

Computer Hardware and Software

and their Implementation in the different institutions in the community

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BSCS-1

What is a computer?

A **computer** is an electronic device designed to process data, perform calculations, and execute instructions automatically. It operates by accepting input, manipulating that data according to programmed instructions, and producing output.

Types of Computers

- **Personal Computers (PCs):** Designed for individual use, including desktops and laptops.
- **Mainframes:** Powerful machines used for large-scale computing tasks.
- **Supercomputers:** Extremely fast computers used for complex computations in fields like scientific research and weather forecasting.
- **Embedded Systems:** Computers integrated into other devices (like appliances or vehicles) to control specific functions



Supercomputers

A supercomputer is a highly advanced computing system designed to perform complex calculations at extremely high speeds, often measured in floating-point operations per second (FLOPS).



Notable Supercomputers

1. **Frontier** - world's fastest supercomputer at 1 exaFLOP (1 quintillion FLOPS)
2. **Fugaku** - second fastest at 442 petaFLOPS.
3. **Summit** - at 148.6 petaFLOPS, Summit is the predecessor of the Frontier.



Fugaku Supercomputer

RIKEN Center for Computational Science, Kobe, Japan



Frontier Supercomputer
Oak Ridge National Laboratory, Tennessee, USA

Historical Context

The concept of a computer has evolved significantly over time. Early mechanical devices laid the groundwork for modern computing. The first electronic programmable computer, ENIAC, was developed in the 1940s, marking a significant milestone in computing history. The theoretical foundation was established by figures like Alan Turing, who proposed the idea of a universal machine capable of performing any computation.



Architecture

Most modern computers are based on the **Von Neumann architecture**, which describes a system where data and instructions are stored in memory. This architecture allows the CPU to execute instructions sequentially, making it efficient for various computing tasks.

Key components include

- **Arithmetic Logic Unit (ALU)**: Performs arithmetic and logical operations.
- **Control Unit**: Directs the operation of the processor and manages the execution of instructions.
- **Memory**: Stores both data and programs necessary for processing.

Computer Hardware

Computer hardware encompasses all the physical components that constitute a computer system. These components can be categorized into **internal** and **external** hardware, each serving distinct functions.

Internal Hardware Components

- Motherboard
- Central Processing Unit (CPU)
- Random Access Memory (RAM)
- **Storage Devices**
 - Hard Disk Drives
 - Solid-state Drives
- Graphics Processing Unit (GPU)
- Power Supply Unit
- **Cooling Systems**
 - Air Cooling
 - Liquid Cooling

External Hardware Components

- Monitors
- Keyboards
- Mice
- Printers
- Scanners

Advanced Components

- Network Interface Card (NIC)
- Sound Card
- Expansion Cards
- BIOS/UEFI

Internal Hardware Components

These are the essential parts located inside the computer case

Motherboard

The main circuit board that connects all components, including the CPU, RAM, and storage devices. It contains slots for expansion cards and interfaces.

Central Processing Unit

Referred to as the **brain** of the computer, the CPU executes instructions from programs and processes data. Modern CPUs are typically multi-core to process multiple tasks.

Random Access Memory

Type of volatile memory that temporarily stores data and instructions that the CPU needs while performing tasks. More RAM allows for better multitasking.

Graphics Processing Unit

A specialized processor designed to handle graphics rendering. Essential for gaming, video editing, and other graphics-intensive tasks.

Internal Hardware Components

These are the essential parts located inside the computer case

Hard Disk Drives (HDDs)

Traditional storage devices using spinning disks to read/write data. They offer larger capacities at lower costs but are slower than SSDs.

Solid-State Drives (SSDs)

Faster storage devices that use flash memory, providing quicker access to data compared to HDDs. SSDs are more reliable due to no moving parts.

Power Supply Unit

Converts electrical power from an outlet into usable power for the internal components of the computer.

Cooling Systems

Air Cooling uses fans and heat sinks to dissipate heat while **Liquid Cooling** uses a pump to circulate liquid, absorbing and moving heat away from the components.

External Hardware Components

These devices connect to the computer to provide input or output functions

Monitors

Display visual output from the computer. Various types include LCD, LED, and OLED screens. There are also monitor panels such as TN, VA, and IPS panels.

Mice

Pointing devices that allow users to interact with on-screen elements. Mice can also be wired or wireless, with varying polling rate, DPI and actuation force.

Keyboards

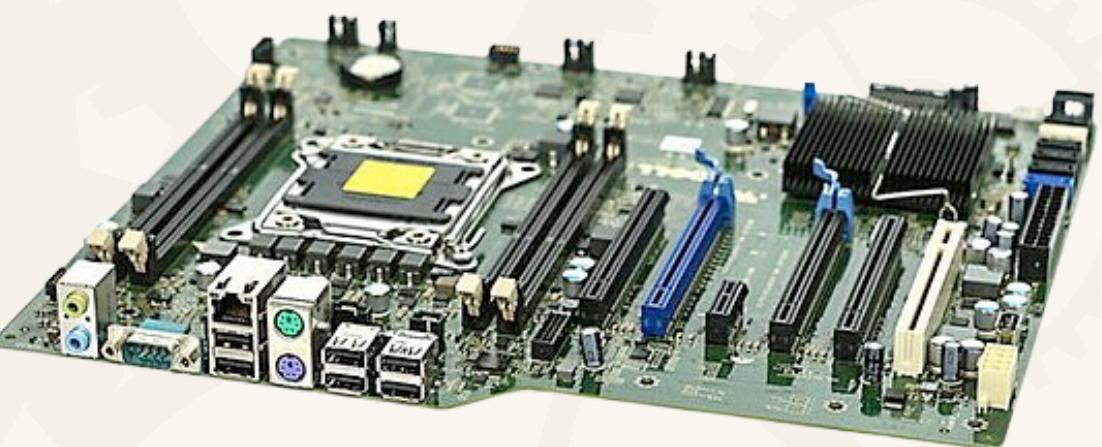
Input devices used for typing and command entry. Keyboards can be wired or wireless through bluetooth or wireless usb dongle. Keyboards have varying switches.

Printers and Scanners

Printers are output devices that produce physical copies of digital documents, while scanners convert physical documents into digital format.

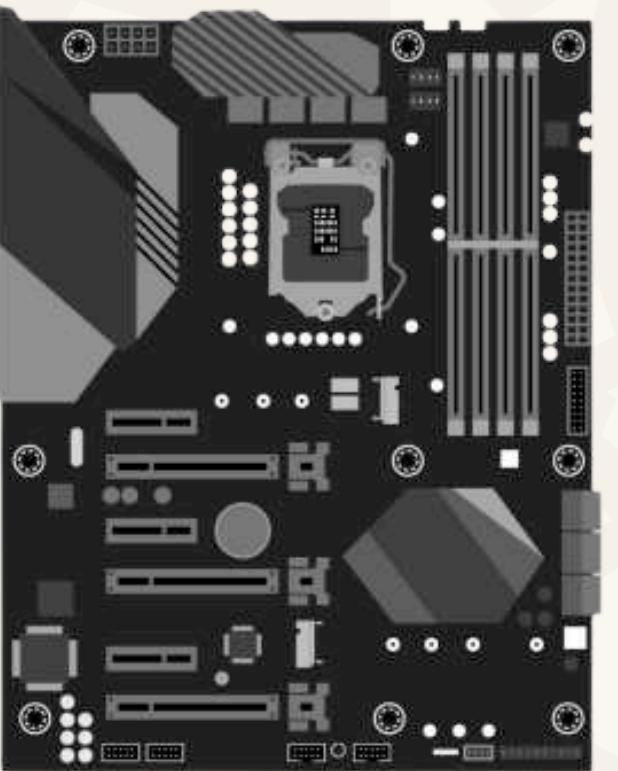
Motherboard

The main circuit board that connects all components, including the CPU, RAM, and storage devices. It contains slots for expansion cards and interfaces for peripherals.

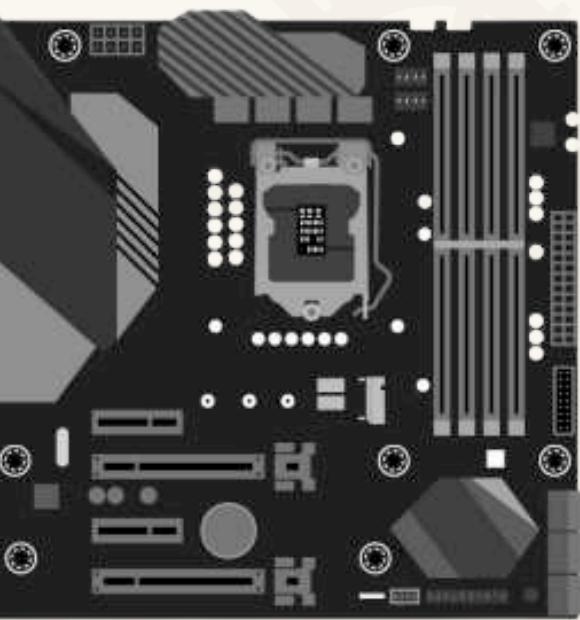


Common Types of Motherboard

Motherboards vary widely in size, design, and functionality, catering to different computing needs—from high-performance gaming rigs to compact home theater setups. The choice of motherboard affects not only the physical size of the computer but also its expandability and overall performance capabilities.



ATX

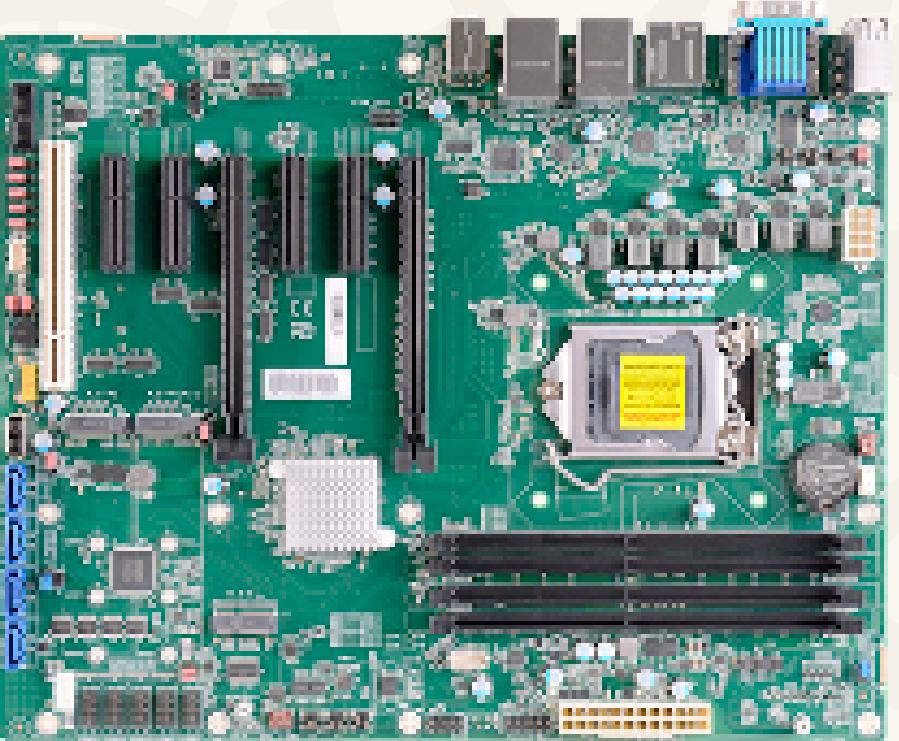


MICRO-ATX



MINI-ITX

Common Types of Motherboard



ATX

Developed by intel in 1995, ATX motherboards are the most common among desktop computers. It is approximately 12 in x 9.6 in. Ideal for high performance systems.



Micro ATX (M-ATX)

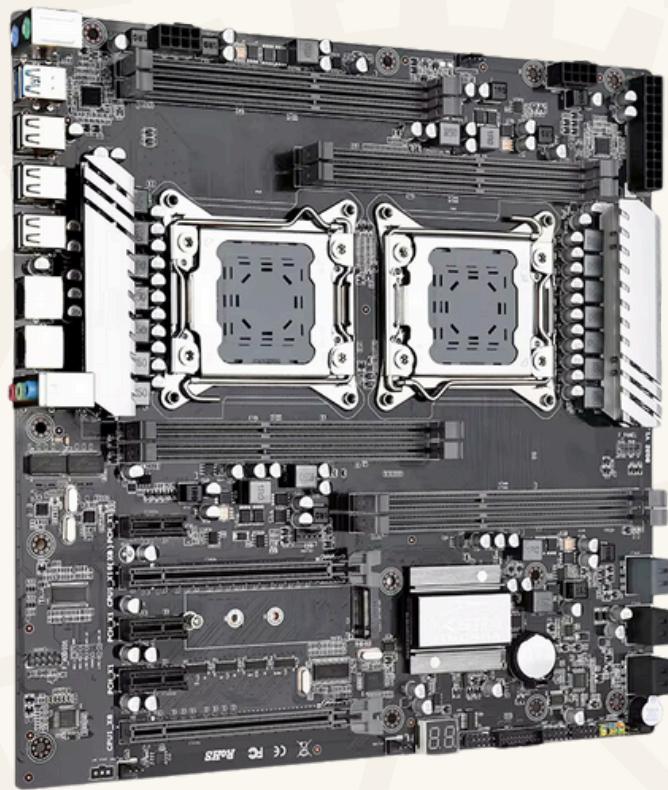
A smaller variant of the ATX, introduced in 1997. It typically measures 9.6 in x 9.6 in. It is suitable for budget builds or compact systems. It supports fewer expansion slots.

Common Types of Motherboard



Mini ITX

It was developed by VIA Technologies in 2001. It measures 6.7 in x 6.7 in, and has limited expansion slots. It is designed for low power consumption and efficient cooling.



extended ATX (E-ATX)

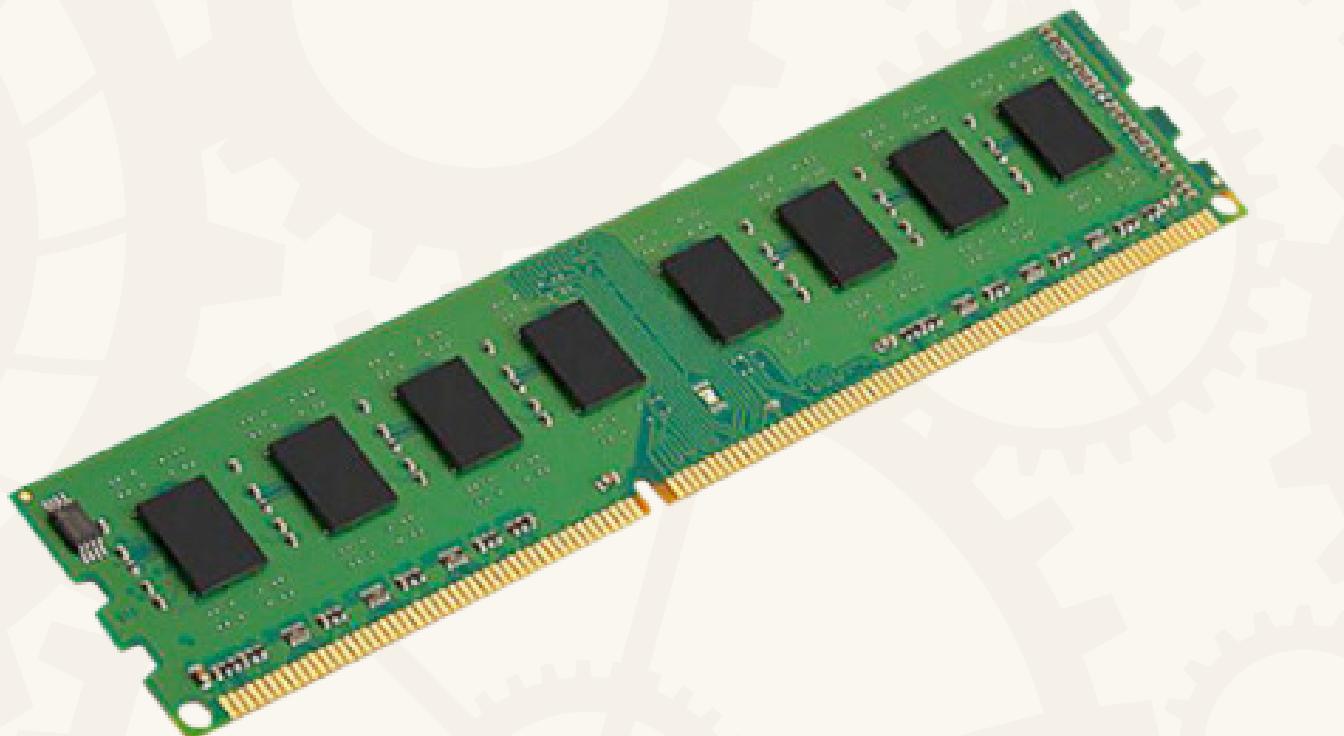
A larger version of the standard ATX motherboard. Its size is approx. 13.6 in x 12.8 in. It supports dual CPU slots, more RAM and PCIe slots. It is designed for high-end workstations.

Random Access Memory (RAM)

Random Access Memory (RAM) is a crucial component of modern computing systems, enabling fast data access and processing. RAM is a type of volatile memory used in computers and other devices to store data temporarily that the CPU needs while performing tasks. Unlike permanent storage (like hard drives), RAM loses its contents when the power is turned off. It allows for quick read and write access to a storage medium, which significantly enhances the speed and efficiency of the computer.

Basic Types of RAM

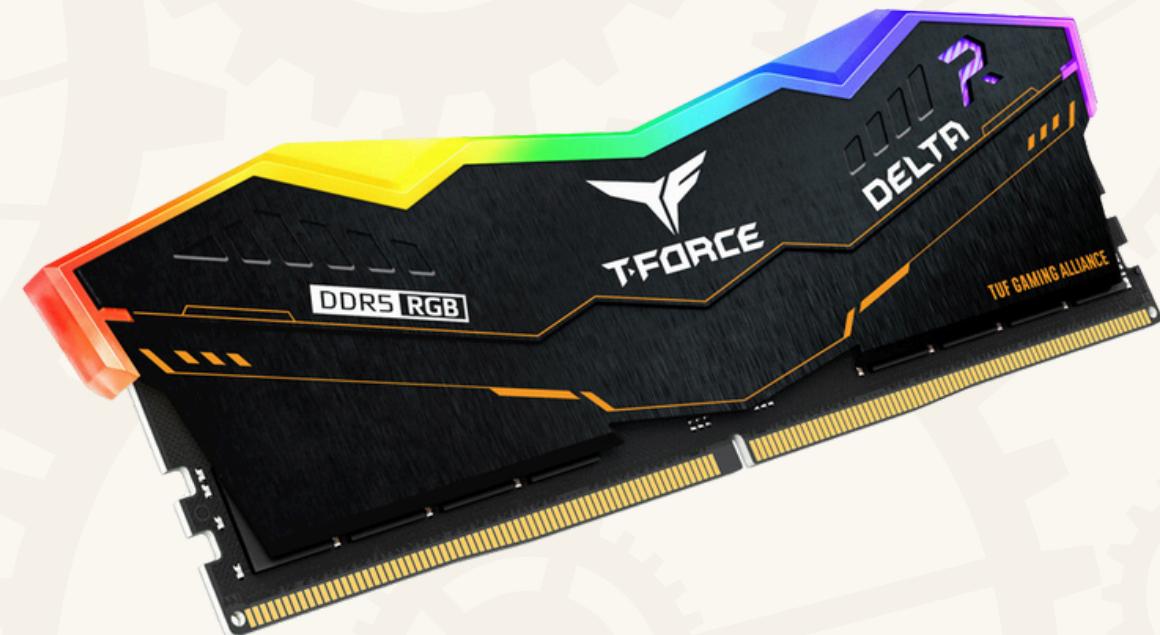
- Static RAM (SRAM)
- Dynamic RAM (DRAM)
- Synchronous Dynamic RAM (SDRAM)
- **Double Data Rate Synchronous Dynamic RAM (DDR SDRAM)**
- **Graphics Double Data Rate (GDDR)**



Double Data Rate Synchronous Dynamic RAM

Double Data Rate Synchronous Dynamic RAM (DDR SDRAM) is a type of memory technology used in computers and other electronic devices. It is an improvement over earlier Single Data Rate (SDR) SDRAM because it effectively doubles the data transfer rate without increasing the clock frequency.

It is one of the **most commonly used** type of RAM among **Personal Computers**. You may hear specifications such as DDR4 or DDR5 when picking this hardware. DDR SDRAM includes generations with each generation offering improvements in speed and efficiency.



**DELTA TUF Gaming Alliance RGB DDR5
6400 Mhz DESKTOP MEMORY**

Graphics Double Data Rate

Graphics Double Data Rate (GDDR) is a type of synchronous dynamic random-access memory (SDRAM) specifically optimized for high-performance graphic applications. GDDR is commonly used in graphics processing units (GPUs) and gaming consoles because it provides high bandwidth and low latency, which are essential for rendering complex visuals and processing large amounts of graphical data in real-time.



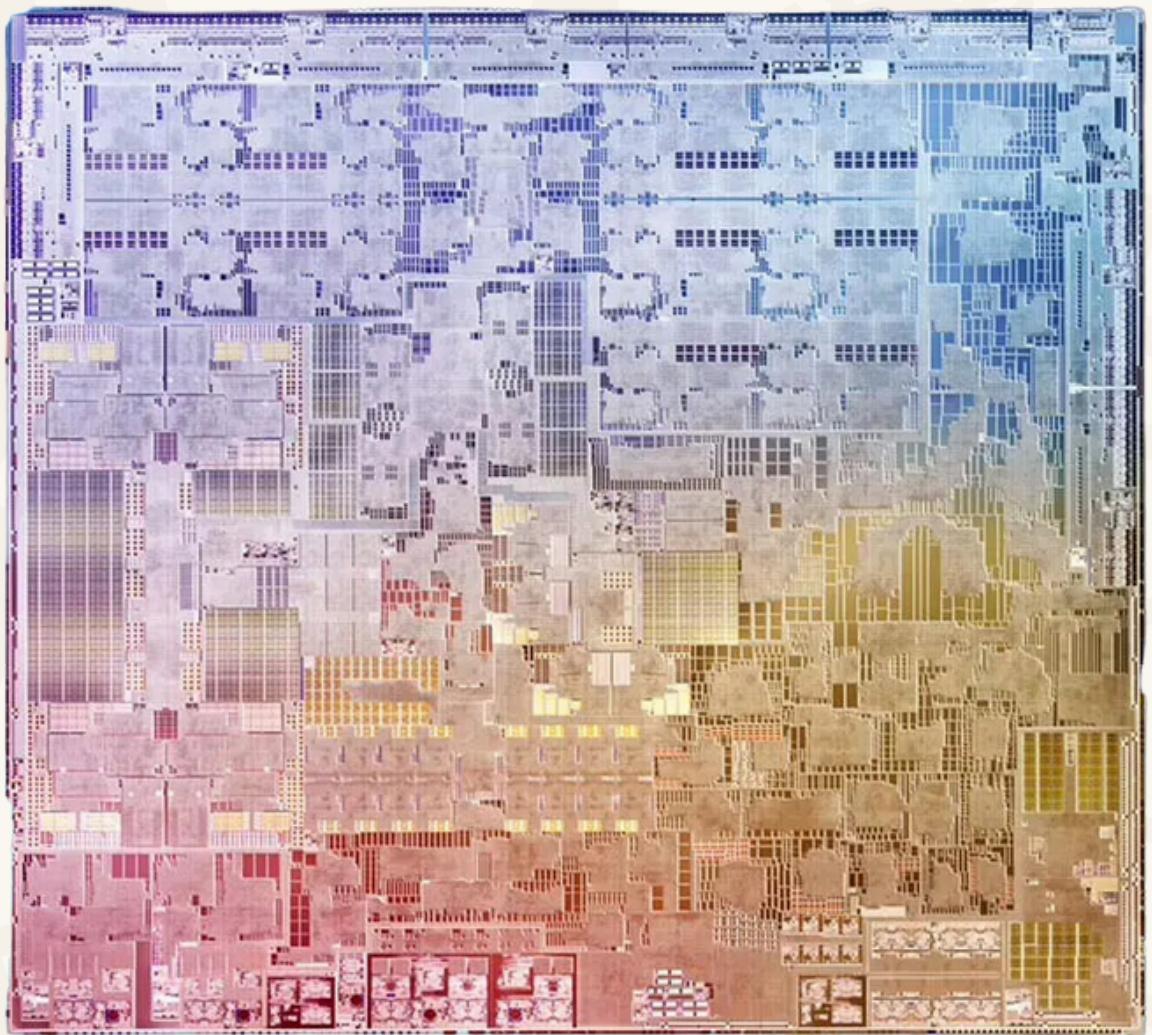
RTX 4090 Founders Edition with 24 GB
GDDR6X RAM

Central Processing Unit

The Central Processing Unit (CPU) is often referred to as the "brain" of a computer. It is a critical component that performs most of the processing tasks and controls the operation of all other components within a computer system. The CPU executes instructions from programs, performs calculations, and manages data flow between various hardware elements.

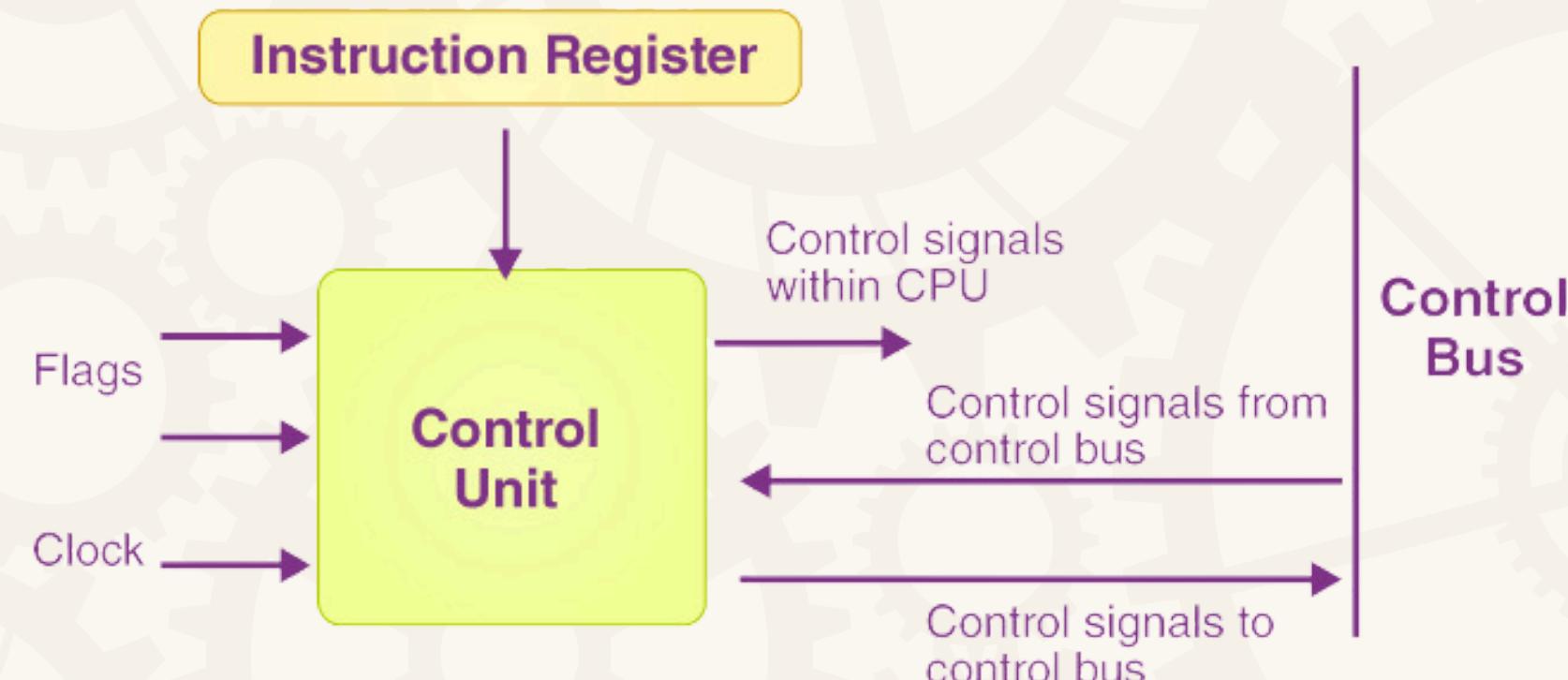
Functionality of a CPU

- **Fetch:** The control unit retrieves instructions from memory.
- **Decode:** The control unit interprets the fetched instruction to determine what action is required.
- **Execute:** The ALU performs the necessary calculations or logical operations based on the decoded instruction



Inside an **Apple M2 Chip**

Components of a CPU

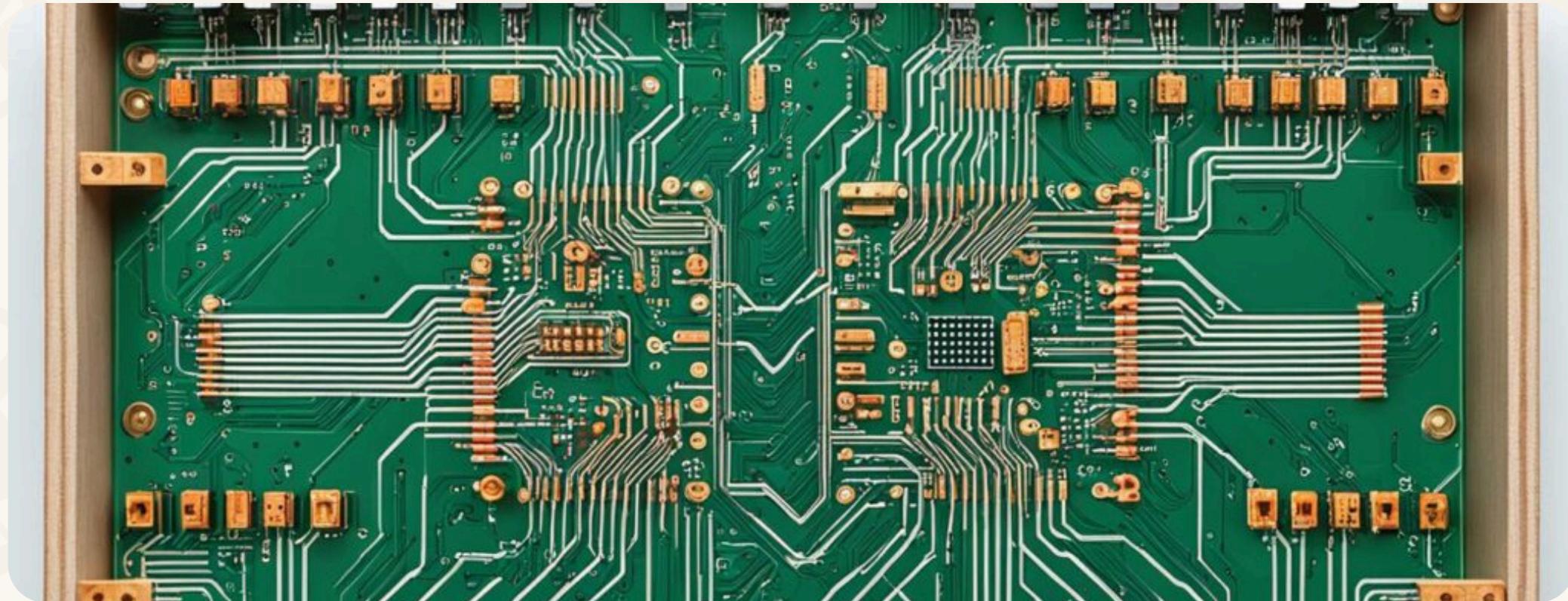


Block Diagram of the Control Unit

Control Unit

The control unit directs the operation of the processor by managing instruction execution and coordinating data flow within the CPU and between other computer components. It fetches instructions from memory, decodes them, and sends control signals to other parts of the CPU to execute these instructions.

Components of a CPU



Arithmetic Logic Unit (ALU)

The ALU performs arithmetic operations (addition, subtraction, multiplication, division) and logical operations (AND, OR, NOT) on data. It receives data from registers or memory, processes it according to the instructions from the control unit, and outputs the results.

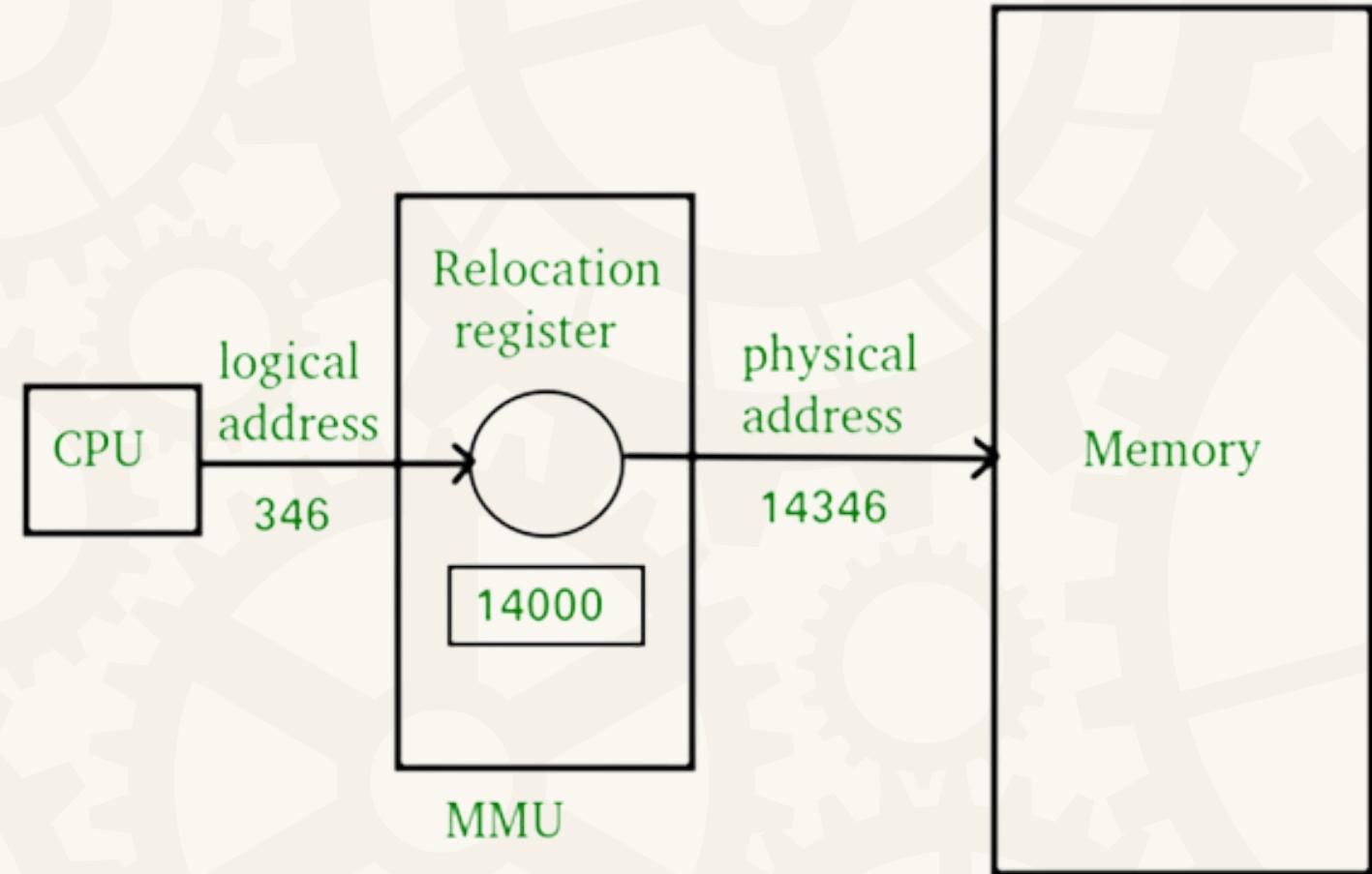
Components of a CPU



Registers

Registers are small, high-speed storage locations within the CPU that temporarily hold data being processed. They provide quick access to frequently used data and instructions.

Components of a CPU



Memory Management Unit (MMU)

The MMU manages interactions between the CPU and main memory (RAM), handling tasks such as virtual memory management and cache memory operations.

Storage Devices

In the context of storage devices, **Solid State Drives (SSDs)** and **Hard Disk Drives (HDDs)** are two primary types of storage devices used in computers and other digital devices. They serve the same basic function of storing data, but they utilize different technologies and offer distinct advantages and disadvantages.



Hard Disk Drive



Solid State Drive

Hard Disk Drive



A **Hard Disk Drive (HDD)** is a traditional storage device that uses spinning disks, or platters, to read and write data. Data is stored magnetically, and the drive has an arm with read/write heads that move across the platters to access different data locations.

Solid State Drive



A **Solid State Drive (SSD)** is a newer type of storage device that uses flash memory to store data. Unlike HDDs, SSDs have no moving parts, relying instead on NAND-based flash memory to retain data. This design allows SSDs to read and write data much faster.

Power Supply Unit

A **Power Supply Unit (PSU)** is an essential component in electronic systems, particularly in computers. Its primary function is to convert mains AC (Alternating Current) into low-voltage regulated DC (Direct Current) power, which is necessary for the operation of internal components like the CPU, motherboard, and storage devices.

Key Functions of a PSU

Voltage Conversion: Converts high-voltage AC from the wall outlet to low-voltage DC suitable for computer components.

Regulation and Filtering: Ensures stable output voltage, free from electrical noise and spikes that could damage components.

Power Distribution: Supplies power to various components via multiple connectors tailored for different hardware needs.



Corsair Enthusiast TX650 V2 ATX12V EPS12V Power Supply

Cooling Systems

Cooling systems are essential for maintaining optimal operating temperatures in computers, preventing overheating, and ensuring reliable performance. The two primary types of cooling systems are air cooling and liquid cooling, each with its own advantages and disadvantages.

Air Cooling

Air cooling utilizes **fans** to blow air over heatsinks attached to heat-generating components like the CPU and GPU. The heatsink absorbs heat from the component, which is then dissipated into the air by the fan.



Liquid Cooling

Liquid cooling systems circulate a **coolant** (usually water or a specialized fluid) through tubes that connect to a water block mounted on the CPU or GPU. The coolant absorbs heat and is then pumped to a radiator, where fans dissipate the heat into the air.



Types of Computers based on Hardware

Desktops



Larger, more modular computers with easy upgradability, offering powerful processors, more RAM, and extensive storage options.

Laptops



Portable, integrated systems with built-in displays, keyboards, and batteries. Laptops often have less upgradability than desktops.

Types of Computers based on Hardware

Servers



Powerful machines optimized for handling, managing, and processing requests on a network, used mainly in business and enterprise environments.

Embedded Systems



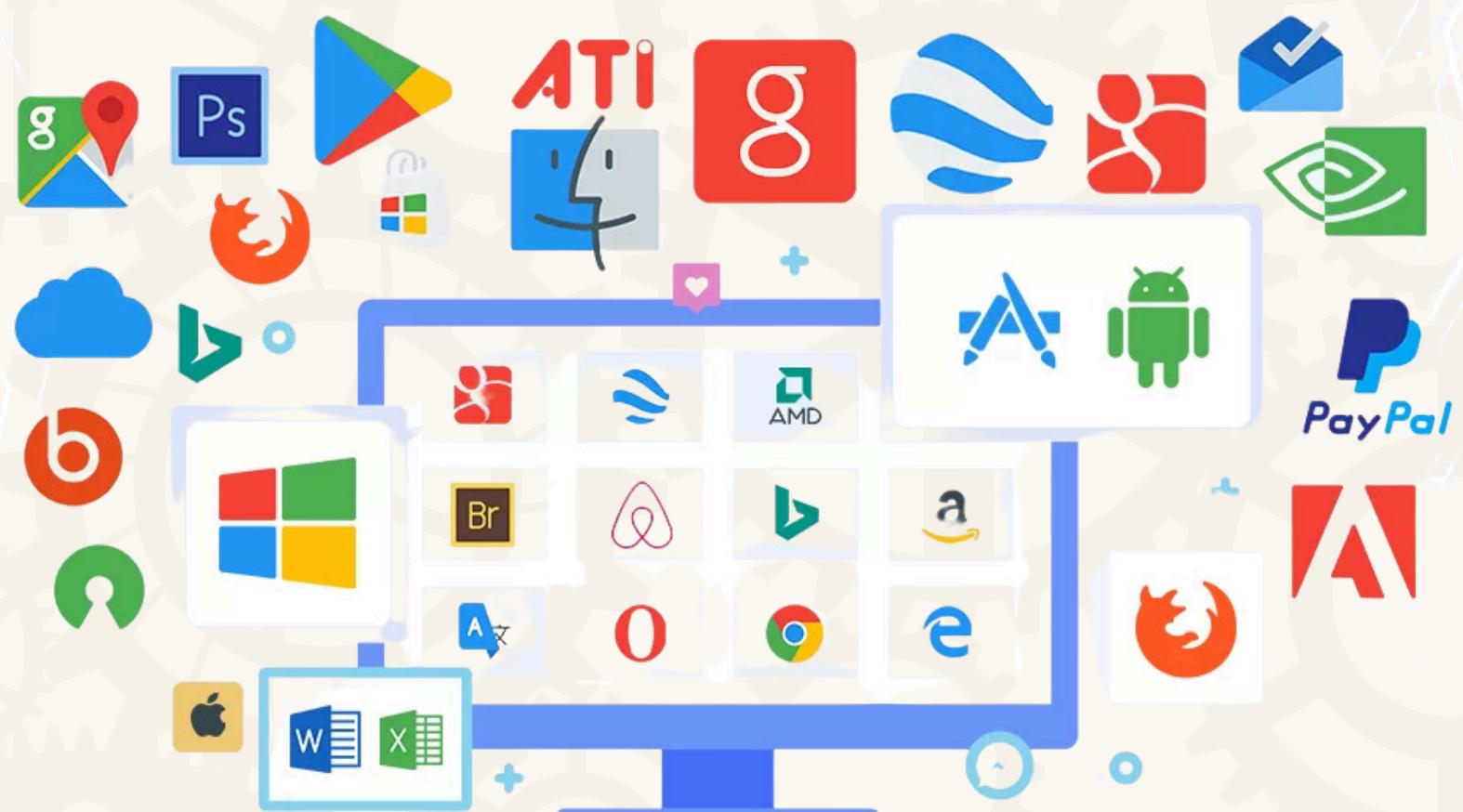
Specialized computers designed for specific tasks, often integrated into other devices (e.g., appliances, cars).



Software

Software

Software refers to a **collection of instructions, data, or programs** that enable a computer to perform specific tasks. It is an essential component of computer systems, functioning alongside hardware to facilitate various operations. Software can be broadly categorized into different types based on its purpose, licensing models, and distribution methods.



System Software

This type includes the **operating system (OS)** and all **utility programs** that manage computer resources at a low level. The OS serves as an intermediary between users and the computer hardware, managing tasks such as memory allocation, file management, and device control.



Windows



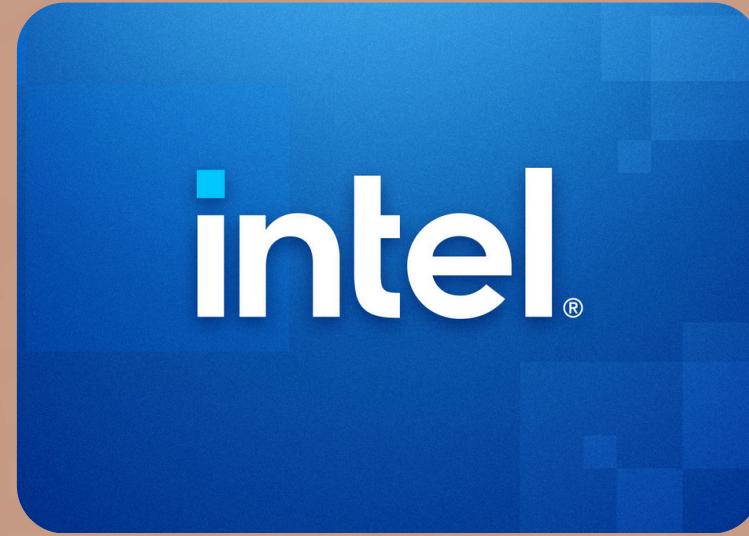
macOS



Linux

Device Drivers

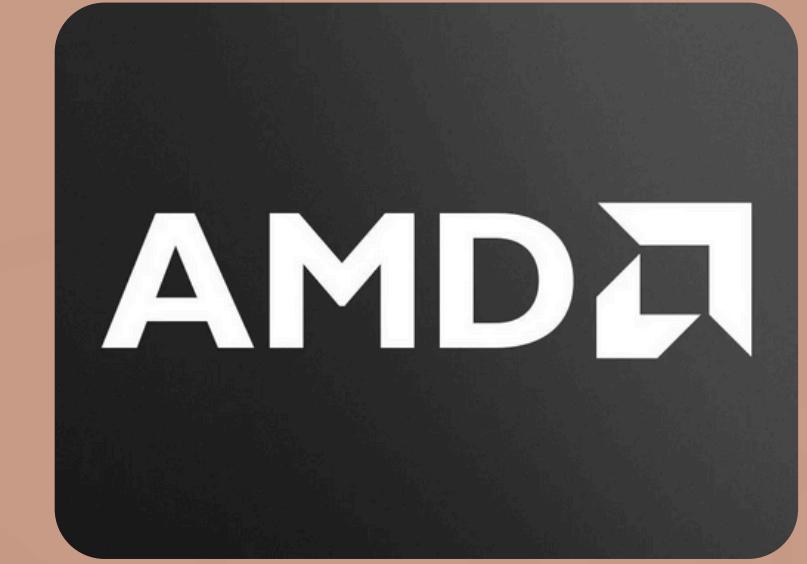
A **device driver** is a specialized program that allows the OS to **interact** with **hardware devices** such as printers, graphics cards, and network adapters. Without these drivers, the OS would not be able to control or utilize the hardware effectively. Each driver is tailored to a specific type of device and is dependent on both the hardware it controls and the operating system it operates within.



Intel



NVIDIA



AMD

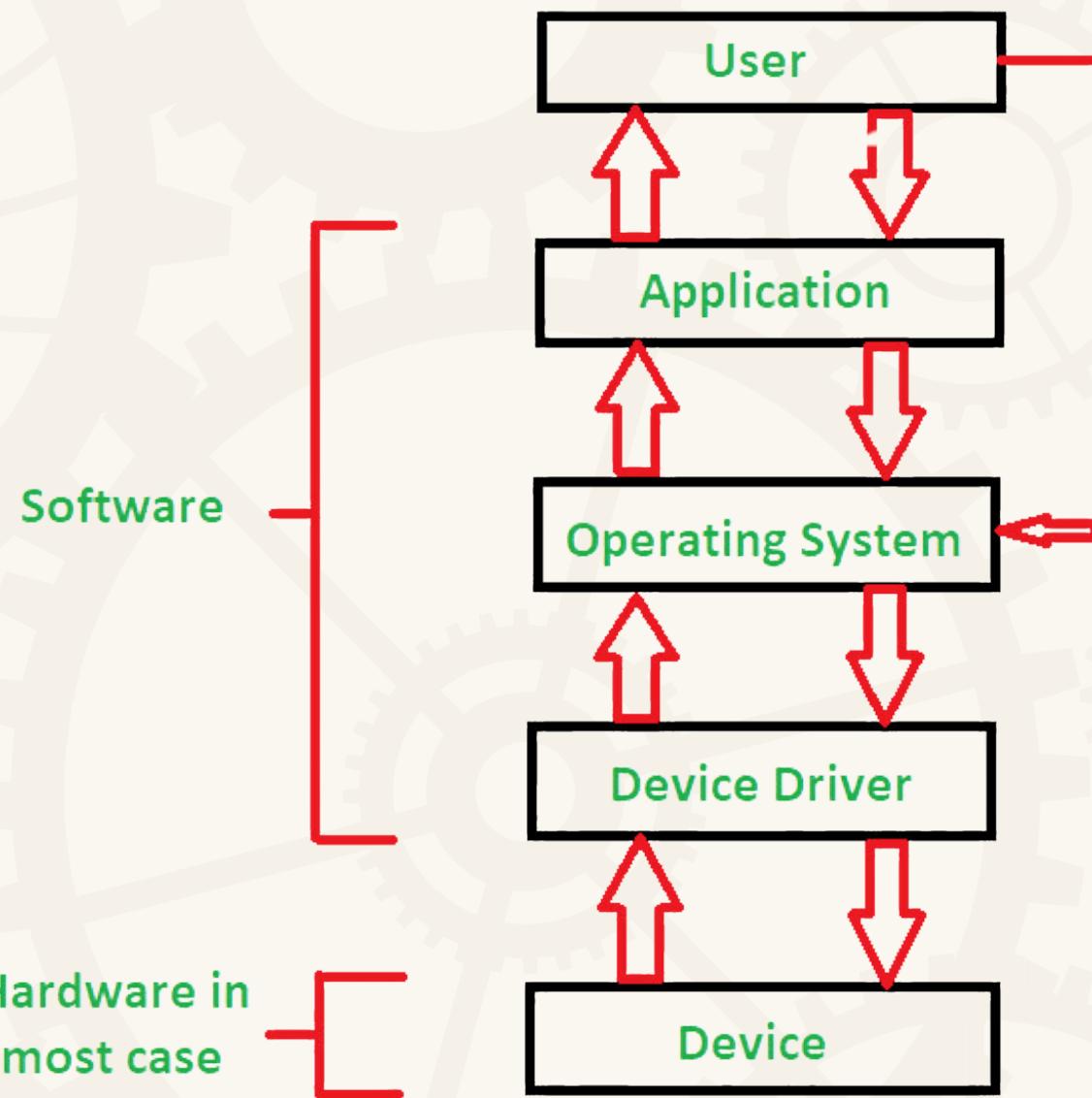
Famous Graphics Card Hardware and Driver Manufacturers

Device Drivers

Device drivers operate in conjunction with the **OS kernel**, which manages system resources. When an application requests an action involving hardware (like printing a document), the OS sends this request to the relevant driver. The driver then communicates directly with the hardware to execute the command and returns any results or status messages back to the OS.

Interaction Process

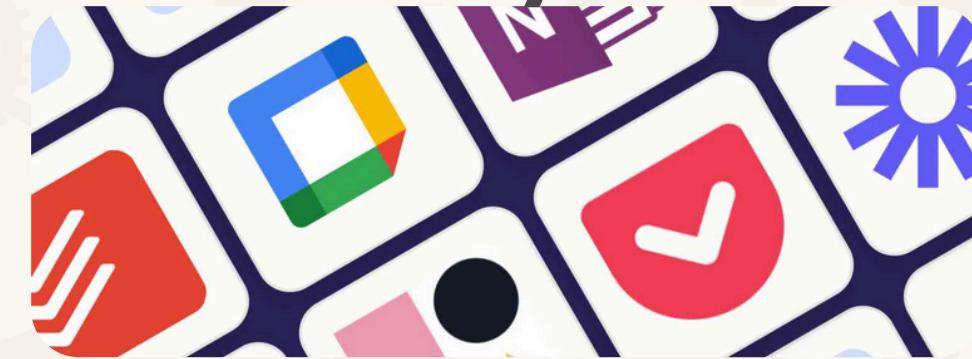
- **Command Issuance:** The OS sends a command to the driver.
- **Execution:** The driver translates this command into instructions for the hardware.
- **Response Handling:** The hardware performs the action and sends feedback to the driver.
- **Feedback Relay:** The driver sends this feedback back to the OS for further processing or display



Application Software

Application software is designed for end-users to perform specific tasks. This category encompasses a wide range of software, including:

Productivity Software



Multimedia Software



Web Browsers



Database Softwares



Application Software: Software Suites

A software suite is a collection of related software applications bundled together to provide users with a cohesive set of tools for specific tasks or functions. These suites typically share a common user interface and integrate seamlessly, allowing for efficient workflow and data exchange among the applications.

Examples of Software Suites



Office 365 Suite



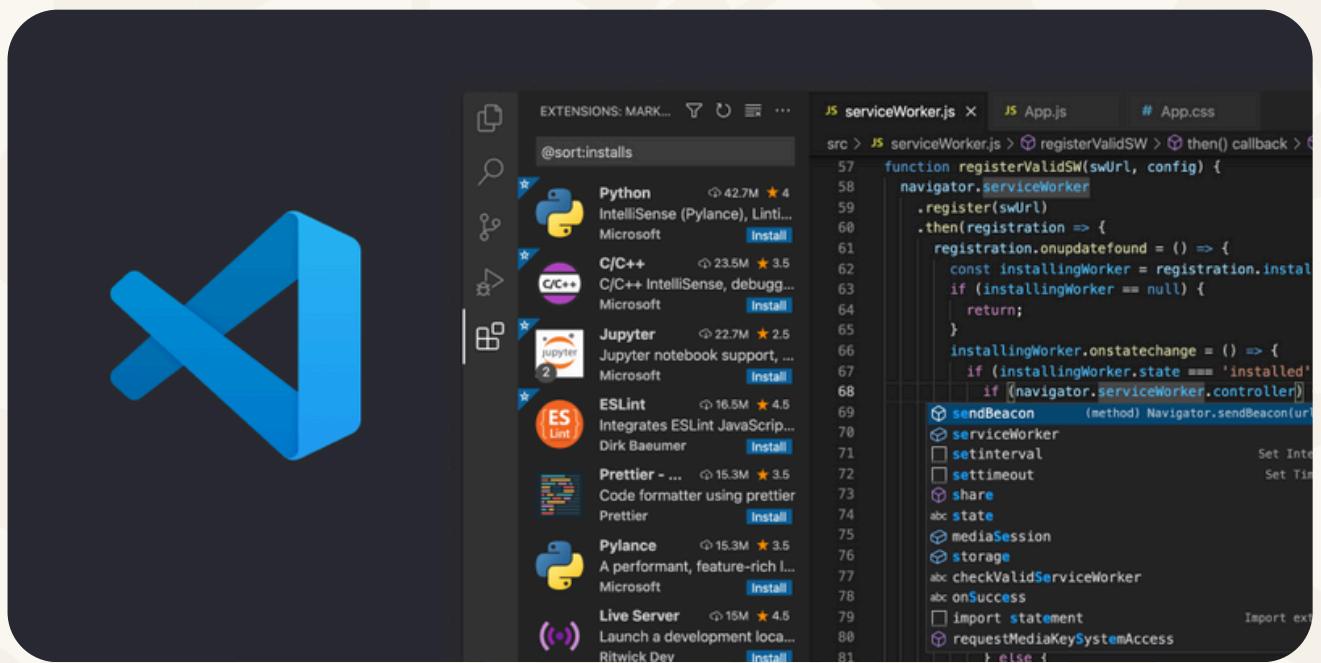
Adobe Creative Cloud



JetBrains

Development Software

This includes tools that developers use to create applications and software solutions. Common development software includes:



Visual Studio Code



git



GitHub



GCC Compiler

Implementation in the different institutions in the community

The integration of computer hardware and software into various community institutions is crucial for enhancing operational efficiency, improving educational outcomes, and fostering community engagement. This implementation varies across sectors such as education, healthcare, business, and non-profit organizations, each with unique needs and challenges.



Educational Institutions



Business Sector



Healthcare Institutions



Non-profit Organizations

Educational Institutions

In educational settings, the deployment of computer hardware and software is fundamental for modern teaching and learning practices. Schools and universities utilize:

Hardware



Desktops, laptops, tablets, and interactive whiteboards facilitate interactive learning experiences.

Software

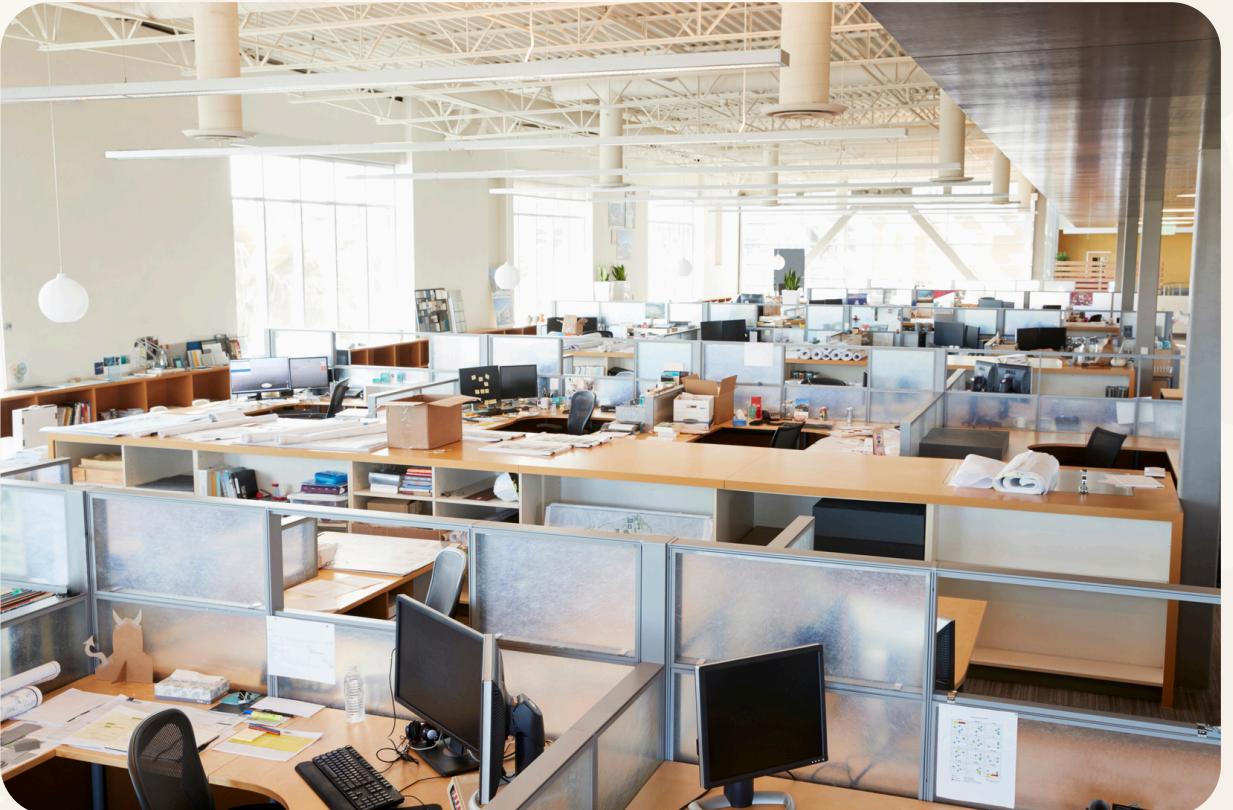


Learning management systems (LMS), Management Information Systems (MIS, such as USC ISMIS), educational applications, and administrative software streamline both teaching and administrative processes.

Business Sector

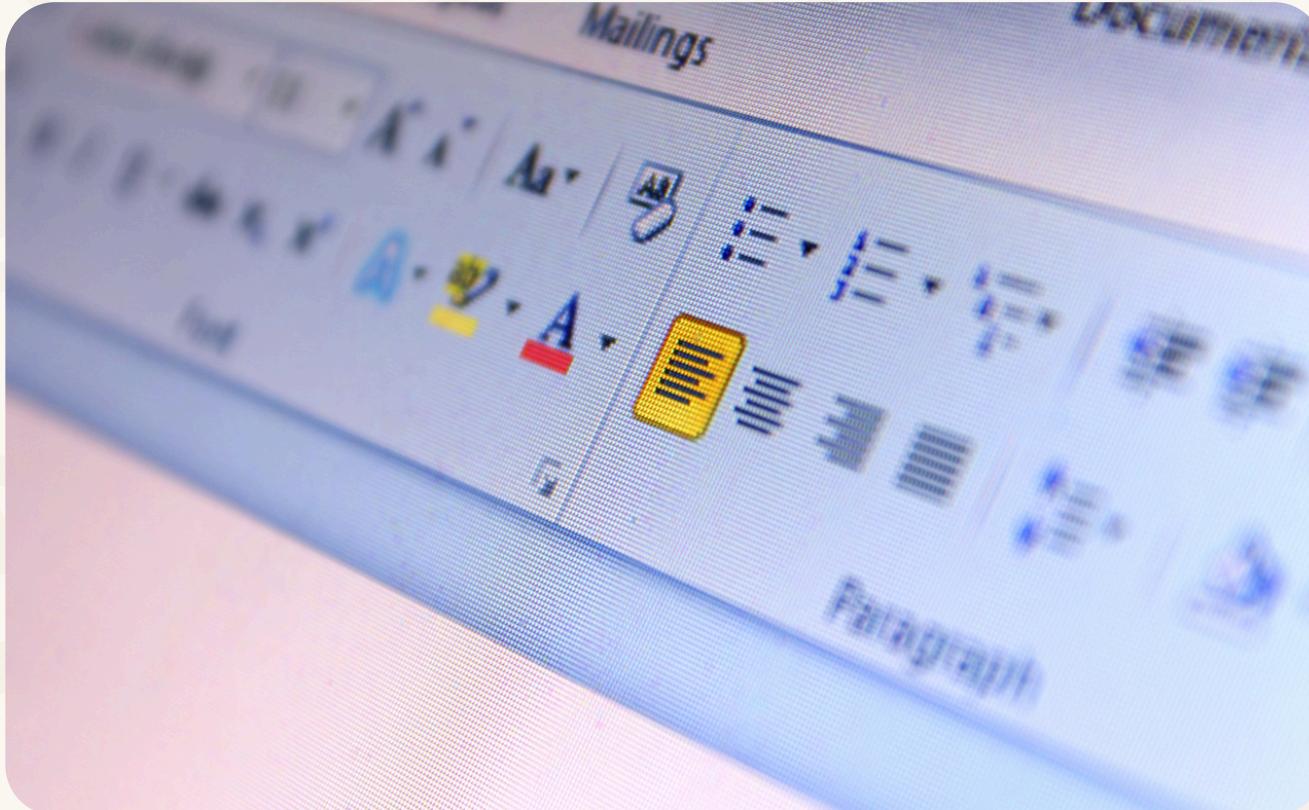
In the business community, the choice of computer hardware and software significantly impacts productivity and operational efficiency. Businesses typically implement:

Hardware



Workstations equipped with high-performance CPUs, multiple monitors, and networking devices to enhance collaboration.

Software



Applications for word processing, spreadsheets, databases, and specialized industry software tailored to specific business needs.

Healthcare Institutions

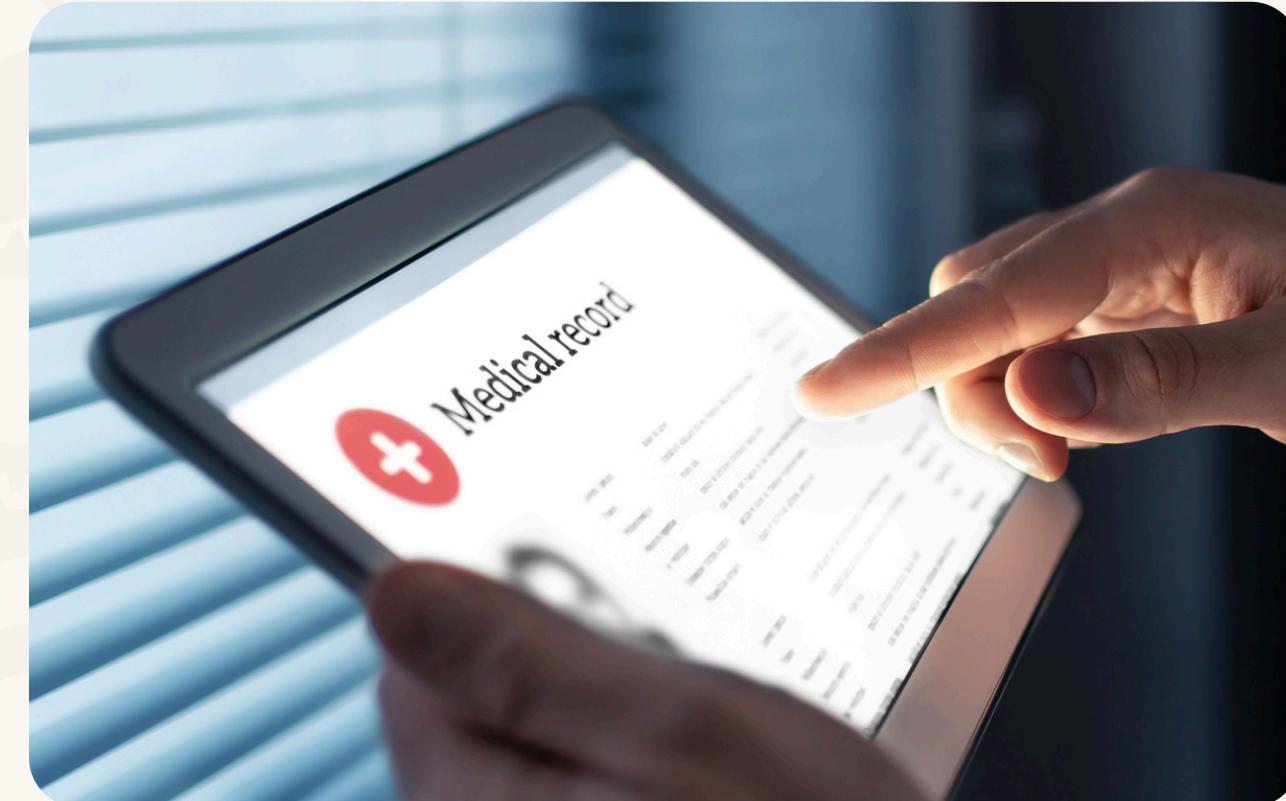
Healthcare facilities increasingly rely on technology for patient care management. A lot in the Healthcare Industry use tech. Key implementations include:

Hardware



Medical devices integrated with computer systems for real-time data monitoring.

Software



Electronic health records (EHR) systems that facilitate patient data management, appointment scheduling, and billing processes.

Non-profit Organizations

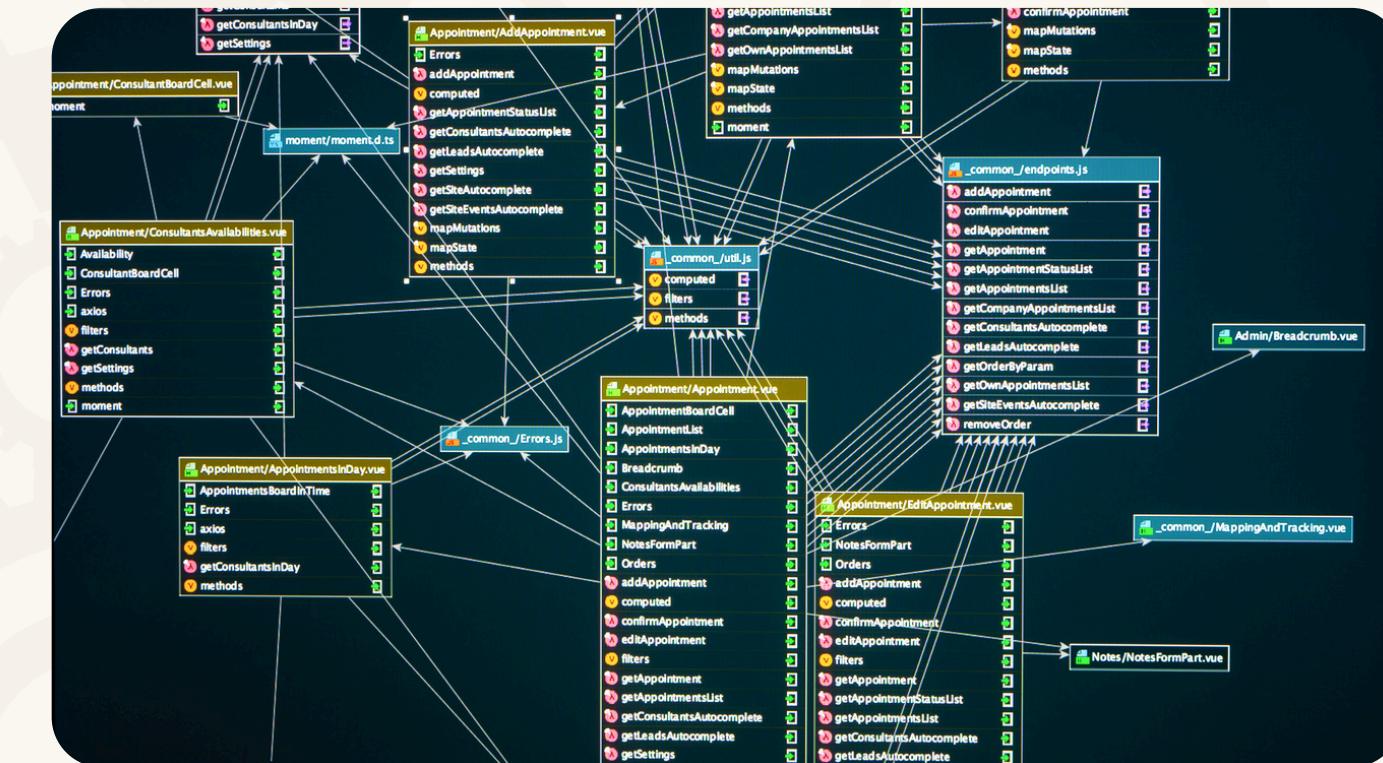
Non-profit organizations leverage technology to improve service delivery and outreach efforts. Their implementations often involve:

Hardware



Computers for administrative tasks and mobile devices for field workers to connect with clients in real-time.

Software



Database management systems to track donations, volunteer activities, and client interactions.

Analysis

Computers were made back in the 1940s, and since then it has evolved exponentially — like Moore's law: which states that the number of transistors in a microchip doubles roughly every two years, to help us humankind in achieving efficiency and usability. Computer hardware and software have developed in tandem, each pushing the other forward. Hardware improvements, like increased processing power and memory, enable much more complex software to be developed. In return, software innovation fuels the demand for better hardware. From early vacuum tubes and punch cards to today's microprocessors and solid-state drives, the changes in hardware have been remarkable. Similarly, software has evolved from simple programs written in machine code to advanced operating systems and applications that run on countless devices. The impact on humankind has been big. Computers have reshaped almost every industry, making them faster, more efficient, and highly automated. Tasks that would take humans hours or days can now be completed in seconds or minutes by machines. Although some won't agree about the digital evolution or the replacement of traditional materials with computing, we can't reject the fact that they've empowered us in ways previously thought impossible, from managing complex data sets in science and medicine to creating realistic virtual worlds in gaming. It has increased our potential in critical thinking, problem solving and real world decision making. Yet, this exponential growth hasn't come without challenges. With increased reliance on computers comes the need for cybersecurity, the threat of data breaches, and the ethical considerations of AI. Since the people who use computers will also increase over time, threats and issues will also increase alongside. More and more computers would need to be protected as well as the people. Nonetheless, the evolution of computers has been a cornerstone of modern innovation, guiding us toward a future where efficiency and usability continue to expand.

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