Unit 2

Register Transfer and Microoperations

2.1 Register and Register Transfer Language

2.2 Bus and Memory Transfers

2.3 Arithmetic, Logic and Shift Micro-operations

2.4 Arithmetic Logic Shift Unit

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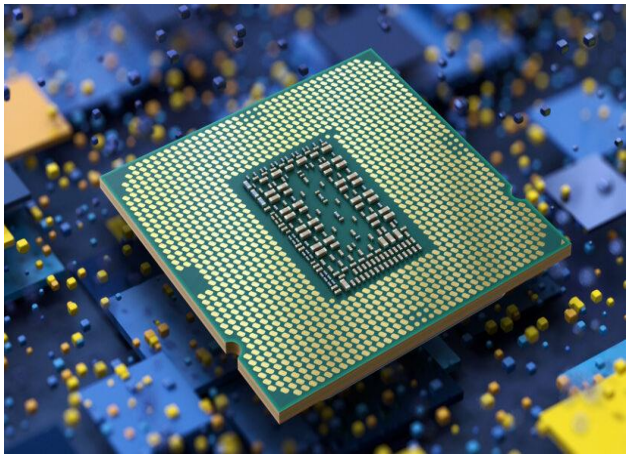
What is a CPU?



The **CPU (Central Processing Unit)** is the **brain of a computer or mobile device**.
It performs all major operations such as:

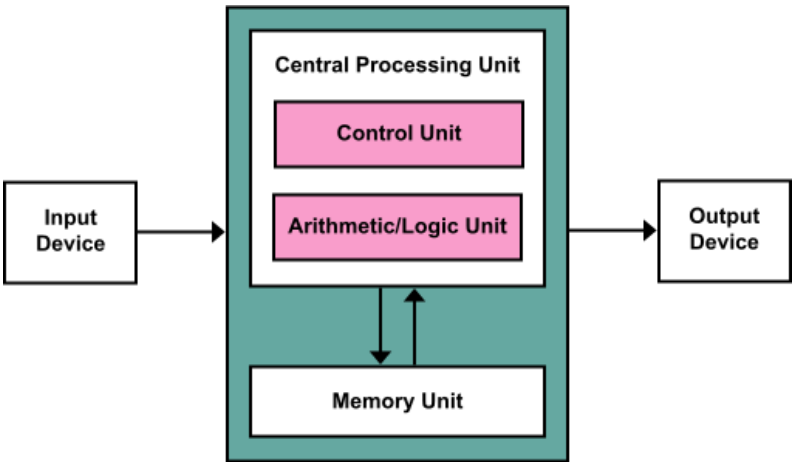
- Fetching instructions
- Decoding them
- Executing mathematical and logical tasks
- Storing or transferring results

A CPU works billions of times per second (GHz speed).

Modern examples

- In laptops: Intel i5, i7, AMD Ryzen CPUs
- In mobile phones: Snapdragon, Apple A16 Bionic, MediaTek, Exynos

Even apps like Facebook, TikTok, PUBG, banking apps all run because the CPU executes the instructions behind them.



CPU Components

A CPU has three main internal units:

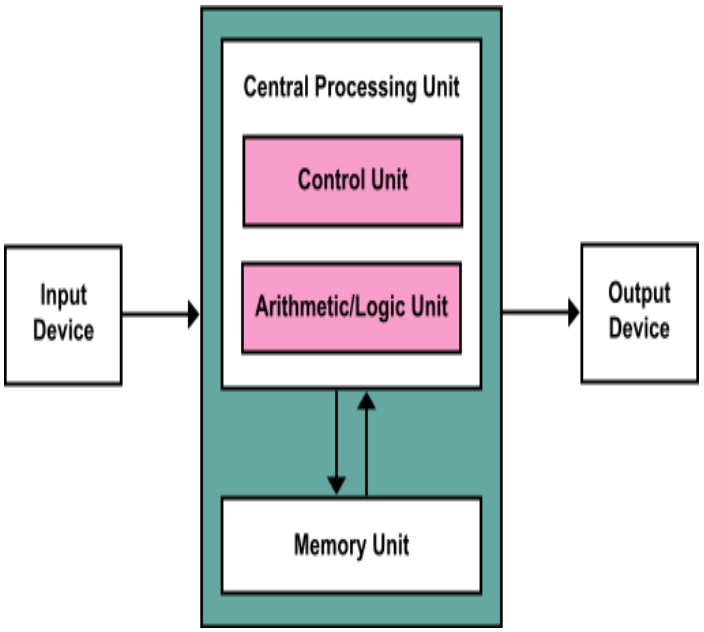
1. Register Set

Small storage areas inside CPU used for fast data access.

2. ALU (Arithmetic Logic Unit)

Performs operations like addition, subtraction, AND, OR, shifts, comparisons, etc.

3. CU (Control Unit)



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Controls the flow of data, signals, timing, fetch–decode–execute cycle.

Modern mobile/PC CPUs also include:

- Cache memory (L1, L2, L3)
- Floating point unit (FPU)
- Vector processing units (NEON in ARM, SIMD on Intel)
- Pipelines
- AI accelerators

How Registers Are Used in Real Devices?

Registers hold temporary values during app execution.

Example from a mobile app:

1. You click "Like" on Facebook → CPU loads instruction into **IR (Instruction Register)**
2. The value '1' is stored in **ALU registers**
3. The address of your account ID is stored in **MAR/MDR**
4. If you press "Send Message" → Characters typed are stored into registers before going into RAM

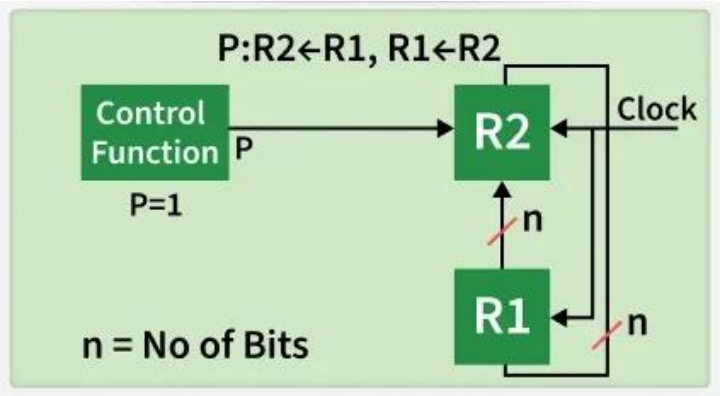
Registers are SUPER FAST (nanoseconds).
They are used for:

- Loop counters
- Temporary variables
- Function parameters
- Memory addresses
- Flags (zero, carry, negative, overflow)

Example:
When PUBG detects a bullet hit, the CPU uses registers to calculate damage instantly.

How Logic Works in CPU (Real Example)

Suppose your calculator app does:



27 + 18

Internally:

- 27 is loaded into register R1
- 18 is loaded into register R2
- ALU performs **binary addition** R1 + R2
- Result stored in R3
- Display unit shows 45

Even simple comparisons like “Password Correct?” use logic (XOR, AND, OR) operations.

How Bus Works (Real Life Example)

A **bus** is a communication path that carries data inside CPU and between components.

Three main types:

1. Data Bus

Carries actual data (e.g., numbers, characters).

2. Address Bus

Carries memory addresses (e.g., location where data is stored).

3. Control Bus

Carries commands like:

- Read
- Write
- Interrupt
- Clock signals

Real-life analogy

Bus system works like:

- Data Bus = “goods”
- Address Bus = “house number”
- Control Bus = “delivery instructions”

When you open Netflix:

- CPU sends address of the movie file → address bus
- It fetches frames/data → data bus
- Control signals manage timing and permissions → control bus

2.1 Register and Register Transfer Language (RTL)

RTL is a symbolic way of describing how data moves between registers.

Basic notation

- R1 ← R2
  Move data of R2 into R1
- R3 ← R1 + R2
  Add R1 and R2, store in R3
- PC ← PC + 1
  Increment program counter

Conditional Transfer Example

If (Z = 1) then PC ← AR

If the zero flag is true, branch to address AR.

Real App Example

When you press "Login", CPU checks:

If (password_match = 1) then jump_to_dashboard

This is conditional RTL happening inside the CPU.

2.2 Bus and Memory Transfers

Memory Transfer Commands

1. **Read Operation**

   MDR ← Memory[MAR]

   Load data from memory.

2. **Write Operation**

   Memory[MAR] ← MDR

Real Example: Opening a photo

- MAR = address of photo in RAM
- CPU reads data and stores it in MDR
- Display system gets data and shows it on screen

Bus Example

When you scroll Instagram:

- The bus continuously fetches new image/video data from RAM/Cache to CPU.

2.3 Arithmetic, Logic, and Shift Micro-operations

Micro-operations are basic operations performed on data stored in registers.

A. Arithmetic Micro-operations

These perform mathematical functions.

Examples:

- R1 ← R1 + R2

- R3 ← R3 – 1
- AC ← AC + DR
- Increment / Decrement

Real Example

When your phone reduces brightness:

level ← level - 1

Arithmetic micro-operations do this.

B. Logic Micro-operations

These perform bitwise operations.

Examples:

- AND
- OR
- XOR
- NOT
- NAND, NOR

Real Example

Fingerprint matching in mobile uses XOR patterns:

match = (fingerprint1 XOR fingerprint2)

If result = 0 → perfect match.

C. Shift Micro-operations

Used to move bits left/right.

Types:

- Logical Shift Left (LSL)
- Logical Shift Right (LSR)
- Arithmetic Shift Left
- Arithmetic Shift Right
- Rotate Left (ROL)
- Rotate Right (ROR)

Real Example

Shifting used in:

- Multiplication/division by 2
- Encryption algorithms
- Graphics rendering
- Screen animations

Example

Binary 1011 shifted left:

1011 → 0110 (LSL)

This is same as multiplying by 2.

How Shift Happens in Reality (Mobile/PC)

In hardware:

- Shifter circuits move bits using multiplexers
- No loops or software needed
- Happens in less than one clock cycle

Example From Mobile:

When applying a filter in TikTok:

- Pixels need brightness × 2
- CPU shifts each pixel value left
- Fast and efficient due to shift circuits

2.4 Arithmetic Logic Shift Unit (ALSU)

The **ALSU** combines:

- Arithmetic unit
- Logic unit
- Shifter

All three are controlled by the **Control Unit (CU)**.

Functions performed by ALSU

- Addition
- Subtraction
- AND, OR, XOR
- Shifts (left/right)
- Rotate
- Increment/Decrement

How ALSU works in a real device

Your mobile camera calculates:

- HDR brightness
- Contrast levels
- Edge detection

These require:

- Addition (blend images)

- Logic operations (masking)
- Shifts (fast multiply/divide)
- Rotate (image transformations)

That is ALSU working behind the scenes.

Examples for ALSU

Example 1:

R3 ← R1 + R2

Arithmetic unit adds values.

Example 2:

R4 ← R4 AND R5

Logic unit applies bitwise operation.

Example 3:

R6 ← shl(R6)

Shift unit moves bits left.

Example 4: Mobile Example

When you zoom an image:

- Pixel coordinates multiply using shift/add operations
- ALSU performs all transformations in microseconds

SUMMARY OF UNIT 2

- The CPU uses registers to store temporary fast data.
- Buses move data between CPU, memory, and I/O.
- Micro-operations (arithmetic, logic, shift) are the building blocks for all tasks.

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- ALSU is the combined unit performing computations efficiently.
- Every app you use (WhatsApp, TikTok, games) uses these operations continuously.

If you want this as:

✓ A Word file
✓ A PDF file
✓ 10 numerical questions
✓ Very short questions
✓ Long questions
✓ Diagrams (register bus, ALU, shifter)

Just tell me!

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