Unit-1 Introduction of Single-Processor Computing and Parallel Computing

MODULE

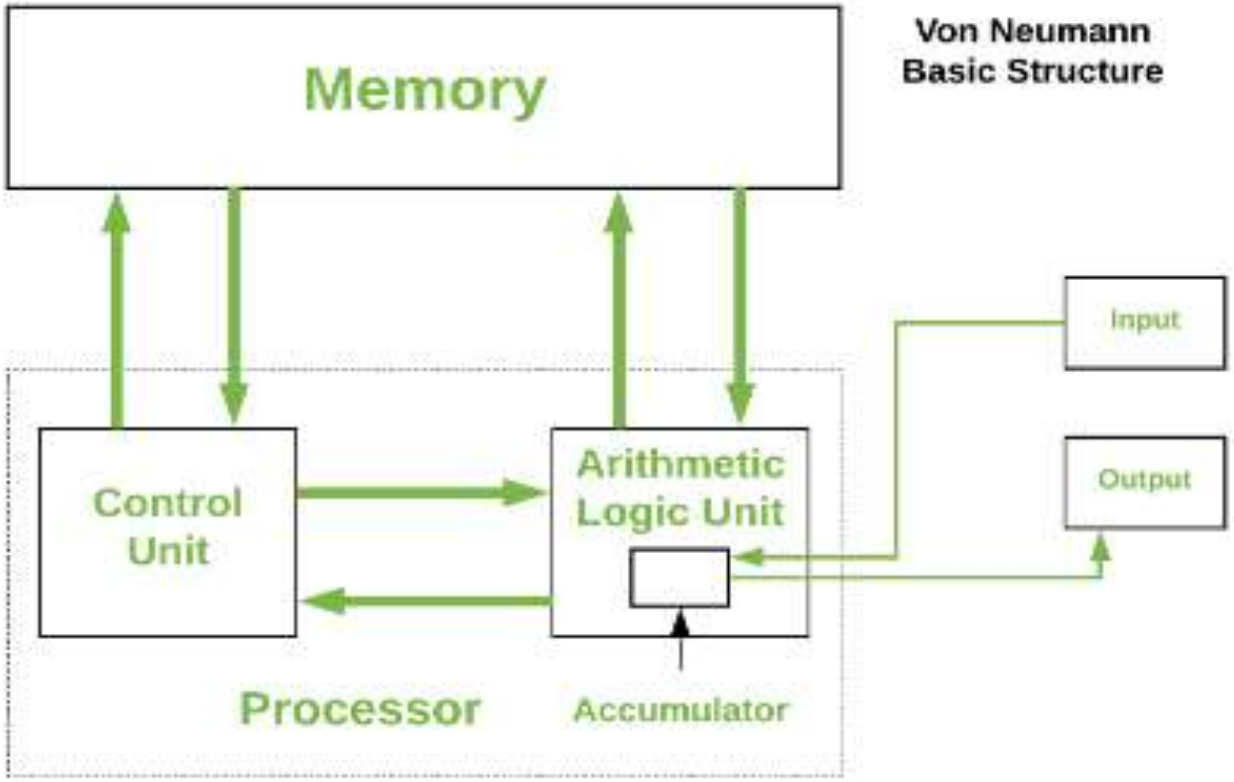
- Single-Processor Computing
- Parallel Computing

The Von Neumann architecture

- There have been 2 types of Computers:
- Fixed Program Computers – Their function is very specific and they couldn't be reprogrammed, e.g. Calculators.
- Stored Program Computers – These can be programmed to carry out many different tasks, applications are stored on them, hence the name.

- Modern computers are based on a stored-program concept introduced by John Von Neumann.
- In this stored-program concept, programs and data are stored in a separate storage unit called memories and are treated the same.
- This novel idea meant that a computer built with this architecture would be much easier to reprogram.

Structure of Von Neumann architecture



- It is also known as **ISA** (Instruction set architecture) computer and is having three basic units:
  - The Central Processing Unit (CPU)
  - The Main Memory Unit
  - The Input/output Device
- Let’s consider them in detail.

- **Control Unit –**
  A control unit (CU) handles all processor control signals. It directs all input and output flow, fetches code for instructions, and controls how data moves around the system.
- **Arithmetic and Logic Unit (ALU) –**
  The arithmetic logic unit is that part of the CPU that handles all the calculations the CPU may need, e.g. Addition, Subtraction, Comparisons. It performs Logical Operations, Bit Shifting Operations, and Arithmetic operations.

- Registers – Registers refer to high-speed storage areas in the CPU. The data processed by the CPU are fetched from the registers.
- There are different types of registers used in architecture :-
  - Accumulator: Stores the results of calculations made by ALU. It holds the intermediate of arithmetic and logical operations. it act as a temporary storage location or device.
  - Program Counter (PC): Keeps track of the memory location of the next instructions to be dealt with. The PC then passes this next address to the Memory Address Register (MAR).

- Memory Address Register (MAR): It stores the memory locations of instructions that need to be fetched from memory or stored in memory.
- Memory Data Register (MDR): It stores instructions fetched from memory or any data that is to be transferred to, and stored in, memory.
- Current Instruction Register (CIR): It stores the most recently fetched instructions while it is waiting to be coded and executed.
- Instruction Buffer Register (IBR): The instruction that is not to be executed immediately is placed in the instruction buffer register IBR.

- **Buses –** Data is transmitted from one part of a computer to another, connecting all major internal components to the CPU and memory, by the means of Buses.
- Types:
  - **Data Bus:** It carries data among the memory unit, the I/O devices, and the processor.
  - **Address Bus:** It carries the address of data (not the actual data) between memory and processor.
  - **Control Bus:** It carries control commands from the CPU (and status signals from other devices) in order to control and coordinate all the activities within the computer**.**

- Input/output Devices – Program or data is read into main memory from the input device or secondary storage under the control of CPU input instruction.
- Output devices are used to output information from a computer.
- If some results are evaluated by the computer and it is stored in the computer, then with the help of output devices, we can present them to the user.

Memory Hierarchies

- In the Computer System Design, Memory Hierarchy is an enhancement to organize the memory such that it can minimize the access time.
- The Memory Hierarchy was developed based on a program behavior known as locality of references. The figure below clearly demonstrates the different levels of the memory hierarchy.

Why Memory Hierarchy is Required in the System?

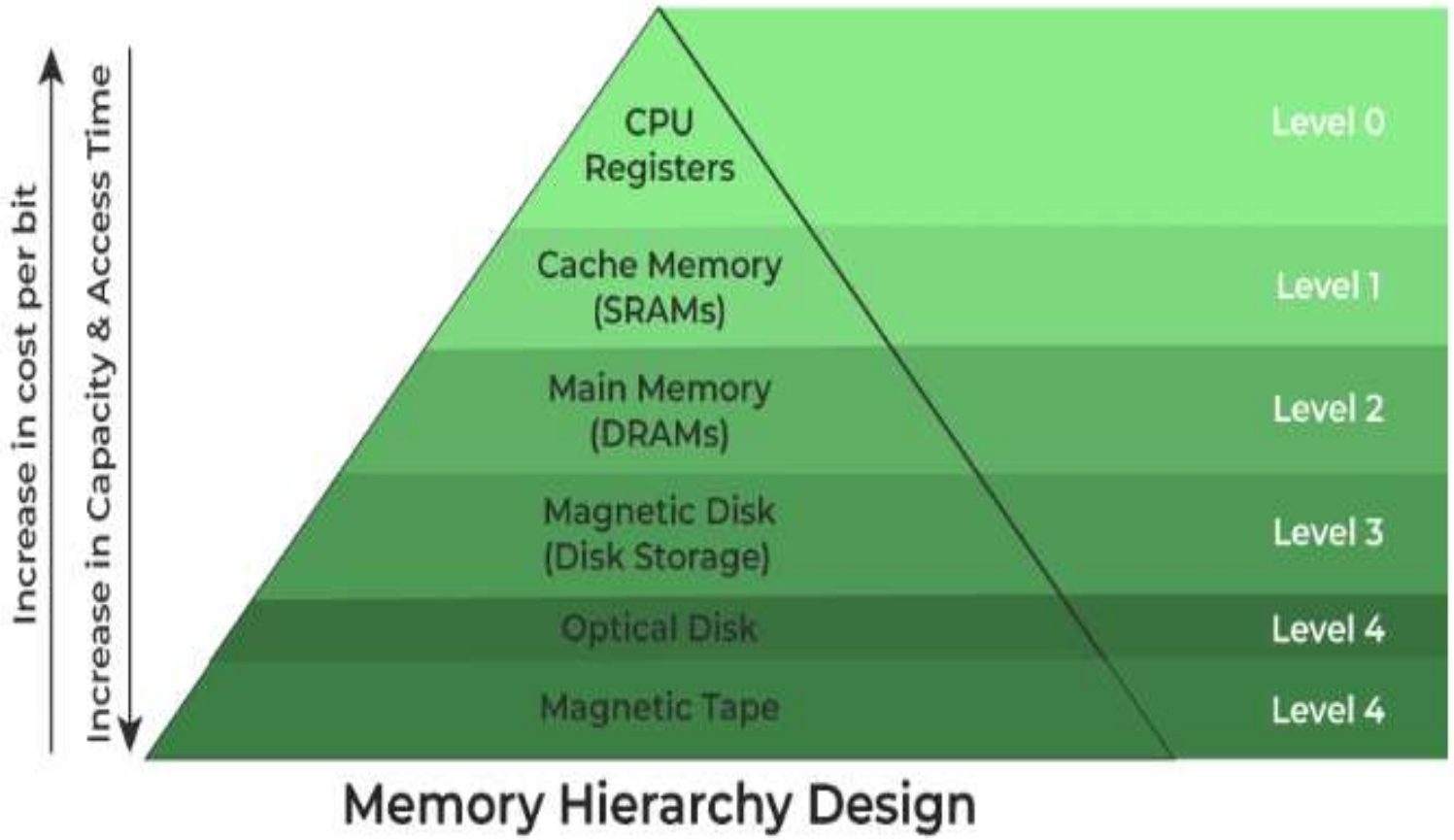
- Memory Hierarchy is one of the most required things in Computer Memory as it helps in optimizing the memory available in the computer.
- There are multiple levels present in the memory, each one having a different size, different cost, etc.
- Some types of memory like cache, and main memory are faster as compared to other types of memory but they are having a little less size and are also costly whereas some memory has a little higher storage value, but they are a little slower.
- Accessing of data is not similar in all types of memory, some have faster access whereas some have slower access.

Types of Memory Hierarchy

- This Memory Hierarchy Design is divided into 2 main types:
- **External Memory or Secondary Memory:**

  Comprising of Magnetic Disk, Optical Disk, and Magnetic Tape i.e. peripheral storage devices which are accessible by the processor via an I/O Module.
- **Internal Memory or Primary Memory:**

  Comprising of Main Memory, Cache Memory & CPU Registers. This is directly accessible by the processor.



Memory Hierarchy Design

Memory Hierarchy Design

- **1. Registers**

  Registers are small, high-speed memory units located in the CPU. They are used to store the most frequently used data and instructions. Registers have the fastest access time and the smallest storage capacity, typically ranging from 16 to 64 bits.

- **2. Cache Memory**

  Cache memory is a small, fast memory unit located close to the CPU. It stores frequently used data and instructions that have been recently accessed from the main memory. Cache memory is designed to minimize the time it takes to access data by providing the CPU with quick access to frequently used data.

- **3. Main Memory**

  Main Memory, also known as RAM (Random Access Memory), is the primary memory of a computer system. It has a larger storage capacity than cache memory, but it is slower. Main memory is used to store data and instructions that are currently in use by the CPU.
- **Types of Main Memory**
  - **Static RAM:** Static RAM stores the binary information in flip flops and information remains valid until power is supplied. It has a faster access time and is used in implementing cache memory.
  - **Dynamic RAM:** It stores the binary information as a charge on the capacitor. It requires refreshing circuitry to maintain the charge on the capacitors after a few milliseconds. It contains more memory cells per unit area as compared to SRAM.

- **4. Secondary Storage**
  - Secondary storage, such as hard disk drives(HDD) and solid-state drives(SSD), is a non-volatile memory unit that has a larger storage capacity than main memory. It is used to store data and instructions that are not currently in use by the CPU. Secondary storage has the slowest access time and is typically the least expensive type of memory in the memory hierarchy.

- **5. Magnetic Disk**
  - Magnetic Disks are simply circular plates that are fabricated with either a metal or a plastic or a magnetized material. The Magnetic disks work at a high speed inside the computer and these are frequently used.
- **6. Magnetic Tape**
  - Magnetic Tape is simply a magnetic recording device that is covered with a plastic film. It is generally used for the backup of data. In the case of a magnetic tape, the access time for a computer is a little slower and therefore, it requires some amount of time for accessing the strip.

Characteristics of Memory Hierarchy

- **Capacity:** It is the global volume of information the memory can store. As we move from top to bottom in the Hierarchy, the capacity increases.
- **Access Time:** It is the time interval between the read/write request and the availability of the data. As we move from top to bottom in the Hierarchy, the access time increases.
- **Performance:** Earlier when the computer system was designed without a Memory Hierarchy design, the speed gap increased between the CPU registers and Main Memory due to a large difference in access time. This results in lower performance of the system and thus, enhancement was required. This enhancement was made in the form of Memory Hierarchy Design because of which the performance of the system increases. One of the most significant ways to increase system performance is minimizing how far down the memory hierarchy one has to go to manipulate data.
- **Cost Per Bit:** As we move from bottom to top in the Hierarchy, the cost per bit increases i.e. Internal Memory is costlier than External Memory.

Advantages of Memory Hierarchy

- It helps in removing some destruction, and managing the memory in a better way.
- It helps in spreading the data all over the computer system.
- It saves the consumer's price and time.