SE1101 : COMPUTER ORGANIZATION
DS1106 : COMPUTER SYSTEM ORGANIZATION

Ms.S.Sweshthika
Lecturer (Probationary)
Department of Software Engineering
Faculty of Computing
Sabaragamuwa University of SriLank

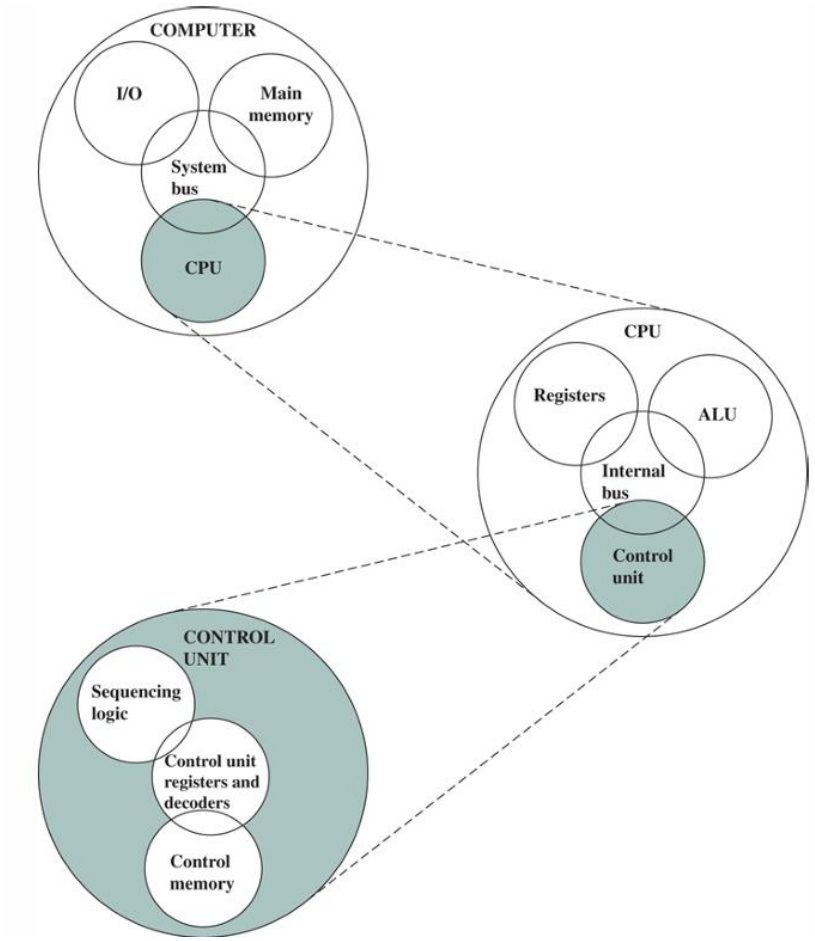
Evolution of Computer Systems: Hardwired Control to Von Neumann Architecture

Objectives

At the end of this lecture you will be able to explain,

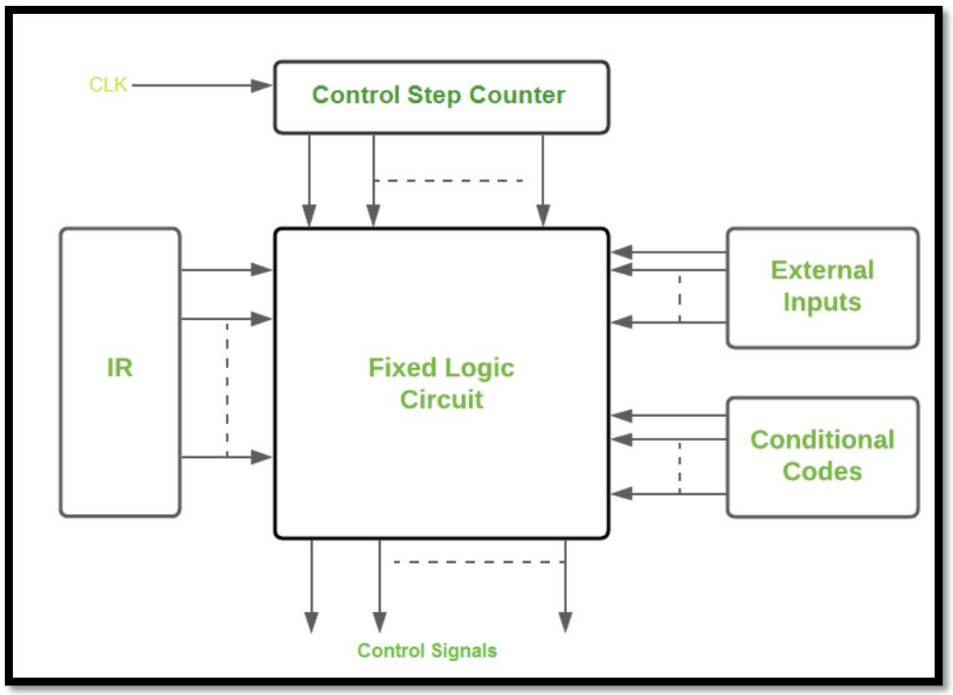
- Understand the basic components of the Von Neumann architecture.
- Explain the stored-program concept.
- Identify how data and instructions flow within a computer system.
- Recognize the limitations of the Von Neumann model

Simple Single-Processor Computer



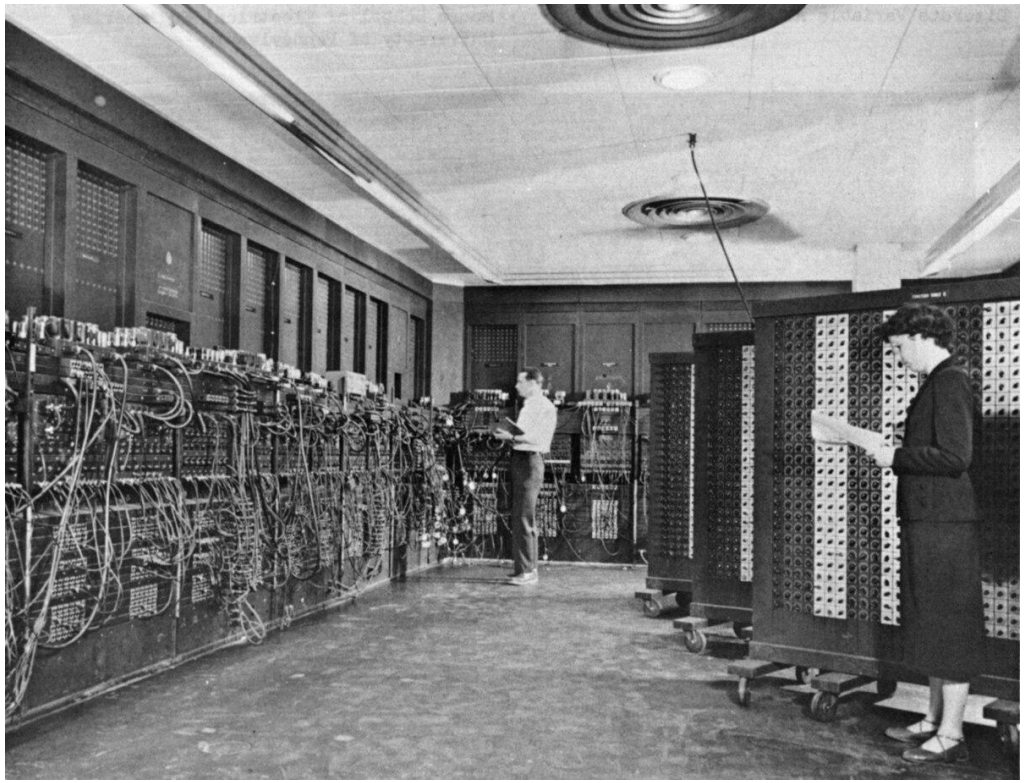
- **CPU (Central Processing Unit)**: Executes instructions and controls the operation of the computer.
- **Main Memory**: Stores both data and program instructions temporarily during execution.
- **I/O (Input/Output)**: Facilitates data exchange between the computer and the external environment.
- **System Interconnection**: Provides a communication path (like a system bus) for data transfer among CPU, memory, and I/O devices.

What is Hardwired Programming?



- Hardwired programming is an early form of computing where the logic for executing a program is physically built into the hardware.
- No software instructions were stored — all control was done through fixed electronic circuits.
- A method where program logic is hardcoded into the system.
- Programs were implemented by manually wiring or configuring circuits.

Characteristics of Hardwired Programming



- Not programmable by software :- instructions are fixed in hardware.
- Rewiring needed to change tasks :- physical changes to circuits.
- Used switches, cables, or relays to “program” the system.
- Designed for a single or limited set of tasks.
- Very limited in terms of functionality and flexibility.

Why Von Neumann Architecture?

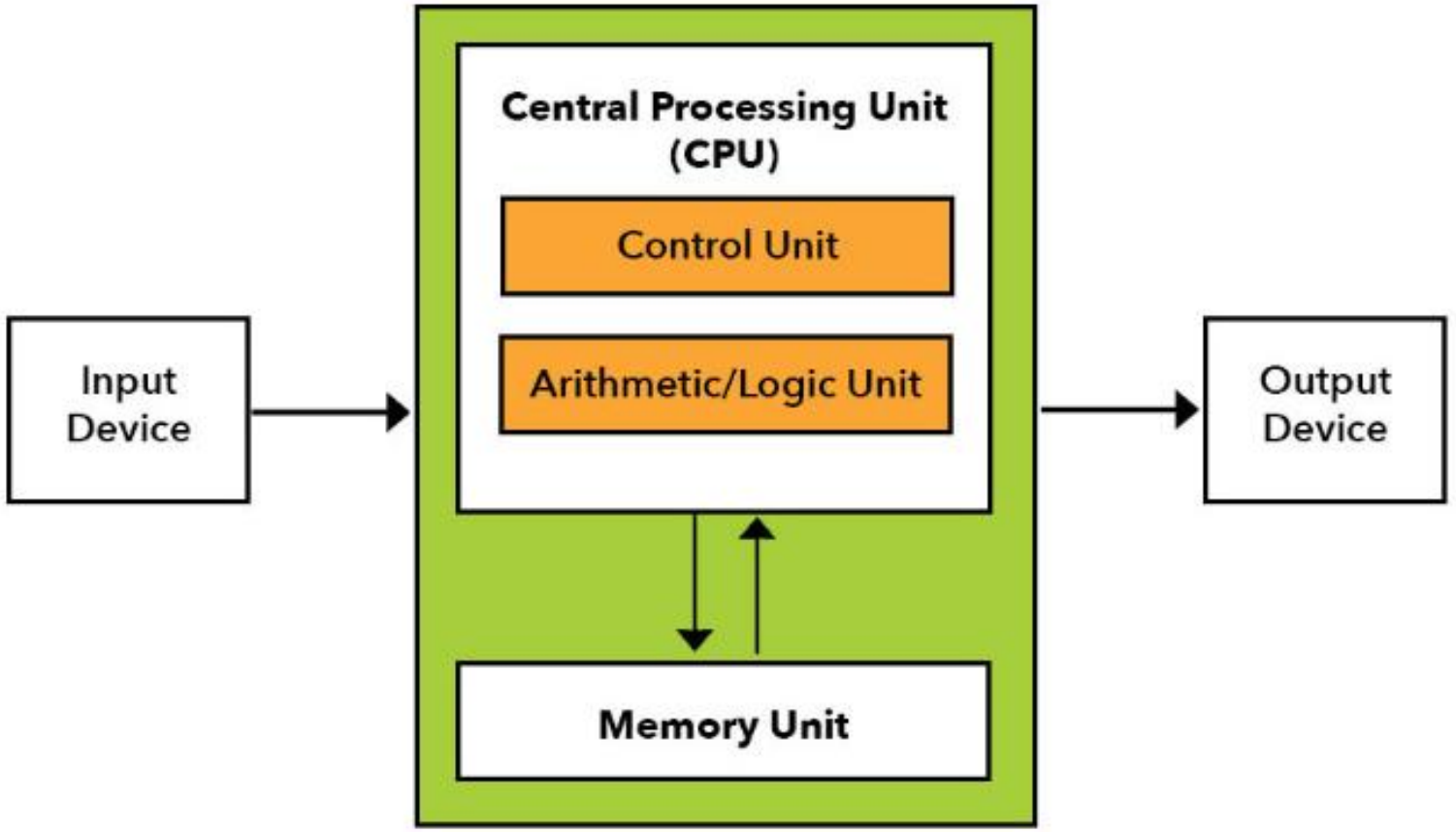
- **Hardwired systems were rigid and inflexible :-** Every new task required physical rewiring.
- **Reprogramming was slow and complex :-** Took days/weeks to change logic.
- **No memory for instructions :-** Instructions weren't stored, only executed through fixed circuits.
- **Von Neumann introduced the concept of a Stored-program computer** :- both data and instructions stored in memory.
- **This made computers more flexible, faster to reprogram, and general-purpose.**

First Stored Program Computer

John Von Neumann

- Father of Modern Computer Architecture.
- The Von Neumann architecture is a specific implementation of the stored program concept, proposed by John Von Neumann in 1945.

Von Neumann Architecture



Von Neumann Architecture Component Functions

- **Control Unit (CU) :-** Directs operations by fetching, decoding instructions, and controlling the execution cycle.
- **Arithmetic Logic Unit (ALU) :-** Performs all arithmetic operations and logical operations.
- **Memory Unit :-** Stores both data and instructions in the same memory.
- **Input Unit :-** Feeds data and instructions from the external world into the system.
- **Output Unit :-** Sends the processed data/results to the external world.
- **System Bus :-** Transfers data, addresses, and control signals among all units.

Main Components of Computer Functions

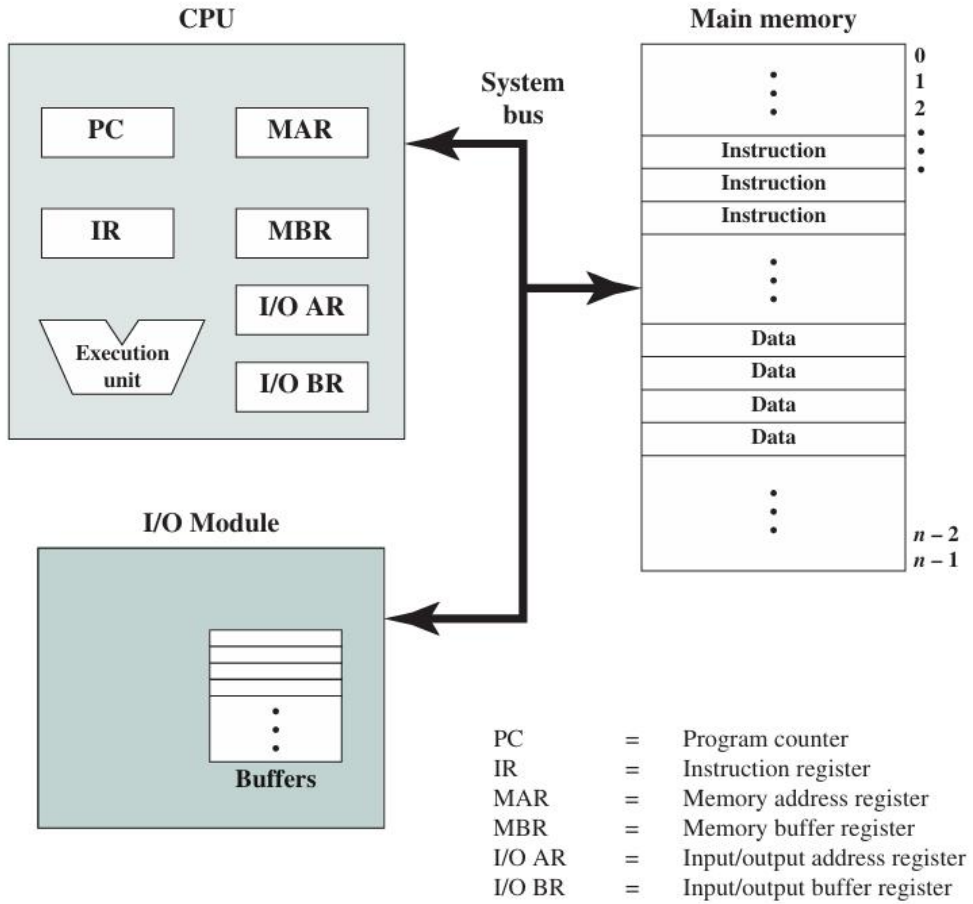


Figure 3.2 Computer Components: Top-Level View

Central Processing Unit

- CPU is like the brain of the computer.
- Main functions:- Fetch data and instructions from memory.
  :- Coordinate the complete execution of each instruction.
- Main Components of the CPU
  - ALU (Arithmetic and Logic Unit).
  - Control Unit.
  - Registers.

Registers in CPU

- Registers are small, high-speed storage units located inside the CPU.
- They temporarily store:
  - -Data
  - -Instructions
  - -Intermediate results
- Modern CPUs have multiple registers, each with a specific role.
- Ex: AH, AL, BH, BL (General purpose registers in x86 architecture)

Types of Registers in CPU

Register Type	Purpose
General Purpose Registers	Temporarily store operands or results of operations
Special Purpose Registers	Used for controlling or monitoring program execution

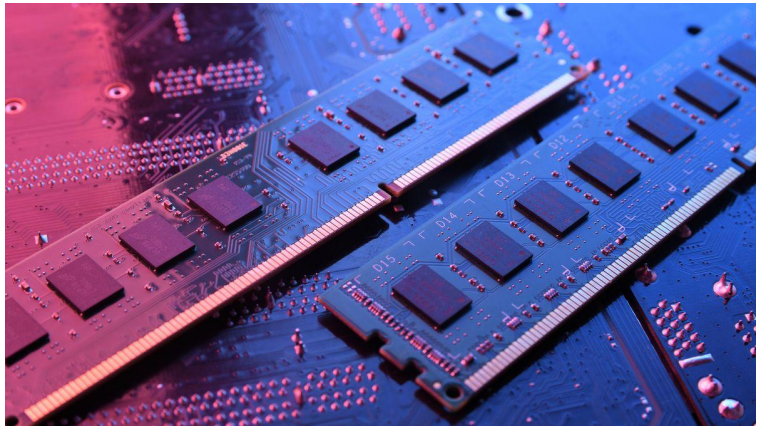
Note :- Special purpose registers include **PC, IR, MAR, MBR, Status Registers**.

Control Registers in CPU

Register	Function
Program Counter (PC)	Contains the address of the next instruction to be fetched
Instruction Register (IR)	Holds the currently executing instruction
Memory Address Register (MAR)	Stores the address in memory for the next read or write operation
Memory Buffer Register (MBR / MDR)	Temporarily holds data to/from memory during read/write
I/O Address Register (I/OAR)	Specifies the address of the I/O device involved in the data transfer
I/O Buffer Register (I/OBR)	Temporarily holds data being transferred to/from an I/O device and the CPU

Memory

•Memory is made up of storage cells, each capable of storing one binary digit (bit).
•A bit can be in one of two states: **0 or 1**, representing logical values.
•By combining multiple bits, we can store larger data such as numbers, characters, and instructions.
•Memory stores both data and instructions, as proposed in the Von Neumann model.

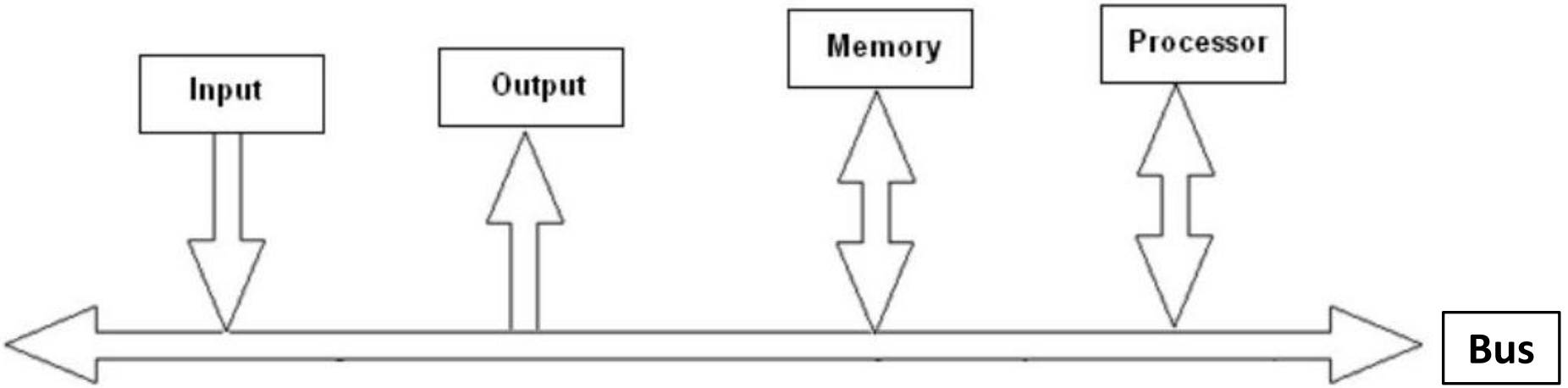


I/O Modules

•Acts as the communication bridge between the computer and the external world.
•**Input Function**: Accepts data and instructions from input devices (e.g., keyboard, mouse) and converts them into internal signals understandable by the system.
•**Output Function**: Converts internal signals into human- or machine-readable form and sends them to output devices (e.g., monitor, printer).
•Collectively called I/O components, they allow user interaction and external device integration.
•Essential for feeding data into the system and reporting results after processing.

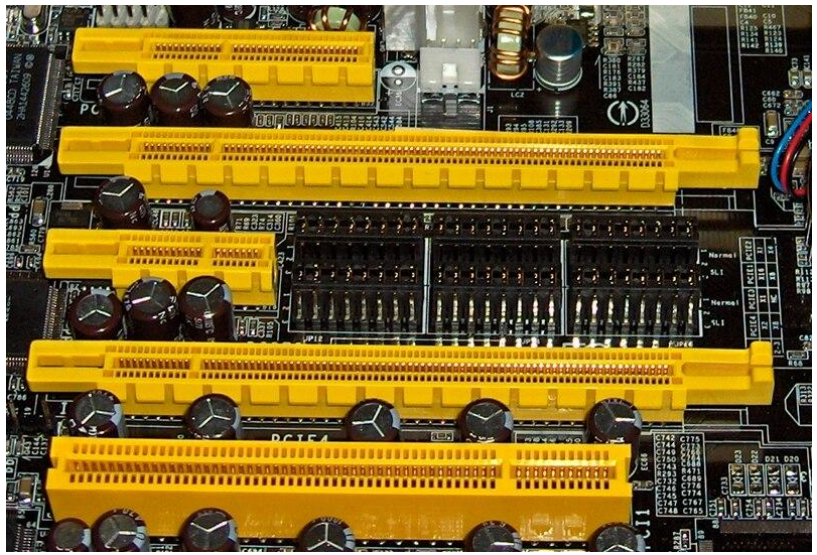
Bus Interconnection in Computer Systems

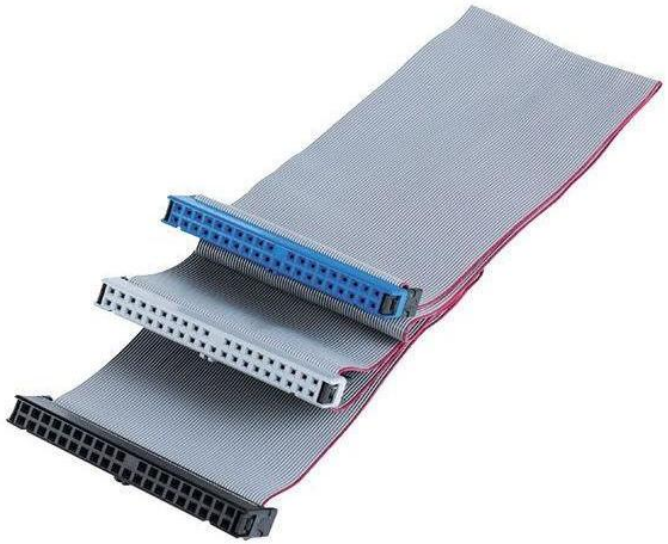
•A bus is a communication pathway connecting two or more devices.
•It is a shared transmission medium.
•Used in general-purpose computers and still common in embedded systems like microcontrollers.



Key Characteristics of a Bus

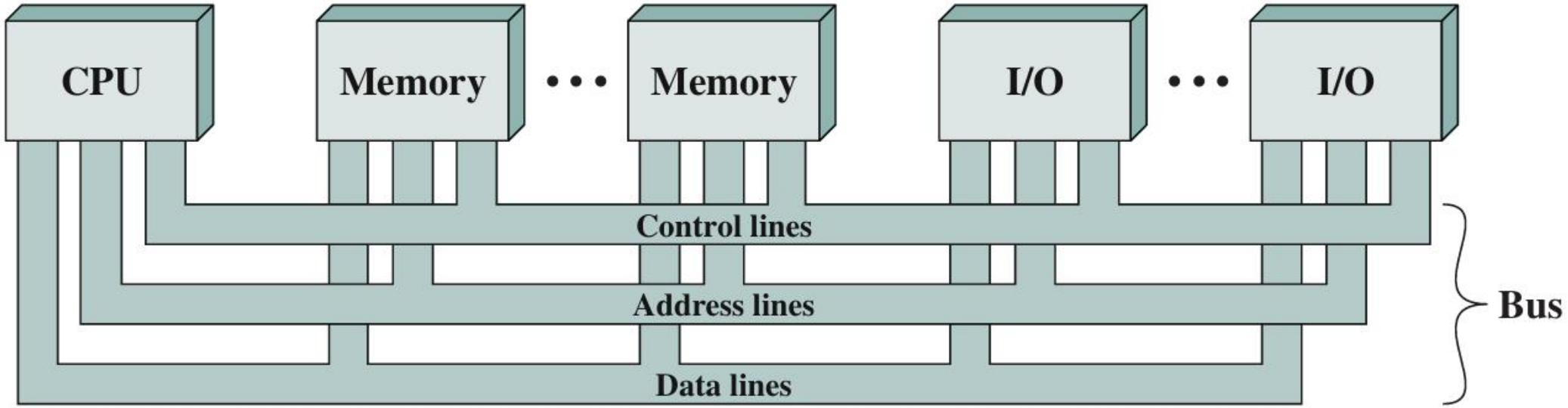
- Shared medium: only one device can transmit at a time.
- If two devices transmit simultaneously, data gets garbled.
- Multiple lines transmit binary data — parallel communication.





Types of Computer Buses

- **System Bus**: Connects CPU, Memory, and I/O modules.
- A system bus typically contains 50–100+ lines.



What is Data Bus?

- Carries data between system modules.
- Width (Eg: 32-bit, 64-bit) determines how many bits are transferred at a time.
- Impacts system performance.
- Bidirectional

What is Address Bus?

- Specifies the source or destination of data.
- Determines memory capacity.
- Used for both memory and I/O addressing.
- Uni-directional

What is Control Bus?

- Coordinates the operations of system modules.
- Sends command and timing signals.
- Important control signals:
  - Memory Read / Write
  - I/O Read / Write
  - Bus Request / Grant
  - Interrupt Request / ACK
  - Clock & Reset

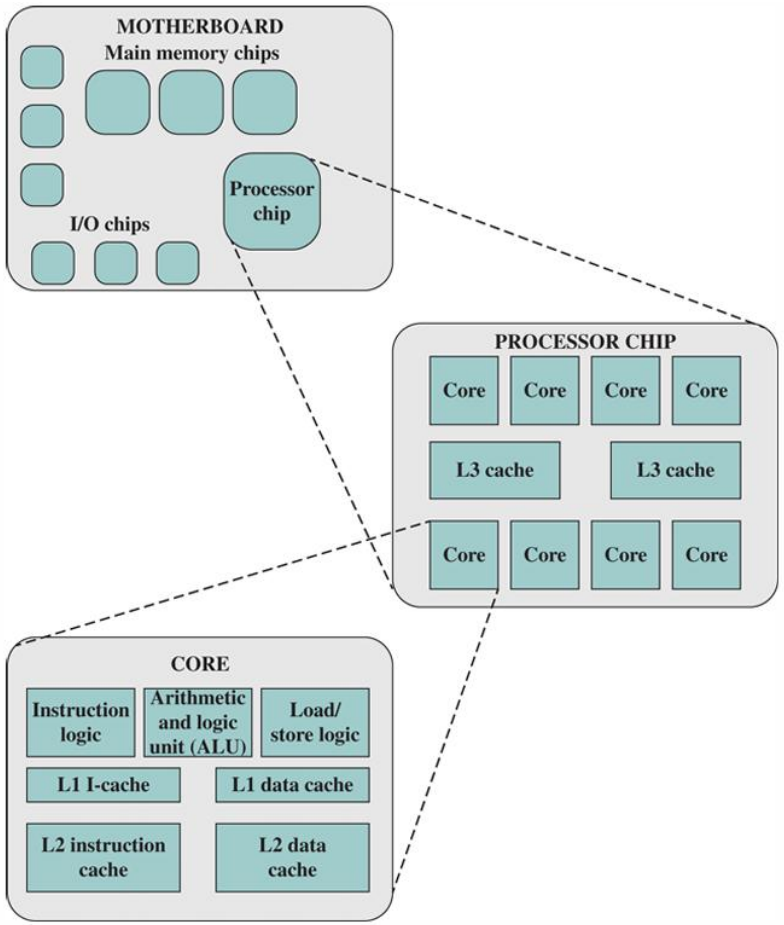
Note :- Control Bus is crucial for managing the flow of data and instructions.

:- May be bi-directional depending on system design.

Operation of a Bus

- To send data:
  - Request control of the bus.
  - Transmit data over the data bus.
- To receive data:
  - Request control of the bus.
  - Send read request.
  - Wait for data response.

Multicore Computer Structure



- **Core**: Each core functions like an independent CPU — it includes instruction logic, an ALU, registers, and local cache (L1/L2), capable of executing programs independently.
- **L3 Cache**: Shared, high-speed memory used by all cores to reduce access time to frequently used data and instructions.
- **Processor Chip**: A physical silicon component that integrates multiple cores and shared cache, enabling parallel processing and efficient multitasking.
- **System Board (Motherboard)**: Hosts the processor chip, memory slots, I/O controllers, and expansion slots to interconnect all major components of a computer system.

Key Takeaways

•The Von Neumann Architecture introduced the stored-program concept, enabling flexible and general-purpose computing.
•Core components of the Von Neumann model:
•CPU, Memory, I/O modules, and Buses.
•The CPU consists of Control Unit, ALU, and Registers that manage instruction execution.
•Memory stores both data and instructions in binary format.
•I/O Modules handle data exchange with external devices.
•The System Bus (data, address, control lines) enables communication among all system parts.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Thank
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