Unit-2
The Computer System Hardware

Hardware

All the electronic devices which we can touch & feel is called hardware. Hardware is tangible components. As for example, Mother board, hard disk,RAM,ROM,CPU & printer etc.

Different hardware components

- Motherboard
- CPU
- RAM
- Hard drive
- Solid-state drive (SSD)
- Optical drive
- Heat sink

Different hardware components

- There are five main hardware components in a computer system: **Input, Processing, Storage, Output and Communication devices**. Are devices used for entering data or instructions to the central processing unit.

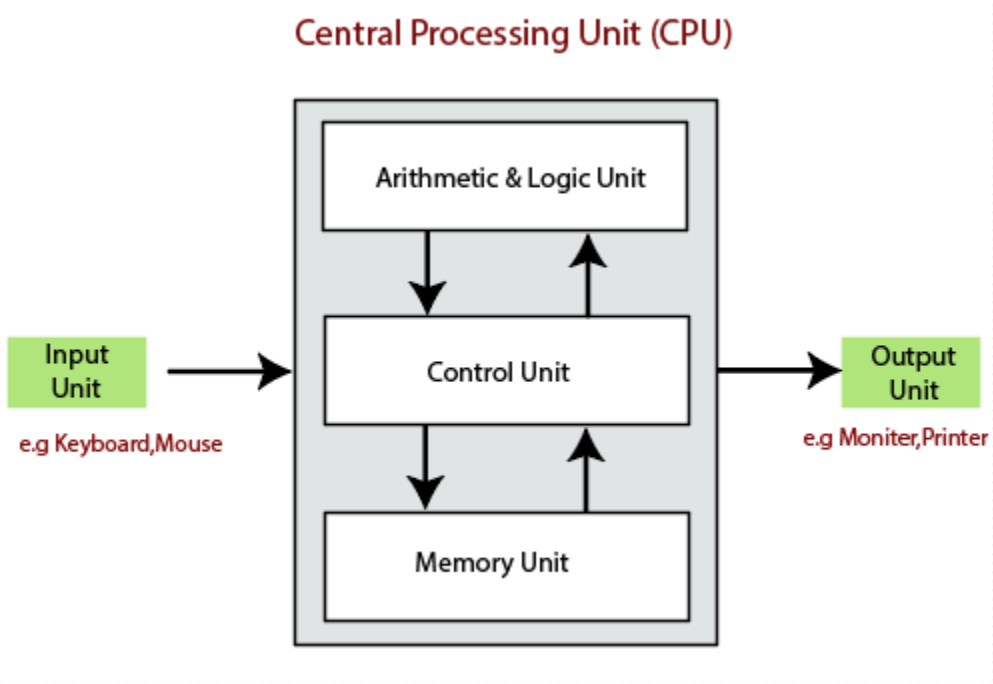
Components of CPU

- Control unit (CU)
- Arithmetic logic unit (ALU)
- Registers.

Central Processing Unit(CPU)

CPU or central processing unit is an electronic circuitry that carries out the instruction given by a computer program. CPU execute instruction by performing basic arithmetic, logical, control and I/O operations as required per instruction. CPU is considered to be the brain of the computer. The speed and efficiency of a computer mostly depends that of it's CPU. It is both the combination of control unit(CU) and ALU. It is also known as heart of computer.

Block diagram of Processor



Functions of CPU

- Transferring data between memory and I/O devices
- Controlling all other parts of the machine and sending timing signals.
- Fetching data and instructions from memory
- Decoding instruction
- Performing arithmetical and logical operations
- Executing programs stored in memory
- Performing communication among the I/O devices etc.

Memory Unit

Memory

Memory is basically a device that has the capacity to store information. A memory unit is the amount of data that the memory can hold. Besides, we measure this storage capacity in terms of bytes. Moreover, there are different units of memory as per the requirement.

Parts of Memory

- **Primary Memory**

This is the internal memory that stores the data and instructions of the CPU. It is volatile in nature (data is lost when the power is disconnected).

The primary memory has two types:

- **RAM (Random Access Memory)**

Data can be accessed randomly and quickly.

- **ROM (Read Only Memory)**

We can only read data and cannot write (store) to it.

Parts of Memory

- **Secondary Memory**

As we know that the primary memory is volatile therefore, we need some devices to store the data permanently so we use some external storage devices for this purpose which we name as the secondary memory. Some examples: CD, DVD, etc.

Units of Memory

The storage capacity of the memory is expressed in various units of memory. These are as follows:

- **Bit**

A microprocessor uses binary digits 0 and 1 to decide the OFF and ON state respectively, of various circuits. Furthermore, a bit is the smallest unit of representation in the binary language.

- **Nibble**

A nibble is a collection of 4 bits.

Units of Memory

- **Byte**

A byte is the representation of a group of 8 bits. Moreover, a byte is a unit that expresses any word, symbol, or character in the computer language. Besides, computer memory is always in terms of multiples of bytes.

Units of Memory

- **Word**

A computer word is similar to a byte, as it is also a group of bits. Moreover, a computer word is fixed for each computer. At the same time it varies from computer to computer. Besides, the length of a computer word is the **word-size or word length**. Therefore, a computer stores information in the form of computer word.

Byte Value	Bit Value
1 Byte	8 Bits
1024 Bytes	1 Kilobyte
1024 Kilobytes	1 Megabyte
1024 Megabytes	1 Gigabyte
1024 Gigabytes	1 Terabyte
1024 Terabytes	1 Petabyte
1024 Petabytes	1 Exabyte
1024 Exabytes	1 Zettabyte
1024 Zettabytes	1 Yottabyte
1024 Yottabytes	1 Brontobyte

Instruction format

What is instruction format?

- An instruction is normally made up of a combination of an operation code and some way of specifying an operand, most commonly by its location or address in memory

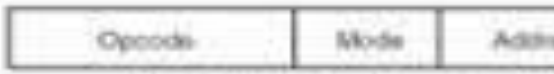
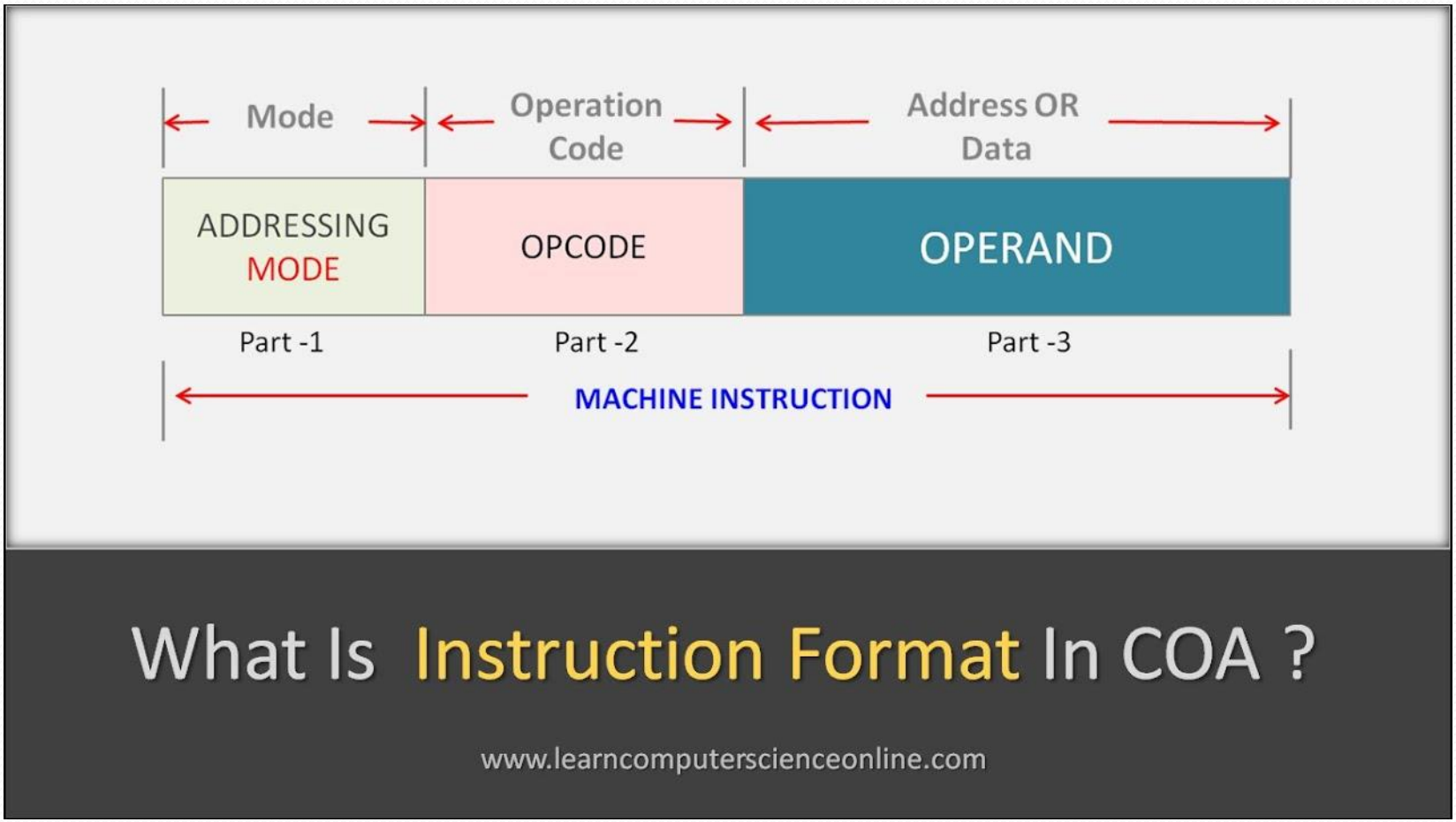


Fig. 9-3. Instruction Format with Mode Field

Concept of operation code and operand



Concept of operation code and operand

- **Addressing Modes**– The term addressing modes refers to the way in which the operand of an instruction is specified. The addressing mode specifies a rule for interpreting or modifying the address field of the instruction before the operand is actually executed.

Concept of operation code and operand

- In computing, an op code (abbreviated from operation code, also known as instruction machine code, instruction code, instruction syllable, instruction parcel or opstring) is **the portion of a machine language instruction that specifies the operation to be performed**.

Concept of operation code and operand

- An operand is **the part of an instruction representing the data manipulated by the operator**. For example, when you add two numbers, the numbers are the operand and "+" is the operator.

Instruction Set

An instruction set is a group of commands for a central processing unit (CPU) in machine language. The term can refer to all possible instructions for a CPU or a subset of instructions to enhance its performance in certain situations.

Examples of instruction set

- **ADD** - Add two numbers together.
- **COMPARE** - Compare numbers.
- **IN** - Input information from a device, e.g., keyboard.
- **JUMP** - Jump to designated RAM address.
- **JUMP IF** - Conditional statement that jumps to a designated RAM address.
- **LOAD** - Load information from RAM to the CPU.
- **OUT** - Output information to device, e.g., monitor.
- **STORE** - Store information to RAM.

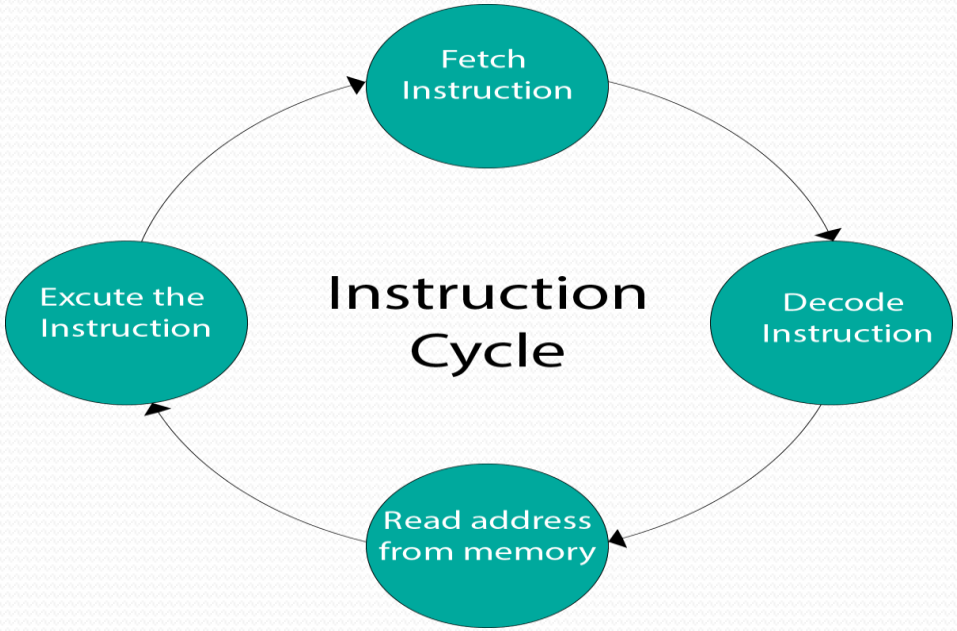
Instruction Cycle

A program residing in the memory unit of a computer consists of a sequence of instructions. These instructions are executed by the processor by going through a cycle for each instruction.

In a basic computer, each instruction cycle consists of the following phases.

1. Fetch instruction from memory.
2. Decode the instruction.
3. Read the effective address from memory.
4. Execute the instruction.

Example of Instruction Cycle



Microprocessor

- A microprocessor is an integrated circuit (IC) which incorporates core functions of a computer's central processing unit (CPU). It is a programmable multipurpose silicon chip, clock driven, register based, accepts binary data as input and provides output after processing it as per the instructions stored in the memory.

How does a Microprocessor work ?

- A processor is the brain of a computer which basically consists of Arithmetical and Logical Unit (ALU), Control Unit and Register Array. As the name indicates ALU performs all arithmetic and logical operations on the data received from input devices or memory. Register array consists of a series of registers like accumulator (A), B, C, D etc. which acts as temporary fast access memory locations for processing data. As the name indicates, control unit controls the flow of instructions and data throughout the system.
- So, basically a microprocessor takes input from input devices, process it as per instructions given in the memory and produces output.

Advantages of a Microprocessor

- **Low cost**

Microprocessors are available at low cost due to integrated circuit technology. Which will reduce the cost of a computer system.

- **High speed**

Microprocessor chips can work at very high speed due to the technology involved in it. It is capable of executing millions of instructions per second.

Advantages of a Microprocessor

- **Small size**

Due to very large scale and ultra large scale integration technology, a microprocessor is fabricated in a very less footprint. This will reduce the size of the entire computer system.

- **Versatile**

Microprocessors are very versatile, the same chip can be used for a number of applications by simply changing the program (instructions stored in the memory).

Advantages of a Microprocessor

- **Low power consumption**

Microprocessors are usually manufactured using metal oxide semiconductor technology, in which MOSFETs (Metal Oxide Semiconductor Field Effect Transistors) are working in saturation and cut off modes. So the power consumption is very low compared to others.

Advantages of a Microprocessor

- **Less heat generation**

Compared to vacuum tube devices, semiconductor devices won't emit that much heat.

- **Reliable**
  Microprocessors are very reliable, failure rate is very less as semiconductor technology is used.
- **Portable**
  Devices or computer system made with microprocessors can be made portable due to the small size and low power consumption.

RISC and CISC Architecture

RISC & CISC is the technologies on which design & architecture of microprocessor is based.

RISC

RISC means reduced instruction set computer in which each instruction has dedicated electronic circuits made from gates, to generate control signal . As for example Power PC,ULTRASPARC etc.

RISC and CISC Architecture

Characteristics

- Simple instruction set.
- Same length instructions.
- 1-machine –cycle instructions.

Advantages of RISC

- Speed : 2 to 4 times the performance.
- Simpler hardware.
- Shorter design cycle : They can be design more quickly.

CISC

CISC means complex instruction set computer which based on microprogramming techniques. The hardware is controlled by instructions coded in control memory. Such instruction is called microinstruction & coding process is called micro programming. CISC is more complex but efficient processor designing technique. As for example,80386,80486,80586,80686,I3,I5,I7 etc.

Advantages

- Microprogramming is easy as assembly language to implement & much expensive than hardwiring a control unit.
- Micro coding instructions allowed to the designers to make CISC machine upwardly compatible.
- As each instruction become more capable ,fewer instructions could be used to implement a given task.

Disadvantages

- Earlier generations of a processor family were generally contained as a subset in every new versions so instruction set & each generations of computers are varying.

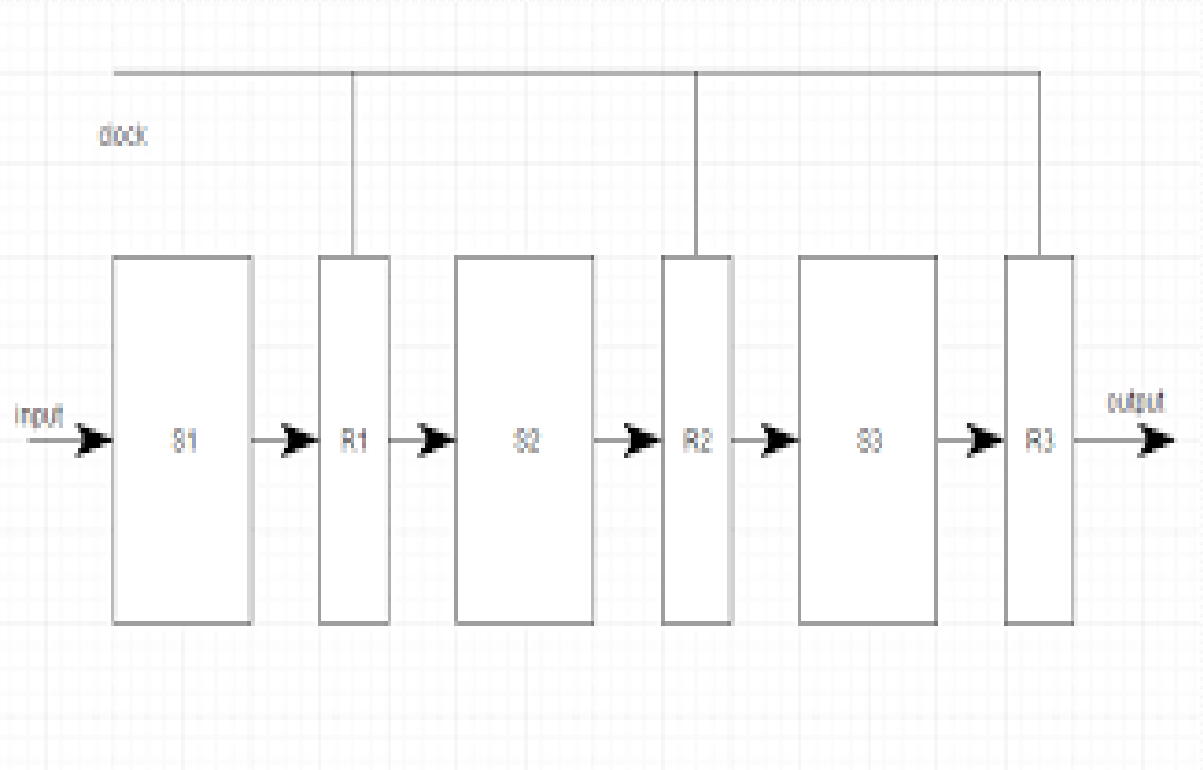
RISC VS CISC

RISC	CISC
Emphasis on software	Emphasis on hardware
Small number of fixed length instructions	Large number of instructions
Simple, standardized instructions	Complex, variable-length instructions
Single clock cycle instructions	Instructions can take several clock cycles
Heavy use of RAM	More efficient use of RAM

Concept of Pipelining

- Pipelining is **a technique where multiple instructions are overlapped during execution**. Pipeline is divided into stages and these stages are connected with one another to form a pipe like structure. Instructions enter from one end and exit from another end. Pipelining increases the overall instruction throughput.

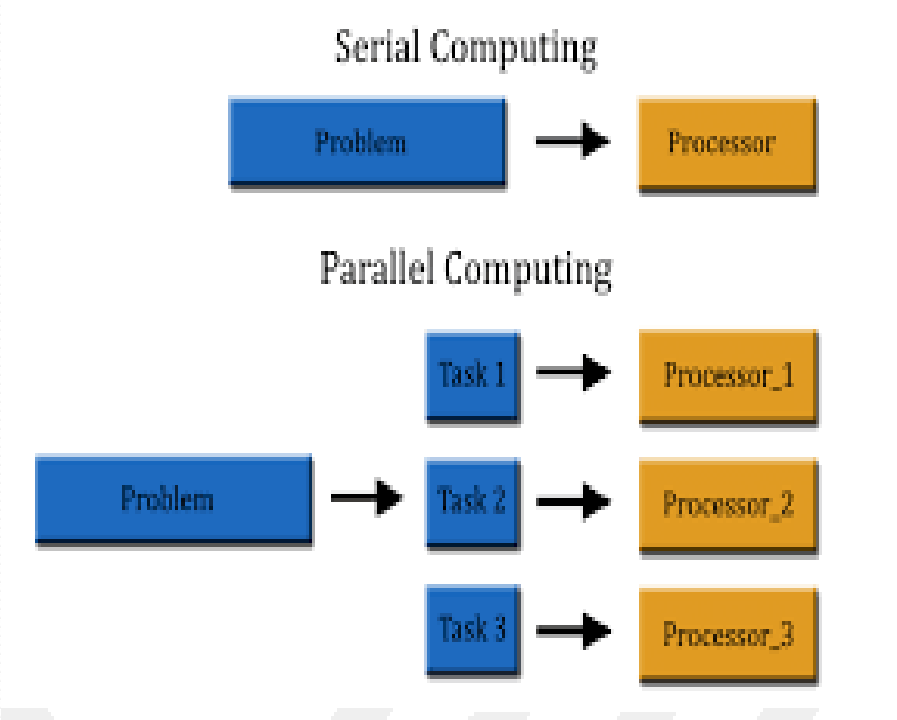
Example



Parallel Processing

Parallel processing is **a method in computing of running two or more processors (CPUs) to handle separate parts of an overall task**. Breaking up different parts of a task among multiple processors will help to reduce the amount of time to run a program.

Example


Serial Computing
Problem
Processor
Parallel Computing
Problem
Task 1
Task 2
Task 3
Processor_1
Processor_2
Processor_3

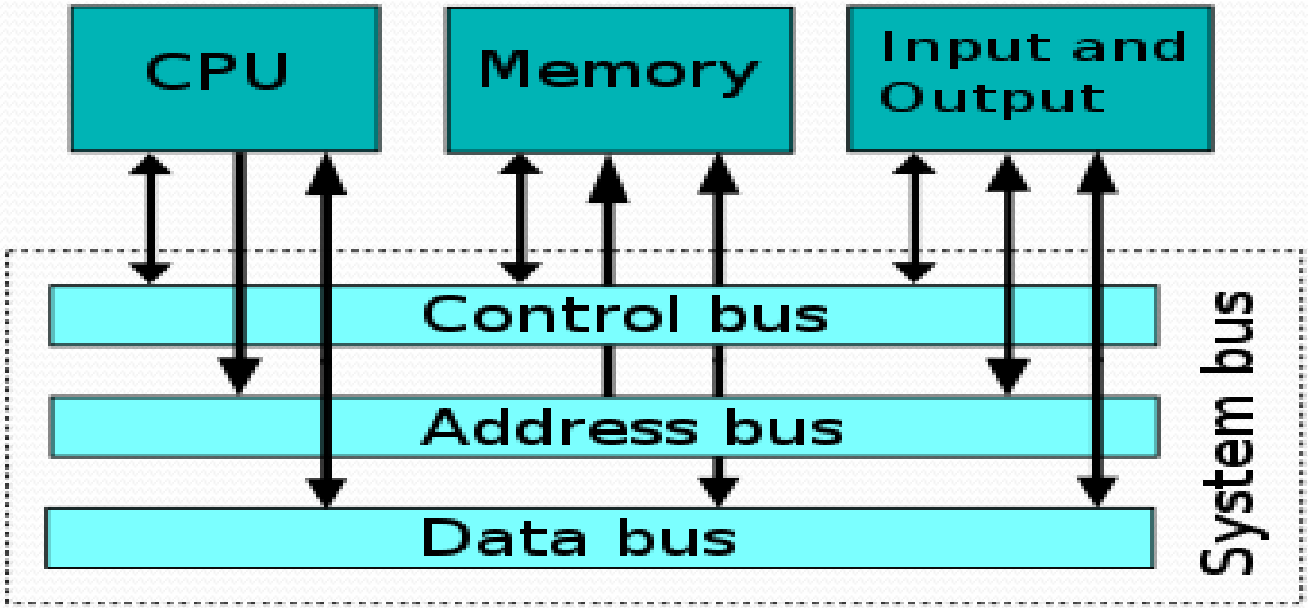
Interconnecting the Units of Computers

- Inside computers, there are many internal components. In order for these components to communicate with each other, they make use of wires that are known as a '**bus**'.
- A **bus** is a **common pathway** through which information flows from one computer component to another. This pathway is used for communication purpose and it is established between two or more computer components.

A computer bus can be divided into two types: **Internal Bus** and **External Bus**.

- **Internal Bus:** Internal bus is used to connect the internal components of computer system such as processor, RAM, chipset, hard disk. It is also called the **System Bus.**
- **External Bus:** External bus is used to connect the external components of computer system such as monitor, keyboard, printer. The external bus allows various devices to be attached to the computer. It allows for the expansion of computer's capabilities. It is generally slower than the system bus. It is also referred to as the **Expansion Bus**.

- A system bus or expansion bus comprise of three kinds of buses: data bus, address bus and control bus.



System Bus

The functions of data bus, address bus and control bus, in the system bus, are as follows:

- **Data Bus:** It transfers data between the CPU and memory. The bus width of a data bus affects the speed of computer. The size of data bus defines the size of the processor. A processor can be 8, 16, 32 or 64-bit processor. An 8–bit processor has 8 wire data bus to carry 1 byte of data. In a 16–bit processor, 16–wire bus can carry 16 bits of data, i.e., transfer 2 bytes, etc.

System Bus

- **Address Bus:** It connects CPU and RAM with set of wires similar to data bus. Address bus carries memory addresses for read and write operations. The width of address bus determines the maximum number of memory locations the computer can address. Currently, Pentium Pro, II, III, IV have 36–bit address bus that can address 236 bytes or 64 GB of memory.
- **Control Bus:** It specifies whether data is to be read or written to the memory etc.

Expansion Bus

The functions of data bus, address bus and control bus, in the expansion bus, are as follows:

- **Data Bus:** It is used to transfer data between I/O devices and CPU. The exchange of data between CPU and I/O devices is according to the industry standard data buses. The most commonly used standard is Extended Industry Standard Architecture (EISA) which is a 32-bit bus architecture. Some of the common bus technologies are:

  -Peripheral Component Interconnect (PCI) bus for hard disks, sound cards, network cards and graphics cards,

Expansion Bus

-Accelerated Graphics Port (AGP) bus for 3–D and full motion video.

-Universal Serial Bus (USB) to connect and disconnect different devices.

- **Address Bus:** It carries the addresses of different I/O devices to be accessed like the hard disk, CD ROM etc.
- **Control Bus:** It is used to carry read/write commands, status of I/O devices etc.

External Ports

The peripheral devices interact with the CPU of the computer via the bus. The connections to the bus from the peripheral devices are made via the ports and sockets provided at the sides of the computer. The different ports and sockets facilitate the connection of different devices to the computer. Some of the standard port connections available on the outer sides of the computer are— port for mouse, keyboard, monitor, network, modem, and, audio port, serial port, parallel port and USB port.

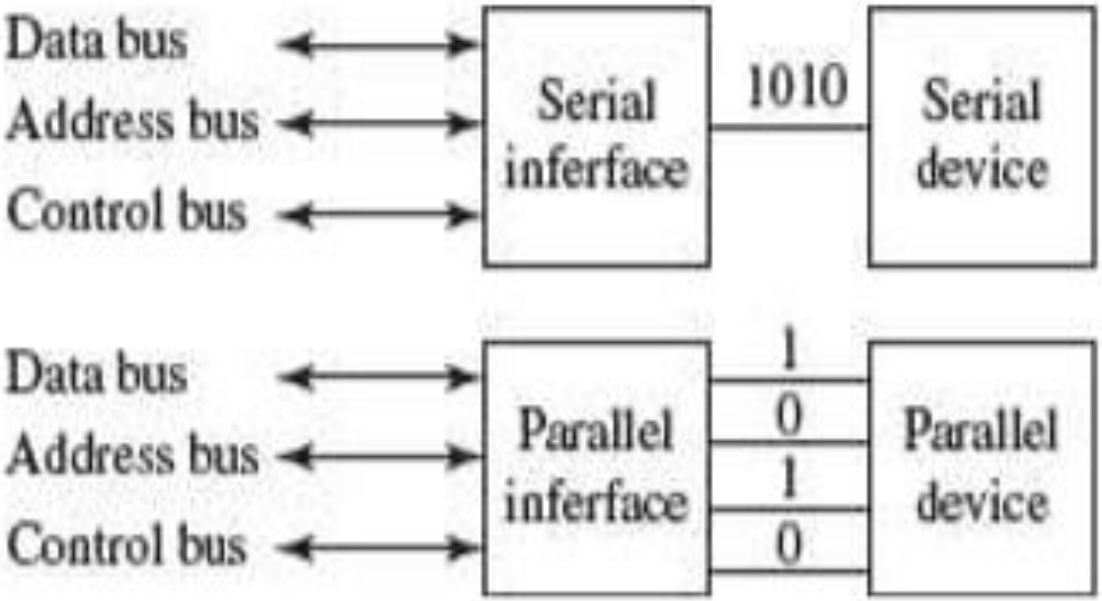


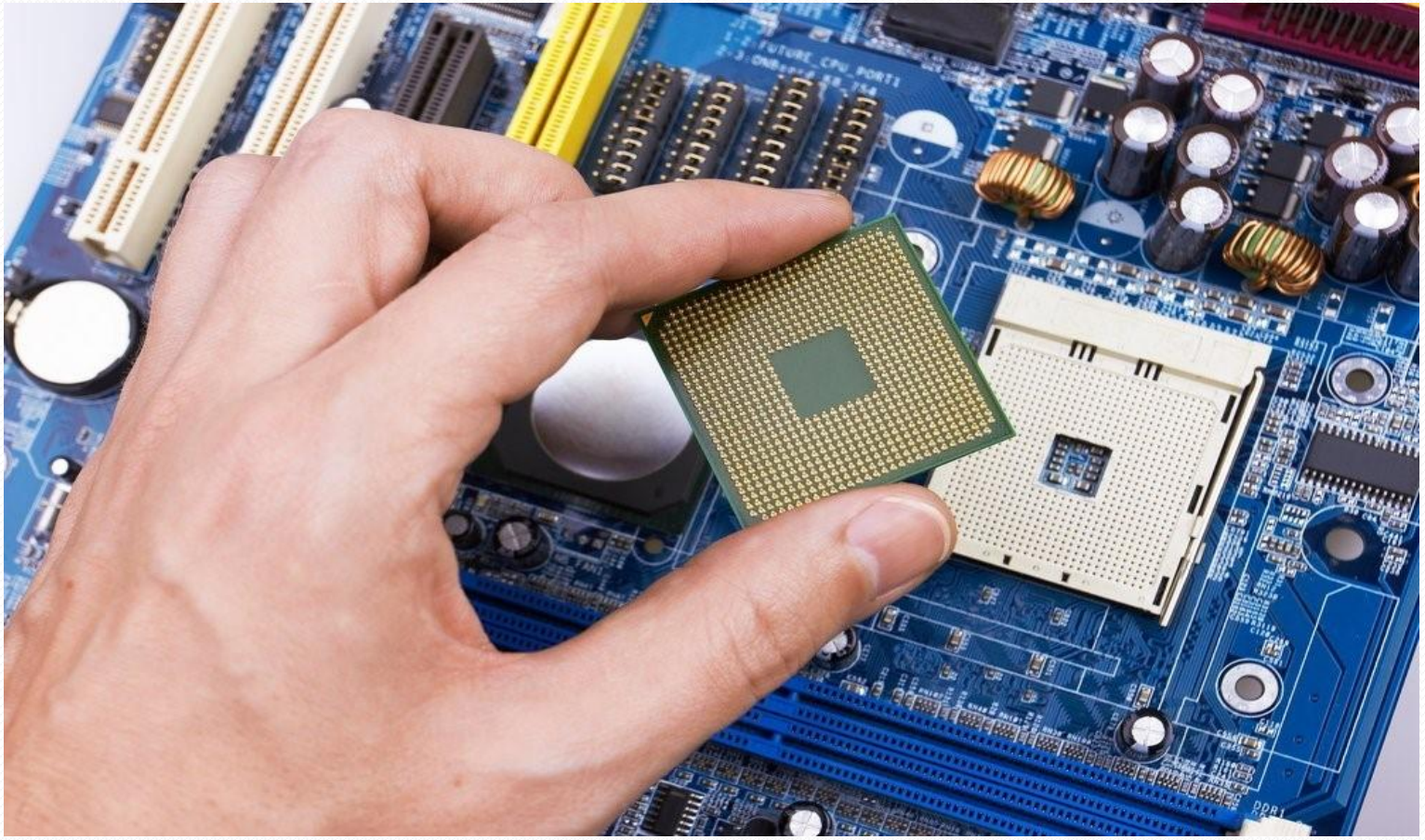
Fig: Interaction of serial and parallel port interfaces

Computer Cabinet

These are the main parts/components of a computer cabinet/tower:

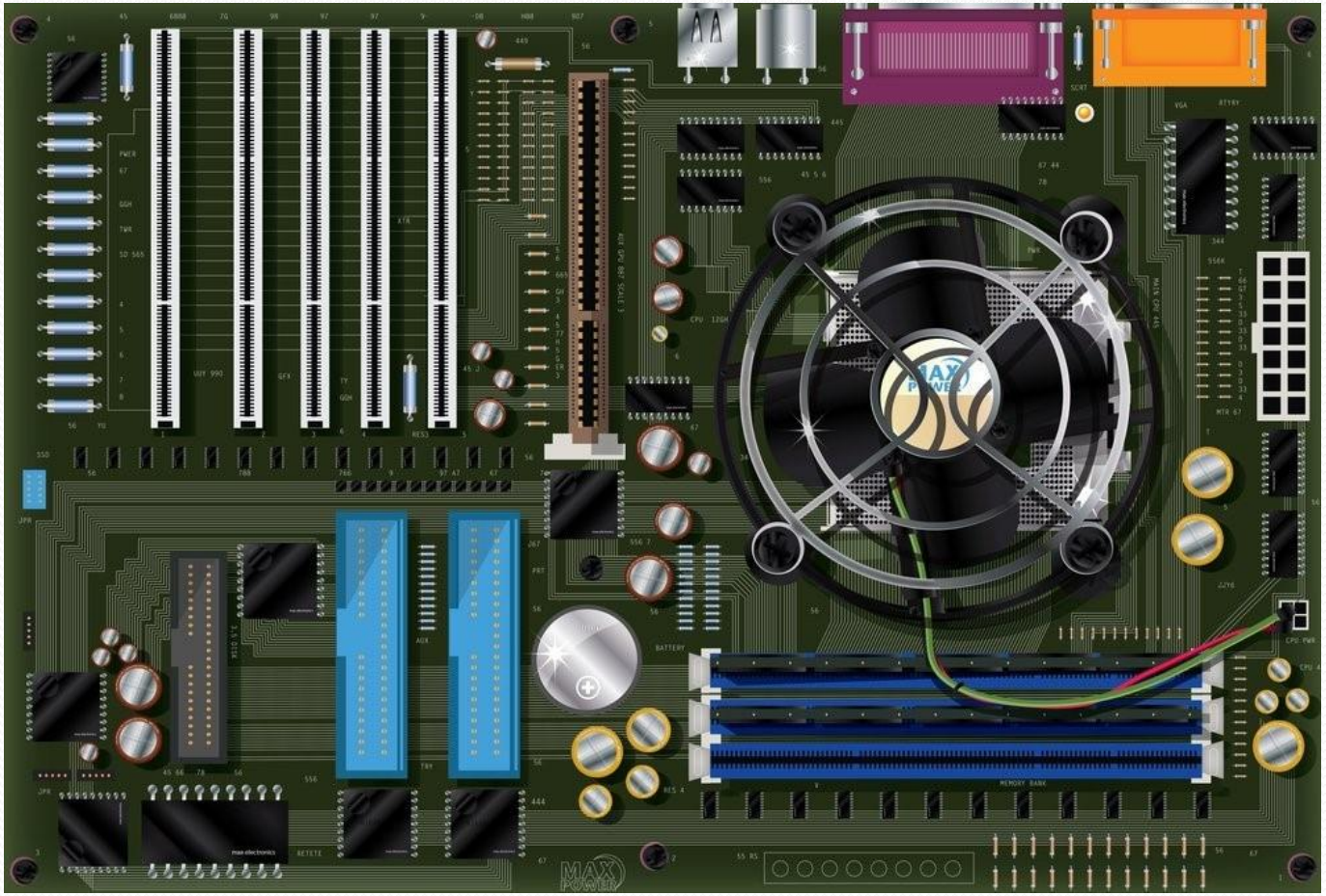
- Processor
- Motherboard
- Hard drive
- Power supply
- These are the biggest, most obvious parts you see when you open the computer cabinet.

Processor



Motherboard

The motherboard supplies power to the processor, RAM, hard disk, and other hardware components. It houses every wire and connector you can see inside the case. It also houses the famous RAM (Random Access Memory), also known as primary memory. The motherboard also houses other important components such as a graphics card, LAN card, etc.



Hard drive

Power Supply

- Also known as the SMPS – Switched Mode Power Supply, or PSU – Power Supply Unit, is the part of the enclosure that supplies power to every single component within the enclosure. It converts an alternating current of 220-230 V into a direct current that the computer can use. It is normally located in the upper corner of the enclosure and is equipped with a small fan to prevent overheating.
- There are also other parts in the cabinet, such as a floppy drive into which you insert your CDs and DVDs, an expansion card, and many wires.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+12V
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-12V
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