

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

What is the typical configuration of a computer sold today?

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## 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?

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## Basic Concepts of Computer Hardware

```
graph LR; Input[Input Units] --> CPU[CPU (Central Processing Unit)]; CPU --> Output[Output Units]; CPU <--> Memory[Primary Memory];
```

- 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.

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## 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.

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## 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.

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## 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

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## Input Devices

- Common Basic Technologies for Storing Binary Information:
  - Electronic
  - Magnetic
  - Optical

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## Input Devices

- 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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## 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.



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## Input Devices

- **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.



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## Input Devices

- **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.

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## Input Devices

- **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

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## Input Devices

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

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

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## 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.

Examples:	Cost for drive	Cost for medium
Floppy drive (1.4MB)	59.00	.50
Zip 100 (100 MB)	99.00	10.00
CD-WR (650 MB)	360.00 and up	1.00

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## 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).

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## 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 electronic 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.

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## 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)  
Accumulator (Results of computations kept here)
    2. **Control Unit** (Has two locations where numbers are kept)  
**Instruction Register** (Instruction placed here for analysis)  
**Program Counter** (Which instruction will be performed next?)
    3. **Instruction Decoding Unit** (Decodes the instruction)
  - **Motherboard:** The place where most of the electronics including the CPU are mounted.

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## 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 to pass through it.
      - Developed primarily for portable computers.
  - Audio Output
  - Disk Output (CD - R, CD-RW)

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## 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 MG
• One Compact Disk.	650 MG
• One DVD.	up to 17 GB

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### 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:

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### Moving Information Within the Computer

- 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.

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### Moving Information Within the Computer

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

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### 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.

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**Computer Architecture**

- This has just been an introduction to the computer architecture, more specific details will follow!

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