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I confirm that I understand my coursework needs to be submitted online via MST Classroom under the relevant module page before the deadline in order for my assignment to be accepted and marked. I am fully aware that late submissions will be treated as non-submission and a mark of zero will be awarded.

9/23/2024

Table Of Contents

Table of Figures

1. Research On Kernel

1.1 Introduction

kernel is the core part of an operating system which is responsible for managing a computer's hardware and its operations, such as memory and CPU usage, It is an important component of an operating system. The kernel connects applications to the hardware by managing data processing through system calls and communication between processes. It helps the software interact with the hardware smoothly and efficiently. It manages tasks such as executing programs, accessing files, and connecting to devices like printers and keyboards. There are different types of kernel such as **Monolithic Kernel, Micro Kernel, Hybrid Kernel** and **Exo Kernel** (geeksforgeeks, 2024)**.**

This report explores the detailed aspects of the kernel, focusing on its various functions, types, and overall structure. It also examines how the kernel is designed and the important role it plays in different operating systems. By understanding these key elements, the report provides insight into how the kernel manages essential tasks within a system, ensuring efficient communication between software and hardware components. Additionally, the discussion will highlight how different operating systems implement and utilize kernels to handle their core operations.

1.2 Aim

The aim of this report is to give a clear explanation of the kernel, which is the core and most important part of an operating system. The report will look at how the kernel manages and controls a computer's hardware and software interactions to ensure they work smoothly. It will also explore the kernel's role in tasks like memory management, device management, and resource allocation. In addition, the report will discuss different types of kernels, such as monolithic, micro, hybrid, and exokernels, and explain how they work in various operating systems, highlighting their advantages and disadvantages. Overall, the report aims to

provide a better understanding of the vital role the kernel plays in keeping computer systems running effectively.

1.3 Objectives

- To explain the role of a kernel and its importance in an operating system.
- To describe the key functions of a kernel, such as memory management, device control, and resource allocation.
- To discuss the various types of kernels, including monolithic, micro, and hybrid kernels.
- To explore how the kernel facilitates communication between software and hardware.
- To provide examples of how kernels are implemented in widely-used operating systems.
- To highlight the strengths and weaknesses of different kernel types.

1.4 Required Tools

MS Word: Microsoft Word is a popular word processing software developed by Microsoft. It is part of the Microsoft Office suite of productivity tools but can also be bought separately. First released in 1983, Microsoft Word has undergone many updates over the years. It is available for both Windows and macOS. Commonly referred to as Word or MS Word, this program is widely used for creating and editing documents (Margaret Rouse, 2022).

Figure 1: MS Word

Google : Google is an online search engine that uses a unique algorithm to collect and organize search results, ensuring it provides the most reliable and relevant information available (Margaret Rouse, 2023).

Figure 2: Google

2. Concepts

The kernel is the most crucial part of an operating system. It serves as the main link between a computer's hardware and its processes, ensuring that resources are managed efficiently. The kernel is stored and loaded into a dedicated memory area called protected kernel space, which is shielded from access by application programs or less critical parts of the operating system. Programs like browsers, word processors, and media players run in their own memory space, known as user space. These two separate spaces prevent the user data and kernel data from interfering with each other, helping to avoid system slowdowns and instability.

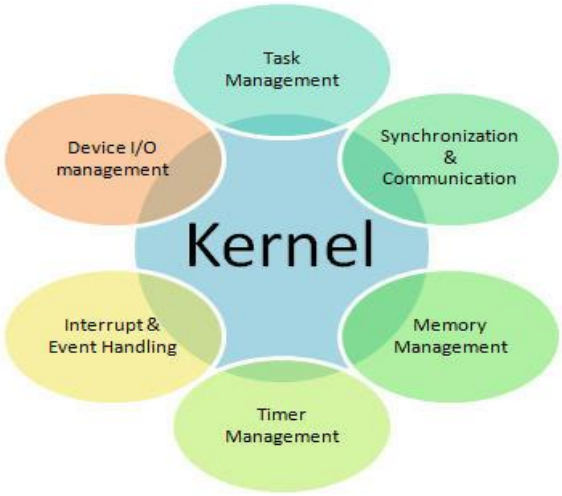

Figure 3: Purposes

The Kernel has several important functions such as :-

Device Management

To perform tasks, processes need access to devices like a mouse, keyboard, and other peripherals connected to the computer. The kernel manages these devices through device drivers. A device driver is a program that allows the operating system to communicate with hardware. The kernel keeps track of all available devices, which might already be known, set up by the user, or detected by the OS during operation.

Memory Management

The kernel has full control over the computer's memory. Each process requires memory to function, and the kernel ensures processes can safely access it. The first step in allocating memory is called virtual addressing, which is done through methods like paging or segmentation. This assigns virtual memory spaces to processes, preventing them from interfering with each other and causing crashes.

Resource Management

One of the key roles of the kernel is to distribute resources among various processes. It ensures that each process gets access to the resources in a balanced way. The kernel also provides methods for synchronization and communication between processes (IPC) and handles context switching between them.

Accessing Computer Resources

The kernel is responsible for managing access to computer resources like RAM and I/O devices. RAM stores both data and instructions for programs, and since many programs need more memory than is available, the kernel decides how memory is allocated to each process and what to do when there's not enough. The kernel also manages application requests for I/O devices like keyboards, microphones, and printers (javatpoint, 2024).

There are different types of kernel as given below:-

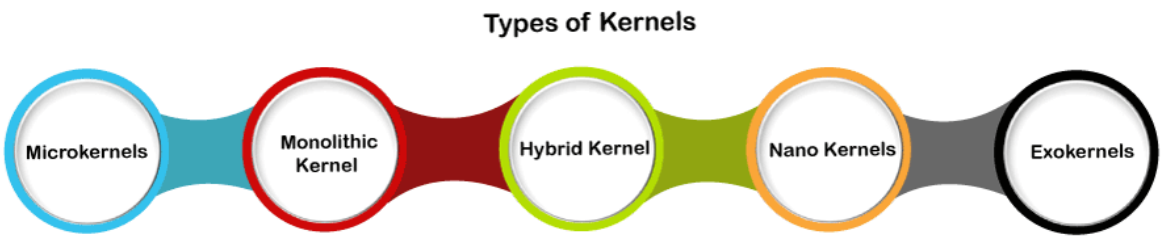

Figure 4:TypesofKernel

1. **Monolithic Kernel**: A Monolithic Kernel manages essential system functions like file handling, memory management, and resource allocation, keeping all components in the kernel space. Operating systems that use a Monolithic Kernel include DOS, Solaris, AIX, Linux, and OpenVMS. It's the type of Kernel which performs tasks like CPU scheduling and system calls, due to its simpler resource management Monolithic Kernel-based systems are usually chosen for financial projects because of they are reliable, secure and provide fast access.

   The **advantages** of Monolithic Kernel are:-

   - It is fast because important services like memory and file management are handled in the same space.
   - The Processes are running in a single address space, which speeds up execution.
   - The kernel is a single and unchanging file.
   - There are fewer bugs and security issues.
   - System calls are used to manage operations.
   - Processes run quickly because the user and kernel have separate memory spaces.

   The **disadvantages** of Monolithic Kernel are:-

   - If an issue occurs in one area of the Kernal space it can significantly impact other areas as well.
   - The entire system can crash if the service fails.

- Adding new features requires updating the entire system which makes it more complicated.

2. Microkernel Kernels

A microkernel is an operating system architecture which is particularly designed to manage files, memory, and process scheduling, along with other tasks. Even though it shares similarities with a monolithic kernel, a microkernel makes space for functions like file sharing and scheduling, while allowing each service to have its own address. This approach helps to reduce the overall size of both the kernel and the operating system.

The main idea behind a microkernel is to improve reliability by dividing the operating system into smaller, independent modules. It enables communication between client programs and user-space services. New services can be added in user space without needing to modify the kernel, which enhances security because if a service fails, it does not impact the rest of the operating system.

The **advantages** of Microkernel Kernels are:-

- They are secure because only essential parts that could affect system functionality are included.
- Thanks to the modular design, microkernels experience fewer system downtime and are easier to manage.
- New features can be added to a microkernel without the need for Reassembling the entire system later.
- The Kernel would not be affected even If their different modules are swapped, reloaded and modified.

The **disadvantages** of Microkernel Kernels are:-

- providing services tends to be more expensive compared to a monolithic system in a microkernel-based OS.
- When drivers are implemented as methods**,** context switches or function calls are required.
- Potential problems can be caused due to the performance of microkernel system staying consistent.

3. Hybrid Kernels

Hybrid kernels merge aspects of both monolithic and microkernel designs, enhancing the microkernel structure by adding more code and features to the kernel space for better performance. Unlike pure microkernels, where all components are placed in servers and user-level drivers, hybrid kernel designers decide which elements should they keep within the kernel and which one should they move outside. This approach improves performance, makes the system simpler, and it also reduces reliance on specific providers. Hybrid kernel development begins with integrated components and slowly transitions some elements to the user space over time.

The **advantages** of Hybrid Kernels are:-

- The number of layers is not large.
- Better defense and protection.
- A hybrid kernel is manageable because of its structured, layered design.

The **disadvantages** of Hybrid Kernels are:-

as a hybrid kernel balances the advantages of both monolithic and microkernels, some benefits from each are reduced.

4. Nano Kernal

Nano Kernal is a tiny kernel that mainly contains essential hardware code, running with nanosecond-level clock precision.

The **advantages** of Nano Kernal are:-

- It delivers high efficiency performance.

The **Disadvantages** of Nano Kernal are:-

- It lacks many features that are typically built-in.
- It is not widely adopted due to its close resemblance to microkernels.

5. Exokernels

An exokernel operating system allows applications to manage hardware resources directly at the application level. It separates protection from management, giving more flexibility to customize. In traditional operating systems, high-level abstractions hide hardware complexity from applications, which can reduce performance and restrict the types of applications supported. Exokernels reduce these abstractions, giving developers greater control over hardware and the ability to create their own abstractions.

The **advantages** of Exokernels are:-

- Provides better control for applications.
- Offers a low-level interface for developers.

The **disadvantages** of Exokernels are:-

- Each developer may create their applications differently, which can reduce overall consistency.
- The interface design for an exokernel is often more complex (Aditya Saxena, 2024).

3. Steps required for lab

For my lab work focused on studying the kernel, I started by inquiring my tutor regarding the research and as I got to know more information regarding the lab work, I started discussing with my peers and began to thoroughly research about Kernel. At the beginning I encountered some confusion regarding the topic but through my consistent dedication I discovered plenty of information that includes the topic I was researching on, which made it easier for me to continue my report making.

I got my information regarding this topic through few websites that made my research very insightful and knowledgeable and I had all my best regards towards my teachers for assigning this report to us which enriched my knowledge.

4. Conclusion

In conclusion, this report has provided a thorough overview of the kernel while emphasizing its critical role in operating systems. The kernel is at the heart of the system, connecting software to hardware and ensuring smooth interactions between them. It manages essential operations like memory allocation, device control, and resource distribution. This makes the kernel vital for running any computer or device effectively. By exploring different types of kernels—such as Monolithic, Microkernel, Hybrid, Nano Kernel, and Exokernel we discover that each one of them has their own strengths and weaknesses, depending on the system's needs. For example, Monolithic kernels offer speed and simplicity, while Microkernels improve reliability by dividing the system into smaller modules.

Through this report, I have gained a deeper understanding of how these different types of kernels work and the important role they play in modern computing. The knowledge I gained through this research has helped me see why kernel design choices are important for the stability and performance of an operating system. Learning about how kernels manage memory, devices, and resources provided me proper insight into the complex tasks that go on behind the scenes every time we use a computer or phone. I now appreciate how much work the kernel does to ensure that different programs run smoothly and don’t interfere with each other.

Completing this report required extensive research, which was both challenging and rewarding. While I encountered some difficulties in understanding the more technical aspects of kernel architecture at first, My continuous effort and discussions with my peers and tutor helped clarify these concepts. By the end of this project, I felt confident in my understanding of the topic and proud of the work I had put into this report.

Ultimately, studying the kernel has improved my knowledge of operating systems and their inner workings. It has given me valuable insights into how the foundational layers of computing work, making me better prepared to engage with more complex topics in the future. This report not only fulfilled the academic requirements but also strengthened my

appreciation for the complex design and operations that make modern technology possible.

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