Computer Organization and Architecture

2022_23

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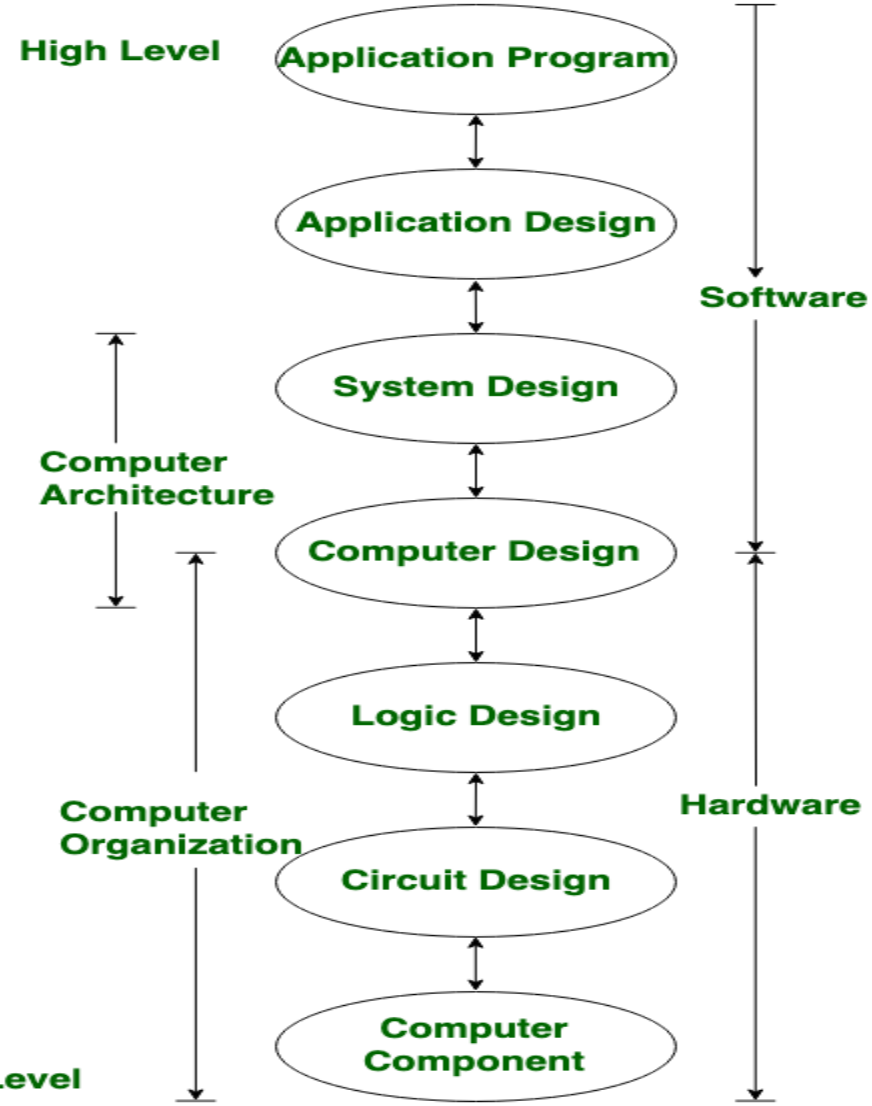
UNIT 1

- **Overview**
- General Organization
- Structural/functional view
- Functional Components.

Computer System



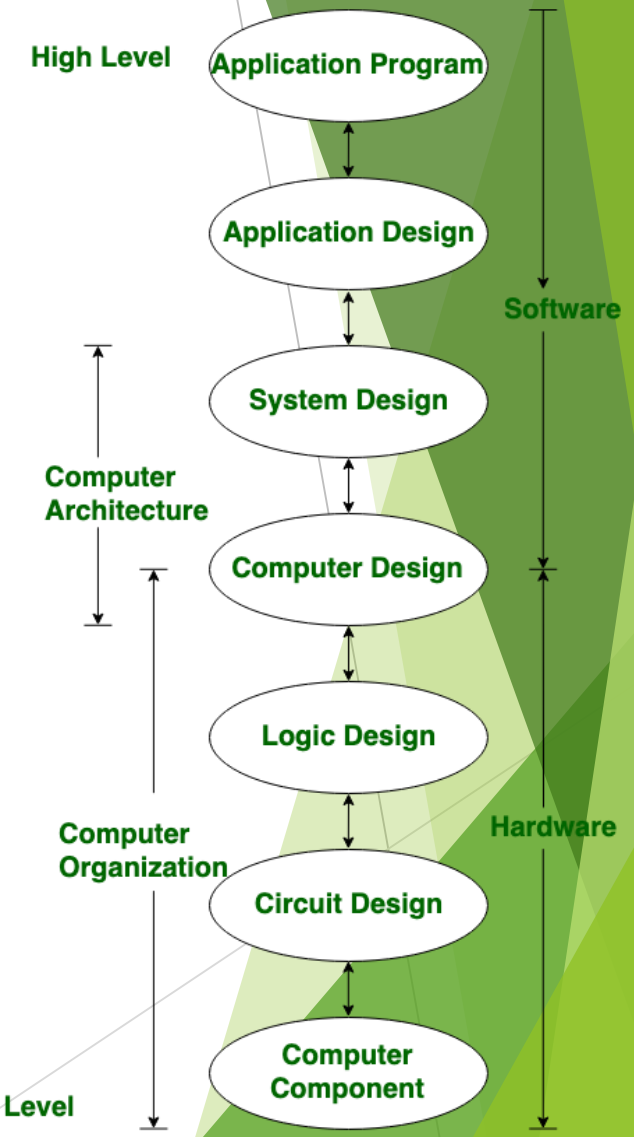
What is Computer Architecture and Organization?

- In general terms, the *Architecture* of a computer system can be considered as a catalogue of tools or attributes that are visible to the user such as instruction sets, number of bits used for data, addressing techniques, etc.
- **Computer Architecture** is a functional description of requirements and design implementation for the various parts of a computer. It deals with the functional behavior of computer systems. It comes before the computer organization while designing a computer.

- Whereas, *Organization* of a computer system defines the way system is structured so that all those catalogued tools can be used. The significant components of Computer organization are ALU, CPU, memory and memory organization.
- **Computer Organization** comes after the decision of Computer Architecture first. Computer Organization is how operational attributes are linked together and contribute to realizing the architectural specification. Computer Organization deals with a structural relationship.

Difference between Comp. Architecture and Comp Organization

S.NO	Computer Architecture	Computer Organization
1.	Architecture describes what the computer does.	The Organization describes how it does it.
2.	Computer Architecture deals with the functional behavior of computer systems.	Computer Organization deals with a structural relationship.
3.	In the above figure, it's clear that it deals with high-level design issues.	In the above figure, it's also clear that it deals with low-level design issues.
4.	Architecture indicates its hardware.	Where Organization indicates its performance.
5.	For designing a computer, its architecture is fixed first.	For designing a computer, an organization is decided after its architecture.
6.	Computer Architecture is also called instruction set architecture.	Computer Organization is frequently called microarchitecture.
7.	Computer Architecture comprises logical functions such as instruction sets, registers, data types, and addressing modes.	Computer Organization consists of physical units like circuit designs, peripherals, and adders.
8.	Architecture coordinates between the hardware and software of the system.	Computer Organization handles the segments of the network in a system.



Functional Units of Digital System

- A computer organization describes the functions and design of the various units of a digital system.
- A general-purpose computer system is the best-known example of a digital system. Other examples include telephone switching exchanges, digital voltmeters, digital counters, electronic calculators and digital displays.
- Computer architecture deals with the specification of the instruction set and the hardware units that implement the instructions.
- Computer hardware consists of electronic circuits, displays, magnetic and optic storage media and also the communication facilities.
- Functional units are a part of a CPU that performs the operations and calculations called for by the computer program.
- **A computer consists of five main components namely,**
- **1. Input unit 2. Central Processing Unit 3. Memory unit Arithmetic & logical unit, 4. Control unit and an 5. Output unit.**

UNIT 1

Computer Architecture	Computer Organization
Computer Architecture is concerned with the way hardware components are connected together to form a computer system.	Computer Organization is concerned with the structure and behaviour of a computer system as seen by the user.
It acts as the interface between hardware and software.	It deals with the components of a connection in a system.
Computer Architecture helps us to understand the functionalities of a system.	Computer Organization tells us how exactly all the units in the system are arranged and interconnected.
A programmer can view architecture in terms of instructions, addressing modes and registers.	Whereas Organization expresses the realization of architecture.
While designing a computer system architecture is considered first.	An organization is done on the basis of architecture.
Computer Architecture deals with high-level design issues.	Computer Organization deals with low-level design issues.
Architecture involves Logic (Instruction sets, Addressing modes, Data types, Cache optimization)	Organization involves Physical Components (Circuit design, Adders, Signals, Peripherals)

Evolution

ENIAC (Electronic Numerical Integrator and Computer) was the first computing system designed in the early 1940s. It consisted of 18,000 buzzing electronic switches called vacuum tubes, 42 panels each 9'x 2'x1'. It was organized in U-Shaped around the perimeter of a room with forced air cooling.

- **Atanasoff-Berry Computer (ABC)** design was known as the first digital electronic computer (though not programmable). It was designed and built by **John Vincent Atanasoff and his assistant, Clifford E. Berry in 1937**.
- **In 1941, Z3** was invented by **German inventor Konrad Zuse**. It was the first working programmable, fully automatic computing machine.
- **Transistors** were invented in **1947 at Bell Laboratories** which were a fraction the size of the vacuum tubes and consumed less power, but still, the complex circuits were not easy to handle.
- **Jack Kilby and Robert Noyce** invented the **Integrated Circuit** at the same time. In July 1959 Noyce filed a patent for this.
- **In 1968, Robert Noyce co-founded Intel Electronics company** which is still the global market leader in IC manufacturing, research, and development.
- **In 1983, Lisa was launched as the first personal computer** with a graphical user interface (GUI) that was sold commercially; it ran on the Motorola 68000, dual floppy disk drives, a **5 MB hard drive and had 1MB of RAM**.
- In 1990, Apple released the Macintosh Portable; it was heavy weighing 7.3 kg (16 lb) and extremely expensive. It was not met with great success and was discontinued only two years later.
- In 1990, Intel introduced the Touchstone Delta supercomputer, which had 512 microprocessors. This technological advancement was very significant as it was used as a model for some of the fastest multi-processors systems in the world.

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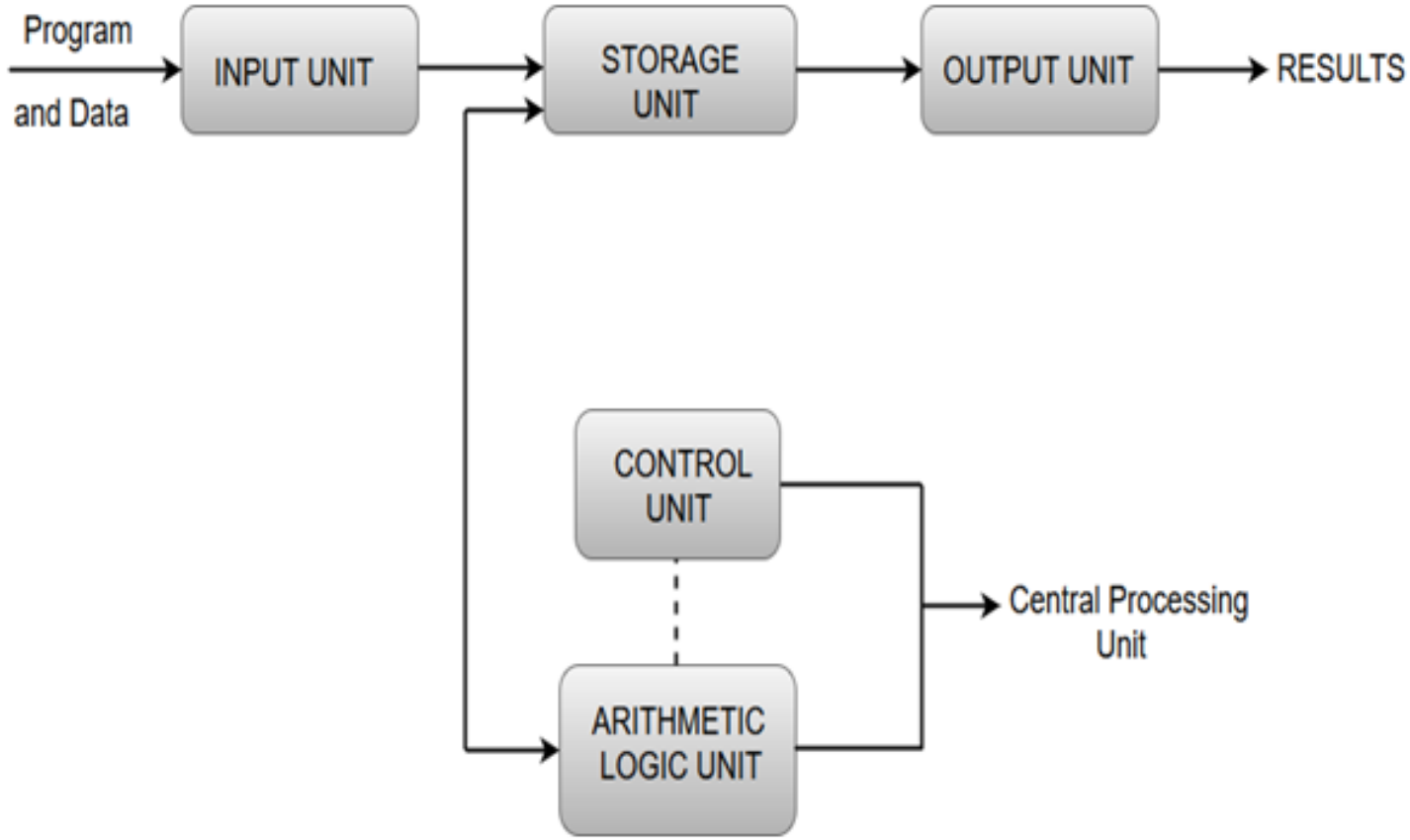
- Functional units of a computer system are parts of the CPU (Central Processing Unit) that performs the operations and calculations called for by the computer program. A computer consists of five main components namely, Input unit, Central Processing Unit, Memory unit Arithmetic & logical unit, Control unit and an Output unit.

Functional Units of Digital System Cont…



Functional Units of Digital System Cont…

Input unit

- Input units are used by the computer to read the data. The most commonly used input devices are keyboards, mouse, joysticks, trackballs, microphones, etc.
- However, the most well-known input device is a keyboard. Whenever a key is pressed, the corresponding letter or digit is automatically translated into its corresponding binary code and transmitted over a cable to either the memory or the processor.

Central processing unit

- Central processing unit commonly known as CPU can be referred as an electronic circuitry within a computer that carries out the instructions given by a computer program by performing the basic arithmetic, logical, control and input/output (I/O) operations specified by the instructions.

Functional Units of Digital System Cont…

Memory unit

- The Memory unit can be referred to as the storage area in which programs are kept which are running, and that contains data needed by the running programs.
- The Memory unit can be categorized in two ways namely, primary memory and secondary memory.
- It enables a processor to access running execution applications and services that are temporarily stored in a specific memory location.
- Primary storage is the fastest memory that operates at electronic speeds. Primary memory contains a large number of semiconductor storage cells, capable of storing a bit of information. The word length of a computer is between 16-64 bits.
- It is also known as the volatile form of memory, means when the computer is shut down, anything contained in RAM is lost.

Functional Units of Digital System Cont…

Memory unit

- Cache memory is also a kind of memory which is used to fetch the data very soon. They are highly coupled with the processor.
- The most common examples of primary memory are RAM and ROM.
- Secondary memory is used when a large amount of data and programs have to be stored for a long-term basis.
- It is also known as the Non-volatile memory form of memory, means the data is stored permanently irrespective of shut down.
- The most common examples of secondary memory are magnetic disks, magnetic tapes, and optical disks.

Functional Units of Digital System Cont…

Arithmetic & logical unit

- Most of all the arithmetic and logical operations of a computer are executed in the ALU (Arithmetic and Logical Unit) of the processor. It performs arithmetic operations like addition, subtraction, multiplication, division and also the logical operations like AND, OR, NOT operations.

Control unit

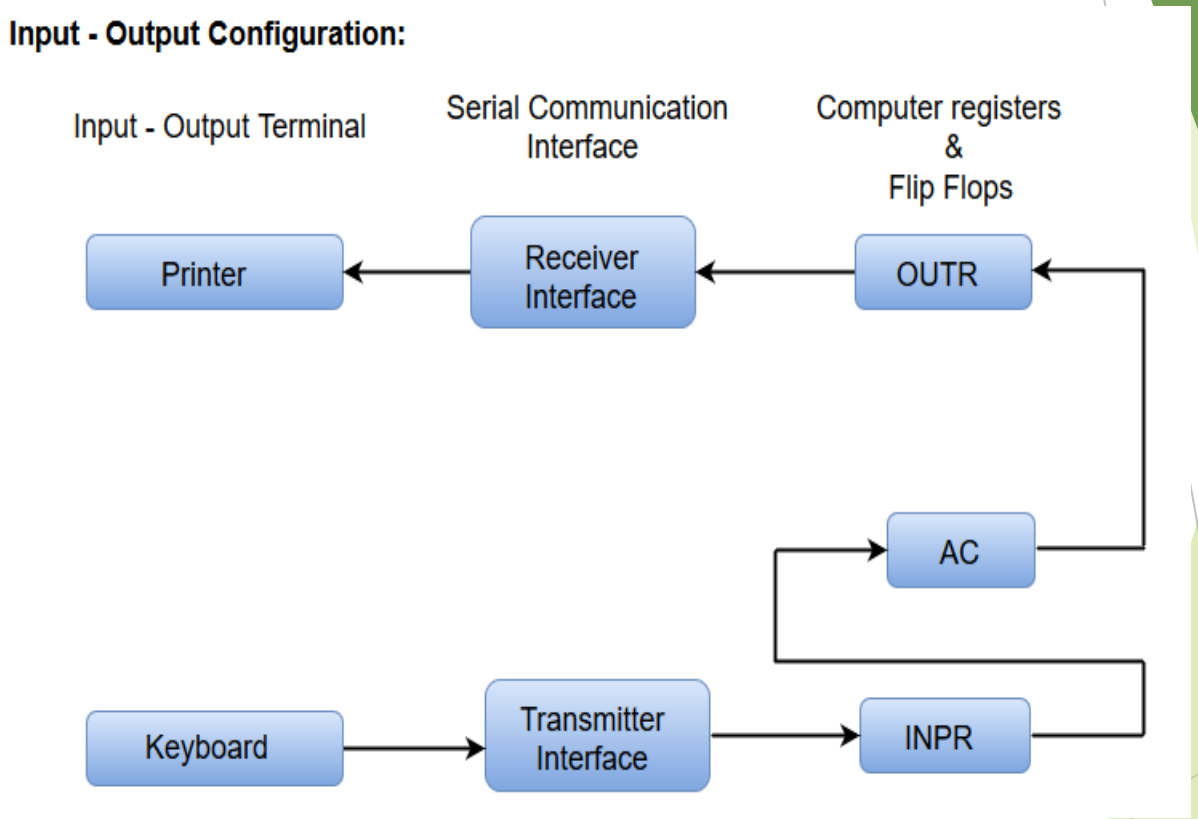
- The control unit is a component of a computer's central processing unit that coordinates the operation of the processor. It tells the computer's memory, arithmetic/logic unit and input and output devices how to respond to a program's instructions.
- The control unit is also known as the nerve center of a computer system.
- Let's us consider an example of addition of two operands by the instruction given as Add LOCA, RO. This instruction adds the memory location LOCA to the operand in the register RO and places the sum in the register RO. This instruction internally performs several steps.

Functional Units of Digital System Cont…

- **Output Unit**
- The primary function of the output unit is to send the processed results to the user. Output devices display information in a way that the user can understand.
- Output devices are pieces of equipment that are used to generate information or any other response processed by the computer. These devices display information that has been held or generated within a computer.
- The most common example of an output device is a monitor.

Input-Output Configuration

- In computer architecture, input-output devices act as an interface between the machine and the user.
- Instructions and data stored in the memory must come from some input device. The results are displayed to the user through some output device.



Control Unit

- The Control Unit is classified into two major categories:

1. **Hardwired Control**

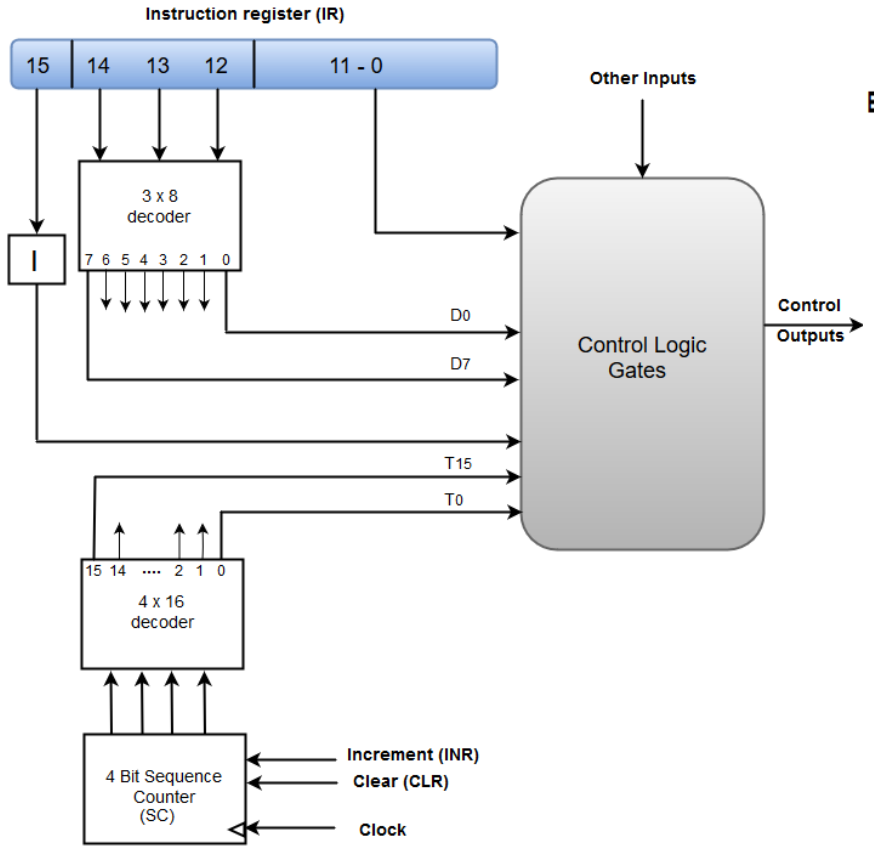
The Hardwired Control organization involves the control logic to be implemented with gates, flip-flops, decoders, and other digital circuits.

2. **Microprogrammed Control**

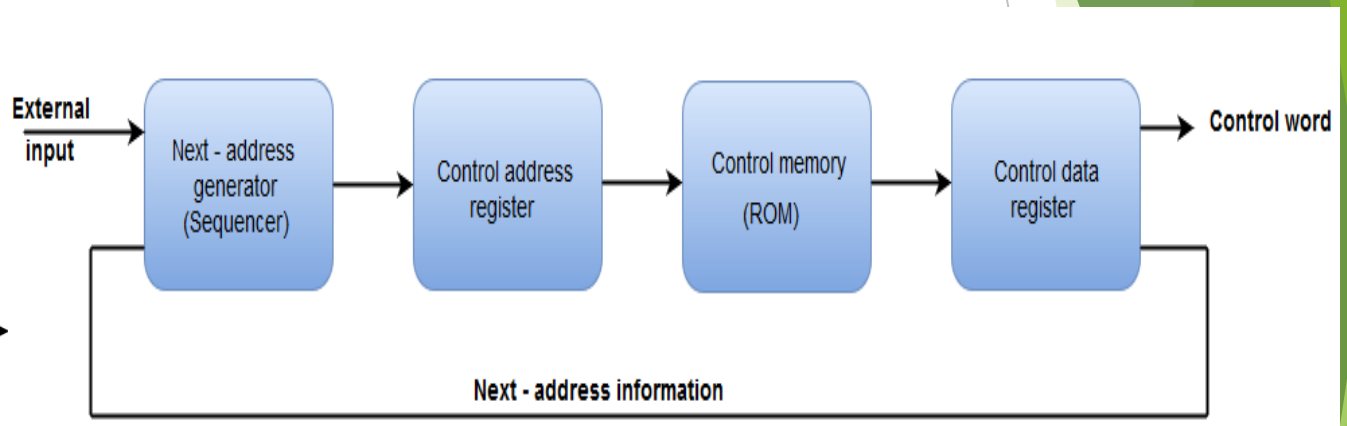
The Microprogrammed Control organization is implemented by using the programming approach.

Control Unit

Hardwired Control



Microprogrammed Control



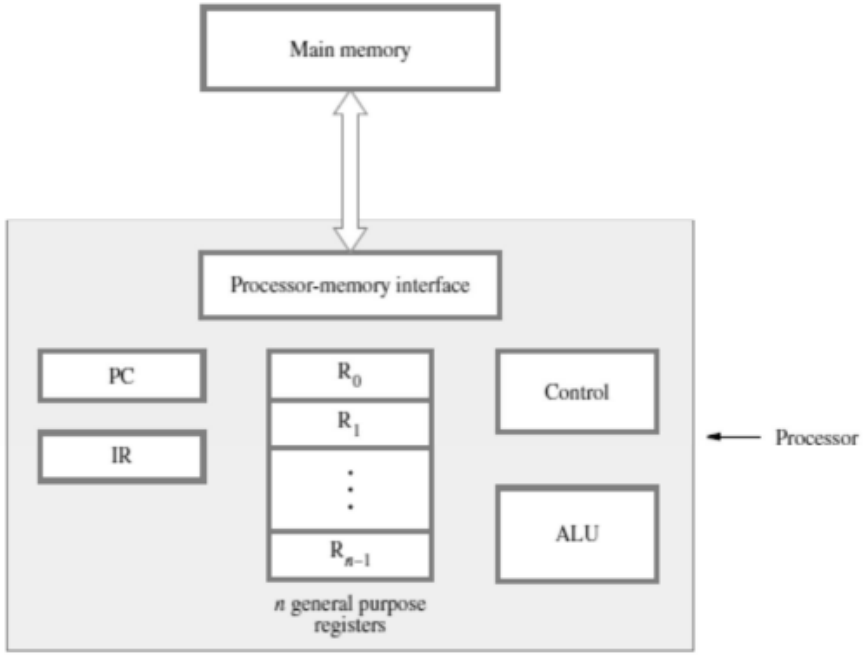
Basic Operational Concepts

- 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.

Basic Operational Concepts Cont…

- The special function registers include program counters (PC), instruction registers (IR), memory address registers (MAR) and memory and memory data registers (MDR).
- The Program counter is one of the most critical registers in CPU.
- The Program counter 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.

Memory and the processor Interconnection



Basic Operational Concepts Cont…

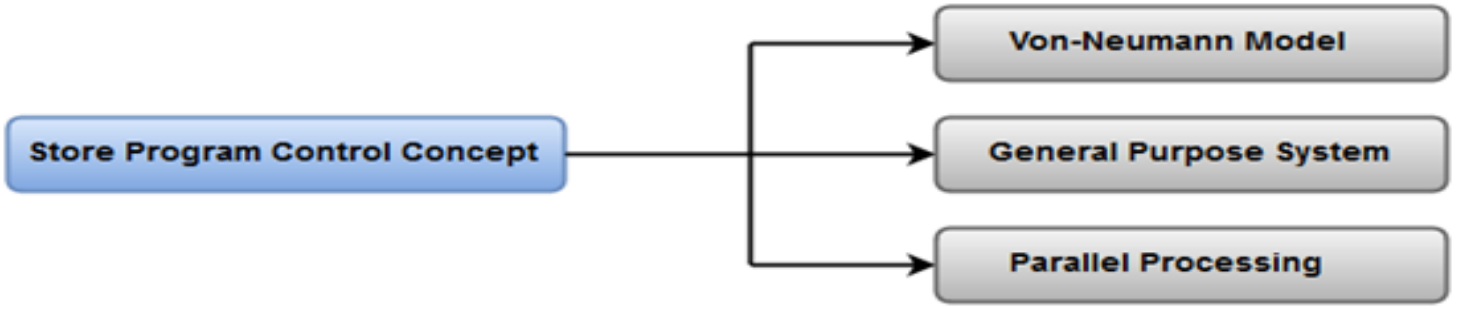
- The contents of IR are available to the control unit, which generate the timing signals that control, the various processing elements involved in executing the instruction.
- The two registers MAR and MDR are used to handle the data transfer between the main memory and the processor.
- The MAR holds 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.

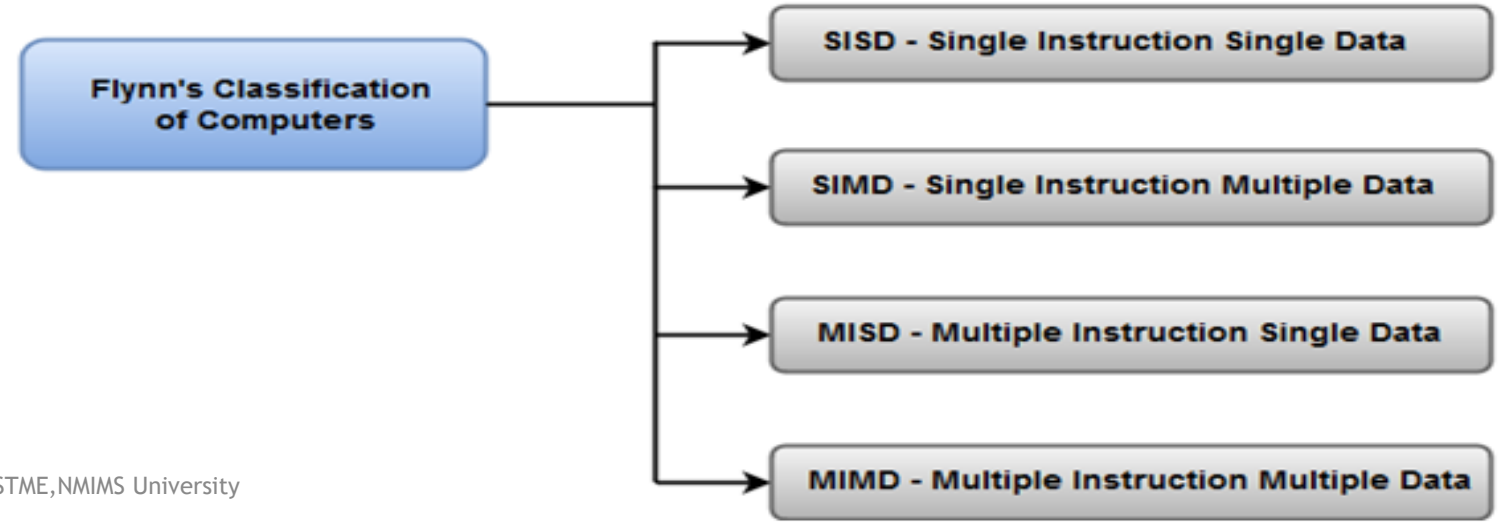
General System Architecture…

- In Computer Architecture, the General System Architecture is divided into two major classification units.

- Store Program Control Concept
- Flynn's Classification of Computers

General System Architecture…



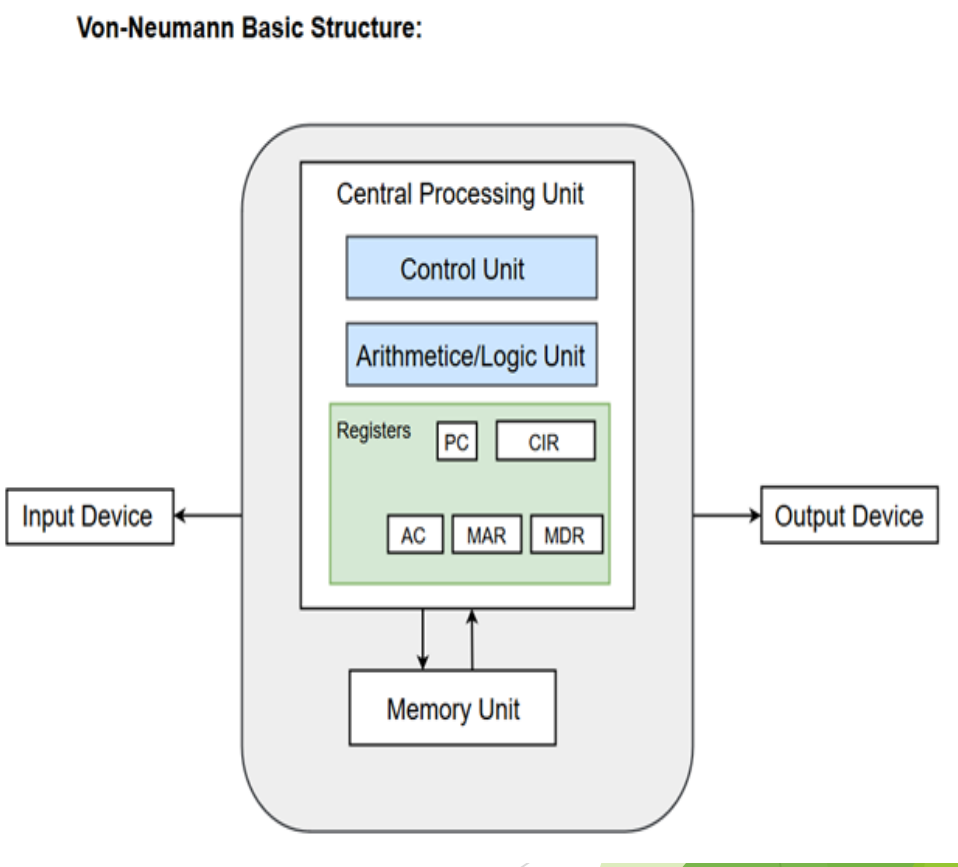


General System Architecture…

- Store Program Control Concept
- The term **Stored Program Control Concept** refers to the storage of instructions in computer memory to enable it to perform a variety of tasks in sequence or intermittently.
- The idea was introduced in the late 1040s by John von Neumann who proposed that a program be electronically stored in the binary-number format in a memory device so that instructions could be modified by the computer as determined by intermediate computational results.
- **ENIAC (Electronic Numerical Integrator and Computer)** was the first computing system designed in the early 1940s. It was based on Stored Program Concept in which machine use memory for processing data.
- Stored Program Concept can be further classified in three basic ways:
- Von-Neumann Model
- General Purpose System
- Parallel Processing

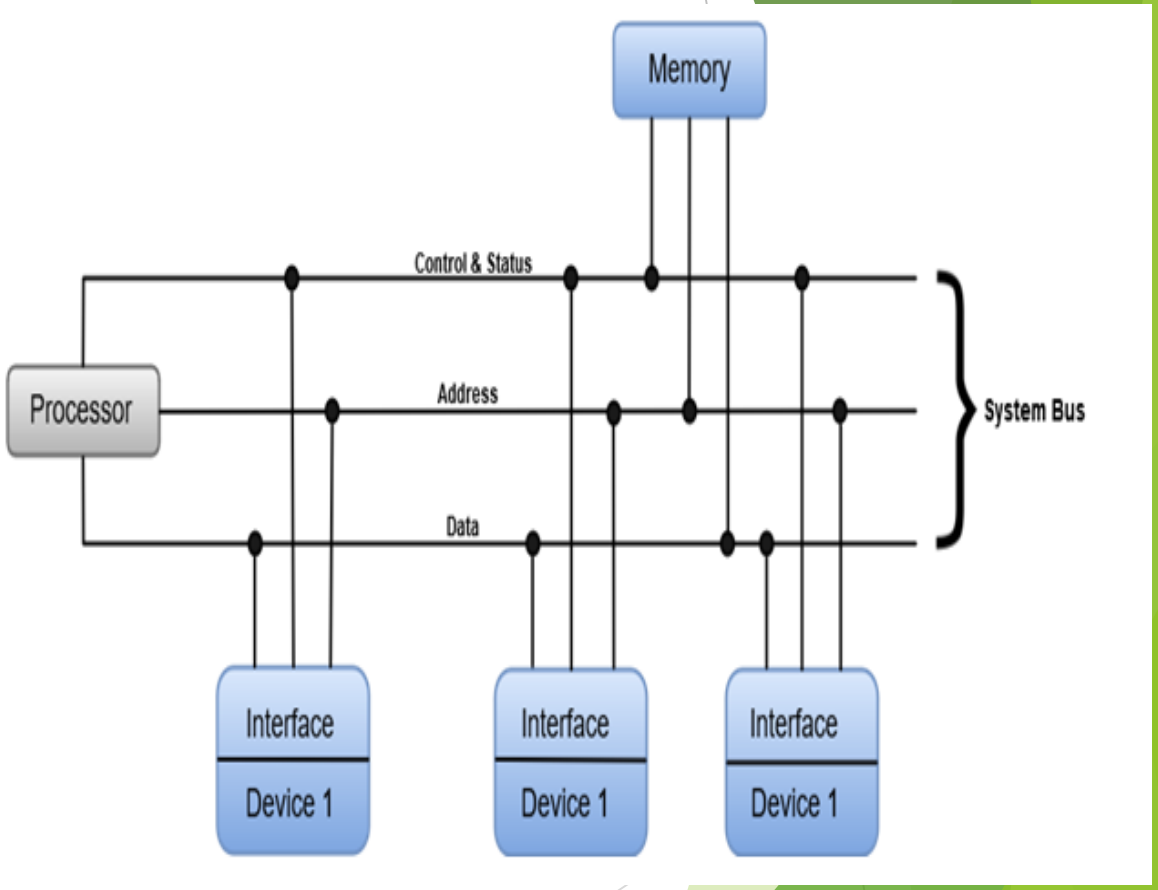
General System Architecture-Von-Neumann Model

- Von-Neumann proposed his computer architecture design in 1945 which was later known as Von-Neumann Architecture. It consisted of a Control Unit, Arithmetic, and Logical Memory Unit (ALU), Registers and Inputs/Outputs.
- Von Neumann architecture is based on the stored-program computer concept, where instruction data and program data are stored in the same memory. This design is still used in most computers produced today.
- A Von Neumann-based computer:
- Uses a single processor
- Uses one memory for both instructions and data.
- Executes programs following the fetch-decode-execute cycle



General System Architecture-Von-Neumann Model

- **General Purpose System**
- The General Purpose Computer System is the modified version of the Von-Neumann Architecture. In simple words, we can say that a general purpose computer system is a modern day architectural representation of Computer System.
- The CPU (Central Processing Unit) consists of the ALU (Arithmetic and Logic Unit), Control Unit and various processor registers.
- The CPU, Memory Unit and I/O subsystems are interconnected by the system bus which includes data, address, and control-status lines.
- The following image shows how CPU, Memory Unit and I/O subsystems are connected through common single bus architecture.



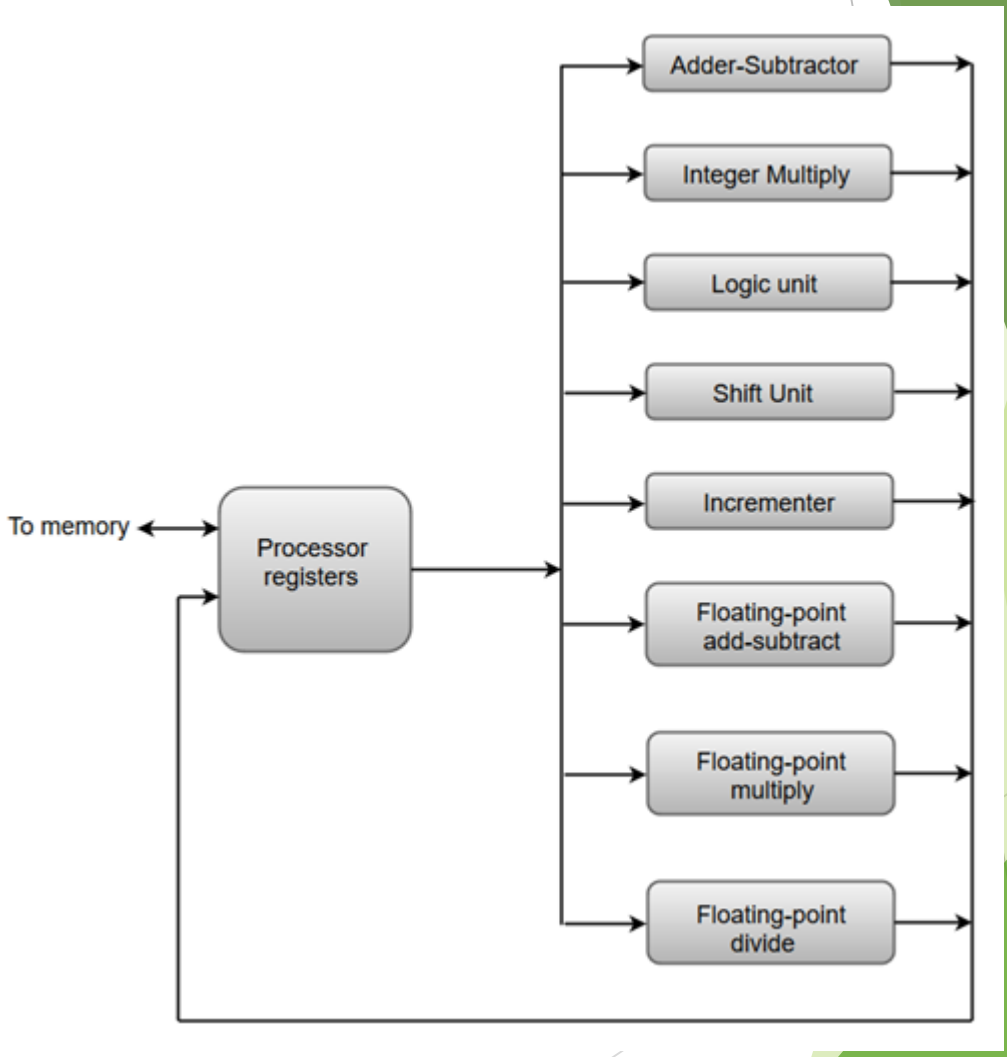
General System Architecture-Von-Neumann Model

Parallel Processing

- Parallel processing can be described as a class of techniques which enables the system to achieve simultaneous data-processing tasks to increase the computational speed of a computer system.
- A parallel processing system can carry out simultaneous data-processing to achieve faster execution time. For instance, while an instruction is being processed in the ALU component of the CPU, the next instruction can be read from memory.
- The primary purpose of parallel processing is to enhance the computer processing capability and increase its throughput, i.e. the amount of processing that can be accomplished during a given interval of time.
- A parallel processing system can be achieved by having a multiplicity of functional units that perform identical or different operations simultaneously. The data can be distributed among various multiple functional units.

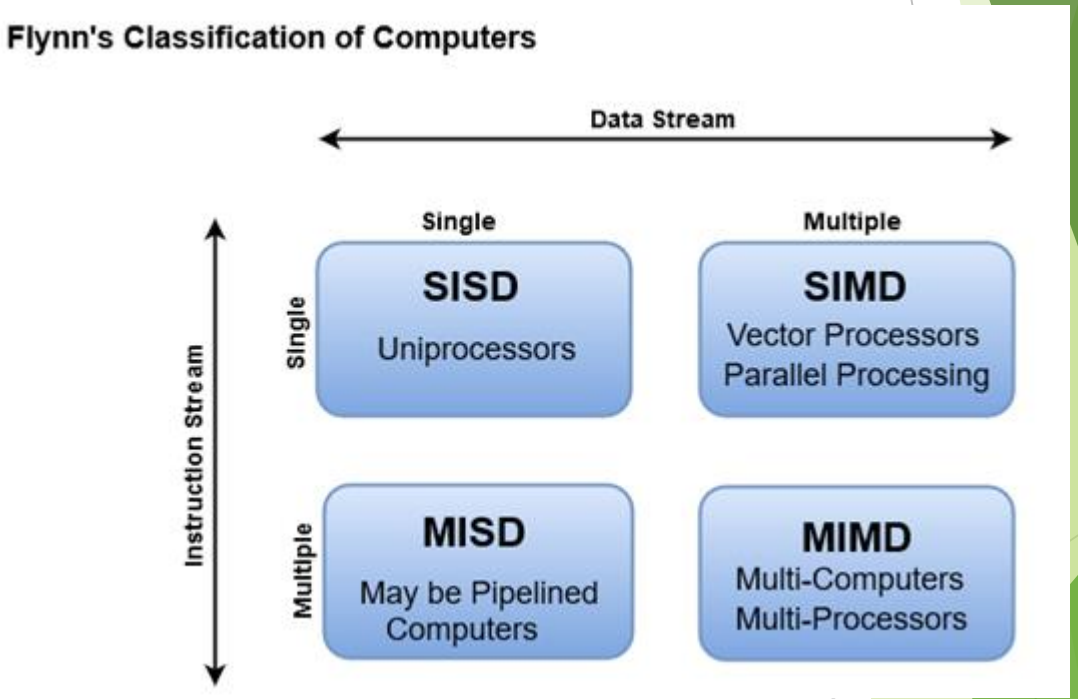
General System Architecture-Von-Neumann Model

- Parallel Processing-The following diagram shows one possible way of separating the execution unit into eight functional units operating in parallel.
- The operation performed in each functional unit is indicated in each block if the diagram:



Flynn's classification

- Flynn's classification divides computers into four major groups that are:
- Single instruction stream, single data stream (SISD)
- Single instruction stream, multiple data stream (SIMD)
- Multiple instruction stream, single data stream (MISD)
- Multiple instruction stream, multiple data stream (MIMD)



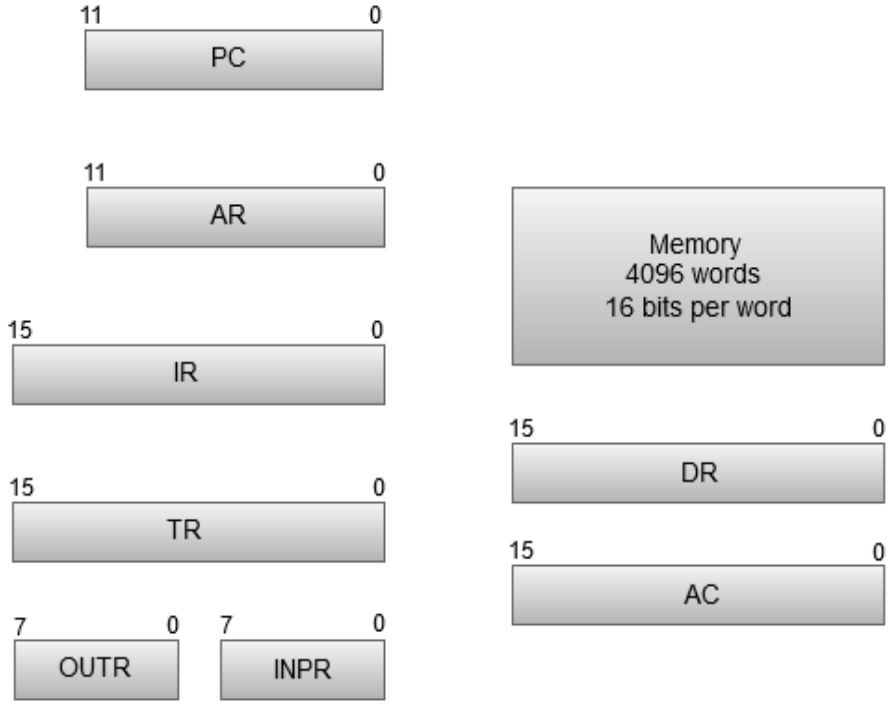
Computer Registers

- Registers are a type of computer memory used to quickly accept, store, and transfer data and instructions that are being used immediately by the CPU. The registers used by the CPU are often termed as Processor registers.
- A processor register may hold an instruction, a storage address, or any data (such as bit sequence or individual characters).
- The computer needs processor registers for manipulating data and a register for holding a memory address. The register holding the memory location is used to calculate the address of the next instruction after the execution of the current instruction is completed.

Register	Symbol	Number of bits	Function
Data register	DR	16	Holds memory operand
Address register	AR	12	Holds address for the memory
Accumulator	AC	16	Processor register
Instruction register	IR	16	Holds instruction code
Program counter	PC	12	Holds address of the instruction
Temporary register	TR	16	Holds temporary data
Input register	INPR	8	Carries input character
Output register	OUTR	8	Carries output character

Computer Registers

Register and Memory Configuration of a basic computer:



- The Data Register (DR) contains 16 bits which hold the operand read from the memory location.
- The Memory Address Register (MAR) contains 12 bits which hold the address for the memory location.
- The Program Counter (PC) also contains 12 bits which hold the address of the next instruction to be read from memory after the current instruction is executed.
- The Accumulator (AC) register is a general purpose processing register.
- The instruction read from memory is placed in the Instruction register (IR).
- The Temporary Register (TR) is used for holding the temporary data during the processing.
- The Input Registers (IR) holds the input characters given by the user.
- The Output Registers (OR) holds the output after processing the input data.
- The Memory unit has a capacity of 4096 words, and each word contains 16 bits.