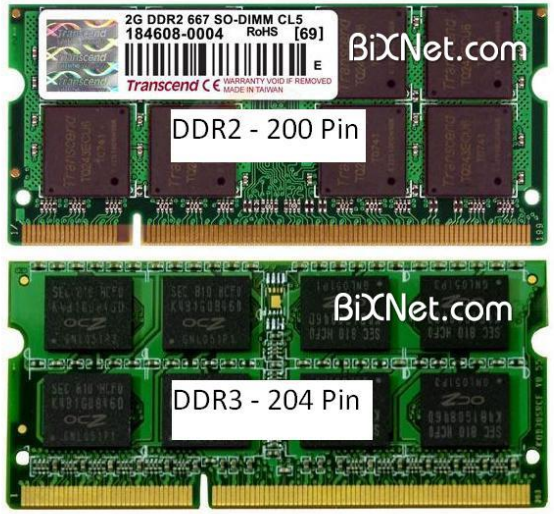
4.4. Memory slots and RAM (DIMM)

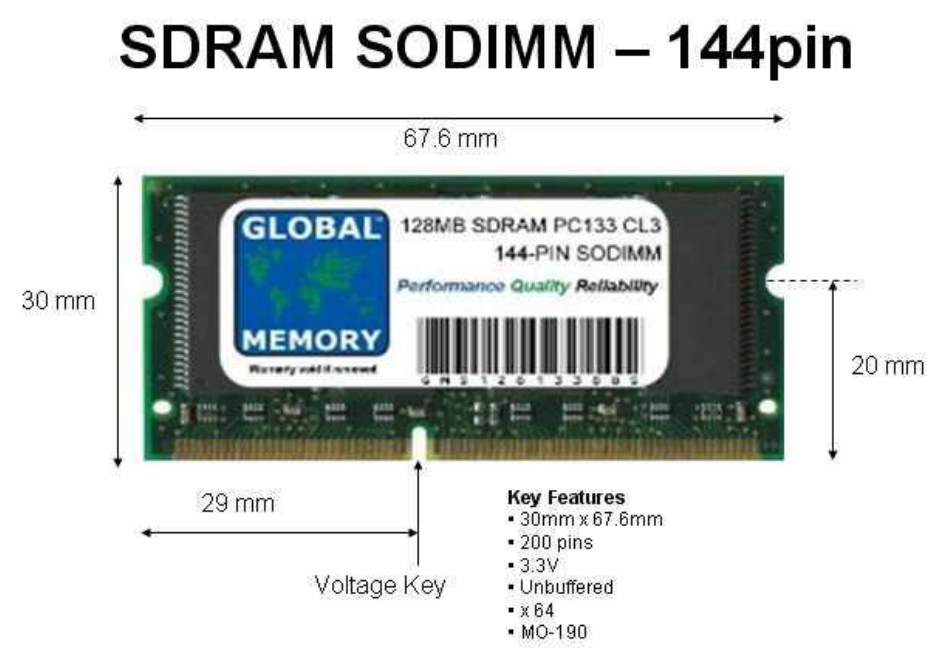
- **Compare and study the differences between the following slots.**

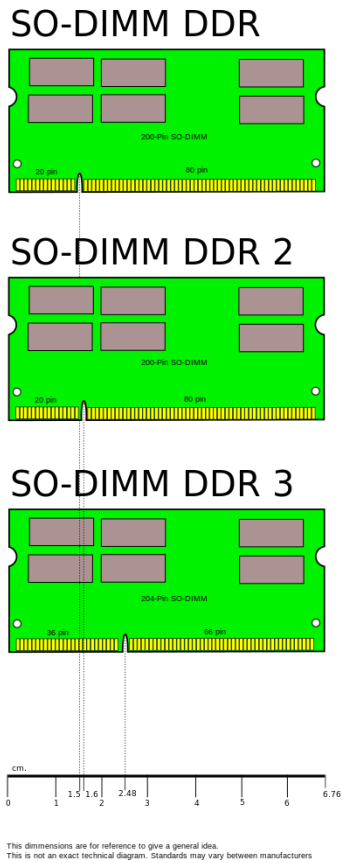


4.4. Memory slots and RAM (SO-DIMM)

- **SO-DIMMs** are a smaller alternative to a DIMM often used in systems that have limited space like laptops. Most typical SO-DIMMS are:
  - ✓ 144-pin SO-DIMMs (SDRAM)
  - ✓ 200-pin SO-DIMMs (DDR Y DDR2)
  - ✓ 204-pin SO-DIMMs (DDR3)
  - ✓ 260-pin SO-DIMMs (DDR4)







4.4. Memory slots and RAM (RIMM)

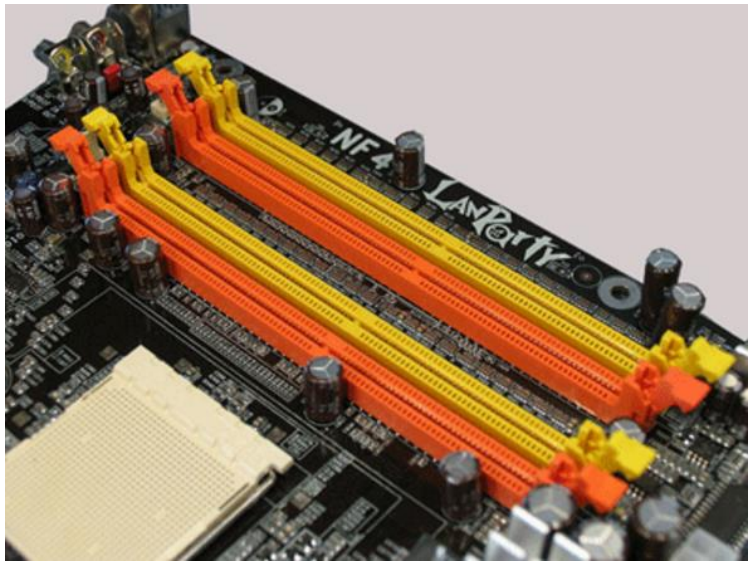
- **RIMM** means "Rambus In-line Memory Module" (Rambus is an American technology licensing company). It is the memory module used with RDRAM chips. Similar to a DIMM package, but uses different pin settings. RDRAM was packaged as a 184-pin RIMM. RIMM technology has mainly been used in videogame consoles, such as Nintendo 64 or different generations of PlayStation.

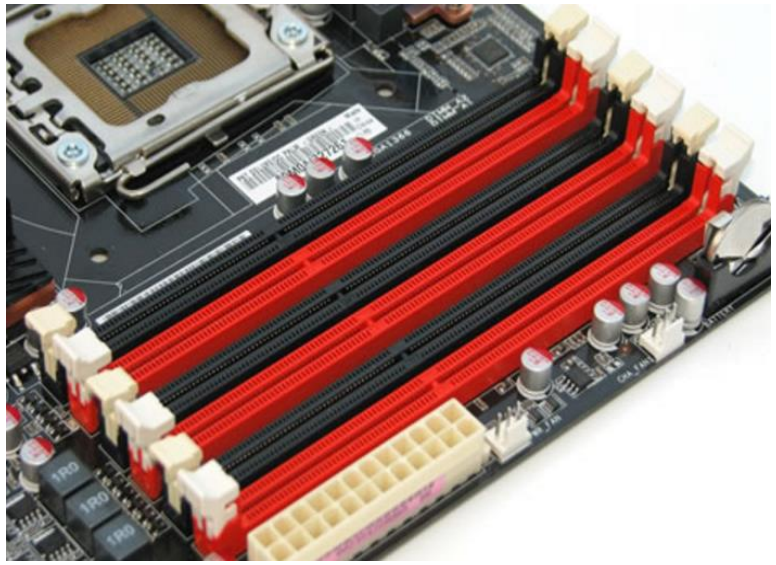
4.4. Memory slots and RAM (Parameters)

- **Speed:** Determines the name of the memory
  - ✓ Bus Clock of the memory or clock rate (MHZ): DDR3-1600 (DDR3 memories actually works at 200 MHz in this case, transferring eight times of data per clock cycle), DDR-1333 (DDR memories actually works at 666.6 MHz in this case, transferring two data per clock cycle).
  - ✓ Memory bandwidth (MB/second) is the rate at which data can be read from or stored into a semiconductor memory by a processor. Bandwidth = Clock rate x 8 bytes. Examples: PC3-12800 (DDR3-1600, so 1600x8=12800), PC-10600 (similar to the previous one using DDR-1333, but some model numbers are rounded, as 1333x8=10664).
  - ✓ Let's take a look about the speed for various DDR generations: https://en.wikipedia.org/wiki/DIMM
- **Multi-channel memory architecture** is a technology that increases the data transfer rate between the RAM memory and the memory controller by adding more channels of communication between them. There is 3 types:
  - ✓ Dual Channel.
  - ✓ Triple Channel.
  - ✓ Quad Channel (in case you find the term confusing, it quadruples the available memory bandwidth).
  - ✓ Learn more in http://www.hardwaresecrets.com/everything-you-need-to-know-about-the-dual-triple-and-quad-channel-memory-architectures/8/

4.4. Memory slots and RAM (Parameters)

- Dual Channel (on the left), Triple Channel (in the center), Quad Channel (on the right, two pairs of channels in each side)





4.5. Boot system

- **BIOS**, an acronym for Basic Input/Output System, is a non-volatile firmware used to perform hardware initialization during the booting process. Unified Extensible Firmware Interface (**UEFI**) is the successor to BIOS, aiming to address its technical defects.
- **Flash memory** is an electronic (solid-state) non-volatile computer storage medium that can be electrically erased and reprogrammed. BIOS software used to be stored on a non-volatile ROM chip on the motherboard, but in modern computer systems, the BIOS contents are stored on flash memory so it can be rewritten without removing the chip from the motherboard.

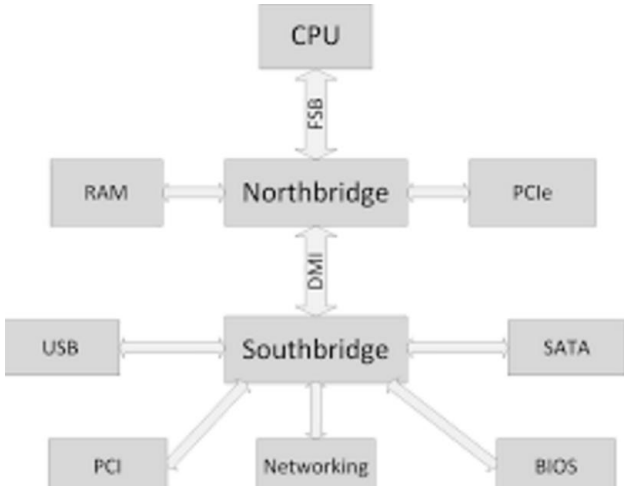
4.5. Boot system

- **CMOS memory** stores specific parameters for startup and initializing components. This data should be permanent because it is necessary to boot, but the information in RAM memory disappears when you power off the computer. The BIOS needs the CMOS to start.

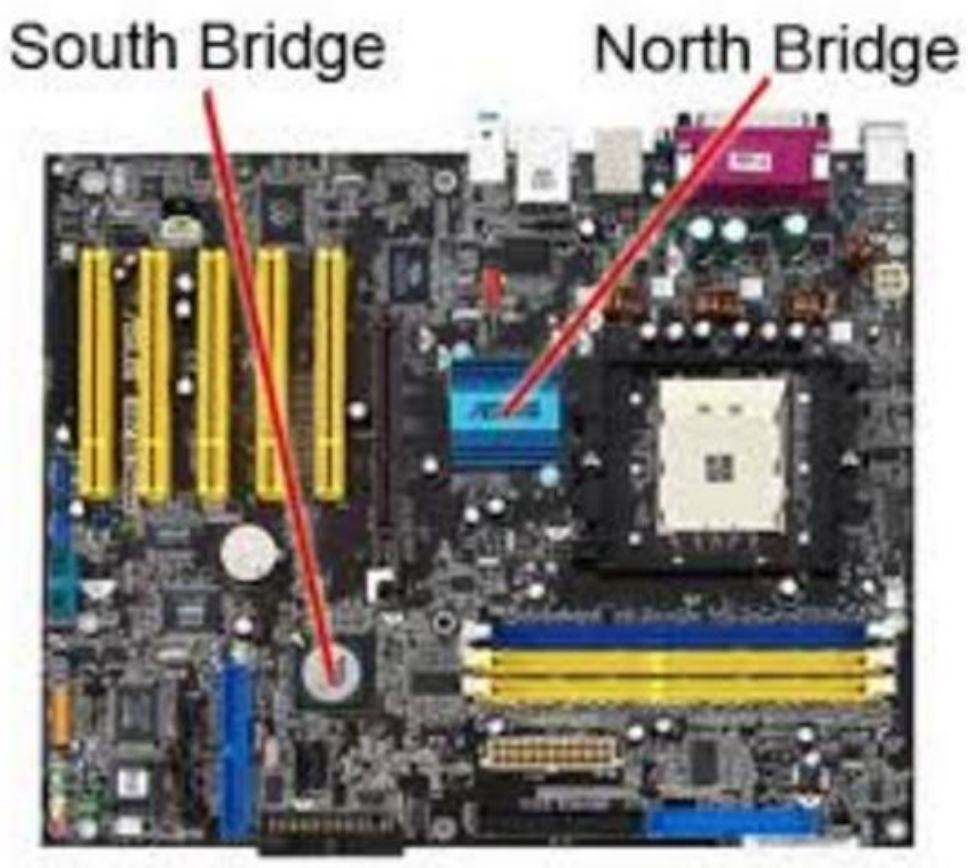
- **CMOS battery:** The standard lifetime of a CMOS battery is around 10 years. If the CMOS battery is failing the computer cannot right data and it does not boot correctly.

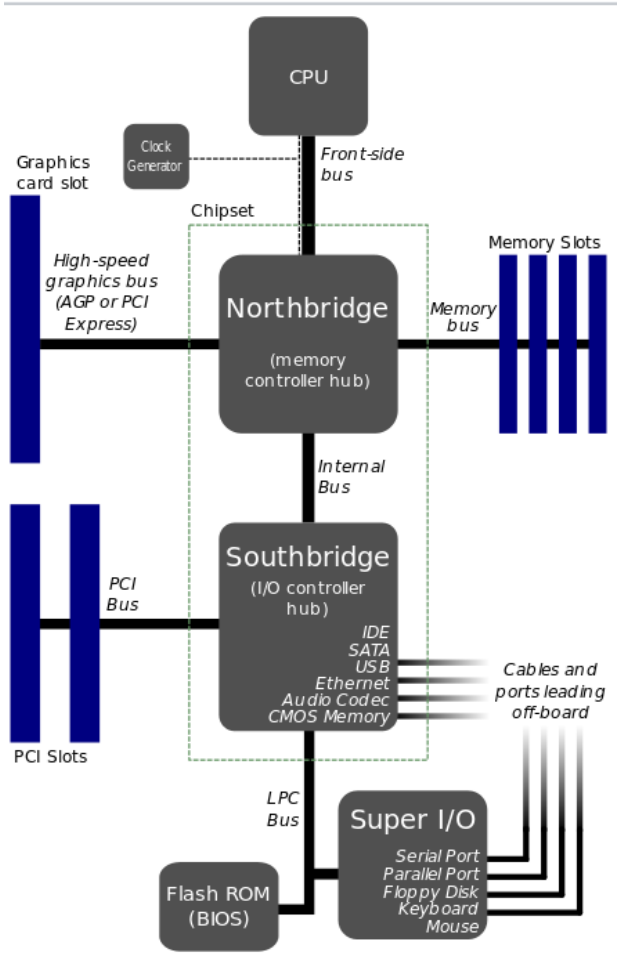
4.6. Chipset

- A **chipset** is a set of electronic components in an integrated circuit that manages the data flow between the processor, memory and peripherals. There are two chips in the core logic chipset architecture on a PC motherboard.
  - ✓ The **Northbridge** typically handles communications among the CPU, in some cases RAM, and PCI Express (or AGP) video cards, and the Southbridge. Northbridges usually contain integrated video controllers.
  - ✓ A **Southbridge** chipset handles all of a computer's I/O functions, such as USB, audio, serial, the system BIOS, the ISA bus, the interrupt controller and the IDE channels.



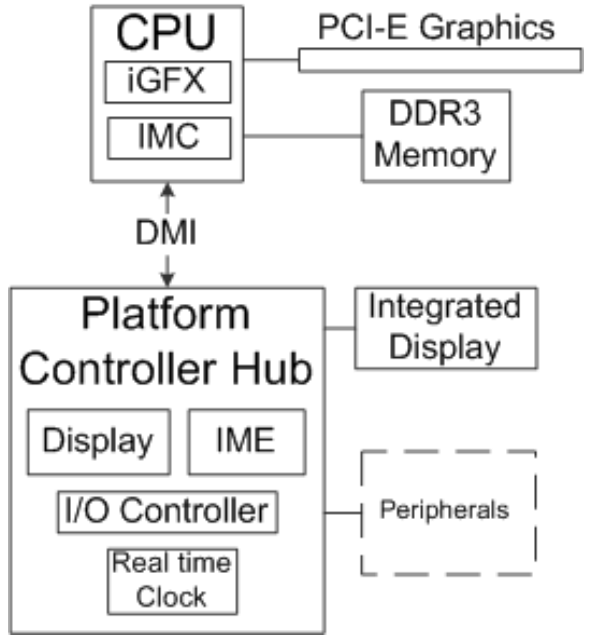
4.6. Chipset


South Bridge
North Bridge


CPU
Clock Generator
Front-side bus
Graphics card slot
Chipset
Memory Slots
High-speed graphics bus (AGP or PCI Express)
Northbridge
(memory controller hub)
Memory bus
Internal Bus
Southbridge
(I/O controller hub)
PCI Bus
IDE
SATA
USB
Ethernet
Audio Codec
CMOS Memory
Cables and ports leading off-board
PCI Slots
LPC Bus
Super I/O
Serial Port
Parallel Port
Floppy Disk
Keyboard
Mouse
Flash ROM (BIOS)

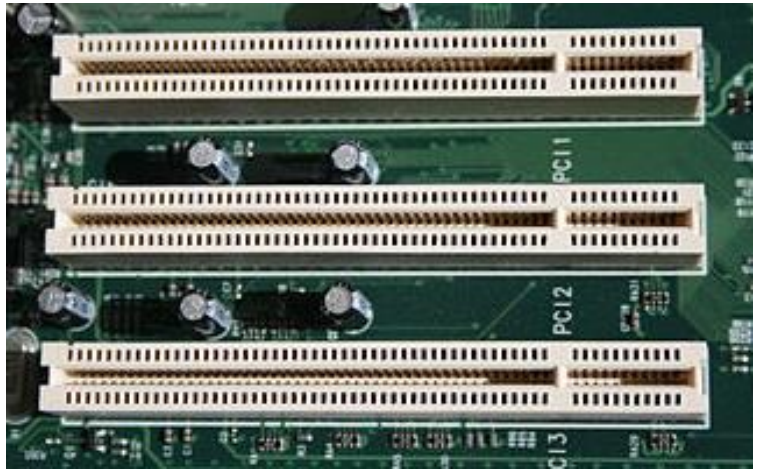
4.6. Chipset

- Nowadays, northbridge and southbridge are being replaced with the so-called Platform Controller Hub (PCH).
- On the one hand, there is no northbridge anymore. The CPU perfoms part of its functions and the others have been assigned to the PCH.
- Some of the northbridge functions and the memory controller and PCI-e lanes are integrated into the CPU, whereas the **PCH** will take over the remaining functions in addition to the traditional roles of the southbridge
- The PCH also controls certain data paths and support functions typical of the northbridge including clocking (the system clock), Flexible Display Interface (FDI, for graphics) and Direct Media Interface (DMI, old communication between northbridge and southbridge).



4.7. Expansion slots

- A **bus slot**, **expansion port** or **expansion slot** is a connection or port located inside a computer on the motherboard that allows a computer hardware expansion card to be connected.
  - ✓ **PCI** stands for Peripheral Component Interconnect, and it used to be the most common expansion slot standard. Typical PCI cards included: network cards, sound cards, modems, extra ports such as USB or serial, TV tuner cards and disk controllers.

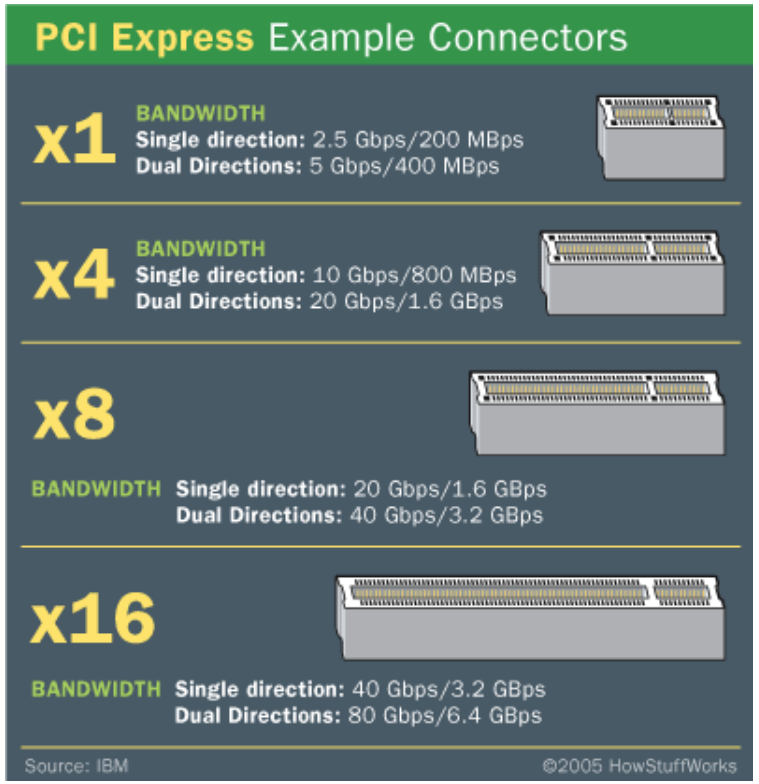


4.7. Expansion slots

- ✓ The **Accelerated Graphics Port** (**AGP**) is a high-speed point-to-point channel for attaching a video card to a computer system, primarily to assist in the acceleration of 3D computer graphics. Since 2004, AGP has been progressively replaced in favor of PCI Express (PCIe)

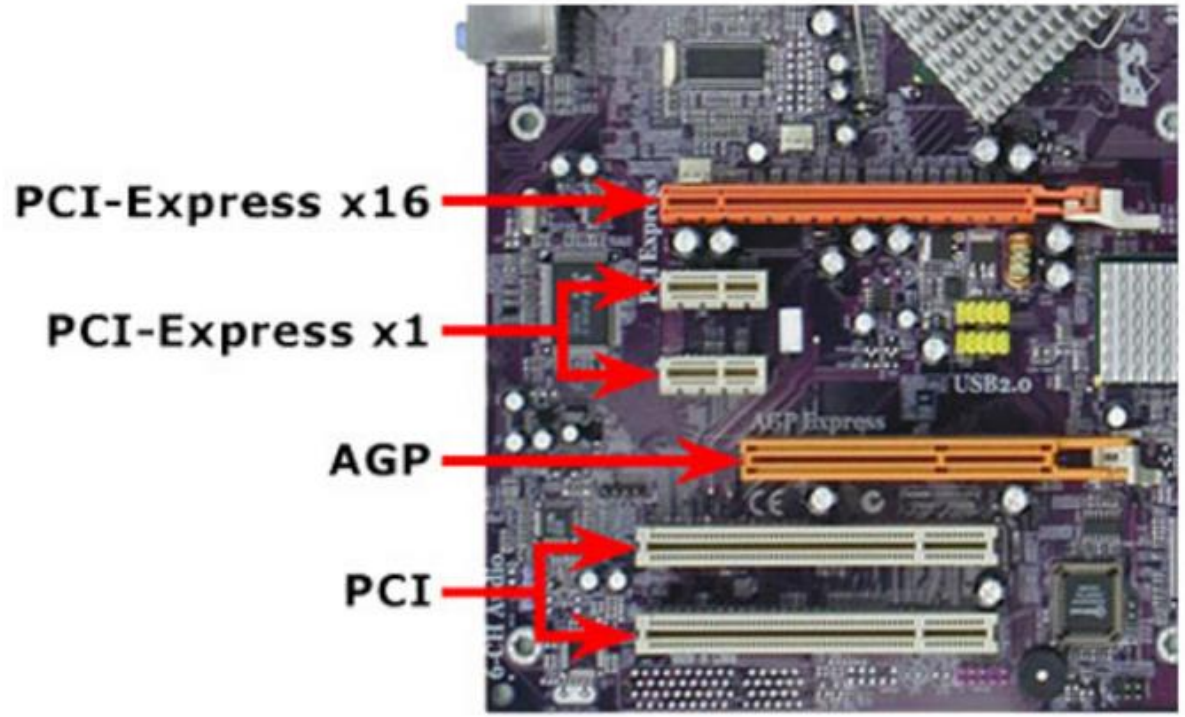
4.7. Expansion slots

- ✓ **PCI Express** (**Peripheral Component Interconnect Express**), officially abbreviated as **PCIe** or **PCI-e**, is a high-speed serial computer expansion bus standard, designed to replace the older PCI and AGP bus standards.



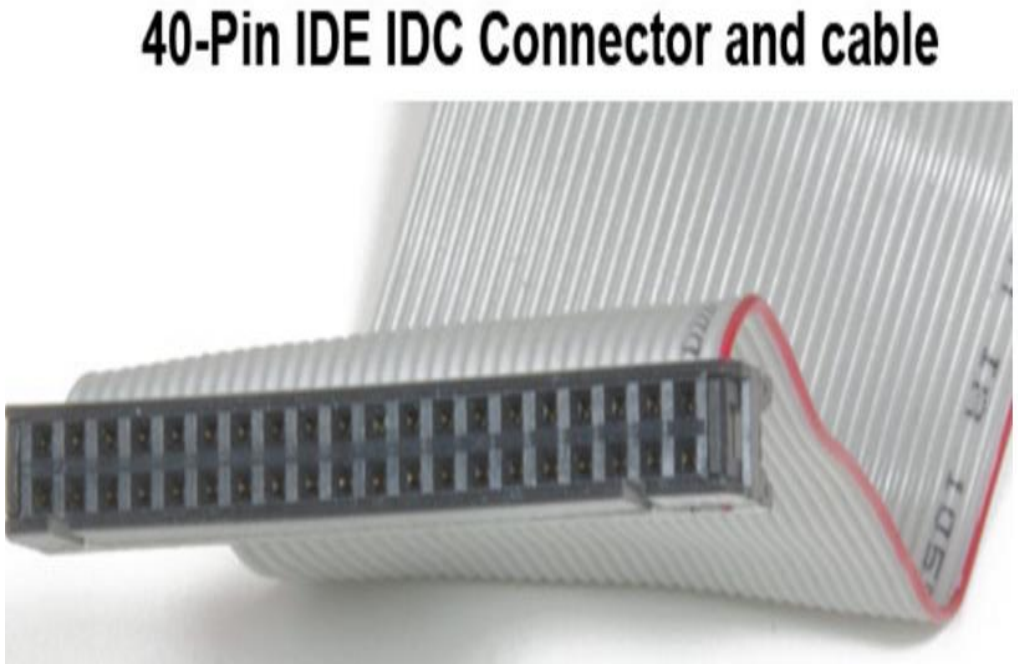
4.7. Expansion slots

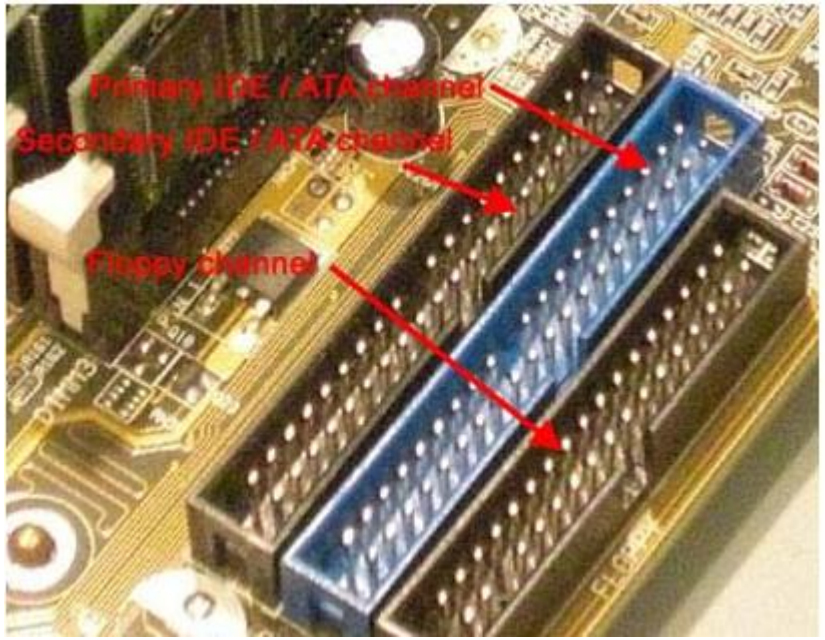
- ✓ **Comparison**



4.8. Internal connectors

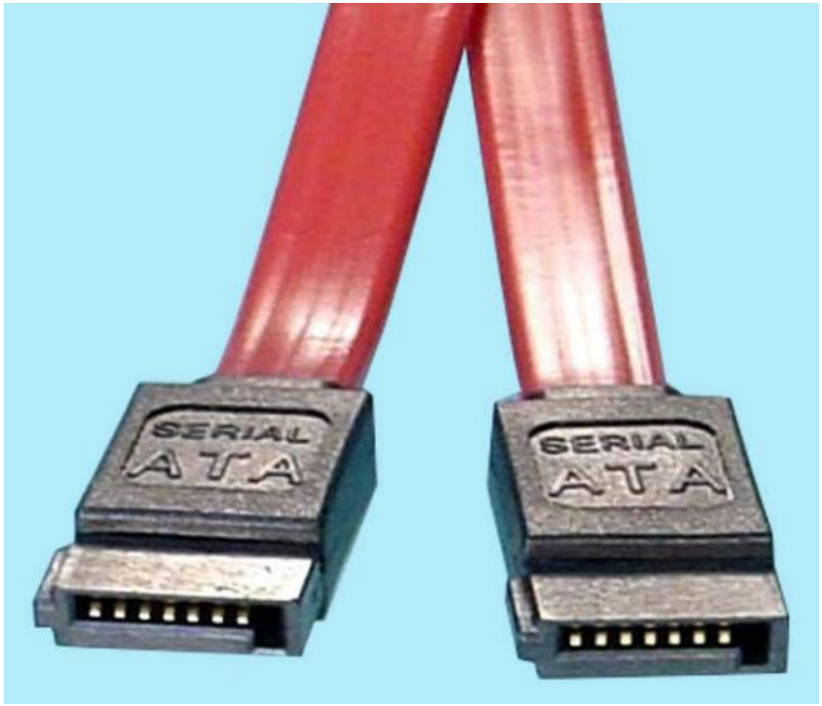
- Elements of motherboard intended to connect internal devices, such as hard drives, DVD, etc.
  - ✓ **IDE:** Short for Integrated Drive Electronics or IBM Disc Electronics, IDE is more commonly known as ATA or **Parallel ATA (PATA)**. It is a standard interface for the connection of storage devices such as hard disk drives, floppy disk drives, and optical disc drives in computers





4.8. Internal connectors

- ✓ **Serial ATA** (**SATA**, abbreviated from **Serial AT Attachment**) connects host bus adapters to mass storage devices such as hard disk drives, optical drives, and solid-state drives. Serial ATA succeeded the older Parallel ATA (PATA) standard.

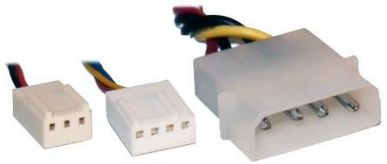


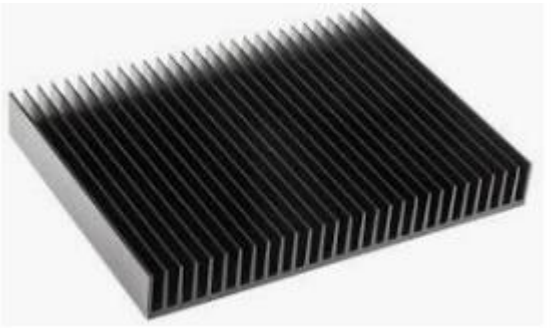
4.8. Internal connectors

- ✓ **eSATA** (*e* standing for external) provides a variant of SATA meant for external connectivity. eSATA cables are not the same as SATA cables, they are shielded and have a different connector than the L shaped design.

4.8. Internal connectors

- ✓ **Fan connectors** (below). Some modern computers also have a fanless heatsink (on the right).





- ✓ The fans are also common in the chipset

4.8. Internal connectors

- ✓ **Sockets**

8-pin EPS12V with detachable 4-pin ATX12V

6-pin PCI Express power

- ✓ **Internal USB, Firewire or audio connectors**

4.9. External connectors (standards)

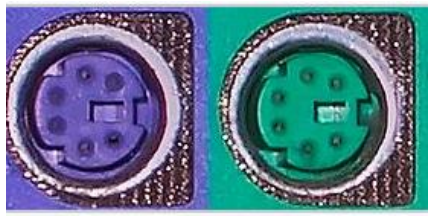
- The **external connectors** of a computer are designed to receive data (input/output) to or from other computers or digital equipment, and to interconnect units of the same computer together. There are many varieties of connectors.
- **DIN:** There are DIN standards for a large number of different connectors. Some of these connectors have mainly been used in analog audio applications. From 3 to 8 pins, 13.2 mm.

- **Mini-DIN:** Mini-DIN connectors are 9.5 mm in diameter and come in seven patterns, with the number of pins from three to nine. S-Video or PS/2 are two of the most well-known Mini-DIN examples.

- **D-sub:** The D-subminiature or D-sub is a common type of electrical connector. They are named for their characteristic D-shaped metal shield.

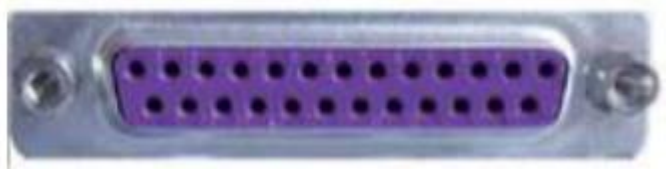
4.9. External connectors (types)

- **PS/2:** For a mouse (green) or keyboard (purple). Nowadays replaced with USB.



- **Serial:** For peripherals such as mice, gaming controllers, modems, and older printers. Obsolete, usually replaced with USB.

- **Parallel:** For connecting external equipment or peripherals, especially printers.



4.9. External connectors (types)

- **Which standards do serial, parallel and PS/2 belong to?**

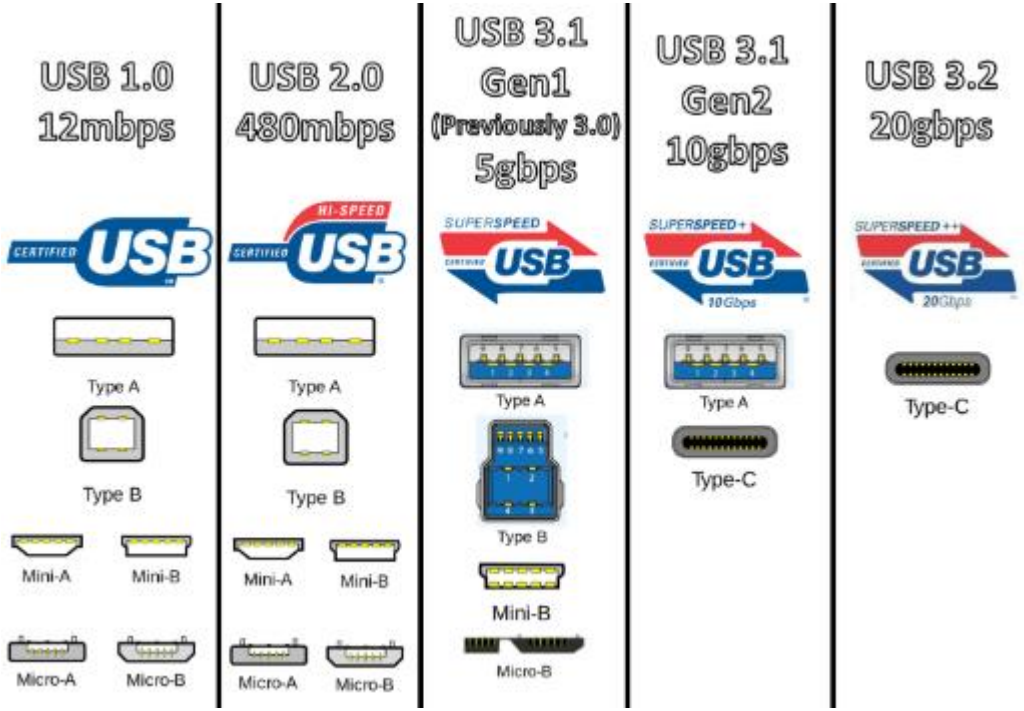
- **Do you think these connectors are used nowadays?**

4.9. External connectors (types)

- **USB:** Universal Serial Bus. The most common type of computer port. USB was designed to standardize the connection of computer peripherals. Plug-and-play system.

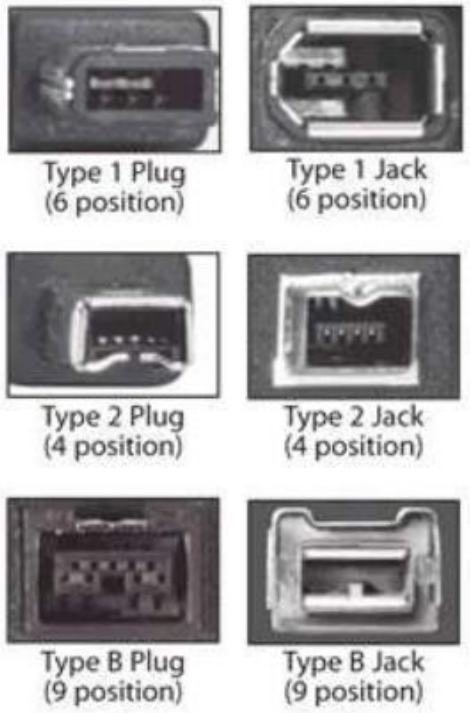
4.9. External connectors (types)

- **USB summary and comparative**



4.9. External connectors (types)

- **Firewire:** It is an interface bus standard that supports data transfer rates of up to 400 Mbps and can connect up to 63 external devices. Plug-and-play system.



4.9. External connectors (types)

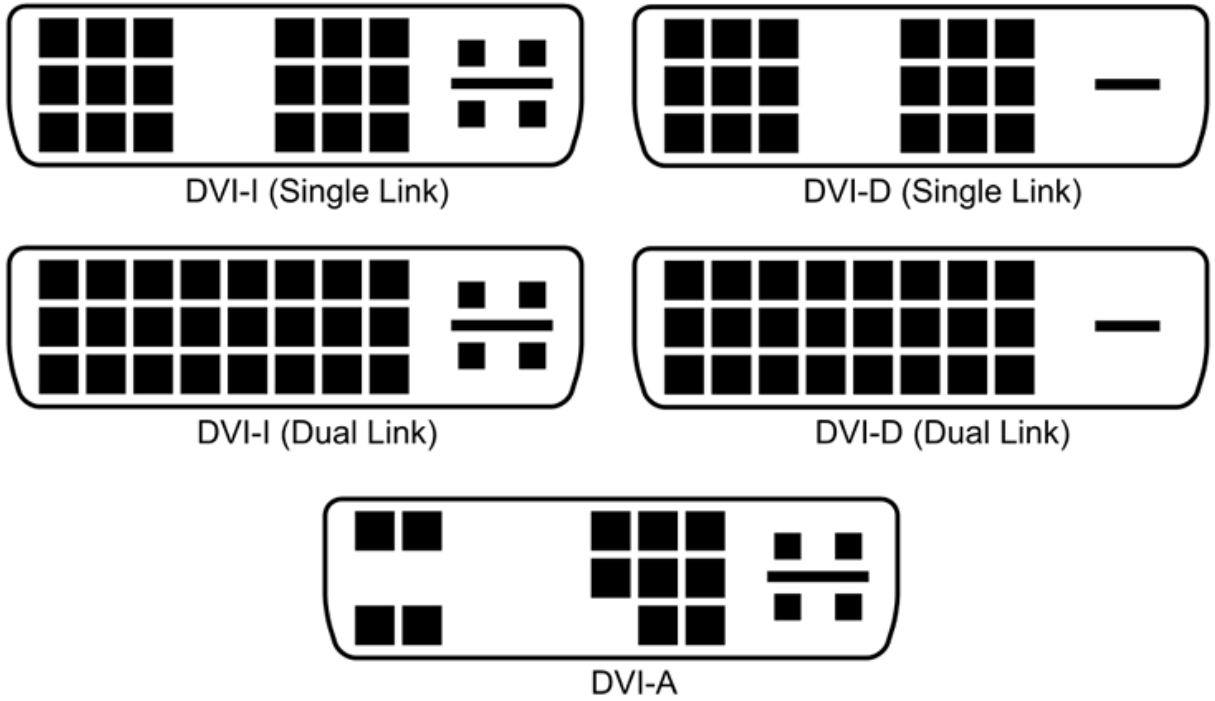
- **Thunderbolt:** It is the brand name of a hardware interface developed by Apple and Intel that allows the connection of external peripherals to a computer. Thunderbolt 1 and 2 use the same connector as Mini DisplayPort (MDP), whereas Thunderbolt 3 uses USB Type-C.

Thunderbolt 1/2 port

A Thunderbolt connector (v1/v2)

4.9. External connectors (video)

- **DVI:** The digital interface is used to connect a video source, such as a video display controller, to a display device, such as a computer monitor. Although DVI is predominantly associated with computers, it is sometimes used in other consumer electronics such as television sets and DVD players.



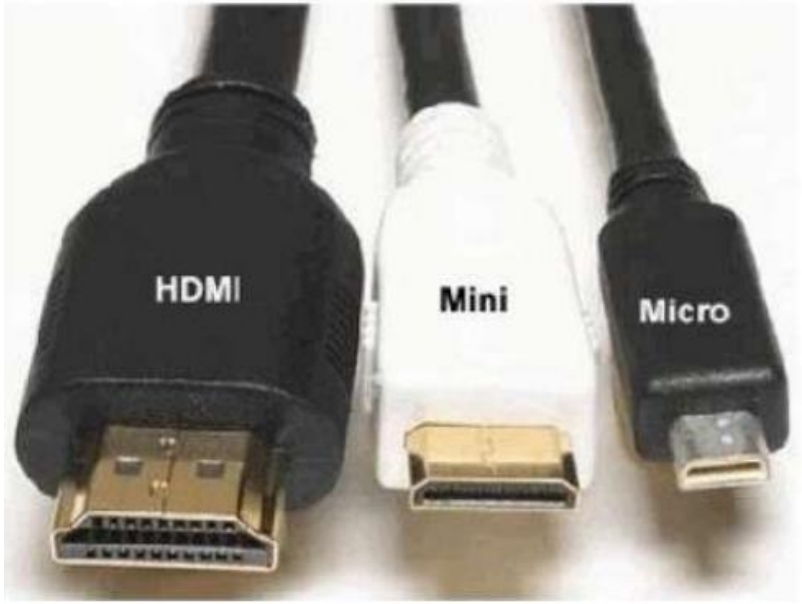
4.9. External connectors (video)

- **VGA:** It provides analogue output to a monitor.

- **SVGA:** Short for Super VGA, a set of graphics standards designed to offer greater resolution than VGA. It uses the same connector as VGA.

4.9. External connectors (audio and video)

- **HDMI:** A high-definition connection for carrying digital video and audio. It is commonly found on televisions and laptops.



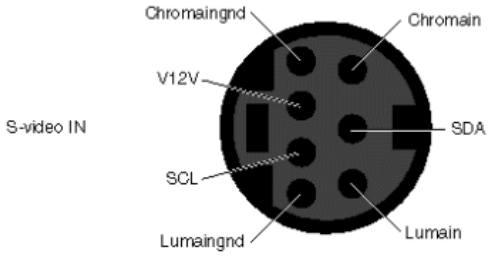
- **Do you have devices which use HDMI?**

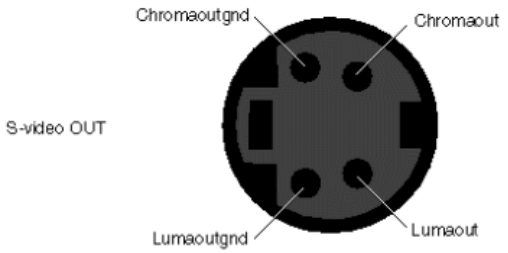
4.9. External connectors (audio and video)

- **DisplayPort:** It is an open digital display interface primarily used to connect a video source to a display device such as a computer monitor, and it can also carry audio, USB, and other forms of data. DisplayPort was designed to replace VGA, DVI, and FPD-Link. The interface is backward compatible with other interfaces, such as HDMI and DVI, through the use of either active or passive adapters.

4.9. External connectors (audio and video)

- **S-Video:** Another signalling standard for video. By separating the black-and-white and colouring signals, it achieves better image quality than composite video, but has lower colour resolution than component video.





- **RCA:** It is commonly used to carry audio and video signals. All RCA cables and compatible devices use a color code system to indicate the correct socket for each cable plug. The most common RCA cable colors found in a household setting are red, yellow and white. In the color code, red and white stand for audio to the right and left speakers respectively, and yellow stands for composite video.

4.9. External connectors (audio)

- **Jack:** A **phone connector**, also known as **phone jack**, **audio jack**, **headphone jack** or **jack plug**, is a family of electrical connector typically used for analog signals. There is a wildly accepted color **standard** for computer sound card input and output jacks, but connector colors may vary between different brands.

Phone connectors:

- 2.5 mm mono (TS)
- 3.5 mm mono (TS)
- 3.5 mm stereo (TRS)
- 6.35 mm (¼ in) (TRS)

Color	Connector
Lime Green	Line-Out, Front Speakers, Headphones
Pink	Microphone
Light Blue	Stereo Line In
Orange	Subwoofer and Center out
Black	Rear Surround Speakers for 5.1 and 7.1 systems
Gray	Middle Surround Speakers for 7.1 systems
Gold	Midi / Game port (Joystick)

4.9. External connectors (audio)

- **S/PDIF:** SPDIF, also written as S/PDIF, stands for Sony/Phillips Digital Interface, and is an interface to transmit digital audio. S/PDIF interconnects components like home cinema and other digital high-fidelity systems. The S/PDIF interface can be implemented in two different ways: coaxial and optical fiber.

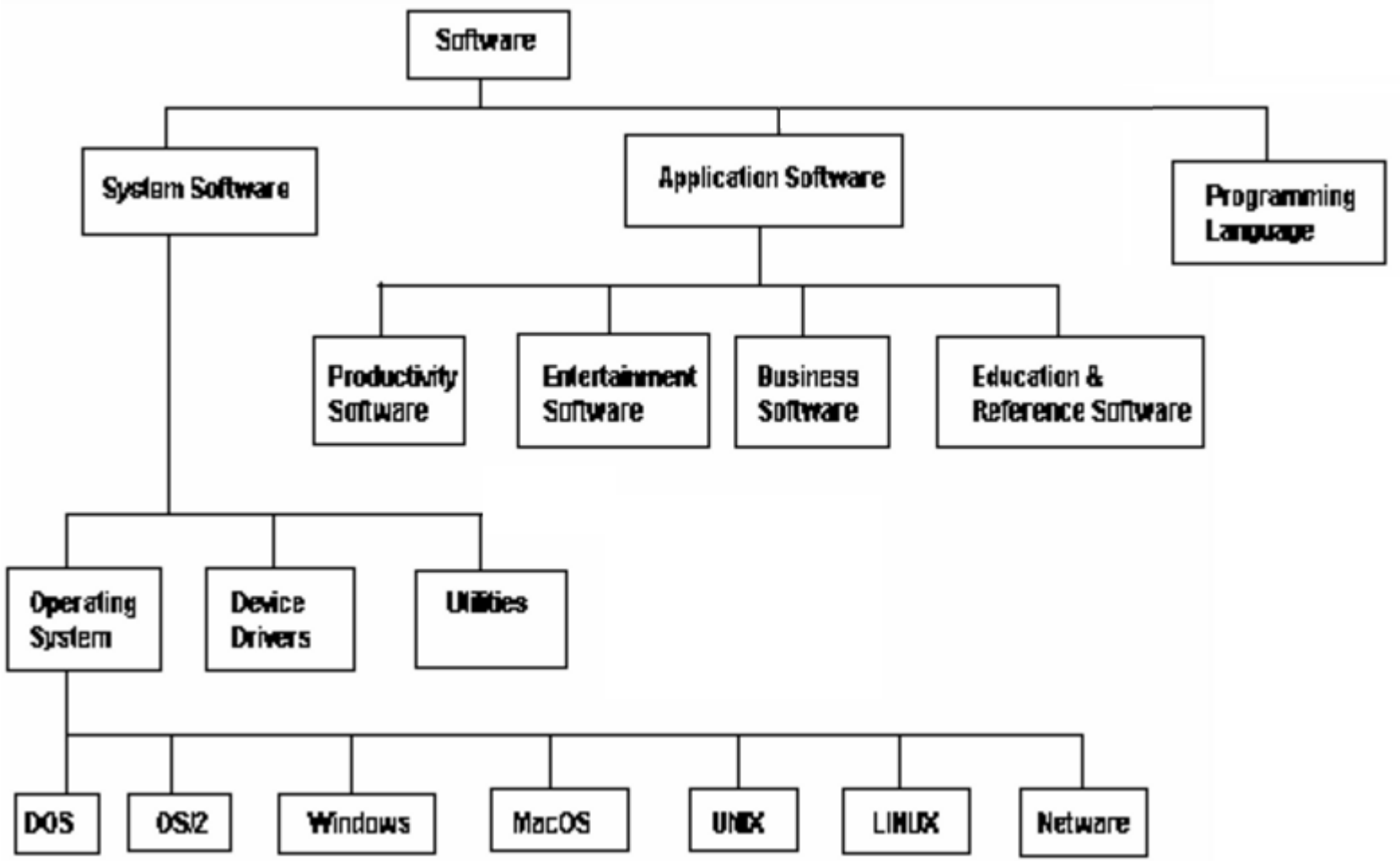
Coaxial

Optical

5. Software

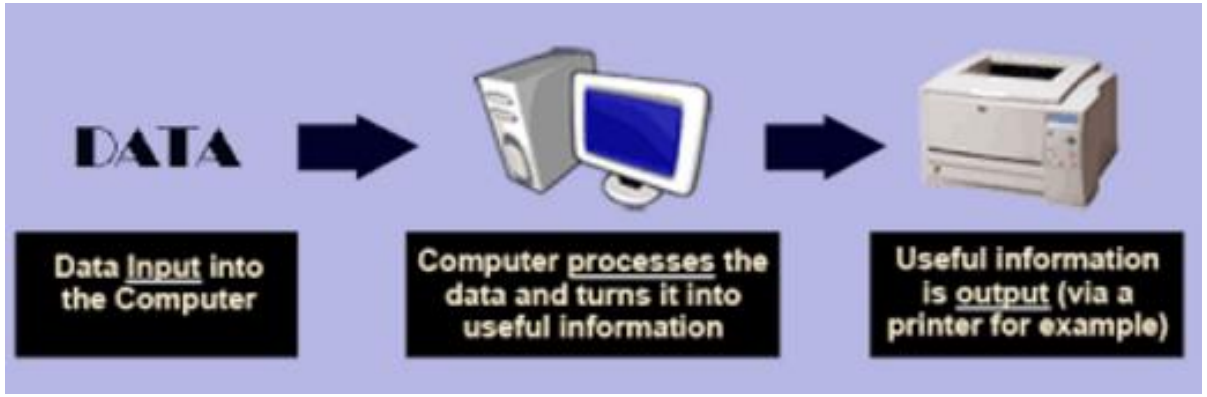
- Computer software can be put into categories based on common function, type, or field of use. There are three broad classifications:
  - ✓ **Application** is the general designation of computer programs for performing tasks. There are many different types of application software, because the range of tasks that can be performed with a modern computer is so large (entertainment, web browsing, accounting, etc.).
  - ✓ **System software** is a generic term referring to the computer programs used to start and run computer systems including diverse application software and networks. System software includes Operating Systems, device drives and utilities to assist users in the maintenance and care of their computers.
  - ✓ **Computer programming tools**, such as compilers and linker, are used to translate and combine computer program source code and libraries into executable RAMs (programs that will belong to one of the three said)

5. Software


Software
System Software
Application Software
Programming Language
Productivity Software
Entertainment Software
Business Software
Education & Reference Software
Operating System
Device Drivers
Utilities
DOS
OS/2
Windows
MacOS
UNIX
LINUX
Netware

5. Software

- A computer system need three types of data to be useful: input, processing data and output



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