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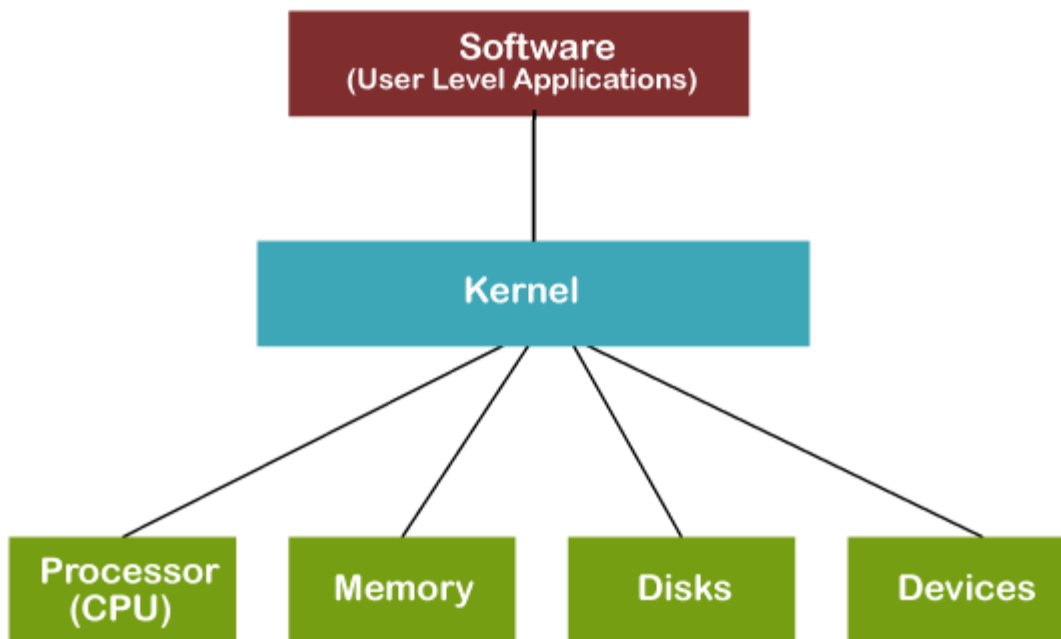
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## 1. Introduction

Kernel is the core part of an OS (Operating system which it has full control over everything in the system. A kernel is normally accessed and maintained in a area of memory which is called Protect Kernel Space. The kernel plays important part to its operation. Process, device drivers, memory are included and managed by kernel.



*Figure 1: Components of kernel*

The important functions that is managed by kernel are mentioned below:

- **Process Management:**  
In this step, it carryout tasks which is managed by kernel. It controls and decide how long will it take for every device to access the CPU for, and also to start and stop them.
- **Memory Management:**  
The kernel plays an important role in managing the memory of computer, which also ensure that every program has plenty area to work freely without any distraction and disturbance.

- **Device Management:**  
In this step, the kernel always makes sure that software can freely and easily access hardware devices which are printer and disks by connecting with them using device drivers. It also helps in interaction between OS and hardware.
- **File System Management:**  
The kernel focuses on managing the storage devices of the computer which handles the stored file and provide access to protocols. In this system, the file and folders are properly handled and.
- **Security and Access Control:**  
In this process, the main job for kernel is to control who is allowed to have access on what resources by making sure that outsiders and unapproved users are unable to access the essential files. ACLs (Access Control List) is a system that provides advanced security to the system and limit who is allowed to access to specific files.

Therefore, all these major activities are important to manage system resources.

## 2. Objective

A kernel's first aim and main task is to handle the resources of computers and make sure that each and everything operates efficiently for the achievement of organizational goal. Thus, the main objectives of kernel are explained below:

- **Resource Management:**  
In this process, CPU, memory, and I/O devices are the hardware resources of the computer which are handled by kernel. The kernel main objective is to make sure that every process has received the same amount of CPU time.
- **Process Management:**  
In this step, the main objective of kernel is to develop a new method and provide the resources that are necessary when the program is introduced. It also allows multitasking in this process without any disturbance which helps to run program efficiently.
- **Memory Management:**  
The main aim for this process is to guarantee that every program has the memory that must run, system memory which is RAM and virtual memory are controlled by kernel. If an operation begins, a memory is created by kernel and then when it ends, then it is cancelled.
- **File Management System:**  
In this process, the main goal of kernel is to develop, read, write and remove file from program which is only possible due to system features given by kernel for easy access. If file is properly organized, users can easily access and change data according to their will.
- **Security:**  
The most important objective of kernel is to limit the ability to use system resources by following safety measures and authorizing user. It reduces the chance of harmful viruses and unwanted access that damage the system.

Therefore, these are the pre-eminent goal of kernel that helps to achieve the efficiency in overall systems.

### 3. Types of Kernel

Kernel is classified on various features that is based on two several ways. It is based according to structures and according to how exactly companies handle different operations.

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.

#### 1. Based on Structure:

This description focuses on inner structure and design of the kernel. Microkernel and Monolithic Kernel are the two major and essential versions.

- **Monolithic Kernel:**

This kernel is also called single source kernel. In this kernel, every necessary feature is given by kernel because all of the OS along with device drivers, file systems, memory management are also added which is performed by kernel.

Advantages:

- In this process, as all the services are worked and operated together it works very quick and less-time consuming.

Disadvantages:

- In this step, as every little thing is interrelated and connected closely, when a driver or another part of kernel fails, the whole system may break and all the data will be at risk.

The best example of Monolithic kernel is Linux.

- **Micro Kernel:**  
In this kernel, memory management, IPC, CPU control are the most important tasks that are performed by microkernel and outside of kernel, file system and device drivers are operated.

Advantages:

- This kernel mainly focuses on increasing security and safety that make it reliable to use. Even if there is some issues and crash in the system, the main structure keeps working because several elements work independently.

Disadvantages:

- This kernel is less effective because of the extra communication cost that occurs between kernel and user space operations, it might run less quick and less efficient

## 2. Based on how they run processes:

-This approach describes the way how the kernel handles the running operation. Preemptive kernel and non-preemptive kernel are essential and advanced kernel that handles the process.

- **Preemptive Kernel:**  
In this process, according to the demand and value of the system, to make our work more efficient and function properly preemptive kernel allows the system to run an ongoing task and transfer to a new one
- **Advantages:**  
Kernel will stop trivial and secondary programs to start main programs which have more priority, it can be achieved with the help multitasking and flexibility.
- **Disadvantages:**  
Regular shift in context in all the programs, because it is difficult to accomplish and might cause overhead.



- Non-preemptive kernel:  
-In this approach, it follows a step where if a process moves into kernel mode in a non-preemptive kernel, unless it completes its role it is unable to stop.
- Benefits:  
The most essential advantage of non-preemptive kernel is that there are few changes and shifts in context as well as easier to achieve and carry out.
- Cons:  
In this context, a minor and secondary job could hinder and delay top and important activities unless it is finished, which could end up leading the system less flexible and cannot act quickly and smoothly.

## 4. Popular Kernels and History

1. What kernels are used by most popular operating systems (iOS, Windows, and Ubuntu) and how did these kernels come to exist?

-The basic part of every operating system is the kernel because it depends on the system to operate and execute. There is a short summary of Ubuntu, IOS and Windows and how they are installed and executed.

- iOS (XNU Kernel)

iOS Kernel Programming combines essential operating system and kernel architecture knowledge with a highly practical approach that will help you write effective kernel-level code.

The reason: BSD Unix which is also called monolithic kernel and Mach which is a micro kernel are put together in XNU, necessary and simple operations of microkernel are memory management which are controlled by Mach for efficient operation and as for the advanced operations that includes systems files and networking are managed by BSD for smooth functioning.

Current time: Talking about present time, nowadays in mac operating system XNU is found. This also includes the operating system for iPads, iPhones, iOS and MacBook and for the achievement of safety and reliability, both monolithic and microkernel properties are put together to operate.

- Windows (NT Kernel):

-This kernel is developed for the achievement of solid and trustworthy operating system; Windows NT kernel was established in starting of 1900s for both users and organizations.

Growth: In this approach, MS-DOS and the first release of Windows which was the operating system of Microsoft was not very reliable and trustworthy. Then, to lead the ongoing progress of NT engineer David Cutler was selected by Microsoft and he enhanced NT and made it more stronger than before through multitasking and upgraded memory management.

Current time: In this approach, Windows 10 and Windows 11 are the latest model of Windows that are designed on NT kernel and for the excellent stability, speed, power and maximum storage.

- Ubuntu (Linux Kernel):
- Ubuntu is an operating system and a distribution of Linux, based on Debian that gives it some characteristics features.

Growth: In this brief summary, to further enhance the Linux kernel many individuals have regularly struggled across the world. It is very useful and common because it is freely available and anyone can change it.

Current time: Recently, Ubuntu is fastest and most commonly used operating system that use Linux. A large number of cell phones manage Android, it also relies on Linux Kernel for operation and for its reliability, consistency trustworthy feature it is trending and known widely.

## 5. Boot Process

The BIOS contains low-level I/O software, including procedures to read the keyboard, write to the screen, and do disk I/O, among other things. It is also known for its complexity, difficult, tangled and complicated system.

**Power-On Self-Test (POST):** In this boot process, after booting up, the computer starts hardware diagnostics to guarantee that the CPU and RAM are working properly and effectively.

**BIOS/UEFI Execution:** In this boot process, The Unified Extensible Firmware Interface which is also called Basic Input Output System (BIOS), which selects the boot like hard disk and set up hardware.

**Bootloader Execution:** In this boot process, an operating system is set up by boot loader which is a GRUB that is installed in the memory.

**Kernel Loading:** In this last process, after being installed in the memory, the operating system kernel begins to run.

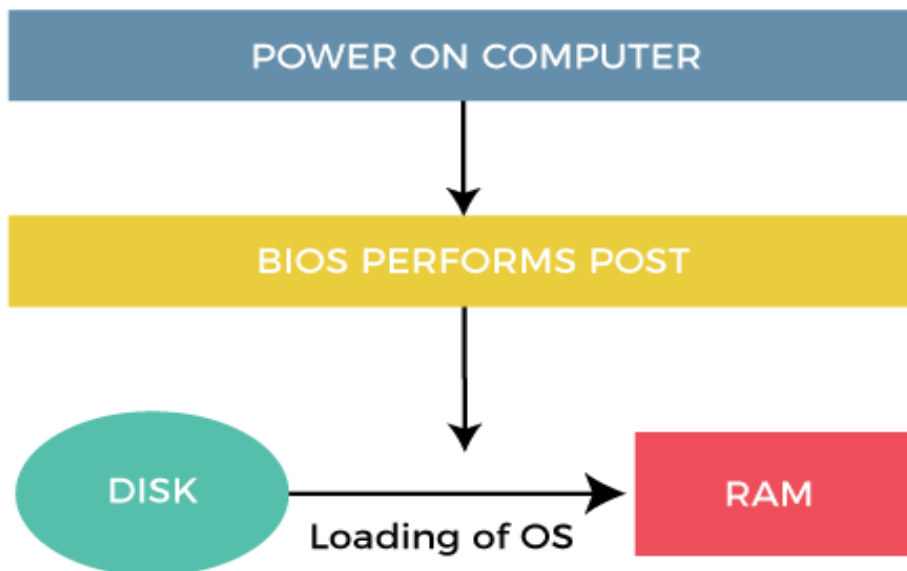


Figure 2 Boot Process of a Modern Operating System

## 6. Conclusion

Kernel is the first process loaded at boot time, and it remains in continuous use for the duration of the session. It has the role for providing hardware and software communication properly and effectively. According to the demand of system, micro kernel and monolithic kernel which are various kernel types perform different operations. Windows, Ubuntu and IOS that is of the operating system which is commonly used.

They have created different kernel idea that are mainly designed to fit their desire. The kernel is put to life and the whole useful operating environment becomes available that is accessible by boot process which is made up of various important factors. This method, which is important for modern computing because it holds a quick effect on the speed and a device starts easily. Therefore, in today's technology an operating system kernel plays an important part in the safety, reliability and flexibility. They continue to be necessary when the hardware grows and develops while the needs of user get more hard to fulfil. Kernel is classified on various features that is based on two several ways. It is based according to structures and according to how exactly companies handle different operations.

Furthermore, the kernel has change to fulfil the new requirements of latest and trending devices, that also add safety, better processing as well as help more powerful hardware. This improves the performance of operating system.

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