

OPERATING SYSTEM SECURITY: A COMPARATIVE ANALYSIS OF WINDOWS 11, LINUX MINT 22 CODENAMED “WILMA”, AND MACOS 14 SONOMA

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Abstract

This paper is a comprehensive comparative analysis of three popular operating systems: Windows 11, Linux Mint 22 "Wilma," and macOS 14 Sonoma. The study analyzes their features, performance, security, user experience, and target audiences. Windows 11 stands out in versatility, gaming optimization, and integration with the overall ecosystem but lags in terms of strict hardware requirements and privacy concerns. Linux Mint 22, being very lightweight, flexible, and cost-effective, appeals to developers and privacy-conscious user while suffering from low availability of software and hardware compatibility. macOS 14 Sonoma offers a premium, seamless experience within the Apple ecosystem through a focus on security, creativity, and performance but is way off from both ends due to its highly price-related exclusivity to Apple devices.

The findings indicate that the choice of an operating system depends on individual priorities, such as affordability, customizability, or high-end functionality, with each OS catering to distinct user needs. Recommendations are provided for users, developers, and organizations to optimize system selection and usage.

Keywords: *Operating System Security, Windows 11 Security, Linux Mint 22 Security, macOS 14 Sonoma Security, Comparative Analysis, Security Frameworks.*

Introduction

Operating System Security: An Overview

Operating system (OS) security is the backbone of modern computing, serving as the first line of defense against a wide range of cyber threats. With the exponential growth of connected devices and an ever-expanding digital ecosystem, ensuring robust OS security has become more critical than ever. The security implementations at the level of the operating system are actually aimed at defending core system functions, user information, and all forms of communications over the networks against unauthorized accesses, malicious attacks, and exploitable vulnerabilities. The developing nature of this technology, then, calls upon developers to take on more modern and advanced techniques of security inside their systems. This paper analyzes the security paradigms of three leading operating systems: Windows 11, Linux Mint 22 (codenamed "Wilma"), and macOS 14 Sonoma. It offers a comparative analysis of their design philosophies, strengths, and challenges [5].

Windows 11: Reinventing Security for the Modern Age

Microsoft's Windows 11 is a giant leap forward in terms of OS security, based on the foundation laid by its predecessor, with enhanced hardware-based security, secure boot protocols, and a strong focus on zero-trust architecture. Windows Hello for biometric authentication and virtualization-based security (VBS) are some of the features that Windows 11 aims to create a secure environment for personal and enterprise users alike. It also focuses on high-level encryption algorithms and offers BitLocker for protecting confidential information. Although it has progressed much, Windows 11 still lags in its consistency with regard to security because of the varied nature of hardware and user settings. This paper discusses the security features of Windows 11 and evaluates the reaction of Windows 11 toward the already established vulnerabilities and cyber threats [8].

Linux Mint 22 "Wilma": The Open-Source Security Paradigm

Linux Mint 22, codenamed "Wilma," is a manifestation of the open-source community's commitment to security and user-centric development. Being lightweight and providing extensive customization, Linux Mint has attracted privacy-conscious users and developers, who value transparency and control over their computing environment. Through the use of kernel-level security features such as SELinux and AppArmor and regular security updates from the Linux community, "Wilma" ensures its reputation as a secure OS. The decentralized

nature of its development encourages rapid responses to vulnerabilities, making it a resilient choice against cyber threats. Linux Mint is challenging in its attempt to ensure smooth security integration for non-technical users and enterprises that require large-scale deployment. This paper examines the distinctive characteristics of Linux Mint 22's security mechanisms, highlighting its strengths and limitations [7].

macOS 14 Sonoma: Apple's Walled Garden Approach to Security

Apple's macOS 14 Sonoma epitomizes a seamless blend of innovation and security, leveraging its tightly controlled ecosystem to deliver unparalleled protection. By enforcing stringent app vetting protocols through the Mac App Store and implementing cutting-edge security features like Gatekeeper and System Integrity Protection (SIP), macOS continues to set a high standard for OS security. Sonoma introduces further refinements, including improvements in kernel integrity protection and expanded support for hardware-backed encryption. However, Apple's closed-source approach has sparked debates over transparency and user control. While its security framework effectively mitigates a wide range of threats, it is not immune to zero-day vulnerabilities and targeted attacks. This research investigates macOS 14 Sonoma's security infrastructure and evaluates its effectiveness compared to its peers [2].

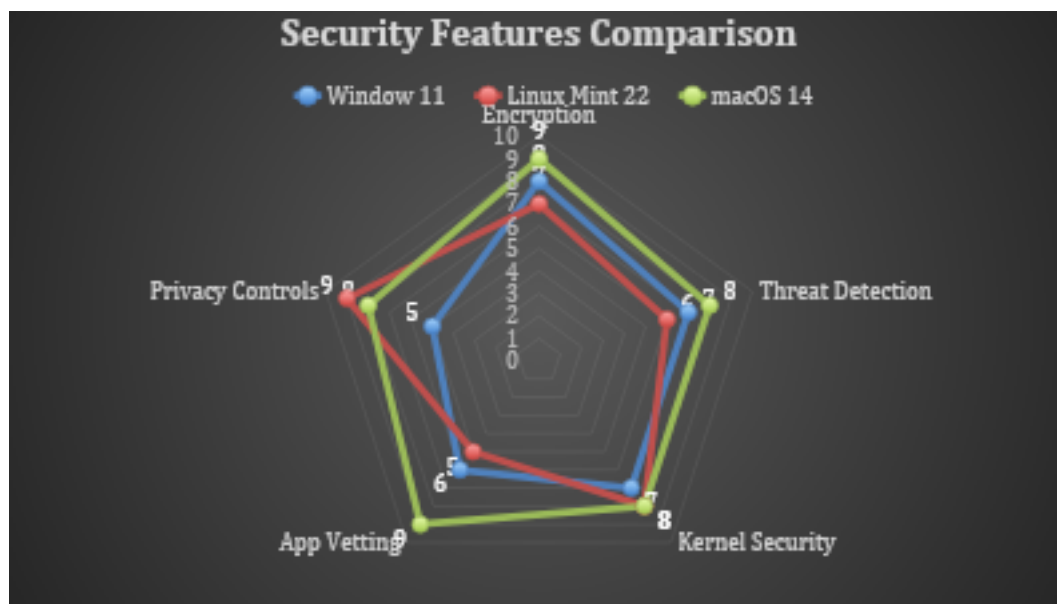


Figure 1 - Comparison of the Security Features

The radar chart is a comparison of the security features of Windows 11, Linux Mint 22, and macOS 14 Sonoma on five categories: encryption, threat detection, kernel security, app vetting, and privacy controls with a score from 0-10.

- Windows 11: Strong overall, but slightly weaker in app vetting and privacy.
- Linux Mint 22: Excels in kernel security and privacy, but slightly lags in encryption and app vetting.
- macOS 14: High scores across all areas, especially encryption and app vetting.

Literature review

This paper titled **"Windows, Linux, Mac Operating System and Decision Making"** identifies the factors determining the choice between Windows, Linux, and macOS. Seven factors for convenience, capability, security, interface, recovery, boot time, and cost were analyzed using a mixed-methods approach comprising literature review and user data analysis to assess these systems' advantages and disadvantages. Findings reveal that Windows is the most used due to its user-friendliness and compatibility, Linux appeals to programmers due to its customizability and cost-effectiveness, and macOS is favored by creatives due to its superior graphical capabilities and security. The study stresses the importance of aligning operating system choice with user-specific needs and technological requirements [3].

The research paper, **"A Comparative Study of Operating Systems: Case of Windows, UNIX, Linux, Mac, Android, and iOS,"** aims at the analysis and comparison of six major operating systems: Windows, UNIX, Linux, MacOS, Android, and iOS, focusing on their features, strengths, and weaknesses. This qualitative study looks into such aspects as security, compatibility, user-friendliness, and market trends. The findings identify the fact that although Windows and Android have dominated due to cost effectiveness, usability, and compatibility, Linux and Android go with an open-source feature and are free. MacOS is seen to be the most secure and reliable, but its hefty price tag poses a constraint for access. It is also found that Windows and MacOS have inbuilt firewalls, whereas Android has increased malware susceptibility than iOS does. This analysis is useful for end-users and developers, who can make informed decisions about which operating systems to use [1].

The paper titled **"An Analytical Approach to Assess and Compare the Vulnerability Risk of Operating Systems"** aims at evaluating and comparing the vulnerability risks of major operating systems (Windows 7, 8, 10, macOS, and Linux) utilizing data from the National Vulnerability Database and the CVE system. Utilizing a quantitative methodology, the research employs a Markov model in calculating risk factors based on 6,838 vulnerabilities reported up to October 30, 2018. The results showed that Windows 7 and 10 had higher mean risk factors than Linux, which was the lowest. The findings also show improvements in security across newer versions of Windows. However, there are significant differences in risk factors across operating systems, as supported by statistical analyses such as ANOVA and non-parametric tests. This approach highlights the need for comprehensive evaluation methods to enhance OS security reliability [6].

The paper aims to **compare the characteristics, relative merits, and demerits of six operating systems: Windows, Android, Linux, Unix, iOS, and macOS**. Qualitative analysis is used to evaluate parameters such as compatibility, user-friendliness, security, cost, and market share. Findings indicate that Windows and Android are leading because they are affordable, accessible to users, and have a wide range of applications. macOS and iOS are more secure but costlier and have limited hardware compatibility. Linux and Unix are preferred for their open-source flexibility and customization, though they have limited commercial software. In conclusion, selection of the operating system is determined by the needs of the user, mainly enterprise solutions concerning stability and security and open-source systems in dependence on community-driven enhancements [4].

The paper focuses on **"A comparative study of contemporary operating systems by memory management as well as the security framework : A Case of Windows, iOS, and Android."** These researches find various features that pose challenges while applying the said operation systems by aspects of the comparison between memories along with how every system guards one's stored files. It used the comparative analysis method to evaluate architectural differences, memory allocation strategies, and security measures like firewalls, encryption, and application sandboxes. Findings indicated that Windows performed well in terms of robustness and variety of applications, but at a higher risk of vulnerability issues, iOS performs better in providing much better security due to built-in encryption and biometric authentication, whereas Android delivers high flexibility and advanced memory management but is frequently met with security concerns. The analysis points out that OS selection must be tailored according to the user's needs and technological requirements [10].

The paper, **"MacOS versus Microsoft Windows: A Study on the Cybersecurity and Privacy User Perception of Two Popular Operating Systems,"** explores user perceptions about the cybersecurity and privacy features of macOS and Windows. It aims to investigate how users evaluate these two operating systems in these domains and assess how these perceptions influence user behavior. Using a mixed-method approach combining qualitative thematic analysis and quantitative statistical modeling, the study utilized a survey of 208 participants on Amazon Mechanical Turk. The main findings are that macOS is perceived by users to be a safer and privacy-oriented platform than Windows, with reputation and Unix-based architecture most often cited as reasons. However, false beliefs, such as that made by many participants by assuming macOS to be "malware-proof," were widespread and led to lax security behaviors among its users. In addition, Windows users had more proactive security practices, such as antivirus and regular backups. The study recommends increased security awareness and targeted operating system feature enhancements to better match user perceptions with actual risks [9].

This literature review examines the strengths, weaknesses, and security frameworks of major operating systems, including Windows, Linux, macOS, Android, and iOS. Key factors such as compatibility, security, cost, and user-friendliness are analyzed. Building on these findings, this paper provides a comparative analysis of Windows 11, Linux Mint 22, and macOS 14, focusing on design philosophies, security measures, and usability. The aim is to guide users in choosing an operating system that meets their modern computing needs while understanding the associated trade-offs.

Comparative Analysis of Windows 11, Linux Mint 22 codenamed “Wilma” and MacOS 14 Sonoma

Operating system security is a critical aspect of modern computing, influencing personal, organisational, and governmental IT strategies. This analysis compares three prominent operating systems: Windows 11, Linux Mint 22 (codenamed "Wilma"), and macOS 14 (Sonoma). The focus will be on their security architectures, built-in features, update mechanisms, user permissions, and overall vulnerabilities.

Table 1: OS Comparison: Windows 11, Linux Mint 22, and macOS 14

Criteria	Windows 11	Linux Mint 22 "Wilma"	macOS 14 Sonoma
User Interface	Modern interface with centered Start Menu, Snap Layouts for multitasking.	Traditional and customizable desktop via Cinnamon environment.	Sleek, polished design with interactive widgets and seamless Apple ecosystem.
Performance	Optimized for diverse hardware; gaming-focused features like DirectStorage and Auto HDR.	Lightweight, efficient, suitable for older and modern hardware alike.	Tailored for M-series processors; high energy efficiency and
Compatibility	Broad compatibility with a wide range of devices and software.	Supports varied hardware configurations; open-source nature allows flexibility.	Exclusive to Apple devices, limited but optimized hardware compatibility.
Security	Hardware-based protections (e.g., TPM 2.0), advanced encryption, virtualization-based security.	Built-in Linux kernel security features like SELinux and AppArmor; community updates.	Strong security measures, including app sandboxing, encryption, and threat monitoring.
Target Audience	Gamers, professionals, and general users seeking versatility.	Developers, privacy-focused users,	Creative professionals and users invested in the Apple ecosystem.

		and those needing a free, customizable OS.	
Cost	Requires licensing fees; included with most new PCs.	Free and open-source.	Included with Apple devices, cost reflected in premium hardware pricing.
Ecosystem Integration	Integrates with Microsoft Office, Xbox, and cloud services.	Limited ecosystem integration; third-party tools are available.	Tight integration with Apple devices and services like iCloud and Continuity.
Updates	Regular feature updates and security patches; requires system restarts.	Rolling community-driven updates; updates are less disruptive.	Seamless updates with minimal user intervention, tailored for specific hardware.
Flexibility	Limited to Microsoft's framework and app store.	Highly flexible and customizable; open-source development encourages control.	Restricted customization; emphasizes consistency and reliability.

This section compares Windows 11, Linux Mint 22, and macOS 14 Sonoma, highlighting their design philosophies and target audiences. Each OS has strengths and weaknesses:

Windows 11: versatile, modern, and gaming-friendly, but resource-intensive and costly.

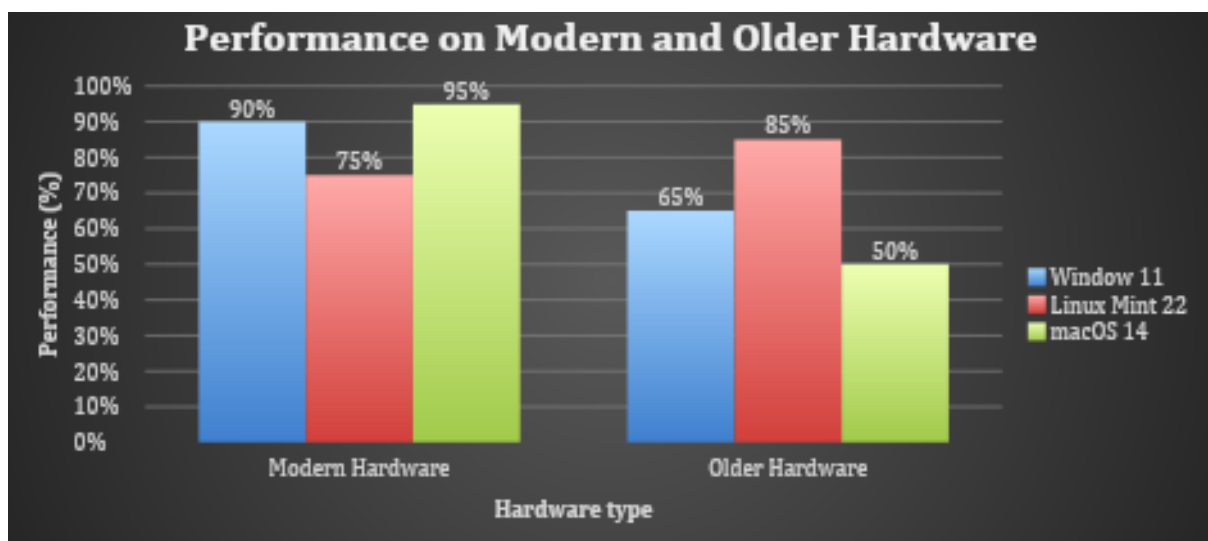
Linux Mint 22: customizable, secure, and cost-effective, but limited by ecosystem integration and proprietary software support.

macOS 14 Sonoma: premium performance, seamless ecosystem, and strong security, but exclusive to Apple devices and expensive.

Ultimately, the choice depends on user priorities, such as affordability, adaptability, or high-end functionality.

Windows 11 is versatile and feature-rich, appealing to a broad audience. Linux Mint 22 focuses on flexibility and resource efficiency, ideal for users seeking cost-effective alternatives. macOS 14 Sonoma provides a premium, integrated experience tailored to Apple's ecosystem and creative professionals. The Choice depends on individual needs and preferences.

Figure 2 - Hardware efficiency of Windows 11, Linux Mint 22, and macOS 14 Sonoma



The bar chart compares the hardware efficiency of Windows 11, Linux Mint 22, and macOS 14 Sonoma:

- Windows 11: Excels on modern hardware (90%) but drops to 65% on older systems due to high requirements.
- Linux Mint 22: Extremely flexible, with 75% compatibility on new and 85% on old hardware.
- macOS 14: Leads on modern systems (95%) but falls off sharply to 50% on older hardware.

The chart indicates trade-offs between modern performance and backward compatibility.

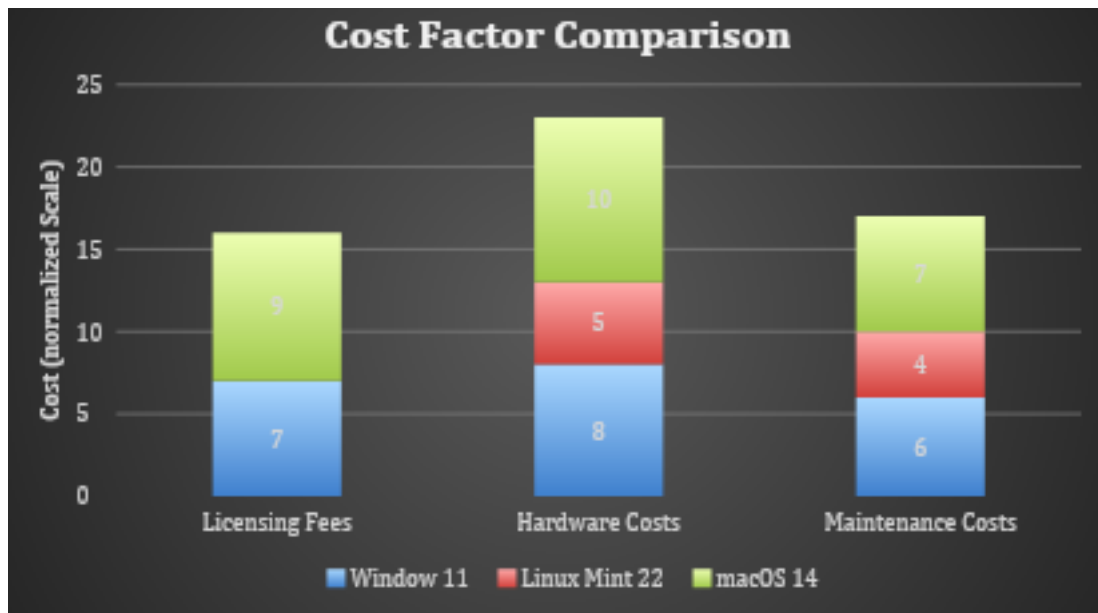


Figure 3 - Cost Factor Comparison

The stacked bar chart in a figure 3 shows the cost differences between Windows 11, Linux Mint 22, and macOS 14 Sonoma:

- Windows 11: Moderate costs, with high licensing fees (7/10) and hardware demands (8/10), balanced by manageable maintenance (6/10).
- Linux Mint 22. Most affordable option, free software, no license fees (0/10) and low-cost hardware (5/10). Maintenance cost would be around (4/10).
- macOS 14: The most expensive, relying on high licensing fees (9/10), Apple specific hardware cost (10/10), and notable maintenance costs (7/10).

Their target audience is depicted below in the pie chart: Windows appeals generally, Linux Mint suits budget and legacy users, while macOS targets premium, professional users.

The pie chart illustrates the user demographics of Windows 11, Linux Mint 22, and macOS 14 Sonoma.

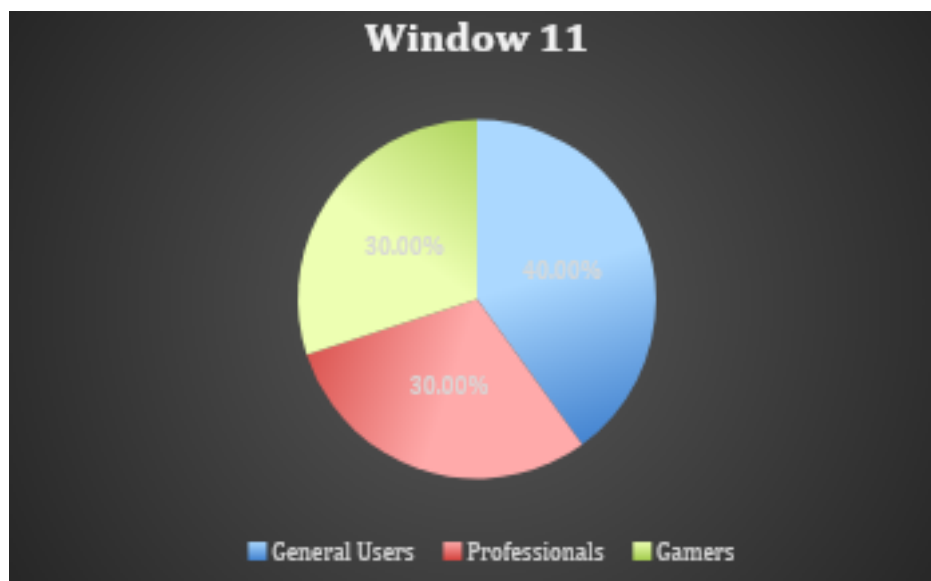


Figure 4 - Wide audience appeal

Windows 11: Wide audience appeal-general users (40%), professionals (30%), and gamers (30%).

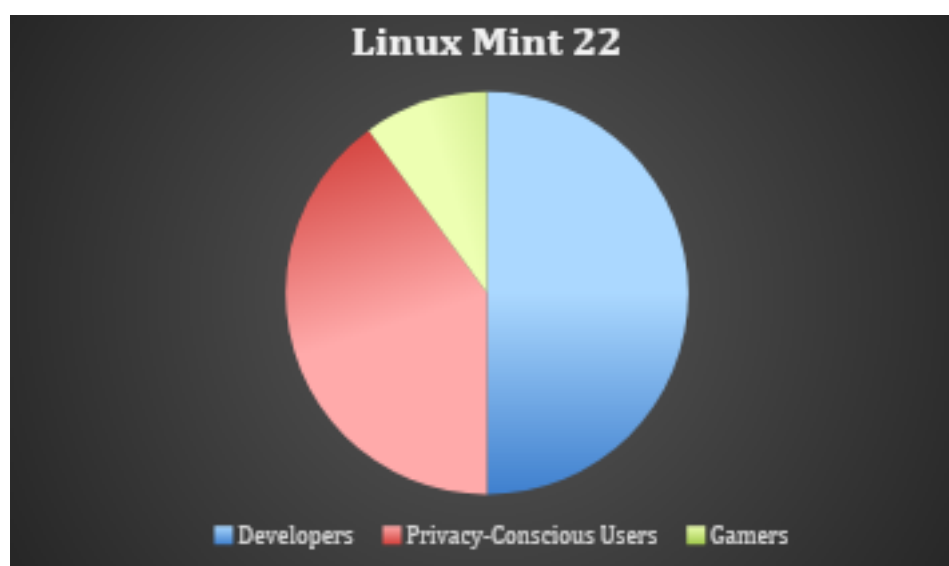


Figure 5 - Linux Mint 22 More Popular Among Developers

Linux Mint 22: More popular among developers (50%) and privacy-focused users (40%), with only 10% of gamers.

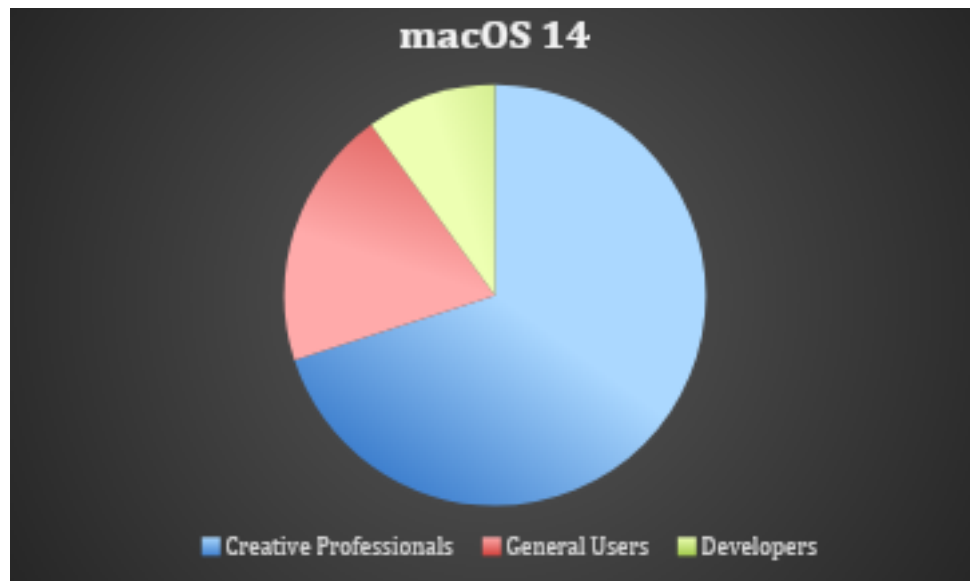


Figure 6 - mac OS 14

macOS 14: creative pros (70%), casual user (20%), and developers (10%).

Each OS serves a different user's needs and preferences.

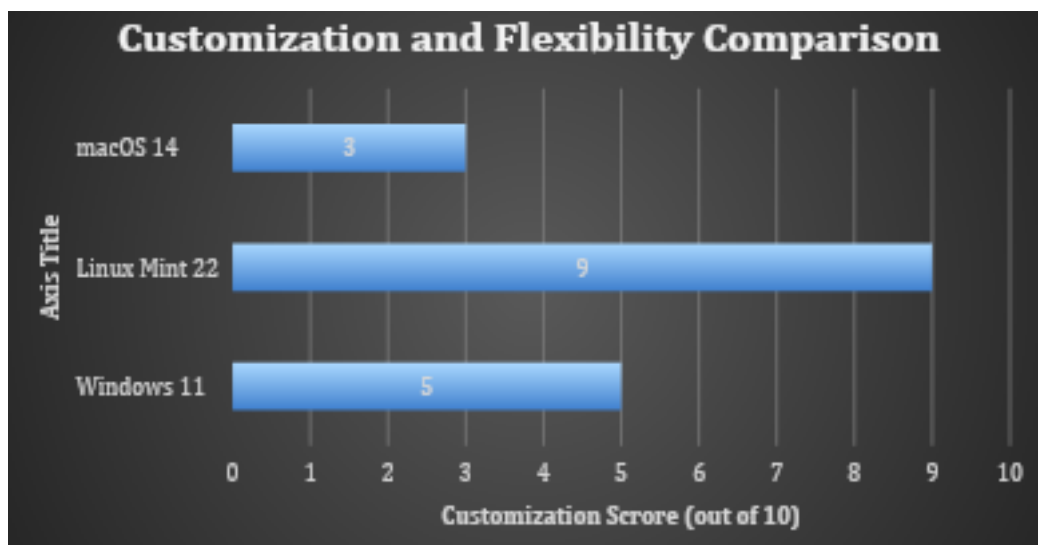


Figure 7 - Comparison of System Customization

The horizontal bar chart compares system customization:

- Windows 11: Medium (5/10), very few options due to its proprietary design.
- Linux Mint 22: Very high adaptability degree with 9/10 due to its open-sourced nature and customization capabilities.

- macOS 14: Very minimalistic, 3/10; closed ecosystem, preferring simplicity over user control.

Linux Mint is the customization leader, whereas Windows and macOS sacrifice control for ease of use.

Discussion

The comparison of Windows 11, Linux Mint 22 "Wilma," and macOS 14 Sonoma shows the strengths and weaknesses of these operating systems, which differ in their philosophies of design and target audience. Windows 11 balances versatility with innovation to appeal to a wide range of users through its modern interface, gaming optimization, and strong ecosystem integration. However, its strict requirements on hardware and privacy concerns also limit it while its licensing can be costly at times. Linux Mint 22, meanwhile, is much better in lightweight, customizable, and cost-efficient solutions, as it appeals most to developers as well as private users. This flexibility, on the other hand, poses difficulty in software and ease of usability for non-technical users. For the creative professional or for someone who puts much importance on security and reliability, macOS 14 Sonoma really does shine as polished, well-refined, and so tightly integrated into an Apple ecosystem. Of course, exclusivity to Apple hardware and its relatively steep cost may put this OS beyond budget-friendly budgets.

The areas in which each operating system shines include compatibility and gaming with Windows 11, adaptability and affordability with Linux Mint 22, and premium performance and integration with macOS 14 Sonoma. In essence, the conclusion shows the significance of the user needs matching the characteristics that each of these operating systems has to offer. It would either be in terms of cost, customization, or high-end functionality, and therefore determines which would best fit for use.

Conclusion

Windows 11, Linux Mint 22 "Wilma," and macOS 14 Sonoma are optimized for the diverse requirements of the new computing world. Windows 11 is a complete package, with all the features one might need for personal and professional use, but it is costly and requires a variety of hardware. Linux Mint 22 is a great alternative for those who want to customize and

save money but will not be enough for those who require proprietary software or seamless ecosystem support. macOS 14 Sonoma is the epitome of integration and performance in the Apple ecosystem, ideal for creatives and professionals but not for users who require affordability or hardware flexibility.

Ultimately, no single operating system emerges as a definitive choice for all users, as their unique attributes cater to different preferences and priorities. The decision largely depends on whether the user values affordability, ecosystem integration, or high-performance features.

Recommendations

1. Users

- Choose Windows 11 if you need a versatile and gaming-friendly system with a strong ecosystem and compatibility.
- Opt for Linux Mint 22 "Wilma" if affordability, customizability, and security are your top priorities.
- macOS 14 Sonoma should be chosen if the user is on the Apple ecosystem and needs top-grade performance for artistic work.

2. Developers

- Use cross-platform apps to fill out the gaps that exist in terms of software availability, especially with Linux.
- Gamification support as well as compatibility of third-party applications should be developed on Linux and macOS to have a wider scope.

3. Organizations

- Scalability, Cost, and Maintenance.
- Windows 11 is best suited to companies that need extensive software support and compatibility.
- Linux Mint works great for low-cost solutions with community support.
- macOS will appeal to creative teams and security-conscious environments.

Once the capabilities and limitations of these operating systems are known, it can help the users or organizations in making the right choices in line with their technical and financial needs.

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