Ministry of Higher Education and Scientific Research
العلمي البحث و العالي التعليم وزارة

BADJI MOKHTAR-ANNABA UNIVERSITY
UNIVERSITE BADJI MOKHTAR-ANNABA

جامعة باجي مختار-عنابة

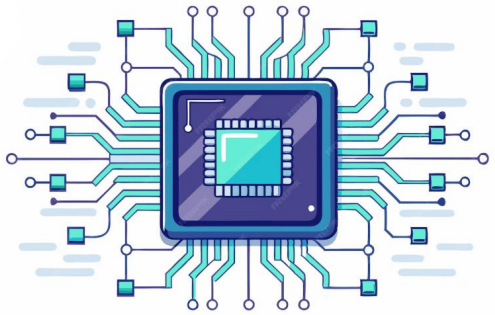
Faculty of technology
Electronics departement

Embedded Computing Systems course

Teaching method : Distance learning

Chapter 2
Architecture of Microprocessors

Course 3



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Promotion : 2025/2026

❑ Von Neumann and Harvard Architecture

There are two main architectures for microprocessors (MP) and computer systems:

In a **Von Neumann architecture** , Data and instructions (program code) share the same memory and the same bus system; The CPU can access only one item at a time from the shared memory either an instruction or data, but not both simultaneously.

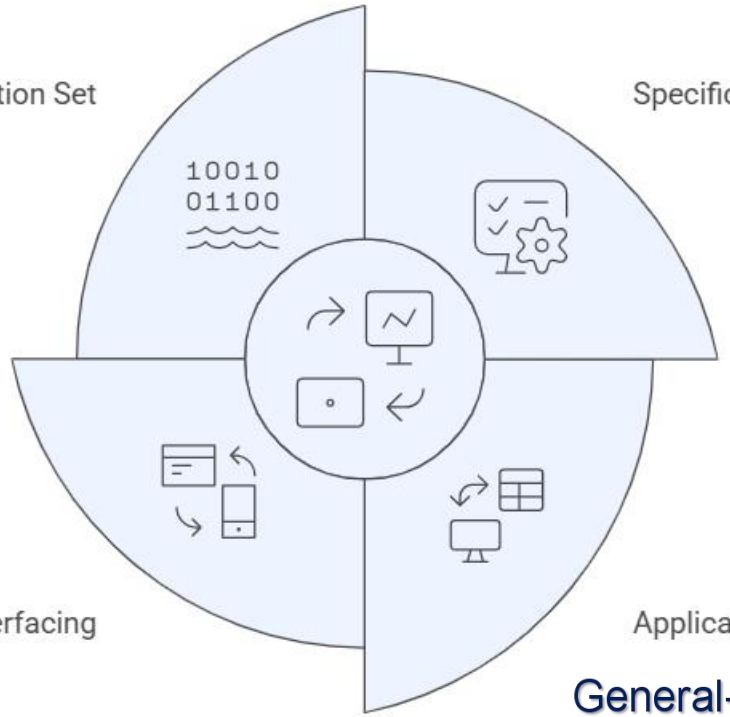
In the **Harvard architecture** , Data and instructions are stored separately in different memories, each with its own bus; The CPU can fetch instructions and data simultaneously faster performance.

❖ Classification of Microprocessors

Classification of Microprocessors based on their specifications, applications, interfacing, and instruction set

CISC (Complex Instruction Set Computer)/ RISC (Reduced Instruction Set Computer) or both

Instruction Set



Specifications

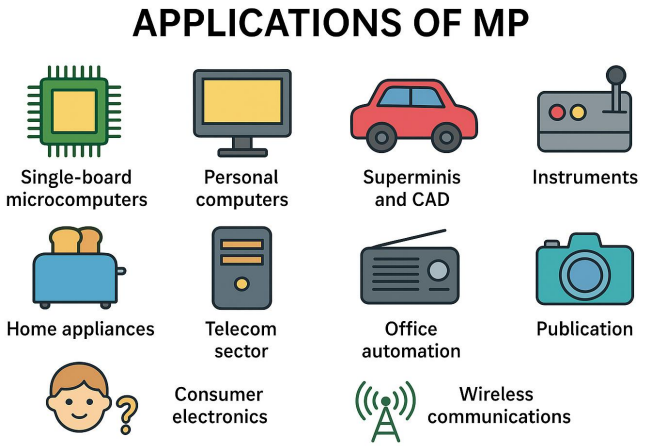
Word length, speed, bus width
words: can be 8, 16, or 32 bits…

Connecting the Mp with memory and I/O devices to enable communication

Interfacing

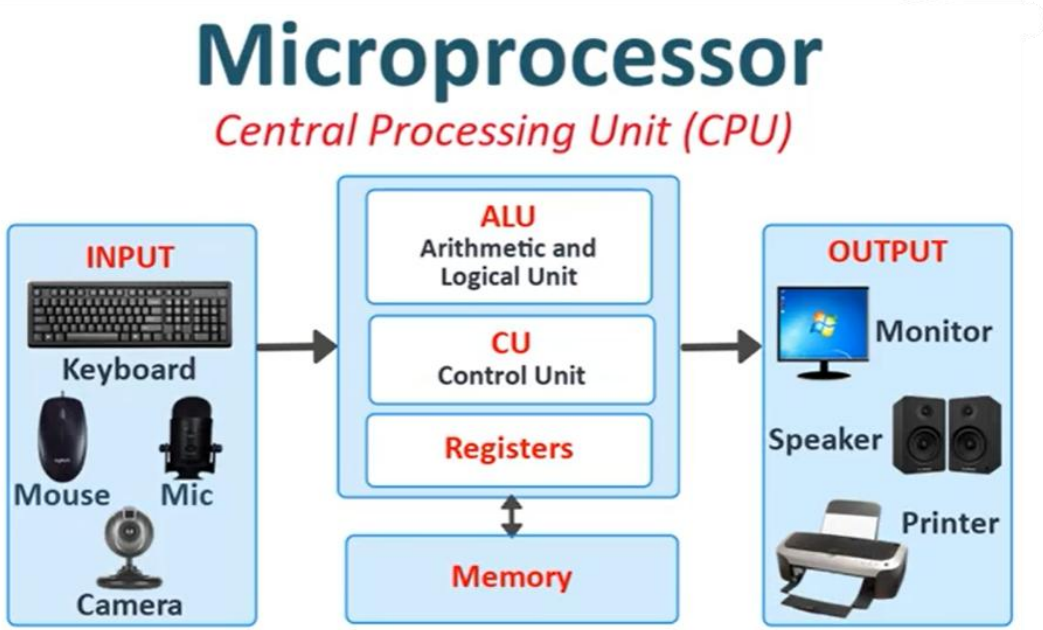
Applications

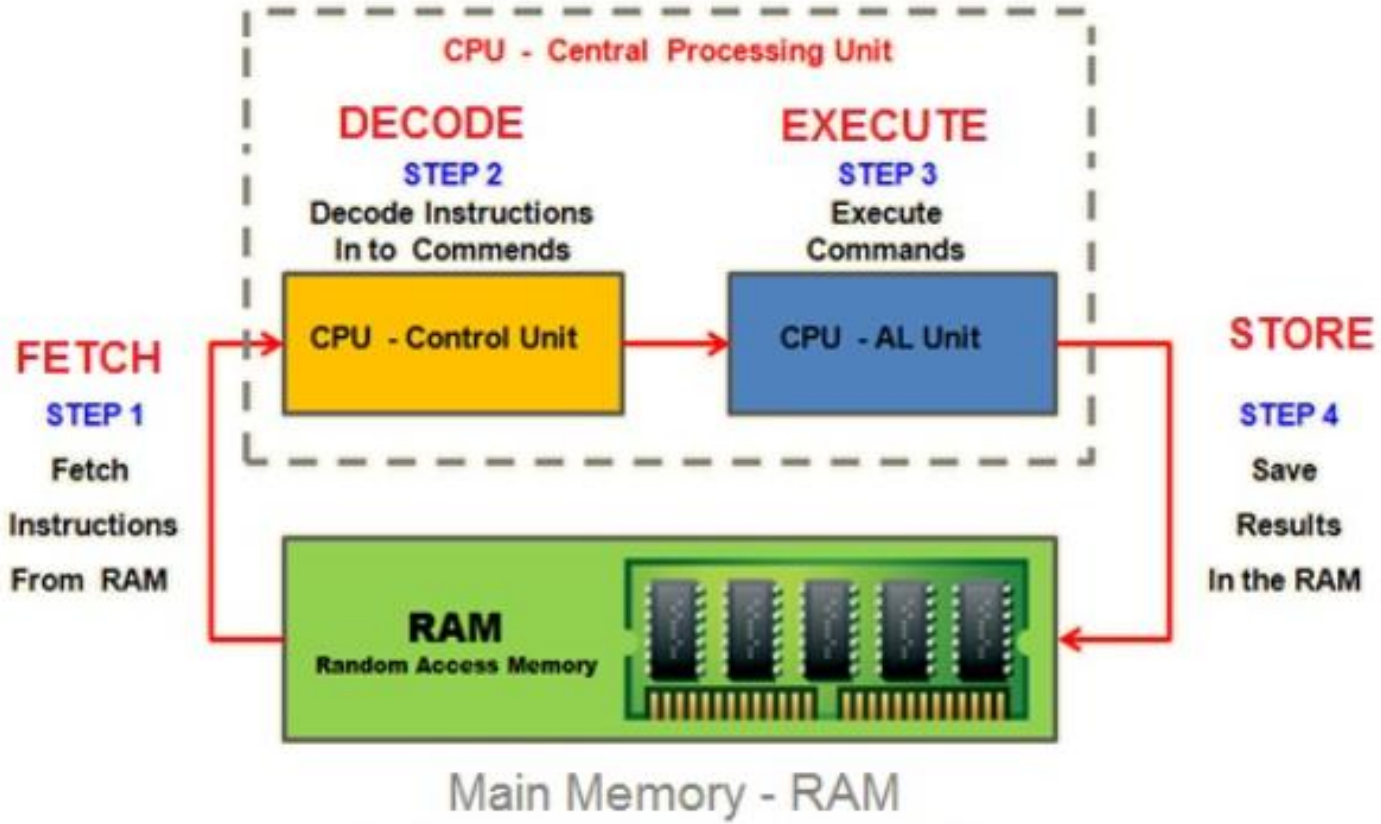
General-purpose, embedded, DSP, microcontroller



❖ External architecture of a Microprocessor:

The external architecture describes how the microprocessor connects to the outside world — memory, input/output devices, and buses; it communicates with **memory** and I/O devices through buses. Inside the CPU, the **ALU** performs arithmetic and logic operations, the **Control Unit (CU)** manages instruction execution, and the **Registers** temporarily store data and addresses.




CPU - Central Processing Unit
DECODE
STEP 2
Decode Instructions
In to Commends
EXECUTE
STEP 3
Execute
Commands
CPU - Control Unit
CPU - AL Unit
FETCH
STEP 1
Fetch
Instructions
From RAM
STORE
STEP 4
Save
Results
In the RAM
RAM
Random Access Memory
Main Memory - RAM

- **Memory** is the storage area where the microprocessor keeps data and program instructions, It is used to store information temporarily or permanently works closely with the CPU through address, data, and control buses to ensure smooth data transfer and program execution; There are two main types of memory: **RAM** (Random Access Memory)and **ROM** (Read-Only Memory)
- **I/O devices:** allow the microprocessor to communicate with the external world
  - Input devices (like keyboards, sensors, or switches) send data and signals to the microprocessor.
  - Output devices (LEDs, motors, or printers) receive data from the microprocessor to perform actions or display results.
- **The external clock** provides timing pulses that synchronize all CPU operations. Its frequency (in Hz) determines how fast the microprocessor executes instructions higher frequency means faster processing.
- **The Reset signal** initializes the microprocessor and sets it to a known starting state; It clears all registers, resets the Program Counter (PC) to zero (or a fixed address), and stops any current operations, preparing the system to start or restart program execution safely.
- **Interrupt (INT)** is a signal that temporarily stops the normal execution of a program to allow the CPU to respond to an urgent task or event.

How to calculate memory capacity from data and address buses?

- **Data bus width (D):** number of bits transferred in parallel (e.g. 8, 16, 32 bits).

- **Address bus width (A):** number of address lines; it determines how many memory locations can be addressed: 2^A (each address corresponds to one byte (8 bits)

- Total capacity in bits:

Number of addressable locations:

$$\text{Locations} = 2^A$$

Total capacity in bits: $\text{Capacity}_{bits} = 2^A \times D$

Total capacity in bytes: $\text{Capacity}_{Bytes} = \frac{2^A \times D}{8}$

The microprocessor performs three main tasks within a computer system:

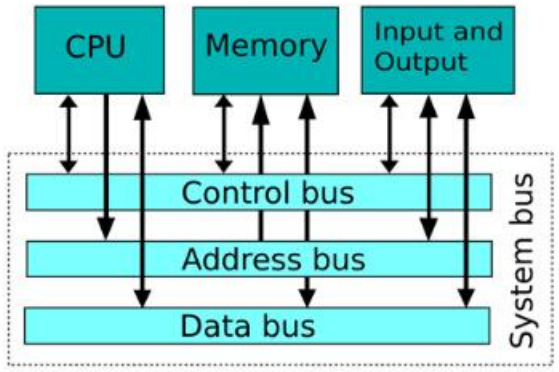
- ✓ Data transfer between itself and the memory or input/output (I/O) devices,
- ✓ Arithmetic and logic operations for data processing,
- ✓ Program execution through simple decision-making processes.

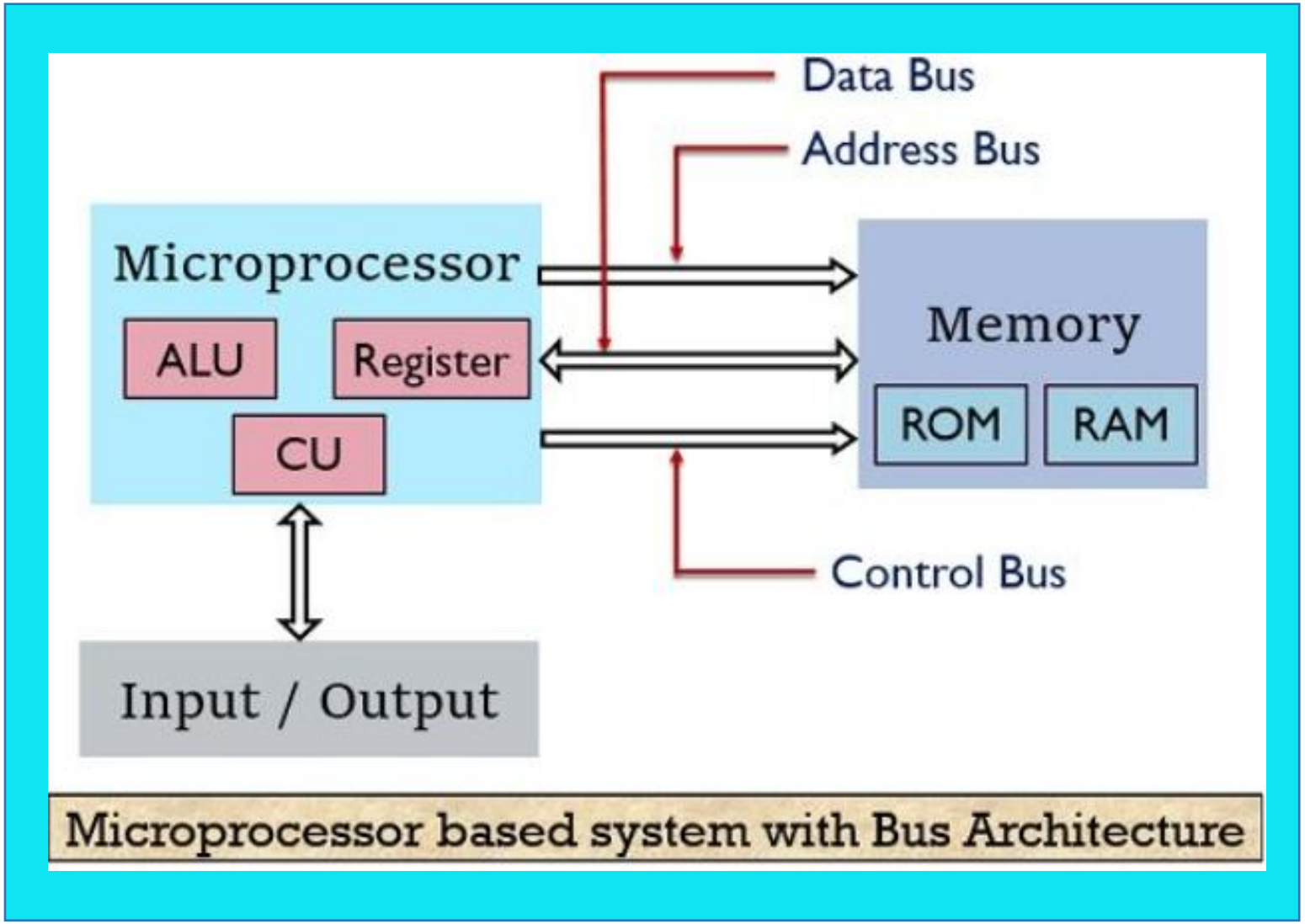
To carry out these tasks efficiently, the microprocessor uses buses — communication pathways that transfer data, addresses, and control signals between the CPU, memory, and I/O systems.

→ **Data Bus:** Transfers data between the microprocessor and other devices; It is bidirectional (data can move both ways).

→ **Address Bus:** Transfers the address of a memory location or device; It is unidirectional (address goes only one way: from CPU to memory/peripherals).

→ **Control Bus:** Transfers control signals (for example: read, write, clock, reset).




Data Bus
Address Bus
Microprocessor
ALU
Register
CU
Memory
ROM
RAM
Control Bus
Input / Output
Microprocessor based system with Bus Architecture

❖ Internal architecture of a Microprocessor:

The internal architecture refers to the components inside the CPU chip the parts that perform computation, control, and data processing.

1. ALU (Arithmetic Logic Unit): Performs arithmetic operations: addition, subtraction, multiplication; Performs logical operations: AND, OR, compare (<, >, =).

It contains several key components:

- **Adder and Subtractor:** Perform addition and subtraction of binary numbers , they are used for arithmetic calculations and address generation.
- **Logic Circuit:** Executes logical operations such as AND, OR, NOT, XOR, etc.
- **Comparator:** Compares two binary values to determine their relationship (equal, greater than, or less than) and used in decision-making and conditional instructions.
- **Accumulator:** Works closely with the ALU; holds one operand and stores the result of operations.

2. Control Unit:

Produces control signals, directs the operation of the microprocessor and other devices and

Ensures that everything works synchronously with the clock:

- Generates control signals to command other CPU parts (ALU, registers, memory, I/O).
- Directs the sequence of operations : fetch, decode, execute, and store.
- Interprets instructions received from the instruction register.
- Ensures synchronization of all actions with the clock signal.

3. Registers:

Small, high-speed storage locations inside the CPU that temporarily hold data, addresses, and instructions. They provide much faster access than the main memory.

- **Temporary Register:** Holds the second operand for ALU operations; works with the accumulator
- **General Purpose Registers:** Store data temporarily during program execution; accessible to programmers
- **Instruction Register:** Holds the current instruction fetched from memory
- **Decoder:** Interprets the instruction and sends signals to the Control Unit
- **Status Register/Flags:** Register contains individual bits that indicate the outcome of operations, such as carry, overflow, zero result, and others. These flags help in making decisions and controlling program flow based on the results of previous operations
- **Program Counter (PC):** Contains the address of the next instruction to be fetched.
- **Stack Pointer (SP):** Points to the top of the stack in memory (used for subroutines and interrupts).

- **Internal buses** are the communication pathways inside the CPU that connect its internal components such as the ALU, Control Unit, and Registers, they transfer data, addresses, and control signals within the microprocessor, allowing all parts to work together efficiently.
- The internal clock (Inside the CPU) is the timing circuit within the microprocessor that synchronizes all internal operations, It ensures that every part of the CPU :ALU, registers, and control unit works together in perfect timing.