Exploring the Landscape of Mobile Operating Systems: A Comprehensive Survey

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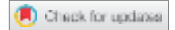
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ABSTRACT

The use of smartphones has increased in recent era. Every phone needs an operating system of some kind to run its functionalities. The features and capabilities of your device are determined by the operating system. The mobile operating system is another factor that determines whether a third-party application, or so-called mobile app, is accepted. Every manufacturer will have selected a certain operating system for their product. To determine the support for mobile applications and device compatibility, we need to understand the mobile operating systems. This survey paper provides information about several mobile operating systems, also a comparison of mobile operating systems is also included.

1. INTRODUCTION

From being used primarily as a communication tool, smartphones are now used for performing variety of applications like PCs. Now, mobile operating systems are just as important as computer operating systems. Most actions that were performed on a computer are now covered by it [1]. We can observe that many of them rely heavily on their mobile phones for work-related tasks like sending emails and other communications. This suggests that mobile operating systems are utilizing the high capabilities. This shift is the result of the creation of cutting-edge mobile operating systems and the distinctive features of smartphones. Smartphones are convenient, portable gadgets that offer many, continuous access points to their own applications. The operating system maintains the device's software and hardware resources and carries out a variety of other functions. Mobile operating systems have grown significantly in the previous years. Analysts are enthusiastic about potential future developments [3]. Today's markets provide a large range of mobile phones from different companies that run on multiple operating systems. So, choosing the best and safest one is a difficult challenge [4].

2. MOBILE OPERATING SYSTEMS

An OS, or operating system, is a software interface. Operating systems (OSes) control how a device or piece of digital hardware, like a computer, operates and functions while facilitating user use. Operating a computer without an operating system is nearly impossible. All the operations and applications are run by an operating system. Some important functions are Managing Memory, Managing Processor, Managing Devices, Management of File System, Job allocation, Computer Security, Controlling Performance of the System, Detection of Errors, and Troubleshooting, Coordinating other users and software applications. Like the operating system for personal computers, mobile operating systems are software interfaces that enable all apps and basic operations on mobile devices possible. These mobile operating systems are used on a wide range of gadgets, including cell phones, smartphones, PDAs, tablet computers, etc. Almost all the functionality of an operating system for a computer now can be enjoyed on small, portable devices with a touchscreen, Bluetooth, Wi-Fi, GPS navigation, camera, music player, voice search, and other features of mobile phones [1, 2].

The following qualities should be included in an ideal mobile operating system:

1. It should be easy to use with eye-catching graphics.

2. It should offer a reliable, helpful app store.

3. It should not consume too much battery.

4. Should be good at managing data and network usage

A native modem and wireless service provider is one of the extremely significant and distinguishing characteristics offered by mobile operating systems. As compared to computer operating systems, which demand Ethernet, this lets us to directly connect our mobile devices to the internet.

A broad variety of native, built-in applications are available on some mobile operating systems. For instance, most popular mobile operating systems, like iOS and Android, offer the capability of an app store. Examples of such applications include web browser applications, email applications, etc.

This gives customers the option to either pay for or download alternative applications for free, depending on their needs. This feature gives scope to enhance the in-built user interface and run different applications.

Some examples of mobile OS are IOS, Android OS, Windows Phone, Palm OS, Blackberry OS, Web OS, and Symbian OS. Figure 1 shows the overview of leading Mobile Operating Systems in the market.
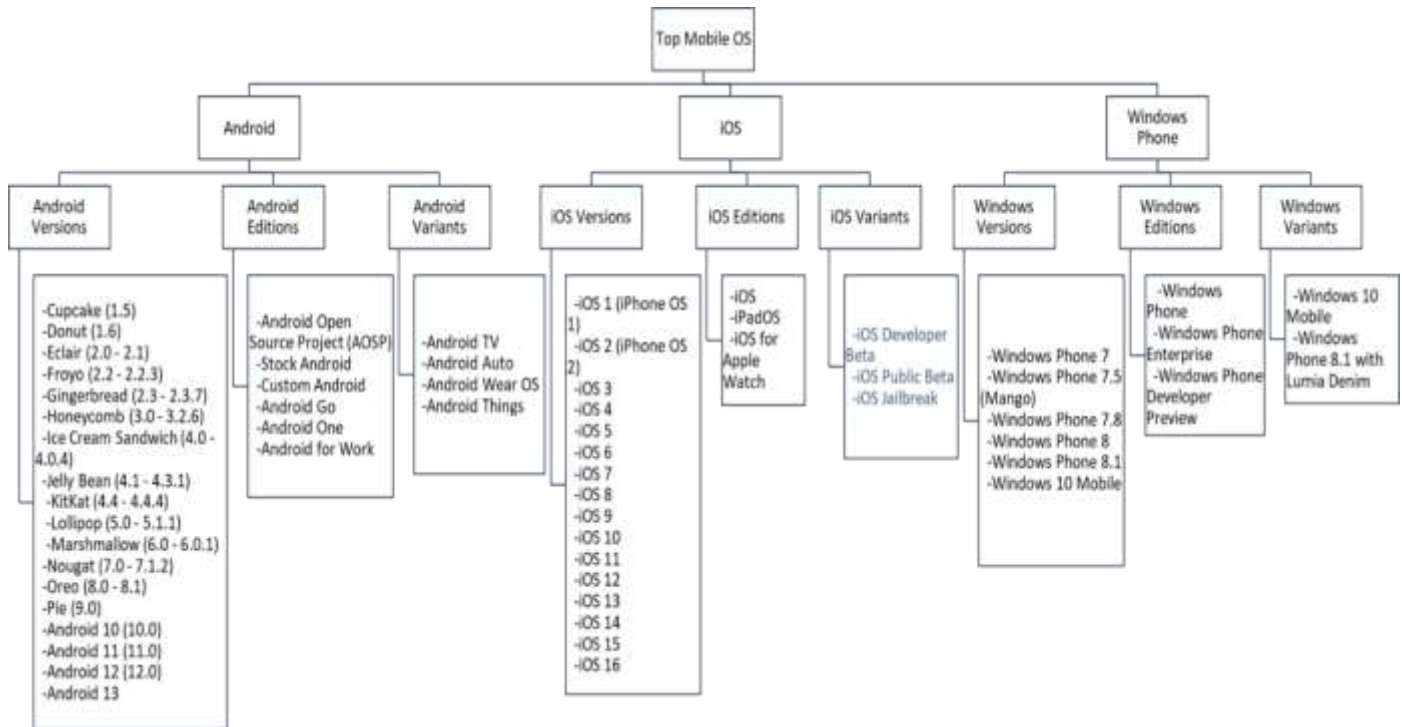

Fig. 1 Taxonomy of Top Mobile Operating Systems

2.1 Android

2.1.1 Android Versions:

1) Cupcake (1.5)

2) Donut (1.6)

3) Eclair (2.0 - 2.1)

4) Froyo (2.2 - 2.2.3)

5) Gingerbread (2.3 - 2.3.7)

6) Honeycomb (3.0 - 3.2.6)

7) Ice Cream Sandwich (4.0 - 4.0.4)

8) Jellybean (4.1 - 4.3.1)

9) KitKat (4.4 - 4.4.4)

10) Lollipop (5.0 - 5.1.1)

11) Marshmallow (6.0 - 6.0.1)

12) Nougat (7.0 - 7.1.2)

13) Oreo (8.0 - 8.1)

14) Pie (9.0)

15) Android 10 (10.0)

16) Android 11 (11.0)

17) Android 12 (12.0)

2.1.2 Android Editions:

i. Android Open-Source Project (AOSP): The pure, open-source version of Android without any manufacturer-specific modifications.

ii. Stock Android: A version of Android with a clean, unmodified user interface and features as designed by Google.

iii. Custom Android: A version of Android that includes additional features and modifications made by device manufacturers or third-party developers.

iv. Android Go: A lightweight version of Android optimized for low-end hardware and limited internet connectivity.

v. Android One: A version of Android that features an optimized, streamlined user experience and is designed to receive regular updates for a longer period.

vi. Android for Work: A version of Android designed for business use, with additional security features and tools for managing work-related apps and data.

2.1.3 Android Variants:

i. Android TV: A version of Android designed specifically for smart TVs, with a user interface optimized for use on a large screen and support for TV-specific features like voice commands and recommendations.

ii. Android Auto: A version of Android designed for use in cars, with a simplified user interface and support for voice commands and other hands-free features.

iii. Android Wear OS: A version of Android designed for smartwatches, with a user interface optimized for small screens and support for fitness tracking, voice commands, and mobile payments.

iv. Android Things: A version of Android designed for IoT devices, with support for sensors, cameras, and other hardware components.

Google created the Android, a mobile operating system that is mostly used for mobile phones, tablets, and touchscreen gadgets. Because of the way it is made, users may operate their mobile devices naturally using finger movements that replicate regular actions like tapping, pinching, and swiping. Additionally, Android software is used in watches, televisions, and automobiles by Google, each of which has an own user interface. Before Google acquired Android Inc. in 2005, the Silicon Valley-based software startup had originally developed the Android operating system. Analysts in the electronics industry and investors have questioned Google's true objectives for entering the mobile market since that acquisition. However, shortly after that, Google announced that their first Android-powered product would be made available for purchase in 2007, even though it didn't go on sale until 2008 [4][9].
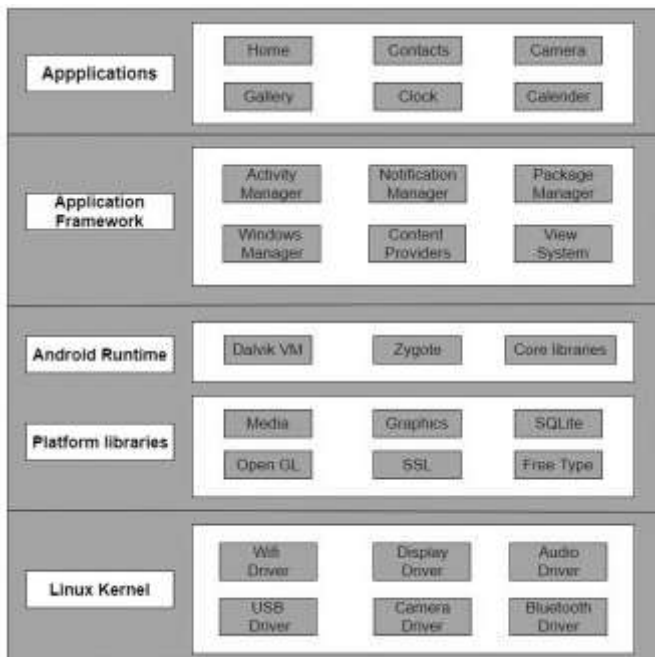

Fig.2. Architecture of Android OS [6]

Since then, Android technology has enabled software and application developers to develop mobile apps, which are then available for purchase through app stores like Google Play [10] [11]. Customers also have the choice of linking their mobile devices to other Google products, such as cloud storage, email services, and streaming platforms, since Android is a Google product. To develop open standards for mobile devices, the source code of Android is made available in an open-source format [5].

Although Android gives customers a good option for choosing mobile operating systems, there are still a few drawbacks. On the developer end, creating complex user interfaces and user experiences is a frequently challenging process that needs a stronger reliance on Java than Objective-C. In comparison to other app shops, the Android Market's requirements for apps are typically lower for customers [7].

In other words, consumers are more likely to experience data breaches because of the apps' lower security profiles. Android's strong reliance on advertising and absence of a voice-activated assistant, though, may turn off some consumers.

Figure 2 shows the internal architecture of Android Mobile Operating system. The Linux kernel, Android runtime, application layer, application framework, libraries, and Linux kernel are the different parts of the operating system.

2.2 iOS

2.2.1 iOS Versions:

1) iOS 1	6) iOS 6	11) iOS 11
2) iOS 2	7) iOS 7	12) iOS 12
3) iOS 3	8) iOS 8	13) iOS 13
4) iOS 4	9) iOS 9	14) iOS 14
5) iOS 5	10) iOS 10	15) iOS 15

2.2.2 iOS Editions:

i. iOS: The standard version of iOS that is pre-installed on iPhones, iPads, and iPod touches.

ii. iPad OS: A version of iOS specifically designed for iPads, with features optimized for larger screens and the use of the Apple Pencil.

iii. iOS for Apple Watch: A version of iOS designed specifically for the Apple Watch, with a user interface optimized for small screens and features like notifications, messaging, and fitness tracking.

2.2.3 iOS Variants:

i. iOS Developer Beta: A pre-release version of iOS made available to registered Apple developers for testing and feedback.

ii. iOS Public Beta: A pre-release version of iOS made available to the public for testing and feedback.

iii.   iOS Jailbreak: A version of iOS modified by users to bypass Apple's security restrictions and allow for greater customization and access to third-party apps and features.

Apple iOS is the name of the operating system used by the iPhone, iPad, and other mobile devices made by Apple. Apple iOS was developed to offer simple, seamless networking between a variety of Apple products and is based on Mac OS, the operating system that powers Apple's line of Mac desktop and laptop computers [1].

The second-most widely used smartphone operating system is Apple iOS. In June 2007, the same month that the iPhone went on sale for the first time, the initial version of iOS was launched. The operating system that powers every Apple smart device is called iOS, sometimes referred to as the iPhone Operating System [9].

The name iOS was not officially given to the software until that year, following Apple's release of the software development kit (SDK) for the iPhone, which allowed anyone to develop apps for the platform [12]. The user-friendly design and efficiency of iOS are frequently cited as reasons for the iPhone's appeal. By the end of 2018, about 218 million iPhones had been sold, making it the most commercially successful single product ever [4][5].

According to some estimates, since their introduction in 2007, iOS devices have generated more than $1 trillion.

Many innovations have been made possible by iOS over the years, and these innovations have influenced both iPhone owners and non-owners alike.

The first generation of iOS marked a huge shift in society by introducing in the touch-screen smartphone, replacing Blackberry-style gadgets and flip phones. The world would never be the same after the invention of the iPhone, which merged numerous features into a single gadget, including a phone, media player, web browser, and camera [13].

In the second release, when Apple also made its SDK available to programmers wanting to develop applications for the platform, the company finally gave iOS a name. Apple released the first version of FaceTime with iOS 4. iOS devices now support multitasking as of version 4 [7].

iOS 5 brought about the introduction of Siri, a voice-activated personal helper, the iOS Notification Center and iMessage as a centralized messaging platform. In later updates, which included the addition of Apple Pay, Touch ID, Airdrop, and the highly panned Apple Maps mapping system, the software's features and appearance were greatly improved [2].

On June 4, 2018, Apple announced iOS version 12, which brought numerous enhancements to FaceTime, Siri, and other crucial iOS features. In 2022 Apple has released iOS 16 version [14].

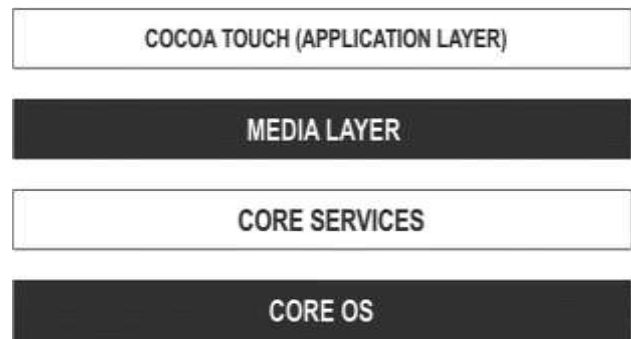Architecture of iOS is shown in Figure 3.

Fig. 3 Architecture of iOS [6]

2.3 Windows Phone

2.3.1   Windows Phone Versions:

1) Windows Phone 7	4) Windows Phone 8
2) Windows Phone 7.5 (Mango)	5) Windows Phone 8.1
3) Windows Phone 7.8	6) Windows 10 Mobile

2.3.2   Windows Phone Editions:

i.   Windows Phone: The standard version of the operating system.

ii.   Windows Phone Enterprise: A version of Windows Phone designed for enterprise customers, with additional security features and management tools.

iii.   Windows Phone Developer Preview: A pre-release version of the operating system made available to registered developers for testing and feedback.

2.3.3   Windows Phone Variants:

i.   Windows 10 Mobile: A version of Windows Phone that is designed to be compatible with the full Windows 10 operating system and includes features such as Continuum, which allows users to use their phone as a desktop PC with the help of a docking station.

ii.   Windows Phone 8.1 with Lumia Denim: A variant of Windows Phone 8.1 that includes additional features and improvements for Lumia devices, such as improved camera capabilities and updated Lumia-specific apps.

On December 10, 2019, Microsoft officially ended support for Windows 10 Mobile and has since shifted its focus to the development of Windows 10 for desktop and laptop devices [15]. As a result, there will likely be no further updates or new versions of the Windows Phone operating system.

Zune and Windows Mobile were discontinued, so Microsoft created the Windows Phone series of mobile operating systems

for smartphones [22]. The Metro design language was used to create the redesigned Windows Phone user interface. In comparison to Windows Mobile, it had a stronger consumer-focused approach than a commercial one.

It debuted with Windows Phone 7 in October 2010. It was succeeded by Windows Phone 8, which made its debut in 2012 [2] and switched from Windows Phone 7's Windows CE-based kernel to the Windows NT kernel present in Windows PC versions. The OS was no longer compatible with any Windows Phone 7 handsets that were already on the market, however it continued to support Windows Phone 7-specific apps [3][4].

Microsoft launched the Windows Phone 8.1 update in 2014 to allow programmers to create cross-platform applications that run on both PCs and Phones. Support for Cortana, Microsoft's virtual personal helper, was also included [2].

To promote greater integration and harmony with its PC equivalent, Microsoft unveiled Windows 10 Mobile in 2015. This includes the ability to link devices to a docking station or external monitor to show an interface like that of a PC. Even though Microsoft withdrew the Windows Phone brand to concentrate more on the connections with Windows 10 for PCs, the Windows Phone line was formally maintained at this point and upgrades were provided for some Windows Phone 8.1 devices [16].

The user interface on Windows Phone is based on "Metro" design language of Microsoft and was influenced by the one on the Zune HD. The "Living Tiles" that make up the home screen, also known as the "Start screen," served as the model for the live tiles in Windows 8. Links to apps, features, functions, and specific things are found in tiles (such as contacts, media items, applications, or web pages) [9]. Tiles can be added, moved, or removed by users [17]. The number of unread emails would be displayed on the tile for an email account, for instance, or a tile could show a live weather update. Tiles are dynamic and change in real time. Live tiles may now be scaled to appear tiny, medium, or large from Windows Phone 8 [18].

As a result of Windows Phone's connection with well-known social networks like Windows Live, Facebook, and Twitter, several of its features are categorized into "hubs" that integrate offline and online content [19]. For instance, the People hub displays contacts compiled from various sources, such as Facebook, Windows Live, and Gmail, while the Photos hub displays images taken with the device's camera as well as the user's Facebook picture albums. Users can instantly remark on and "like" social network updates from the hub. Xbox Live Gaming, Xbox Music and Video, Microsoft Office and Windows Phone Shop are the additional built-in hubs [20].
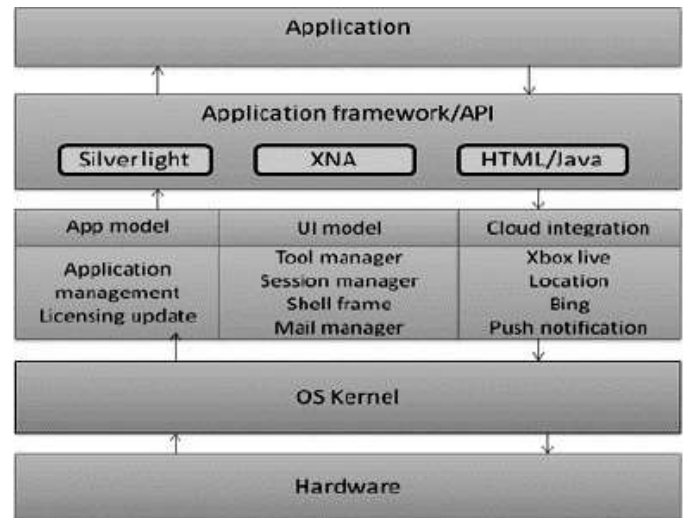

Fig. 4 Architecture of Windows Phone OS [6]

Multitouch is used by Windows Phone. Because light is not emitted by entirely black pixels, the dark theme of the Windows Phone user interface extends OLED screens' battery life. Users can also select a light theme from the settings menu on their phone. Moreover, the user has a variety of accent colour options. Links, buttons, and other user interface components are displayed using the accent colour the user has selected. These colours can be automatically used to theme third-party programs. Transparent tiles and a changeable Start screen backdrop image are two new features of Windows Phone 8.1. The image can be seen through the translucent portions of the tiles and when scrolling, a parallax effect creates the appearance of depth. If a background image is not selected by the user, the theme's accent colour is used when the tiles are rendered.

Figure 4 shows the architecture of Windows Phone OS. It consists of different parts.

2.4 BlackBerry OS:

2.4.1 BlackBerry Versions:

1) BlackBerry OS 1	6) BlackBerry OS 6
2) BlackBerry OS 2	7) BlackBerry OS 7
3) BlackBerry OS 3	8) BlackBerry OS 7.1
4) BlackBerry OS 4	9) BlackBerry OS 10
5) BlackBerry OS 5	

2.4.2 BlackBerry Editions:

i. BlackBerry OS: The standard version of the operating system.
ii. BlackBerry Enterprise Server: A server software designed to provide mobile device management

and security for BlackBerry devices in enterprise environments.

2.4.3 BlackBerry Variants:

i. BlackBerry 10: A modern version of the BlackBerry operating system that was designed to compete with iOS and Android. It features a new user interface and is compatible with BlackBerry's new touchscreen devices.

ii. BlackBerry Android: A variant of the BlackBerry operating system that runs on Android, with additional BlackBerry-specific features and security enhancements. This variant is found on devices such as the BlackBerry Priv, KeyOne, and Key2.

It's worth noting that in 2016, BlackBerry announced that it would no longer be developing its own mobile operating systems and would instead focus on developing software for other platforms. As a result, there have been no new BlackBerry OS releases since the release of BlackBerry 10 in 2013, and the company has since shifted its focus to developing enterprise software and security solutions for mobile devices [3].

The BlackBerry smartphones from Research in Motion (RIM) come with a unique mobile operating system called BlackBerry OS. The BlackBerry OS is used by smartphones bearing the BlackBerry brand, such as the Curve, Bold, Storm and Pearl series [1].

Strong support for push Internet email is one of the hallmarks of the BlackBerry OS, an operating system for smartphones. Its push email functionality is handled by the specific BlackBerry Enterprise Server (BES), which is available in versions for Lotus Domino, Novell Groupwise and Microsoft Exchange.

Other mobile operating systems, including Android, Microsoft Windows Mobile, and Symbian, can be used on a variety of phone brands while the BlackBerry OS can only be used on BlackBerry phones. BlackBerry OS and Apple's iOS are like each other in this regard [2].

BlackBerry apps have typically been developed using Java, more specifically the Java Micro Edition (Java ME) platform. Nevertheless, RIM unveiled the BlackBerry Web development platform in 2010, allowing developers to create rapid, standalone Web apps using HTML, CSS, and JavaScript using the widget software development kit (SDK).

An integrated development environment (IDE), The BlackBerry Java Development Environment (JDE) containing an editor, debugger, device simulator, and memory viewer, is available to developers who choose to work with Java. From the BlackBerry website, the JDE can be downloaded. It can be used either alone or as a plug-in for the graphical IDE Eclipse. The Sun Java compiler and The RAPC compiler and are additional tools that work with the JDE. There are three ways to install apps on a BlackBerry OS device: wirelessly via the device's built-in browser, through BlackBerry App World, or using BlackBerry Desktop Manager [4].

To run Adobe AIR and BlackBerry Webworks apps, BlackBerry Ltd. created the BlackBerry Tablet OS, which is currently only available on the BlackBerry Playbook tablet computer. BlackBerry Tablet OS is based on the real-time operating system QNX Neutrino. The first tablet to use a QNX operating system is the BlackBerry Tablet OS [6].
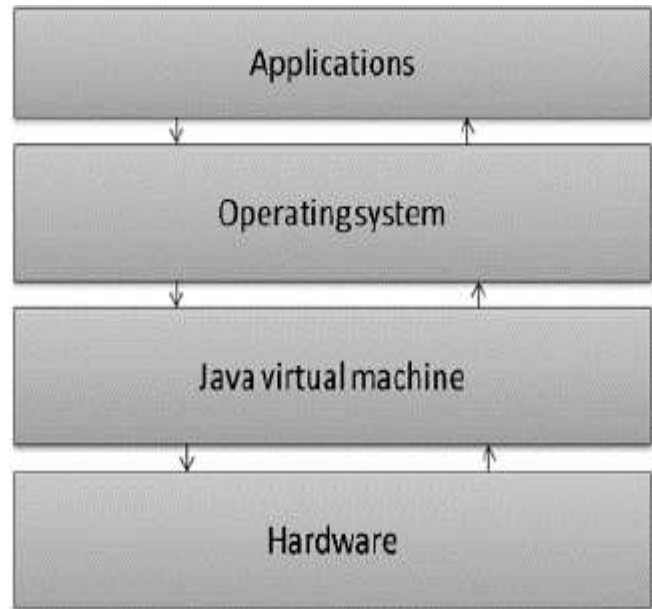

Fig. 5 Architecture of BlackBerry OS [6]

Standard BlackBerry Java apps are supported by BlackBerry Tablet OS. Sandbox "app players" that may be sideloaded by users or ported by developers have been announced to support Android apps. The BlackBerry Playbook tablet computer was the first product to run BlackBerry Tablet OS. After version 7, a comparable QNX-based operating system called BlackBerry 10 took the role of the venerable BlackBerry OS on mobile devices.

Figure 5 shows architecture of BlackBerry OS. It consists of four parts which are applications, Operating System, Java Virtual Machines and Hardware.

2.5 Symbian OS:

2.5.1 Symbian Versions:

1) Symbian OS 6	6) Symbian Anna
2) Symbian OS 7	7) Symbian Belle
3) Symbian OS 8	8) Symbian Carla
4) Symbian OS 9	9) Symbian Donna
5) Symbian^3 (Symbian OS 9.5)	

2.5.2 Symbian Editions:

i. Symbian OS: The standard version of the operating system.

ii. Symbian S60: A user interface layer for Symbian that was used on many Nokia smartphones, including the popular N-series.

iii. Symbian UIQ: A user interface layer for Symbian used on several Sony Ericsson smartphones.

2.5.3 Symbian Variants:

i. Nokia Belle: A variant of Symbian that was released in 2012, following Nokia's acquisition of Symbian. It was designed to improve the user interface and add new features, and was compatible with devices running Symbian^3, Symbian Anna, and Symbian Belle Refresh.

ii. Symbian Anna: A variant of Symbian that was released in 2011, which introduced a new user interface, improved web browsing, and new features such as split-screen texting and a portrait QWERTY keyboard.

iii. Symbian Belle Refresh: An update to Symbian Belle that was released in 2012, which added new features and improvements such as a new lock screen, resizable widgets, and a new version of the web browser.

Symbian was once the world's most popular mobile operating system, but its popularity declined rapidly with the rise of iOS and Android. In 2013, Nokia announced that it was discontinuing the use of Symbian on its devices, and the operating system has since been replaced by other mobile operating systems.

Nokia's advanced or data-enabled smart phones run on the Symbian OS mobile phone operating system. Symbian OS is based on ARM processors and evolved from Psion's EPOC, which was designed as a basic operating system for early electronic organizers [1]. Beginning in the late 1990s, the Psion EPOC OS was referred to as EPOC16 to help distinguish it from the more recent 32-bit Operating system EPOC32, which eventually evolved into Symbian OS. Ericsson, Motorola, and Nokia collaborated with Psion Software to form the Symbian joint venture, which later changed its name to Symbian Software and renamed EPOC32 Symbian OS.

The software platform and user interface S60, also referred to as Series 60, is built on top of Symbian [6].

In the past, Symbian UIQ, Series 80, and Series 90 were among the other versions that were accessible. Symbian S60 is also the version used by Symbian phones.

Symbian features a Java runtime environment, like Android and BlackBerry, but it only supports the Java "Mobile Information Device Profile" (MIDP). Symbian Java programs are extremely portable because they are restricted to MIDP, however the list of available APIs is very small and does not meet the needs of mobile researchers [2].

Symbian has always made use of a native graphics toolkit known as AVKON (Series 60). The S60 was designed to be controlled via an interface that resembled a keyboard, such as a mini-QWERTY keyboard or a 15-key enhanced telephone keypad. Binary compatibility exists between software created using AVKON and Symbian models up to and including Symbian 3. The user interface toolkit for new apps that is currently advised is the Qt framework, which is a component of Symbian 3. For earlier Symbian devices, Qt can also be installed [4].

To support touch-based user interfaces, Symbian 4 was to feature a new GUI library foundation called "UI Extensions for Mobile," or UIEMO (internal project name "Orbit"). It was planned to be released in January 2010. Nokia did, however, disclose that Orbit/UIEMO had been abandoned in October 2010.
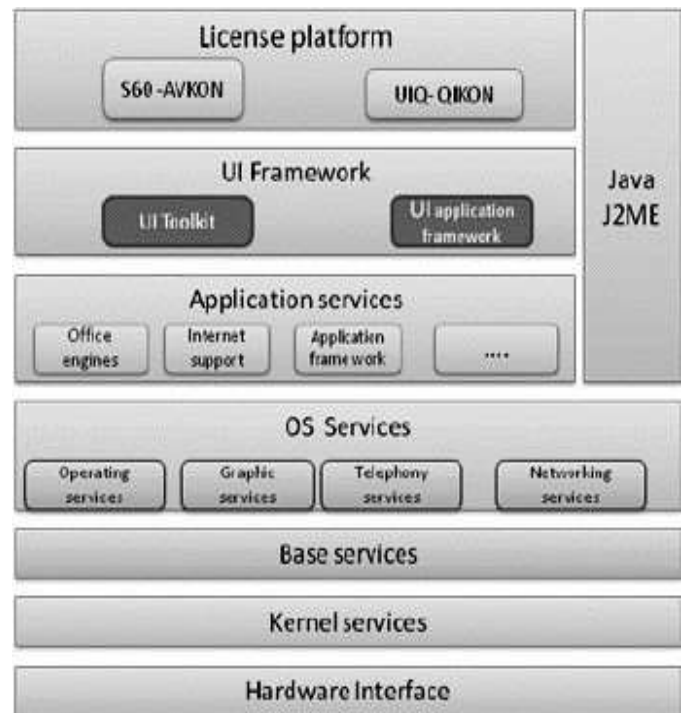

Fig. 6 Architecture of Symbian OS [6]

Eventually, Nokia urged programmers to use Qt Quick with QML, a new high-level declarative UI and scripting framework that enabled development for both Symbian and MeeGo and will be made accessible as a Qt update for pre-existing Symbian 3 devices. The outdated S60 framework (AVKON) would ultimately be deprecated and no longer included with new devices, breaking binary compatibility with current S60 apps as more applications increasingly adopt a user interface reworked in Qt [3].

Figure 6 shows the internal architecture of Symbian OS. It consists of several components.

2.6 Ubuntu Touch OS:

Ubuntu Touch, also known as Ubuntu Phone, was a mobile operating system developed by Canonical Ltd. Here is a possible taxonomy for Ubuntu Touch:

Ubuntu Touch 1.0: The first version of Ubuntu Touch was designed to run on a limited number of devices, including the Galaxy Nexus, the Nexus 4, and the Nexus 7.

Ubuntu Touch 1.5: Ubuntu Touch 1.5, also known as Utopic Unicorn, was released in 2015. It was based on Ubuntu 14.10 and introduced new features such as improved support for Bluetooth and a new camera app [21].

Ubuntu Touch 2.0: Ubuntu Touch 2.0, also known as Vivid Vervet, was released in 2015. It was based on Ubuntu 15.04 and introduced a new version of the Unity 8 interface, which was designed to work on both phones and desktops.

Ubuntu Touch 15.04: Ubuntu Touch 15.04, also known as OTA-4, was released in 2016. It introduced new features such as support for VPNs and improvements to the address book and messaging apps.

Ubuntu Touch 16.04: Ubuntu Touch 16.04, also known as OTA-13, was released in 2016. It was based on Ubuntu 16.04 and introduced new features such as support for 64-bit ARM processors and a new app store.

Ubuntu Touch 16.10: Ubuntu Touch 16.10, also known as OTA-14, was released in 2016. It introduced new features such as support for the Nexus 5 and improvements to the camera app.

Ubuntu Touch 17.04: Ubuntu Touch 17.04, also known as OTA-15, was released in 2017. It introduced new features such as improvements to the browser app and support for more languages.

Ubuntu Touch 18.04: Ubuntu Touch 18.04, also known as OTA-4, was released in 2018. It was based on Ubuntu 18.04 and introduced new features such as improvements to the notifications system and support for fingerprint authentication.

In 2017, Canonical announced that it would no longer develop Ubuntu Touch, and the project was eventually taken over by the Aborts community. The Aborts team continues to develop and maintain Ubuntu Touch, with new updates and features being added on an ongoing basis [1][4].

2.7 Web OS:

1. Palm webOS:

1) webOS 1.0	4) webOS 1.3	7) webOS 2.1
2) webOS 1.1	5) webOS 1.4	8) webOS 3.0
3) webOS 1.2	6) webOS 2.0	9) webOS 3.0.5

2. HP webOS:

1) webOS 3.0.2	2) webOS 3.0.4	3) webOS 3.0.5

3. LG webOS:

1) webOS 1.0	4) webOS 3.5	7) webOS 5.0
2) webOS 2.0	5) webOS 4.0	
3) webOS 3.0	6) webOS 4.5	

It's worth noting that webOS was originally developed by Palm, which was later acquired by HP. After HP discontinued development of webOS, the operating system was acquired by LG, which has since used it as the operating system for its smart TVs and other smart home devices. The versions of webOS used on LG devices are not directly compatible with the versions of webOS used on Palm and HP devices and represent a separate branch of the operating system's development [4].

3. COMPARISION

This section shows the comparison of Android OS, iOS and Windows phone based on different parameters. Table 1 shows the comparison based on general terms and Table 2 shows the comparison based on technical terms of Android OS, iOS and Windows phone which are leading and most captured in mobile phone market.

Table. 1 General Comparison of Android, iOS, and Windows Phone Operating System

Feature	Android	iOS	Windows Phone
Developer	Google	Apple	Microsoft
Initial Release	September 2008	June 2007	October 2010
Latest Release	Android 12	iOS 15	Windows 10 Mobile
Market Share (2021)	71.9%	27.4%	0.7%
App Store	Google Play Store	Apple App Store	Microsoft Store
Number of Apps	3.5 million (approx.)	2.2 million (approx.)	669,000 (approx.)

Customization	Highly customizable	Limited customization	Limited customization
Security	Open-source, potentially vulnerable to malware and viruses	Highly secure and closed source, less vulnerable to malware and viruses	Secure and closed source, but less secure than iOS
User Interface (UI)	Highly customizable	Consistent and intuitive	Metro UI
Voice Assistant	Google Assistant	Siri	Cortana
Multitasking	Yes	Yes	Yes
Cross-platform	Yes	No	No
Price range	Low to high-end	High-end only	Low to high-end

Table. 2 Technical Comparison of Android, iOS, and Windows Phone Operating System

Feature	Android	iOS	Windows Phone
Kernel Type	Linux	Darwin (based on BSD Unix)	Windows NT
Programming Language	Java, C++, Kotlin, others	Objective-C, Swift	C#, VB.NET
Development Environment	Android Studio	Xcode	Visual Studio
Default File System	ext4	HFS+	NTFS
Virtual Assistant	Google Assistant	Siri	Cortana
Default Web Browser	Google Chrome	Safari	Microsoft Edge
Multitasking	Yes	Yes	Yes
File Transfer	USB, Bluetooth, Wi-Fi	USB, Wi-Fi	USB, Bluetooth, Wi-Fi
NFC Support	Yes	Yes	Yes
Wireless Charging	Yes	Yes (iPhone 8 onwards)	No
RAM Management	Automatic and Manual	Automatic	Automatic
Default Map Application	Google Maps	Apple Maps	Bing Maps
Voice Calling	Yes	Yes	Yes
Messaging	SMS, MMS, instant messaging	SMS, iMessage	SMS, MMS
Biometric Authentication	Fingerprint, Face Recognition, Iris Scanning, others	Face ID, Touch ID	Fingerprint, Face Recognition
App Store	Google Play Store	Apple App Store	Microsoft Store
Update Frequency	Varies by Manufacturer	Regular	Varies by Manufacturer
Root Access	Possible	Not possible	Not possible

4. CONCLUSION

The survey gives information about some leading mobile OS available in market. From a technological and developer perspective, the paper was able to review and contrast the main mobile operating systems and user interface toolkits. Currently, Android, iOS, and Windows Phone are the three most popular mobile operating systems. Google's Android initiative to create an operating system that can run on all mobile devices has propelled Android to become the most widely used and preferred mobile operating system worldwide, followed by Apple iOS.

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