COS 101: INTRODUCTION TO COMPUTER SCIENCE

Module 1

Understanding the Computer

A Comprehensive Guide to Concepts, History, and Classification

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Part 1: Basic Concepts

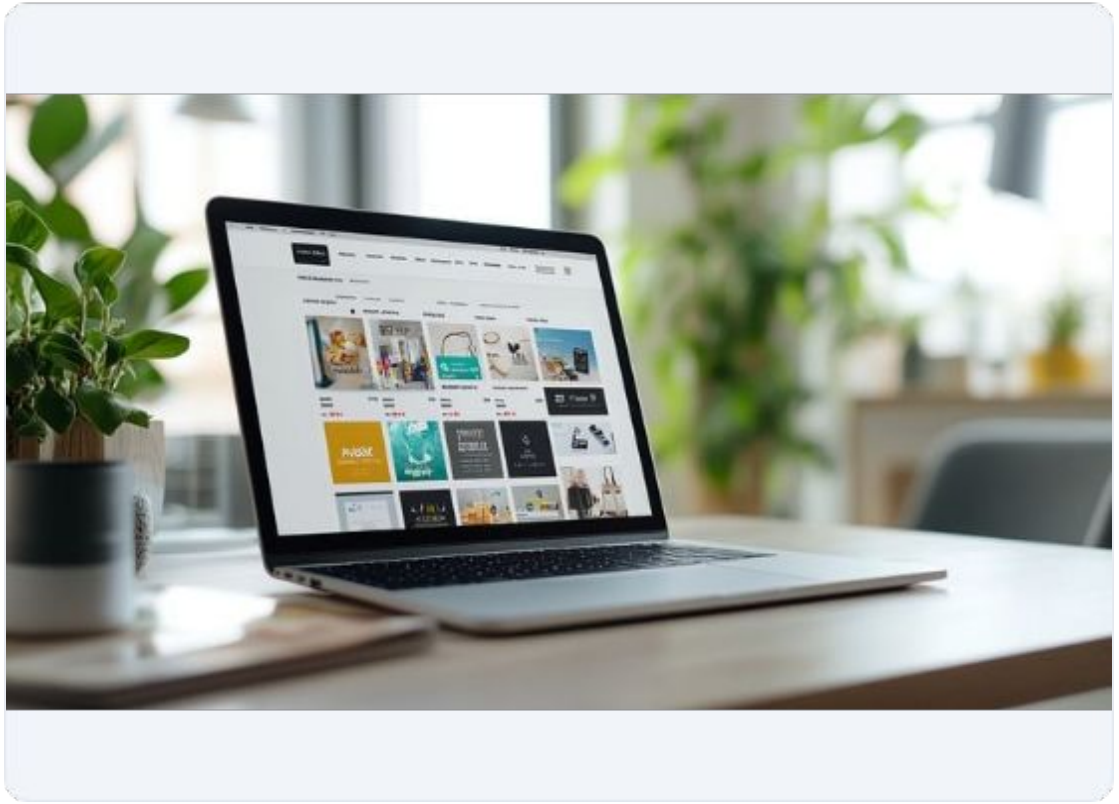
Foundations of Computing Technology

What is a Computer?

Definition

A computer is an electronic device that accepts data (input), processes it according to a set of instructions (program), produces results (output), and stores them for future use.

- It derives from the Latin word *'computare'*, meaning to calculate.
- It works on the principle of the IPOS cycle.



Data vs. Information

Data

Raw, unprocessed facts, figures, and symbols. It has no meaning on its own.

- Examples:
- "James", 19, 5000
- 32, 55, 12

Information

Processed data that is organized, meaningful, and useful for decision making.

- Examples:
- "James is 19 years old."
- "Average Score: 33"

The IPOS Cycle: Input

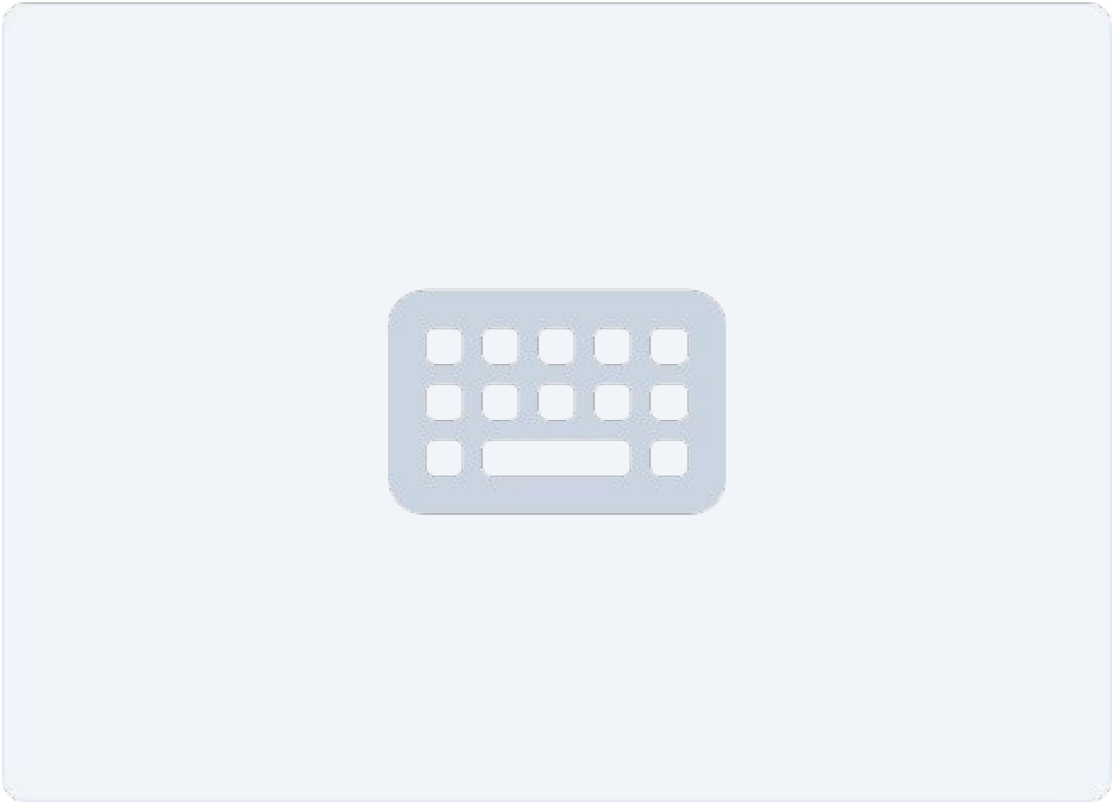
Entering Data

Input is the process of entering data and instructions into the computer system.

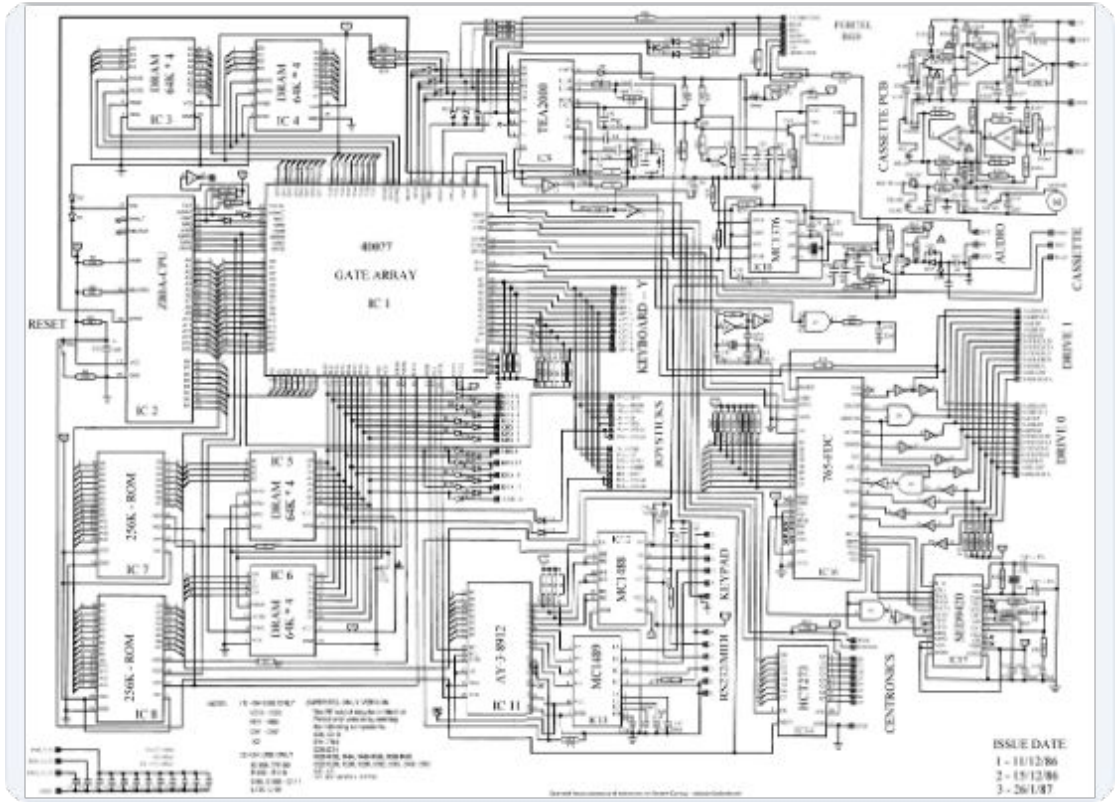
Without input, a computer acts like a sleeping brain—capable but inactive.

Common Devices:

- Keyboard (Typing)
- Mouse (Pointing)
- Microphone (Audio)
- Scanner (Images)



The IPOS Cycle: Processing



The Brain of the Computer

Processing involves manipulating data to transform it into information. This happens in the **Central Processing Unit (CPU)**.

- **ALU (Arithmetic Logic Unit):** Math & Logic.
- **CU (Control Unit):** Traffic cop of data.
- **Registers:** High-speed temporary storage.

The IPOS Cycle: Output

Soft Copy

Intangible output displayed on a screen or played through speakers. It exists only electronically.

Hard Copy

Tangible output printed on paper or 3D material. It is permanent and physical.

Devices: Monitors, Printers, Speakers, Projectors.

The IPOS Cycle: Storage

Primary Storage (RAM)

Volatile memory. Holds data currently being used by the CPU. Data is lost when power is off.

Secondary Storage (ROM/HDD)

Non-volatile. Stores data permanently even when power is off. Examples: Hard Drives, SSDs, USBs.

Computer Number Systems

Understanding how data is represented in computing

What is a Number System?

Definition

A number system is a technique used to represent and work with numbers. It is a set of values used to represent different quantities.

Base (Radix)

The total number of unique digits available in a number system.

- **Decimal (Base 10):** 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
- **Binary (Base 2):** 0, 1

The Decimal System (Base 10)

The Human Standard

The decimal system is what humans use in daily life.

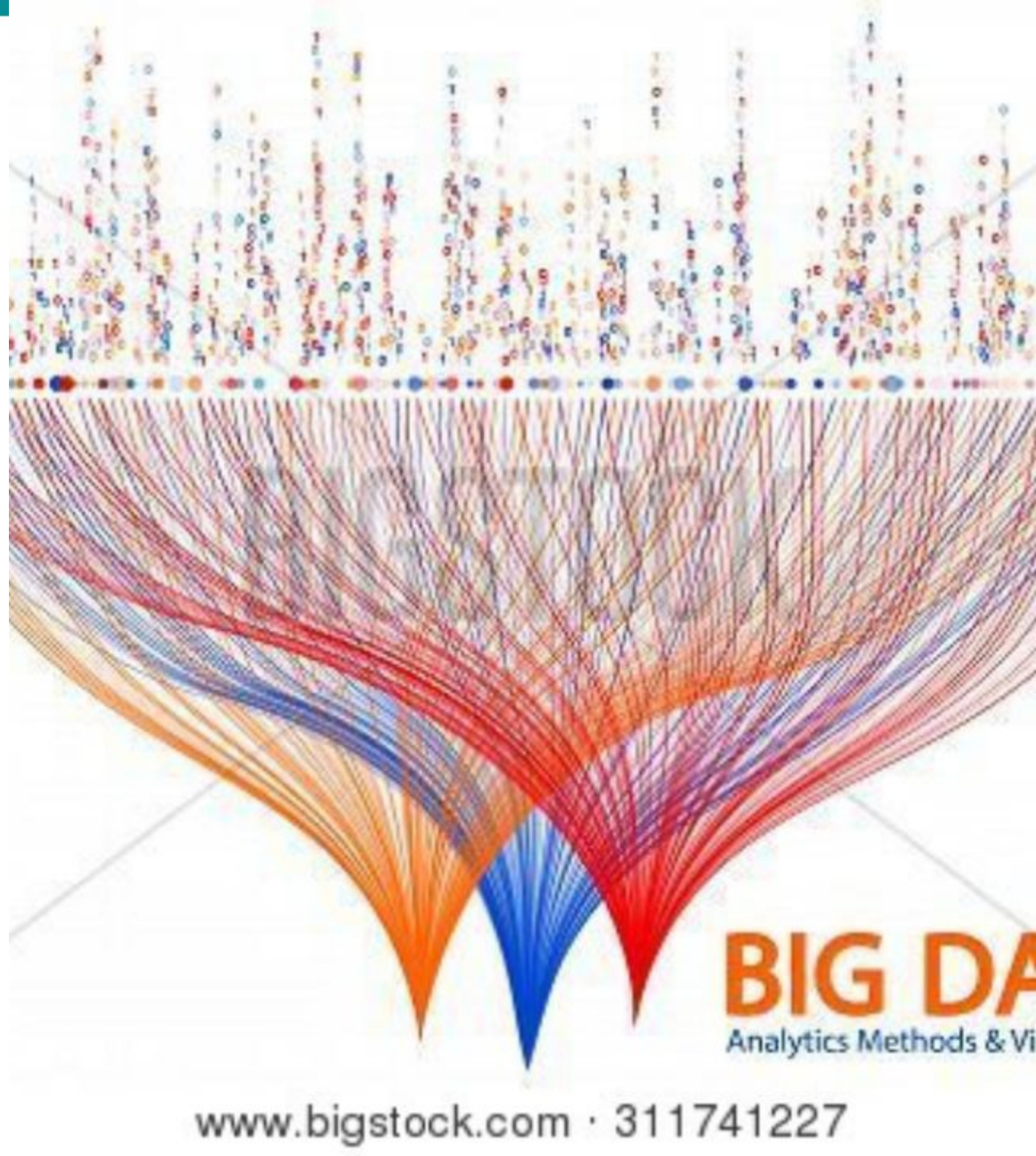
- **Base:** 10
- **Digits:** 0 through 9
- **Positional Value:** Each digit's value depends on its position (units, tens, hundreds).
- *Example:* $456 = (4 \times 10^2) + (5 \times 10^1) + (6 \times 10^0)$

The Binary System (Base 2)

The Machine Language

Computers understand only two states: On and Off (High voltage and Low voltage).

- **Base:** 2
- **Digits:** 0 and 1
- **Bit:** A single binary digit.
- **Byte:** A group of 8 bits.



Octal and Hexadecimal

Octal (Base 8)

Uses 8 digits: 0, 1, 2, 3, 4, 5, 6, 7.

Used in early computing systems (like the PDP-8).

Hexadecimal (Base 16)

Uses 16 alphanumerics: 0-9 and A-F.

A=10, B=11... F=15

Widely used today to simplify binary addresses and represent colors (e.g., #FFFFFF).

System Comparison

Decimal (Base 10)	Binary (Base 2)	Hexadecimal (Base 16)
0	0000	0
1	0001	1
5	0101	5
10	1010	A
11	1011	B
15	1111	F
16	10000	10

Components: Hardware

"Hardware is the part of the computer that you can kick."

— Popular Tech Saying

Input Devices

Processing Unit

Output Devices

Storage Media

Components: Software

System Software

Programs that run the computer hardware itself. The base layer.

- Operating Systems (Windows, Linux)
- Device Drivers
- Utilities (Antivirus)

Application Software

Programs designed for the end-user to perform specific tasks.

- Word Processors (Word)
- Web Browsers (Chrome)
- Games & Media Players

Characteristic 1: Speed

Incredible Processing Power

Computers work at incredible speeds, performing millions or billions of instructions per second (MIPS/BIPS).

A task that takes a human entire year can be done by a computer in a few seconds.

Characteristic 2: Accuracy

Error-Free Calculation

Computers are 100% accurate. Errors in computing are usually caused by human mistakes (bad data input or bad programming).

GIGO: Garbage In, Garbage Out.

Diligence & Versatility

Diligence

A computer never gets tired, bored, or distracted. It can perform the same task 10 million times with the exact same speed and accuracy as the first time.

Versatility

Computers can perform widely different tasks. At one moment it's playing music, the next it's solving a complex math problem or printing a document.

Limitations of a Computer

No I.Q.

A computer cannot think on its own. It only does exactly what it is told to do by the user or programmer.

No Feelings

Computers have no emotions, taste, knowledge, or experience. They don't get happy or sad.

Dependency

It is fully dependent on humans for instructions and electricity for power.

Part 2:
History of Computing

From Ancient Tools to Artificial Intelligence

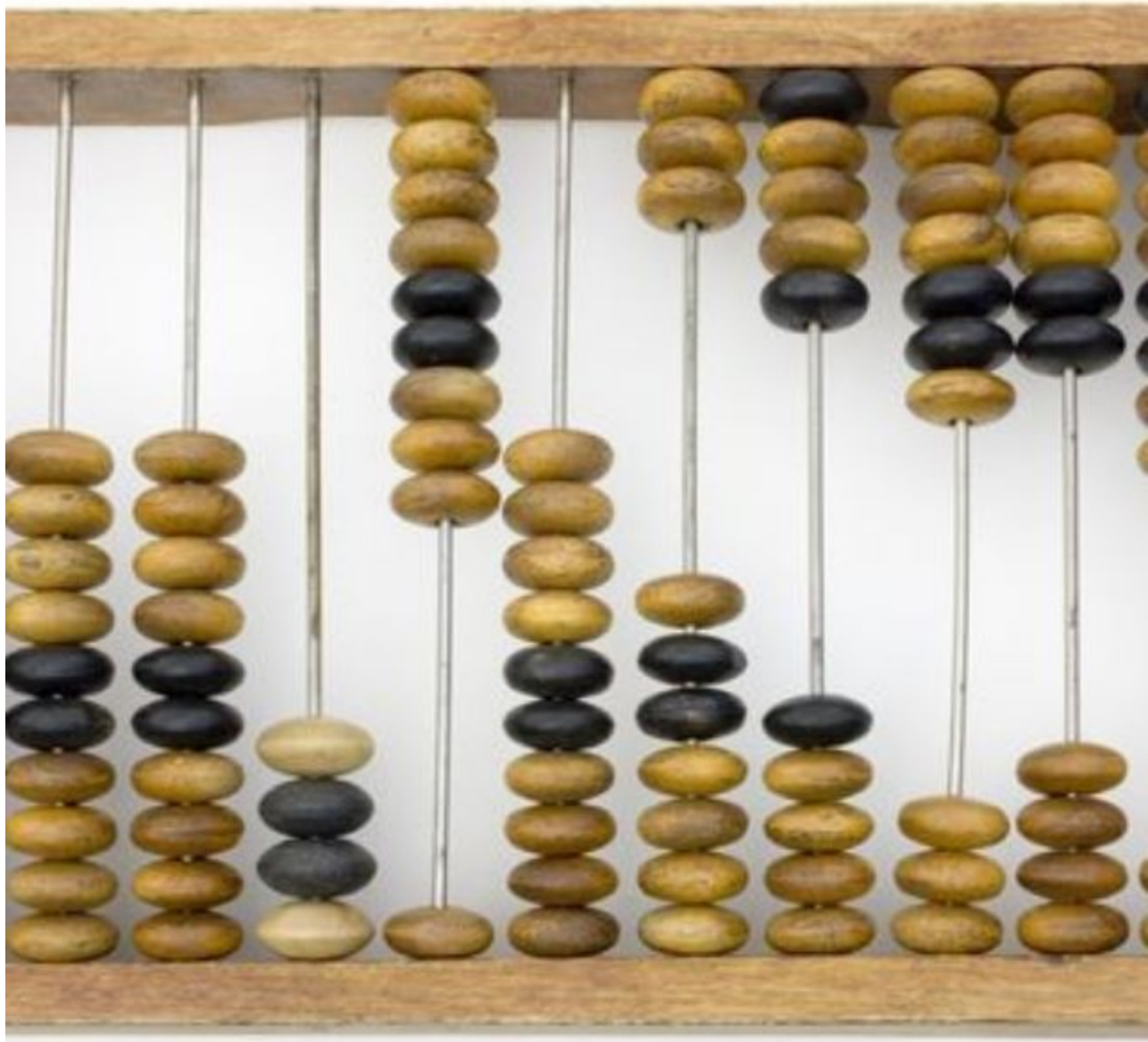
The Abacus

The First Calculation Tool

Believed to be invented by the Chinese around 4000 years ago.

It consists of a wooden rack with metal rods and beads. Sliding the beads allows for addition, subtraction, and representation of numbers.

It is still used today in some parts of the world for teaching basic math.



17th Century Innovations

Napier's Bones (1617)

Invented by John Napier. A set of ivory rods used for multiplication and division. It introduced the concept of logarithms.

Pascaline (1642)

Invented by Blaise Pascal at age 19. The first mechanical calculator. It used gears and wheels to perform addition and subtraction.

Charles Babbage

Father of the Computer

In the 1800s, he designed two machines:

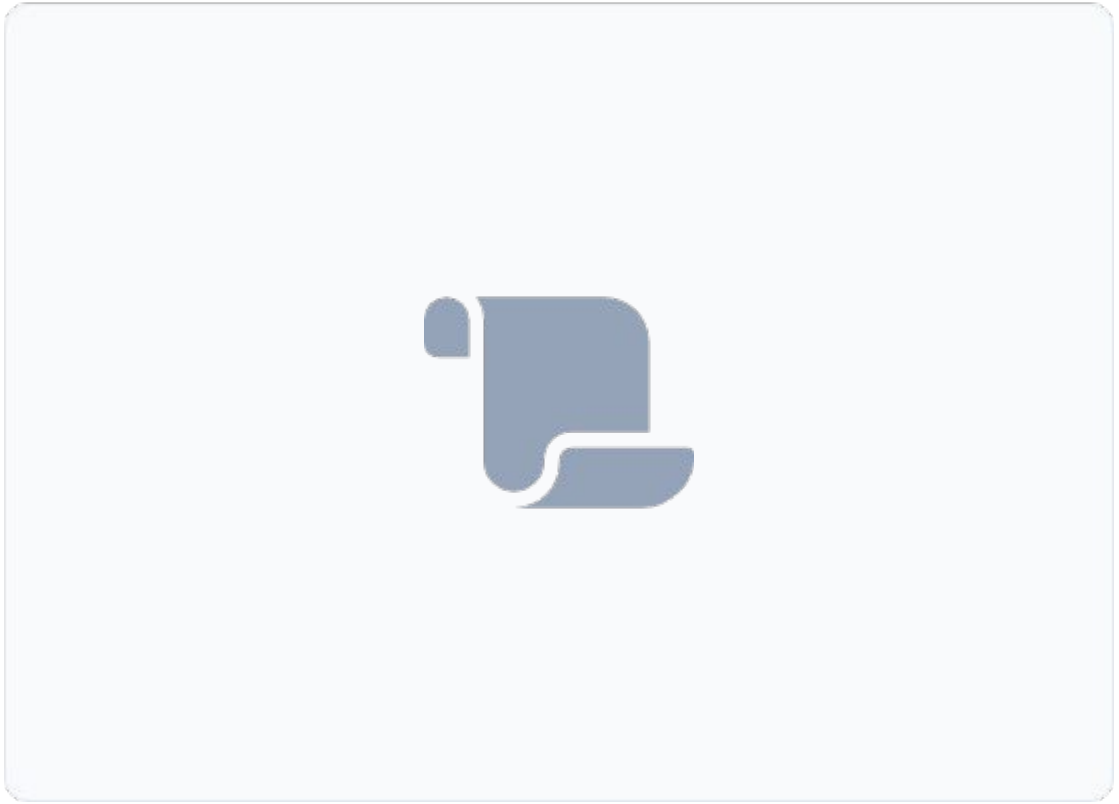
- **Difference Engine:** For calculating mathematical tables.
- **Analytical Engine:** A general-purpose mechanical computer design that had all elements of a modern computer (Input, Store, Mill/CPU, Output).

Lady Ada Lovelace

The First Programmer

She was a mathematician and writer, and a friend of Charles Babbage.

She realized that Babbage's Analytical Engine could do more than just calculate numbers—it could process symbols. She wrote the very first algorithm intended to be processed by a machine.



Herman Hollerith

The Tabulating Machine (1890)

Designed to summarize the information stored on punched cards for the US Census.

It reduced the time required to process census data from years to months.

His company later merged with others to form IBM (International Business Machines).

1st Generation (1940-56)

Vacuum Tubes

The first computers used vacuum tubes for circuitry and magnetic drums for memory.

Characteristics:

- Huge in size (filled entire rooms).
- Very expensive to operate.
- Generated massive heat.
- Relied on machine language (0s and 1s).

1st Gen Examples

ENIAC

Electronic Numerical Integrator and Computer.

Weighed 30 tons, used 18,000 vacuum tubes.

UNIVAC

Universal Automatic Computer.

The first commercial computer delivered to a business client (US Census Bureau).

2nd Generation (1956-63)

Transistors

Transistors replaced vacuum tubes. One of the most important inventions in history.

Impact:

- Computers became smaller.
- Faster and more reliable.
- More energy efficient.

Evolution of Language

From Binary to English-like

Second-generation computers moved from cryptic binary **Machine Language** to symbolic **Assembly Language**.

Later, high-level languages were developed, allowing programmers to give instructions in English-like words.

- `COBOL (Common Business-Oriented Language)`
- `FORTRAN (Formula Translation)`

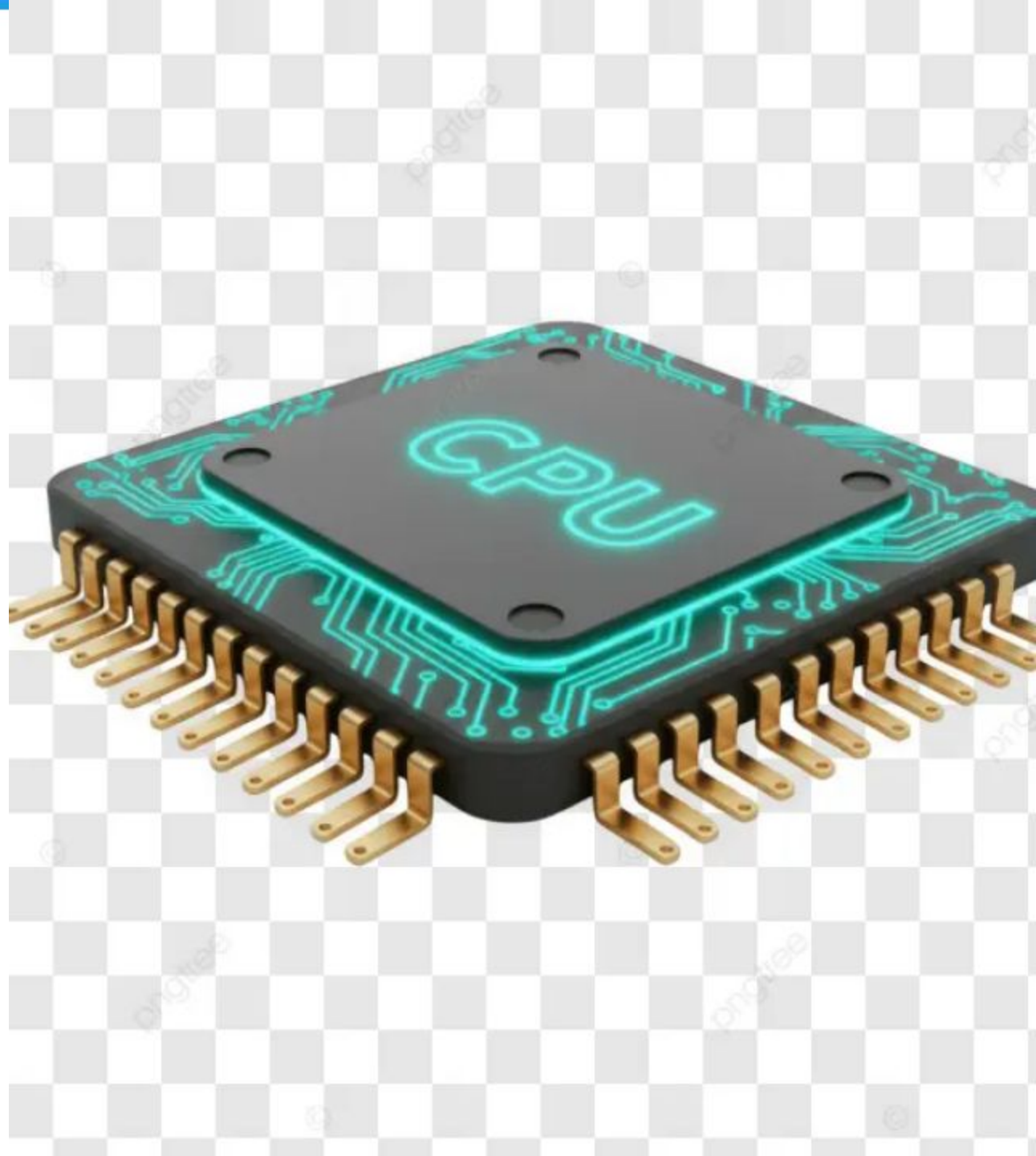
3rd Generation (1964-71)

Integrated Circuits (IC)

Transistors were miniaturized and placed on silicon chips, called semiconductors.

This drastically increased the speed and efficiency of computers.

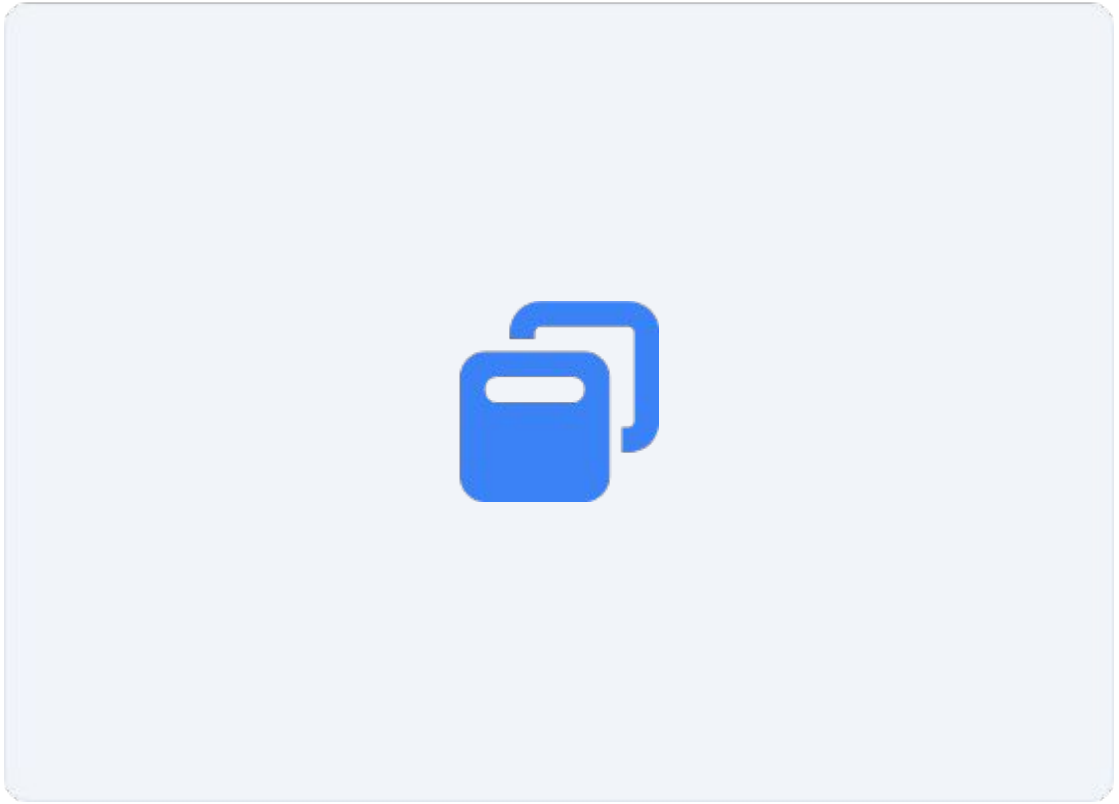
Users began interacting via keyboards and monitors instead of punch cards.



The Rise of Operating Systems

Multi-tasking

For the first time, computers used an **Operating System** that allowed the device to run many different applications at one time with a central program monitoring the memory. Computers became accessible to a mass audience because they were smaller and cheaper than ever before.



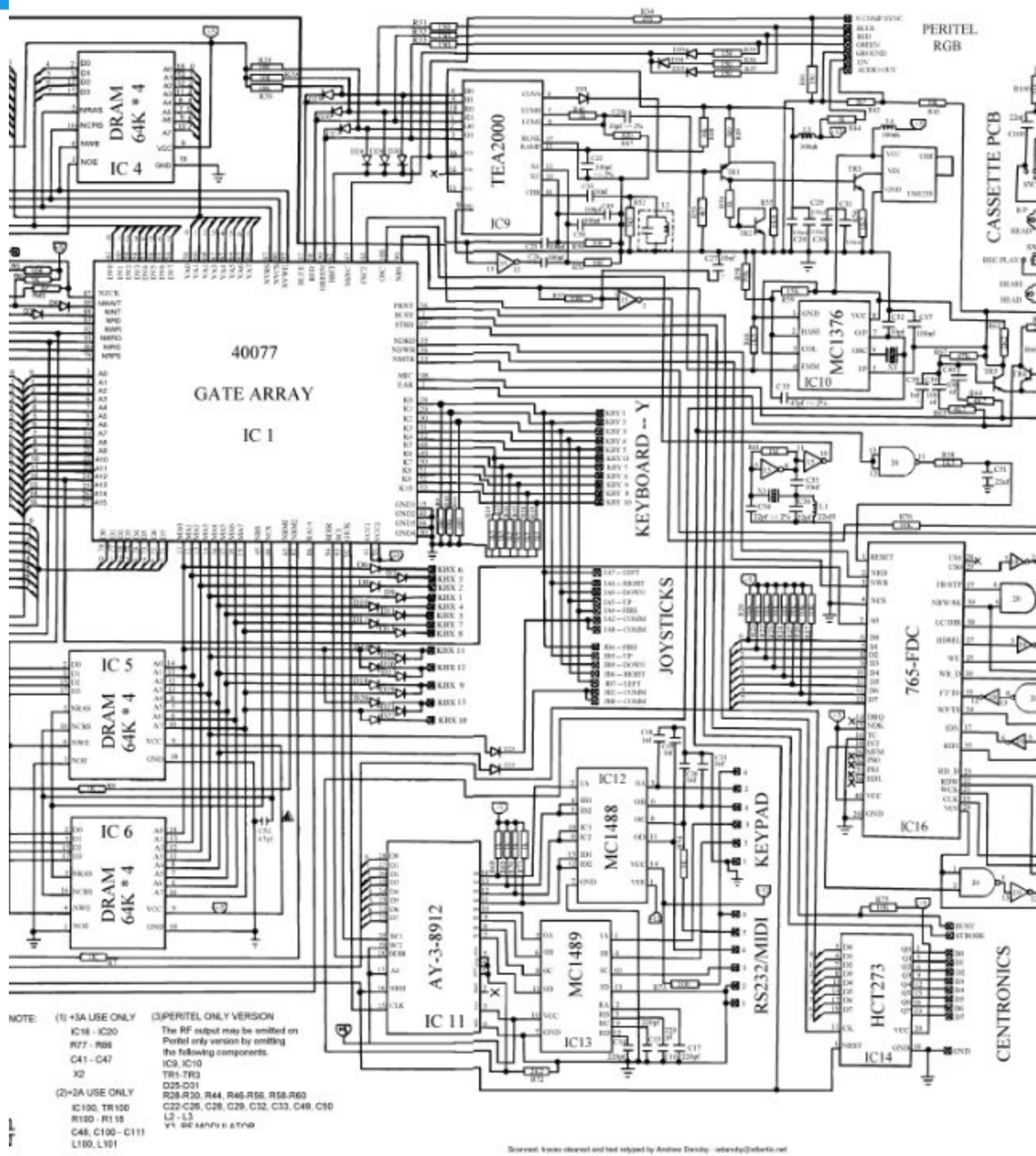
4th Generation (1971-Present)

Microprocessors

Thousands of integrated circuits were built onto a single silicon chip.

What in the first generation filled an entire room could now fit in the palm of the hand.

The **Intel 4004** chip, developed in 1971, located all the components of the computer (CPU, memory, input/output controls) on a single chip.



The PC Revolution

Personal Computers

In 1981, IBM introduced its first computer for the home user. In 1984, Apple introduced the Macintosh.

The Internet

Fourth-generation computers also saw the development of GUIs (Graphical User Interfaces), the mouse, and handheld devices. Networked computers led to the internet.

5th Generation (Present & Beyond)

Artificial Intelligence

Computers that can think and learn (e.g., Voice Recognition).

Parallel Processing

Using many processors simultaneously to solve complex problems.

Quantum Computing

Computing based on quantum mechanics, offering exponential speedups.

Part 3:
Classification of Computers

Categorizing by Purpose, Data Handling, and Size

Classification by Purpose

General Purpose

Designed to perform a variety of tasks. You can use them to write a letter, play a game, or browse the web.

Ex: Laptops, Desktops, Tablets.

Special Purpose

Designed to perform a specific, single task. They are often embedded systems.

Ex: ATMs, Washing Machine Controllers, Traffic Lights.

Analog Computers

They process **continuous data** (physical quantities that change constantly).

They do not deal with numbers directly but with measuring physical variables like voltage, pressure, temperature, or speed.

Examples: Speedometer, Mercury Thermometer, Seismometer.

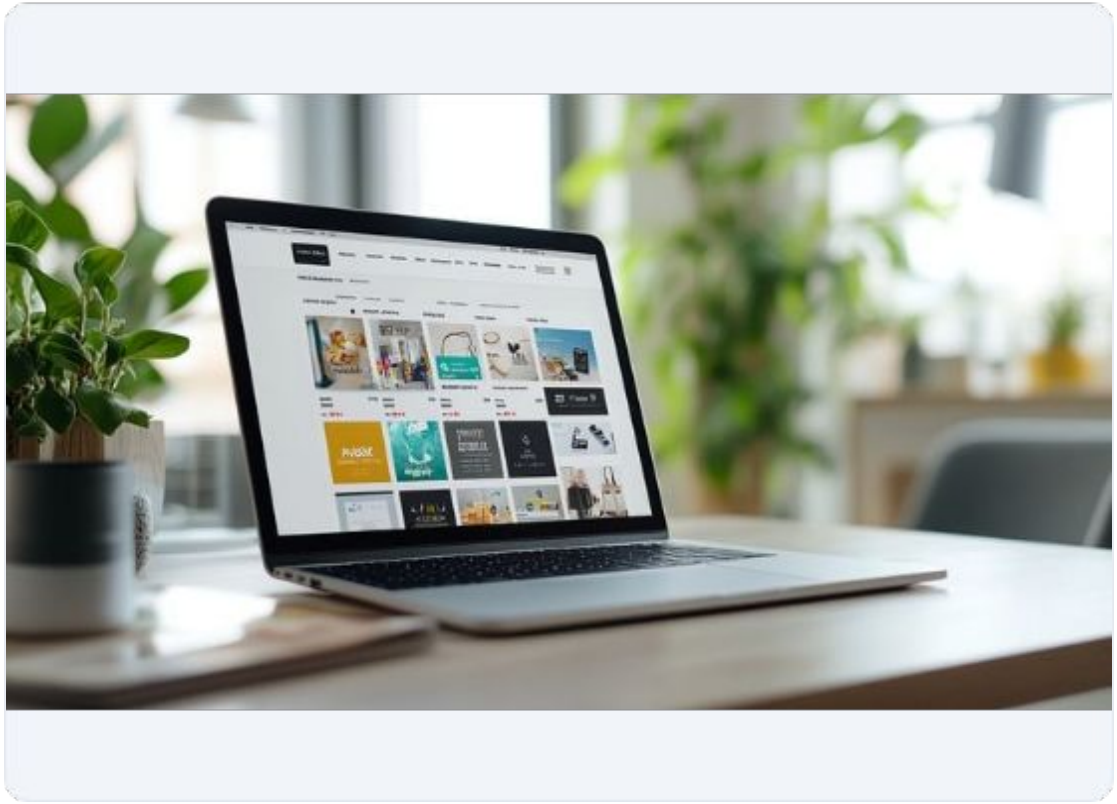
Digital Computers

Discrete Data

They process data in **discrete form** (0s and 1s). They are accurate and faster than analog computers.

Everything we use today—text, sound, images—is converted into binary numbers for the digital computer to process.

Examples: All modern PCs, Smartphones.



Hybrid Computers

Best of Both Worlds

Hybrid computers combine the desirable features of analog and digital computers.

They are fast like analog computers and accurate like digital computers.

Use Case: ICU Hospital Monitors

Analog part measures the patient's heartbeat (continuous). Digital part displays the numbers on the screen (discrete).

Microcomputers

Also known as **Personal Computers (PCs)**.

Small, inexpensive, and designed for individual use. They are based on the microprocessor technology.

- Desktop Computers
- Laptops / Notebooks
- Tablets / Smartphones
- Workstations (High-end PCs)

Minicomputers

Mid-Range Servers

Minicomputers are larger than microcomputers but smaller than mainframes.

They support multiple users simultaneously (from 4 to 200).

Uses: Small to medium business organizations, departmental systems, billing, and inventory tracking.

Note: The term is less common today; usually referred to as "Mid-range Servers".

Mainframe Computers

Large, expensive, and powerful computers capable of supporting hundreds or thousands of users simultaneously.

They are known for their **reliability** and ability to process vast amounts of data.

Uses: Banks (ATM networks), Airlines (Reservation systems), Insurance companies.

Supercomputers

The fastest and most powerful computers in the world.

They are extremely expensive and are used for specialized applications that require immense mathematical calculations.

Uses: Weather forecasting, Nuclear energy research, Space exploration.

Examples: Cray, Summit, Fugaku.

The Future of Computing

Wearables

Computing woven into clothing or accessories (Smartwatches, AR Glasses).

IoT

Internet of Things. Everyday objects connected to the internet (Smart Fridges, Thermostats).

Cloud Computing

Moving processing and storage from local devices to massive server farms on the internet.

Questions?

Module 1: Understanding the Computer

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