Chapter 3: Computer Hardware Components: CPU, Memory, and I/O

What is the typical configuration of a computer sold today?

Computer Hardware Components

- In this lecture:
  - How did the computer become known as the stored-program computer?
  - Do they all have the same characteristics?
  - Memory on chips and memory on magnetic media, how do they differ?
  - What do you look for when comparing memory devices?
  - How is information moved around within the computer?

Basic Concepts of Computer Hardware

- Input/Output (I/O): Refers to the process of getting information into and out of the computer.
  - Input: Those parts of the computer receiving information to programs.
  - Output: Those parts of the computer that provide results of computation to the person using the computer.

This model of the typical digital computer is often called the von Neumann computer.
- Programs and data are stored in the same memory: primary memory.
- The computer can only perform one instruction at a time.
Sources of Data for the Computer

- Two types of data stored within a computer:
  - Original data or information: Data being introduced to a computing system for the first time.
    - Computers can deal directly with printed text, pictures, sound, and other common types of information.
  - Previously stored data or information: Data that has already been processed by a computer and is being stored for later use.
    - These are forms of binary data useful only to the computer.
    - Examples: Floppy disks, DVD disks, and music CDs.

- Two categories of input hardware:
  - Those that deal with original data.
  - Those that handle previously stored data.

Input Devices

- Input hardware: Those that deal with original data.
  - Keyboard
  - Mouse
  - Voice recognition hardware
  - Scanner
  - Digital camera

- We won’t say much more about the input devices that deal with original data here
  - See book for more information
  - Communicate via ports, and device drivers

Common Basic Technologies for Storing Binary Information:

- Electronic
- Magnetic
- Optical

Electronic Circuits

- Most expensive of the three forms for storing binary information.
- A flip-flop circuit has either one electronic status or the other.
  - It is said to flip-flop from one to the other.
- Electronic circuits come in two forms:
  - Permanent (ROM – Read Only Memory)
  - Non-permanent (RAM – Random Access Memory)
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The Computer Continuum

**Input Devices**

**Magnetic Technology**
- Two parts to most of the magnetic forms of information storage:
  - The medium that stores the magnetic information.
    - Example: Floppy disk. Tiny spots on the disk are magnetized to represent 0s and 1s.
  - The device that can “read” that information from the medium:
    - The drive spins the disk.
    - It has a magnetic sensing arm that moves over the disk.
    - Performs nondestructive reading.

**Optical**
- Uses lasers to “read” the binary information from the medium, usually a disc.
  - Millions of tiny holes called “pits” are “burned” into the surface of the disc.
  - The holes are interpreted as 1s. The absence of holes are interpreted as 0s.

**Secondary Memory Input Devices**
- Disks (floppy, hard drive, or CD-ROM) considered secondary memory devices
- These input devices are used by a computer to store information and then to retrieve that information as needed.
- External to the computer.
- Secondary memory uses binary.
  - The usual measurement is the byte.
  - A byte consists of 8 binary digits (bits). The byte is a standard unit.

**The four most important characteristics of storage devices:**
- Speed and access time
- Cost / Removable versus non-removable
- Capacity
- Type of access
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Input Devices

- **Speed (Access time)** - How fast information can be taken from or stored onto the computer memory device’s medium
  - Electronic circuits: Fastest to access. 
    - 40 billionths of a second.
  - Floppy disks: Very slow in comparison.
    - Takes up to 1/2 second to reach full speed before access is even possible.

- We could further break access time down into:
  - Seek Time
  - Rotational Delay Time
  - Data Transfer Time

Input Devices

- **Capacity** - The amount of information that can be stored on the medium.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Description</th>
<th>Approximate Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 bit</td>
<td>1 binary digit</td>
<td></td>
</tr>
<tr>
<td>1 nibble</td>
<td>4 bits</td>
<td>1 character</td>
</tr>
<tr>
<td>1 byte</td>
<td>8 bits</td>
<td>≈ 1/2 page, double spaced</td>
</tr>
<tr>
<td>1 kilobyte</td>
<td>1,024 bytes</td>
<td>≈ 500,000 pages</td>
</tr>
<tr>
<td>1 megabyte</td>
<td>1,048,576 bytes</td>
<td>≈ 5 million pages</td>
</tr>
<tr>
<td>1 gigabyte</td>
<td>1,073,741,824 bytes</td>
<td>≈ 5 billion pages</td>
</tr>
<tr>
<td>1 terabyte</td>
<td>1 trillion bytes</td>
<td>≈ 5 billion pages</td>
</tr>
</tbody>
</table>

Input Devices

- **Cost**
  - Megabyte: A million bytes.
  - Gigabyte: A billion bytes.
  - Two parts to a removable secondary storage device:
    - The cost of the medium. *(Cheaper if bought in quantity)*
    - The cost of the drive.

<table>
<thead>
<tr>
<th>Example</th>
<th>Cost for drive</th>
<th>Cost for medium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floppy drive (1.4MB)</td>
<td>59.00</td>
<td>50</td>
</tr>
<tr>
<td>Zip 100 (100 MB)</td>
<td>99.00</td>
<td>10.00</td>
</tr>
<tr>
<td>CD-WR (650 MB)</td>
<td>360.00 and up</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Input Devices

- **Type of Access**
  - **Sequential** - Obtained by proceeding through the storage medium from the beginning until the designated area is reached (as in magnetic tape).
    - Good for something like backup tasks
  - **Random Access** - Direct access (as in floppy and hard disks).

The Computer Continuum
Primary Memory

- **Primary storage or memory**: Is where the data and program that are currently in operation or being accessed are stored during use.
  - Consists of electronics, circuits: Extremely fast and expensive.
  - Two types:
    - **RAM** (non-permanent)
      - Programs and data can be stored here for the computer’s use.
      - Volatile: All information will be lost once the computer shuts down.
    - **ROM** (permanent)
      - Contents do not change.

The Central Processing Unit

- **The Central Processing Unit (CPU)**
  - Often referred to as the “brain” of the computer.
  - Responsible for controlling all activities of the computer system.
  - The three major components of the CPU are:
    1. **Arithmetic Logic Unit** (Computations performed)
    2. **Control Unit** (Has two locations where numbers are kept)
    3. **Instruction Decoding Unit** (Decodes the instruction)
  - **Motherboard**: The place where most of the electronics including the CPU are mounted.

Output Devices

- **Output units store and display information (calculated results and other messages)** for us to see and use.
  - Floppy disk drives and Hard disk drives.
  - Display monitors: Hi-resolution monitors come in two types:
    - **Cathode ray tube (CRT)** - Streams of electrons make phosphors glow on a large vacuum tube.
    - **Liquid crystal display (LCD)** - A flat panel display that uses crystals to let varying amounts of different colored light pass through it.
  - Developed primarily for portable computers.
  - Audio Output
  - Disk Output (CD-R, CD-RW)

Output Devices

- **Storage Requirements**: How much storage capacity is needed for...
  - One keystroke on a keyboard: 1 byte (8 bits)
  - One page single-spaced document: 4.0 K
  - Nineteen pages formatted text: 75 K
  - One second of high-fidelity sound: 95-110 K
  - Complete word processing program: 8.4 MG
- **Storage Capacity**: How much data can be stored on...
  - One inch of 1/2 in. wide magnetic tape: 4 K
  - One 3 1/2” floppy disk, high density: 1.4 MB
  - One Compact Disk: 650 MB
  - One DVD: up to 17 GB
Moving Information Within the Computer

- How do binary numerals move into, out of, and within the computer?
  - Information is moved about in bytes, or multiple bytes called words.
  - Words are the fundamental units of information.
  - The number of bits per word may vary per computer.
  - A word length for most large IBM computers is 32 bits.

- Bits that compose a word are passed in parallel from place to place.
  - Ribbon cables:
    - Consist of several wires, molded together.
    - One wire for each bit of the word or byte.
    - Additional wires coordinate the activity of moving information.
    - Each wire sends information in the form of a voltage pulse.

Example of sending the word WOW over the ribbon cable:
- Voltage pulses corresponding to the ASCII codes would pass through the cable.

Packaging the Computer

- The many physical forms of the general purpose computer:
  - All follow general organization:
    - Primary memory
    - Input units
    - Output units
    - Central Processing Unit
  - Grouped according to speed, cost, size, and complexity.
This has just been an introduction to the computer architecture, more specific details will follow!