Computer Architecture

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Reference Book

- “Computer Organization and Architecture” by William Stallings; 8th Edition.
  - Any later edition is fine.

Overview

- **Computer Architecture** refers to those attributes of a system which are visible to a programmer or
- Those attributes that have a direct impact on the logical execution of a program.
- Examples of architectural attributes: Instruction set, the number of bits used to represent various data types (e.g., numbers, characters), I/O mechanisms, and techniques for addressing memory.

- **Computer Organization** refers to the operational units and their interconnections that realize the architectural specifications.
- Example of organizational attributes: Control signals; ALU; interfaces between the computer and peripherals; and the memory technology used.

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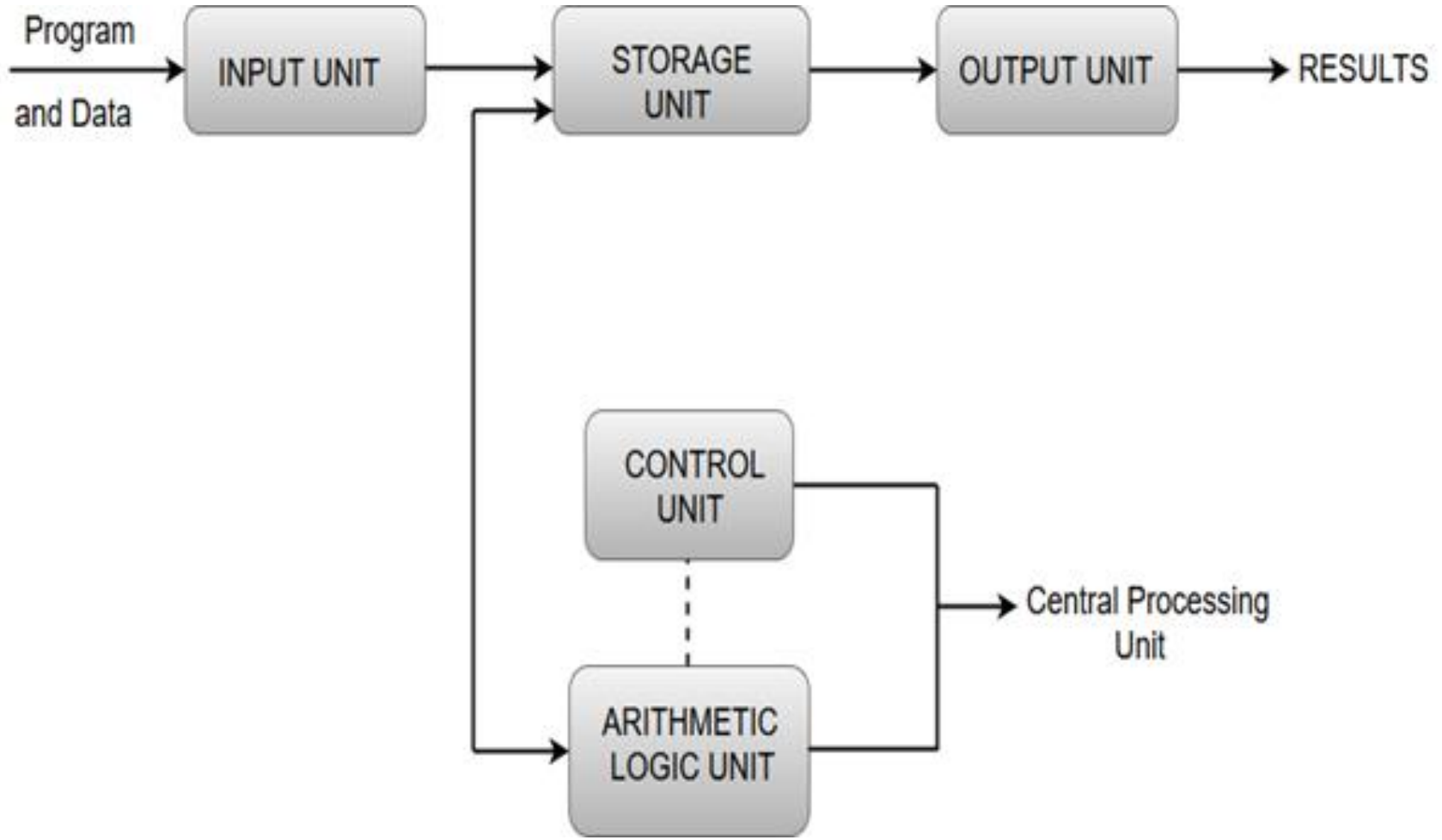
- For example, it is an **architectural** design issue whether a computer will have a multiply instruction.
- On the other hand, it is an **organizational** issue whether that instruction will be implemented by a special multiply unit or by a mechanism that makes repeated use of the add unit of the system.

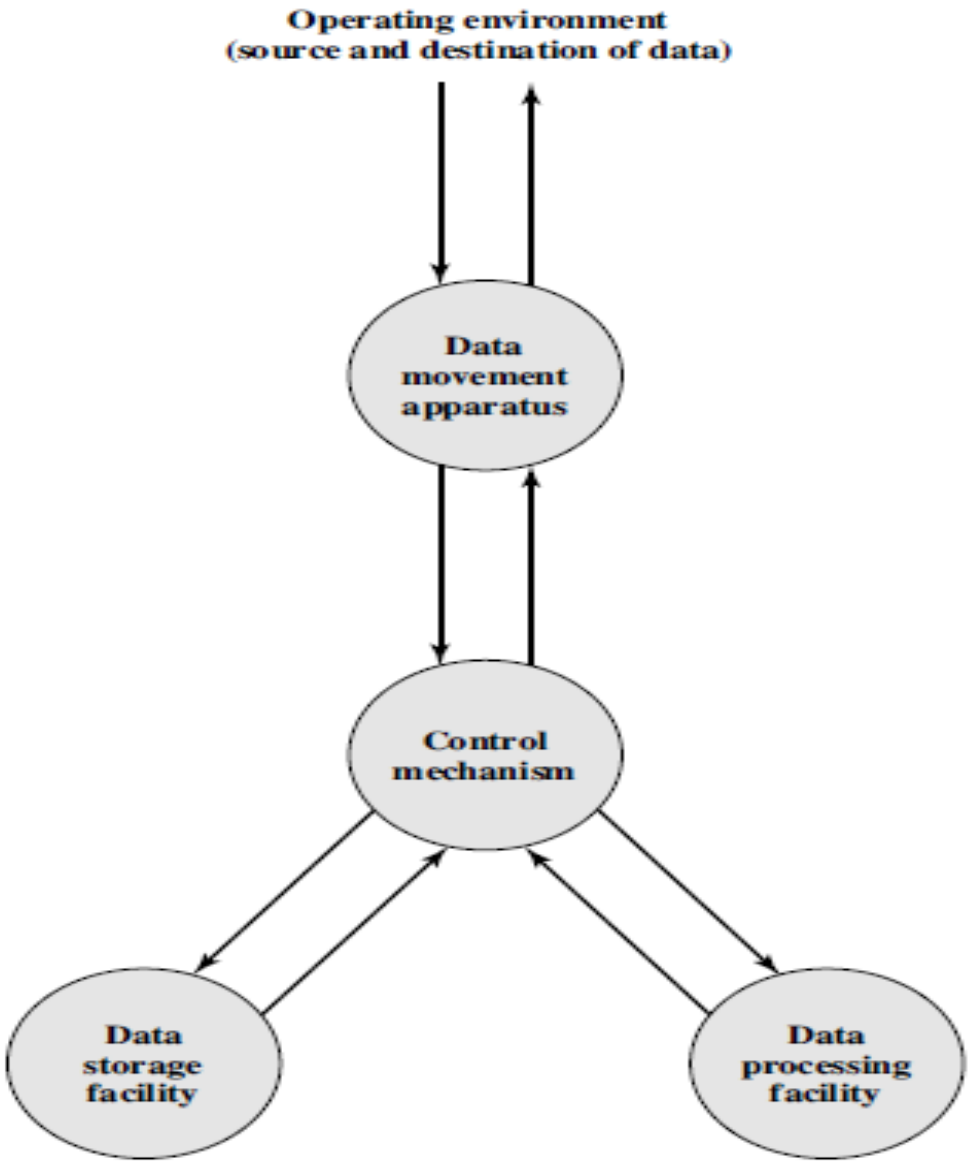
Computer System Components



STRUCTURE AND FUNCTION

- A computer is a complex system.
- The hierarchical nature of complex systems is essential to both their design and their description.
- The designer need only to deal with a particular level of the system at a time.
- At each level, the system consists of a set of components and their inter-relationships, and the designer is concerned with associated structure and function:
  - **Structure:** The way in which the components are interrelated.
  - **Function:** The operation of each individual component as part of the structure.

Functional View of a Computer



Functional Units

- Functional units of a computer system are parts of the CPU (Central Processing Unit) that performs the operations and calculations called for by the computer program.
- In general terms, there are only four functional units:
- **Data processing**: The computer must be able to process data.
  - The data may take a wide variety of forms, and the range of processing requirements is broad.
- **Data storage**: It is also essential that a computer store data.
  - If the computer is processing data on the fly (i.e., data come in and get processed, and the results go out immediately), the computer must temporarily store at least those pieces of data that are being worked on at any given moment.
  - Thus, there is at least a short-term data storage function.
  - Equally important, the computer performs a long-term data storage function also.
  - Files of data are stored on the computer for subsequent retrieval and update.

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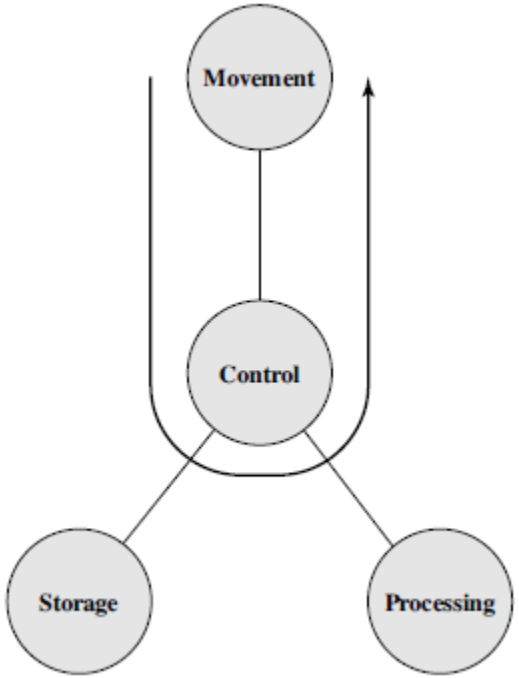
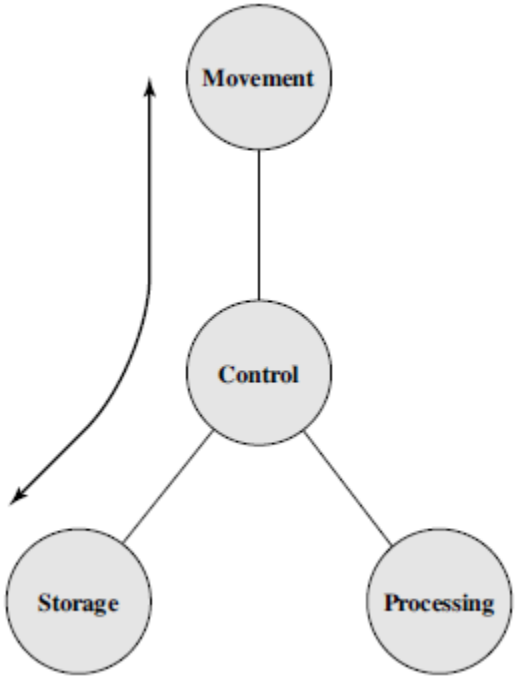
- **Data movement**: The computer must be able to move data between itself and the outside world.
  - The computer's operating environment consists of devices that serve as either sources or destinations of data
  - When data are received from or delivered to a device that is directly connected to the computer, the process is known as input–output(I/O), and the device is referred to as a peripheral.
  - When data are moved over longer distances, to or from a remote device, the process is known as data communications.
- **Control**: There must be control of these three functions
  - Within the computer, a control unit manages the computer's resources and ensures the performance of its functional parts in response to those instructions.

Possible Operations





- The computer can function as a data movement device (Figure 1), simply transferring data from one peripheral or communications line to another.
- It can also function as a data storage device (Figure 2), with data transferred from the external environment to computer storage (read) and vice versa (write).

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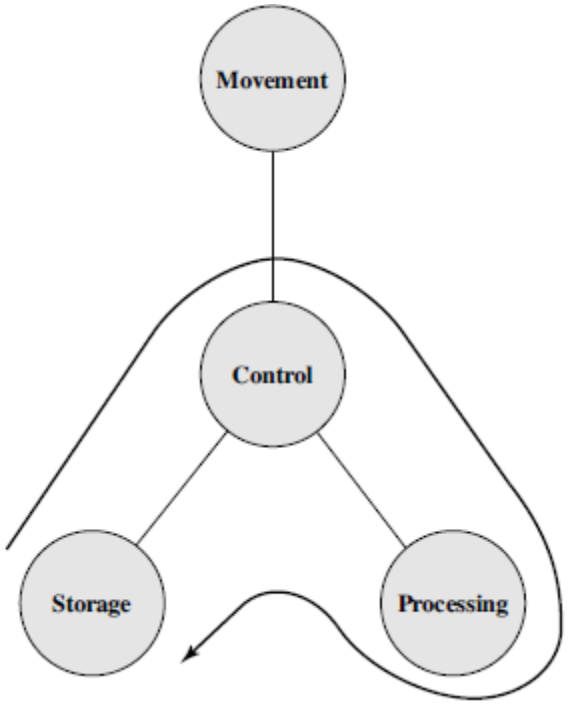
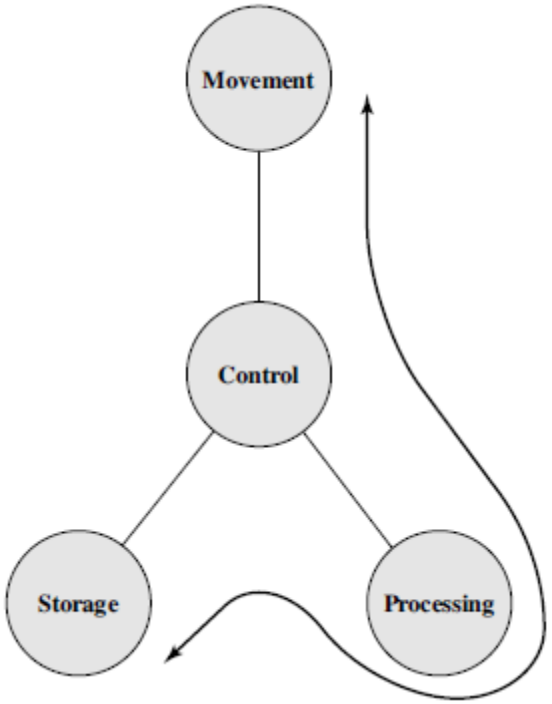
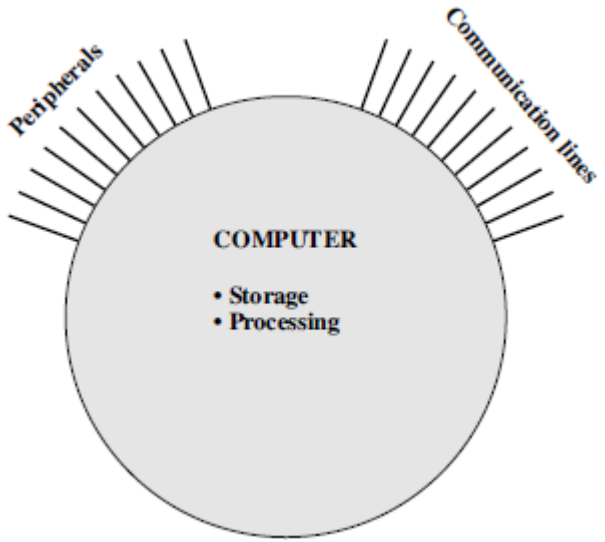




- The final two diagrams show operations involving data processing, on data either in storage (Figure 3) or en route between storage and the external environment (Figure 4).

Structural Units/Components



- This is the simplest possible depiction of a computer
- The computer interacts in some fashion with its external environment.
- In general, all of its linkages to the external environment can be classified as peripheral devices or communication lines.

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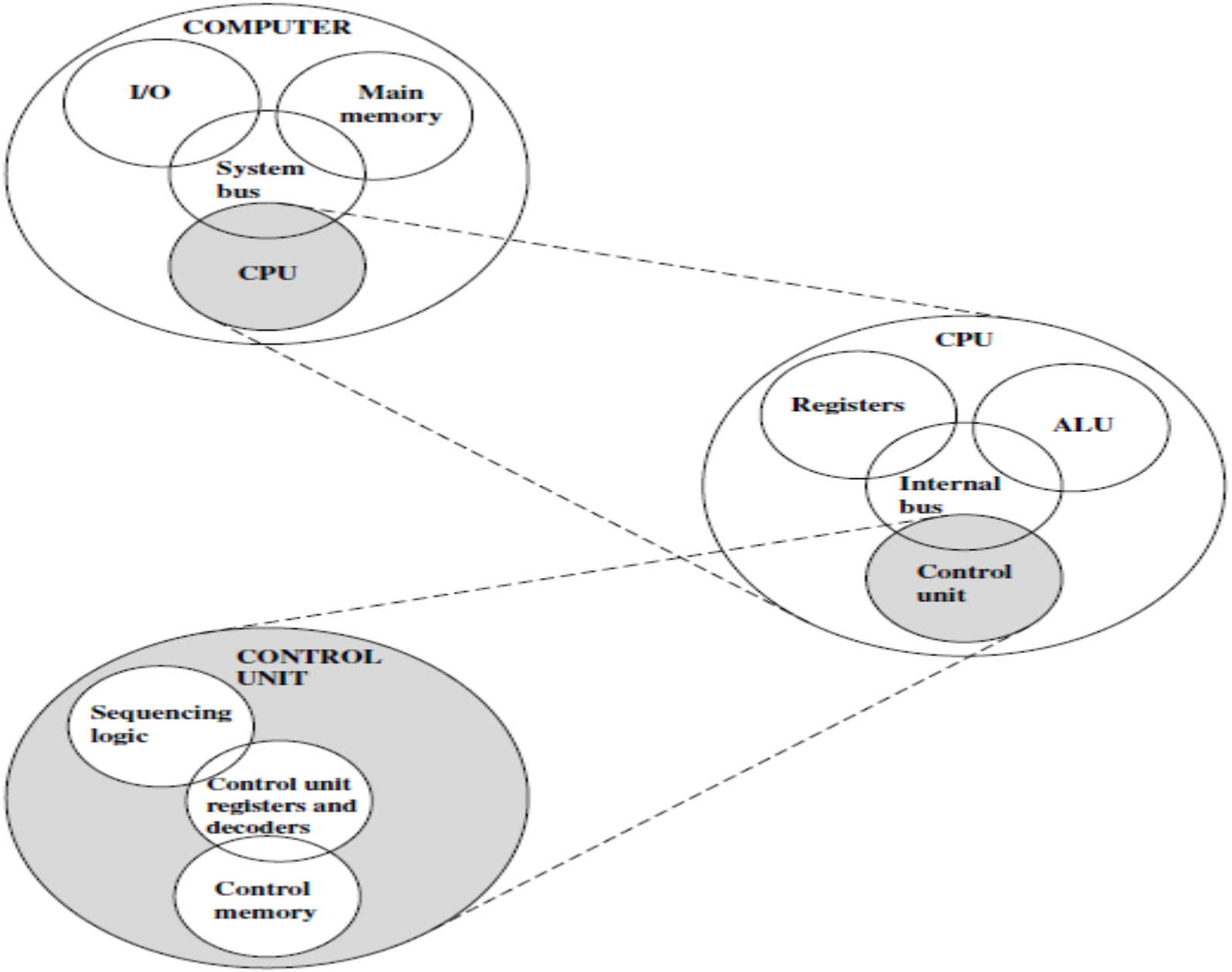
- There are four main structural components:
- **Central processing unit (CPU):** Controls the operation of the computer and performs its data processing functions.
  - Often simply referred to as processor.
- **Main memory**: Stores data.
- **I/O**: Moves data between the computer and its external environment.
- **System interconnection**: Some mechanism that provides for communication among CPU, main memory, and I/O.
  - A common example of system interconnection is by means of a **system bus,** consisting of a number of conducting wires to which all the other components attach.

Top-Level Structure



Basic Operational Concepts

- The primary function of a computer system is to execute a program (sequence of instructions). These instructions are stored in computer memory.
- These instructions are executed to process data which are already loaded in the computer memory through some input devices.
- After processing the data, the result is either stored in the memory for further reference, or it is sent to the outside world through some output port.
- To perform the execution of an instruction, in addition to the arithmetic logic unit, and control unit, the processor contains a number of registers used for temporary storage of data and some special function registers.
- The special function registers include program counters (PC), instruction registers (IR), memory address registers (MAR) and memory data registers (MDR).
- The Program counter is one of the most critical registers in CPU.
  - It monitors the execution of instructions. It keeps track on which instruction is being executed and what the next instruction will be.
- The instruction register IR is used to hold the instruction that is currently being executed.
  - The contents of IR are available to the control unit, which generate the timing signals that control, the various processing elements involved in executing the instruction.

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- The two registers MAR and MDR are used to handle the data transfer between the main memory and the processor.
- The MAR holds the address of the main memory to or from which data is to be transferred.
- The MDR contains the data to be written into or read from the addressed word of the main memory.
- Whenever the processor is asked to communicate with devices, we say that the processor is servicing the devices. The processor can service these devices in one of the two ways.
- One way is to use the polling routine, and the other way is to use an interrupt.
- Polling enables the processor software to check each of the input and output devices frequently. During this check, the processor tests to see if any devices need servicing or not.
- Interrupt method provides an external asynchronous input that informs the processor that it should complete whatever instruction that is currently being executed and fetch a new routine that will service the requesting device.

Thank You ☺