

Introduction to Computers:

A computer is an electronic device that processes data and executes activities based on a program, which is a set of instructions. Computers come in a variety of configurations, ranging from personal laptops and desktops to servers and supercomputers. They are essential in our daily lives, assisting us with jobs ranging from simple computations to complicated data analysis.

Computers are made up of both hardware and software components. Physical components of hardware include the central processor unit (CPU), memory, storage devices, input devices (such as keyboards and mice), and output devices (such as monitors and printers). The software consists of applications and operating systems that manage the functionality of the computer and allow users to interact with it.

Number System:

Number systems are mathematical systems that employ numbers to express and manipulate them. Different types of number systems are:

Decimal System (Base-10): The standard number system used by humans, based on ten digits: 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9.

Binary System (Base-2): Used by computers, it consists of two digits: 0 and 1. Each digit is called a bit, and a group of 8 bits is called a byte.

Octal System (Base-8): Less commonly used today but still employed in some computing contexts. It uses eight digits: 0, 1, 2, 3, 4, 5, 6, and 7.

Hexadecimal System (Base-16): Widely used in computing and programming. It uses sixteen digits: 0-9 and A-F (where A stands for 10, B for 11, C for 12, D for 13, E for 14, and F for 15).

Computer BUS:

A computer bus is a communication system that transports data between computer components or between computers. It facilitates communication and coordination inside the system by acting as a conduit for information to pass between the various hardware components. Buses are a crucial component of computer design, allowing data to be exchanged seamlessly between the CPU, memory, peripherals, and other devices. Here are some key characteristics of computer buses:

Types of buses:

Address Bus: Carries signals that specify a memory address or an I/O port address. It determines where the data should be read from or written to.

Data Bus: Transfers actual data between the CPU, memory, and peripherals. The width of the data bus (in bits) determines how much data can be transferred simultaneously.

Control Bus: Manages the control signals that coordinate and regulate the activities of the various components connected to the bus.

Computer buses play a vital role in the overall performance and functionality of a computer system. They provide a communication pathway that allows different hardware components to work together harmoniously. The design and efficiency of the bus architecture contribute significantly to a computer's speed and capabilities.

Evolution of computers:

Computers have evolved over several decades, with substantial advances in technology, architecture, and capabilities. Here's a quick rundown of the important stages in computer evolution:

First Generation Computers (1940s-1950s):

- Mechanical and electromechanical components were replaced with electronic vacuum tubes.
- Among the first electronic computers were the ENIAC (Electronic Numerical Integrator and Computer) and the UNIVAC I.

Second Generation Computers (1950s-1960s):

- Transistors replaced vacuum tubes, resulting in smaller size and lower power usage.
- High-level programming language development (for example, Fortran, COBOL).
- Magnetic core memory is introduced.
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Third Generation Computers (1960s-1970s):

- Integrated circuits (ICs) have taken the place of discrete transistors, increasing speed and reliability.
- Minicomputers such as the DEC PDP series are introduced.
- Operating system development and time-sharing.

Fourth Generation Computers (1970s-1980s):

- Microprocessors appeared, with the complete CPU housed on a single chip.
- Personal computers (PCs) became accessible to individuals.
- Introduction of graphical user interfaces (GUIs) and the mouse.

Fifth Generation Computers (1980s-Present):

- Parallel processing, artificial intelligence, and expert systems have all advanced.
- The development of networking technology resulted in the creation of the internet.
- Portable computers, such as laptops and, subsequently, smartphones, became popular.

Data representation in a computer:

In a computer, data representation is encoding information in a format that the computer can comprehend and modify. The fundamental unit of information in computers is binary code, which consists of 0s and 1s. Numbers and characters are the two fundamental components for data representation in a computer.

1. Representation of Numbers:

Binary (Base-2) System:

The binary number system is used by computers to represent data. Each digit in binary is referred to as a bit (binary digit), and a set of 8 bits is referred to as a byte.

Hexadecimal(Base-16) System:

Hexadecimal is frequently used to represent binary in a more human-readable format. Each hexadecimal digit is equivalent to four binary digits (half a byte).

Representation of a Floating Point:

Computers utilize floating-point notation to express real numbers with fractions and decimals. A sign bit, an exponent, and a mantissa are all part of it.

2. Representation of Characters:

American Standard Code for Information Interchange (ASCII):

ASCII is a character encoding system that assigns each alphanumeric and control character a unique 7-bit code. 8 bits are used in Extended ASCII. For instance, the ASCII code for the letter 'A' is 65.

Unicode:

Unicode is a character encoding system that provides unique codes to characters from different writing systems, allowing it to represent a greater range of characters than ASCII. Unicode encoding techniques include UTF-8, UTF-16, and UTF-32.

Memory System

In the context of computers, "memory" refers to the electronic storage space where data and instructions are saved for short-term or long-term usage by the computer. Memory is an essential component of a computer system, and there are various varieties, each having a distinct purpose. A computer's basic forms of memory are:

RAM (Random Access Memory).

- RAM is volatile memory, which means that its contents are lost when the power is switched off. It is used to store data and software instructions that the CPU need in real-time.
- RAM enables fast read and write access, making it ideal for jobs requiring speedy data retrieval, such as running apps and multitasking.
- In current computers, RAM is commonly measured in gigabytes (GB).

- Read-Only Memory (ROM):

ROM(Read only memory):

- ROM is a type of non-volatile memory that keeps its contents even after the power is switched off. It comprises firmware or software that is permanently written during the manufacturing process and is difficult to modify using standard computer techniques.
- A computer's BIOS (Basic Input/Output System) is an example of firmware stored in ROM. It is required for basic computer functions such as booting up.
- There are ROM variants that allow for limited alterations, such as PROM (Programmable ROM), EPROM (Erasable Programmable ROM), and EEPROM (Electrically Erasable Programmable ROM).

Secondary Storage

- Secondary storage devices such as hard disk drives (HDDs) and solid-state drives (SSDs), while not strictly part of the computer's primary memory, are critical for long-term data and program storage.
- Secondary storage, unlike RAM, is non-volatile, which means it stores data even when the power is turned off. It stores the operating system, applications, and user files.

Cache Memory

- Cache memory is a compact, high-speed type of volatile computer memory that stores frequently used computer programs, applications, and data and offers high-speed data access to a CPU.
- In current processors, cache levels such as L1, L2, and L3 exist, with L1 being the fastest but smallest and L3 being larger but slower.

Memory is an important aspect in determining the performance of a computer. Memory size and speed influence how quickly a computer can accomplish tasks and switch between apps. The many forms of memory in a computer system work together to provide efficient data storage and retrieval.

Memory hierarchy

The memory hierarchy is the structure and arrangement of many types of computer memory, each having a distinct capacity, performance, and cost. A memory hierarchy's purpose is to provide the computer system with the most efficient and cost-effective method of storing and retrieving data possible. The memory hierarchy is often made up of several layers, each of which serves a distinct purpose. The following are the primary levels of a typical memory hierarchy, from fastest and most expensive to slowest and least expensive:

- Registers
- Cache Memory
- RAM (Random Access Memory)
- Secondary Storage

The memory hierarchy is intended to achieve the best possible mix of speed, cost, and storage capacity. Faster, more expensive memory levels are used to store frequently accessible and vital data, whereas slower, less expensive memory levels are used to store less often accessed or bigger datasets. This hierarchical structure enables computer systems to provide great performance by reducing the time required for the CPU to retrieve the data it requires. Caches, in particular, are critical in closing the speed gap between the CPU and main memory.

Registers

Registers are small, quick storage areas within a computer's central processor unit (CPU). They are used to temporarily store data during program execution and to allow the CPU to access it quickly. Registers are the quickest type of memory in a computer system, because they are incorporated directly into the CPU. Here are some essential register properties and functions:

Speed: Registers operate at the CPU clock cycle speed, making them exceptionally quick when compared to other types of memory.

Size: Registers are small in size and can only carry a limited amount of data.

They are normally measured in bits, and current CPUs offer a variety of register sizes (for example, 32-bit or 64-bit registers).

Purpose: Registers are the principal storage location for data that the CPU is currently consuming or processing. They store operands for arithmetic and logical operations, intermediate results, and memory location addresses.

Registers in computer architecture are classified as general-purpose registers or special-purpose registers, with each having a specialized function within the central processing unit (CPU).

General-Purpose Registers:

- General-purpose registers are adaptable and can be used to store data, intermediate results, and memory addresses, among other things.
- They are not devoted to a particular purpose and can be used by the CPU for a variety of activities throughout program execution.

Special-Purpose Registers:

- Special-purpose registers are used to regulate specific features of program execution or to perform specific functions within the CPU.
- They may manage exceptions, govern program flow, or handle certain types of data.

Volatile memory and Non-Volatile memory

Volatile memory is temporary storage that loses its content when the power is turned off. This type of memory is used to store data and program instructions that are actively being used by the computer while it's powered on. The key characteristics of volatile memory include:

Data Loss: Volatile memory loses its contents when the power is interrupted or turned off. This is because the data is stored in electronic components that require a constant supply of electricity to retain their state.

Speed: Volatile memory is generally faster in terms of data access and retrieval compared to non-volatile memory. This is why it is used for tasks that require quick access to data during the computer's operation.

For example, RAM (Random Access Memory): This is the primary type of volatile memory in a computer. RAM is used for the temporary storage of data and program instructions that the CPU needs for real-time processing.

Non-volatile memory retains its content even when the power is turned off. It is used for long-term storage of data, applications, and the operating system. Unlike volatile memory, non-volatile memory is slower but provides persistent storage. The key characteristics of non-volatile memory include:

Data Persistence: Non-volatile memory retains its stored information even when the power is turned off. This makes it suitable for storing data that needs to be preserved between power cycles.

Speed: Non-volatile memory, such as storage devices like hard disk drives (HDDs) and solid-state drives (SSDs), is generally slower than volatile memory. Access times are slower, but it provides high-capacity, long-term storage.

For examples

- Hard Disk Drives (HDDs): Traditional mechanical storage devices that use rotating disks to store data.
- Solid-State Drives (SSDs): Modern storage devices that use flash memory for faster and more reliable data access.

In short, volatile memory is utilized for temporary storing during the active operation of a computer, allowing for quick access to data. Non-volatile memory is used for long-term data storage that must be retained even after the power is turned off, offering persistence but with slower access times than volatile memory.

Semiconductor memory

A sort of electronic data storage device that stores data using semiconductor technology is known as semiconductor memory. Because they enable quick and easy access to data, these memories are essential parts of computers and other electronic devices. Volatile and non-volatile semiconductor memory are the two primary categories into which it can be divided.

In today's computing and electronic devices, semiconductor memory is essential because it facilitates quick access to data and a wide range of uses, from system memory to long-term data storage. Progress in semiconductor memory technology

leads to enhancements in system performance, data storage capabilities, and access speeds

Optical storage systems

Laser beams are used by optical storage systems to read and write data on optical discs. Multimedia playback, software distribution, and long-term data storage are prominent uses for these devices. The following are the most popular kinds of optical storage devices:

- Compact Disc (CD)
- Digital Versatile Disc (DVD)
- Blu-ray Disc (BD)
- Optical Disc Drives

Advantages: Optical storage provides non-volatile, removable storage. Optical discs are relatively inexpensive, making them cost-effective for distribution.

Disadvantages: Slower data transfer rates compared to some other storage technologies. Limited capacity compared to modern solid-state and magnetic storage.

Solid-State Device (SSD)

An electronic component that depends on the characteristics of semiconductors to carry out different tasks is referred to as a solid-state device. These devices regulate the flow of electrical current using solid-state materials, most often crystalline or amorphous semiconductors like silicon.

Advantages:

- Solid-state devices are more reliable and durable than many mechanical and electromechanical devices.
- They are smaller in size, lighter, and more energy-efficient compared to older technologies.

Solid-state devices have completely changed the electronics industry by making it possible to create high-performance, small, and effective electronic systems for a

variety of uses. Their continuous progress propels technological developments and aids in the creation of gadgets that are both more potent and energy-efficient.

Flash memory

One kind of non-volatile storage technology that keeps data safe even in the event of a power outage is flash memory. Because of its speed, robustness, and small size, it is frequently employed for data storage in a range of electronic products.

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