UNIVERSITY INSTITUTEOF ENGINEERING

Bachelor of Engineering (Computer Science & Engineering)

Operating System (CST-328)

Topic: Introduction to Operating System

DISCOVER . LEARN . EMPOWER

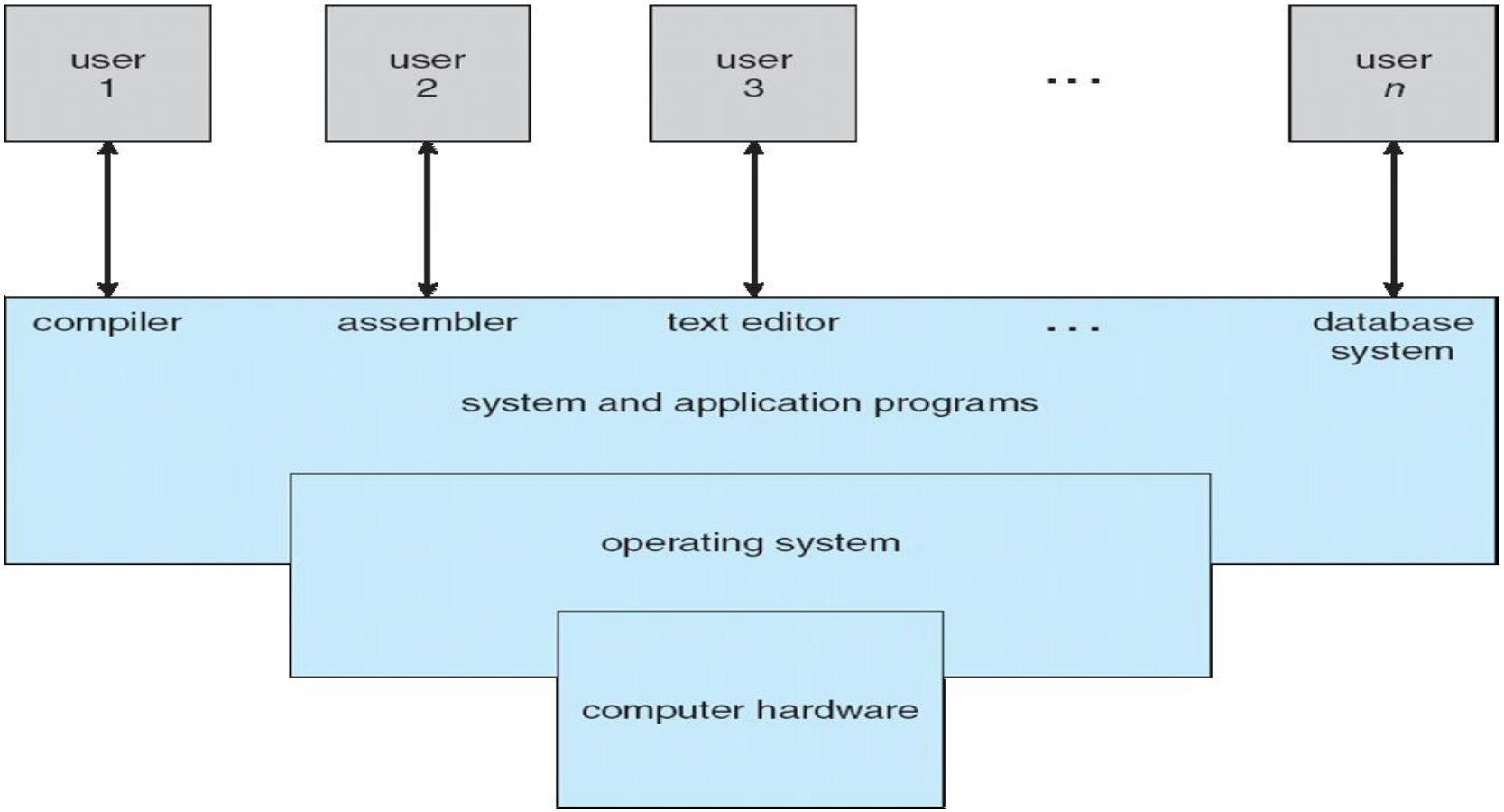
Outline

- Need of Operating System
- Components of Operating System
- Definition : Operating System
- Functions of Operating System
- Operating System Structures
  - Layered
  - Simple Structure MS-DOS
  - Microkernel
- Kernel
  - Monolithic Kernel
  - Microkernel
- Difference between Monolithic and Microkernel

Why do we need an OS?

- Allows you to hide details of hardware by creating an abstraction
- Easy to use with a GUI.
- Offers an environment in which a user may execute programs/applications.
- Operating System acts as an intermediary among applications and the hardware components.
- It provides the computer system resources with easy to use format
- Acts as an intermediate between all hardware's and software's of the system

Static View of System Components



Computer System Components

1. **Hardware –** provides basic computing resources (CPU, Memory, I/O devices, Communication).
2. **Operating System –** controls and coordinates use of the hardware among various application programs for various users.
3. **System & Application Programs –** ways in which the system resources are used to solve computing problems of the users (Word processors, Compilers, Web browsers, Database systems, Video games).
4. **Users –** (People, Machines, other computers).

Computer System Components

OS as a platform for Application programs:

- The operating system provides a platform, on top of which, other programs, called application programs can run.
- These application programs help the users to perform a specific task easily. It acts as an interface between the computer and the user.
- It is designed in such a manner that it operates, controls, and executes various applications on the computer.

Managing Input-Output unit:

- Operating System also allows the computer to manage its own resources such as memory, monitor, keyboard, printer, etc.
- Management of these resources is required for effective utilization. The operating system controls the various system input-output resources and allocates them to the users or programs as per their requirements.
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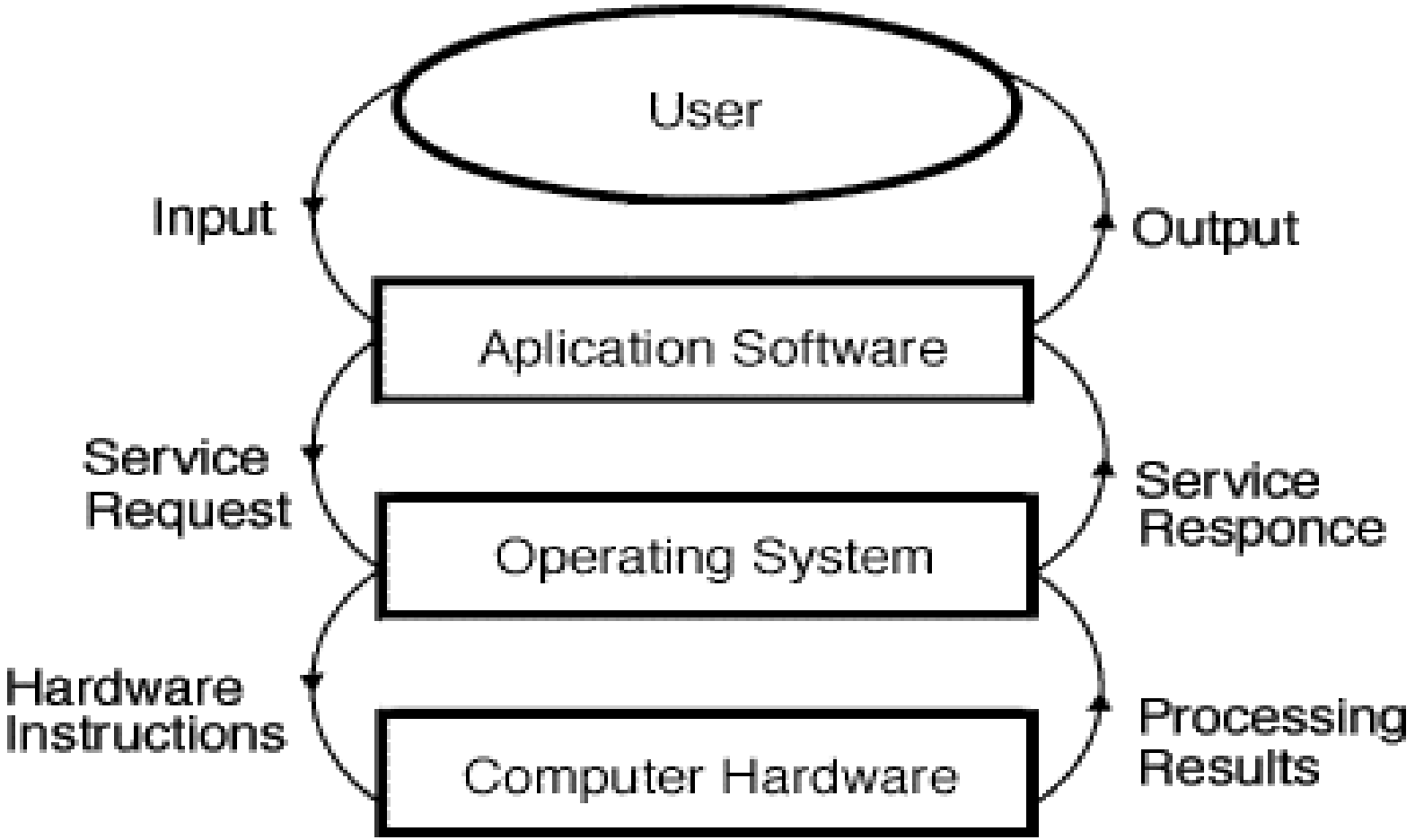
Dynamic View of System Components



What is OS?

- **Operating System is a software, which makes a computer to actually work.**
- It is the software the enables all the programs we use.
- The OS organizes and controls the hardware.
- OS acts as an interface between the application programs and the machine hardware.

Examples: Windows, Linux, Unix and Mac OS, etc.

- **Operating system goals:**
  - Execute user programs and make user problems easier.
  - Make the computer system convenient to use.
  - Use the computer hardware in an efficient manner.

Basic Functions of OS

- **Convenience:** An OS makes a computer more convenient to use.
- **Efficiency:** An OS allows the computer system resources to be used efficiently.
- **Ability to Evolve:** An OS should be constructed in such a way as to permit the effective development, testing, and introduction of new system functions at the same time without interfering with service.
- **Throughput:** An OS should be constructed so that It can give maximum **throughput**(Number of tasks per unit time).

Major Functions of OS

- **Resource Management:** When parallel accessing happens in the OS means when multiple users are accessing the system the OS works as Resource Manager, Its responsibility is to provide hardware to the user. It decreases the load in the system.
- **Process Management:** It includes various tasks like **scheduling**, **termination** of the process. OS manages various tasks at a time. Here **CPU Scheduling** happens means all the tasks would be done by the many algorithms that use for scheduling.
- **Storage Management:** The **file system** mechanism used for the management of the storage. **NIFS**, **CFS**, **CIFS**, **NFS**, etc. are some file systems. All the data stores in various tracks of Hard disks that all managed by the storage manager. It included **Hard Disk**.

Major Functions of OS(cont.)

- **Memory Management:** Refers to the management of primary memory. The operating system has to keep track, how much memory has been used and by whom. It has to decide which process needs memory space and how much. OS also has to allocate and deallocate the memory space.
- **Security/Privacy Management:** Privacy is also provided by the Operating system by means of passwords so that unauthorized applications can't access programs or data. For example, Windows uses **Kerberos** authentication to prevent unauthorized access to data.

Responsibilities of an Operating System

There are three basic responsibilities (in literature):

1. **Resource Manager** – manages and allocates resources.
2. **Control program** – controls the execution of user programs and operations of I/O devices.
3. **Command Executer** – Provides an environment for running user commands.

- But one more modern view: the Operating System as a Virtual Machine.

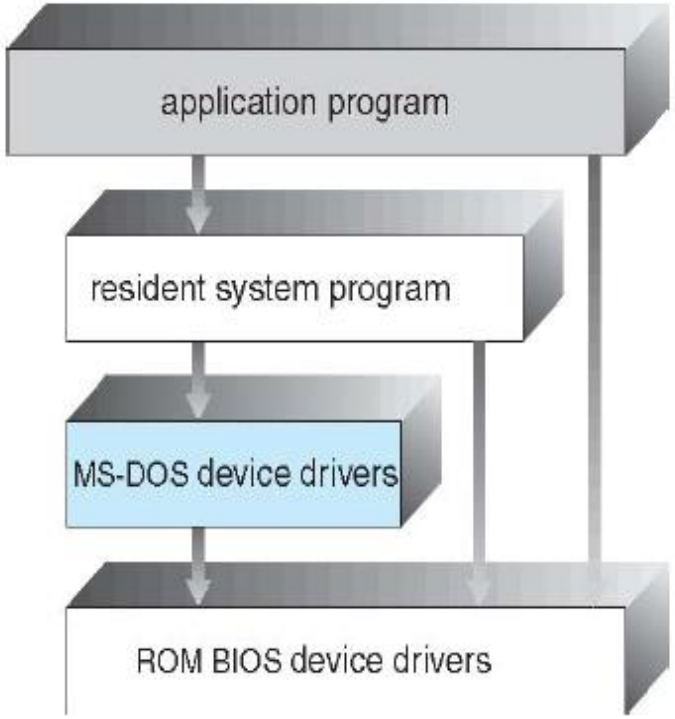
Operating-System Structure

- General-purpose OS is very large program

- Various ways to structure ones
  - Simple structure – MS-DOS
  - More complex -- UNIX
  - Layered – an abstraction
  - Microkernel -Mach

Simple Structure -- MS-DOS

- 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.



Simple Structure -- MS-DOS

Advantages of Simple structure:

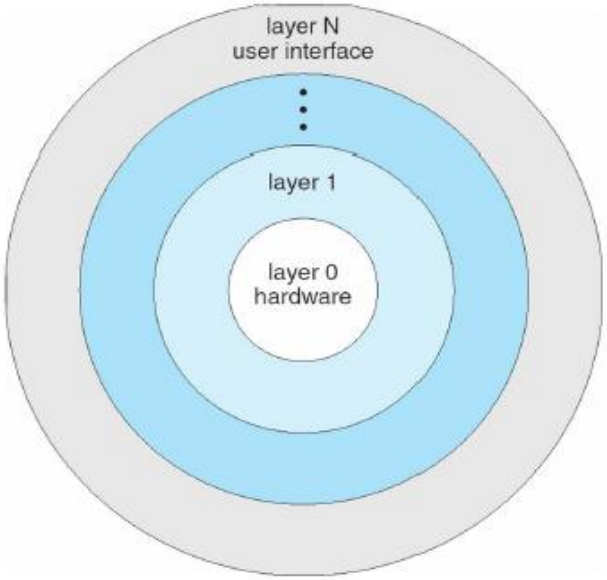
- It delivers better application performance because of the few interfaces between the application program and the hardware.

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 Approach

- 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.



Layered Approach

Advantages of Layered structure:

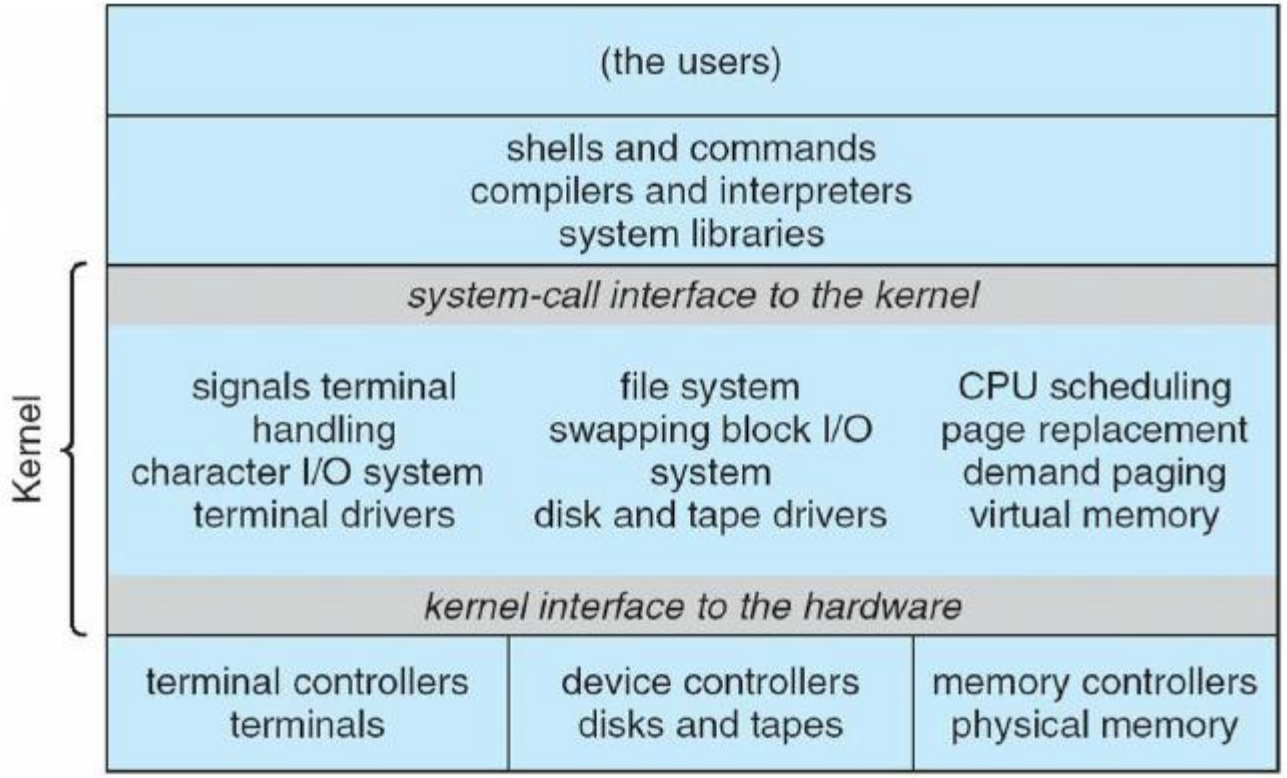
- Layering makes it easier to enhance the operating system as implementation of a layer can be changed easily without affecting the other layers.
- It is very easy to perform debugging and system verification.

Disadvantages of Layered structure:

- It requires careful planning for designing the layers as higher layers use the functionalities of only the lower layers.

UNIX

Beyond simple but not fully layered



What is a Kernel?

- The kernel is a computer program at the core of a computer's operating system with complete control over everything in the system. It is an integral part of any operating system.

Features of Kernel

- Low-level scheduling of processes
- Inter-process communication
- Process synchronization
- Context switching

Micro-kernel

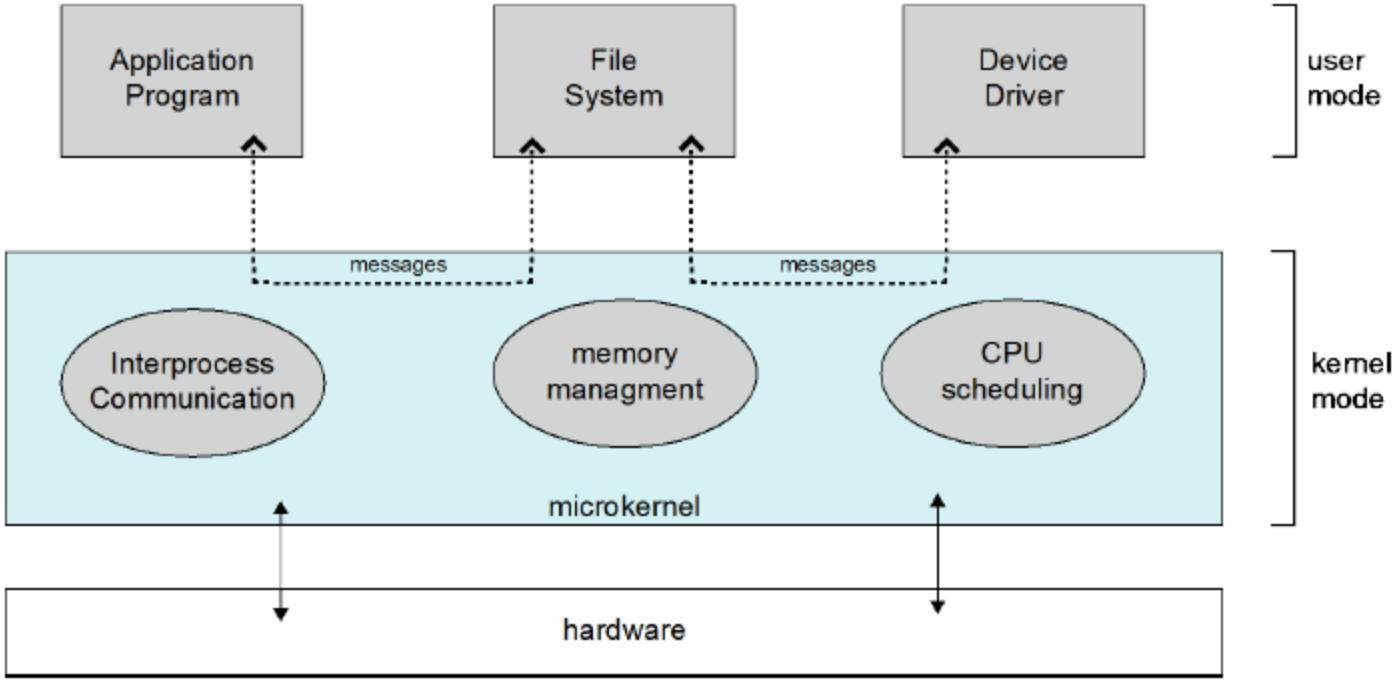
- This structure designs the operating system by removing all non-essential components from the kernel and implementing them as system and user programs. This result in a smaller kernel called the micro-kernel.
- Advantages of this structure are that all new services need to be added to user space and 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.

Or

- A microkernel is one of the classifications of the kernel. Being a kernel it manages all system resources. But in a microkernel, the **user services** and **kernel services** are implemented in different address spaces. The user services are kept in **user address space**, and kernel services are kept under **kernel address space**, thus also reduces the size of kernel and size of an operating system as well.

Microkernel System Structure

Kernel is a computer program that manages I/O requests from software and translates them into data processing instructions for CPU and other electronic components of computer.



Micro-kernel

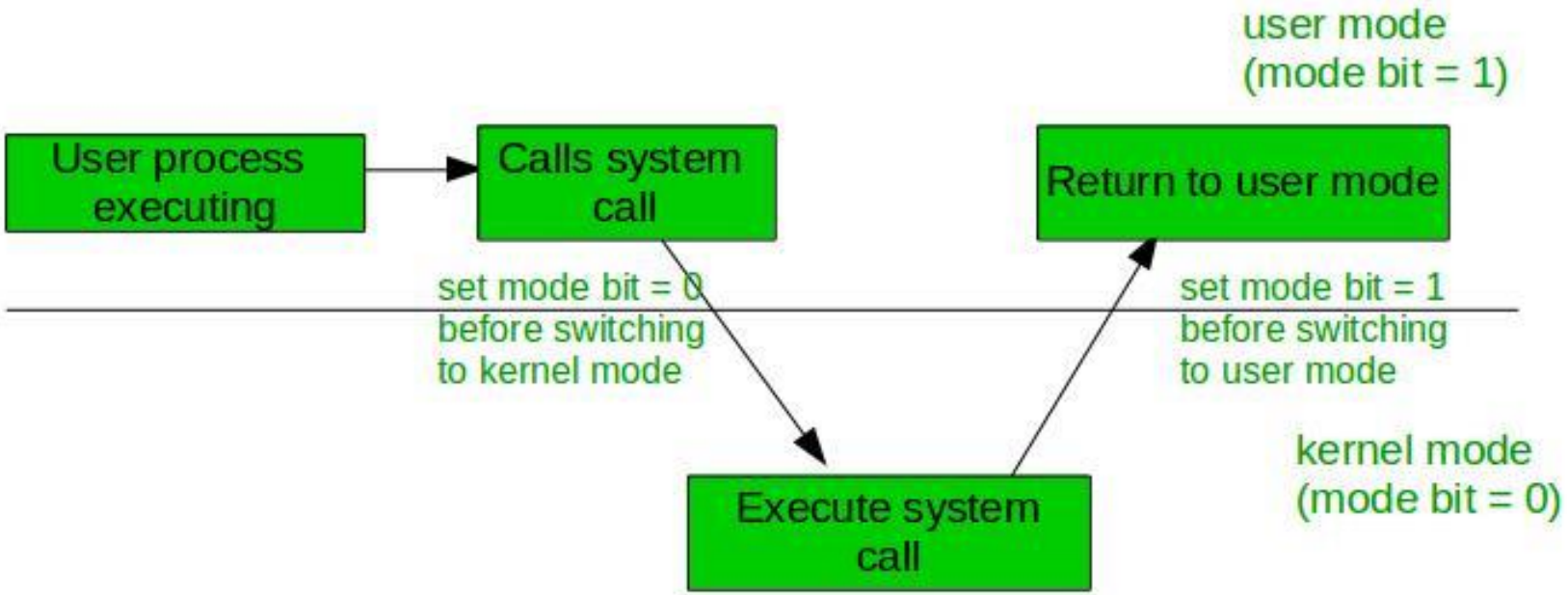
Advantages of Micro-kernel structure:

- 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.

Dual mode of Operations in OS



Dual mode of Operations in OS

An error in one program can adversely affect many processes, it might modify data of another program, or also can affect the operating system.

For example, if a process stuck in the infinite loop then this infinite loop could affect the correct operation of other processes. So to ensure the proper execution of the operating system, there are two modes of operation:

User mode –

When the computer system is run by user applications like creating a text document or using any application program, then the system is in user mode. When the user application requests for a service from the operating system or an interrupt occurs or system call, then there will be a transition from user to kernel mode to fulfill the requests.

Dual mode of Operations in OS(contd.)

Kernel Mode –

When the system boots, hardware starts in kernel mode and when the operating system is loaded, it starts user application in user mode. To provide protection to the hardware, we have privileged instructions which execute only in kernel mode. If the user attempts to run privileged instruction in user mode then it will treat instruction as illegal and traps to OS. Some of the privileged instructions are:

- Handling Interrupts
- To switch from user mode to kernel mode.
- Input-Output management.

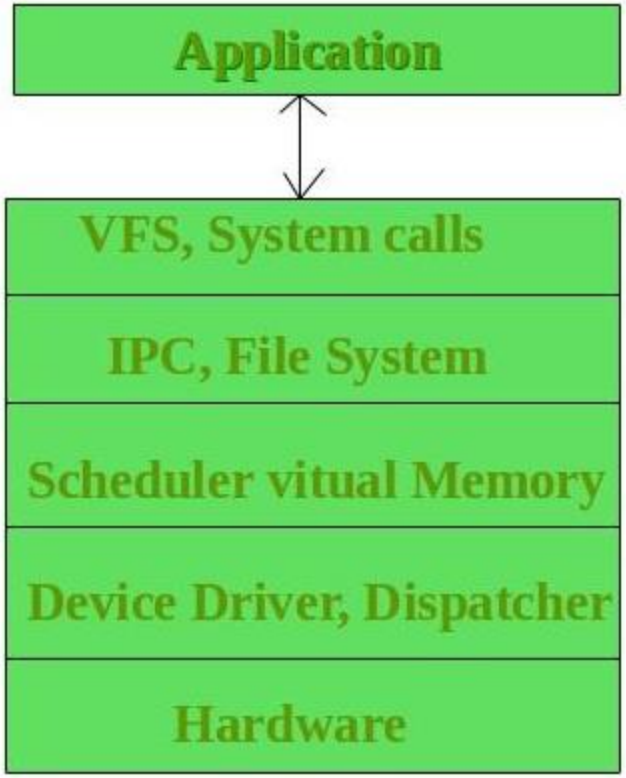
Monolithic Kernel

- Apart from microkernel, Monolithic Kernel is another classification of Kernel. Like microkernel, this one also manages system resources between application and hardware, but user services and kernel services are implemented under the same address space.
- It increases the size of the kernel, thus increases the size of the operating system as well.

- This kernel provides CPU scheduling, memory management, file management, and other operating system functions through system calls. As both services are implemented under the same address space, this makes operating system execution faster.

Monolithic Kernel

- If any service fails the entire system crashes, and it is one of the drawbacks of this kernel. The entire operating system needs modification if the user adds a new service.



Monolithic Kernel

Monolithic Kernel

- **Advantages of Monolithic Kernel –**
- One of the major advantages of having a monolithic kernel is that it provides CPU scheduling, memory management, file management, and other operating system functions through system calls.
- The other one is that it is a single large process running entirely in a single address space.
- It is a single static binary file. Examples of some Monolithic Kernel-based OSs are Unix, Linux, Open VMS, XTS-400, z/TPF.

Disadvantages of Monolithic Kernel –

- One of the major disadvantages of a monolithic kernel is that if anyone service fails it leads to an entire system failure.
- If the user has to add any new service. The user needs to modify the entire operating system.

Monolithic Kernel v/s Microkernel

Basis for Comparison	Microkernel	Monolithic Kernel
Size	Microkernel is smaller in size	It is larger than microkernel
Execution	Slow Execution	Fast Execution
Extendible	It is easily extendible	It is hard to extend
Security	If a service crashes, it does effects on working on the microkernel	If a service crashes, the whole system crashes in monolithic kernel.
Code	To write a microkernel more code is required	To write a monolithic kernel less code is required
Example	QNX, Symbian, L4Linux etc.	Linux,BSDs(FreeBSD,OpenBSD,NetBSD)etc.

Applications of Operating System

- Security
- Control over system performance
- Job accounting
- Error detecting aids
- Coordination between other softwares and users

Conclusion

This lecture makes the student familiar with basics of operating systems like OS Definition, need of OS, OS structure, kernel, applications of OS etc.

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Thank You

For any Query, you can contact

Er. Inderjeet Singh(e8822)

Ph. No: 86-99-100-160

Email id: inderjeet.e8822@cumail.in

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Topic: Functions and Types of Operating System

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Outline

- **Functions of Operating System**
- **Types of Operating System**
  - Simple Batch Systems
  - Multiprogrammed Batch Systems
  - Time-sharing operating systems
  - Distributed operating System
  - Network operating System
  - Real Time operating System
  - Hard real-time systems
  - Soft real-time systems

Functions of Operating System

- Process Management
- Memory Management
- File Management
- I/O Management
- Error detecting aids
- Control over system performance
- Protection & Security
- Networking
- Command Interpretation or Shell

Process Management

- In a multi-programming environment, the OS decides the order in which processes have access to the processor, and how much processing time each process has. This function of OS is called process scheduling.

An Operating System performs the following activities for processor management.

- Keeps track of the status of processes.
- The program which performs this task is known as a traffic controller.
- Allocates the CPU that is a processor to a process.
- De-allocates processor when a process is no more required.

Process Management Activities

- The operating system is responsible for the following activities in connection with process management:

- Creating and deleting both user and system processes
- Suspending and resuming processes
- Providing mechanisms for process synchronization
- Providing mechanisms for process communication
- Providing mechanisms for deadlock handling

Memory Management

- To execute a program all (or part) of the instructions must be in memory
- All (or part) of the data that is needed by the program must be in memory.
- Memory management determines what is in memory and when
  - Optimizing CPU utilization and computer response to users

- Memory management activities
  - Keeping track of which parts of memory are currently being used and by whom
  - Deciding which processes and data to move into and out of memory
  - Allocating and de-allocating memory space as needed.

File System Management

- Files usually organized into directories
- Access control on most systems to determine who can access what
- OS activities include
  - Creating and deleting files and directories
  - Primitives to manipulate files and directories
  - Mapping files onto secondary storage
  - Backup files onto stable (non-volatile) storage media

I/O Subsystem

- One purpose of OS is to hide peculiarities of hardware devices from the user
- I/O subsystem responsible for
  - Memory management of I/O including buffering (storing data temporarily while it is being transferred), caching (storing parts of data in faster storage for performance), spooling (the overlapping of output of one job with input of other jobs)
  - Handles General device-driver interface
  - Manages Drivers for specific hardware devices

Protection and Security

Protection – any mechanism for controlling access of processes or users to resources defined by the OS

Security – defense of the system against internal and external attacks

- Huge range, including denial-of-service, worms, viruses, identity theft, theft of service

Systems generally first distinguish among users, to determine who can do what

- User identities (**user IDs**, security IDs) include name and associated number, one per user
- User ID then associated with all files, processes of that user to determine access control
- Group identifier (**group ID**) allows set of users to be defined and controls managed, then also associated with each process, file
- **Privilege escalation** allows user to change to effective ID with more rights

Other Functions of OS

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

Types of Operating System

- Batch Systems
- Multiprogrammed Batch Systems
- Time-sharing operating systems
- Distributed operating System
- Network operating System
- Real Time operating System
- Hard real-time systems
- Soft real-time systems

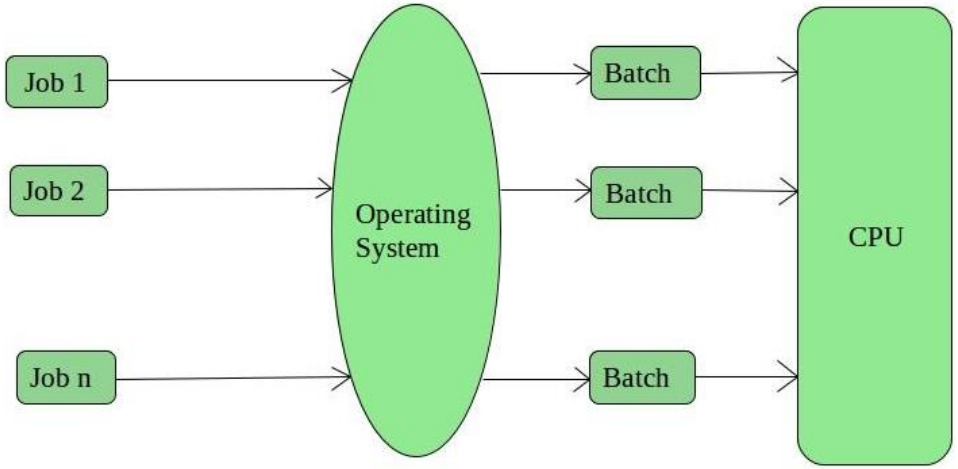
Batch Operating System

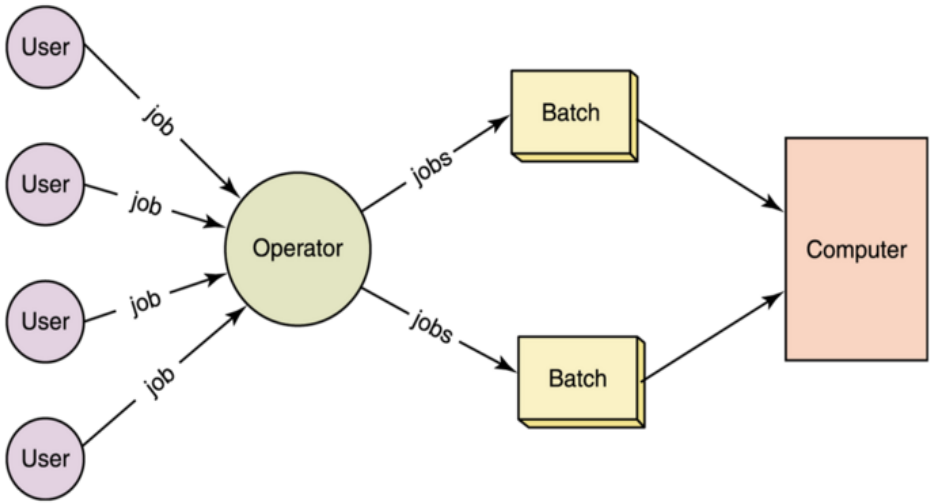
- In early days, computer work was given on punch cards and then these punch cards behave as input to the computer.
- These jobs or batch jobs were then executed by the computer one by one. So that computers were called as batch computers or batch systems.
- The work done by batch systems are in parts i.e. one job is processed then another job in the queue is processed and so on.
- The various jobs of the users are collected in a queue. This process is known as **Spooling (Simultaneous Peripheral Operations On Line).**
- This type of operating system does not interact with the computer directly. There is an operator which takes similar jobs having the same requirement and group them into batches. It is the responsibility of the operator to sort jobs with similar needs.

Batch Operating System

Examples of Batch based Operating System:

Payroll System, Bank Statements, etc.





Batch Operating System

Advantages -

- Repeated jobs are done fast in batch systems without user interaction.
- You don’t need special hardware and system support to input data in batch systems.
- Best for large organizations but small organizations can also benefit from it.

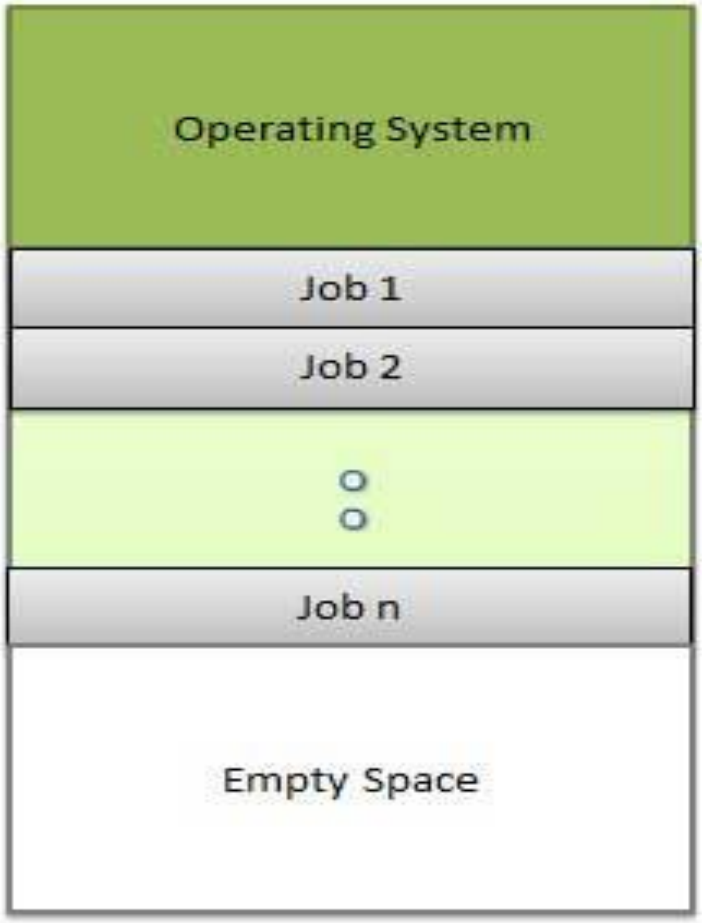
Disadvantages -

- Lack of interaction between the user and job.
- CPU is often idle, because the speeds of the mechanical I/O devices is slower than CPU.
- Difficult to provide the desired priority.

Multiprogrammed Systems

- This allows to execute multiple programs.
- In this, several processes are kept in memory (set of jobs are kept in **Job Pool**) & CPU execute all these processes concurrently.
- When one process start performing I/O operations , the CPU is allocated to another user process in the main memory that is ready to use the CPU.
- Multiprogramming **increases CPU utilization** by organizing jobs so that the CPU always has one to execute.

Multiprogrammed Systems



Multiprogrammed Systems

Advantages –

- It increases CPU utilization.
- It increases throughput also by utilizing idle time of CPU for running other programs that are already present in main memory.
- It lowers the Response time by recognizing the priority of a job as it enters the system & by processing jobs on a priority basis.

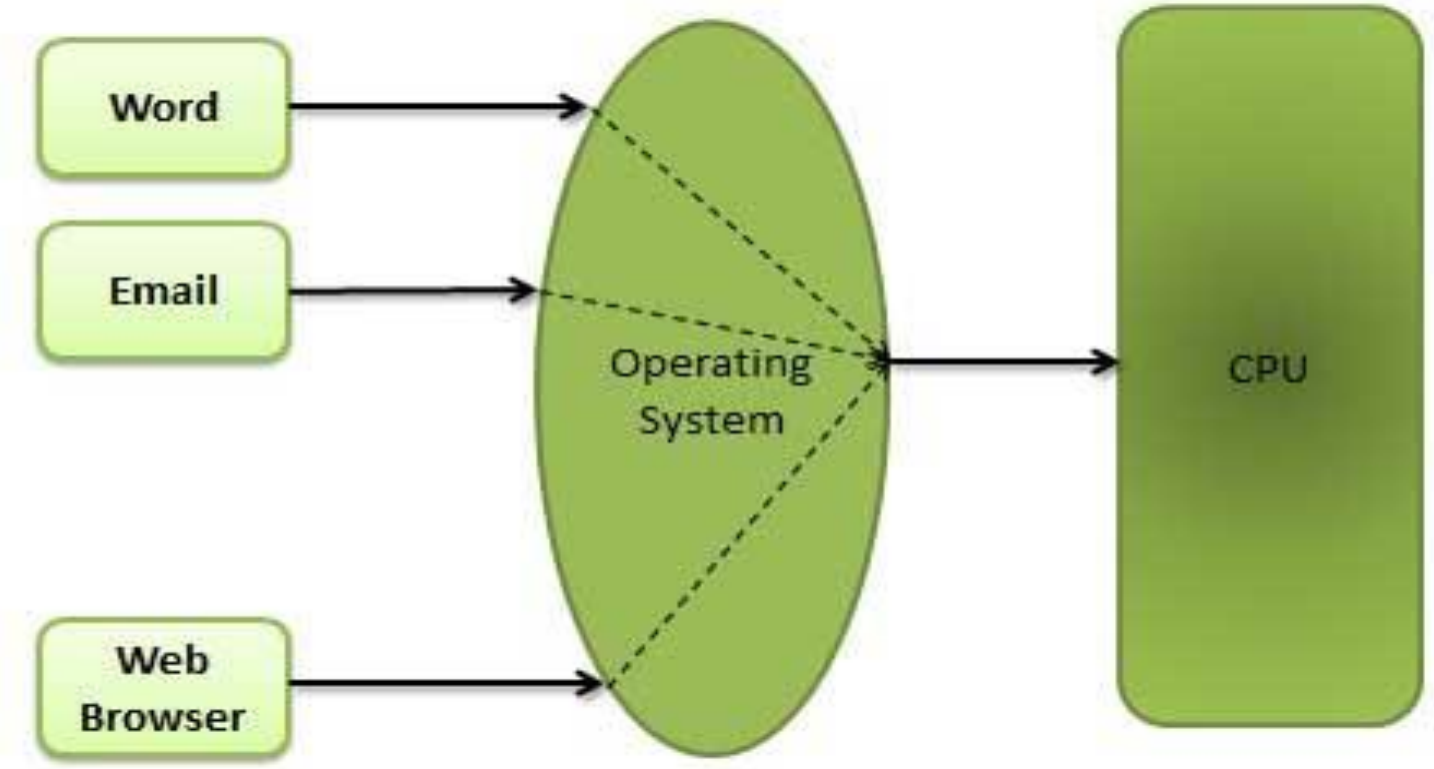
Disadvantages -

- It is fairly sophisticated and more complex.
- A multiprogramming operating system must keep track of all kinds of jobs it is concurrently running.

Multitasking and Time-sharing operating systems

- Time-sharing or Multitasking is a logical extension of multiprogramming.
- Processor's time which is shared among multiple users simultaneously is termed as time-sharing.
- It refers to term where multiple jobs are executed by the CPU simultaneously by switching between them.
- A time sharing operating system is that in which each task is given some time to execute and all tasks are given time so that all processes run seamlessly without any problem.
- Suppose there are many users attached to a single system then each user has given time of CPU.
- No user can feel to have trouble in using the system

Multitasking and Time-sharing operating systems



Multitasking and Time-sharing operating systems

Advantages –

- Provide advantage of quick response.
- Reduces CPU idle time.

Disadvantages -

- Problem of reliability.
- Security and Integrity of user programs and data is at risk.
- It consumes much resources so it need special operating systems.
- Switching between tasks becomes overhead sometimes.

Multiprocessing systems

Multiprocessing is the use of two or more central processing units (CPUs) within a single computer system.

The term also refers to the ability of a system to support more than one processor and/or the ability to allocate tasks between them.

Advantage -

1.Increased throughput
2.Economy of scale
3. Increased reliability

Disadvantage -

1) If one processor fails then it will affect in the speed
2) Multiprocessor systems are expensive
3) Large main memory required.

Types of Multiprocessing systems

- **Symmetric Multiprocessor (SMP) –**

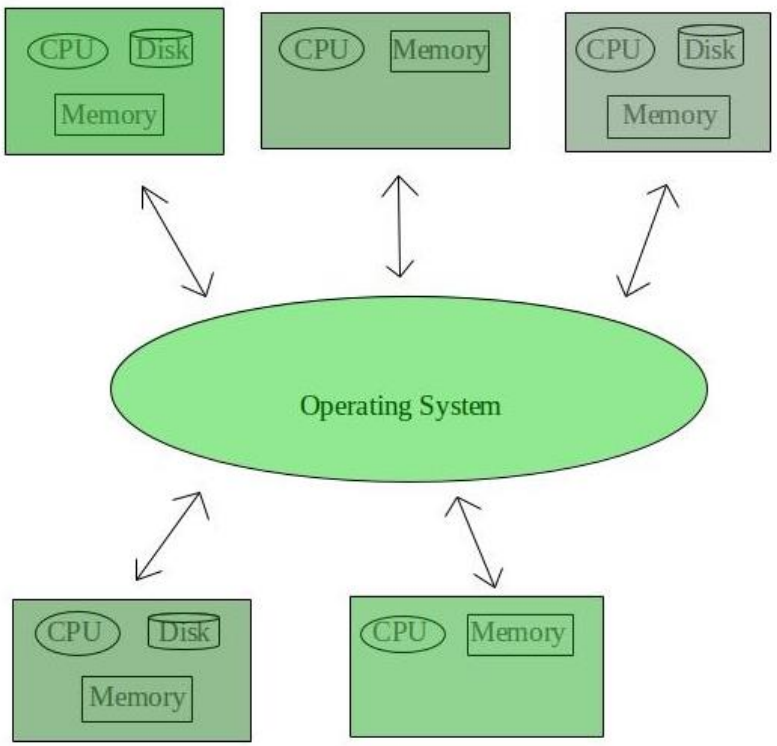
  In this, each CPU runs an identical copy of OS and can communicate as needed.

- **Asymmetric Multiprocessor (ASMP) –**

  In this, each processor assigned a specific task. This model is called master-slave since one CPU is the master and all the others are slaves.

Distributed Systems

- 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.
- Data processing jobs are distributed among the processors accordingly to which one can perform each job most efficiently.



Distributed Systems

Advantages –

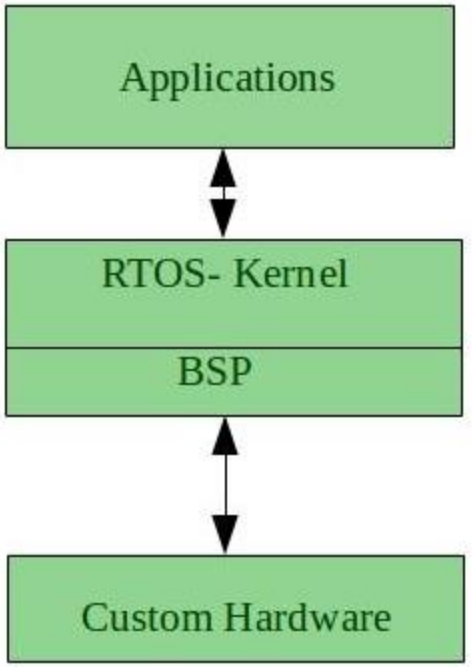
- Speedup the exchange of data with one another via electronic mail.
- Reduction of the load on the host computer.
- Reliability (fault tolerance) - if some of the machines crash, the system can survive.
- Sharing of data/resources - shared data is essential to many applications (banking, computer- supported cooperative work, reservation systems); other resources can be also shared (e.g. expensive printers).

Disadvantages –

- **Complex System -** Distributed systems are much more complex to setup and difficult to maintain.
- **Security problems -** sharing generates the problem of data security.
- **Networking problems**: several problems are created by the network infrastructure, which have to be dealt with: loss of messages, overloading, ...

Real Time Systems

- 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.



Real Time Systems

Hard Real-time systems -

Hard real-time systems guarantee that critical tasks complete on time. For Ex. Scientific experiments, medical imaging systems, industrial control systems, weapon systems, robots, and home-applicance controllers, Air traffic control system etc.

Soft Real-time systems -

Soft real time systems are less restrictive. Critical real-time task gets priority over other tasks and retains the priority until it completes. Soft real-time systems have limited utility than hard real-time systems. For example, Multimedia, virtual reality, Advanced Scientific Projects like undersea exploration and planetary rovers etc.

Real Time Systems

Advantages -

- **Focus on Application** - These type of operating system focus on applications which are running and usually give less importance to other application residing in waiting stage of life cycle. So less applications or tasks are managed and give exact result on current execution work.
- **Error Free** - RTOS (Real Time Operating System) is error free that mean it has no chances of error in performing tasks.
- **24-7 systems**: – RTOS can be best used for any applications which run 24 hours and 7 days because it do less task shifting and give maximum output.
- **Memory Allocation**: - Memory allocation is best managed in these type of systems.

Disadvantages –

- **Expensive**: - RTOS are usually very expensive because of the resources they need to work.
- **Not easy to program**: - The designer have to write proficient program for real time operating system which is not easy as a piece of cake.
- **Low Priority Tasks**: - The low priority tasks may not get time to run because these systems have to keep accuracy of current running programs

System Calls

- A **system call** is the programmatic way in which a computer program requests a service from the kernel of the operating system it is executed on.
- A system call is a way for programs to **interact with the operating system**. A computer program makes a system call when it makes a request to the operating system's kernel.
- System call **provides** the services of the operating system to the user programs via Application Program Interface(API). It provides an interface between a process and operating system to allow user-level processes to request services of the operating system. System calls are the only entry points into the kernel system. All programs needing resources must use system calls.

System Calls

Services Provided by System Calls :

- Process creation and management
- Main memory management
- File Access, Directory and File system management
- Device handling(I/O)
- Protection
- Networking, etc.

Types of System Calls : There are 5 different categories of system calls –

1.Process control: end, abort, create, terminate, allocate and free memory.

2.File management: create, open, close, delete, read file etc.

3.Device management

4.Information maintenance

5.Communication

System Calls

Process Control	CreateProcess() ExitProcess() WaitForSingleObject()	fork() exit() wait()
File Manipulation	CreateFile() ReadFile() WriteFile() CloseHandle()	open() read() write() close()
Device Manipulation	SetConsoleMode() ReadConsole() WriteConsole()	ioctl() read() write()
Information Maintenance	GetCurrentProcessID() SetTimer() Sleep()	getpid() alarm() sleep()
Communication	CreatePipe() CreateFileMapping() MapViewOfFile()	pipe() shmget() mmap()
Protection	SetFileSecurity() InitlializeSecurityDescriptor() SetSecurityDescriptorGroup()	chmod() umask() chown()

Conclusion

This Lecture makes the student to understand various functions and services offered by the operating system.

It also gives students the opportunity to compare different types of operating systems on the basis of advantages and disadvantages mentioned in these slides.

Learning this will make the student understand the requirement of operating system for managing different functions and types of operating system.

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Thank You

For any Query, you can contact

Er. Inderjeet Singh(e8822)

Ph. No: 86-99-100-160

Email id: inderjeet.e8822@cumail.in