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I confirm that I understand my coursework needs to be submitted online via Google 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.

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Introduction to Kernel:

A kernel is critical part of computer’s operating system. It provides a bridge between software/application to hardware and IO devices communication with computer’s operating system. It is bunch of codes that is instructed to perform certain function. Kernel controls hardware as per operating software’s allocation of resources like process management, memory allocation, system security. It provides an interface to physical hardware to operating software or server. They are responsible for providing access to CPU, memory, storage, I/O, bus.

Functions of Kernel:

- Process Management:
  It handles the task provided by operating software and manages the hardware resources accordingly and provides instructions to operating software, decides which process to run at the given time.
- Resource Management:
  Kernel is interface for inter-process communication with hardware and operating software and applications running in operating software, and processes synchronization.
- Device Manager:
  It enables access of different process to exchange data and information and stores information of data storage and memory location.
- File system and Security:
  Kernel communicates with storage hardware and manages file system of data to retain data’s integrity, so it ensures that same piece of software can run with various hardware platform.

Objective:

In this report, I am exploring the concept of kernel and its importance in computing. I will emphasize learning about types of kernels and functions of Kernel and its history, discuss more about kernel. How operating system and kernel work together and to perform a task of computing data by using hardware resources. Understanding more on how a boot process works.

Types of Kernels:

Kernels classification based on design.

Monolithic Kernel:

A monolithic kernel integrates all important operating system from device drivers, file system, memory. All of the hardware-controlling software programme sets and components for processing are embedded within the kernel, facilitating direct communication. (Saxena, 2022) Ex: Linux kernel, Unix system, OpenVMS's kernel etc.

Advantages:

- Entire kernel runs on a single space.
- No inter process communication makes system call function faster execution.

Disadvantages:

- If a service fails it leads to failure of entire system.
- Modularity issues makes difficulty to add a new system service.

Micro Kernel:

A micro kernel uses approach where basic tasks are operated in kernel space (memory management, process scheduling), with other services running in user space. This architecture is modular and simple that can run multiple operating system.

Advantages:

- Micro kernels are more secure as it runs on user space.
- Modular because they run services separated by user space and kernel space.

Disadvantages:

- Generally, they are slower compared to monolithic kernels.
- Development of Microkernel tends to be difficult.

Kernels classification based on operation.

Hybrid Kernel:

A hybrid kernels are based on both monolithic and microkernels. It runs system services in kernel space for better performance and being modular like Micro kernel making it easier to maintain. Systems using hybrid kernel deals with less Inter Process Communication (IPC) and direct system call. Ex: Windows XP,7,8 ‘s kernel, Apple’s macOS, watchOS, ipadOS, iOS ‘s kernel.

Advantages:

- It is flexible and functional, having attributes of micro and monolithic architecture.
- Balanced in terms of reliability and performance, different level of abstraction.

Disadvantages:

- Hybrid kernels tends to be difficult to develop.
- Big load for old hardware, requires ample computing power.

Exo Kernel:

This kernel architecture gives application direct access to hardware resources for maximum performance and minimize hardware and application layers for communication. Exo kernels are providing minimal hardware interference and allows applications to manage resources. (Dawson R. Engler)

Advantages:

- This arcitecture is best for both performance and efficiency.
- Direct hardware access to system applications.

Disadvantages:

- Developers must manage resource allocation and security at application level.
- Lacks the abstraction for system services, system calls are to be hard coded.

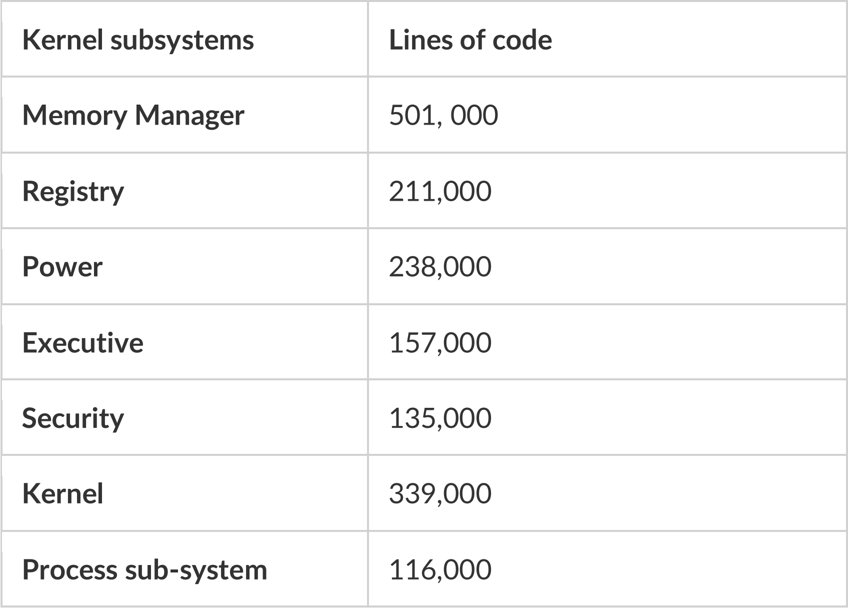
Popular Kernel and their history

Windows Kernel:

Windows's kernel was designed by Microsoft around 1988, as windows NT kernel. It is organized into NTOS to handle run-time library, Scheduling, Executive services, I/O, memory, process and other resources management and HAL insulating NTOS and drivers from hardware details also handles devices, file system, network. It is a hybrid kernel that supports advanced features like multitasking, security models, and compatibility across different hardware architectures.

- NT Timeline first 17 years

2/1989 Coding Begins
7/1993 NT 3.1 9/1994 NT 3.5
5/1995 NT 3.51 7/1996 NT 4.0
12/1999 NT 5.0 Windows 2000
8/2001 NT 5.1 Windows XP
3/2003 NT 5.2 Server 2003
8/2004 NT 5.2 Windows XP SP2
4/2005 NT 5.2 Windows XP 64 Bit Edition (& WS03SP1)
2006 NT 6.0 Windows Vista (client)



Kernel subsystems	Lines of code
Memory Manager	501, 000
Registry	211,000
Power	238,000
Executive	157,000
Security	135,000
Kernel	339,000
Process sub-system	116,000

Fig: stats on lines of code written for NT kernel.

(Pulapaka, Tech community Microsoft, n.d.)

Linux Kernel:

Linux kernel initially established by Linus Torvalds in 1991 for x86 bits personal computers, later Linus made it free for public to operate, tweak, share the software programme. The first version of Linux kernel was on FTP file transfer protocol called version 0.01 with 10,239 lines of code. Afterward, the Linux kernel version 2.2.13, compatible with enterprise-level (particularly IBM mainframe patches) machines, was developed on December 18, 1999. The current Linux kernel versions contain over 27 million lines of code and operate on all-powerful supercomputers. The Linux kernel also operates on servers, smartphones, desktops, and laptops and powers the Internet of Things (IoT).

The Boot Process:

Boot, short for bootstrap, refers to the process of starting up a computer system. Boot process is start of initializing the hardware components of a computer and loads the operating system into memory, and make sure the computer is ready for use. When you turn on your computer, the power supply sends electricity to the components. The computer's embeded firmware called the basic input/output system (BIOS) or the unified extensible firmware interface (UEFI), is responsible for initializing the hardware and locating the boot device.

Boot process refers to start of system in running state where it is ready to take input and processes the input to output, Kernel plays major role from beginning of boot process sequence.

- BIOS or UEFI:

Basic Input Output System (BIOS) or Unified Extensible Firmware Interface (UEFI) they are already present in motherboard. When a system is powered on it perform hardware initialization, power-on self-test (POST) to ensure everything is working correctly.

- Bootloader Execution:

Once the hardware gets initialized the bootloader takes the action to load operating system from storage drive. Bootloader does load operating system’s kernel into memory after POST.

- Kernel Initialization:

When bootloader loads kernel, it controls the system of hardware management (CPU, memory, storage drives, I/O devices) and loads the operating system in user space.

Conclusion:

In summary, Kernel is the backbone of operating system, that provides essential hardware and software management system. Kernel takes care of processes management, memory management, and keeps the hardware and software in check. Kernel plays the role of mediator if you shut down your computer, the operating software process the command and make communication with kernel and kernel perform the shutdown command in low level communicating with hardware.

Moreover, after this report I get to understand the various types of kernels, their design, operation, boot process and resource management and appreciate the task performed by kernel in computing after the device is turned on. I also found out about monolithic kernels, microkernels are their architecture, how a system behave with different types of kernels.

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