Lecture 3

Learning outcomes:

- *A functional system diagram of a computer*
- *The microprocessor*
- *The bus. Memory, libraries*
- *Turing machine*
- *Neumann principle*

A functional system diagram of a computer

A functional System Diagram of a Computer

- ❖ The basic functional components or elements of a digital computer system basically have the hardware and software.

- ➢ The hardware is the physical component/part such as a keyboard, mouse, monitor, etc.

- ➢ The software is the set of programs and instructions that perform several specific operations.

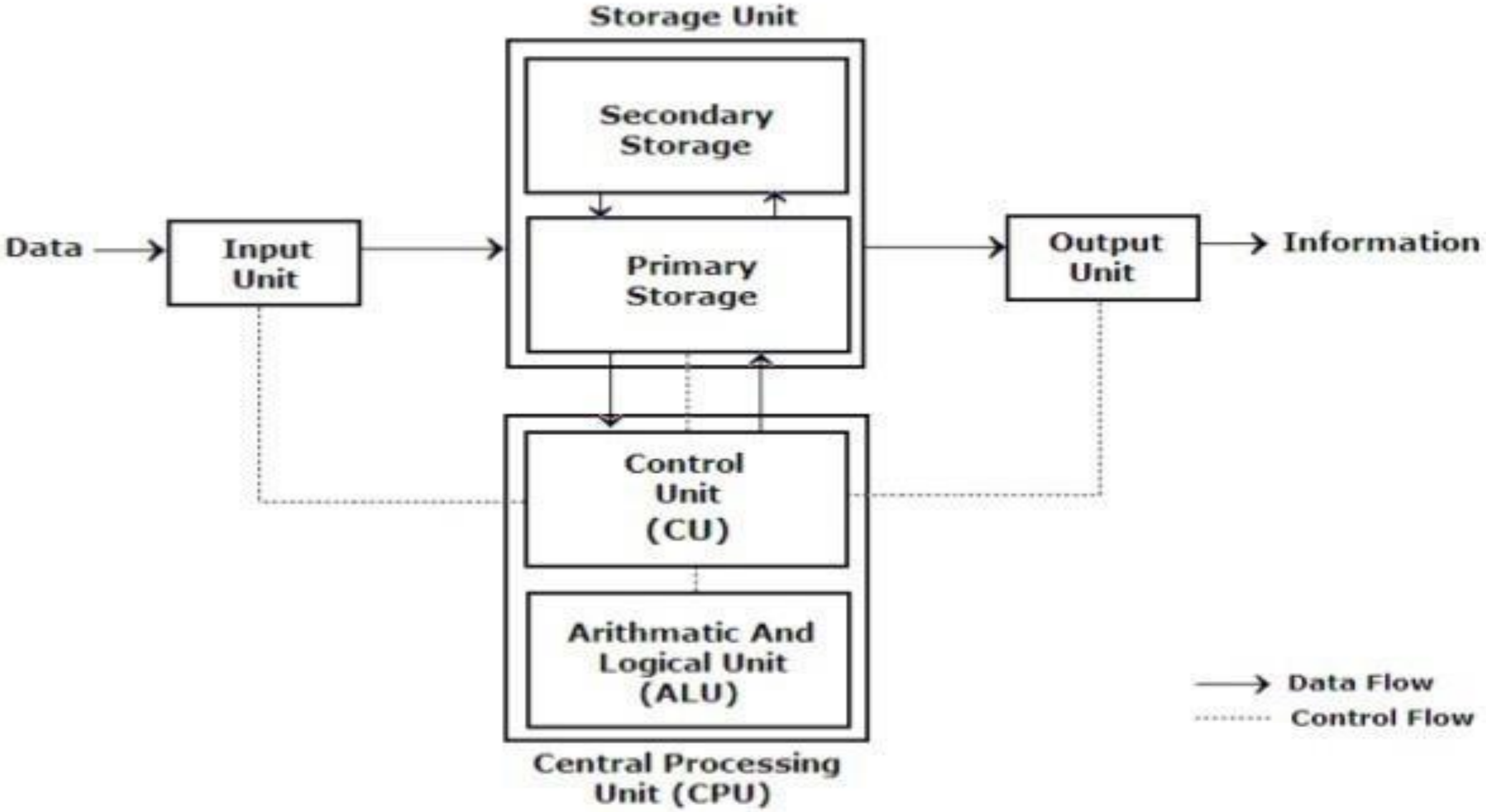
What is Block Diagram of Computer System?

- The Block Diagram of a Computer shows how data and instructions flow between the CPU, memory, and I/O devices, managed by the Control Unit.
- Simply put, it explains how computers work, from taking input, processing it, to giving the desired output.
- A computer system has three main parts: Input Units, CPU, and Output Units. These parts work together smoothly to perform tasks effectively.

Components of a Computer’s Block Diagram

- Input Unit
- Output Unit
- Central Processing Unit (CPU)
- Control Unit (CU)
- Arithmetic and Logic Unit (ALU)
- Memory Unit a) Primary Memory b)Secondary Memory

Block diagram of computer



Input Devices:

- Acts as the initial point for data entry into the computer system.
- Comprises devices like keyboards, mice, and scanners.
- Converts raw data into machine-readable form.
- Transmits converted data to the computer’s main memory.
- Facilitates the seamless exchange of information between users and computers.

Central Processing Unit (CPU):

- Often referred to as the brain of the computer, the CPU executes instructions, performs calculations, and manages data manipulation.
- Functions as the computer’s “brain,” overseeing all tasks and operations.
- Executes arithmetic and logical operations.
- Controls data processing, software operations, and hardware interactions.
- Consists of the Arithmetic Logic Unit (ALU), Control Unit (CU) and Memory.

Arithmetic Logic Unit (ALU) and Control Unit (CU):

- Arithmetic Logic Unit handles arithmetic and logical operations.

- The Control Unit coordinates and manages the flow of data and instructions within the computer. It fetches instructions from memory, decodes them, and directs the CPU and other components to execute the required operations.

Memory:

- Serves as the central storage hub for data within the computer system.
- Divided into primary (e.g., RAM) and secondary memory (e.g., hard disks).
- Primary memory stores temporary data for quick access.
- Secondary memory provides long-term storage capabilities.
- Works closely with the CPU to facilitate swift data access and processing.

Output Devices:

- Delivers processed information to users in readable formats.
- Includes devices like printers and monitors.
- Presents data as either soft copy (on-screen) or hard copy (on paper).
- Converts binary data into human-readable formats.
- Completes the cycle of information exchange by enabling users to interpret and utilize results effectively.

The microprocessor

The bus. Memory, libraries

Turing machine

Neumann principle

The microprocessor

- A microprocessor is a central processing unit (CPU) that serves as the brain of a computer or electronic device.

- It is an integrated circuit that performs arithmetic and logic operations, controls input and output devices, and executes instructions from memory.

- Microprocessors have revolutionized the computing world by enabling the development of powerful and versatile devices.

- The first microprocessor was the Intel 4004, introduced in 1971. The 4004 was not very powerful; it was primarily used to perform simple mathematical operations in a calculator called “Busicom.”

How do microprocessors work?

- Modern microprocessors combine millions of small transistors, resistors and diodes assembled on a semiconductor material to create the key components of a CPU.
- These components are arranged into various types of unique computer architecture to perform computations and run instructions.
- An average microprocessor's functions can be broken down into four main steps.

Key microprocessor steps

1. **Fetch:** The microprocessor retrieves (or "fetches") instructions from computer memory. The fetch process can be initiated by automatic or manual input.
2. **Decode:** The microprocessor "decodes" the instructions, essentially interpreting the input or command into a request and instigating a specific process or computation.
3. **Execute**: Simply put, the microprocessor performs the required or requested operation.
4. **Store:** The result of the execution is committed to the computer’s memory.

Microprocessor Components

- Microprocessors can complete these processes by combining the main components of a CPU into a singular circuit.
- **The key components of a microprocessor are the following:**

➢ Arithmetic logic unit (ALU): The main logic unit of the CPU, this component performs logical operations, including mathematical calculations and data comparisons.

➢ Control unit (CU): The CU circuit interprets instructions and initiates their execution, directing the processor's basic operations.

- Registers: Registers provide small, fast memory storage used by a CPU to temporarily hold data and instructions during computational processes.

- Cache memory: Microprocessors and CPUs use cache memory, a high-speed form of memory located close to the CPU, to store frequently accessed data to accelerate performance.

- Busses and bus interfaces: Bus interfaces provide entry and exit points for data to travel across various groups of wires (referred to as busses), such as the address bus or data bus. Busses and interfaces physically connect different internal components, enabling and facilitating communication within the CPU and other peripherals like input/output (I/O) units.

- Transistors: transistors are small semiconductors that regulate, amplify and generate electrical currents and signals. They can also act as simple switches or be combined to form logic gates. The number of transistors is a common indicator of microprocessor power.

- Processor cores: Individual processing units within microprocessors are known as cores. Modern processors frequently incorporate multiple cores (dual-core, quad-core) allowing for parallel processing by enabling the performance of multiple tasks simultaneously.

- Clock: Although not all microprocessors contain an internal clock, they are all clock-driven. Some rely on external clock chips, which are known for improved accuracy. Whether internal or external, a microprocessor's clock cycle determines the frequency at which it will carry out commands. Modern clock speeds are measured in megahertz (MHz) and gigahertz (GHz).

The Bus. Memory, Libraries

❖ **Bus System:** The bus system consists of a set of communication pathways that enable data transfer between different components of the computer. It facilitates the exchange of information between the CPU, memory, input/output devices, and other peripherals. This can include:

- Data Bus: Carries the actual data.
- Address Bus: Carries the address where the data needs to go.
- Control Bus: Carries control signals.

❖ ***What is the memory bus?***

- The memory bus is a type of computer bus, usually in the form of a set of wires or conductors which connects electrical components and allow transfers of data and addresses from the main memory to the central processing unit (CPU) or a memory controller.

❖ ***What is bus on RAM?***

- System RAM speed is controlled by bus width and bus speed. Bus width refers to the number of bits that can be sent to the CPU simultaneously, and bus speed refers to the number of times a group of bits can be sent each second. A bus cycle occurs every time data travels from memory to the CPU.

- ❖ **Libraries:** These are collections of precompiled routines, functions, or resources that programs can utilize to perform specific tasks, simplifying the development process by providing reusable code. In a broader sense, this might refer to:

- Static Libraries: Included in the executable at compile time, becoming part of the program itself.

- Dynamic Libraries: Loaded at runtime, allowing for shared use across different programs, offering flexibility and memory efficiency.

Turing Machine

- A Turing machine is an idealised model of a central processing unit (CPU) that controls all data manipulation done by a computer, with the canonical machine using sequential memory to store data.

- **Components of a Turing Machine:**

1. **Tape:** An infinite strip divided into cells, each containing a symbol from a finite alphabet. The tape serves as both input and memory for the machine.

2. **Head:** The part of the machine that reads and writes symbols on the tape and can move left or right one cell at a time.

3. State Register: Holds the current state of the Turing machine. There is a finite set of states, one of which is the initial state and one or more are halting states.

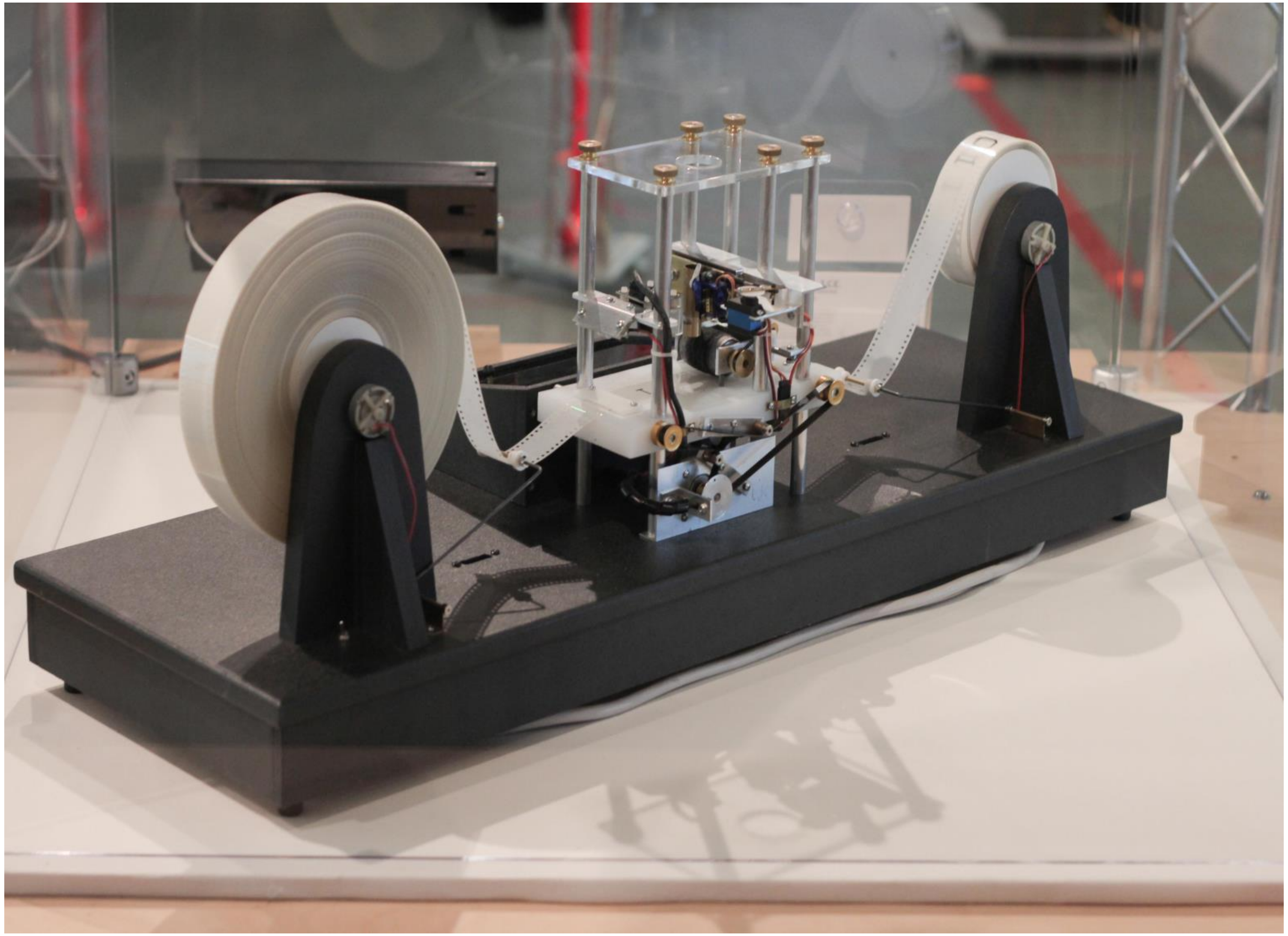
4. Transition Function: A set of rules that determine the machine's actions based on the current state and the symbol it is reading. The rules specify:

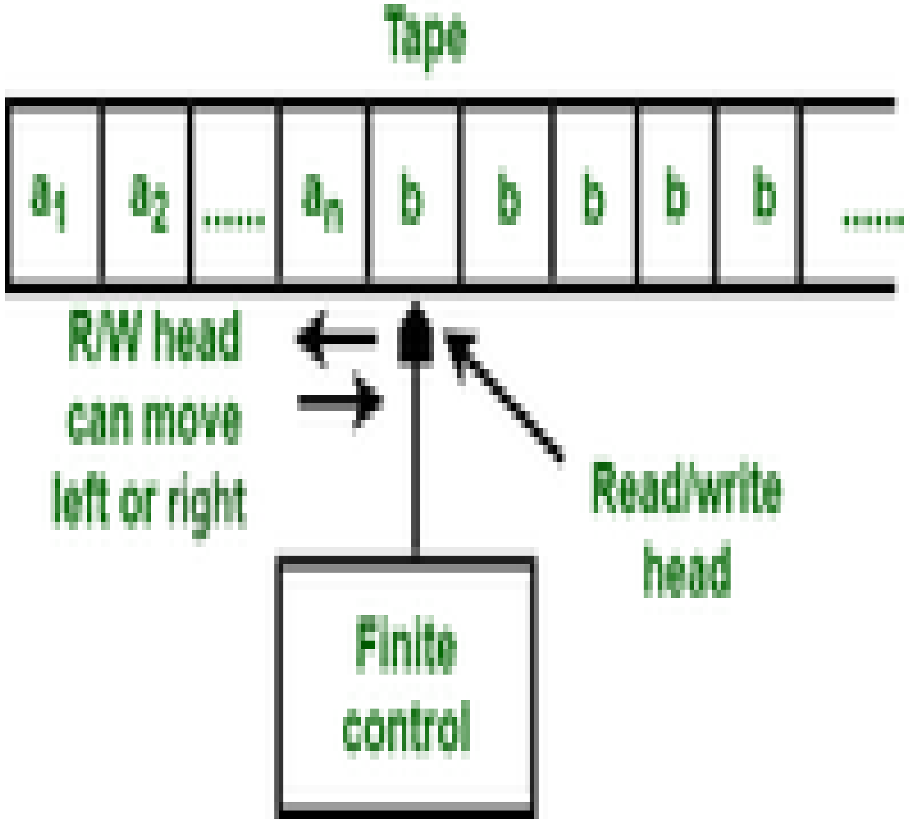
✓The new symbol to write on the tape.

✓The direction (left or right) to move the tape head.

✓The next state of the machine.

Turing Machine





How a Turing Machine Works

1. The machine starts in the initial state with the head positioned at a specific cell on the tape.
2. It reads the symbol in the current cell under the head.
3. Based on the current state and the symbol read, the machine uses the transition function to:

✓Write a new symbol in the current cell.

✓Move the head left or right.

✓Transition to a new state.

4. This process repeats until the machine reaches a halting state.

Example of Turing Machine Usage

- Algorithm Simulation: Turing machines can simulate any algorithm. They provide a way to formally define the steps involved in algorithmic computation.

- Decidability and Computability: They help in exploring questions of what problems can be solved by computers (decidability) and the resources required for their solution (computability).

Neumann Principle

- The Von Neumann architecture, named after the mathematician and physicist John von Neumann, describes a design framework for computers that has become the foundation for most of the computing systems in use today.

- This architecture is characterized by a specific organization of a computer system, emphasizing a few key principles and components.

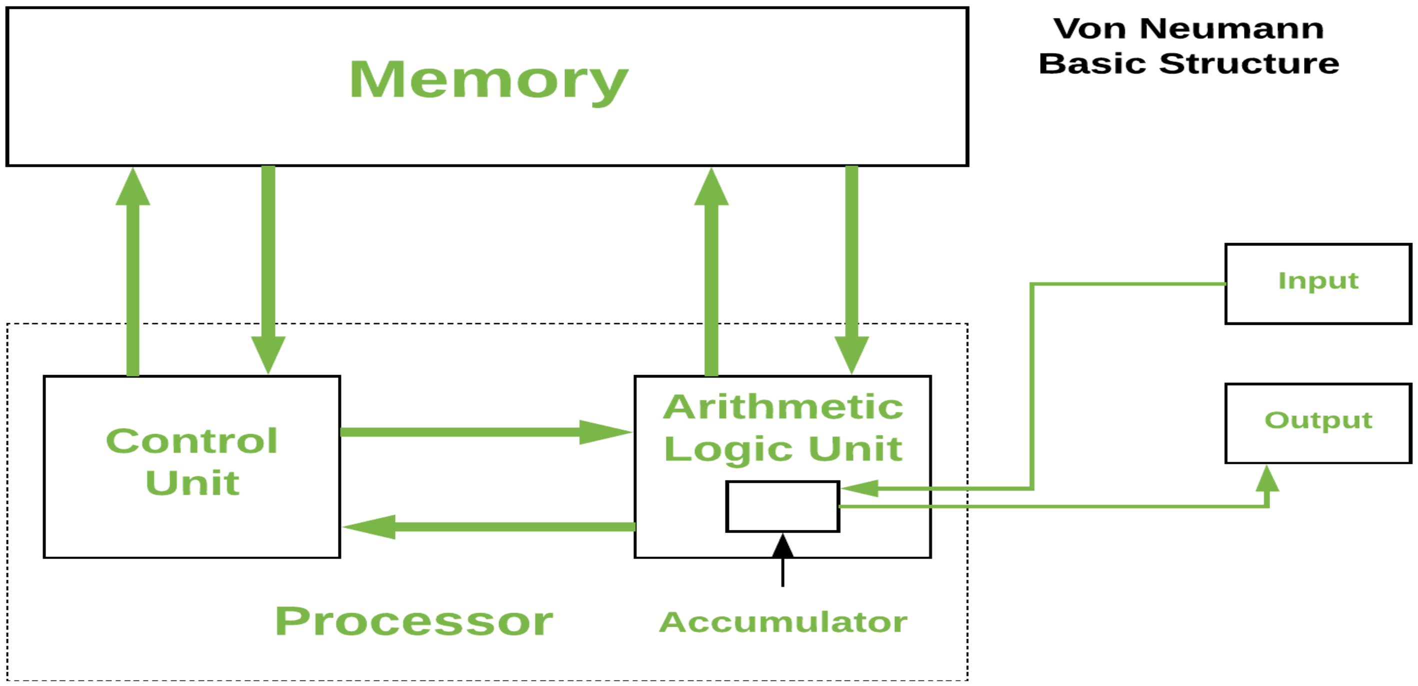
- The Von Neumann architecture laid the groundwork for modern computing by introducing the stored-program concept, where data and instructions coexist in memory, and the CPU follows a systematic cycle of fetching, decoding, and executing instructions.

Key Principles of the Von Neumann Architecture:

- Stored Program Concept:

- Both data and instructions are stored in the same memory.
- Instructions are fetched sequentially from memory and executed by the CPU, this creates a uniform address space, simplifying the design of the memory and CPU interaction.

Von Neumann Architecture



❑ Advantages of Von Neumann Architecture:

- ➢Simplicity: The design is straightforward, with a single memory for both data and instructions, reducing the complexity of hardware.

- ➢Flexibility: Storing programs in memory means they can be easily changed or updated by simply loading a new set of instructions.

- ➢Cost-Efficiency: The architecture is more cost-effective as fewer hardware components are required compared to other designs, such as Harvard architecture (***which separates data and instruction memory***).

❑ Disadvantages of Von Neumann Architecture:

- ➢Von Neumann Bottleneck: Since instructions and data share the same memory and buses, the system can be slowed down by the limited bandwidth between the CPU and memory. The processor must wait for data or instructions to be fetched sequentially, which can become a performance bottleneck.

- ➢Memory Latency: Accessing memory can slow down the system, especially in cases where frequent memory read/write operations are required.