Comparative Analysis of Modern Operating Systems

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Abstract

An operating system (OS) is a collection of programs that manages computer hardware and provides shared services to software applications. The operating system of a computer system is a critical component of the system software. It is typically required for application programs to function, it controls the execution of all other programs of the system software that allow humans to manage and use computer systems. In essence, is a group of software programs whose purpose is to manage computer resources and provide an interface for client applications to interact with various computer hardware. Different operating systems have emerged over the years having varieties of features and functionalities. In view of this, the comparative analysis of different OS is needed to provide details on the similarities and difference in recent types of OS vis-à-vis their pros and cons. This paper highlights the comparative analysis of Windows, Android, Linux, Unix, iOS and Mac operating systems based on the OS features and their weaknesses. A qualitative analysis of the six different operating systems is carried out and the result showed that Windows 11 had 0.05 malware file present while Windows 7 machine was 0.09 higher percentage of mobile malware target Androids than iOS. Windows 11, Linux, UNIX and Mac OS are more secured and reliable. Windows and Android are more popular, user-friendly, easy to use and allow more application program than Mac OS. Linux and Android are free while Windows is moderately cost and Mac OS is very costly. Except for Mac and iOS others provide compatibility. Windows 11 and Mac OS possess integrated firewall. Windows and Android tend to be the most widely used because of their affordability, secure, reliable, compatible and user friendly. The paper is structured as follows: Section one presents the introduction, addressing the rationale for the research including the background, section two present the comparative analysis of Windows, UNIX, Linux, Mac, Android, and iOS, their pros and cons and Conclusion is presented in Section three.

Keywords: Windows, Linux, Comparative analysis, Android, Operating System, Mac OS, UNIX, iOS

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INTRODUCTION

The primary purpose of this research is to examine the six selected operating systems with aim of providing comparison, pros and cons respectively. OS is a general part from the computer system software, which controls and coordinates the working of processor and other devices in the system. It maintains the work of application software and separate the necessary hardware recourses, also manage the access of the different applications to them. It is a special kind of software, which cares about the managing of all devices in one computer and interacts between them and the user programs.

Operating system are resource managers. The main resource is computer hardware in the form of processors, storage, input/output, communication devices and data. Some of the operating system functions are: implementing the user interface, sharing hardware among users, allowing users to share data among themselves, preventing users from interfering with one another, scheduling resources among users, facilitating input/output, recovering from errors, accounting for resource usage, facilitating parallel operations, organizing data for secure and rapid access and handling network communications. Controlling the computer involves software at several levels. kernel services, library services and application-level services all of which are part of the operating system. Processes run applications, which are linked together with libraries that perform standard services.

The systems of the 1960's were batch processing systems, but they were able to take better advantage of the computer's resources by running several jobs at once. So, operating system designers developed the concept of multiprogramming in which several jobs are in main memory at once, a processor is switched from job to job as needed to keep several jobs advancing while keeping the peripheral device in use. For example, on the system with no multiprogramming, when the current job paused to wait for other I/O operation to complete, the CPU simply sat idle until the I/O is finished. The solution for this problem that evolved was to partition the memory into several pieces, with a different job in each partition. While one job was waiting for I/O to complete, another job could be using the CPU. The purpose of a computer system is to allow the user to execute programs. So, the operating system provides an environment where the user can conveniently run programs. The user does not have to worry about the memory allocation or multitasking. These things are taken care of by the operating systems. Each program requires an input and produces output. This involves the use of I/O. The operating system hides the user the details of underlying hardware for the I/O, all the user see is that the I/O has been performed without any details, the operating system by providing I/O makes it convenient for the user to run programs.

BACKGROUND OF THE STUDY

This section provides background on the six various kind of operating systems. A more detailed discussion is elaborated on the selected operating systems.

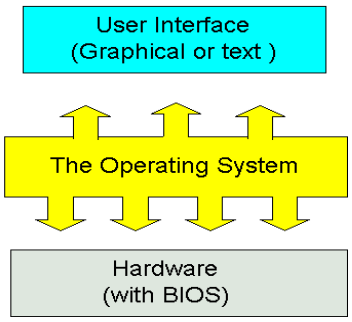

Figure 1. major component of OS

FUNCTIONS OF AN OPERATING SYSTEM

i. Booting the computer

The process of starting or restarting the computer is known as booting. A cold boot is when you turn on a computer that has been turned off completely. A warm boot is the process of using the operating system to restart the computer.

ii. Performs basic computer tasks

The operating system performs basic computer tasks, such as managing the various peripheral devices such as the mouse, keyboard and printers. For example, most operating systems now are plug and play which means a device such as a printer will automatically be detected and configured without any user intervention.

iii. Provides a user interface

A user interacts with software through the user interface. The two main types of user interfaces are: command line and a graphical user interface (GUI). With a command line interface, the user interacts with the operating system by typing commands to perform specific tasks. An example of a command line interface is Disk Operating System (Brain, 2021).

iv. Handles system resources

The operating system also handles system resources such as the computer's memory and sharing of the central processing unit (CPU) time by various applications or peripheral devices. Programs and input methods are constantly competing for the attention of the CPU and demand memory, storage and input/output bandwidth (Chris, 2020).

CONCEPT OF WINDOWS OPERATING SYSTEM

Microsoft Windows is a proprietary operating system that targets the Intel-based PC architectures. Windows including all its versions is estimated to have 92.03% total net market share making it the largest dominant operating system for personal computers. Windows is designed by Microsoft Corporation who originated it in 1985 as an add-on for MS DOS,

which was the standard operating system shipped on most Intel-based PCs at the time. Today, Microsoft Windows has gone through several versions, the most recent version for personal computers is Windows 11; while, the most recent version for server computers is Windows Server 2022, which is built on Windows Server 2019, the release includes advanced multi-layer security, hybrid capabilities with Azure and a flexible platform to modernize applications. Windows is the *defacto* standard operating environment for PCs which must be used in conjunction with MS-DOS, and provides a layer of basic system functionality also defines a system interface that Windows must preserve. As Windows and MS-DOS are usually used together, the term "Windows" is use to refer to the composition of Windows running on top of MS-DOS. The windows operating system designed by Microsoft is one of the best options for personal computers and laptops it comes preinstalled on many computer systems and it is the best operating system for desktop computers and laptops because of its unity, functionality, productivity, support and system utilities. Windows OS has many familiar operating system features to promote security, efficiency and privacy (Anjalee, Shrikant, Rahul, 2021).

1.3.1 1975 - 1981: Microsoft boots up

It's the 1970s. At work users rely on typewriters, to copy a document, a mimeograph or carbon paper is being used. Few have heard of microcomputers, but two young computer enthusiasts, Bill Gates and Paul Allen, see that personal computing is a path to the future. In 1975, Gates and Allen form a partnership called Microsoft. Like most startups, Microsoft begins small, but has a huge vision (Daniel, Marco, 2019).

1.3.2 1982 - 1985: Introducing Windows 1.0

Microsoft works on the first version of a new operating system. Interface Manager is the code name and is considered as the final name, but Windows prevails because it best describes the boxes or computing "windows" that are fundamental to the new system. Windows is announced in 1983, but it takes a while to develop. Skeptics call it "vaporware." (Guptal, 2020).

1.3.3 1987 - 1992: Windows 2.0 - 2.11 - More windows, more speed

On December 9, 1987 Microsoft releases Windows 2.0 with desktop icons and expanded memory. With improved graphics support, which can now overlap windows, control the screen layout and use keyboard shortcuts to speed up your work. Some software developers write their first Windows–based programs for this release (Huang, 2019)

1.3.4 1990 - 1994: Windows 3.0 - Windows NT- Getting the graphics

On May 22, 1990, Microsoft announces Windows 3.0, followed shortly by Windows 3.1 in 1992. Taken together, they sell 10 million copies in their first 2 years, making this the most widely used Windows operating system yet. The scale of this success causes Microsoft to revise earlier plans. Virtual Memory improves visual graphics. In 1990 Windows starts to

look like the versions to come. Windows now has significantly better performance, advanced graphics with 16 colors, and improved icons (Lian, 2018).

1.3.5 Windows NT

When Windows NT releases on July 27, 1993, Microsoft meets an important milestone: the completion of a project begun in the late 1980s to build an advanced new operating system from scratch. "Windows NT represents nothing less than a fundamental change in the way that companies can address their business computing requirements," Bill Gates says at its release. Unlike Windows 3.1, however, Windows NT 3.1 is a 32-bit operating system, which makes it a strategic business platform that supports high-end engineering and scientific programs.

1.3.6 1995 - 2001: Windows 95-the PC comes of age (the Internet)

On August 24, 1995, Microsoft releases Windows 95, selling a record-setting 7 million copies in the first five weeks. It's the most publicized launch Microsoft has ever taken on. Television commercials feature the Rolling Stones singing "Start Me Up" over images of the new Start button. The press release simply begins: "It's here."

1.3.7 1998 - 2000: Windows 98, Windows 2000, Windows Me

Released on June 25, 1998, Windows 98 is the first version of Windows designed specifically for consumers. PCs are common at work and home, and Internet cafes where you can get online are popping up. Windows 98 is described as an operating system that "Works Better, Plays Better" (Mark, 2019).

1.3.8 2001 - 2005: Windows XP-Stable, usable, and fast

On October 25, 2001, Windows XP is released with a redesigned look and feel that's centered on usability and a unified Help and Support services center. It's available in 25 languages. From the mid-1970s until the release of Windows XP, about 1 billion PCs have been shipped worldwide.

1.3.9 2006 - 2008: Windows Vista-Smart on security

Windows Vista is released in 2006 with the strongest security system yet. User Account Control helps prevent potentially harmful software from making changes to the computer. In Windows Vista Ultimate, BitLocker Drive Encryption provides better data protection, as laptop sales and security needs increase. Windows Vista also features enhancements to Windows Media Player as more and more people come to see their PCs as central locations for digital media (Youssef, 2021).

1.3.10 2009: Windows 7

Windows 7 was built for the wireless world that arose in the late 2000s. By the time it was released, laptops were outselling desktops, and it had become common to connect to public wireless hotspots in coffee shops and private networks in the home. Windows 7 included new ways to work with windows-like Snap, Peek and Shake which both improved functionality and made the interface more fun to use. It also marked the debut of Windows Touch, which let touchscreen users browse the web, flip

through photos and open files and folders.

1.3.11 2012: Windows 8

Windows 8 is Windows reimagined from the chipset to the user experience. It functions as both a tablet for entertainment and a full-featured PC for getting things done. It introduces a totally new interface that works smoothly for both touch and mouse and keyboard. Windows 8 also includes enhancements of the familiar Windows desktop, with a new taskbar and streamlined file management.

1.3.12 Windows 8.1

Windows 8.1 is a personal computer operating system that was produced by Microsoft and released as part of the Windows NT family of operating systems. It was released to manufacturing on August 27, 2013, and reached general availability on October 17, 2013, about a year after the retail release of its predecessor.

1.3.13 Windows 10

Windows 10 is the most recent version of the operating system from Microsoft. Officially it was released in 2015 and was initially offered free of charge to legitimate users of Windows 7 and Windows 8.1. This new version combines features from those two previous instalments to suit the users in a better way for both desktop/laptop computers as well as mobile devices.

1.3.14 Windows 11

Is the latest major release of Microsoft's Windows NT operating system, released in October 2021. It is free upgrade to its predecessor, Windows 10, available for any Windows 10 devices that meet the new Windows 11 system (Anjalee, 2021).

Figure 2. Logo of Windows 11 OS.

CONCEPT OF UNIX OPERATING SYSTEM

Unix is a family of multitasking and multi-user computer operating system that derive from the original AT&T Unix, whose development started in 1969 at the Bell Labs research center by Ken Thompson, Dennies Ritchie, and others. Initially intended for use inside the Bell System, AT&T licensed Unix to outside parties in the late 1970s, leading to a variety of both academic and commercial Unix variants from vendors including University of California, Berkeley (BSD), Microsoft (Xenix), Sun Microsystems (SunOS/Solaris), HP/HPE (HP-UX), and IBM (AIX). In the early 1990s, AT&T sold its rights in Unix to Novell, which then sold the UNIX trademark to The Open Group, an industry consortium founded in 1996. The Open Group allows the use of the mark for certified operating systems that comply with the Single UNIX Specification (SUS) (Addison, 2019).

Figure 3. Logo of UNIX OS.

CONCEPT OF LINUX OPERATING SYSTEM

Linux is a UNIX-based operating system. Its original creator was a Finnish student name Linus Torvalds, although being 'open source' it has changed a great deal since its original conception. It belongs to nobody and is free to download and use. Any changes to it are open for all to adopt, and as a result it has developed into a very powerful OS that is rapidly gaining in popularity worldwide, particularly among those seeking an alternative to Windows. Despite this, most Linux distros, especially the major ones, are very intuitive and user-friendly. Also, the desktop environments in Linux are in many ways similar to Windows in their appearance (Marcel, 2018). In 1969, a team of developers in the Bell Labs laboratories started working on a solution for the software problem, to address these compatibility issues. They developed a new operating system, which was Simple and elegant, Written in the C programming language instead of assembly code (Nelson, 2020). Below is the Logo of Linux OS.

Figure 4. Logo of LINUX OS.

CONCEPT OF MAC OPERATING SYSTEM

The Mac OS is previously OS X and originally Mac OS X is a Unix operating system developed and marketed by Apple Incorporation. since 2001. It is the primary operating system for Apple' Mac Computers within the market of desktop and laptop computers it is the second most widely used OS after Microsoft Windows and ahead of ChromeOS. MacOS succeeded the classic Mac OS, a Mac operating system with nine releases from 1984 to 1999. During this time, Apple cofounder Steve Jobs had left Apple and started another company, NeXT, developing the NeXTSTEP platform that would later be acquired by Apple to form the basis of macOS(Maurice, 1998). The first desktop version, Mac OS X 10.0, was released in March 2001, with its first update, 10.1, arriving later that year. All releases from Mac OS X 10.5 Leopard and after are UNIX 03 certified, with an exception for OS X 10.7 Lion. Apple's other operating systems (iOS, iPadOS, watchOS, tvOS, audioOS) are derivatives of MacOS.

Figure 5. Logo of MacOS.

MacOS's core is a POSIX-compliant operating system built on top of the XNU kernel, with standard Unix facilities available from the command line interface. Apple has released this family of software as a free and open source operating system named Darwin. On top of Darwin, Apple layered a number of components, including the Aqua interface and the Finder, to complete the GUI-based operating system which is MacOS.

Table 1. **Mac OS X, OS X and MacOS version information**

Mac OS X, OS X AND MacOS VERSION INFORMATION								
Version	**Release Name**	**Darwin version**	**Processor support**	**Application support**	**Kernel**	**Date announced**	**Release date**	**Most recent version**
Rhapsody Developer Release	Grail1Z4/Titan1U (internal codename)	Un-known	32-bit PowerPC	32-bit PowerPC	32-bit	January 7, 1997	August 31, 1997	DR2 (May 14, 1998)
Mac OS X Server 1.0	Hera (internal codename)	Un-known				Unknown	March 16, 1999	1.2v3 (October 27, 2000)
Mac OS X Developer Preview	Unknown	Un-known				May 11, 1998	March 16, 1999	DP4 (April 5, 2000)
Mac OS X Public Beta	Kodiak (internal codename)	Un-known				May 15, 2000	September 13, 2000	–
Mac OS X 10.0	Cheetah (internal codename)	1.3.1				January 9, 2001	March 24, 2001	10.0.4 (4Q12) (June 22, 2001)
Mac OS X 10.1	Puma (internal codename)	1.4.1/5				July 18, 2001	September 25, 2001	10.1.5 (5S60) (June 6, 2002)
Mac OS X 10.2	Jaguar	6	32/64-bit PowerPC[e 1]			May 6, 2002	August 24, 2002	10.2.8 (October 3, 2003)
Mac OS X 10.3	Panther	7				June 23, 2003	October 24, 2003	10.3.9 (7W98) (April 15, 2005)
Mac OS X 10.4	Tiger	8	32/64-bit PowerPC and Intel	32/64-bit PowerPC and Intel		May 4, 2004	April 29, 2005	10.4.11 (November 14, 2007)
Mac OS X 10.5	Leopard	9				June 26, 2006	October 26, 2007	10.5.8 (9L31a) (August 13, 2009)
Mac OS X 10.6	Snow Leopard	10	32/64-bit Intel	32/64-bit Intel 32-bit PowerPC]	32/64-bit	June 9, 2008	August 28, 2009	10.6.8 (10K549) (July 25, 2011)
Mac OS X 10.7	Lion	11	64-bit Intel	32/64-bit Intel		October 20, 2010	July 20, 2011	10.7.5 (11G63) (October 4, 2012)
OS X 10.8	Mountain Lion	12			64-bit	February	July 25,	10.8.5 (12F2560)

						16, 2012	2012	(August 13, 2015)
OS X 10.9	Mavericks	13				June 10, 2013	October 22, 2013	10.9.5 (13F1911) (July 18, 2016)
OS X 10.10	Yosemite	14				June 2, 2014	October 16, 2014	10.10.5 (14F2511) (July 19, 2017)
OS X 10.11	El Capitan	15				June 8, 2015	September 30, 2015	10.11.6 (15G22010) (July 9, 2018)
macOS 10.12	Sierra	16				June 13, 2016	September 20, 2016	10.12.6 (16G2136) (September 26, 2019)
macOS 10.13	High Sierra	17				June 5, 2017	September 25, 2017	10.13.6 (17G14042) (November 12, 2020)
macOS 10.14	Mojave	18				June 4, 2018	September 24, 2018	10.14.6 (18G9323) (July 21, 2021)
macOS 10.15	Catalina	19		64-bit Intel		June 3, 2019	October 7, 2019	10.15.7 (19H2026) (July 20, 2022)
macOS 11	Big Sur	20	64-bit Intel and ARM	64-bit Intel and ARM[Note 4]		June 22, 2020	November 12, 2020	11.7.2 (20G1020) (December 13, 2022)
macOS 12	Monterey	21				June 7, 2021	October 25, 2021	12.6.2 (21G320) (December 13, 2022)
macOS 13	Ventura	22				June 6, 2022	October 24, 2022	13.1 (22C65) (December 13, 2022)

Source: setapp, 2022

CONCEPT OF ANDROID OPERATING SYSTEM

This operating system was first developed by Android Inc., a software company located in Silicon Valley before it was acquired by Google in 2005. Android is a mobile operating system based on a modified version of the Linux kernel and other open-source software, designed primarily for touchscreen mobile devices such as smartphones and tablets. Android is developed by a consortium of developers known as the Open Handset Alliance though its most widely used version is primarily developed by Google. It was unveiled in November 2007, with the first commercial Android device, the HTC Dream, being launched in September 2008. At its core, the operating system is known as Android Open Source Project (AOSP) and is free and open-source software (FOSS) primarily licensed under the Apache License. However most devices run on the proprietary Android version developed by Google, which ship with additional proprietary closed-source software pre-installed, most notably Google Mobile Services (GMS) which includes core apps such as Google Chrome, the digital distribution platform Google Play, and the associated Google Play Services development platform. While AOSP is free, the "Android" name and logo are trademarks of Google, which imposes standards to restrict the use of Android branding by "uncertified" devices outside their ecosystem. Over 70 percent of smartphones based on Android Open Source Project run Google's ecosystem (which is known as simply Android), some with vendor-customized user interfaces and software suites, such as TouchWiz and

later One UI by Samsung and HTC Sense (Akinlolu, 2020).

Figure 6. Logo of Android OS.

CONCEPT OF iOS OPERATING SYSTEM

iOS is a mobile operating system, developed by Apple Inc. for iPhone, iPad, and iPod Touch. Updates for iOS are released through the iTunes software and, since iOS 5, via over-the-air software updates. iOS is the world's most advanced mobile operating system. iOS 16 provides an abundance of exciting new APIs and capabilities that help to empower people to do more easily. iOS (formerly iPhone OS) is an operating system created exclusively for its hardware. It is the operating system that powers many of the company's mobile devices, including the iPhone. It is the world's second-most widely installed mobile operating system.

Figure 7. Logo of iOS.

COMPARATIVE ANALYSIS OF WINDOWS, ANDROID, LINUX, UNIX, iOS AND MAC OPERATING SYSTEMS.

The research comprises of a comparative study of the following operating systems: Windows, Android, Linux, Unix, iOS and Mac operating systems. Issues of concern are: Computer Architecture Supported, File System Supported, Manufacturer, Target System Type, Development and Distribution, Compatibility, Integrated Firewall, Security Threats, Shell Terminal, Kernel Type, Reliability and User Friendly also the pros and cons of each of the operating systems were listed. The comparison of the operating systems based on features and functionalities is presented below:

Table 2. Comparative Analysis of Windows, Android, Linux, Unix, iOS and Mac Operating systems.

O.S → / FEATURES ↓	WINDOWS	ANDROID	LINUX	UNIX	iOS	MAC
Computer Architecture Supported	x86, x86-64	Android-x86 powered by AMD and Intelx86 processors.	x86, x86-64, PowerPC, SPARC, Alpha, Others	Available on PA-RISC and Itanium machines. Solaris also available for x86/x64 based systems. OSX is PowerPC (10.010.5)/x86(10.4)/x64 (10.5-10.8)	ARM	68k, PowerPC
File System Supported	NTFS, FAT & exFAT with ISO 9660; UDF, 3rd Party driver that supports file system ext2, and ext3, ReiserFS, and HFS	Ext4	ext2, ext3, ex4, ReiserFS, FAT, ISO 9660, UDF, NFS, and others.	jfs, gpfs, hfs, hfs+, ufs, xfs, zfs format	HFS+, FTP	ext2, ext3, ex4, ReiserFS, FAT, ISO 9660, UDF, NFS, and others.
Manufacturer	Microsoft Inc.	Open source OS designed &developed by Android Inc. Google is now the current owner.	Linux is developed as open source OS under the GNU project by the Originator, Linus Torvalds and many others.	Three biggest distributions are Solaris running (Oracle), AIXon (IBM) & HPUX Hewlett Packard. And Apple Makes OSX, an Unix based OS.	Apple Inc. closed, with components that are source openly.	Apple Inc. for their Macintosh line of computer systems.
Target System Type	Workstation, Personal Computer, Media Centre, Tablet PC, Embedded.	Consumer, Enterprise, education	Desktop/Server Depends on Distribution	8086 UNIX system, PDP-11/70 system	Smartphone, music system player, Tablet system/ computer	Workstation, Personal Computer, embedded
Development and Distribution	Developed and distributed by Microsoft.	OHA (Open Handset Alliance)	Linux is Open Sourced and distributed by various vendors.	Unix system has various flavors, most of which are developed by AT&T with other commercial vendors and non-profit orgs.	Apple Inc. developed and distributed iOS.	Mac OS was designed only to be deployed by Apple Computers.
Compatibility	Can co-exist on local networks with Windows, BSD, Macs, and other	Better than iOS	Linux has few programs and games like Windows. But is	Unix does not have as many programs and games as Windows	Compatibility is fair.	Only few programs will run on Mac.

	Unix-like systems. More compatible.		more compatible and scalable than Unix			
Integrated Firewall	Windows Firewall	iptables	Chroot capability-based security, [s 5] seccomp, SELinux	IPFilter	Firewall-IP for iOS	Application Firewall
Security Threats	Huge	Negligible	Negligible	Mild	Negligible	Negligible
Shell Terminal	CMD	Mesh	Bash shell powerful shell with many features	Originally the Bourne Shell. Now it's compatible with many others including BASH, Korn & C.	Bank Shell	BASH
Kernel Type	Hybrid	Linux kernel	Monolithic with modules	Monolithic with modules	XNU kernel of Darwin	Monolithic with modules
Reliability	Great	Could be unstable	Great	Greater	More than Android	Greatest
User Friendly	Very User Friendly	Very User Friendly	Depends on Distribution. Friendlier to users.	Unix is user-friendly. It's just choosy about	Very User Friendly	Very User Friendly

PROS AND CONS OF WINDOWS, ANDROID, LINUX, UNIX, iOS AND MAC OPERATING SYSTEMS.

Table 3. Pros and Cons of Windows OS

PROS	CONS
It comes with antivirus software to the system from malware.	Windows is a closed-source software
Focus Assist to turn off notifications while working	Has expensive license agreements
In case a new hardware gets release, windows roll out updates and support for products.	Poor support for older hardware

Table 4. Pros and Cons of Android OS.

PROS	CONS
Open Source Platform supported by a wide-range of mobile device manufacturer and communities	Unstable and disposed to crashes compared to other OS.
Easy access to many free and premium app from communities of Apps developers that support Android OS	Being open source, so many apps are created. Very few of these applications might have bugs which can be abused by hackers or viral infections.
Multitasking: Android Operating system has the capability of running many applications and processes within the same available time.	Poor battery backup management.

Table 5. Pros and Cons of Linux OS

PROS	CONS
Simple graphical user interface	Less popularity
High level of customization and flexibility	Less commercial software availability
Incredible level of security	Compatibility issues with newer hardware

Table 6. Pros and Cons of Unix OS.

PROS	CONS
UNIX provides more control by the user.	Successfully usage of UNIX requires that an expert will be needed on site. Simple installation of new products and updates may be difficult if one is not a UNIX expert.
On UNIX, user has no limitation as anything can be done in as much as the operating system offers it.	Interacting with UNIX system using its command process is difficult, more difficult for a novice, this is why UNIX is most used by sophisticated users.
UNIX also can offer both freedom and danger because the operating system can be changed and make more compatible with desired one.	UNIX operating system is a customizable OS.

Table 7. Pros and Cons iOS

PROS	CONS
Stable and safe Operating System for mobile phones.	iOS only support Apple Hardware, and less operability.
Probably the most loved interface for any mobile OS in the market. Good looking designed desktop and app icons which go hand to hand with the stunning looks of Apple devices.	Very costly
Minimal viruses and safe OS with the consideration of very high standard when applications were developed and when updates were also made.	Too simple and doesn't support computer work as in other OS

Table 8. Pros and Cons of MacOS

PROS	CONS
Apple Macs get almost no viruses. This is because Windows has a very large and superior market share over other OS.	The cost of purchase of Mac is more than that of Windows.
Apple computers offers itself for Macs to run only on it, and hence less prone to crashing of hardware and software.	Only available on Apple computers: Already having a computer system that is not an Apple, one will not be able to install MAC in such system. Otherwise, one will need to purchase a new computer system.

Table 8. Operating System Market Share Worldwide (gs.statcounter, 2022)

Operating Systems	December 2021 %	December 2022 %
Windows	27.8	29.0
Android	38.3	44.49
Linux	0.88	1.11
Unix	8.35	1.87
iOS	14.3	18.0
MacOS	1.81	5.53
Others	8.56	0.00

According to the web usage as of December 2021 and 2022, Android operating system is the most popular operating system in the world. It holds a market share of 38.3% and 44.49% worldwide, followed by Windows with 27.8% and 29%, iOS 14.3% and 18%, MacOS 1.81% and 5.53%, Unix

8.35% and 1.87%, Linux 0.88% and 1.11% respectively. Microsoft Windows is the most dominant desktop operating system (OS) worldwide as of December, 2022.

CONCLUSION

This paper elaborates the comparison, pros and cons of the six most important operating systems, Microsoft Windows, Android, Linux, Unix, iOS and MacOS. The various features and their main components including the architecture were covered extensively, showing the key similarities and differences between them. In fact, both OSs have a lot of common features and mechanisms, though sometimes implemented differently. What differ between them are few attributes such as Computer Architecture Supported, File System Supported, Manufacturer, Target System Type, Development and Distribution, Compatibility, Integrated Firewall, Security Threats, Shell Terminal, Overall, Kernel Type, Reliability and User Friendly, Windows operating systems provide comparatively adequate multi-level security technologies making it certified as trusted operating systems that can cope with hostile situations and attacks and provide a secure environment for computer users and their applications also Windows and Android tend to be the most widely used especially the newest versions. It is because they are affordable, secured, reliable, compatible and User-friendly. It could be concluded that every operating system, with a particular direction, was developed by considering targeted customers and their interest. Every Operating System, mobile OS inclusive, provides competitive and distinct features and services for their customers. However, all open sourced Operating Systems enjoys addition of new ideas, in applications and updates every day by various community developers, this also enhanced their security features and performance, while the enterprise OS lacks flexibility of design. This will not underscore the fact that every OS is good, but users' choice depends on the services required of it.

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