Chapter 6 – CPU & Storage

HOW THE CPU WORKS: The CPU is the brain of the computer. It processes all instructions and controls all activities. CPUs contain millions of tiny switches called transistors. The number of transistors doubles every 18 months → **Moore's Law.**

MAIN COMPONENTS OF A CPU

ALU (Arithmetic Logic Unit): Performs integer arithmetic and logic operations.

FPU (Floating Point Unit): Performs decimal (floating-point) calculations.

Control Unit: Controls and manages all CPU activities.

Prefetch Unit: Fetches instructions early to improve CPU performance.

Decode Unit: Converts fetched instructions into a form the CPU understands.

Registers: Very fast, small memory inside the CPU.

Internal Cache: Stores frequently used data for fast access.

Bus Interface Unit: Connects CPU with RAM and other cores.

SYSTEM CLOCK & MACHINE CYCLE

System Clock: The motherboard's system clock synchronizes all computer operations by sending regular timing signals. Each signal is called a cycle, and the number of cycles per second is measured in hertz (Hz). One megahertz (MHz) equals one million clock cycles per second.

Machine Cycle (4 steps): Whenever the CPU processes a single piece of micro code, it is referred to as a machine cycle:

1. **Fetch**—the program instruction is fetched.
2. **Decode**—the instructions are decoded so the control unit, ALU, and FPU can understand them.
3. **Execute**—the instructions are carried out.
4. **Store**—the original data or the result from the ALU or FPU execution is stored in the CPU's registers.

MAKING COMPUTERS FASTER

There are several remedies to make computer faster such as_

1. Add more **RAM**. Clean and **maintain** the hard drive.
2. Upgrade the **hard drive**, **internet**, or **graphics card**, depending on the primary role of the computer and where the processing **bottleneck** appears to be.
3. Some of the strategies are all being implemented, including improved architecture, pipelining, multiprocessing, parallel processing, graphene, 3D chips, nanotechnology, and quantum computing.
4. Nanotechnology aims to build computer components at the atomic and molecular levels, and products like NRAM and carbon-nanotube-based devices already use it. Researchers are also exploring advanced technologies such as quantum computing, optical computers, silicon photonics, terascale, and exascale computing for future high-performance systems.

STORAGE

Two parts:

1. **Storage Medium** 2. **Storage Device**

Storage Medium: A storage medium is the hardware where data is stored, like a DVD or memory card.It is used by inserting it into a storage device that reads or writes data. Sometimes the medium is removable, but in devices like hard drives or USB drives, both parts are permanently combined.

Storage devices: Storage devices can be internal, external, or remote. Internal devices are faster and require no extra space, while external devices are portable and can be stored securely. Remote storage is accessed over a network and can be used from any Internet-connected computer.

Volatility: RAM is volatile, so its data is erased when not needed or when the power is off. Storage media are nonvolatile and keep data even without power. Therefore, storage is used to save programs and files for future use.

ACCESS METHODS

Random Access: Random (direct) access lets you retrieve data from any location instantly, like a DVD jumping to a specific scene. Most modern storage devices—hard drives, DVDs, USB drives—use random access with unique addresses for each data piece.

Sequential Access: Sequential access retrieves data in order, like magnetic tapes, where you must move through earlier data to reach the desired point.

TYPES OF STORAGE TECHNOLOGY

Magnetic Storage

- Magnetic storage saves data using **magnetic patterns**, such as in HDDs.
- 0s and 1s are stored using **different magnetic alignments** on the disk surface.
- These alignments can be changed, so data can be **written, deleted, and rewritten** easily.
- Traditional hard drives are the most common form of magnetic storage.

Optical Storage

- Optical media like DVDs store data using **laser beams**.
- The laser creates **tiny marks** or changes the disc's **reflectivity** to represent 0s and 1s.
- Some discs are **permanent** (cannot be rewritten), while rewritable discs allow the data to be **modified again**.
- Some storage systems combine magnetic and optical technologies.
- Flash memory stores data using **electrons** in memory cells (USBs, phones, SSDs).

Hard Drives

- Hard drives are the **primary storage** used in most computers.
- Internal hard drives are **fixed inside** the system unit.
- External hard drives connect through **USB or Thunderbolt** and provide extra storage space.

- They are useful for storing **large files** like photos and videos, especially on devices with limited internal storage.
- Three main types of hard drives are:
    - **Magnetic Hard Drives (HDDs)**
    - **Solid-State Drives (SSDs)** – faster and more reliable
    - **Solid-State Hybrid Drives (SSHDs)** – a mix of HDD + SSD technology

FLASH MEMORY TYPES

Embedded Flash:

- It refers to **tiny flash memory chips built directly inside devices** like smartphones, tablets, and smartwatches.
- It provides **built-in storage**, so no separate memory card is needed.
- Flash memory is **small, fast, and efficient**, which is why it is used as the **primary storage** in most mobile devices.

Flash Memory Cards:

- They are **small removable storage cards** containing flash chips and a controller.
- They come in many formats like **CF** (compact Flash)**, SD** (secure digital)**, MMC** (multimedia card)**, xD** (xD Picture card)**, XQD, and MS** (memory stick), and these formats are **not interchangeable**.
- They are widely used in **digital cameras, smartphones, and portable devices**.
- These cards help store data and **transfer files to computers** when needed.
- Most computers and many phones have **built-in card readers** to read these memory cards.