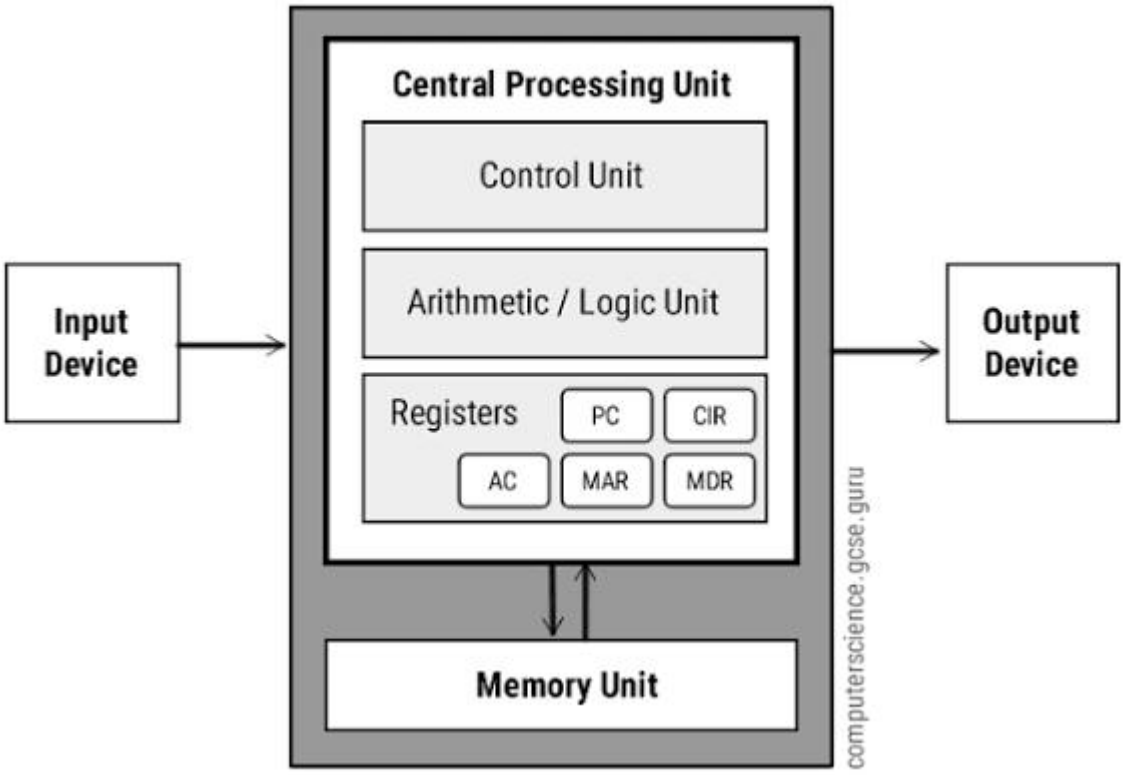
Computer Architecture Overview

1. CPU (Central Processing Unit)

Diagram: Basic CPU Architecture



The CPU is the brain of a computer responsible for executing instructions. It performs arithmetic operations, logical decisions, and controls data movement.

1.1 CPU Components

- **ALU (Arithmetic Logic Unit):** Performs mathematical and logical operations.
- **CU (Control Unit):** Directs operations of the processor by controlling data flow.
- **Registers:** Small, high- speed storage units inside the CPU holding temporary data and instructions.

1.2 CPU Clock Speed

Measured in GHz. Higher clock speed generally means faster execution, but performance also depends on architecture, number of cores, and cache.

1.3 Instruction Cycle

1. **Fetch:** Instruction is fetched from memory.
2. **Decode:** CPU interprets the instruction.
3. **Execute:** Instruction is carried out.

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2. CPU Cores and Multithreading

Diagram: Multi-Core CPU

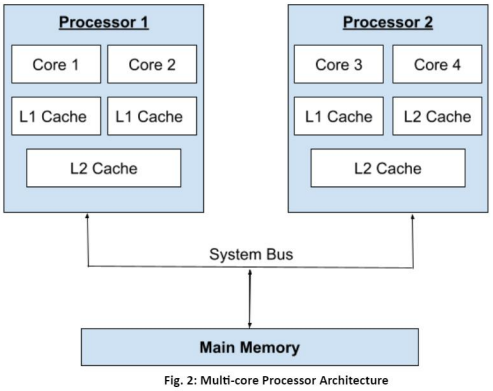

Fig. 2: Multi-core Processor Architecture

2.1 What is a Core?

A core is a separate processing unit capable of handling its own task. A multi- core CPU can perform multiple operations simultaneously.

- **Single Core:** One stream of execution.
- **Dual Core / Quad Core / Octa Core:** Multiple simultaneous parallel operations.

2.2 Threads

Threads represent smaller sequences of instructions handled by a core.

- **Single- Thread:** One instruction stream.
- **Multi- Threading:** Allows handling multiple instruction sets.
- **Hyper- Threading / SMT:** Allows one core to execute two threads, improving parallelism.

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3. RAM (Random Access Memory)

Diagram: Memory Hierarchy Position

CPU Registers (Fastest, Smallest)

↓

Cache

↓

RAM

↓

SSD / HDD (Slowest, Largest)

RAM is the temporary working memory of a computer where data is stored for quick access by the CPU.

3.1 Characteristics of RAM

- **Volatile:** Data is lost when the system turns off.
- **Fast Access:** Much faster than storage drives.
- **Measured in GB:** Higher RAM allows more programs to run at once.

3.2 RAM Speed and Channels

- Measured in MHz; higher frequency improves performance.
- **Single Channel vs Dual Channel:** Dual channel doubles data transfer paths, improving throughput.

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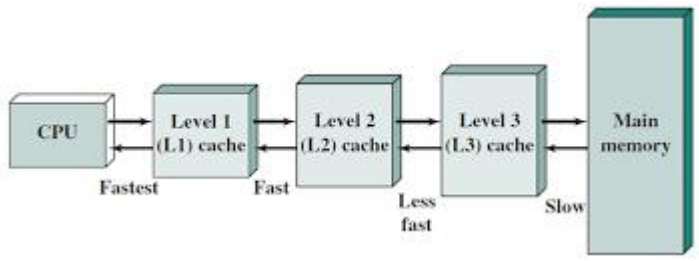
4. Cache Memory

Diagram: Cache Levels



Cache is a small, ultra- fast memory located inside the CPU, designed to reduce the time needed to access data.

4.1 Need for Cache

RAM is fast, but the CPU is even faster. Cache bridges this speed gap.

4.2 Cache Levels

- **L1 Cache:** Smallest and fastest; stores frequently used data.
- **L2 Cache:** Larger but slightly slower.
- **L3 Cache:** Shared across cores; improves inter- core communication.

4.3 Cache Hit & Miss

- **Cache Hit:** Data found in cache → fast access.
- **Cache Miss:** Data not in cache → fetched from RAM → slower.

4.4 Importance of Cache

Larger and efficient caches significantly improve CPU performance in real- world tasks like gaming, compiling, and multitasking.