

# Comparing the Features of Various Operating Systems

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**Abstract**— This paper provides a comparison of three most popular operating systems: Windows, Linux, and MacOS. Memory, Scheduling, file management, architecture, and security are the main aspects which are compared across various operating systems. Every operating system has its own set of differences in terms of composition and structure, and this research focuses on the operating system's fundamental strengths and weaknesses.

**Keywords**— Linux, Windows, macOS, Security, Files, User Interface, Architecture.

## I. INTRODUCTION

Operating System is a program that acts as an intermediary between the user and the hardware of a computer. Its goals include execution of user programs and solving user's problems, providing efficient UI which makes performing tasks on a computer and utilization of resources easy to the end user and takes care that computer hardware is utilized effectively. The major duties of an Operating system include security, multi-processing, multi-threading, CPU scheduling, Process synchronization, main memory utilization, Inter process communication and so on. All these tasks when performed efficiently with respect to time, space and priority constraints form a reliable Operating System. In this paper, we compare Windows, Linux and macOS operating systems in these aspects and contrast the similarities and differences between them. Before that we will learn a little about each of these operating systems.

**WINDOWS** – Windows is an operating system designed by Microsoft and was released on 20 November 1985. It is based on MS-DOS (Disk Operating System). It very soon became the most popular GUI based operating system. Windows has provided many innovative solutions through its various versions. The Windows NT operating system series is a multi-user and has absolute memory protection. Windows Vista introduced a privilege elevation system called User Account Control. A logon session is created and a token with only the most basic access is assigned when a typical user logs in. Windows XP has been a very successful product with sub versions such as Windows XP Professional, Windows XP Home Edition, Windows XP Embedded, etc.

**LINUX** – Linux is a Unix Operating system based on Linux kernel. It was released on September 17, 1991. The main feature of a GNU/Linux system is that it is a multi-user OS. Debian, Fedora and Ubuntu are few of the popular Linux distributions. Linux was originally made to be used in personal computers, but due to its success in the market, it has expanded its business into smart phones. It is internally

used in Android. It is also used in Chromebook, a very successful laptop/notebook product from Google.

macOS – Macintosh is one of the most famous operating systems and it was developed and released by Apple in the year 1984, a year before Microsoft launched Windows. macOS succeeded the very successful Macintosh operating system and released its first desktop version in the year 2001. User Interface is very well designed and easy to operate in the macOS. It uses a GUI with water like elements called Aqua. With the spatial anti-aliasing technology, ColorSync, and many other features, it stands as an Operating system with the best user experience. It is deemed to be the most secure operating system compared to Windows and Linux.

## II. FEATURES OF WINDOWS VS LINUX VS MACOS

### A. User Interface

**WINDOWS**- Because the Graphical User Interface (GUI) is an essential part of Windows, it cannot be replaced. A command shell program can also be run directly. Programs are run in distinct "windows," as the name implies. Because each application runs in its own window, we can have multiple programs running at the same time. For home computers, this is the most prevalent operating system.

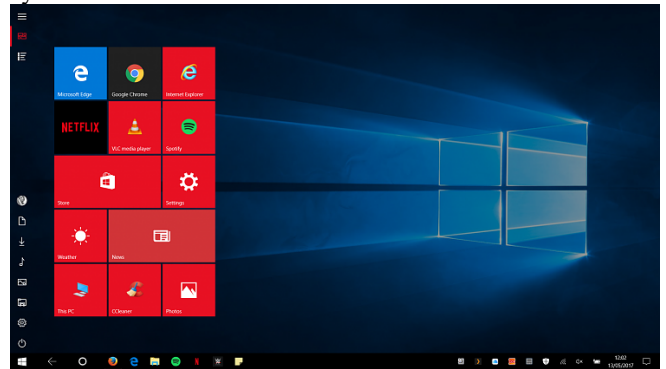


Fig 1. Windows 10 User Interface

**MAC OS** – As mentioned in the Introduction, "AQUA" is the name of Apple's graphical user interface and visual theme. Its original theme was 'water,' and it included droplet-like elements as well as reflection and translucency motifs. Its goal in macOS applications is to incorporate color, depth, and sophisticated textures into a visually

pleasing interface.



Fig 2. macOS User Interface

**LINUX** - You can use both the GUI and the command line with Linux. Although the CLI appears to be superior to the GUI, this is not the case. CLI can never be used to edit movies, and a graphical audio player is considerably more likely to be used to create playlists, for example. A graphical user interface is also plainly required for image editing.

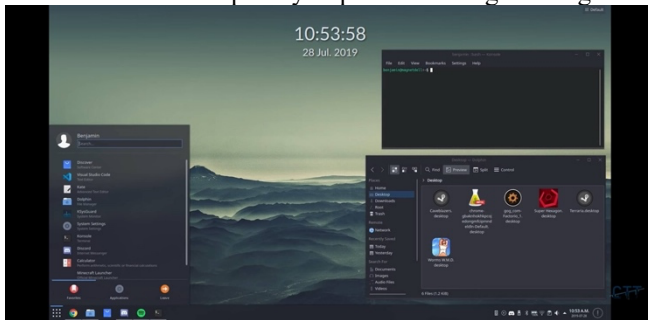


Fig 3. User Interface of Linux

## B. File Management

**WINDOWS**- Microsoft has two major strategies to keep their file systems up to date. FAT is the name of the classic file allocation table. The FAT12 system was the initial iteration of the FAT system, with 12 denoting the number of bits in a file system block. FAT12 became obsolete as time passed, and was superseded by FAT16, which supported larger files (due to the larger number of bits). FAT16 was superseded by FAT32, which is now the current Windows file system standard. In comparison to the modest 4096 blocks (or 212) provided by the original FAT12, FAT32 may use up to 4294967296 blocks of data (or 232).

**MAC OS** – MacOS is as straightforward as it gets. All you must do is access your hard drive to get your files back. All your apps are grouped together in this folder for convenient access. All the system software and technical files are likewise easy to locate. All your downloads and documents are stored if you click "Users" and open the folder with your name on it.

Apple's file system is known as the Apple File System (APFS). Apple, like NTFS, stores metadata about files, such as file descriptors, file beginning pointers, and so on. APFS also includes a "copy on write" file approach that assures maximum security and compression. To ensure speed and efficiency, APFS stores certain data items in superblocks.

**LINUX** - Linux is unlike any other operating system in terms of how it works. It has a tree-like structure for storing files and directories on a hard drive. The tree-structure is the most popular among Linux users, but the operating system also supports over a thousand additional file systems, some of which are quite old. A Linux-enabled gadget is your greatest option when it comes to providing freedom and control. The trade-off for that freedom and control is that learning Linux is quite difficult. It is without a doubt the most difficult of the three operating systems covered in this article.

Linux mostly makes use of the Ext file system, which is a Linux native file system (this also means it is exclusive to Linux users). The Ext file system, like the FAT file system, has gone through several versions over the years, including ext2, ext3, and the most recent ext4 filing system.

This filing system extends all the way to the root, creating branches of files that are all related to the root in some way. Imagine a tree with all its branches connected to the root; this is exactly how Linux's file system works. Although it is simple and effective, it may not be suitable for everyone, which is why it is not yet applied across many platforms available on the market.

## C. Registry

**WINDOWS** - The Windows registry is a central database that stores all your computer's settings. It oversees keeping all user information, including passwords and device-related data. There is an editor in the registry that allows you to inspect all keys, values and drivers if needed.

**MAC OS** – All application settings are saved by MAC in a list of .plist files, which are stored in the various preferences folders. All properties are stored in plain text or binary format in this .plist file. These can be found in the /Library/Preferences folder on your Mac.

**LINUX** - Linux, on the other hand, lacks its own registry. All application settings are saved on a program-by-program basis under different users in the same file hierarchy format. Because there is no centralized database for keeping these details, there is no need to clear them on a regular basis.

## D. Interchangeable Interfaces

**WINDOWS** - Until Windows 8, the Windows interface was not interchangeable. Windows XP offered several improvements, but they were insufficient. Windows Explorer, the Start menu, the taskbar, and the system tray.

**MAC OS** – A feature of MAC is the ability to connect virtual network interfaces. Go to System Preferences and manage the interfaces to accomplish this.

**LINUX** - Switching interfaces in Linux is simple. You can change the surroundings without carrying out all the necessary installations. GNOME and KDE are two utilities that can aid with these requirements. They assist in focusing on various aspects

## E. Architecture

**WINDOWS** - Many CPU designs contain some type of ring protection. The kernel, drivers, and applications run on ring 3 under DOS (albeit this is only true when protected-mode drivers and/or DOS extenders are used; as a real-mode OS, the system operates with no protection), but 386 memory managers like EMM386 run on ring 0. The four separate modes of the x86 processors are grouped into four rings. Ring 0 programs can do whatever they want with the system, and Ring 3 code should be able to crash at any time without affecting the rest of the system. Although Rings 1 and 2 are rarely used, they can be set up with varying levels of access. Switching from "user mode" to "kernel mode" in most existing systems comes at a significant performance cost.

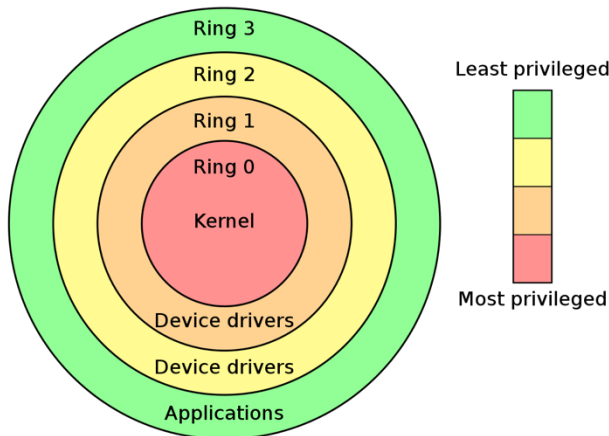


Fig 4. Protection ring of windows

Hardware Abstraction Layer, which is the first abstraction layer that abstracts the hardware details from the operating system. The operating system can then call the same API functions and the HAL takes care of how they are executed on the underlying hardware. Every driver that is loaded in the kernel mode uses HAL to interact with the hardware components, so even the drivers don't interact with hardware directly. The kernel drivers can interact with the hardware directly, but usually they don't need to, since they can use HAL API to execute some action. The hardware abstraction layer's API is provided with the hal.dll library file that is in the C:\WINDOWS\system32\ directory.

## Windows Architecture

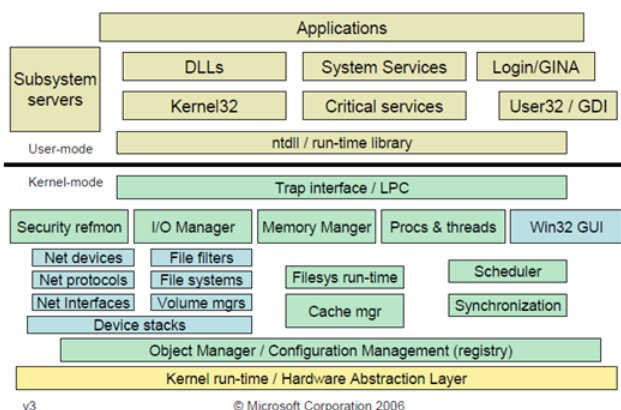


Fig 5. Windows Architecture

**MAC OS** - Apple made a change at the 1998 Worldwide Developers Conference (WWDC) in response to criticism from Macintosh software developers who were unhappy with Rhapsody's two alternatives (Yellow Box and Blue Box). To Rhapsody's existing developer APIs, Mac OS X would add a new one. The Macintosh Toolbox's key APIs would be implemented in Mac OS X, allowing them to operate directly on the BSD layers of the operating system rather than the simulated Macintosh layer. This new interface, dubbed Carbon, would replace around 2000 difficult API calls (out of a total of over 8000) with those that are compatible with modern operating systems. [4] Apple also stated that the Mach side of the kernel had been updated with sources from the OSFMK 7.3 (Open-Source Foundation Mach Kernel) [5] project, and that the BSD side of the kernel had been updated with sources from the FreeBSD, NetBSD, and OpenBSD projects at the same conference. [4] They also unveiled I/O Kit, a new driver model designed to replace NeXTSTEP's Driver Kit, noting Driver Kit's lack of power management and hot-swap capabilities, as well as its lack of automatic setup capability. [6]

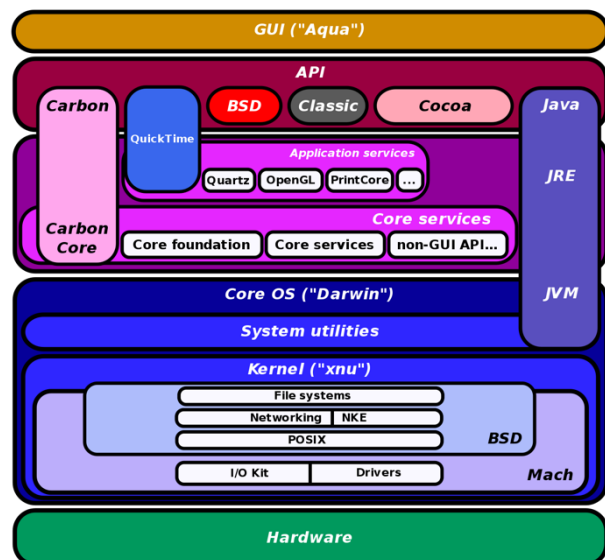


Fig 6. macOS Architecture

**LINUX** - The Kernel, Libraries, System Utility Programs, Hardware layer, and Shell utility are the primary components of the Linux operating system's architecture.

**Kernel:-** It is in charge of all of the Linux OS's primary functions. This operating system is made up of different sorts of modules and works directly with the hardware. The kernel provides the necessary abstraction for the system to hide low-level hardware or application program specifics. Monolithic kernels, Micro kernels, Exo kernels, and Hybrid kernels are some of the most common kernel kinds.

**Libraries:** These libraries can be given as a set of distinct functions. These are used to implement operating system functionality and do not require code access rights to kernel modules.

**System Utility Programs:** This group is responsible for performing specialized and specific tasks.



**Hardware layer:** The Linux operating system has a hardware layer that includes Central Processing Unit, Hard disk drive, and RAM, among other peripheral devices.

**Shell:** A shell serves as a link between the kernel and the user. It can afford kernel's services. It can accept commands from the user and perform kernel activities. The shell is available for a variety of operating systems.

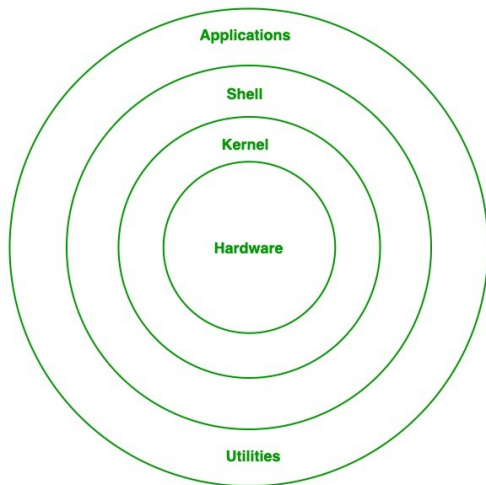


Fig 7. Linux Architecture

#### F. Security

**WINDOWS** - Windows Security is a pretty simple program. It's built into Windows. Virus and threat prevention, Account protection, Firewall & network protection, App & browser management, Device security, Device performance & health, and Family options are the seven components of the program. Microsoft has greatly beefed up its antiviral capabilities in the area of virus and threat protection, and its antivirus program is still called as Windows Defender. Previously, Windows' built-in security did its job quietly in the background. You can conduct four different types of scans with the current edition, all of which are quite normal for antivirus. You may perform a quick scan to look for viruses and malware in the most popular hiding locations. A lengthy complete scan segment examines all the files and programs on your hard drive. You may also run a custom scan to go through specific files or folders. Finally, there's the Windows Defender Offline scan, which shuts down your computer and examines it for malicious software that other scans are unlikely to detect. Windows Security also has the advantage of not pestering you every few days with offers to upgrade to a paid program.

It lacks features such as encrypted cloud storage for important documents, secure file deletion, a password manager, and a VPN subscription that you'd find in a top-tier security suite. Windows Defender can defend your computer and fulfilling its name's promise, and it has no flaws. However, popular free antivirus competitors like as Bitdefender or Kaspersky are superior and installing another app to replace Defender isn't difficult.

**MAC OS** - It has a higher level of security than Windows. It used to be thought of being a completely secure operating system with very few security issues. However, in recent years, we've seen hackers develop new flaws for

macOS. Attackers are diversifying their attacks and aren't ignoring the Mac universe. When it comes to choosing a more secure OS, Comparitech security expert Lee Muson argues that "macOS is likely to be the pick of the lot," but he cautions that it is not impregnable, as once imagined. "It still benefits from a touch of security through obscurity vs the still much larger target given by Microsoft's product," according to its advantage. Because it isn't as frequently targeted as Windows and because Apple does a fantastic job of staying on top of security vulnerabilities, macOS X has a great track record when it comes to security out of the box. With Screen Time, Apple provides robust parental controls in macOS, and the system, which already has a stellar reputation for security, has been toughened even more in the current Catalina edition, which separates the OS and user data on different disks.

Apple generates money by selling high-end gear, so it has less incentive to spy on its customers for profit than firms like Google, whose entire business strategy is based on violating their privacy. Apple has recently made a great show about its commitment to consumer privacy.

**LINUX** - Experts unanimously agree that Linux is the most secure operating system. While it's the operating system of choice for servers, it's a rare organization that uses it on the desktop. And even if you did decide that Linux was the way to go, you'd still have to figure out which Linux distribution to use, which is where things become a little trickier. Users will want a familiar user interface, and you will want the most secure operating system. The fact that Linux is open source is, of course, a significant differentiator. The ability for developers to view and comment on each other's work may appear to be a security nightmare, yet it turns out to be a key reason for Linux's security. It can be reviewed by anyone to ensure that there are no bugs or back doors.

In the area of information security, Linux and Unix-based operating systems have less exploitable security weaknesses. The tech community reviews Linux code, which lends itself to security: There are fewer weaknesses, bugs, and threats with so much control.

Linux has some disadvantages, such as requiring more technical knowledge than ordinary users. Choose another operating system if you're afraid of seeing a command line. Another issue is that it lags behind Windows, macOS, and even Chrome OS in terms of support for hardware peripherals and popular application applications. Another flaw in Ubuntu is the lack of key programs like Photoshop and Microsoft Office. You can discover replacements that perform the same essential duties, but you'll miss out on the slickness and extensive tool set of the actual product.

### III. CONCLUSION

In Conclusion, there are many operating systems out there in the market, with many latest advancements suiting various user requirements. Every operating system has its own set of advantages and disadvantages. In this paper we have compared few of the features of an OS between the three operating systems Windows, macOS and Linux. While it is difficult to say which operating system is best overall, we have tried to discuss better aspects in each operating

system, It is up to the user to select an operating system that fits their requirements.

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