OPERATING SYSTEM NOTES

UNIT-I

❖ *Introduction of Operating System*

An operating system acts as an intermediary between the user of a computer and computer hardware. The purpose of an operating system is to provide an environment in which a user can execute programs conveniently and efficiently.

An operating system is a software that manages computer hardware. The hardware must provide appropriate mechanisms to ensure the correct operation of the computer system and to prevent user programs from interfering with the proper operation of the system.

Mainframe Computer

Mainframes are a type of computers, which are made for **'throughput'** as fast as possible; a throughput can be defined as **"the rate at which the data is processed"** . And also mainframes are majorly used for transaction processing; a transaction can be defined as "a set of operations including disk read and write, operating system calls, transferring data from one subsystem to another, etc…"

The mainframes have more processing power compared to servers and microcomputers (like- laptop, PC, etc…), but have less processing power compared to a supercomputer.
The main focus of the Main-frames is throughput, "A throughput is a rate at which something is processed."

Components of a Mainframe Computer

The mainframes have two types of processors, the first one is the Main processor and another one is System assistance Processor or SAP. The SAP processors do not process any data but move the data from one place to another as fast as possible.
Each processor can have up to 7 to 10 cores which are specially designed and engineered for 'higher throughput'.
Each mainframe can have up to 160 of I/O cards. And also they have got some serious amount of ROM (Solid State Drives) for faster data storage and transfer.

The fact that the main-frames have so many I/O cards is because these are made for redundancy that is, if one card fails, other cards will take over the work-load of that card until the card is replaced.

Why are mainframe computers used?

Main-frames are used for Reliability, Redundancy, and availability. These are must computers to have where '0' downtime is acceptable.

Due to the fact that these computers are reliable and have redundancy that is if an I/O card fails due to any reason, its workload will automatically get transferred to other I/O card ensuring '0' downtime which is of great importance for ensuring proper transactions.

Similarly, if there is some problem with a processor module, the workload will be transferred to other processors.

How are Mainframes different from Supercomputer?

The Main-Frames are used for fast processing or 'throughput' whereas the Supercomputers are used for number crunching where they deal with a colossal amount of data to predict weather, solve complex mathematical models for computation and are majorly used in research only.

Advantages

- The processing speed is very fast.
- Can handle multiple inputs at same time.
- Redundancy, Can withstand failure of a part without affecting the function of rest of the computer.
- Always available, as once started they will remain on for rest of the time.
- Reliability.

Disadvantages

- Mainframes cannot be used as a normal computer, because they are made for specific task only.
- It requires a special OS to run.
- Are very expensive.
- Mainly used for commercial purposes like transaction processing.
- Cannot calculate or solve complex problems like a supercomputer.

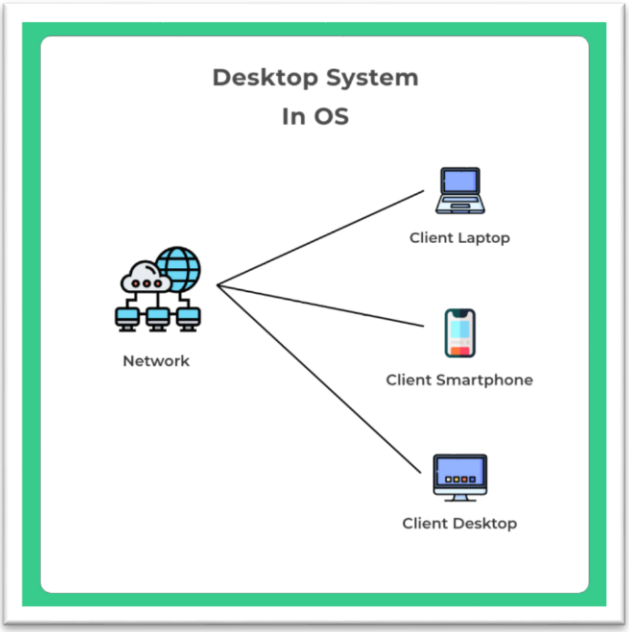
Desktop Systems

Overview

The control program that operates in a **user's machine** is termed the **desktop system**. Such a system is also referred to as a **client operating system**.

The client can be said as a computer in a network where the user performs some task or activity over the network.

Such computer operating systems do not have complete control over the resources but use the network to access them. Also, these operating system only use the network to carry out tasks such as downloading a file from the network or browsing the internet.



Desktop operating systems usually operate with a server computer which has the complete control over the resources. Also, the processing power remains completely in the hand of the server operating system. The **server operating system** is developed in such a way that it can fulfill all the requirements and requests of the client or the desktop operating system.

Desktop or the client operating system is completely dependent on the server operating systems and are ineffective in the absence of a server.

Basic Features

Some of the features of a client operating system are:

- Basic operating features such as data sharing, internet browsing, and detecting hardware.
- Needs minimal memory requirements
- Highly budget-friendly
- Better utilization of resources
- Less operational complexity

Advantages

Some of the advantages of a client operating system are:

- Centralization of resources as all the resources are present at a common location.
- Better management of resources as the files are stored at a single place. This also avoids redundancy of resources such as printers and scanners.

- Remote access to the server gives processing power to every user.
- High security as only the server needs to be secured from threats and attacks.
- The server can play different roles for the different

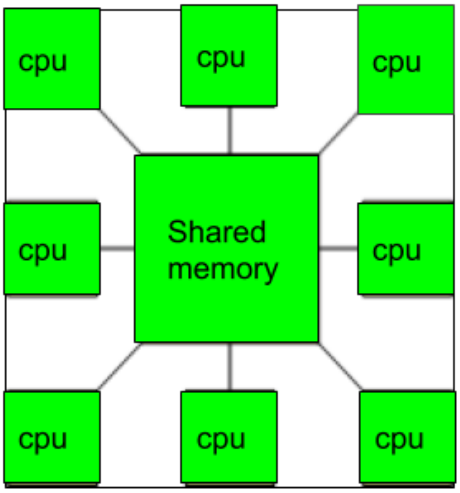
Disadvantages

Some of the disadvantages of a client operating system are:

- Network congestion as multiple requests from the clients can block the network traffic.
- The architecture of request and response is not robust enough for heavy processing.
- If the server fails, all the desktop systems connected over the network fails.
- If the service interrupts, the task has to be started from scratch. For instance, if a desktop system requests a file download which gets interrupted, the file becomes corrupt, and the entire process needs to be carried out from the start.
- The operating system architecture is highly costly.
- A professional IT personnel is needed to manage and maintain such an operating environment.

Multiprocessor System

A Multiprocessor is a computer system with two or more central processing units (CPUs) share full access to a common RAM. The main objective of using a multiprocessor is to boost the system's execution speed, with other objectives being fault tolerance and application matching.



- There are two types of multiprocessors, one is called shared memory multiprocessor and another is distributed memory multiprocessor. In shared memory multiprocessors, all the CPUs shares the common memory but in a distributed memory multiprocessor, every CPU has its own private memory.

- **Applications of Multiprocessor** –

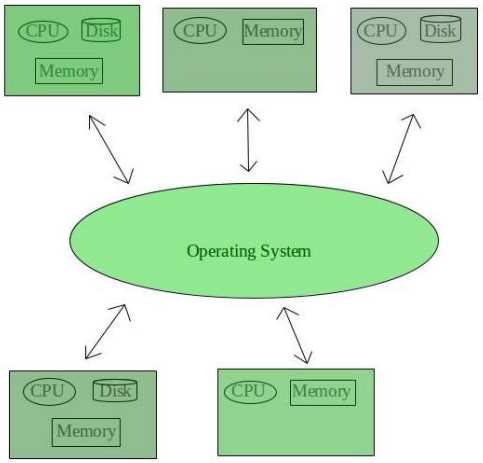
1. As a uniprocessor, such as single instruction, single data stream (SISD).

2. As a multiprocessor, such as single instruction, multiple data stream (SIMD), which is usually used for vector processing.
3. Multiple series of instructions in a single perspective, such as multiple instruction, single data stream (MISD), which is used for describing hyper-threading or pipelined processors.
4. Inside a single system for executing multiple, individual series of instructions in multiple perspectives, such as multiple instruction, multiple data stream (MIMD).

Benefits of using a Multiprocessor –

- Enhanced performance.
- Multiple applications.
- Multi-tasking inside an application.
- High throughput and responsiveness.
- Hardware sharing among CPUs.

Distributed Operating System –



- These types of the operating system is a recent advancement in the world of computer technology and are being widely accepted all over the world and, that too, with a great pace. Various autonomous interconnected computers communicate with each other using a shared communication network. Independent systems possess their own memory unit and CPU. These are referred to as **loosely coupled systems** or distributed systems.
- These system's processors differ in size and function. The major benefit of working with these types of the operating system is that it is always possible that one user can access the files or software which are not actually present on his system but some other system connected within this network i.e., remote access is enabled within the devices connected in that network.

Advantages of Distributed Operating System:

- Failure of one will not affect the other network communication, as all systems are independent from each other
- Electronic mail increases the data exchange speed

- Since resources are being shared, computation is highly fast and durable
- Load on host computer reduces
- These systems are easily scalable as many systems can be easily added to the network
- Delay in data processing reduces

Disadvantages of Distributed Operating System:

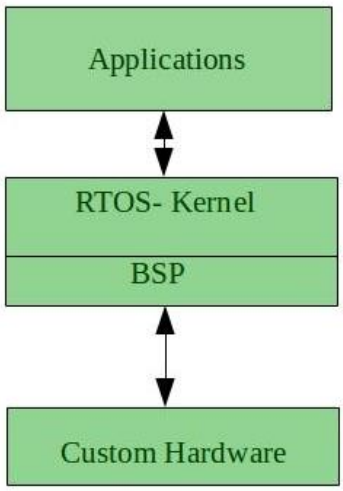
- Failure of the main network will stop the entire communication
- To establish distributed systems the language which is used are not well defined yet
- These types of systems are not readily available as they are very expensive. Not only that the underlying software is highly complex and not understood well yet

Examples of Distributed Operating System are- LOCUS, etc.

Real-Time Operating System –

These types of OSs serve real-time systems. The time interval required to process and respond to inputs is very small. This time interval is called **response time**.

Real-time systems are used when there are time requirements that are very strict like missile systems, air traffic control systems, robots, etc.



Two types of Real-Time Operating System which are as follows:

- **Hard Real-Time Systems:**
  These OSs are meant for applications where time constraints are very strict and even the shortest possible delay is not acceptable. These systems are built for saving life like automatic parachutes or airbags which are required to be readily available in case of any accident. Virtual memory is rarely found in these systems.
- **Soft Real-Time Systems:**
  These OSs are for applications where for time-constraint is less strict.

Advantages of RTOS:

- **Maximum Consumption:** Maximum utilization of devices and system, thus more output from all the resources

- **Task Shifting:** The time assigned for shifting tasks in these systems are very less. For example, in older systems, it takes about 10 microseconds in shifting one task to another, and in the latest systems, it takes 3 microseconds.
- **Focus on Application:** Focus on running applications and less importance to applications which are in the queue.
- Real-time **operating system in** the **embedded system:** Since the size of programs are small, RTOS can also be used in embedded systems like in transport and others.
- **Error Free:** These types of systems are error-free.
- **Memory Allocation:** Memory allocation is best managed in these types of systems.

Disadvantages of RTOS:

- **Limited Tasks:** Very few tasks run at the same time and their concentration is very less on few applications to avoid errors.
- **Use heavy system resources:** Sometimes the system resources are not so good and they are expensive as well.
- **Complex Algorithms:** The algorithms are very complex and difficult for the designer to write on.
- **Device driver and interrupt signals:** It needs specific device drivers and interrupts signals to respond earliest to interrupts.
- **Thread Priority:** It is not good to set thread priority as these systems are very less prone to switching tasks.

Examples of Real-Time Operating Systems are: Scientific experiments, medical imaging systems, industrial control systems, weapon systems, robots, air traffic control systems, etc.

Handheld Operating System:

Handheld operating systems are available in all handheld devices like Smartphones and tablets. It is sometimes also known as a Personal Digital Assistant. The popular handheld device in today's world is Android and iOS. These operating systems need a high-processing processor and are also embedded with various types of sensors.

Some points related to Handheld operating systems are as follows:

1. Since the development of handheld computers in the 1990s, the demand for software to operate and run on these devices has increased.
2. Three major competitors have emerged in the handheld PC world with three different operating systems for these handheld PCs.

3. Out of the three companies, the first was the Palm Corporation with their PalmOS.
4. Microsoft also released what was originally called Windows CE. Microsoft's recently released operating system for the handheld PC comes under the name of Pocket PC.
5. More recently, some companies producing handheld PCs have also started offering a handheld version of the Linux operating system on their machines.

Features of Handheld Operating System:

1. Its work is to provide real-time operations.
2. There is direct usage of interrupts.
3. Input/Output device flexibility.
4. Configurability.

Types of Handheld Operating Systems:

Types of Handheld Operating Systems are as follows:

1. Palm OS
2. Symbian OS
3. Linux OS
4. Windows
5. Android

Palm OS:

- Since the Palm Pilot was introduced in 1996, the Palm OS platform has provided various mobile devices with essential business tools, as well as the capability that they can access the internet via a wireless connection.
- These devices have mainly concentrated on providing basic personal-information-management applications. The latest Palm products have progressed a lot, packing in more storage, wireless internet, etc.

Symbian OS:

- It has been the most widely-used smartphone operating system because of its ARM architecture before it was discontinued in 2014. It was developed by Symbian Ltd.
- This operating system consists of two subsystems where the first one is the microkernel-based operating system which has its associated libraries and the second one is the interface of the operating system with which a user can interact.
- Since this operating system consumes very less power, it was developed for smartphones and handheld devices.
- It has good connectivity as well as stability.
- It can run applications that are written in Python, Ruby, .NET, etc.

Linux OS:

- Linux OS is an open-source operating system project which is a cross-platform system that was developed based on UNIX.
  It was developed by Linus Torvalds. It is a system software that basically allows the apps and users to perform some tasks on the PC.
- Linux is free and can be easily downloaded from the internet and it is considered that it has the best community support.
- Linux is portable which means it can be installed on different types of devices like mobile, computers, and tablets.
- It is a multi-user operating system.
- Linux interpreter program which is called BASH is used to execute commands.
- It provides user security using authentication features.

Windows OS:

- Windows is an operating system developed by Microsoft. Its interface which is called **Graphical User Interface** eliminates the need to memorize commands for the command line by using a mouse to navigate through menus, dialog boxes, and buttons.
- It is named Windows because its programs are displayed in the form of a square. It has been designed for both a beginner as well professional.
- It comes preloaded with many tools which help the users to complete all types of tasks on their computer, mobiles, etc.
- It has a large user base so there is a much larger selection of available software programs.
- One great feature of Windows is that it is backward compatible which means that its old programs can run on newer versions as well.

Android OS:

- It is a Google Linux-based operating system that is mainly designed for touchscreen devices such as phones, tablets, etc.
  There are three architectures which are ARM, Intel, and MIPS which are used by the hardware for supporting Android. These lets users manipulate the devices intuitively, with movements of our fingers that mirror some common motions such as swiping, tapping, etc.
- Android operating system can be used by anyone because it is an open-source operating system and it is also free.
- It offers 2D and 3D graphics, GSM connectivity, etc.

- There is a huge list of applications for users since Play Store offers over one million apps.
- Professionals who want to develop applications for the Android OS can download the Android Development Kit. By downloading it they can easily develop apps for android.

Advantages of Handheld Operating System:

Some advantages of a Handheld Operating System are as follows:

1. Less Cost.
2. Less weight and size.
3. Less heat generation.
4. More reliability.

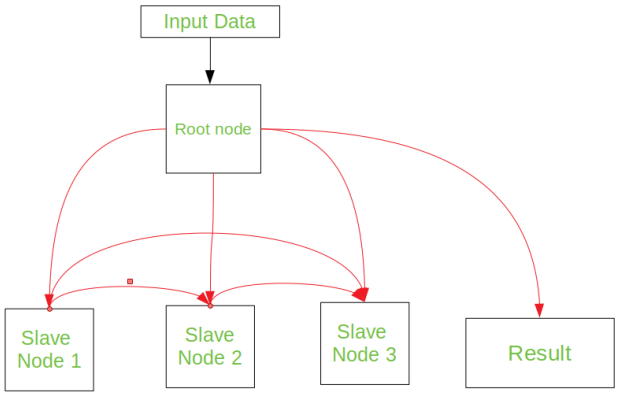
Disadvantages of Handheld Operating System:

Some disadvantages of Handheld Operating Systems are as follows:

1. Less Speed.
2. Small Size.
3. Input / Output System (memory issue or less memory is available).

Clustered Operating System

Clustered Operating Systems work similarly to Parallel Operating Systems as they have many CPUs. Cluster systems are created when two or more computer systems are merged. Basically, they have an independent computer but have common storage and the systems work together.

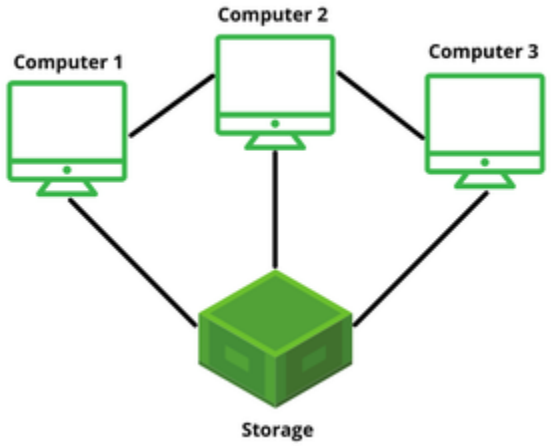


The *components of* clusters are usually connected using fast area networks, with each node running its own instance of an operating system. In most circumstances, all the nodes use the same hardware and the same operating system, although in some setups different hardware or different operating systems can be used in some setups.

For making cluster more efficient there exist two clusters:

- **Hardware Cluster**
- **Software Cluster**

Hardware Cluster helps in enable high-performance disk sharing between systems, while the **Software Cluster** allows all systems to work together.



Types of Cluster Systems:

Primarily, there are two types of Cluster Systems:

- **Asymmetric Cluster:** In this type of clustering, all the nodes run the required applications, and one node is in hot standby mode. The Hot standby node is used for monitoring the server till it fails, when it fails then it takes its place.
- **Symmetric Cluster:** In this type of clustering, all the nodes run applications and monitor other nodes at the same time. This clustering is more efficient than Asymmetric clustering as it doesn't have any hot standby key.

Classification of Clusters:

Computer Clusters are arranged together in such a way to support different purposes from general-purpose business needs such as web-service support to computation-intensive scientific calculation. Basically, there are three types of Clusters, they are:

- **Load-Balancing Cluster** – A cluster requires an effective capability for balancing the load among available computers. In this, cluster nodes share a computational workload to enhance the overall performance. For example- a high-performance cluster used for scientific calculation would balance the load from different algorithms from the web-server cluster, which may just use a round-robin method by assigning each new request to a different node. This type of cluster is used on farms of Web servers (web farm).

- **Fail-Over Clusters** – The function of switching applications and data resources over from a failed system to an alternative system in the cluster is referred to as fail-over. These types are used to cluster database of critical mission, mail, file, and application servers
- **High-Availability Clusters** – These are also known as "HA clusters". They offer a high probability that all the resources will be in service. If a failure does occur, such as a system goes down or a disk volume is lost, then the queries in progress are lost. Any lost query, if retried, will be serviced by a different computer in the cluster. This type of cluster is widely used in web, email, news, or FTP servers.

Benefits:

- **Absolute scalability** – It is possible to create large clusters that beats the power of even the largest standalone machines. A cluster can have dozens of *multiprocessor machines.*
- **Additional scalability** – A cluster is configured in such a way that it is possible to add new systems to the cluster in small increments. Clusters have the ability to add systems horizontally. This means that more computers may be added to the clusters to improve their performance, redundancy, and fault tolerance(the ability for a system to continue working with malfunctioning of the node).
- **High availability** – As we know that each node in a cluster is a standalone computer, the failure of one node does not mean loss of service. A single node can be taken down for maintenance, while the rest of the clusters takes on a load of that individual node.
- **Preferable price/performance** – Clusters are usually set up to improve performance and availability over single computers, while typically being much more cost-effective than single computers of comparable speed or availability.

Functions of an operating System:

1. **Security** –
   The operating system uses password protection to protect user data and similar other techniques. it also prevents unauthorized access to programs and user data.

2. **Control over system performance** –
   Monitors overall system health to help improve performance. records the response time between service requests and system response to having a complete view of the system health. This can help improve performance by providing important information needed to troubleshoot problems.

3. **Job accounting –**
   Operating system Keeps track of time and resources used by various tasks and users, this information can be used to track resource usage for a particular user or group of users.

4. **Error detecting aids –**
   The operating system constantly monitors the system to detect errors and avoid the malfunctioning of a computer system.

5. **Coordination between other software and users –**
   Operating systems also coordinate and assign interpreters, compilers, assemblers, and other software to the various users of the computer systems.

6. **File Management –**
   A file system is organized into directories for efficient or easy navigation and usage. These directories may contain other directories and other files. An Operating System carries out the following file management activities. It keeps track of where information is stored, user access settings and status of every file, and more… These facilities are collectively known as the file system.

Computing Environments

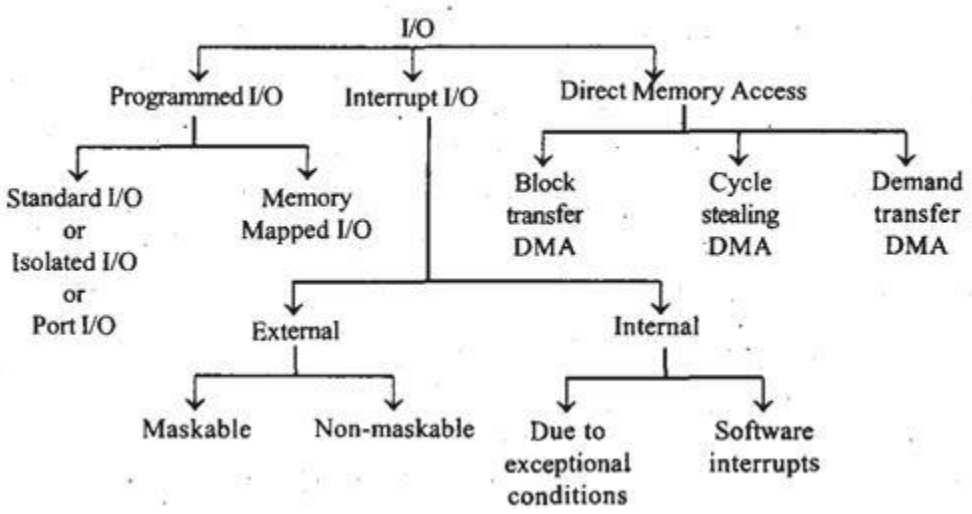
1. **Personal Computing Environment :** In personal computing environment there is a stand-alone machine. Complete program resides on computer and executed there. Different stand-alone machines that constitute a personal computing environment are laptops, mobiles, printers, computer systems, scanners etc. That we use at our homes and offices.
2. **Time-Sharing Computing Environment :** In Time Sharing Computing Environment multiple users share system simultaneously. Different users (different processes) are allotted different time slice and processor switches rapidly among users according to it. For example, student listening to music while coding something in an IDE. Windows 95 and later versions, Unix, IOS, Linux operating systems are the examples of this time sharing computing environment.
3. **Client Server Computing Environment :** In client server computing environment two machines are involved i.e., client machine and server machine, sometime same machine also serve as client and server. In this computing environment client requests resource/service and server provides that respective resource/service. A server can provide service to multiple clients at a time and here mainly communication happens through computer network.

4. **Distributed Computing Environment** : In a distributed computing environment multiple nodes are connected together using network but physically they are separated. A single task is performed by different functional units of different nodes of distributed unit. Here different programs of an application run simultaneously on different nodes, and communication happens in between different nodes of this system over network to solve task.
5. **Grid Computing Environment** : In grid computing environment, multiple computers from different locations works on single problem. In this system set of computer nodes running in cluster jointly perform a given task by applying resources of multiple computers/nodes. It is network of computing environment where several scattered resources provide running environment for single task.
6. **Cloud Computing Environment** : In cloud computing environment on demand availability of computer system resources like processing and storage are availed. Here computing is not done in individual technology or computer rather it is computed in cloud of computers where all required resources are provided by cloud vendor. This environment primarily comprised of three services i.e software-as-a-service (SaaS), infrastructure-as-a-service (IaaS), and platform-as-a-service (PaaS).

I/O structure

I/O Structure consists of Programmed I/O, Interrupt driven I/O, DMS, CPU, Memory, External devices, these are all connected with the help of Peripheral I/O Buses and General I/O Buses.

Different types of I/O Present inside the system are shown below –



Programmed I/O

In the programmed I/O when we write the input then the device should be ready to take the data otherwise the program should wait for some time so that the device or buffer will be free then it can take the input.

Once the input is taken then it will be checked whether the output device or output buffer is free then it will be printed. This process is continued every time in transferring of the data.

I/O Interrupts

To initiate any I / O operation, the CPU first loads the registers to the device controller. Then the device controller checks the contents of the registers to determine what operation to perform.

There are two possibilities if I / O operations want to be executed. These are as follows –

- **Synchronous I / O** – The control is returned to the user process after the I/O process is completed.
- **Asynchronous I/O** – The control is returned to the user process without waiting for the I/O process to finish. Here, I/O process and the user process run simultaneously.

DMA Structure

Direct Memory Access (DMA) is a method of handling I / O. Here the device controller directly communicates with memory without CPU involvement.

After setting the resources of I/O devices like buffers, pointers, and counters, the device controller transfers blocks of data directly to storage without CPU intervention.

DMA is generally used for high speed I / O devices.

Storage Structure

Basically we want the programs and data to reside in main memory permanently.
This arrangement is usually not possible for the following two reasons:

1. Main memory is usually too small to store all needed programs and data permanently.
2. Main memory is a volatile storage device that loses its contents when power is turned off or otherwise lost.

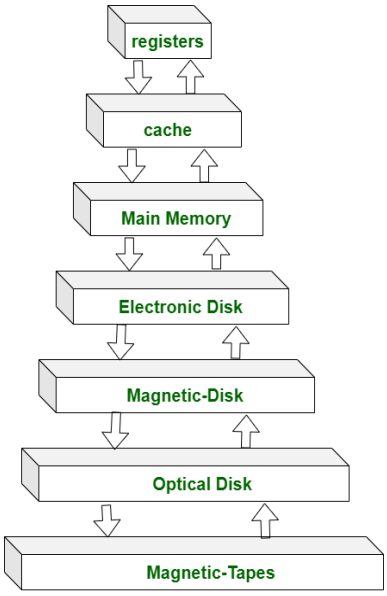
There are two types of storage devices:-

- **Volatile Storage Device –**
  It loses its contents when the power of the device is removed.
- **Non-Volatile Storage device –**
  It does not loses its contents when the power is removed. It holds all the data when the power is removed.

Secondary Storage is used as an extension of main memory. Secondary storage devices can hold the data permanently.

Storage devices consists of Registers, Cache, Main-Memory, Electronic-Disk, Magnetic-Disk, Optical-Disk, Magnetic-Tapes. Each storage system provides the basic system of storing a datum and of holding the datum until it is retrieved at a later time. All the storage devices differ in speed, cost, size and volatility. The most common Secondary-storage device is a Magnetic-disk, which provides storage for both programs and data.

In this fig Hierarchy of storage is shown –



Storage Device Hierarchy

In this hierarchy all the storage devices are arranged according to speed and cost. The higher levels are expensive, but they are fast. As we move down the hierarchy, the cost per bit generally decreases, where as the access time generally increases.

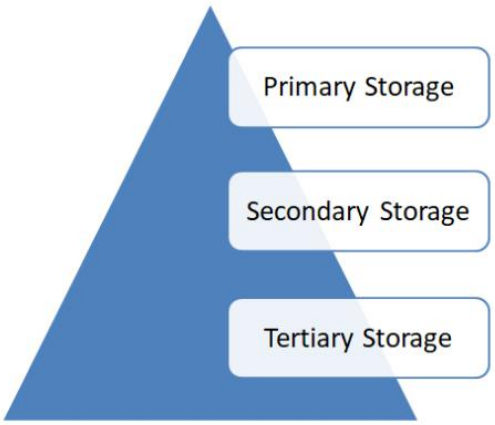
The storage systems above the Electronic disk are Volatile, where as those below are Non-Volatile.

An Electronic disk can be either designed to be either Volatile or Non-Volatile. During normal operation, the electronic disk stores data in a large DRAM array, which is Volatile. But many electronic disk devices contain a hidden magnetic hard disk and a battery for backup power. If external power is interrupted, the electronic disk controller copies the data from RAM to the magnetic disk. When external power is restored, the controller copies the data back into the RAM.

The design of a complete memory system must balance all the factors. It must use only as much expensive memory as necessary while providing as much inexpensive, Non-Volatile memory as possible. Caches can be installed to improve performance where a large access-time or transfer-rate disparity exists between two components

Storage Device Hierarchy

Computer storage has components that store computer data. The different storage types in the storage hierarchy are as follows:



Primary Storage

This is also known as the main memory and is the memory directly accessible by the CPU. All the instructions are executed in the main memory by CPU and the data required by these instructions is also stored in main memory.

Main memory primarily consists of the RAM which is volatile in nature. It is also quite small compared to secondary memory and expensive as well.

Secondary Storage

Secondary or external storage is not directly accessible by the CPU. The data from secondary storage needs to be brought into the primary storage before the CPU can use it.

Secondary storage is non volatile i.e. the data stored is not lost when power is switched off. Mostly hard drives are used as secondary storage.

Tertiary Storage

This is a third level of storage that mostly contains data that needs to be archived. This is because it is quite slow. Data is normally retrieved from tertiary storage to primary storage when it needs to be viewed.

Tertiary storage is mostly formed of tapes and disks.

Characteristics of Storage

The different characteristics of storage devices are as follows:

Volatility

Volatile memory needs power to work and loses its data when power is switched off. However, it is quite fast so it is used as primary memory.

Non - volatile memory retains its data even when power is lost. So, it is used for secondary memory.

Mutability

Mutable storage is both read and write storage and data can be overwritten as required. Primary storage typically contains mutable storage and it is also available in secondary storage nowadays.

Accessibility

Storage access can be random or sequential. In random access, all the data in the storage can be accessed randomly and roughly in the same amount of time. In sequential storage, the data needs to accessed in sequential order i.e. one after the other.

Addressability

Each storage location in memory has a particular memory address. The data in a particular location can be accessed using its address.

Capacity

The capacity of any storage device is the amount of data it can hold. This is usually represented in the form of bits or bytes.

Hardware Protection and Type of Hardware Protection

In this article, we are going to learn about hardware protection and it's the type. so first let's see the type of hardware which is used in a computer system. we know that a computer system contains the hardware like processor, monitor, RAM and many more, and one thing that the operating system ensures that these devices can not directly accessible by the user.

Basically, hardware protection is divided into 3 categories: CPU protection, Memory Protection, and I/O protection. These are explained as following below.

1. CPU Protection:

CPU protection is referred to as we can not give CPU to a process forever, it should be for some limited time otherwise other processes will not get the chance to execute the process. So for that, a timer is used to get over from this situation. which is basically give a certain amount of time a process and after the timer execution a signal will be sent to the process to leave the CPU. hence process will not hold CPU for more time.

2. Memory Protection:

In memory protection, we are talking about that situation when two or more processes are in memory and one process may access the other process memory. and to prevent this situation we are using two registers as:

1. Bare register
2. Limit register

So basically Bare register store the starting address of program and limit register store the size of the process, so when a process wants to access the memory then it is checked that it can access or can not access the memory.

3. I/O Protection:

So when we're ensuring the I/O protection then some cases will never have occurred in the system as:

1. Termination I/O of other process
2. View I/O of other process
3. Giving priority to a particular process I/O

Network Operating System

The basic definition of an **operating system** is that the operating system is the interface between the computer hardware and the user. And in daily life, we use the operating system on our devices which provides a good GUI, and many more features with it. Similarly, a network operating system(NOS) is software that connects multiple devices and computers on the network and allows them to share resources on the network. Let's see what are the functions of the network operating system.

Functions of the NOS :

Following are the main functions of NOS :

- Creating and managing user accounts on the network.
- Controlling access to resources on the network.
- Provide communication services between the devices on the network.
- Monitor and troubleshoot the network.
- Configuring and Managing the resources on the network.

Now let's see the type of Network Operating systems.

Types of Network operating systems :

There are mainly two types of networks, one is peer to peer and another is client/server. Now let's see each type one by one.

- **Peer to Peer –**

  Peer-to-peer network operating systems allow sharing resources and files with small-sized networks and having fewer resources. In general, peer-to-peer network operating systems are used on LAN.

- **Client/server –**
  Client-server network operating systems provide users access to resources through the central server. This NOS is too expensive to implement and maintain. This operating system is good for the big networks which provide many services.
  Features of network operating systems :
  Let's see what are the functions of the network operating system.
- Printers and application sharing on the network.
- File systems and database sharing.
- Provide good security by using functionality like user authentication and access control.
- Create backups of data.
- Inter-networking.
  Now let's see what are the advantages of NOS.

  Advantages of Network operating systems :
- Highly stable due to central server.
- Provide good security.
- Upgradation of new technology and hardware can be easily implemented in the network.
- Provide remote access to servers from different locations.
  Disadvantages of Network operating systems :
- Depend on the central location to perform the operations.
- High cost to buying server.
- Regular updating and maintenance are required.

Components of Operating System

An operating system is a large and complex system that can only be created by partitioning into small parts. These pieces should be a well-defined part of the system, carefully defining inputs, outputs, and functions.

Although Windows, Mac, UNIX, Linux, and other OS do not have the same structure, most operating systems share similar OS system components, such as file, memory, process, I/O device management.

The components of an operating system play a key role to make a variety of computer system parts work together. There are the following components of an operating system, such as:

1. Process Management
2. File Management
3. Network Management
4. Main Memory Management
5. Secondary Storage Management
6. I/O Device Management
7. Security Management
8. Command Interpreter System

Operating system components help you get the correct computing by detecting CPU and memory hardware errors.

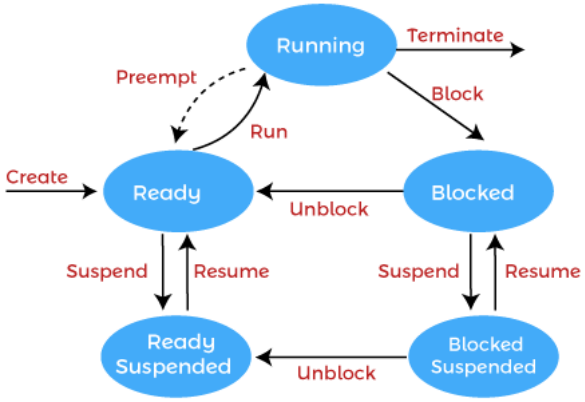
Process Management

The process management component is a procedure for managing many processes running simultaneously on the operating system. Every running software application program has one or more processes associated with them.

For example, when you use a search engine like Chrome, there is a process running for that browser program.

Process management keeps processes running efficiently. It also uses memory allocated to them and shutting them down when needed.

The execution of a process must be sequential so, at least one instruction should be executed on behalf of the process.



Functions of process management

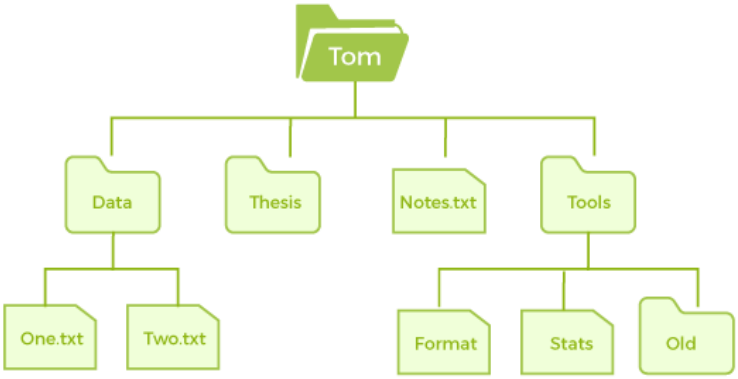
Here are the following functions of process management in the operating system, such as:

- Process creation and deletion.

- Suspension and resumption.
- Synchronization process
- Communication process

File Management

A file is a set of related information defined by its creator. It commonly represents programs (both source and object forms) and data. Data files can be alphabetic, numeric, or alphanumeric.



Function of file management

The operating system has the following important activities in connection with file management:

- File and directory creation and deletion.
- For manipulating files and directories.
- Mapping files onto secondary storage.
- Backup files on stable storage media.

Network Management

Network management is the process of administering and managing computer networks. It includes performance management, provisioning of networks, fault analysis, and maintaining the quality of service.

A distributed system is a collection of computers or processors that never share their memory and clock. In this type of system, all the processors have their local memory, and the processors communicate with each other using different communication cables, such as fibre optics or telephone lines.

The computers in the network are connected through a communication network, which can configure in many different ways. The network can fully or partially connect in network management, which helps users design routing and connection strategies that overcome connection and security issues.

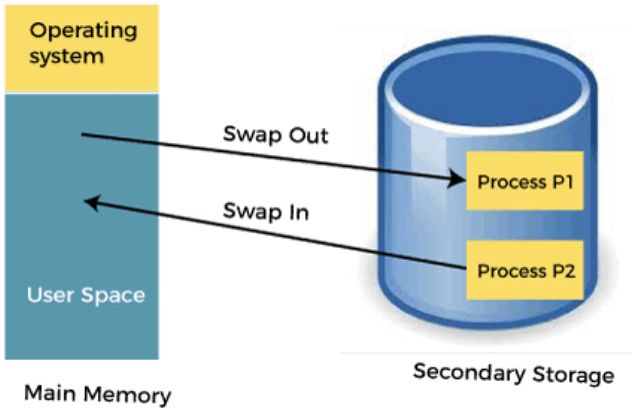
Functions of Network management

Network management provides the following functions, such as:

- Distributed systems help you to various computing resources in size and function. They may involve minicomputers, microprocessors, and many general-purpose computer systems.
- A distributed system also offers the user access to the various resources the network shares.
- It helps to access shared resources that help computation to speed up or offers data availability and reliability.

Main Memory management

Main memory is a large array of storage or bytes, which has an address. The memory management process is conducted by using a sequence of reads or writes of specific memory addresses.



It should be mapped to absolute addresses and loaded inside the memory to execute a program. The selection of a memory management method depends on several factors.

However, it is mainly based on the hardware design of the system. Each algorithm requires corresponding hardware support. Main memory offers fast storage that can be accessed directly by the CPU. It is costly and hence has a lower storage capacity. However, for a program to be executed, it must be in the main memory.

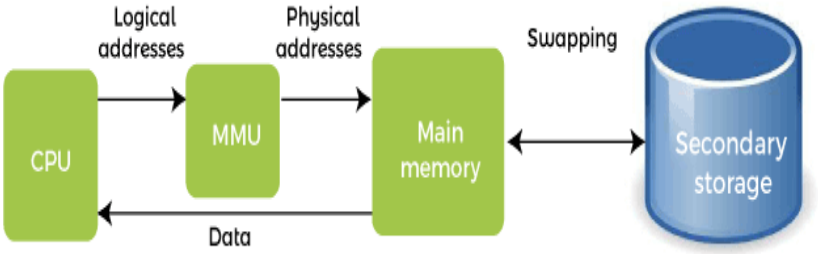
Functions of Memory management

An Operating System performs the following functions for Memory Management in the operating system:

- It helps you to keep track of primary memory.
- Determine what part of it are in use by whom, what part is not in use.
- In a multiprogramming system, the OS decides which process will get memory and how much.
- Allocates the memory when a process requests.
- It also de-allocates the memory when a process no longer requires or has been terminated.

Secondary-Storage Management

The most important task of a computer system is to execute programs. These programs help you to access the data from the main memory during execution. This memory of the computer is very small to store all data and programs permanently. The computer system offers secondary storage to back up the main memory.



Today modern computers use hard drives/SSD as the primary storage of both programs and data. However, the secondary storage management also works with storage devices, such as USB flash drives and CD/DVD drives. Programs like assemblers and compilers are stored on the disk until it is loaded into memory, and then use the disk is used as a source and destination for processing.

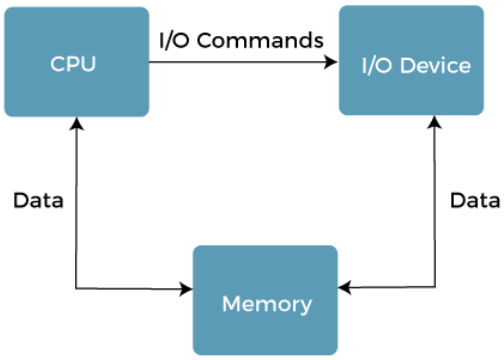
Functions of Secondary storage management

Here are some major functions of secondary storage management in the operating system:

- Storage allocation
- Free space management
- Disk scheduling

I/O Device Management

One of the important use of an operating system that helps to hide the variations of specific hardware devices from the user.

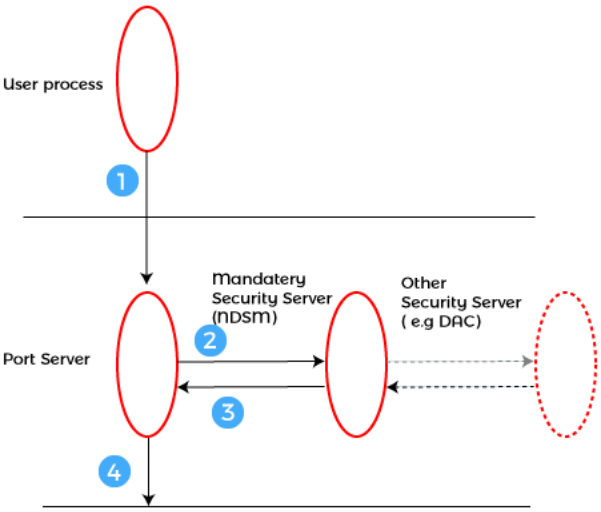


Functions of I/O management

The I/O management system offers the following functions, such as:

- It offers a buffer caching system
- It provides general device driver code
- It provides drivers for particular hardware devices.
- I/O helps you to know the individualities of a specific device.

Security Management



The various processes in an operating system need to be secured from other activities. Therefore, various mechanisms can ensure those processes that want to operate files, memory CPU, and other hardware resources should have proper authorization from the operating system.

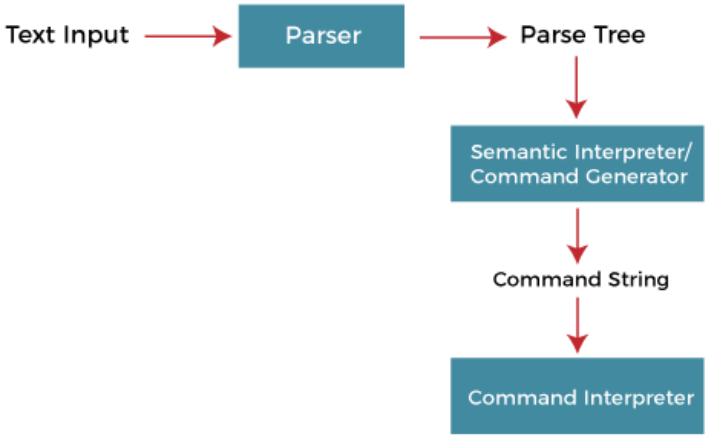
Security refers to a mechanism for controlling the access of programs, processes, or users to the resources defined by computer controls to be imposed, together with some means of enforcement.

For example, memory addressing hardware helps to confirm that a process can be executed within its own address space. The time ensures that no process has control of the CPU without renouncing it. Lastly, no process is allowed to do its own I/O to protect, which helps you to keep the integrity of the various peripheral devices.

Security can improve reliability by detecting latent errors at the interfaces between component subsystems. Early detection of interface errors can prevent the foulness of a healthy subsystem by a malfunctioning subsystem. An unprotected resource cannot misuse by an unauthorized or incompetent user.

Command Interpreter System

One of the most important components of an operating system is its command interpreter. The command interpreter is the primary interface between the user and the rest of the system.



Many commands are given to the operating system by control statements. A program that reads and interprets control statements is automatically executed when a new job is started in a batch system or a user logs in to a time-shared system. This program is variously called.

- The control card interpreter,
- The command-line interpreter,
- The shell (in UNIX), and so on.

Its function is quite simple, get the next command statement, and execute it. The command statements deal with process management, I/O handling, secondary storage management, main memory management, file system access, protection, and networking.

Operating System Services

Services of Operating System

1. Program Execution
2. Input Output Operations
3. File Management
4. Error Handling
5. Resource Management
6. Communication between Processes

Program Execution:

It is the Operating System that manages how a program is going to be executed. It loads the program into the memory after which it is executed. The order in which they are executed depends on the CPU Scheduling Algorithms. A few are FCFS, SJF, etc. When the program is in execution, the Operating System also handles deadlock i.e. no two processes come for execution at the same time. The Operating System is

responsible for the smooth execution of both user and system programs. The Operating System utilizes various resources available for the efficient running of all types of functionalities.

Input Output Operations:

Operating System manages the input-output operations and establishes communication between the user and device drivers. Device drivers are software that is associated with hardware that is being managed by the OS so that the sync between the devices works properly. It also provides access to input-output devices to a program when needed.

File Management:

The operating system helps in managing files also. If a program needs access to a file, it is the operating system that grants access. These permissions include read-only, read-write, etc. It also provides a platform for the user to create, and delete files. The Operating System is responsible for making decisions regarding the storage of all types of data or files, i.e, floppy disk/hard disk/pen drive, etc. The Operating System decides how the data should be manipulated and stored.

Error Handling:

The Operating System also handles the error occurring in the CPU, in Input-Output devices, etc. It also ensures that an error does not occur frequently and fixes the errors. It also prevents the process from coming to a deadlock. It also looks for any type of error or bugs that can occur while any task. The well-secured OS sometimes also acts as a countermeasure for preventing any sort of breach of the Computer System from any external source and probably handling them.

Resource Management:

System resources are shared between various processes. It is the Operating system that manages resource sharing. It also manages the CPU time among processes using CPU Scheduling Algorithms. It also helps in the memory management of the system. It also controls input-output devices. The OS also ensures the proper use of all the resources available by deciding which resource to be used by whom.

Communication between Processes:

The Operating system manages the communication between processes. Communication between processes includes data transfer among them. If the

processes are not on the same computer but connected through a computer network, then also their communication is managed by the Operating System itself.

System Calls in Operating System

A system call is a way for a user program to interface with the operating system. The program requests several services, and the OS responds by invoking a series of system calls to satisfy the request. A system call can be written in assembly language or a high-level language like **C** or **Pascal**. System calls are predefined functions that the operating system may directly invoke if a high-level language is used.

In this article, you will learn about the system calls in the operating system and discuss their types and many other things.

What is a System Call?

A system call is a method for a computer program to request a service from the kernel of the operating system
on which it is running. A system call is a method of interacting with the operating system via programs. A system call is a request from computer software to an operating system's kernel.

The **Application Program Interface (API)** connects the operating system's functions to user programs. It acts as a link between the operating system and a process, allowing user-level programs to request operating system services. The kernel system can only be accessed using system calls. System calls are required for any programs that use resources.

Why do you need system calls in Operating System?

There are various situations where you must require system calls in the operating system. Following of the situations are as follows:

1. It is must require when a file system wants to create or delete a file.
2. Network connections require the system calls to sending and receiving data packets.
3. If you want to read or write a file, you need to system calls.
4. If you want to access hardware devices, including a printer, scanner, you need a system call.
5. System calls are used to create and manage new processes.

Types of System Calls

There are commonly five types of system calls. These are as follows:

1. **Process Control**
2. **File Management**
3. **Device Management**
4. **Information Maintenance**
5. **Communication**

Now, you will learn about all the different types of system calls one-by-one.

Process Control

Process control is the system call that is used to direct the processes. Some process control examples include creating, load, abort, end, execute, process, terminate the process, etc.

File Management

File management is a system call that is used to handle the files. Some file management examples include creating files, delete files, open, close, read, write, etc.

Device Management

Device management is a system call that is used to deal with devices. Some examples of device management include read, device, write, get device attributes, release device, etc.

Information Maintenance

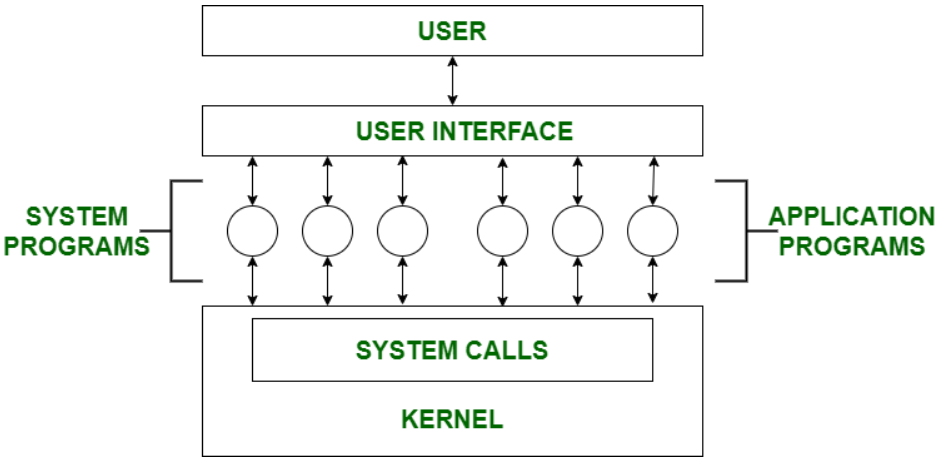
Information maintenance is a system call that is used to maintain information. There are some examples of information maintenance, including getting system data, set time or date, get time or date, set system data, etc.

Communication

Communication is a system call that is used for communication. There are some examples of communication, including create, delete communication connections, send, receive messages, etc.

System Programs in Operating System

System Programming can be defined as the act of building Systems Software using System Programming Languages. According to Computer Hierarchy, one which comes at last is Hardware. Then it is Operating System, System Programs, and finally Application Programs. Program Development and Execution can be done conveniently in System Programs. Some of the System Programs are simply user interfaces, others are complex. It traditionally lies between the user interface and system calls.



1. **File Management** –
A file is a collection of specific information stored in the memory of a computer system. File management is defined as the process of manipulating files in the computer system, its management includes the process of creating, modifying and deleting files.

- It helps to create new files in the computer system and placing them at specific locations.
- It helps in easily and quickly locating these files in the computer system.
- It makes the process of sharing files among different users very easy and user-friendly.
- It helps to store files in separate folders known as directories.
- These directories help users to search files quickly or to manage files according to their types of uses.
- It helps users to modify the data of files or to modify the name of files in directories.

2. **Status Information** –
Information like date, time amount of available memory, or disk space is asked by some users. Others providing detailed performance, logging, and debugging information which is more complex. All this information is formatted and displayed on output devices or printed. Terminal or other output devices or files or a window of GUI is used for showing the output of programs.

3. **File Modification** –
   For modifying the contents of files we use this. For Files stored on disks or other storage devices, we used different types of editors. For searching contents of files or perform transformations of files we use special commands.

4. **Programming-Language support** –
   For common programming languages, we use Compilers, Assemblers, Debuggers, and interpreters which are already provided to users. It provides all support to users. We can run any programming language. All languages of importance are already provided.

5. **Program Loading and Execution** –
   When the program is ready after Assembling and compilation, it must be loaded into memory for execution. A loader is part of an operating system that is responsible for loading programs and libraries. It is one of the essential stages for starting a program. Loaders, relocatable loaders, linkage editors, and Overlay loaders are provided by the system.

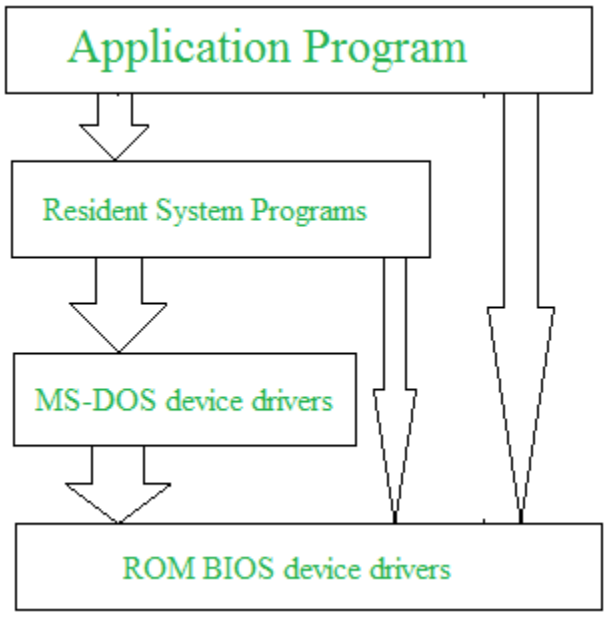
6. **Communications** –
   Virtual connections among processes, users, and computer systems are provided by programs. Users can send messages to another user on their screen, User can send e-mail, browsing on web pages, remote login, the transformation of files from one user to another.

Different approaches or Structures of Operating Systems

Simple structure:

Such operating systems do not have well defined structure and are small, simple and limited systems. The interfaces and levels of functionality are not well separated. MS-DOS is an example of such operating system. In MS-DOS application programs are able to access the basic I/O routines. These types of operating system cause the entire system to crash if one of the user programs fails.

Diagram of the structure of MS-DOS is shown below.



Advantages of Simple structure:

- It delivers better application performance because of the few interfaces between the application program and the hardware.
- Easy for kernel developers to develop such an operating system.

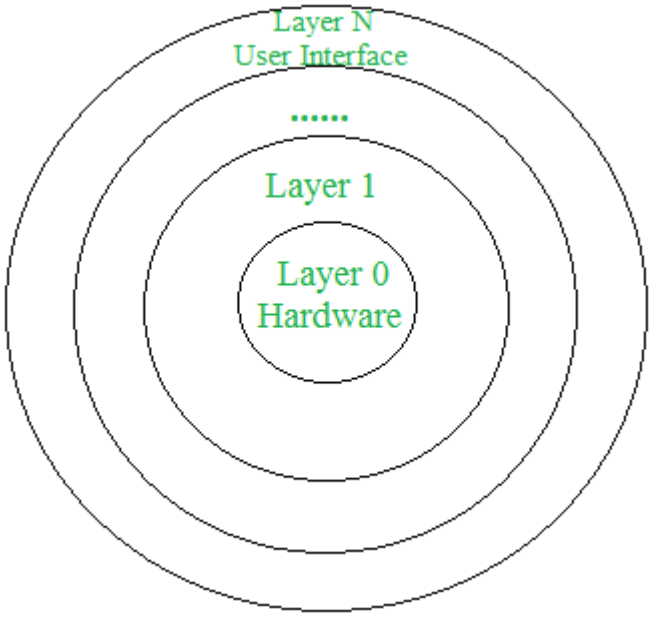
Disadvantages of Simple structure:

- The structure is very complicated as no clear boundaries exists between modules.
- It does not enforce data hiding in the operating system.

Layered structure:

An OS can be broken into pieces and retain much more control on system. In this structure the OS is broken into number of layers (levels). The bottom layer (layer 0) is the hardware and the topmost layer (layer N) is the user interface. These layers are so designed that each layer uses the functions of the lower level layers only. This simplifies the debugging process as if lower level layers are debugged and an error occurs during debugging then the error must be on that layer only as the lower level layers have already been debugged.

The main disadvantage of this structure is that at each layer, the data needs to be modified and passed on which adds overhead to the system. Moreover careful planning of the layers is necessary as a layer can use only lower level layers. UNIX is an example of this structure.



Advantages of Layered structure:

- Layering makes it easier to enhance the operating system as implementation of a layer can be changed easily without affecting the other layers.
- It is very easy to perform debugging and system verification.

Disadvantages of Layered structure:

- In this structure the application performance is degraded as compared to simple structure.
- It requires careful planning for designing the layers as higher layers use the functionalities of only the lower layers.

Micro-kernel:

This structure designs the operating system by removing all non-essential components from the kernel and implementing them as system and user programs. This result in a smaller kernel called the micro-kernel.

Advantages of this structure are that all new services need to be added to user space and does not require the kernel to be modified. Thus it is more secure and reliable as if a service fails then rest of the operating system remains untouched. Mac OS is an example of this type of OS.

Advantages of Micro-kernel structure:

- It makes the operating system portable to various platforms.
- As microkernels are small so these can be tested effectively.

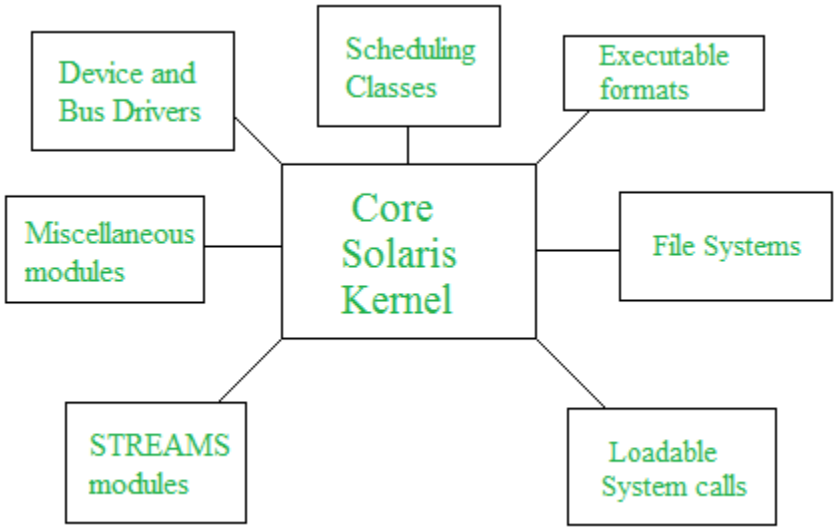
Disadvantages of Micro-kernel structure:

- Increased level of inter module communication degrades system performance.

Modular structure or approach:

It is considered as the best approach for an OS. It involves designing of a modular kernel. The kernel has only set of core components and other services are added as

dynamically loadable modules to the kernel either during run time or boot time. It resembles layered structure due to the fact that each kernel has defined and protected interfaces but it is more flexible than the layered structure as a module can call any other module.
For example Solaris OS is organized as shown in the figure.



Virtual Machines in Operating System

- **Virtual Machine** abstracts the hardware of our personal computer such as CPU, disk drives, memory, NIC (Network Interface Card) etc, into many different execution environments as per our requirements, hence giving us a feel that each execution environment is a single computer. For example, VirtualBox.
- When we run different processes on an operating system, it creates an illusion that each process is running on a different processor having its own virtual memory, with the help of CPU scheduling and virtual-memory techniques. There are additional features of a process that cannot be provided by the hardware alone like system calls and a file system. The virtual machine approach does not provide these additional functionalities but it only provides an interface that is same as basic hardware. Each process is provided with a virtual copy of the underlying computer system.
- We can create a virtual machine for several reasons, all of which are fundamentally related to the ability to share the same basic hardware yet can also support different execution environments, i.e., different operating systems simultaneously.
- The main drawback with the virtual-machine approach involves disk systems. Let us suppose that the physical machine has only three disk drives but wants to support seven virtual machines. Obviously, it cannot allocate a disk drive to each virtual

machine, because virtual-machine software itself will need substantial disk space to provide virtual memory and spooling. The solution is to provide virtual disks.

- Users are thus given their own virtual machines. After which they can run any of the operating systems or software packages that are available on the underlying machine. The virtual-machine software is concerned with multi-programming multiple virtual machines onto a physical machine, but it does not need to consider any user-support software. This arrangement can provide a useful way to divide the problem of designing a multi-user interactive system, into two smaller pieces.

Advantages:

1. There are no protection problems because each virtual machine is completely isolated from all other virtual machines.
2. Virtual machine can provide an instruction set architecture that differs from real computers.
3. Easy maintenance, availability and convenient recovery.

Disadvantages:

1. When multiple virtual machines are simultaneously running on a host computer, one virtual machine can be affected by other running virtual machines, depending on the workload.
2. Virtual machines are not as efficient as a real one when accessing the hardware.