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Subject: Fundamental of Computer Science

Unit-5 COMPUTER HARDWARE

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What is Computer Hardware?

Computer hardware refers to the **physical components** of a computer system that can be touched and seen.

Key Features:

•Tangible parts of the computer.

•Work together to process, store, and display data.

•Controlled by software to perform tasks.

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1. Introduction

Computers are made up of four main components:

- **Processing Units** – Perform calculations and control tasks
- **Memory** – Store data and instructions
- **Input/Output Devices** – Enable interaction with the computer
- **Supporting Architecture** – Connects and coordinates all components.

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2. Central Processing Unit(CPU)

- The Central Processing Unit (CPU) is like the **brain of a computer.**
- It's the part that does most of the thinking, calculating, and decision-making to make your computer work.
- A primary chip that executes instructions from software and hardware to perform calculations, logic, control, and input/output operations, making all computer functions possible

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Central Processing Unit

The CPU handles tasks like:

- Doing math calculations (like adding or multiplying numbers).
- Running apps or games.
- Helping the keyboard, mouse, and screen work together.
- Storing and retrieving information during tasks

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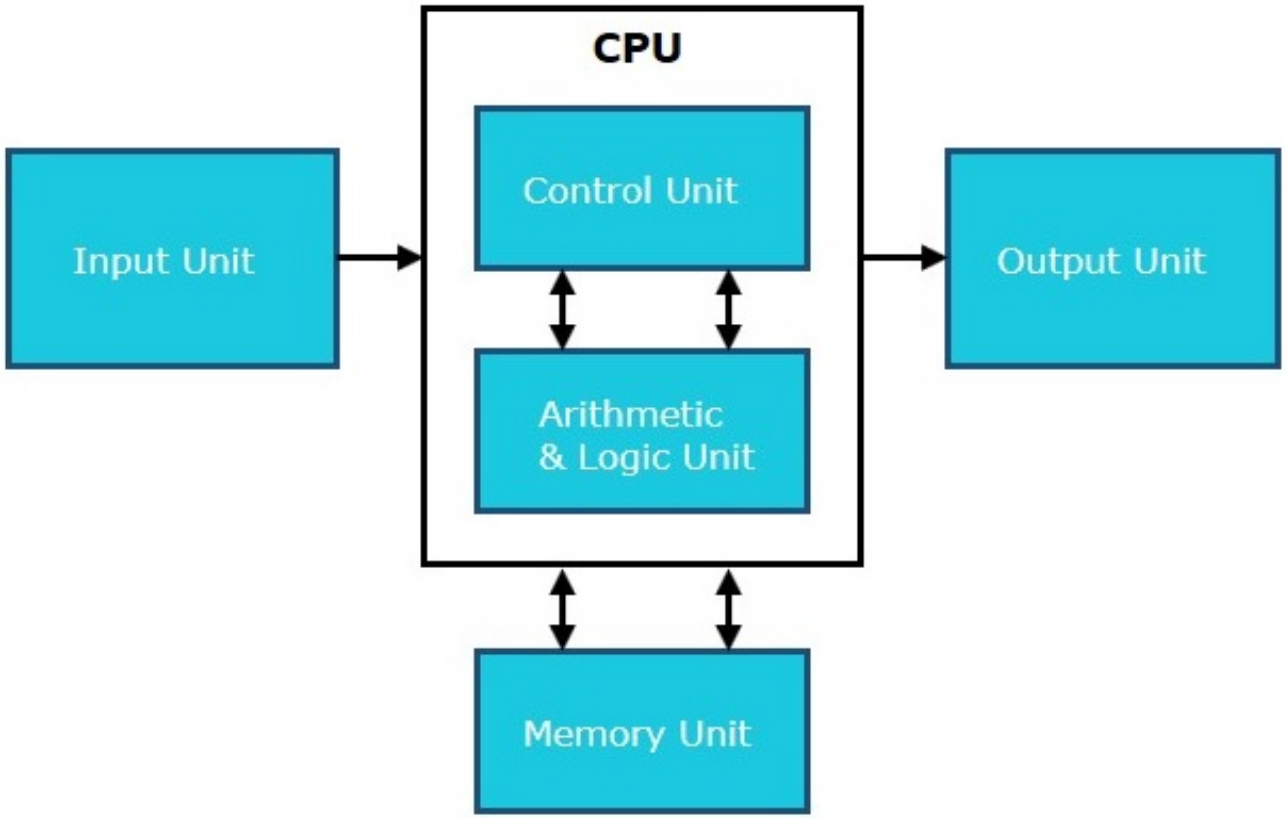
3. Main Components of CPU

The components of a CPU include the ALU (Arithmetic Logic Unit), CU (Control Unit), registers, cache, and clock.

Main Parts:

- Arithmetic Logic Unit (ALU)
- Control Unit (CU)
- Memory Unit
- Registers
- System Clock
- Cache Memory

Basic components of CPU



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Control Unit

- The control unit manages the CPU by sending signals like clock, hold, and reset to its parts.
- It ensures all components work together to complete tasks.
- Plays a key role in the **Fetch–Decode–Execute cycle** by fetching instructions from memory, decoding them, and directing execution.
- For example, it synchronizes data movement from cache memory to the ALU.

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Functions of Control Unit

- **Instruction Fetch:** Gets instructions from RAM
- **Instruction Decode:** Translates instructions
- **Instruction Execution:** Sends signals to ALU & other units
- **Control Flow:** Updates program counter
- **Exception Handling:** Manages errors & interrupts
- **Synchronization:** Coordinates execution across cores

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Arithmetic Logic Unit

- Optimized to perform multiple tasks quickly
- Works with registers, memory, and CU to execute instructions
- Handles **arithmetic operations** (add, subtract, multiply, divide)
- Performs **logical operations** (AND, OR, comparisons)
- Uses addition for complex calculations (e.g., 2×3 = 2+2+2)

Functions of an ALU

- **Arithmetic Operations** − The ALU can perform basic arithmetic operations.
- **Logic Operations** − The ALU can also perform logical operations like AND, OR, NOT, XOR, and bit-shifting operations.

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Memory Unit And Registers

Introduction to Memory Unit

The **Memory Unit** is an essential part of the **Central Processing Unit (CPU)** that stores **data, instructions, and intermediate results** temporarily or permanently.

It acts as the **bridge** between the CPU and the input/output devices.

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Memory Unit And Registers

Types of Memory
Memory in a computer is divided mainly into two categories:

(A) Primary Memory (Main Memory)
Directly accessible by the CPU.
Volatile (data lost when power is off).
Fast but expensive.

Examples:
RAM (Random Access Memory):
Temporary storage for programs and data currently in use.
ROM (Read Only Memory):
Stores firmware or permanent instructions.

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Memory Unit And Registers

(B) Secondary Memory
Non-volatile and used for long-term data storage.
Slower than primary memory but has higher capacity.

Examples: Hard Disk, SSD, CD/DVD.

(C) Cache Memory
Very high-speed memory located between CPU and RAM.
Stores **frequently used instructions** to reduce data access time.

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Memory Unit And Registers

Memory Hierarchy

Level	Type	Speed	Capacity	Cost
1	Registers	Fastest	Very Low	Very High
2	Cache Memory	High	Low	High
3	Main Memory (RAM)	Moderate	Medium	Medium
4	Secondary Memory	Slow	Very High	Low

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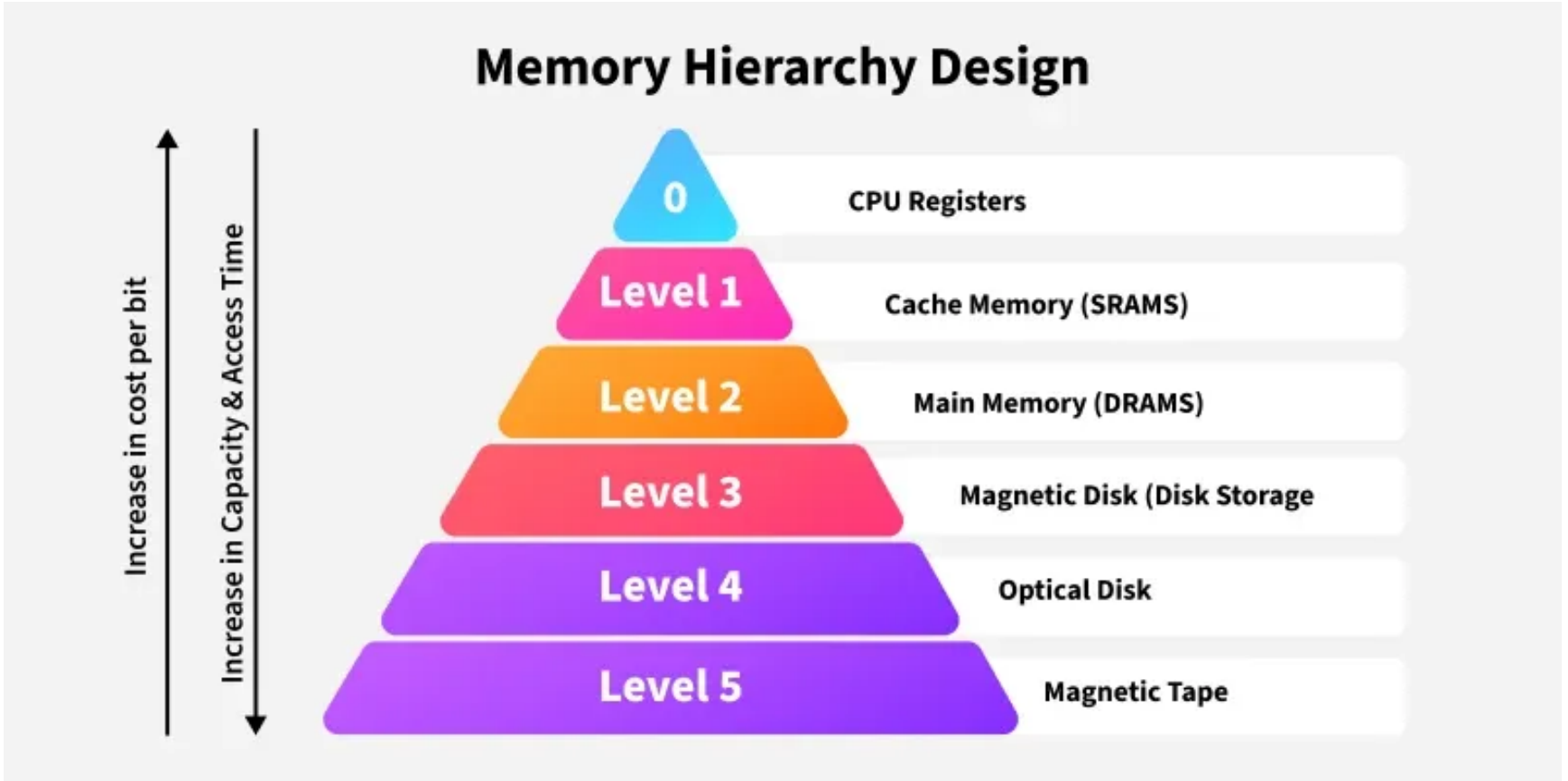
Memory Hierarchy



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Memory Unit And Registers

Registers

Registers are **smallest and fastest memory units** inside the CPU.
Used to hold **data, instructions, or addresses** temporarily while processing.

Types of Registers:
Accumulator (ACC):
Stores intermediate arithmetic and logic results.
Program Counter (PC):
Holds the address of the next instruction to be executed.
Memory Address Register (MAR):
Holds the memory location of data to be accessed.

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Memory Unit And Registers

Memory Data Register (MDR):
Holds the actual data being transferred to/from memory.

Instruction Register (IR):
Holds the current instruction being executed.

General Purpose Registers (R0–R7 etc.):
Used for temporary data storage.

Status Register / Flag Register:
Stores the result of operations (Zero flag, Carry flag, etc.).

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Memory Unit And Registers

Relation Between Memory and Registers

Registers are part of CPU and provide **immediate data access** to the ALU (Arithmetic Logic Unit).

When the CPU executes a program:

1. Instructions are fetched from memory (RAM) → stored in **IR**.
2. Data is fetched from memory → stored in **ACC** or general registers.
3. Results are written back to memory after processing.

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Storage Devices (Secondary Memory)

Permanent, non-volatile storage (data remains after power off)

Types of Storage Devices:

- **Hard Disk Drives (HDDs):** Magnetic storage, high capacity, slower.
- **Solid-State Drives (SSDs):** Flash-based, faster, reliable.
- **USB Flash / Pen Drives:** Portable, convenient, limited size.
- **Optical Disks (CDs, DVDs):** Laser-based, used for media & backups.

Capacity: Ranges from **GBs to TBs** depending on type & size.

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System Clock

- Synchronizes all CPU operations
- Generates electronic pulses; each pulse = one CPU step
- Measured in **Hertz (Hz) / Gigahertz (GHz)**
- Higher clock speed → faster instruction execution

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Functions of CPU:

- Performs arithmetic and logic operations
- Directs operations of processor, I/O units, and memory
- Uses **registers** for temporary data storage
- Executes instructions using **Fetch–Decode–Execute–Store cycle**:

1.Fetch: Get instruction from memory

2.Decode: Translate into CPU signals

3.Execute: Perform operation via ALU/CU

4.Store: Save result in memory/register

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Input Devices

An input device lets you communicate with a computer. Devices that allow users to **enter data and instructions** into a computer.

Examples:

Keyboard: Text and command input

Mouse: Pointing, clicking, navigation

Scanner: Converts images/documents to digital form

Microphone: Captures audio input

Touchscreen: Combines input and display in one device

Sensors: Capture environmental data (e.g., temperature, motion)

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1.KEYBOARD

The most common input device used for entering text, numbers, and commands.

Key Categories:

- **Alphanumeric keys** – A–Z, 0–9
- **Function keys** – F1 to F12 (shortcuts)
- **Modifier keys** – Shift, Ctrl, Alt
- **Navigation keys** – Arrows, Home, End, Page Up/Down
- **Numeric keypad** – For quick calculations

Real-world Uses: Writing documents, coding, gaming.

2. MOUSE

A pointing device to control cursor on screen.

- **Types of Mouse:**
- Mechanical (ball-based, older type)
- Optical (uses LED light)
- Laser (more accurate)
- Wireless (Bluetooth/USB receiver)
- **Functions:** Point, click, drag-and-drop, right-click menu, scroll.
- **Uses:** Gaming, designing, browsing websites.

3. SCANNER

It Converts physical images/documents into digital files.

Types:

•Flatbed Scanner – Used in offices.

•Handheld Scanner – Portable and small.

•Sheet-fed Scanner – Feeds paper automatically.

Applications:

•Digitizing photographs

•Storing printed documents

•OCR (Optical Character Recognition) → text search from books

4. MICROPHONE

Captures sound waves and converts them into digital signals.

Types: Dynamic, Condenser, USB, Wireless.

Applications:

•Online meetings & video calls

•Voice recognition (Google Assistant, Alexa)

•Music recording, podcasting

•Gaming with voice chat

5. TOUCHSCREEN

Touchscreen is a display that works as both input & output device.

Types:

•Resistive (pressure-based)

•Capacitive (finger touch, used in smartphones)

•Infrared (sensors detect touch)

Advantages:

•Easy to use

•No need for separate keyboard/mouse

•**Uses:** Smartphones, ATMs, kiosks, self-order machines.

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6. SENSORS

Sensors are the Hardware that detects environmental/physical changes.

Types & Examples:

•Temperature Sensor → CPU cooling system

•Motion Sensor → Security alarms, gaming consoles (Xbox Kinect)

•Light Sensor → Auto brightness in smartphones

•Fingerprint Sensor → Security in mobiles/laptops

Applications: Robotics, IoT, home automation.

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OUTPUT DEVICES: MONITOR

MONITOR: Visual display unit showing processed information.

Types:

•CRT (older, bulky)

•LCD (flat, better resolution)

•LED (modern, energy efficient)

•OLED (premium, used in high-end devices)

Specifications:

•Resolution (Full HD, 4K)

•Refresh rate (60Hz, 120Hz, 144Hz – important for gaming)

Uses: Watching videos, office work, gaming, designing.

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OUTPUT DEVICE: PRINTER

Printer Produces hard copies of digital documents.

Types:

•Inkjet – Best for photos, low cost, slower.

•Laser – Fast, high-volume printing, professional use.

•3D Printers – Create real objects (plastic, resin).

Applications:

•Schools, offices, homes

•Printing photos, reports

•Manufacturing prototypes (3D printing).

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OUTPUT DEVICE: SPEAKER

It Convert digital audio signals into sound.

Types:

•Stereo Speakers

•Bluetooth Speakers

•Surround sound systems (Home Theatres)

Applications:

•Listening to music

•Watching movies & gaming

•Online calls & virtual meetings

Example: Smart speakers like **Amazon Echo** with voice assistant.

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MOTHERBOARD

Motherboard is the main circuit board that connects and controls all hardware components.

Functions:

- Provides communication between CPU, RAM, storage, and peripherals.
- Distributes power to all components.

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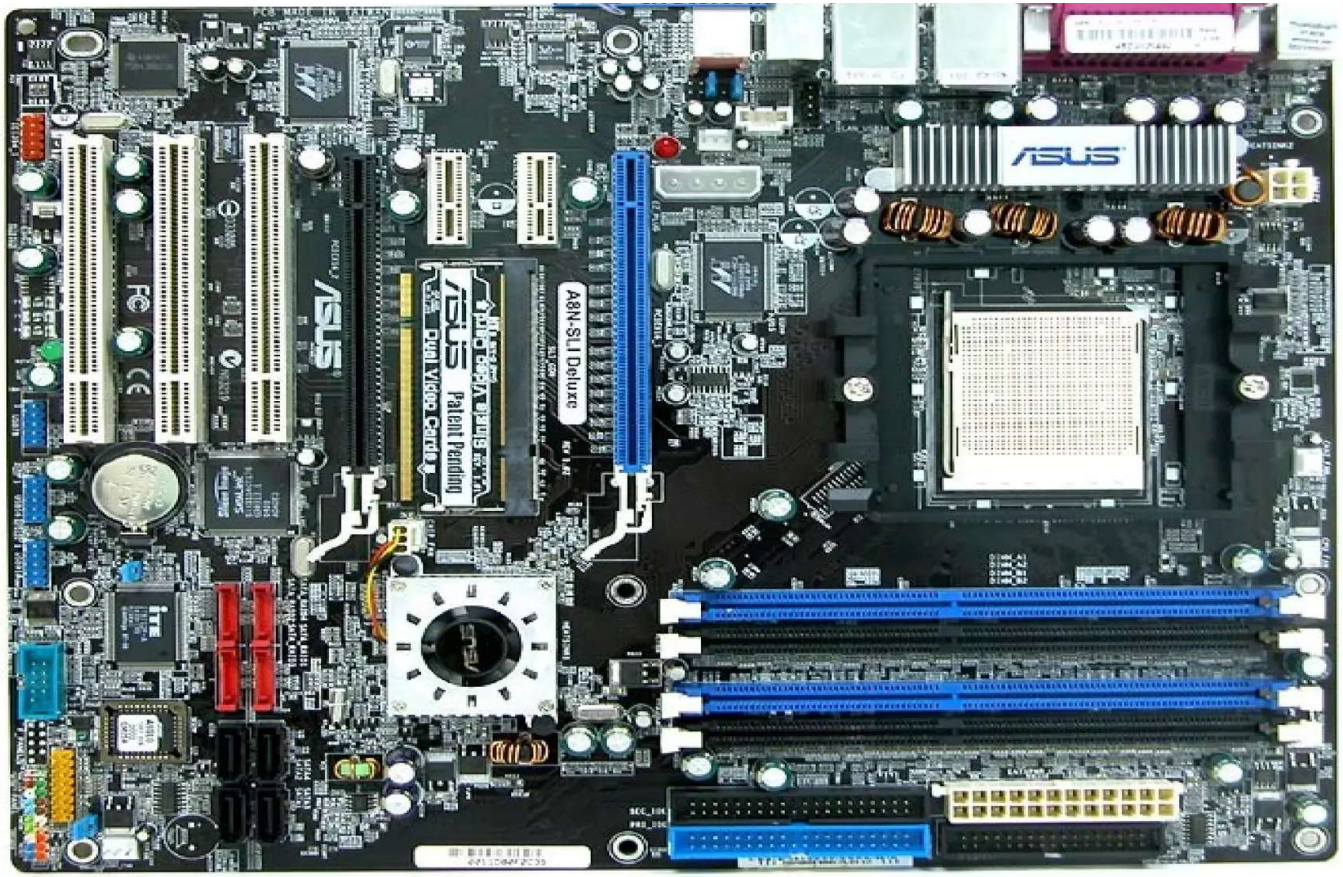
MOTHERBOARD



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MOTHERBOARD COMPONENTS

- **CPU Socket:** Holds the processor.
- **RAM Slots:** Install system memory modules.
- **BIOS/UEFI Chip:** Firmware that starts the computer.
- **Expansion Slots:** For graphic cards, sound cards, Wi-Fi cards.
- **I/O Ports:** USB, HDMI, Ethernet, Audio jacks.
- **Chipset:** Controls data flow between CPU, memory, and peripherals.
- **Power Connectors:** Supply electricity to the board.

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MOTHERBOARD: COMPONENTS

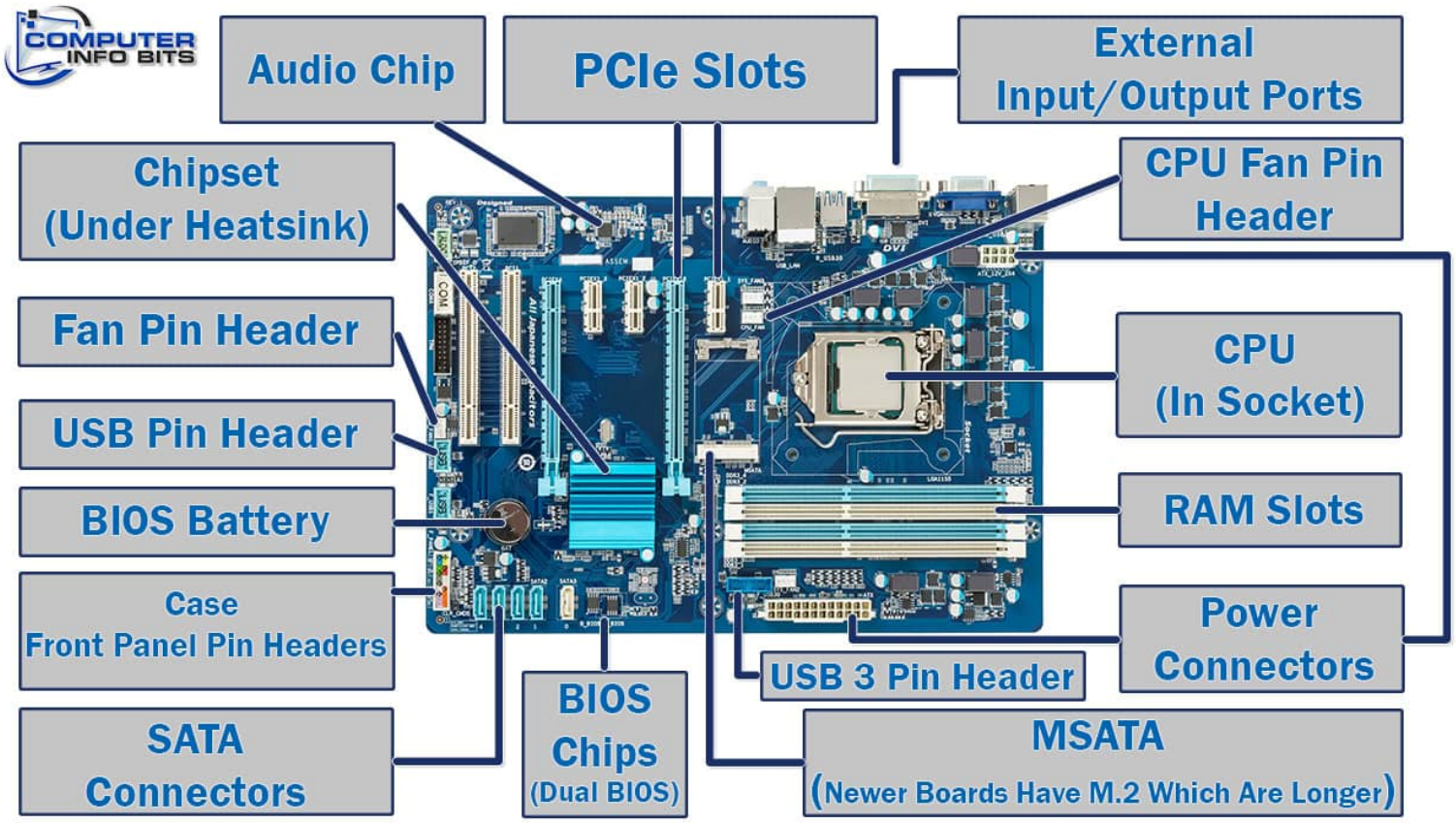

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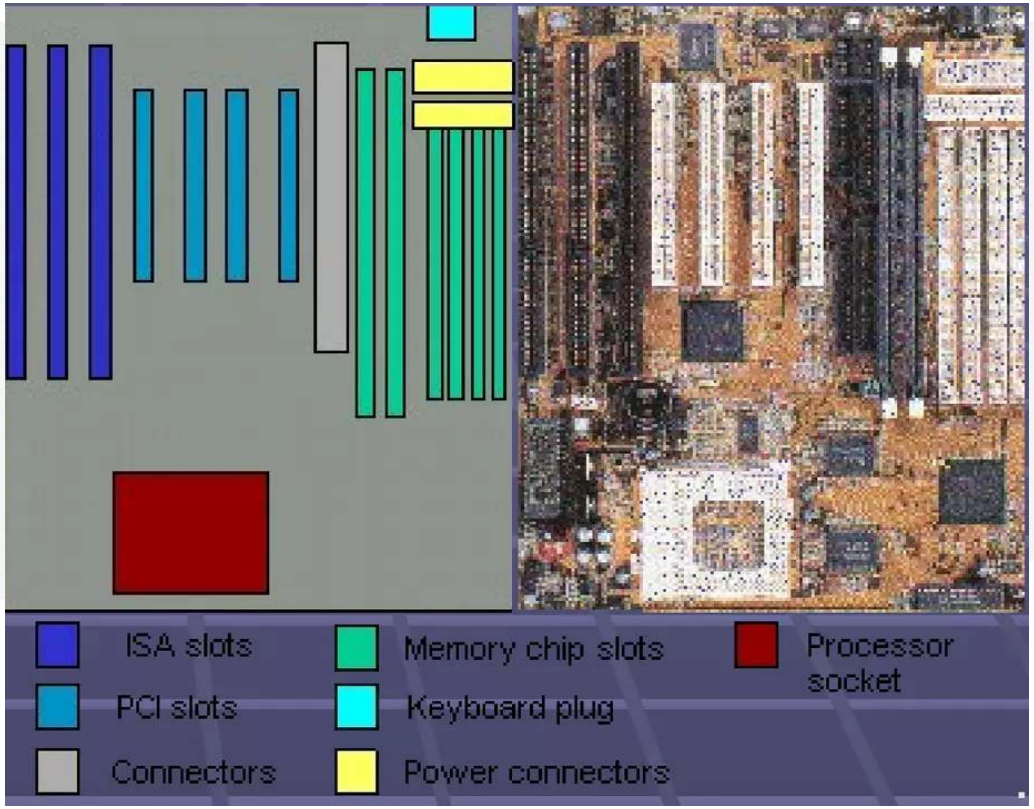
PHOTO AND DIAGRAM OF MOTHERBOARD



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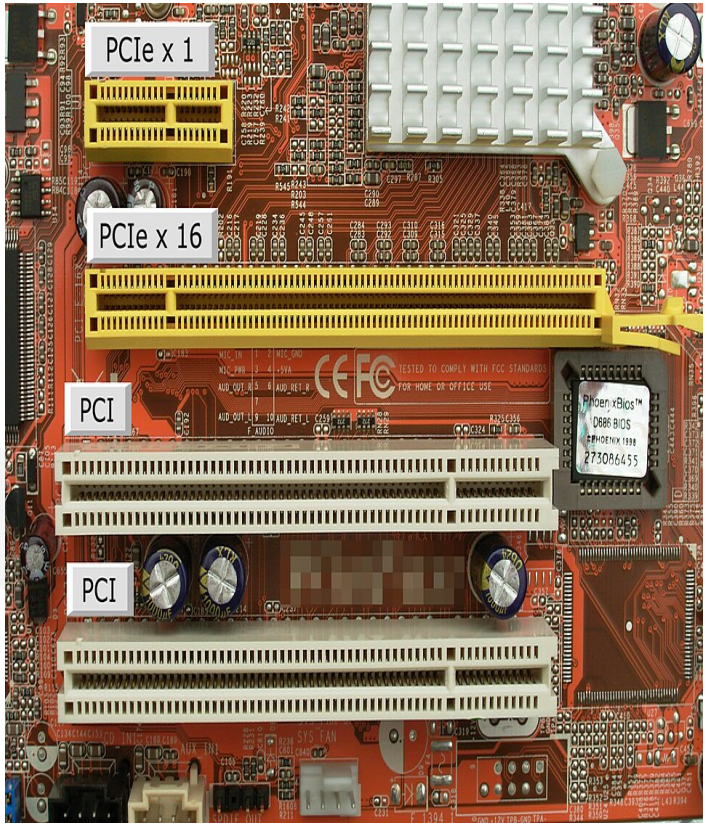
PCI SLOTS

PCI Slot (Peripheral Component Interconnect):A slot on the motherboard used to connect expansion cards (like sound cards, network cards, or graphics cards) to add extra features to a computer.

PCIe Slot (Peripheral Component Interconnect Express): The modern, faster version of PCI slots that allows high-speed connections for devices such as graphics cards, SSDs, and network cards.



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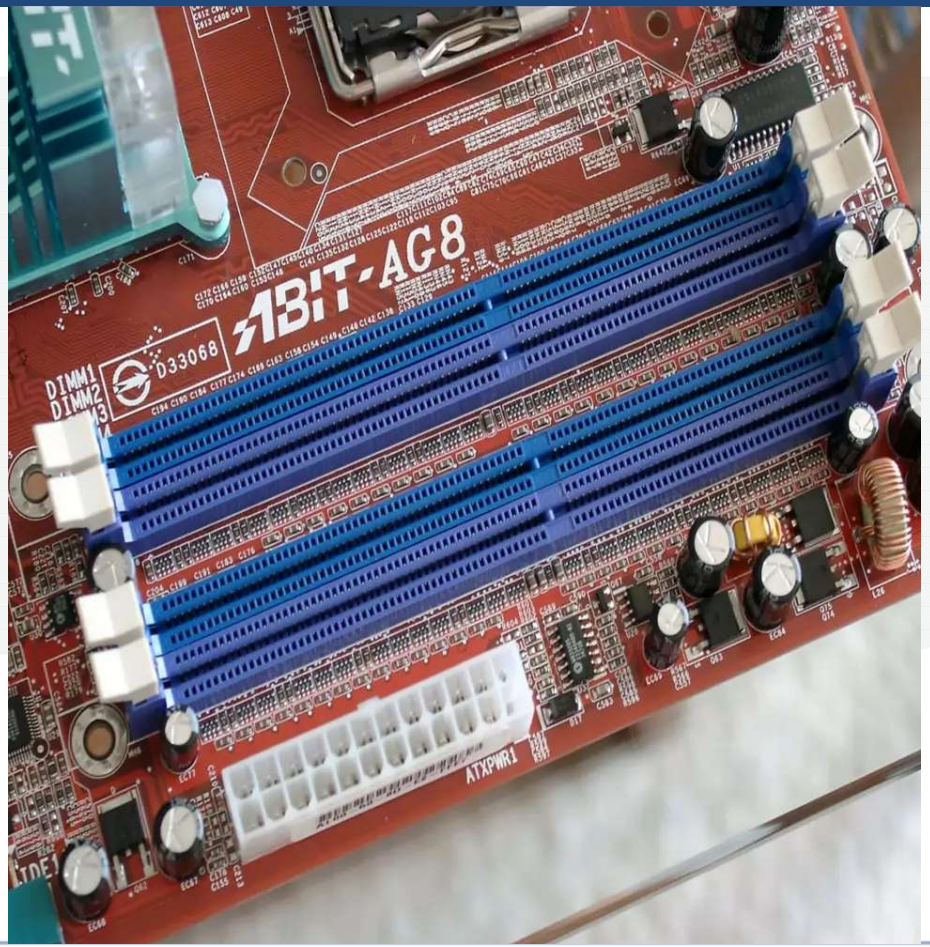
MEMORY SLOTS



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Bus Architecture

•A **bus** is a **communication pathway** that transfers data between the components of a computer.

•It is like a **highway system** inside the computer where different vehicles (data, addresses, and control signals) travel.

•Every component (CPU, RAM, I/O devices) connects to the bus to send and receive information.

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Bus Types

Types of Buses:

- **Data Bus:** Transfers actual data (e.g., numbers, characters).
- **Address Bus:** Transfers memory addresses.
- **Control Bus:** Transfers control signals (read, write, clock).

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Bus Types

1.Data Bus

- Carries the **actual data** (instructions, numbers, characters).
- Bi-directional → Data flows **both ways** (CPU ↔ Memory ↔ Devices).

Bus Types

2. Address Bus

•Carries the **address/location** of data in memory.

•Unidirectional → Only CPU sends addresses to memory or I/O.

•Determines "**where**" the data will be read from or written to.

Bus Types

3. Control Bus : Carries **control signals** that manage operations.

Examples of signals:

- **Read/Write** (whether CPU wants to read or write data)
- **Clock** (synchronization of operations)
- **Interrupts** (signals to CPU when urgent tasks occur)

Ensures data and addresses are transferred at the right time.

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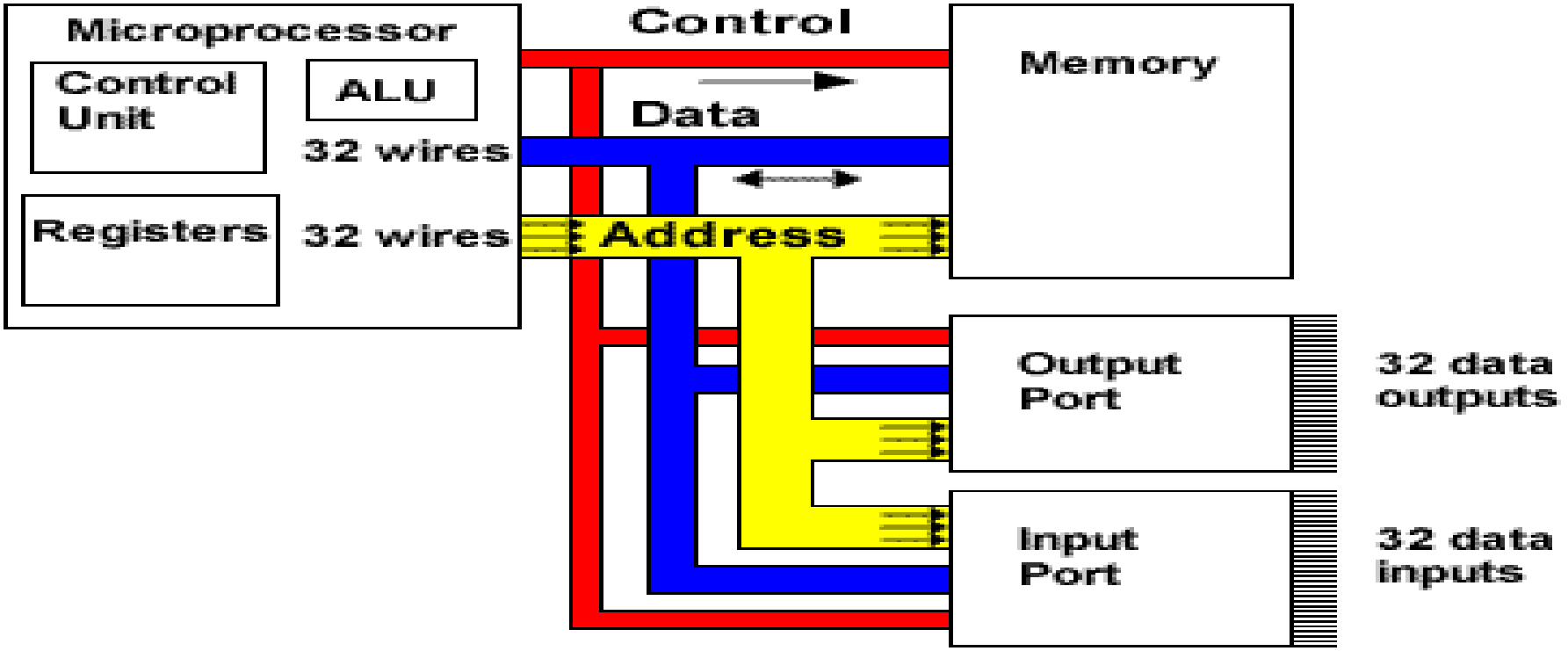
Bus Architecture



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