

Data Structures & Operating Systems

Operating Systems

RAJESH TRIPATHI

Associate Professor, Department of Computer Sci. and Engineering
Motilal Nehru National Institute of Technology Allahabad

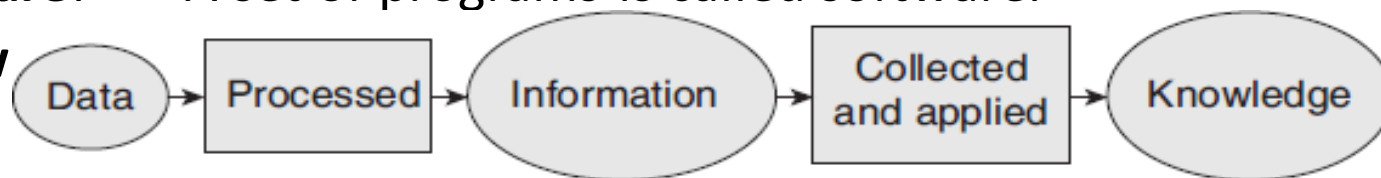
Allahabad-211004, UP, India

Rajesh Tripathi
2020-08-14 12:34:29

RAJESH TRIPATHI

What is a Computer?

- A **computer** is an electronic machine that takes instructions and performs computations based on those instructions.
- **Data** is a collection of raw facts or figures.
- **Information** comprises processed data to provide answers to 'who', 'what', 'where', and 'when' type of questions.
- **Knowledge** is the application of data and information to answer 'how' part of the question.
- **Instructions:** Commands given to the computer that tells what it has to do are instructions.
- **Programs:** A set of instructions in computer language is called a program.
- **Software:** A set of programs is called software.
- **Hardware:** Hardware.



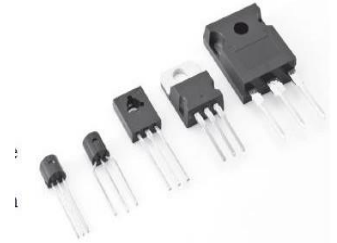
First Generation of Computers (1942 – 1955)

- **Hardware Technology:** Manufactured using thousands of vacuum tubes.
- **Software Technology:** Programming was done in machine language or assembly language.
- **Used for:** Scientific applications
- **Examples:** ENIAC, EDVAC, EDSAC, UNIVAC I, IBM 701
- **Highlights:**
 - They were the fastest calculating device of those times.
 - Computers were too bulky and required a complete room for storage.
 - Highly unreliable as vacuum tubes emitted a large amount of heat and burnt frequently.
 - Required air-conditioned room for installation.
 - Costly
 - Difficult to use
 - Required constant maintenance



Second Generation of Computers (1955 – 1964)

- **Hardware Technology:** Manufactured using thousands of transistors.
- **Software Technology:** Programming was done in high level language.
- **Used for:** Scientific and commercial applications
- **Examples:** Honeywell 400, IBM 7030, CDC 1604
- **Highlights:**
 - Faster, smaller, cheaper, reliable, and easier to use than the first generation computers.
 - Consumed 1/10th the power consumed by first generation computers.
 - Bulky in size and required a complete room for its installation.
 - Dissipated less heat than first generation computers but still required Ac room
 - Costly
 - Difficult to use
 - Required constant maintenance

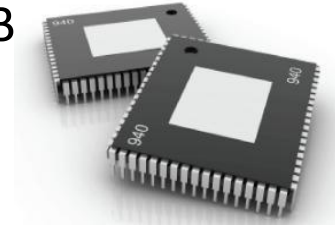


Third Generation of Computers (1964 – 1975)

Hardware Technology: Manufactured using thousands of integrated circuits.

Software Technology: Programming was done in high level language. **Used**

for: Scientific, commercial and interactive applications **Examples:** IB 360/370, PDP-8, PADP-11, CDC6600



Highlights:

- Faster, smaller, cheaper, reliable, and easier to use than the second generation computers.
- They consumed less power than second generation computers.
- Bulky in size and required a complete room for its installation.
- Dissipated less heat than second generation computers but still required AC room.
- Costly
- Easier to use and upgrade.

Fourth Generation of Computers (1975 – 1989)

- **Hardware Technology:** Manufactured using Large Scale and Very Large Scale integrated circuits.
- **Software Technology:** Programming was done in high level language.
- **Used for:** Scientific, commercial, interactive and network applications
- **Examples:** IBM PC, Apple II, TRS-80, VAX 9000, CRAY-1, CRAY-2, CRAY-X/MP
- **Highlights:** Faster, smaller, cheaper, powerful, reliable, and easier to use than the previous generation computers



Fifth Generation of Computers (1975 – 1989)

Hardware Technology: Manufactured using Ultra Large Scale integrated circuits. Use of Internet became widespread. Very powerful mainframes, desktops, portable laptops, smartphones are being used commonly. Super computers use parallel processing techniques.

Software Technology: Programming was done in high level language.

Used for: Scientific, commercial, interactive, network and multimedia applications

Examples: IBM notebooks, Pentium PCs, SUN workstations, IBM SP/2, Param supercomputer

Highlights:

- Faster, smaller, cheaper, powerful, reliable, and easier to use.
- Speed of microprocessors and the size of memory are growing rapidly.
- High-end features available on mainframe computers in the fourth generation are now available on the microprocessors.
- Consume less power than computers of prior generations.
- Air-conditioned rooms required for mainframes and supercomputers but not for microprocessors.

Classification of Computer

Supercomputers: Supercomputer is the fastest, most powerful, and most expensive computer. A single supercomputer can support thousands of users at the same time. They are mainly used for weather forecasting, nuclear energy research, aircraft design, automotive design, online banking, controlling industrial units, etc. Some examples of supercomputers are CRAY-1, CRAY-2, Control Data CYBER 205, and ETA A-10.

Mainframe Computers: Mainframe computers are large-scale computers. They are very expensive and need a very large clean room with air conditioning. Mainframes can also support multiple processors. They are typically used as servers on the World Wide Web. They are also used in organizations such as banks, airline companies, and universities.

Minicomputers: Minicomputers are smaller, cheaper, and slower than mainframes. Minicomputers are used in business, education, hospitals, government organizations, etc. While some minicomputers can be used only by a single user, others are specifically designed to handle multiple users simultaneously. Minicomputers can also be used as servers in a networked environment, and hundreds of PCs can be connected to it.

Classification of Computer

Microcomputers: Microcomputers or PCs are very small and cheap. They can be classified into the following categories:

Desktop can be placed flat on a desk or table. It is widely used in homes and offices.

Laptops are small microcomputers that can easily fit inside a briefcase. They are very handy and can easily be carried from one place to another.

Workstations are single-user computers. Their processing speed matches that of a minicomputer or mainframe. They have advanced processors, more RAM and storage capacity than PCs. Therefore, they are more expensive and powerful than a normal desktop computer.

Network Computers have less processing power, memory, and storage than a desktop. They are designed to be used as terminals in a networked environment. For example, to access data stored on a network.

Handheld Computers include Smartphones, Tablet PCs and Phablets.

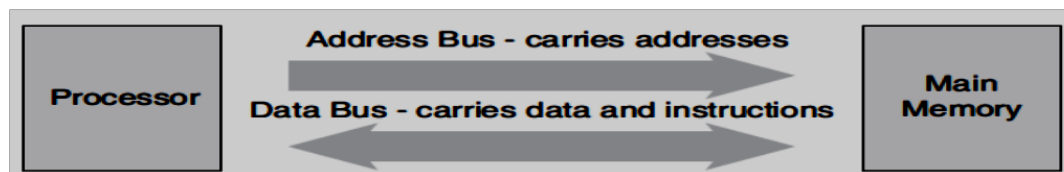
Basic Applications of Computer

- Communication
- Desktop Publishing
- Government
- Traffic Control
- Legal System
- Retail Business
- Sports
- Music
- Movies
- Travel and Tourism
- Business and Industry
- Hospitals
- Simulation
- Geology
- Astronomy
- Education
- Weather Forecasting
- Online Banking
- Industry and Engineering
- Robots
- Decision Support Systems
- Expert System
- Find jobs on the Internet
- Find a suitable match for a boy or girl
- Read news and articles online
- Find one's batchmates
- Send and receive greetings

Stored Program Concept

All digital computers are based on the principle of stored program concept, which was introduced by Sir John von Neumann in the late 1940s. The following are the key characteristic features of this concept:

- Before any data is processed, instructions are read into memory.
- Instructions are stored in the computer's memory for execution.
- Instructions are stored in binary form (using binary numbers—only 0s and 1s).
- Processing starts with the first instruction in the program, which is copied into a control unit circuit. The control unit executes the instructions.
- Instructions written by the users are performed sequentially until there is a break in the current flow.
- Input/ Output and processing operations are performed simultaneously. While data is being read/written, the central processing unit (CPU) executes another program in the memory that is ready for execution.



Components and Functions of Computer System

Input: process of entering data and instructions (also known as programs) into the computer system.

Storage: Process of saving data and instructions permanently in the computer so that it can be used for processing.

Primary Storage also known as the main memory is that storage area which is directly accessible by the CPU at a very fast speed. It is used to store the data and program, the intermediate results of processing and the recently generated results.

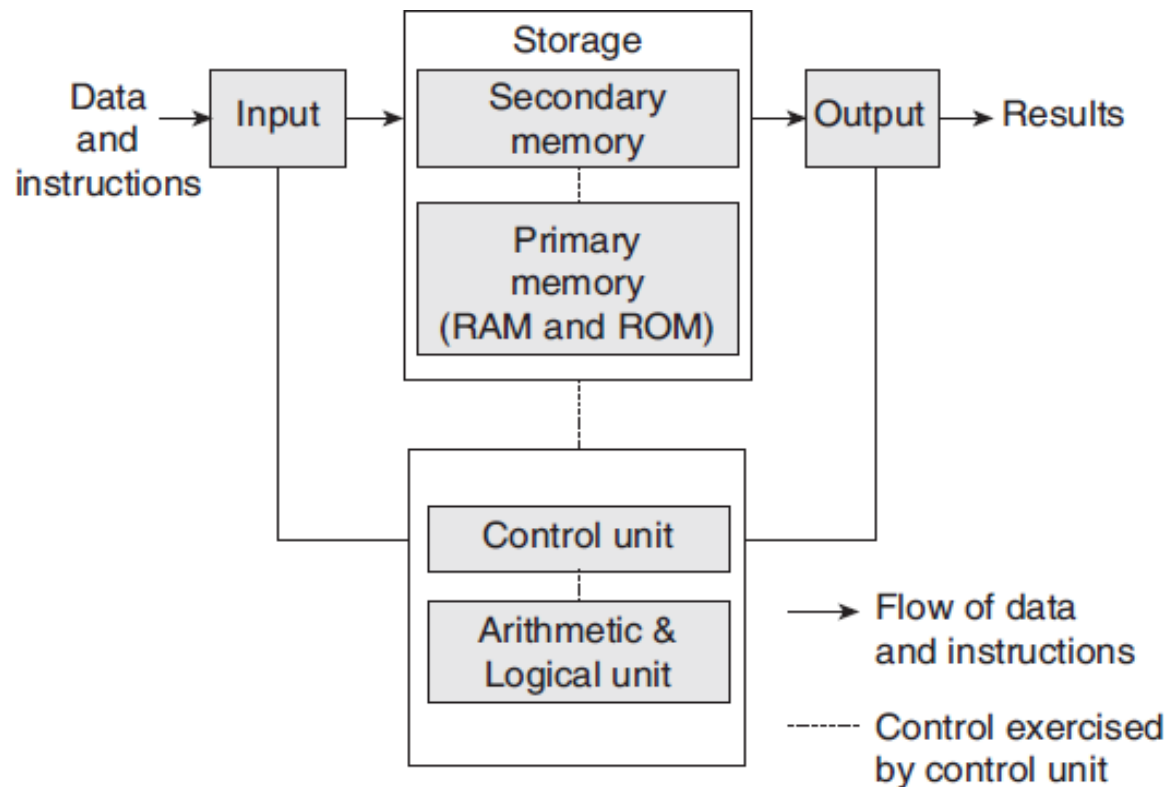
Secondary Storage also known as secondary memory is cheaper, non-volatile and used to permanently store data and programs of those jobs which are not being currently executed by the CPU.

Processing: The process of performing operations on the data as per the instructions specified by the user (program) is called processing.

Output: Process of giving the result of data processing to the outside world (external to the computer system).

Controlling: The function of managing, coordinating, and controlling all the components of the computer system is handled by the control unit, a part of CPU.

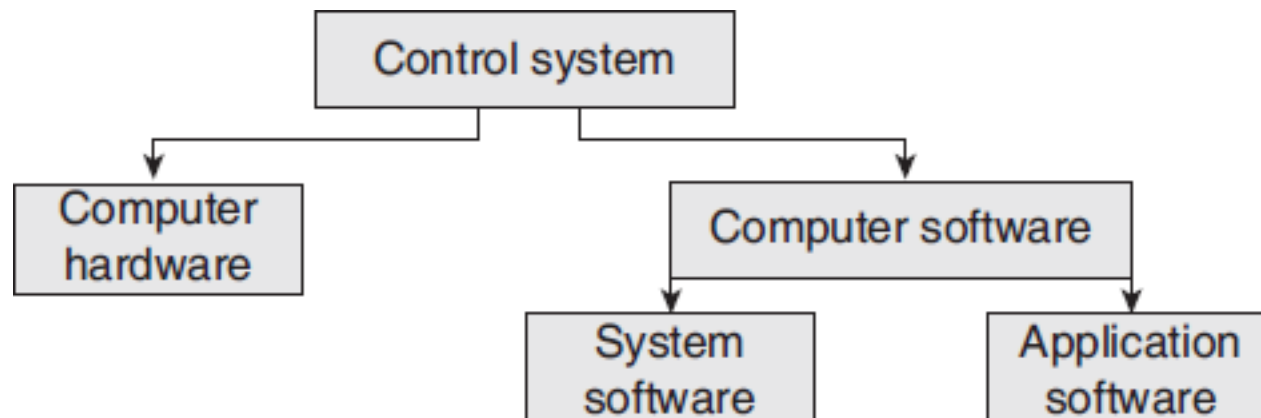
Components and Functions of Computer System



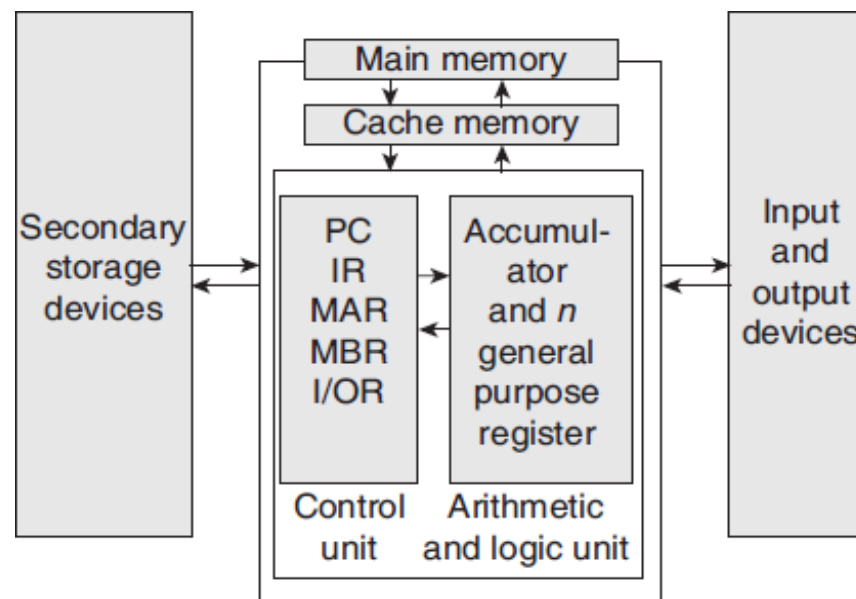
Concept of Hardware and Software

Hardware: All the physical parts that can be touched are called hardware.

Software: The hardware needs a software (a set of programs) to instruct what has to be done. A program is a set of instructions that is arranged in a sequence to guide a computer to find a solution for the given problem. The process of writing a program is called *programming*.



CPU Architecture



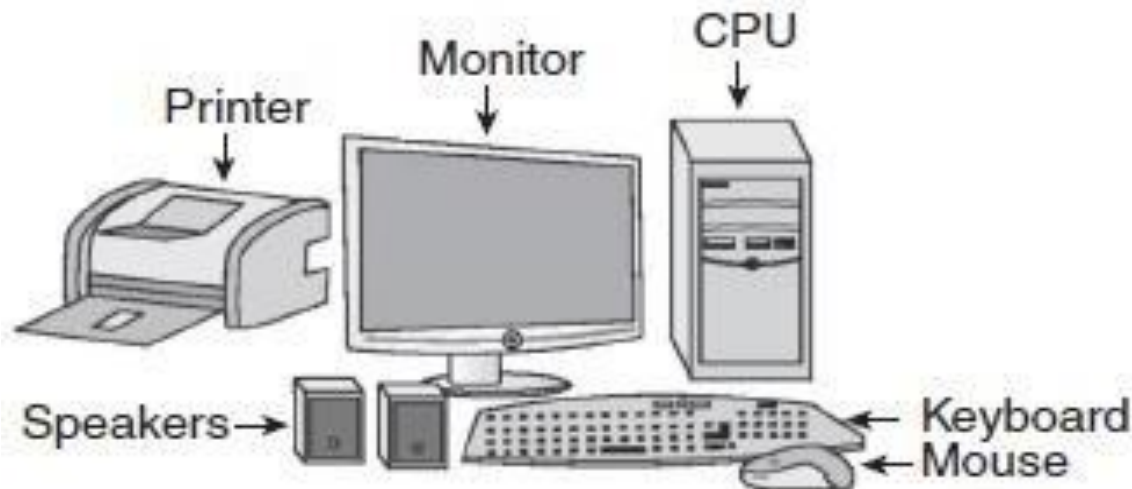
CPU Architecture

- **ALU:** It performs all kinds of calculations, such as arithmetic, comparison and other operations.
- **Control Unit:** It directs and coordinates the computer operations. It interprets the instructions (program) and initiates action to execute them.
- **Register:** It is a computer memory that provides quick access to the data currently being used for processing. The ALU stores all temporary results and the final result in the processor registers
- **Accumulator and general-purpose registers:** These are frequently used to store the data brought from the main memory and the intermediate results during program execution.
- **MAR** stores the address of the data or instruction to be fetched from the main memory.
- **MBR** stores the data or instruction fetched from the main memory
- **IR** stores the instructions currently being executed.
- **I/O** register is used to transfer data or instructions to or from an I/O device.
- **Program counter** stores the address of the next instruction to be executed.

I/O Devices

Input Devices

- **An input device** is used to feed data and instructions into the computer.
- Some of the input devices that are widely used by computer users to feed data or instruction to the computer are keyboard, mouse, trackball, joystick, stylus, touch screen, barcode reader, optical character recognition (OCR) device, optical mark recognition (OMR), MICR, web and digital cameras, etc.



Output Devices

Any device that outputs/gives information from a computer is called an output device.

Soft copy output devices are those O/P devices which produce an electronic version of an output. Features of a soft copy O/P are:

- The output can be viewed only when the computer is switched On.
 - The user can easily edit the soft copy output.
 - Soft copy cannot be used by people who do not have a computer.
 - Searching data in a soft copy is easy and fast.
 - Electronic distribution of a soft copy is cheaper. It can be done easily and quickly.
- Hard copy output devices** are those O/P devices which produce a physical form of output. Features of a hard copy

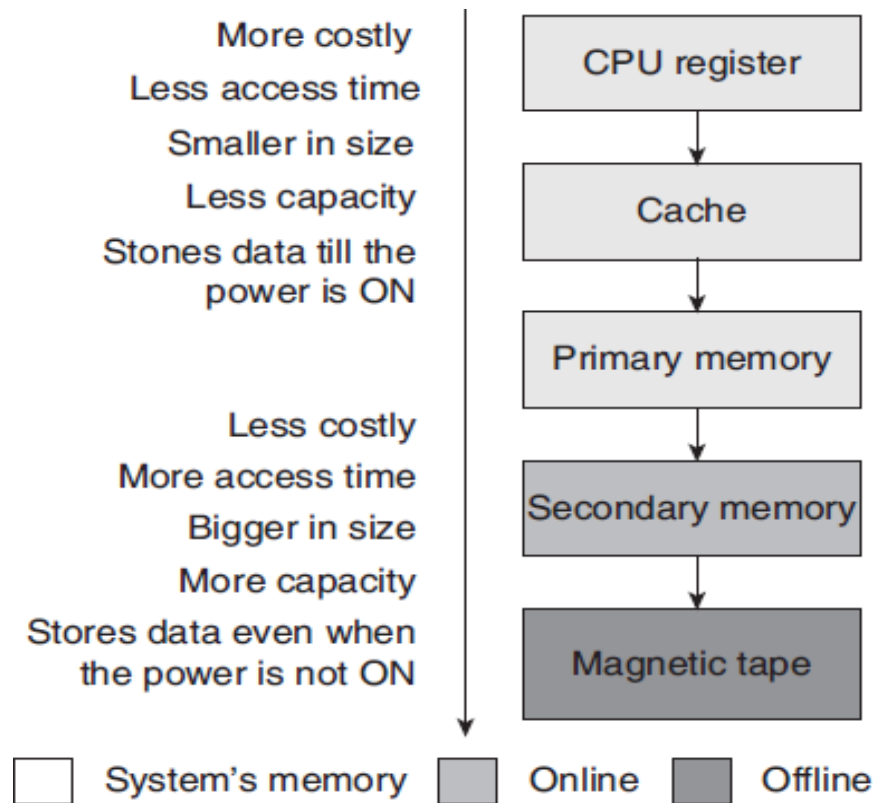
- Computer is not needed to see the output.
- Editing and searching the hard copy is difficult.
- Hard copy output can be easily distributed to people who do not have a computer.
- Distribution of a hard copy is not only costly but also slower.

Memory

Primary memory	Secondary memory
<ul style="list-style-type: none">• It is more expensive.• It is faster and more efficient than secondary memory.• Directly accessed by the CPU.• It is volatile in nature.• Storage capacity is limited.• It has no moving parts.• The memory is power dependent.• The memory is integrated circuit based.• It consumes less power.• It stores data temporarily.	<ul style="list-style-type: none">• It is cheaper.• It is slower and less efficient than secondary memory.• Cannot be accessed directly by the CPU.• It is non-volatile in nature.• It has large storage capacity.• It has moving parts.• The memory is power independent.• The memory is magnetic or optical based.• It consumes more power.• It stores data permanently.

Memory Hierarchy

Cache memory is an intermediate form of storage between registers and the primary memory. It is used to store instructions and data that are repeatedly required to execute programs thereby improving the overall system speed and increase the performance of the computer. Keeping frequently accessed data and instructions in the cache avoids accessing the slower primary memory.



Primary Memory - RAM

RAM is a volatile storage area within the computer typically used to store data temporarily so that it can be accessed by the CPU. The information stored in RAM is loaded from the computer's hard disk, and includes data related to the operating system and applications that are currently being executed by the processor. There are two types of RAM

Static RAM: This is a type of RAM holds data without an external refresh as long as it is powered. SRAM is made of D flip-flops in which the memory cells flip-flop between 0 and 1 without the use of capacitors. Therefore, there is no need for an external refresh process to be carried out. SRAM occupies more space and is more expensive than DRAM

Dynamic RAM: This is the most common type of memory used in personal computers, workstations, and servers today. A DRAM chip contains millions of tiny memory cells. Each cell is made up of a transistor and a capacitor, and can contain 1 bit of information—0 or 1. To store a bit of information in a DRAM chip, a tiny amount of power is put into the cell to charge the capacitor. Hence, while reading a bit, the transistor checks for a charge in the capacitor. If a charge is present, then the reading is 1; if not, the reading is 0.

Primary Memory - ROM

ROM is non-volatile, that is, the data is retained in it even when the computer is turned off.

Rewritable ROM chips include PROMs, EPROMs, and EEPROMs.

- ***Programmable read-only memory (PROM)*** also called one-time programmable ROM can be written to or programmed using a special device called a PROM programmer. The working of a PROM is similar to that of a CD-ROM recorder which enables the users to write programs just once but the recorded data can be read multiple times. Programming a PROM is also called *burning*.

- ***Erasable programmable read-only memory (EPROM)*** is a type of ROM that can be erased and re-programmed. The EPROM can be erased by exposing the chip to strong ultraviolet light typically for 10 minutes or longer and then rewritten with a process that again needs higher than usual voltage applied.

- ***Electrically erasable programmable read-only memory (EEPROM)*** allows its entire or selected contents to be electrically erased, then rewritten electrically. The process of writing an EEPROM is also known as *flashing*.

Difference between ROM and RAM

RAM

- Data can be read as well as written
- Data is stored temporarily
- Data is stored while the computer is being used by users to hold their data
- It is required while the computer is being used by users to run their applications

ROM

- Data can only be read
- Data is stored permanently
- Data is stored during the time of fabrication
- It is required for starting the computer and storing important programs.

Computer Software

Primary Memory - ROM

ROM is non-volatile, that is, the data is retained in it even when the computer is turned off.

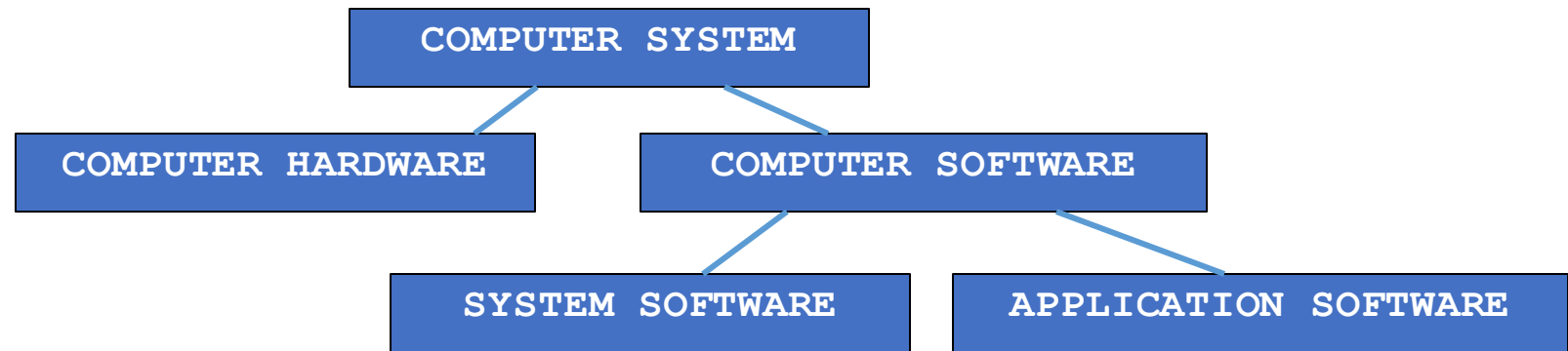
Rewritable ROM chips include PROMs, EPROMs, and EEPROMs.

- ***Programmable read-only memory (PROM)*** also called one-time programmable ROM can be written to or programmed using a special device called a PROM programmer. The working of a PROM is similar to that of a CD-ROM recorder which enables the users to write programs just once but the recorded data can be read multiple times. Programming a PROM is also called *burning*.

- ***Erasable programmable read-only memory (EPROM)*** is a type of ROM that can be erased and re-programmed. The EPROM can be erased by exposing the chip to strong ultraviolet light typically for 10 minutes or longer and then rewritten with a process that again needs higher than usual voltage applied.

- ***Electrically erasable programmable read-only memory (EEPROM)*** allows its entire or selected contents to be electrically erased, then rewritten electrically. The process of writing an EEPROM is also known as *flashing*.

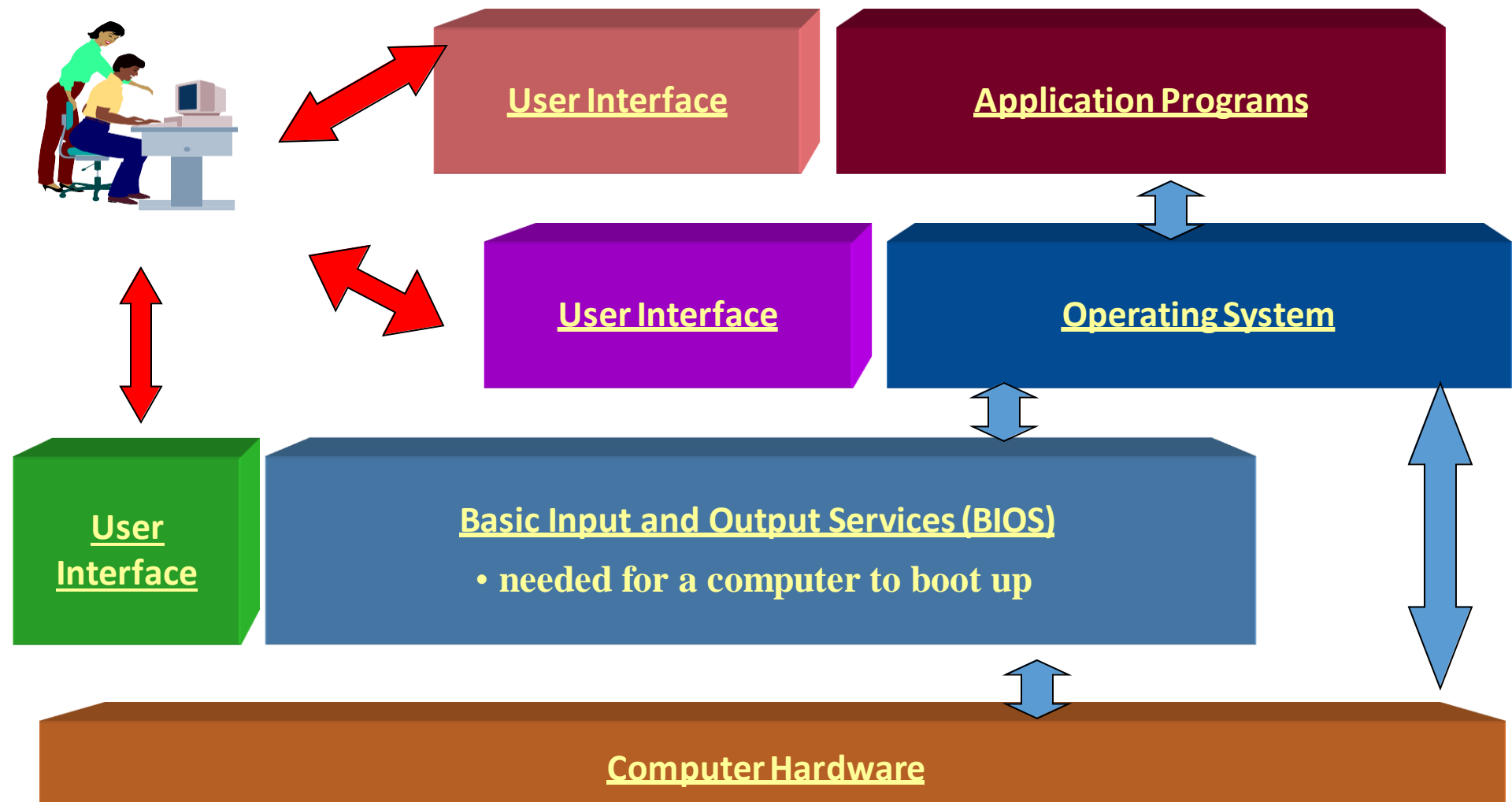
Software



The computer hardware cannot think and make decisions on its own. So, it cannot be used to analyze a given set of data and find a solution on its own. The hardware needs a software (a set of programs) to instruct what has to be done. A program is a set of instructions that is arranged in a sequence to guide a computer to find a solution for the given problem. The process of writing a program is called programming.

Computer software is written by computer programmers using a programming language.

Computer Software Relationships

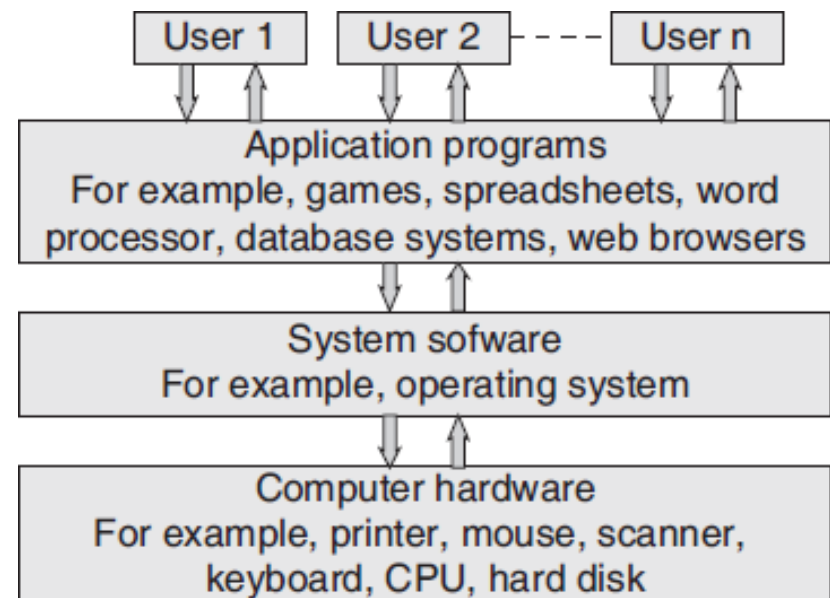


Types of Software

- System Software
- Programming software
- Application Software
- Open source software (OSS)
- Proprietary software

Classification Of Computer Software

- Driver software
- Educational software
- Media players and media development software
- Productivity software
- Operating systems software
- Computer games
- Application software
- System software



System Software

- It includes the Operating System and all the utilities that enable the computer to function.
- It refers to any computer software which manages and controls the hardware so that application software can perform a task.
- Example: Operating Systems, Compiler, Loader, Linker, Interpreter.

System Software

- Operating system is the core of system software
- The remaining part of the system s/w is referred to as utility.
- Thus Operating system and utility are collectively called system software.
- Example: compiler and shell are widely used utility.

Operating System

- Operating System is a software, which makes a computer to actually work.
- It is the software that enables all the programs we use.
- The OS organizes and controls the hardware.
- OS acts as an interface between the application programs and the machine hardware.
- Examples: Windows, Linux, Unix and Mac OS, etc.,

Compiler

It is a program that reads a program in one language – the source language and translates into an equivalent program in another language – the target language.

Source Languages	Target Languages
'C' language	'C' language
'Pascal' language	Machine language
FORTRAN language	
C++ language	
ADA language	

Loader

- It is the part of an operating system that is responsible for loading programs into memory, preparing them for execution and then executing them.
- The loader is usually a part of the operating system's kernel and usually is loaded at system boot time and stays in memory until the system is rebooted, shut down, or powered off.
- In Unix, the loader is the handler for the system call **execve()**.

Linker

- A linker or link editor is a program that takes one or more objects generated by compilers and assembles them into a single executable program.
- Linkers can take objects from a collection called a library. The objects are program modules containing machine code and information for the linker.
- The linker takes care of arranging the objects in a program's address space.

Interpreter

- It is a computer program that translates and executes instructions written in a computer programming language line-by-line, unit by unit etc.,
- An interpreter needs to be able to analyze instructions written in the source language.
- Example: Lisp systems, etc.,

Application Software

- Application Software includes programs that do real work for a user.
- Example: Payroll systems, Inventory Control, Manage student database, Word Processor, Spreadsheet and Database Management System etc.,

Word Processors

- It is a tool that helps user in creating, editing, and printing documents. Word processors will normally have the following capabilities built into them:
 - Spell checking
 - Standard layouts for normal documents
 - Some characters appearing in bold print, italics, or underlined
 - Center lines, make text line up on the left side of the paper, or the right side of the paper
 - Save the document so it can be used again
 - Print the document.
- Examples: WordPerfect and Microsoft Word

Spreadsheets

- The spreadsheet packages are designed to use numbers and formulas to do calculations with ease. Examples of spreadsheets include:
 - Budgets
 - Payrolls
 - Grade Calculations
 - Address Lists

The most commonly used spreadsheet programs are Microsoft Excel and Lotus 123.

Graphic Presentations

- The presentation programs can make giving presentations easier. Other uses include:
 - Slide Shows
 - Repeating Computer Presentations on a computer monitor
 - Using Sound and animation in slide shows
- The most recognized graphic presentation programs are Microsoft PowerPoint and Harvard Graphics.

Database Management System (DBMS):

- A DBMS is a software tool that allows multiple users to store, access, and process data into useful information.
- Database programs are designed for these types of applications:
 - Membership lists
 - Student lists
 - Grade reports
 - Instructor schedules
- All of these have to be maintained so you can find what you need quickly and accurately.
- Example: Microsoft Access, dBASE, Oracle.

Open Source Software

- Open source software (OSS) is computer software whose source code is available under a license that permits users to use, change, and improve the software, and to redistribute it in modified or unmodified form.
- It is often developed in a public, collaborative manner.
- Well-known OSS products are Linux, Netscape/Firefox, Apache , etc.,

Proprietary Software

- Proprietary software (also called non-free software) is software with restrictions on using, copying and modifying as enforced by the proprietor. Restriction on use, modification and copying is achieved by either legal or technical means and sometimes both.
- Proponents of proprietary software are Microsoft.
- Examples: AutoCAD, Norton Antivirus etc.,

System Software vs Application Software

System Software	Application Software
It is a collection of programs that enable the users to interact with hardware components efficiently	It is a collection of programs written for a specific application. Like, we have library system, inventory control system, etc
It controls and manages the hardware	It uses the services provided by the system software to interact with hardware components
System software is machine dependant	It is machine independent
The programmer must understand the architecture of the machine and hardware details to write a system software	The programmer ignores the architecture of the machine and hardware details to write an application software
Interacts with the hardware directly	Interacts with the hardware indirectly through system calls provided by system software
Writing a system software is a complicated task	Writing application programs is relatively very easy
Example: compiler, operating system	Example: MS-WORD, PAINT

Operating Systems

Thank you

Queries ???

RAJESH TRIPATHI

Associate Professor, Department of Computer Sci. and Engineering
Motilal Nehru National Institute of Technology Allahabad

Allahabad-211004, UP, India