Lesson 2: Computer Architecture & Evolution

1. Evolution of Computing

Early Calculating Aids

- **Pre-Mechanical:** Abacus (BC 5000).
- **Mechanical Era (1450-1840):**
  - Pascaline (1642) - Add/Subtract.
  - Stepped Reckoner (1694) - Add/Sub/Mul/Div.
  - Difference Engine (1880) - by **Charles Babbage**, "Father of the Computer".
- **Electro-Mechanical (1840-1940):** Mark I (1939).

Computer Generations

- **1G (1940-56):** Vacuum Tubes. *e.g., ENIAC, EDVAC*.
- **2G (1956-63):** Transistors. *e.g., IBM 1620*.
- **3G (1964-75):** Integrated Circuits (ICs). *e.g., IBM-360*.
- **4G (1975-89):** VLSI Microprocessors.
- **5G (1989-Now):** ULSI & AI. *e.g., Laptops, Desktops*.

Computer Classification

- **By Technology:** Analog ↔ Digital.
- **By Purpose:** Special ↔ General.
- **By Size:** Supercomputer, Mainframe, Mini, Micro.
  - **Modern Portables:** Smartphone, Tablet, Phablet.

2. Hardware & Interfaces

Input Devices

- **Keyboard Entry:** Manual key presses.
- **Direct Entry:** Automated data capture.
  - **Advantages:** Faster, more accurate (less human error), lower data entry cost.
  - **Examples:** Mouse, Scanner, Barcode Reader, Smart Card Reader, Mic, Graphic Tablet, Webcam.

Output Devices

- **Monitors:** CRT, LCD/TFT, LED.
- **Printers:** Dot Matrix (Impact), Inkjet, Laser, 3D.
- **Other:** Plotter, Speakers.

CPU & Motherboard Compatibility

- **Socket:** CPU must match the physical socket.
- **Chipset:** The board's "traffic controller" must support the CPU.
- **Wattage (TDP):** Motherboard must supply enough power for CPU.
- **BIOS:** Startup software may need an update for newer CPUs.

3. Von-Neumann Architecture

Core Concepts

- **Stored Program Concept:** Instructions and data are stored in the same memory and can be fetched.
- **Fetch-Execute Cycle:** CPU's rhythm: **Fetch** instruction → **Decode** it → **Execute** it.

Main Components & Buses

- **CPU (Processor):**
  - **Control Unit (CU):** Directs operations.
  - **ALU:** Performs arithmetic & logic.
  - **Registers:** Tiny, ultra-fast storage inside CPU.
- **Main Memory (RAM):** Stores active programs and data.
- **I/O Devices:** Input and Output hardware.
- **Buses (The Highways):**
  - **Data Bus:** Carries the actual data.
  - **Address Bus:** Carries memory addresses.
  - **Control Bus:** Carries commands from the CU.

Advanced CPU Concepts

- **Multi-core Processors:** Multiple "cores" (CPUs) on a single chip.
  - **Need:** To run multiple instructions/tasks simultaneously (parallelism) for higher performance.
- **Parallel Computing:** One task split into pieces, solved at the same time on multiple processors.
- **Grid Computing:** Many loosely connected computers work on a common goal, forming a "virtual supercomputer".

4. The Memory System

Memory Hierarchy (Top to Bottom)

1. **Registers:** Fastest, smallest, in CPU.
2. **Cache (L1/L2/L3):** Fast buffer. L1 is fastest, on-chip.
3. **RAM (Main Memory):** Slower, larger, volatile.
4. **Secondary Storage:** Slowest, largest, non-volatile.

Characteristics & Types

- **Comparison Criteria:** Access Time, Cost/Bit, Capacity, Physical Type, Access Method (Sequential/Random).
- **Volatility:**
  - **Volatile**：Loses data when power is off. *e.g., RAM, Cache, Registers*.
  - **Non-Volatile**：Retains data without power. *e.g., ROM, HDD, SSD*.

RAM, ROM & Cache Details

- **RAM Types:**
  - **SRAM** (Static): Faster, no refresh needed. Used for Cache.
  - **DRAM** (Dynamic): Slower, needs refreshing. Used for Main Memory.
- **ROM Types:**
  - **PROM** (Programmable): Write-once.
  - **EPROM** (Erasable): Erase with UV light.
  - **EEPROM** (Elec. Erasable): Erase with electricity. *e.g., Flash Memory*.

Secondary Storage

- **By Technology:**
  - **Magnetic:** HDD, Tape (Sequential access).
  - **Optical:** CD (700MB), DVD (4.7GB), Blu-Ray (25GB+).
  - **Solid-State (SSS):** SSD, Flash Drive (no moving parts, faster, less heat).
- **By Access Method:**
  - **Sequential:** Read in order (e.g., Tape).
  - **Random:** Jump directly to data (e.g., HDD, SSD).