Operating Systems

COMP 3410_01

Comparing Desktop Operating systems

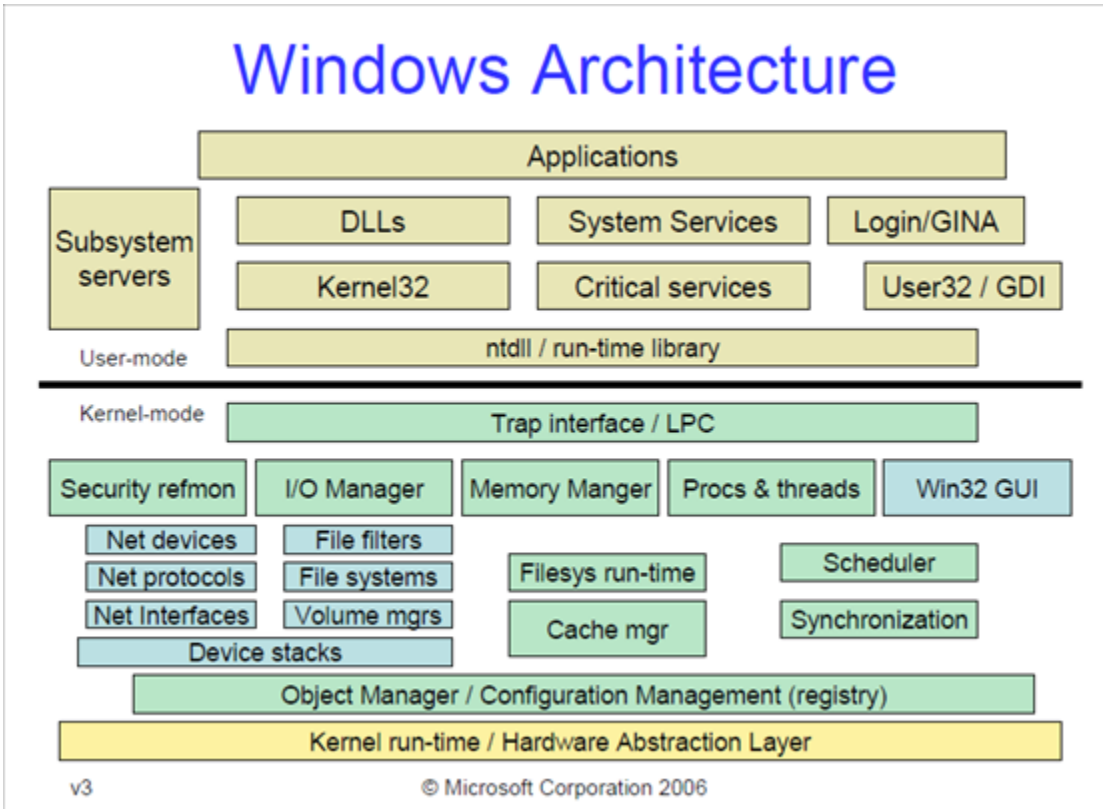
and

Mobile operating systems

Desktop operating systems

Windows vs MacOS

1) Architecture and design



Credit: infosec resources

Windows has a layered design with 2 main components,

- **User mode** – programs in user mode cannot directly access hardware.

- **Kernel mode** – consists of HAL, drivers, executive services, etc. And has unrestricted access to the hardware.

It has a modular structure as shown above for example,

- **HAL (Hardware Abstraction Layer)**
    - It provides an interface between the hardware and operating system.
    - HAL controls the I/O interfaces, Interrupt controller and multiple processors.
    - For example, programs like Video game and VLC media player need access to a certain hardware, HAL uses the drivers to determine which hardware is needed. In this case, Hal gives access to the sound card thereby, allowing multiple programs to run.

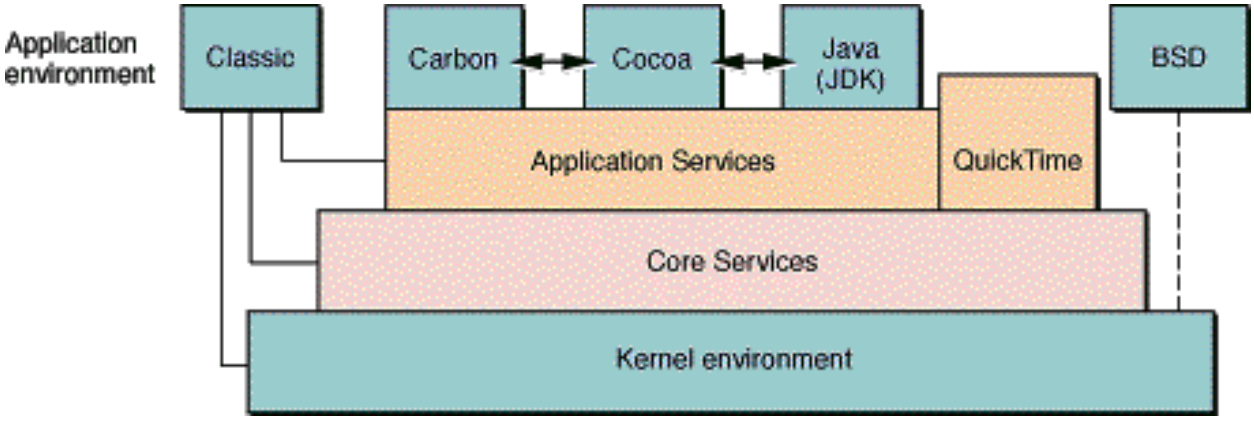
- **Kernel**
    - Kernel synchronizes the activities among processors and schedules activities to be done by CPU.
    - It also restricts user apps to access critical parts of the operating system.

- **Executive services**
    - This section interacts with I/O devices, object management, process management and system security.

- **Environment subsystem**
    - Contains Win32 which controls 32-bit based applications.

- **Integral Subsystem**
    - Creates security token and rights. Manages permissions to user account.

MacOS



It is also a layered design with 4 main components,

- **Application Environment**
  - This is where apps run. It includes XCode, IDE for developing MacOS and iOS apps**.**

- **Application Services**
  - It provides services like core audio for audio processing, core animation and core data for database management.

- **Core Services**
  - These services are finder for file management, spotlight for search and time machine for backup.

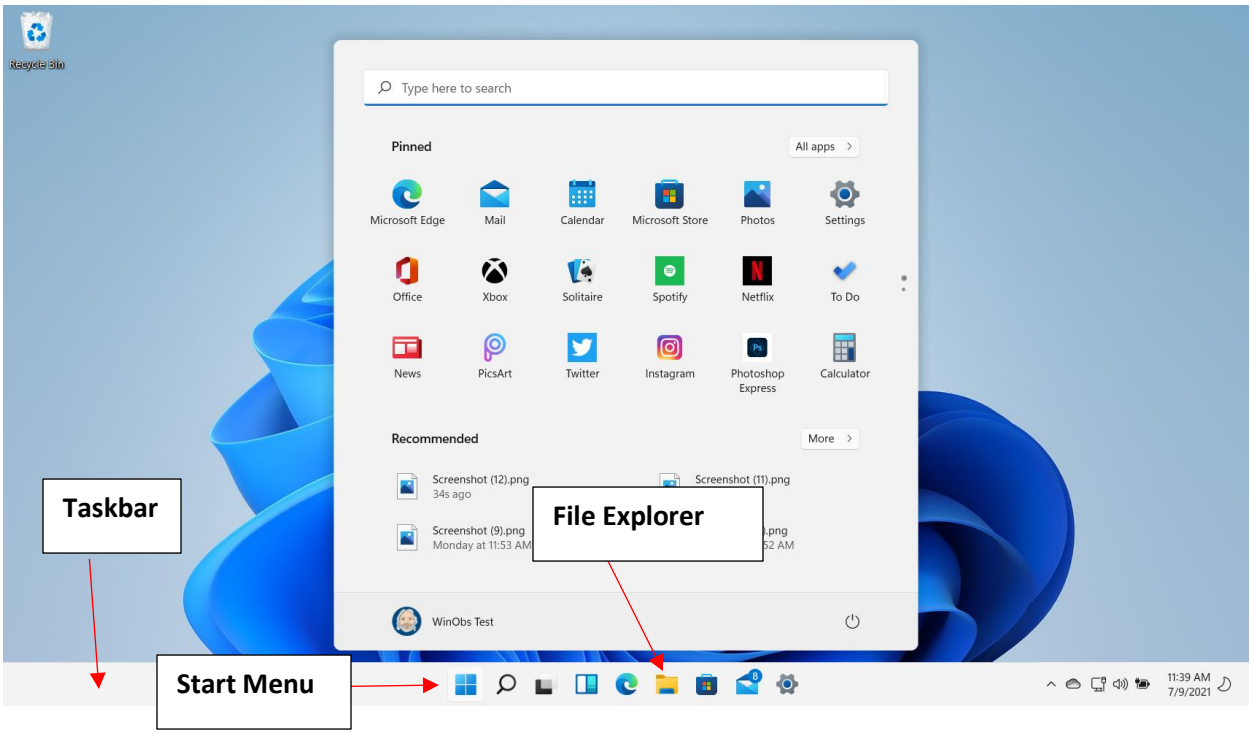
- **Kernel Environment**
  - It is responsible for hardware management and handles system calls, interrupt handling and scheduling tasks**.**

Comparison Table between Windows vs MacOS

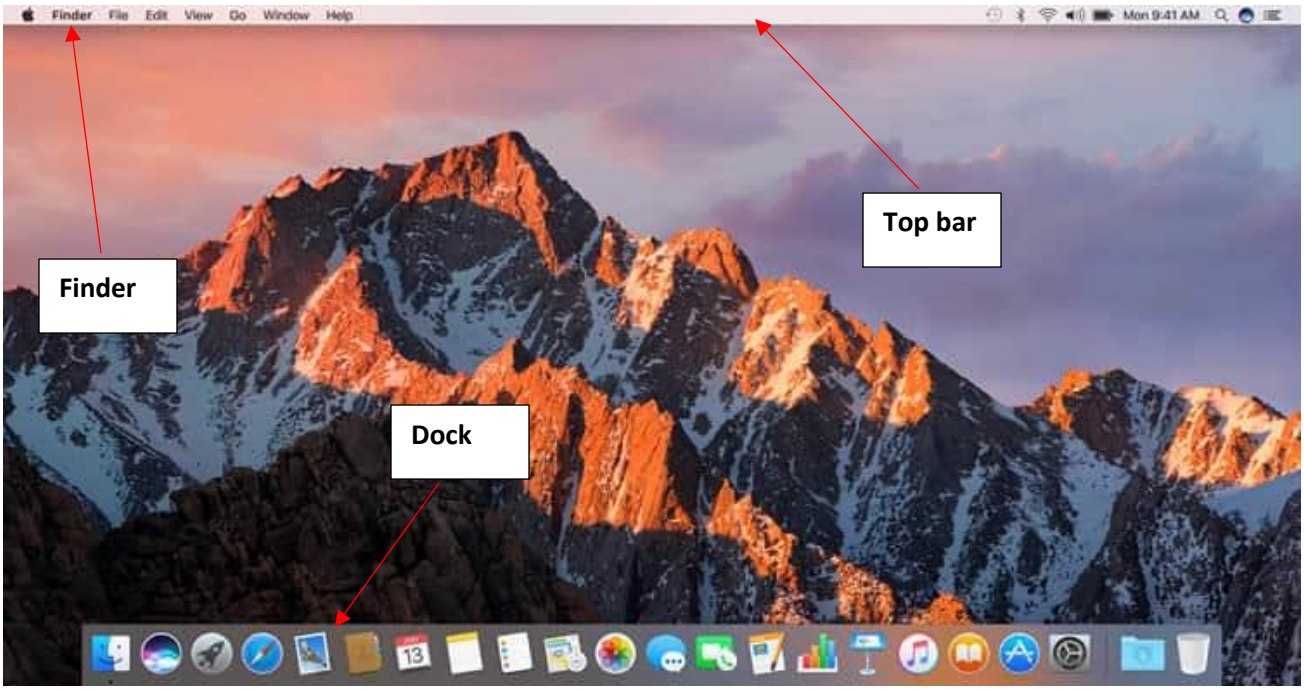
Kernel type	Monolithic kernel – all components are all integrated into a single program.	Both Monolithic and microkernels -This hybrid architecture provides more security.
Hardware compatibility	Works with a wide range of hardware It also supports a lot of drivers.	Works with Apple hardware
Software compatibility	Windows has more software than MacOS, therefore has more software available for it.	MacOS provides specialized software that only work in MacOS for example, Logic pro, iMovie, etc.
customizability	Windows is more customizable and has more options to adjust its appearance and OS.	MacOS doesn't allow a lot of customizability and if adjustments are needed, there are only done by apple.

2) User Interface

Windows



MacOS



Windows	MacOS
Start Menu – this allows users to search for apps and a quick access to settings and recent files.	**Dock –** same functions as the start menu, but it is located at the bottom of the screen and users can add apps to the dock which they frequently access.
Task bar – allows users to switch between open apps and also allows user create new desktop to sperate workspaces.	**Top bar** – displays the name of the app in use and a menu. It has similar feature like windows to create multiple desktops called spaces.
File Explorer – allows users to navigate between files and manage files.	**Finder** – same functions as the file explorer.
Control Panel – allows users to adjust system settings and configure hardware devices	**System Preferences** – same functions as the control panel.

Interaction methods

- Both have context menus that is when the user right clicks it appears.
- Both have keyboard shortcuts that allows users to quickly performs functions like copy, cut, paste, select all etc.

Overall, both have a user-friendly interface but, have different approaches to window management, interface design and customization.

3) Application development

	Windows	MacOS
Programming languages	• **Java** • **Python** • **C#, etc.**	• **Swift** • **Objective-C**
Integrated development Environments (IDE)	• **Visual Studio** • **Eclipse**	• **XCode**
Graphics and Multimedia	• **Adobe photoshop** • **Corel paint shop** • **Capture one pro**	• **Keynote** • **Motion** • **Hype**
Deployment and Distribution	**Developer create MSI packages for installing apps and some can be done from Microsoft store.**	**Distributed by Mac app store.**
Libraries and API's	• **Win32 API** • **.NET Framework** • **DirectX -for gaming**	• **Cocoa** • **Quartz – graphics and image library** • **Metal – for gaming**

For Web app development

- Developer needs to ensure that their apps are compatible in both windows and MacOS browsers because there are some key differences when developing a web app for both Operating systems for example, the CSS safari web-kit vs CSS in Chrome as shown below,

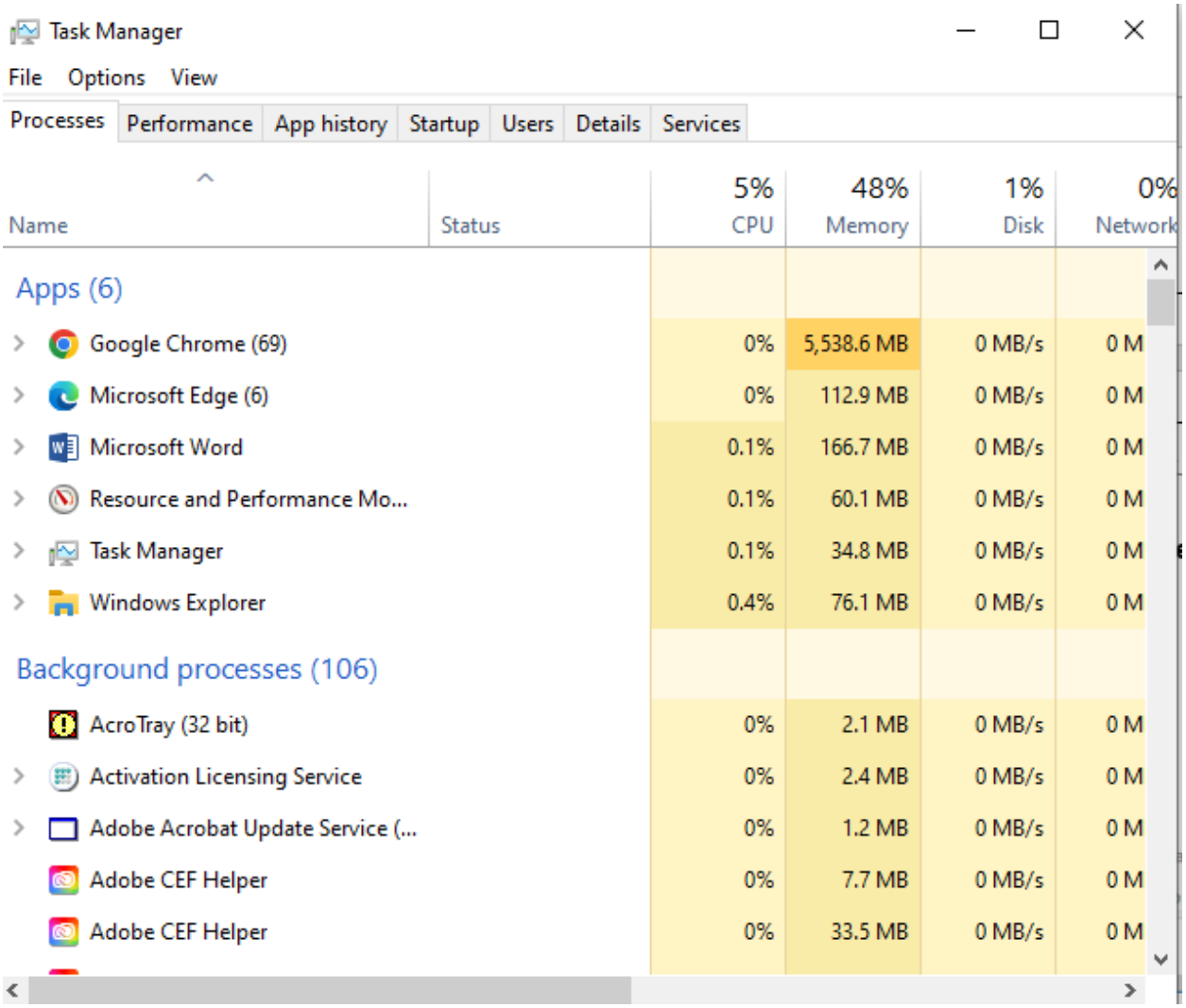
```
#schedule-circle.no-scroll{
  opacity: 0.8;
  position: absolute;
  left: 5%;
  top: 6%;
  -webkit-animation: index-scroll-button-up 3s;
  -moz-animation: index-scroll-button-up 3s;
  -o-animation: index-scroll-button-up 3s;
  -ms-animation: index-scroll-button-up 3s;
  animation: index-scroll-button-up 3s;
}
```

4) Security

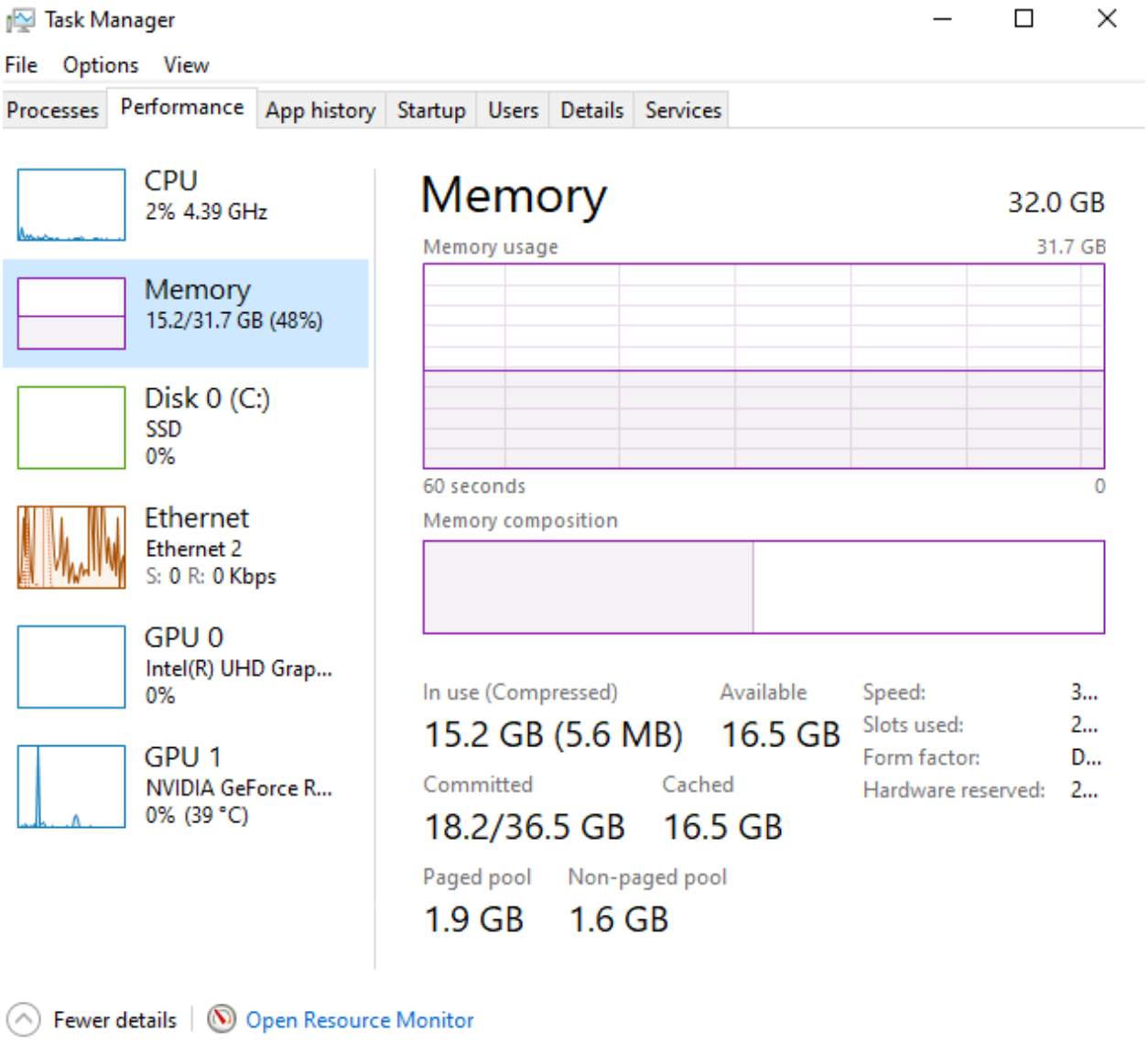
	Windows	MacOS
Hardware level	**Both provide biometric and password or key entry systems to verify access to the user of the device like finger print reader which on sign up prompts the user to place the finger on the reader so that the device stores biometric code, to verify the user for next time access.**	
Software level	**Windows defender which provides virus and malware protection and bit locker which encrypts the data on the hard drive.**	**Gatekeeper in macOS restricts downloads from unverified sources and file vault which encrypts data on the hard drive.**

5) Performance

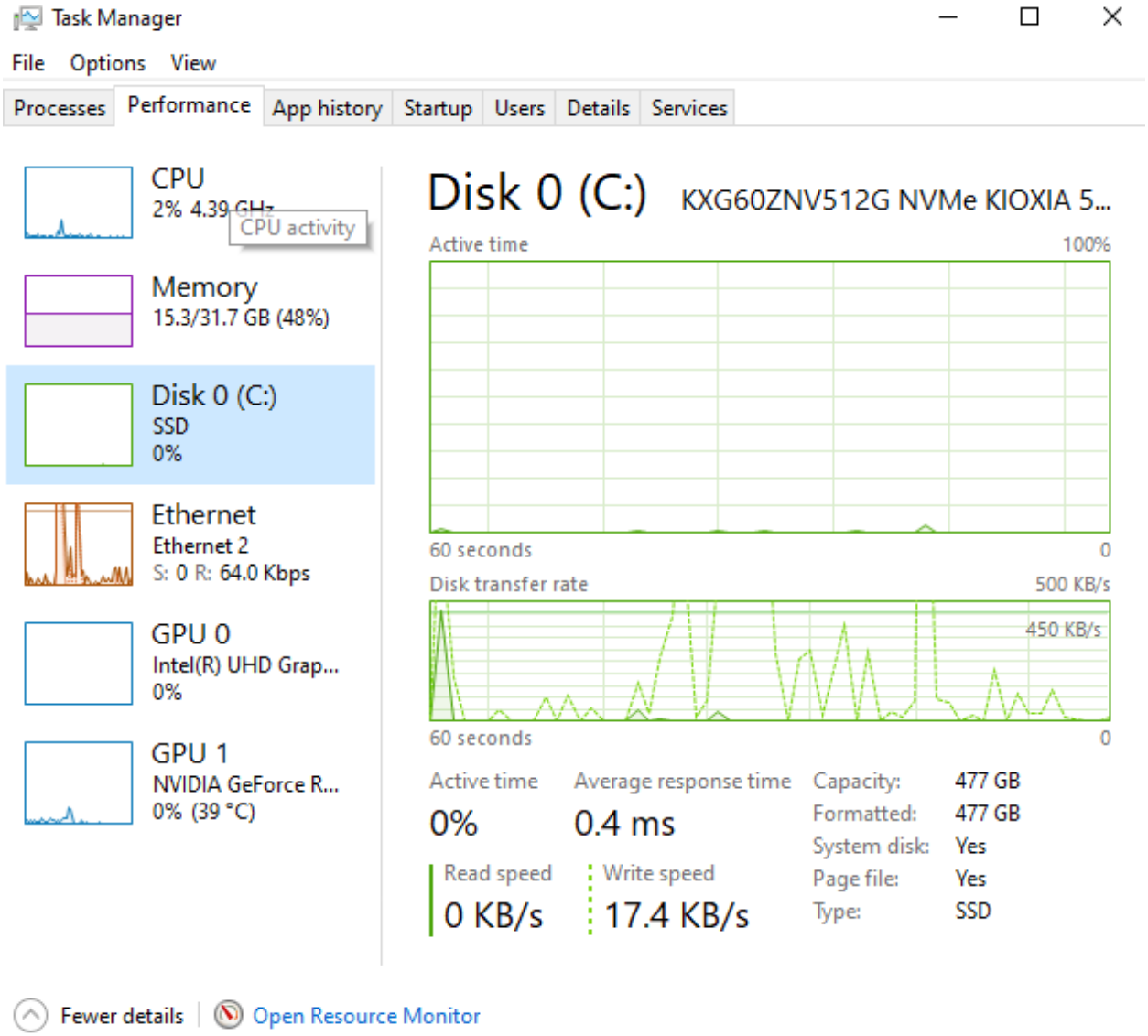
- **Windows uses multiple cores of the CPU to run multiple process together while ensuring the best CPU performance.**
- **Windows task managers provides information on the processes which are running, which help users to distinguish between the light and heavy process as shown below.**



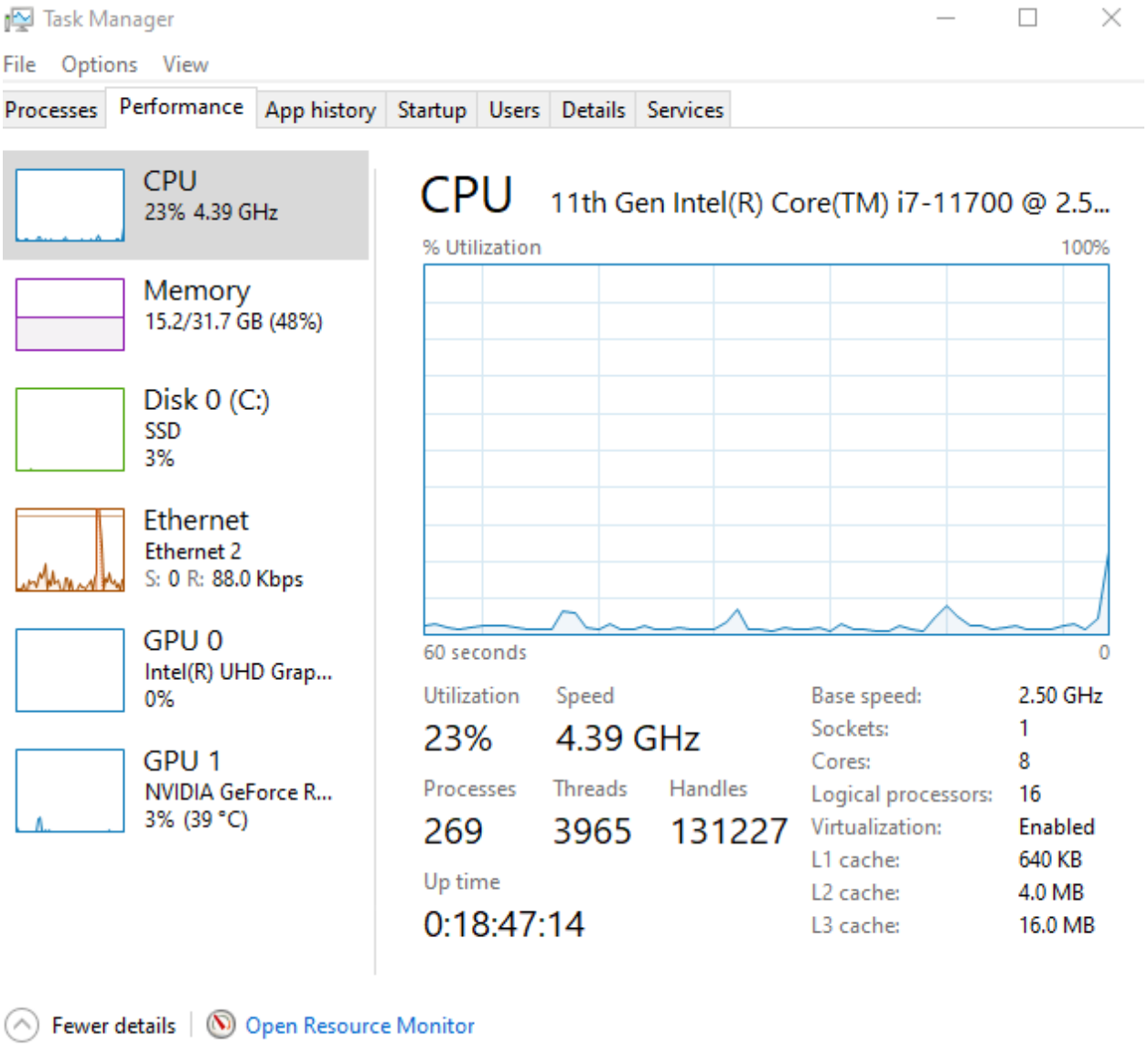
- **Windows also provides users to monitor memory usage from the task bar as shown below.**

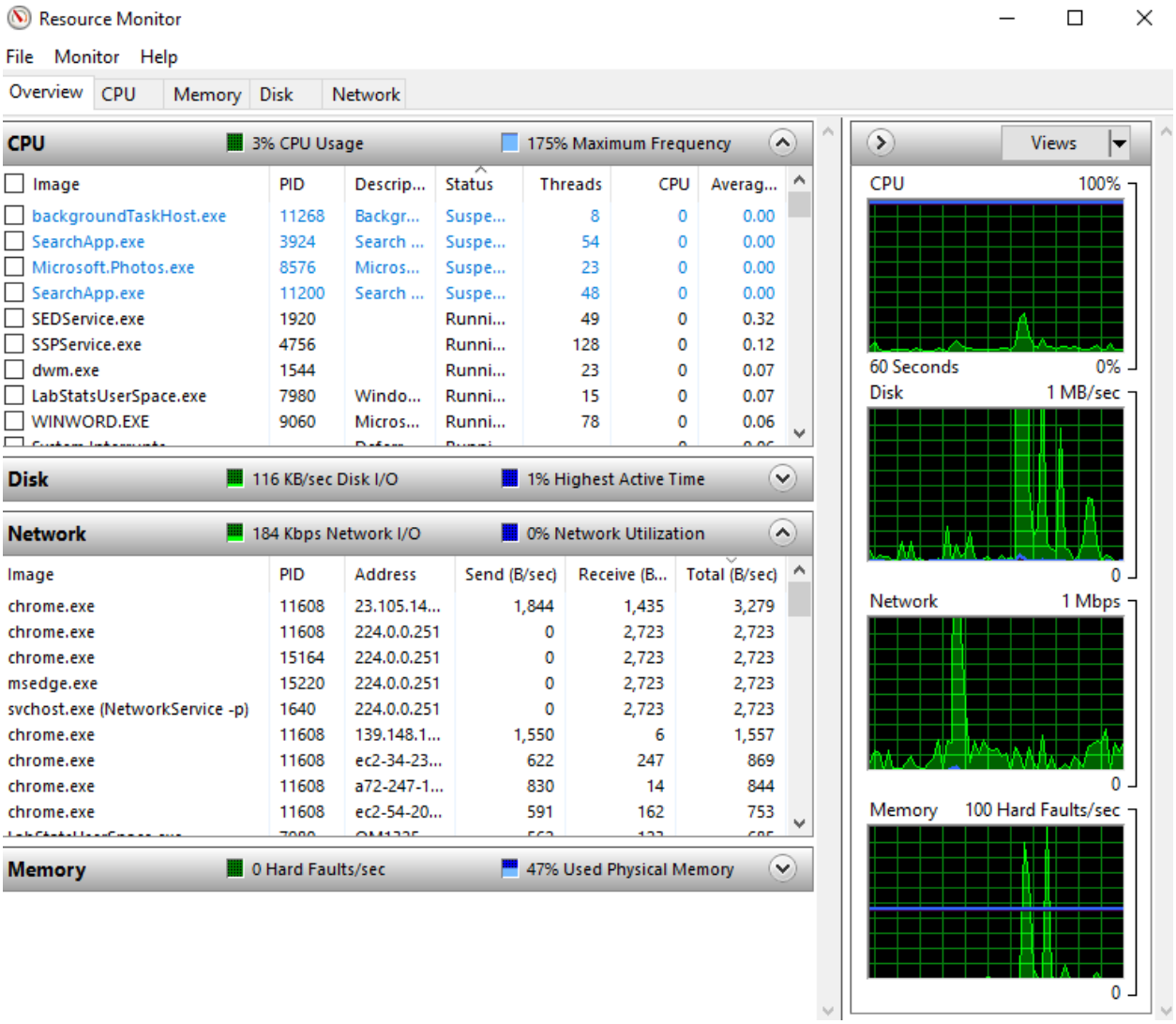


- **Windows also shows storage/disk details and allows disk clean up and users can also monitor form the task bar.**

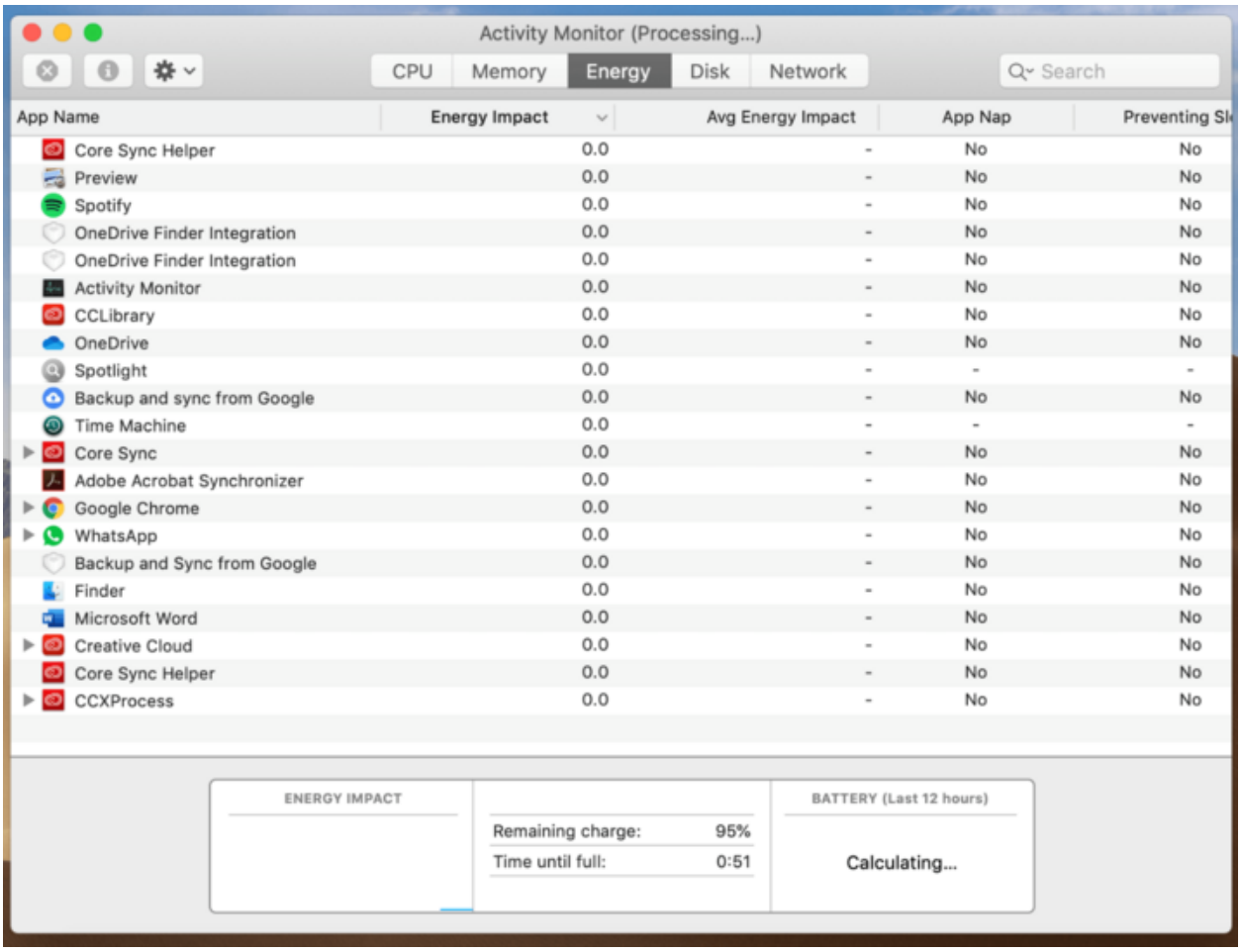


Overall, performance of the CPU can also be monitored from the task manager and resource monitor.




Resource Monitor
File Monitor Help
Overview CPU Memory Disk Network
CPU 3% CPU Usage 175% Maximum Frequency
Image PID Descrip... Status Threads CPU Averag...
backgroundTaskHost.exe 11268 Backgr... Suspe... 8 0 0.00
SearchApp.exe 3924 Search ... Suspe... 54 0 0.00
Microsoft.Photos.exe 8576 Micros... Suspe... 23 0 0.00
SearchApp.exe 11200 Search ... Suspe... 48 0 0.00
SEDService.exe 1920 Runni... 49 0 0.32
SSPService.exe 4756 Runni... 128 0 0.12
dwm.exe 1544 Runni... 23 0 0.07
LabStatsUserSpace.exe 7980 Windo... Runni... 15 0 0.07
WINWORD.EXE 9060 Micros... Runni... 78 0 0.06
Disk 116 KB/sec Disk I/O 1% Highest Active Time
Network 184 Kbps Network I/O 0% Network Utilization
Image PID Address Send (B/sec) Receive (B... Total (B/sec)
chrome.exe 11608 23.105.14... 1,844 1,435 3,279
chrome.exe 11608 224.0.0.251 0 2,723 2,723
chrome.exe 15164 224.0.0.251 0 2,723 2,723
msedge.exe 15220 224.0.0.251 0 2,723 2,723
svchost.exe (NetworkService -p) 1640 224.0.0.251 0 2,723 2,723
chrome.exe 11608 139.148.1... 1,550 6 1,557
chrome.exe 11608 ec2-34-23... 622 247 869
chrome.exe 11608 a72-247-1... 830 14 844
chrome.exe 11608 ec2-54-20... 591 162 753
Memory 0 Hard Faults/sec 47% Used Physical Memory
Views
CPU 100%
60 Seconds 0%
Disk 1 MB/sec
0
Network 1 Mbps
0
Memory 100 Hard Faults/sec
0

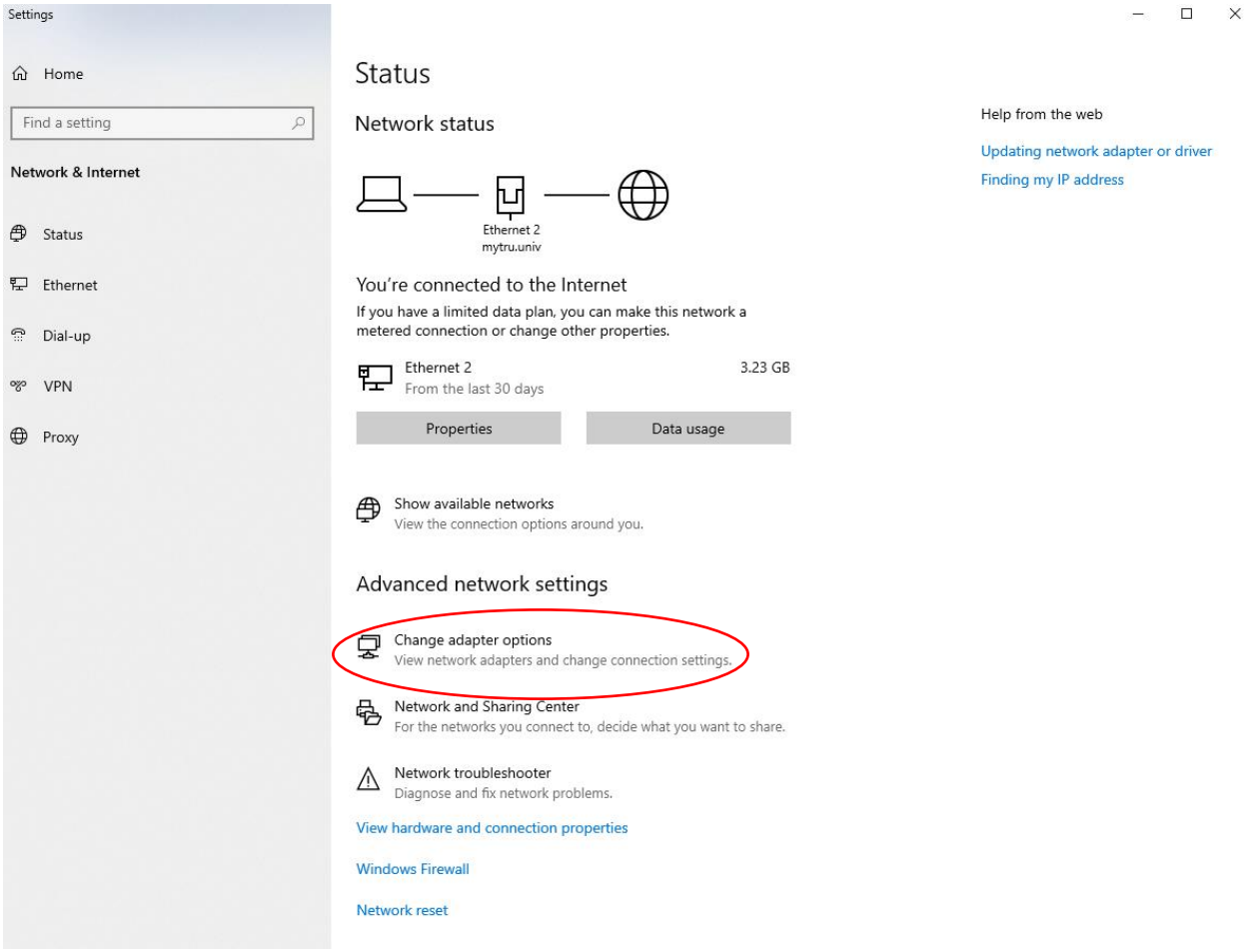
MacOS also provides the same functionality as shown below



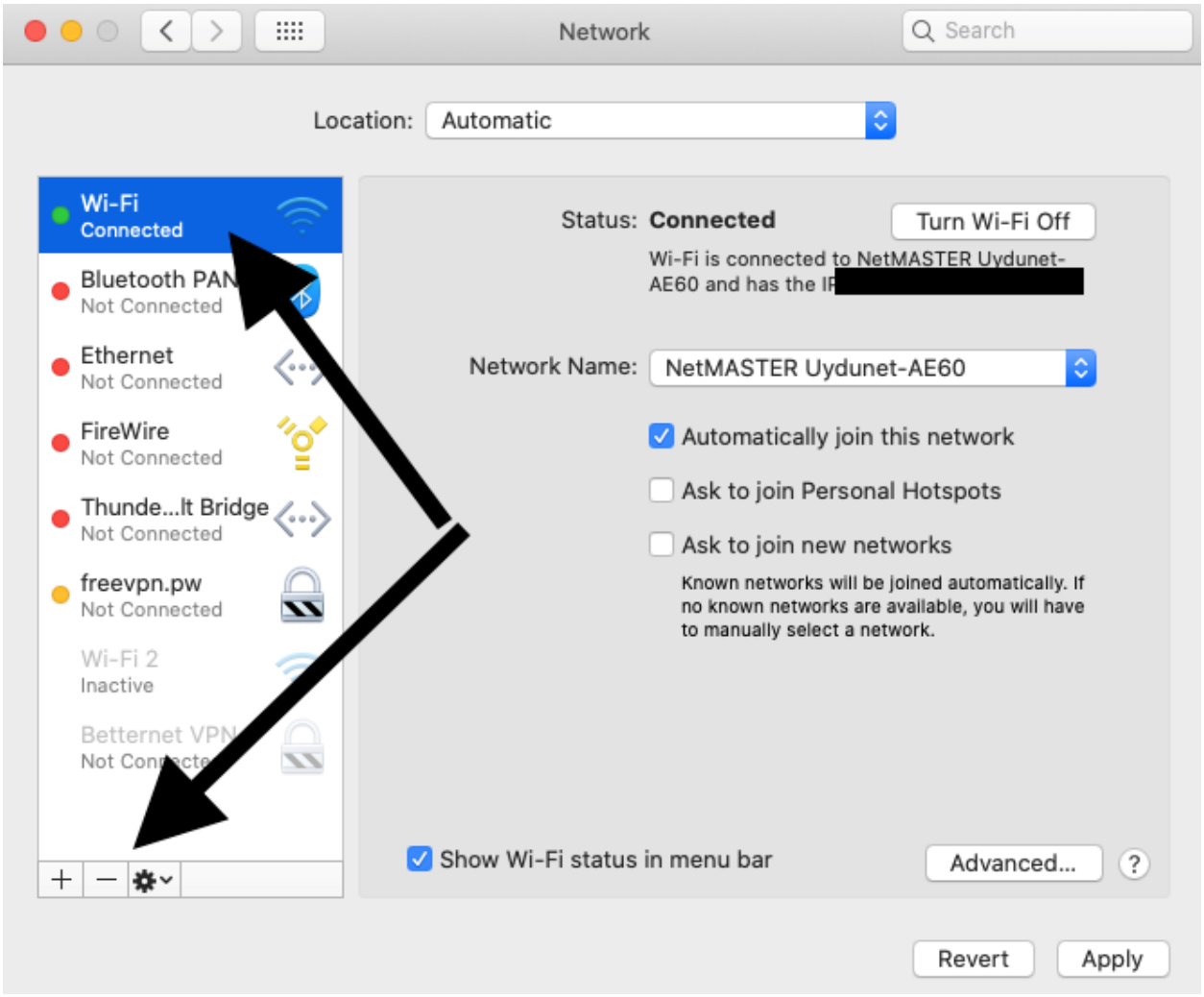
6) Networking

	Windows MacOS
Connectivity	**Both provide several connectivity options like Wi-Fi, Ethernet, Bluetooth, and cellular data.** **Both have a built-in network adaptor that allows users to configure and manage adaptors as shown below.**
Data Transfer	**Both have built-in support for file and printer sharing over a network which allows users to share files and printers between multiple devices on the same network. The protocols used in transfer are FTP, SMB, NFS.**
Communication Protocols	**TCP/IP, HTTP, HTTPS, SMTP and DNS.** **These enable users to communicate to devices over a network such as webservers, email servers and domain name servers.**
Network Security	**Both provide firewalls, user authentication, network encryption and network access control.**

For windows


Settings
Home
Find a setting
Network & Internet
Status
Ethernet
Dial-up
VPN
Proxy
Status
Network status
Ethernet 2
mytru.univ
You're connected to the Internet
If you have a limited data plan, you can make this network a metered connection or change other properties.
Ethernet 2
From the last 30 days
3.23 GB
Properties
Data usage
Show available networks
View the connection options around you.
Advanced network settings
Change adapter options
View network adapters and change connection settings.
Network and Sharing Center
For the networks you connect to, decide what you want to share.
Network troubleshooter
Diagnose and fix network problems.
View hardware and connection properties
Windows Firewall
Network reset
Help from the web
Updating network adapter or driver
Finding my IP address

For MacOS


Network
Search
Location: Automatic
Wi-Fi
Connected
Bluetooth PAN
Not Connected
Ethernet
Not Connected
FireWire
Not Connected
Thunde...lt Bridge
Not Connected
freevpn.pw
Not Connected
Wi-Fi 2
Inactive
Betternet VPN
Status: Connected
Turn Wi-Fi Off
Wi-Fi is connected to NetMASTER Uydunet-AE60 and has the IP
Network Name: NetMASTER Uydunet-AE60
Automatically join this network
Ask to join Personal Hotspots
Ask to join new networks
Known networks will be joined automatically. If no known networks are available, you will have to manually select a network.
Show Wi-Fi status in menu bar
Advanced...
Revert
Apply

7) User experience

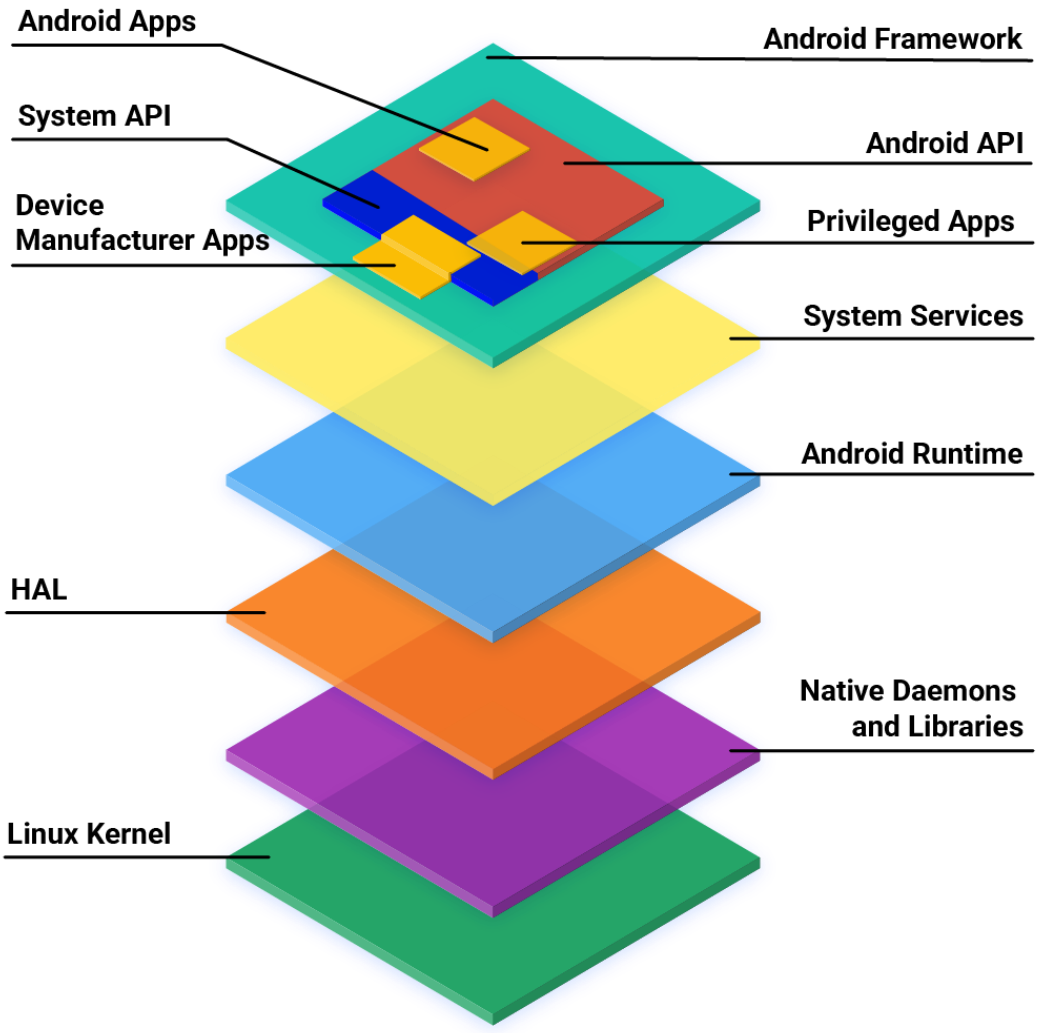
User Experience	Windows	MacOS
Overall Experience	**Powerful and flexible**	**User-friendly**
Ease of use	**It is very easy to use windows since windows is always redesigning its UI for its users.**	**MacOS regularly provides Software updates ensuring users security and preventing any user dissatisfaction.**
Stability	**Both are very stable software. However, recently windows 11 have been getting glitches and bugs which are usually fixed quickly.**	
compatibility	**Supports a wide range of software and hardware**	**MacOS supports all apple made products , but lacks a wide range of software support like windows.**

Mobile operating systems

Android vs IOS

1) Architecture and design

Android



Android is an open-source OS which uses a Linux kernel. It uses a layered architecture, and each layer provides a service for example,

Android apps

- The programs that use the Android operating system are known as Android apps. Anyone with the required technical knowledge can create these apps, which can be downloaded and used on any Android smartphone.

Android framework

- Developers create Android apps using a set of APIs and libraries known as the Android Framework. It comprises system services and managers for managing various parts of the device, as well as a standardized set of tools for developers to create apps.

System API

- A collection of interfaces known as the Android System API enables apps to communicate with the system and utilise system services. Both system-level and third-party apps can make use of these APIs.

Android API

- Access to various hardware and software components of Android devices is made possible by the Android API, which is a set of libraries and tools. Developers can use these APIs to make apps that benefit from the distinctive features of Android devices.

Device Manufacturers Apps and Privileged Apps

- On Android devices, device makers and cell carriers may include their own apps. These applications, which are frequently referred to as "bloatware," can be removed by users. System-level programmes known as privileged apps have access to more private system capabilities and APIs.

System Services

- In Android devices, system services are background operations that never stop. They give the operating system essential features including handling notifications, maintaining network connections, and controlling battery consumption.

Android Runtime

- The element of the operating system in charge of running apps is called the Android Runtime. A just-in-time (JIT) compiler is used to enhance app performance.

HAL (Hardware Abstraction Layer)

- A layer of software called the HAL gives the Android operating system a uniform interface to communicate with hardware parts.

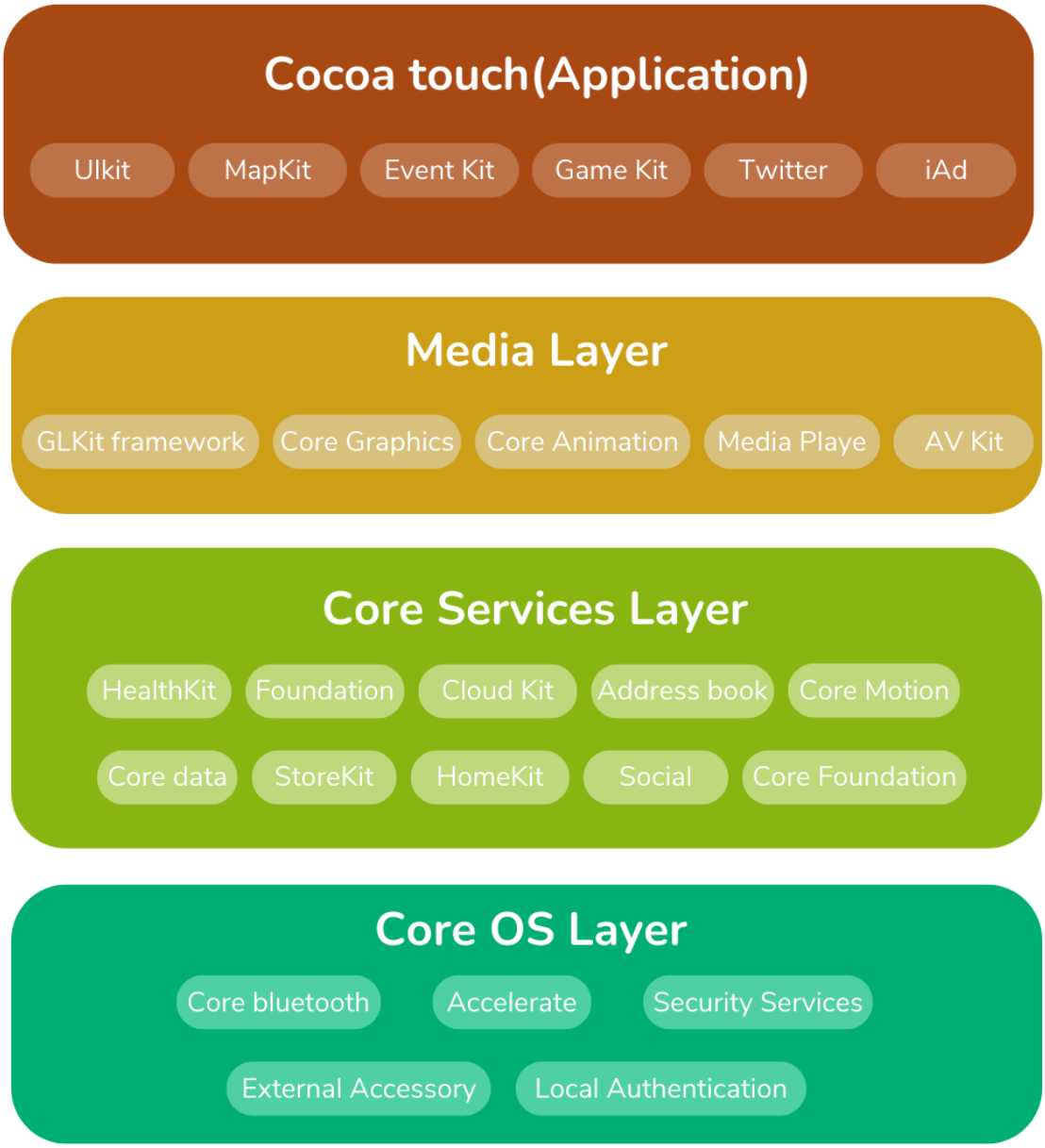
Native Daemons and Libraries

- Native daemons and libraries are low-level system parts that give the Android operating system essential features including handling input events and managing file systems.

Linux Kernel

- The Android operating system is built around the Linux kernel. It offers low-level services including device drivers, memory management, and process management. The Linux operating system's many capabilities and advantages are accessible to the Android operating system because it is based on the Linux kernel.

IOS



The Cocoa Touch layer serves as the basis for creating iOS applications. It features APIs for managing touch events, gestures, and animations in addition to the user interface framework, which offers the building blocks for creating apps with a graphical user interface.

The Media Layer oversees all audio, video, and image content. It offers APIs for accessing media metadata, recording, and editing video and photo content, and playing audio and video files.

Networking, location, and push notifications are just a few of the crucial system services that are part of the **Core Services Layer**. It also gives users access to the file system on the device and supports APIs for managing user accounts and data.

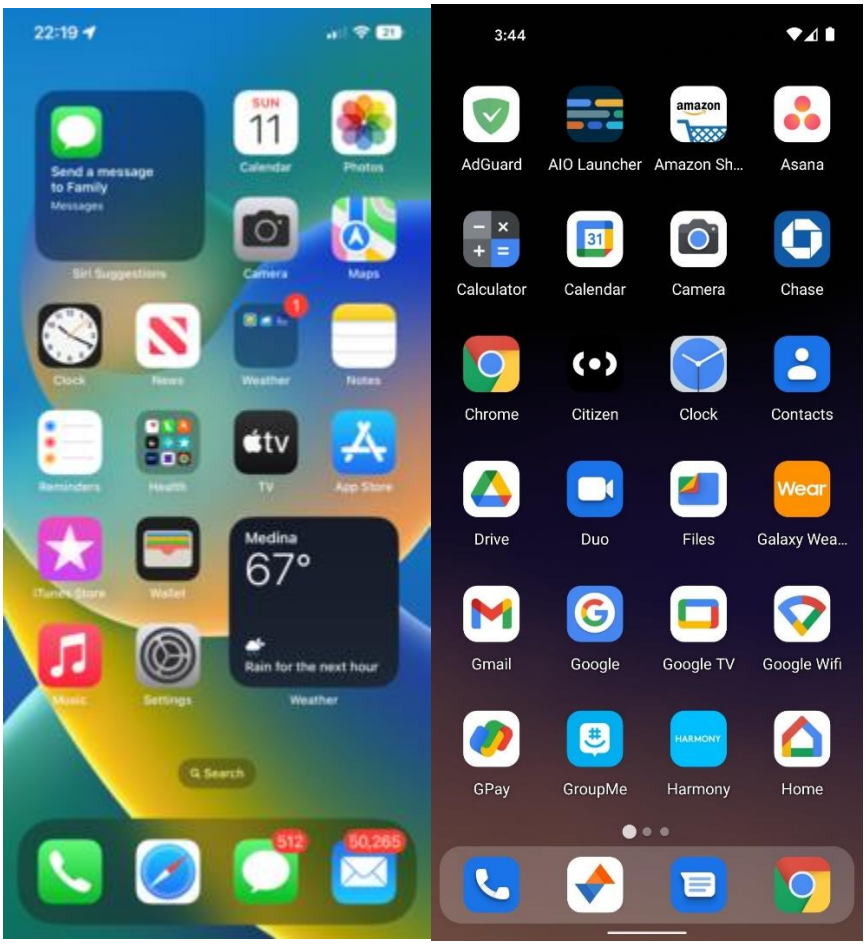
Security, memory management, and process management are just a few of the low-level system services that the **Core OS Layer** offers and that support the iOS operating system. It consists of the kernel, which controls how the device's hardware resources are used, and the security subsystem, which offers functions like data encryption and secure boot.

Comparison table

	ANDROID	IOS
Hardware compatibility	**Android is made to function on a variety of gadgets, such as smartphones, tablets, and smart Televisions. As a result, Android users now have access to a wider range of hardware alternatives.**	**The iPhone, iPad, and iPod are the only Apple devices on which iOS is intended to function. While iOS users have fewer hardware alternatives, this also means that the operating system has been tailored to these particular devices, which may result in improved performance and stability.**

Software Compatibility	**Because Android is an open-source operating system, there is more software interoperability between various devices. The Google Play Store and other third-party app stores are just two of the places users can get programmes from.**	**As iOS is a closed-source operating system, fewer apps are compatible with a variety of devices. Only the official App Store, which is carefully regulated by Apple, allows users to download apps. Better security may result from this, but fewer apps are available to users as a result.**
Customizability	**Android is renowned for its high degree of customizability, which enables users to add unique features to their devices, including unique launchers and themes. Users can further customise the operating system by installing custom ROMs.**	**Because it is intended to provide an uniform and user-friendly experience across many devices, iOS is renowned for its restricted customizability. Although there are still some customization choices available to users, they are more constrained than on Android.**

2) User Interface



	ANDRIOD	IOS
Design Principles	**The "Material Design" philosophy, which stresses the use of vivid colours, clear icons, and basic shapes, is the foundation upon which Android's user experience is constructed. The focus is on offering a contemporary, aesthetically pleasing experience.**	**The "flat" design concept, which emphasises simplicity and minimalism, is the foundation of iOS's user interface. A consistent and user-friendly experience across various devices is the main focus.**
Accessibility	**In order to increase the operating system's accessibility for people with impairments, Android provides a number of accessibility settings, including text-to-speech, large font, and high-contrast mode.**	**In order to increase the operating system's accessibility for users with impairments, iOS also provides a variety of accessibility options, such as voiceover and assistive touch.**
Multitasking	**Users of Android devices may run numerous apps at once and switch between them with ease, enabling full multitasking.**	**Users of iOS can only run a select few apps in the background and move between them via the App Switcher, which is a constrained version of multitasking.**
Notifications	**Android has a very flexible notification system that lets users pick which apps can send notifications and how they are presented.**	**iOS has a more constrained notification system, with alerts showing up as a list on the lock screen or as a banner at the top of the screen.**

Navigation	**To navigate the operating system, Android uses a set of buttons, including a back button, home button, and recent applications button. Users can also access app shortcuts and settings by swiping up from the bottom of the screen.**	**To operate the operating system, iOS uses a set of gestures, such as swiping up to go home or sliding down for alerts. To access recently used apps, users can also use the App Switcher.**

3) Application development

	ANDROID	**IOS**
Programming language	Java kotlin	swift objective-c
IDE	Android studio	

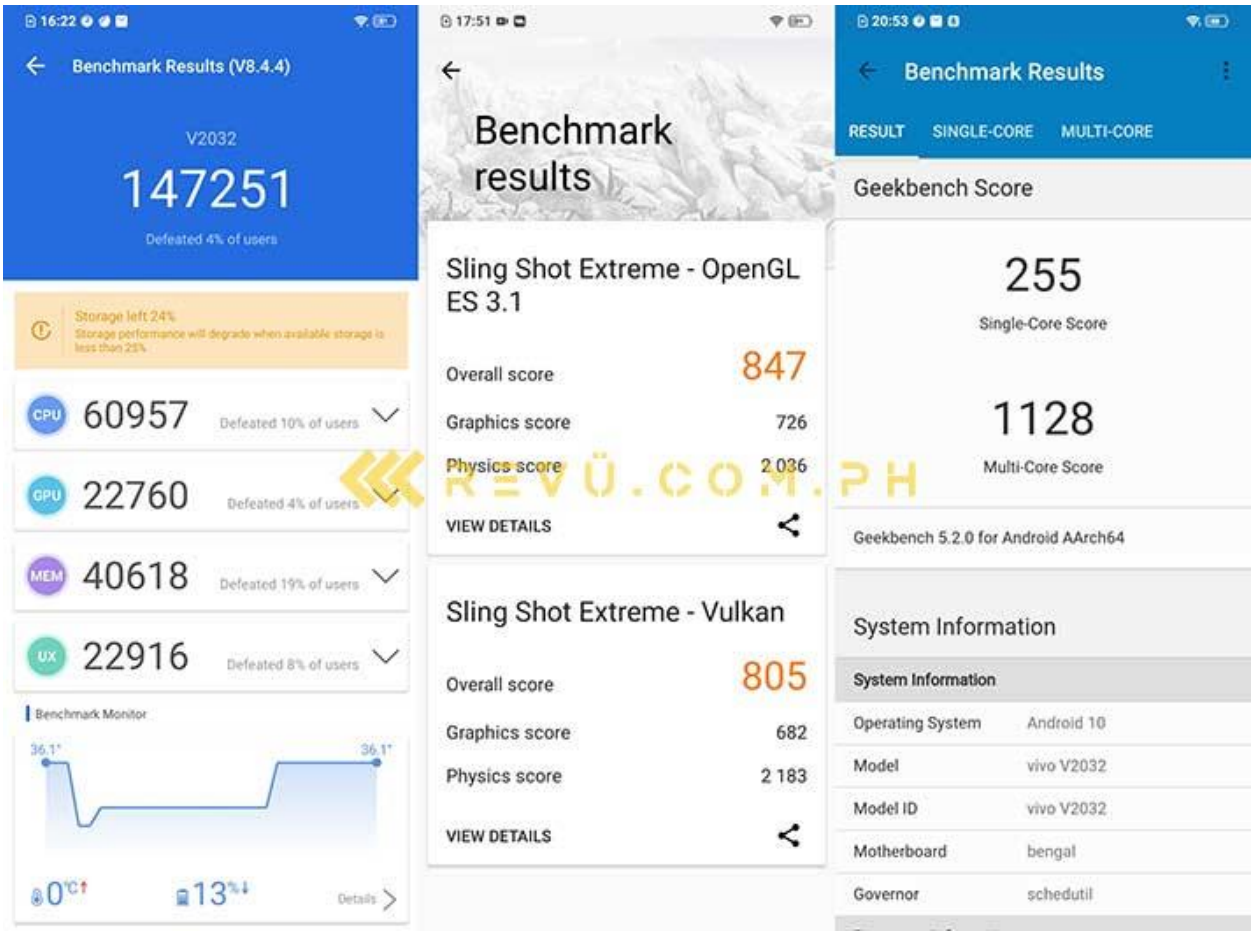
Distribution	Google play store or using APK files	App store by apple
UI development	Android apps create their user interfaces using XML-based layouts. A variety of widgets, views, and layouts are available on the Android platform for creating the user interface.	Storyboards and Interface Builder are tools used in iOS apps to design the user experience. A variety of view controllers, views, and controls are available in iOS for use in creating the user interface.
Testing	A framework for unit tests and instrumentation tests is one of the testing tools offered by Android. Moreover, Android provides functional, user interface, and performance testing capabilities.	The native testing framework for iOS, XCTest, is one of the testing tools offered by iOS. Moreover, iOS provides tools for user interface, functional, and performance testing.

4)Security

	ANDRIOD	IOS
Biometric Authentication	**The biometric authentication options available on Android and iOS include fingerprint scanning and face recognition.**	
Permissions	**Although the permissions system on Android is more versatile, it can also be trickier for users to maintain, which could pose security problems**	**iOS includes a more stringent permission system that restricts the data that programmes may access, hence reducing the risk of security flaws.**
VPN's	**Third-party VPNs and other VPN alternatives are available for usage with Android.**	**Although iOS features a built-in VPN, it only supports VPN protocols that Apple has approved.**
Encryption	**For data at rest and data in transit, Android and iOS both provide encryption.**	
Malware	**Android's open-source nature and laxer app store restrictions make it more vulnerable to malware.**	**Because of its more stringent app store standards and security tools like app sandboxing and code signing, iOS has a lower chance of infection.**
Rooting or jail breaking	**It is possible to root Android devices, which may jeopardise security.**	**Security can also be compromised by jailbreaking an iOS smartphone, however it's more challenging to do so on more recent models.**

5)Performance

- There are some tools to measure the performance of both android and IOS OS.
- Some examples are Antutu, passmark, GeekBench 5, etc.



	ANDROID	IOS
CPU USAGE	Android gives users more control over CPU utilisation, which on some devices can lead to better performance. Poorly optimised apps, however, can also have a detrimental effect on CPU consumption and overall performance.	iOS controls CPU utilisation more strictly, which leads to more consistent performance across devices.
MEMORY MANAGEMENT	Although Android smartphones have greater RAM than iOS devices, memory management can be problematic because of device and vendor fragmentation.	Despite having less RAM than the majority of Android smartphones, iOS devices run more consistently because of better memory management.
STORAGE	Expandable storage is one of the most flexible storage options available on Android devices. Yet, decreased read and write speeds can also be a consequence of this.	iOS devices offer better read and write speeds but less storage flexibility, which leads to speedier performance overall.
GAMING	The more powerful hardware and flexibility of Android devices have generally resulted in superior gaming performance. But, as iOS devices have been more	Due to their tightly integrated hardware and software, iOS devices routinely perform well in games.

	potent over the past few years, this gap has closed.	

6)Networking

	Android	IOS
connectivity	NFC, USB-C, and HDMI are just a few of the more connectivity choices that Android smartphones enable.	Bluetooth, Wi-Fi, and Lightning are the only connectivity methods that iOS devices support.
Data Transfer	Android smartphones provide more alternatives for data transfer, including Bluetooth and USB file transfer, as well as more unrestricted access to the file system.	Due to their closed file system, iOS devices have fewer choices for data transfer, but they provide seamless connection with other Apple devices with AirDrop and iCloud.
Communication protocols	A greater variety of communication protocols, including HTTP, HTTPS, WebSockets, and MQTT, are supported by Android smartphones.	Moreover, a variety of communication protocols, such as HTTP, HTTPS, WebSockets, and MQTT, are supported by iOS devices.
speed	Due to their support for faster network technologies like 5G, Android smartphones typically have better network speeds.	Fast network speeds are also available on iOS devices, albeit depending on the model, some of the most recent high-speed network technologies could not be supported.

7)User Experience

User Experience	Android	IOS
Ease of use	Both are very easy to use and learn.	
Stability	Due to the fact that manufacturers and carriers are in charge of providing updates, Android devices occasionally face delays.	iOS devices typically get their operating system updates more frequently and quickly.
Hardware Diversity	Due to the vast variety of manufacturers who produce Android devices, there are more hardware alternatives available at various price points.	Apple offers fewer products, but they are typically thought to be of good quality.
Integration with Other Services	Android devices have more freedom when it comes to interacting with outside services.	Apple services like iCloud, iMessage, and AirDrop are perfectly integrated with iOS devices, making it simpler for users to transfer their data between platforms.