CHAPTER 3

Operating system

Fundamental Concept

Computer system is a collection of hardware and the software where actual work is done by hardware, where software governs what and how to do that. Without software, a computer is just a piece of metal. It is the software by which the computer can store the data, process it and present it in suitable format. Computer software can be categorized into two types. The first one is system software and another is application software. The job of system software is to manage the operation of computer as a whole whereas the application program serves the purpose of general user of computer system. In other words, system software provides the platform for application software to run. One very good example of system software is operating system. The example of application software are word processor, spreadsheet, and Browser etc.

Introduction to Operating System

The operating System is defined as a set of programs that controls the entire operation of the computer such as handling Input/output operation, user request, interrupts etc. The Operating System manages the resources of a computer system and schedules its operation. It is a master supervisory program which provides a friendly interface for the user to interact with the computer and its peripherals and different application software as well as an environment for program to execute.

An Operating System (OS) is computer program (system software) that acts as an intermediary/ interface between users and computer hardware. This is the first software we see when we turn on the computer and again the last software we see when the computer is turned off. It provides users an environment in which a user can execute programs conveniently and efficiently. In technical terms, it is software which manages hardware. An operating System controls the allocation of resources and services such as memory, processors, devices and information.

Also Operating System provides user a high level abstraction. Without knowing much more internal details of any devices the user can operate them through operating System. For example, operating System provides user files and folders interface to interact with storage device like hard disk. Without having much knowledge of internal details of hard disk user can work on files and folders easily. The operating System hides the internal details of hard disk and provides the user the interface of files and folders. Thus operating System can be regarded as extended machine too.

Application Software like word processor, spreadsheet, and Browser etc. work on top of Operating System. In Other words, OS provides platform to run the application programs. The platform may be GUI(Graphical User Interface) or CUI(Character User Interface), Microsoft Windows series and X-window of Linux are the example of GUI based Operating System . MS-DOS is a non GUI Operating System.

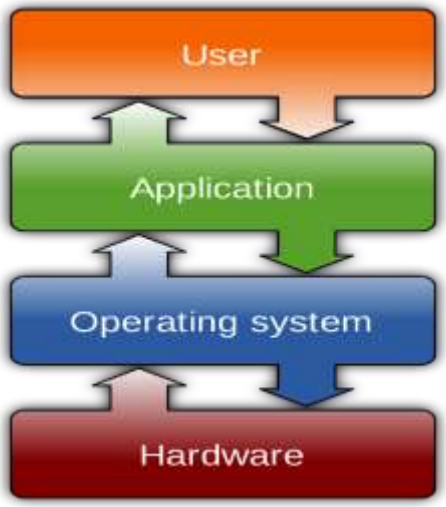


Fig: Operating System (OS)

It manages the hardware, the user interface and all other software running on the computer. Without an operating system, a computer is just a collection of components heating up the room as no-one would be able to make any practical use of the machine.

A large number of operating systems have been developed over the years; each designed with a certain kind of computer in mind. For instance:

- **Windows or Linux -** *for Personal computers*
- **Mac OS -** *for Macs*
- **Unix -** *for Mainframes*
- **Symbian, Android -** *for mobile phones*

Role of Operating System (OS)

- Providing a user interface
- To control and coordinate peripheral devices such as printers, screens, disk drives.
- To help the application program execute its instruction
- To help the user to develop programs
- To monitor the use of the resources of the machine
- To deal with any faults that may occur in the computer and inform the user.
- Managing the computer's memory
- Managing the hardware
- People need a way of interacting with machines if they are to be useful.
- People must also be able to interact with the computer.
- They have to be able to open applications, run them and finally shut them down. They Need to be able to enter data and either see (or listen) to the result of computer processing.
- However, the one that you are most familiar with is Graphical User Interface (GUI). GUI provides you with the functionality to create and manage the windows that you use on your screen. Icons and scrollbars.
- Backup and Recovery is possible.

Functions/Features of an Operating System

OS is an interface between user and the hardware, so it takes the entire burden from user for managing various resources of computer system. Moreover, co-ordination between the resources, reliability, and efficiency are also the key terms OS is directly connected with. In the general, OS does the following core functions.

1. Input/output (I/O) Management
2. Resource Management
3. File Management
4. Data Management
5. User Interface
6. Memory Management
7. Security
8. Timesharing System
9. Event logging
10. Interrupt handling
11. Virtual Storage
12 Deadlock and its Prevention

1. Input/output (I/O) Management

The task of managing various input output devices like keyboard, mouse, monitor, storage device etc. has to be done by OS. Every Operating System has an I/O subsystem for managing its I/O devices.

2. Resource Management

There are various other resources in computer system (for example Printer). They must be Distributed efficiently between the programs without any conflicts.

3. File Management

Operating System handles the file organizations in the secondary storage devices. Operating System does the following activities for file management.

- Maintains a mechanism of files and directories, where files can be kept in separate Directories in an organized manner.
- Maintains authority over files by allowing different types of access permission and Priority.
- Implements different types of efficient searching mechanism of files.

4. Data Management

Data management keeps track of the data on the disk, tape, optical storage device. The application program deals with data by file name and particular location within the file. OS software manages the storage and retrieval of data.

5. User Interface

The OS reads the commands entered by the user interprets them and execute them by hardware. The command entry process is different in different user interface system. In windows system the command entry is done by graphical elements like Menu, Toolbar, Text boxes through the use of mouse and keyboard.

6. Memory Management

For any program to execute it must reside on the main memory. In a system where multiple programs are to be executed each program requires certain amount of memory. The organization

Of memory for running programs should be managed by the operating system. The memory Management component of the operating system manages memory efficiently.

7. Security and Protection

One of the major task of OS is to secure the data and programs space of each job while loaded into the memory. One program isn't allowed to capture the program or data space of other program, for that OS maintains the boundary of each job in the main memory and each job are allowed to run only in that boundary. In multi-user system, the OS must manage security measures to prevent data of one user by other. Following are the major activities of an operating system with respect to protection.

- OS ensures that all access to system resources is controlled.
- OS ensures that external I/O devices are protected from invalid access attempts.
- OS provides authentication feature for each user by means of a password.

8. Time Sharing System

Time Sharing system designed to enable many users to interact with the computer system at the same time by using a terminal keyboard and display device. This strategy was the first step in making the computer available to many people involved in many different types of information processing task.

Multiple interactive sessions are implemented by set of virtual machines one for each user. Each virtual machine is actually a simulation of real hardware implemented by the OS. Each user interacts with the computer system by typing commands to the virtual machine on a virtual system. Each user directs the virtual machine to perform different commands. These commands are then executed on the physical machine in a multiprogramming environment.

The idea of multiprogramming was further used in time sharing system. Multiple terminals are connected to the computer, with each "in-use" terminal being associated with one or more jobs on the computer. The OS is responsible for switching between the jobs in such a way that ever terminal feels that it is occupying the entire computer resources.

Another concept in time –sharing system is priority, interrupt and I/O management. Important jobs can be given high priority so as to execute it fast. If the job has to be done some I/O operation while running in CPU , then another job will be allocated to processor. Thus, it reduces the idle time of CPU and increases the efficiency. If a higher priority job comes or the CPU timer job finishes, then signal is generated to inform that action, which is known as an interrupt.

The initial time sharing machine was VAX/VMS computers. Most of the present day computers also use time sharing/Multiprogramming principles. CTSS operating system was introduced as a full fledge time sharing OS.

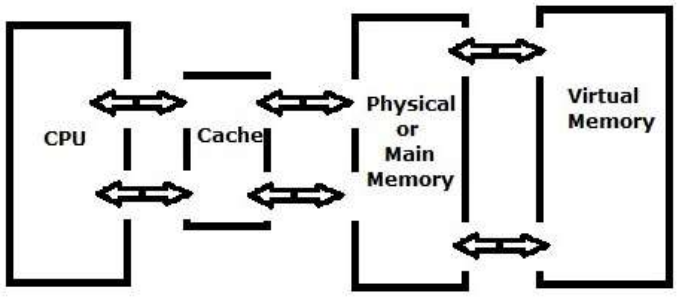
9. Event logging

Operating System records all the events that happen in the computer system. It's very much useful for tracing the past records and troubleshoot (problem detection and correction) if something goes wrong. This is known as event log.

10. Interrupt handling

An interrupt is a signal generated from a device attached to a computer. It is the event that makes the processor stop executing its program to perform requested activity. There are two types of interrupt. Interrupt generated by hardware device such as monitor, printer, mouse, or chips on the system board is called Hardware Interrupt. Interrupt generated by the programs or software are called Software Interrupt.

11. Virtual Storage



Most Computer today have something like 256 or 512 MB of RAM available for the CPU to use. Unfortunately, that amount of RAM is not enough to run all of the programs that, most users expect to run at once. As the demand for the multiple program execution increases more and more may not be enough for all programs that are under execution. In this case modern operating system uses secondary storage for extra memory requirement. This process is known as Virtual Storage. Generally, GUI system needs more memory because of their graphical nature. The virtual memory management are of two type

- Paging
- Segmentation

Paging: External fragmentation is avoided by using paging technique. Paging is a technique in which physical memory is broken into blocks of the same size called pages (between 512 bytes and 8192 bytes). When a process is to be executed, its corresponding pages are loaded into any available memory frames.

Segmentation: Segmentation is a technique to break memory into logical pieces where each piece represents a group of related information. For example, data segments or code segment for each process, data segment for operating system and so on. Segmentation can be implemented using or without using paging. Unlike paging, segment is having varying sizes and thus eliminates internal fragmentation.

12. Deadlock and Prevention

In a multiprogramming environment, several processes may complete for a finite number of resources. A process requests resources, if the resources are not available at that time, the process enters a wait state. Waiting process may never again change state, because the resources they have requested are held by other waiting process. This situation is called deadlock.

For example, if program "A" captures hard disk and ask for printer to print, and program "B" captures printer and ask for hard disk to write, then such condition creates "Deadlock" and system will be halted. Such conditions are avoided by Operating System and resources are efficiently distributed.

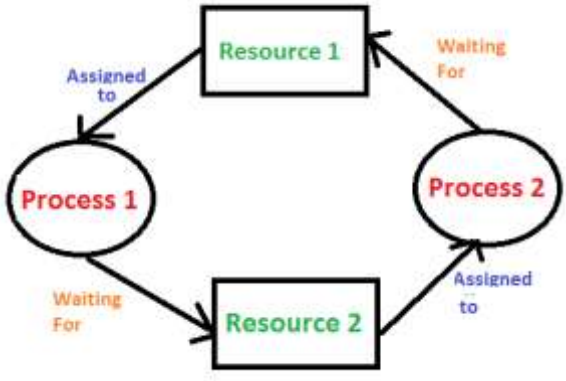
Deadlock can arise if following four conditions hold simultaneously (Necessary Conditions)

Mutual Exclusion: One or more than one resource are non-sharable (Only one process can use at a time)

Hold and Wait: A process is holding at least one resource and waiting for resources.

No Preemption: A resource cannot be taken from a process unless the process releases the resource.

Circular Wait: A set of processes are waiting for each other in circular form.



Types of Operating System: Based on User Interface, User mode and Processing Method

1. Types of OS on the basis of User Interface

a) Graphic User Interface
b) Text User Interface

a. Graphic User Interface

User interacts with operating system through various elements called GUI system. **Graphical User Interface (GUI)** allows the user to use icons or other visual indicators to interact with electronic devices. For example, all versions of Microsoft Windows utilize a GUI. GUI uses windows, icons, and menus to carry out commands, such as opening, deleting, and moving files.Although many GUI operating systems are navigated through the use of a mouse, the keyboard can also be utilized by using keyboard shortcuts or arrow keys.

Features:

- In GUI operating system commands line are through graphical components like menu, toolbar, folder etc.
- Because of graphical components GUI Operating are easy to learn and master.
- In GUI system we can preview the content before it gets printed that is WYSIWYG(What You See Is What You Get)
- GUI Operating System supports multiple programs to execute simultaneously
- GUI operating system demands high resources.
- GUI are generally 32 or 64 bits operating system
- GUI also provides menus, buttons and other graphical objects to the user to perform different tasks.
- GUI is very easy to interact with the computer. So it is user friendly.
- It supports all components of multimedia like: Video, Audio, Graphics, Animation and Text.
- It supports multitasking, multiprogramming, multithreading
- It needs large amount of memory.
- Example: Microsoft Windows, Mac OS, Solaris and Linux

b) Text/Character User Interface (TUI/CUI) or Command line Interface (CLI)

User interacts with operating system through keyboard called CUI system. A command line operating system provides a command prompt on the computer screen. The commands are given to the computer by typing on the keyboard. The commands are typed according to the predefined format. The users have to memorize commands and rules of writing these commands. It is not an easy way to interface with the computer. It supports only text not others components. It can support up to 16 bits.

Features:

- *CUI* operating System commands are issued by text only
- In CUI system the user has to memorize all the commands and syntax
- WYSIWYG(What You See Is What You Get) is not possible in case of CUI system

- CUI operating system like DOS is generally single tasking.
- It is less user friendly
- It is faster than GUI
- It cannot support multimedia environment
- It requires less amount of memory
- It is generally 8 or 16 bit operating system.
- It does not contain components like menus, icons, pointing devices.

Difference between Graphical User Interface (GUI) and Text User Interface (TUI)

SN	Graphical User Interface (GUI)	Text User Interface (TUI)
1	We can work with picture and pointing devices which is much easier.	We must enter or type the command so we must remember all the commands
2	It is easier to remember the graphics symbol.	It is almost impossible to know or remember all the commands of CUI
3	The appearance of GUI is very attractive.	The appearance may not be as good as that of GUI.
4	You can run any program by clicking on the mouse.	You must remember the command and type the command to run or load any program.
5	GUI users have a windows that enable a user to easy view, control, and manage	Although many command line environments are capable of multitasking
6	manipulate multiple things at once and is commonly much faster to do when compared to CUI	they do not offer same ease and ability to view multiple things at once on one screen
7	Although new users may have a difficult at time learning to use the mouse operate and use a GUI, most user pick up this interface much easier when compared to a command line interface.	Because of the memorization and familiarity needed to operate a command line interface new users find it more difficult to successfully navigate and operate a command line interface.
8	It supports pointing devices.	It doesn't support pointing devices.
9	It supports multimedia.	It doesn't support multimedia.
10	Examples: Windows, Android etc.	Examples: Dos, Unix etc.

2. Types of OS on the basis of User Mode:

a. Single User
b. Multi User

a. Single User OS

A single-user operating system is a type of operating system (OS) that is developed and intended for use on a computer or similar machine that will only have a single user at any given time. This is the most common type of OS used on a home computer, as well as on computers in offices and other work environments.

This type of OS is typically used on devices like wireless phones and two-way messaging devices. A single task operating system can only run one program or application at a time, and so it is not as useful for a computer or other device intended to run multiple programs at once. MS-DOS is

a single user OS.

b) Multi User OS

A Multi User operating system allows two or more users to run programs at the same time. Some OS permit hundreds or even thousands of concurrent users. The OS of mainframes and minicomputer are multi-user system. Many different users take advantage of the computer's resources simultaneously. The operating system must make sure that the requirements of the various users are balanced, and that each of the programs they are using has sufficient and

Separate resources so that a problem with one user doesn't affect the entire community of users. UNIX, MVS and mainframe operating systems are examples of multi-user operating systems. A multi-user operating system lets more than one user access the computer system at one time. Examples of multi-user operating systems are UNIX, Linux and mainframes such as the IBM AS400. The multi user operating systems must manage and run all user requests, ensuring they do not interfere with each other. Devices which can only be used by one user at a time, like printers and disks must be shared among all those requesting them so that all the output documents are not jumbled up.

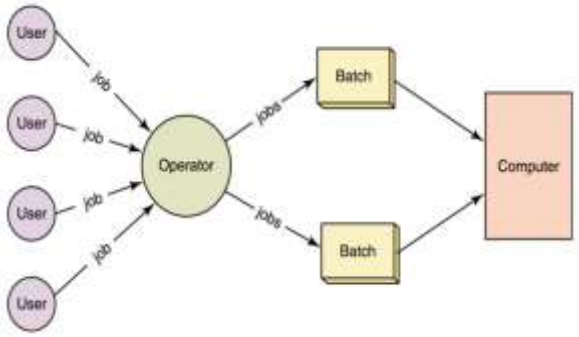
3. Types of OS on the basis of Processing

Based on the technological development Operating System can be divided as follows:

a. Batch processing Operating System
b. Time-Sharing Operating Systems
C. Distributed Operating System
d. Network Operating System
e. Real-Time Operating System
f. On-line processing system
g. Multiprogramming
h. Multitasking
i. Multi-processing
j. Multithreading

a) Batch Processing System

A batch system is one in which jobs are bundled together with the instructions necessary to allow them to be processed without user invention.



The simple operating system also called monitor is system software responsible for interpreting and carrying out the instructions in the batch jobs. When the monitor started a job, it handled over control of the entire computer to the job, which then controls the computer until it is finished. Such batch system is called stacked job or simple batch system.

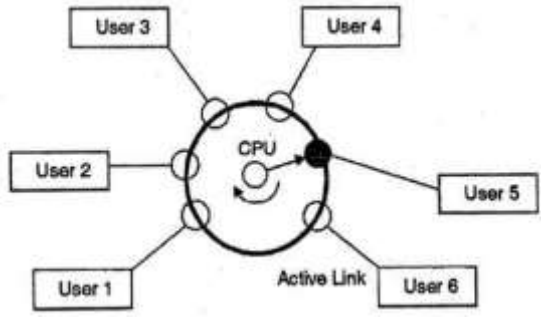
Benefits

- Move much of the work of the operator to the computer
- Increased performance since it was possible for job to start as soon as the previous job Finished

b) Time-Sharing Operating System

Time sharing is a technique which enables many people, located at various terminals, to use a particular computer system at the same time. Time sharing system designed to enable many users

to interact with the computer system at the same time by using a terminal keyboard and display device. This strategy was the first step in making the computer available to many people involved in many different types of information processing task.



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c) Distributed Operating System

A Distributed operating system is one that appears to its user as a traditionally uni-processor system, even though it is actually composed of multiple processors/computers. The user feels like he is working in the terminal in front of him, but actually the work may take place in any machine in the network. Distributed systems use multiple central processors to serve multiple real time application and multiple users. Data processing jobs are distributed among the processors accordingly to which one can perform each job most efficiently.

The processors communicate with one another through various communication lines (such as high speed buses or telephone lines).

d) Network Operating System

Most of the Network OS works under the principle of client-server mechanism. Client-server is a mechanism in which co-operation and communication between various elements of networks takes place and one machine "serves" others for various functions.

In a Network OS, the users are aware of the existence of multiple computers and can be use the functionality of remote machine. In other words, a user doesn't have to sit in front of machine in which he wants to work on.

e. Real Time Operating System

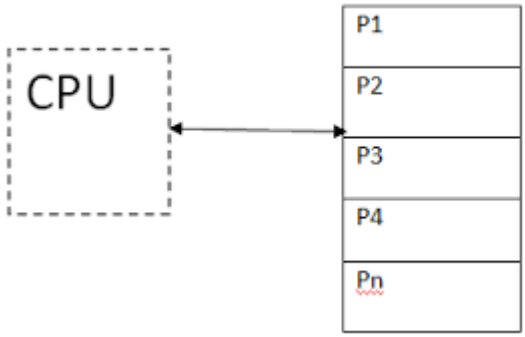
Real Time Operating Systems are dedicated to some well-defined jobs which require very fast response time. The system must be fault-tolerant that is OS must handle the error without going to unstable stage. The execution time is the most critical issue in real time OS and they must finish the execution of job within pre-defined time boundary. The example of programs that run in Real-Time OS are: missile-guiding system, medical monitoring system, flight simulation system, traffic light control etc.

f) On-line Processing System

Online processing operating system is almost similar to real time operating system but the resultMust be obtained in the presence of the user. The system for querying the bank in the account can be best example of Online processing where result is obtained directly from the main database in the presence of the customer demanding information. No need to wait for a long time to execute any operation. Airline reservation, Bus reservation, railway reservation, the passengers making reservation would like to know immediately whether the seat is available or not. Example: ATM Machine.

g. Multiprogramming

As computers started having more and more memory, it was possible to extend the idea of multiprogramming. The concept of multiprogramming is to create systems that would load several jobs into memory at once and cycle through them in some order, working on each one for a specified period of time.



Operating System is responsible for

- Starting user jobs
- Spooling operations
- IO for user jobs
- Switching between user jobs
- Ensuring proper protection while doing the above

h) Multitasking

Multitasking allows more than one program to run concurrently. Multitasking is the ability to execute more than one task at the same time, a task being a program. In Multitasking, only one CPU is involved, but it switches from one program to another so quickly that it gives the appearance of executing all of the programs at the same time.

There are two basic types of multitasking:

- Preemptive
- Cooperative

In **preemptive multitasking**, the OS parcels out CPU time slices to each program. UNIX, Windows 95, Windows XP, Windows NT, OS/2, and later versions of Mac OS are based on pre-emptive multitasking.

In **cooperative multitasking**, each program can control the CPU for as long as it needs it. MultiFinder (for Macintosh computers) and Windows 3.x are the examples of Co-operative multitasking OS.

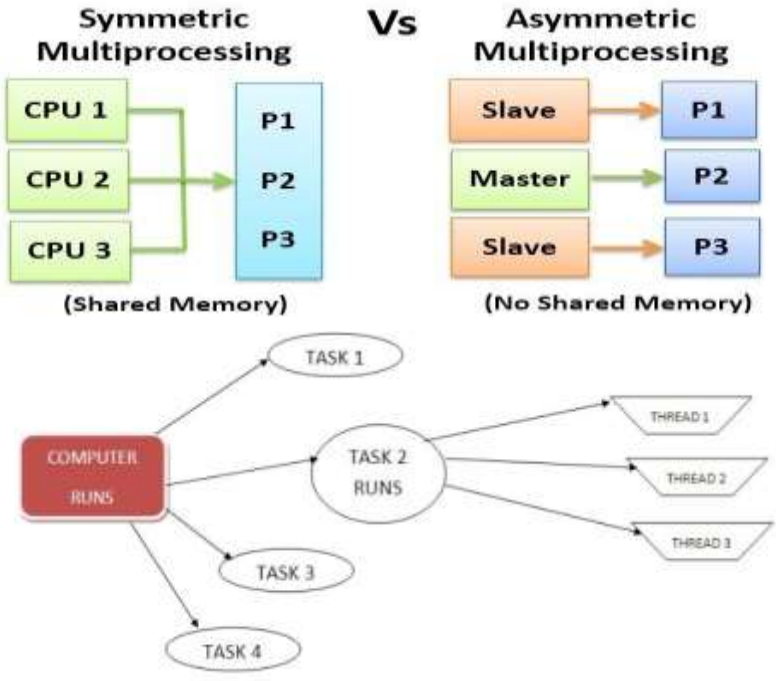
i. Multiprocessing

A Multiprocessing OS is one which runs on the computer having more than one CPU. Such OS Simultaneously execute two or more jobs at a single time. Multiprocessing OS enable several

Programs to run concurrently. MVS and UNIX is two of the most widely used multiprocessing systems. Multiprocessing also refers to the utilization of multiple CPUs in a single computer system.

j. Multithreading

Multithreading allows different parts of a single program to run concurrently. Multithreading is the ability of an operating system to execute different parts of a program, called threads. The programmer must carefully design the program in such a way that all the threads can run at the same time without interfering with each other.



Some OS Related Terms

Spooling (Simultaneous Peripheral Operation On-Line)

From the early days of computer system, the execution speed of the CPU has always been faster than any other I/O devices. If no special techniques are applied, then CPU remains idle most of the time as it has to wait for other peripheral devices to solve this issue, technique like spooling was introduced. It is most widely used in printing technology.

It makes use of computer and input/output device. It is used for storing data temporarily on a computer. It can be carried out online or offline. Spooling waits until the entire operation is done before sending it to the output device or a network. It holds output for a device, such as printer. It probably comes from sending a document to a printer. We know that there is delay between when we press "print" and a document coming out of the paper, the computer processes the entire print job into a format, the printer can handle and sends it down the serial bus to the printer. Since, the processor is fast enough, it sends the data to be printed, to some buffer an intermediate space where data are kept temporarily. This part is done by spooler program. Whenever printer becomes free, then it fetches those buffered data which is done by de-spooling program.

Advantage: CPU and I/O devices work more efficiently and performance of the system is increased.

Buffering:

It is an area of computer's memory (RAM) or devices memory for holding data during data transfer. Normally Input /output devices have low speed then that of processor. This speed difference is adjusted by having temporary data storage in a memory typically called buffer .While the device is in operation data transfer can take place in buffer. This process of holding data temporarily during I/O devices can access data from the buffer.

It is typically associated with video viewing on the web. Buffering is the process where some contents from a remote machine/website are temporarily copied on to our desktop so that we can

view it. Once we finish viewing and close the browser or connection, this file/content would be erased from our machine. Example: YouTube: Everything we view in YouTube would be buffered to our desktop but the moment we close the browser the contents are gone.

Booting:

Booting is a process of loading system files (IO.SYS, MSDOS.SYS, COMMAND.COM) into main memory from bootable disk like floppy disk, CD, DVD, hard disk. Whenever we switch on the computer, the instructions stored in ROM are automatically executed. The instructions in the ROM help to load the operating system from external storage (hard disk) to internal storage (primary memory). This process of loading the files of operating system into primary memory from the secondary memory is known as booting.

Booting of the computer is performed in two ways they are:

1. Cold Boot:
2. Warm Boot:

Cold Boot:

When the computer is switched on for the first time, the booting process is called cold boot. When the computer is at OFF state and the user PUTS ON the power switch of the computer, the computer reads its RAM space and searches for system files of OS from secondary disk. As soon as it finds the system files, the files are resident to the computer memory. This is called cold booting.

- In this process our computer tests its hardware.
- Sometimes it is called hard booting
- The disadvantage of cold booting is that all temporary data is lost.
- Cold booting is powering up the PC after it is OFF.
- We turned OFF the computer last night and this morning we turn it ON i.e. Cold Booting.

Warm Boot:

When we are working on computer suddenly it becomes hanging at that time, computer cannot work so we need to restart the computer is called Warm Boot. Such as pressing reset switch to restart the computer. At the same time, the computer removes all the files from its memory and searches again for system files in the disks and loads them into the RAM. This process of booting is called warm booting. Simply press **RESET** button or **(CTRL +ALT +DEL)** at the same time is also known as warm boot. A warm booting is also called soft booting.

Open source operating system

Open source software is software with source code that anyone can inspect, modify, and enhance.

“Source code" is the part of software that most computer users don't ever see; it's the code computer programmers can manipulate to change how a piece of software—a "program" or "application"—works. Programmers who have access to a computer program's source code can improve that program by adding features to it or fixing parts that don't always work correctly.

What's the difference between open source software and other types of software?

Some software has source code that only the person, team, or organization who created it—and maintains exclusive control over it—can modify. People call this kind of software "proprietary" or "closed source" software.

Only the original authors of Proprietary software can legally copy, inspect, and alter that software. And in order to use proprietary software, computer users must agree (usually by signing a license displayed the first time they run this software) that they will not do anything with the software that the software's authors have not expressly permitted. Microsoft Office and Adobe Photoshop are examples of proprietary software.

Open source software is different. ***Its authors make its source code available to others who would like to view that code, copy it, learn from it, alter it, or share it***. LibreOffice and the GNU Image Manipulation Program are examples of open source software.

As they do with proprietary software, users must accept the terms of a license when they use open source software—but the legal terms of open source licenses differ dramatically from those of proprietary licenses.

Open source licenses affect the way people can ***use, study, modify, and distribute software***. In general, open source licenses grant computer users permission to use open source software for any purpose they wish. Some open source licenses—what some people call "copy left" licenses—stipulate that anyone who releases a modified open source program must also release the source code for that program alongside it. Moreover, some open source licenses stipulate that anyone who alters and shares a program with others must also share that program's source code without charging a licensing fee for it.

By design, open source software licenses promote collaboration and sharing because they permit other people to make modifications to source code and incorporate those changes into their own projects. They encourage computer programmers to access, view, and modify open source software whenever they like, as long as they let others do the same when they share their work.

Best open source operating system

1- **Ubuntu**

2- **Linux Lite**

3- **Fedora**

4- **Linux Mint**

5- **Solus**