

Operating Systems for Mobiles until late 2018: A Comparative Survey and Overview

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Abstract— Smart phones and other latest technologies have been, and continue to be emerging in today's world. The same has been observed to be showcased by the operating systems that supplement each of the said technologies. There are multiple operating systems available today and some of the select operating systems have been made compatible across various devices. For instance, macOS developed by Apple Inc for their lineup of Mac products can synchronize seamlessly with the iOS for other products from the same manufacturer while still promoting collaboration between their phone and laptop lineups. A universal platform was proposed by Microsoft to function across their range of laptops and smart phones. Also, Android which began for smart phones has now been extended to its own version for automobiles. At the same time, there are millions of new releases, both familiar and unfamiliar directed towards dominating the market today. All of these advancements raise questions as to which operating system is to be relied upon and for which application has the ability to outperform one another. This paper is dedicated specifically towards mobile operating systems employed by leading manufacturers followed by a parallel analysis of the same.

Keywords— Smartphones, Android, iOS, Mobile Technology, Mobile Operating Systems

I. INTRODUCTION

Mobile phones were once a device of choice due to its ability to make phone calls and send or receive messages in a flash. They are handy and easy to use. With the consistent advancements in technology, the employment of new features such as cameras to click photos or record videos, Bluetooth and NFC to ease data transfer, etc have made the mobile phone an exceptional device of choice. The above added features make the availability of earlier models negligible or close to obsolete. There are multiple customizable options built into the new operating systems and are being used in mobile phones today. They are referred to as smart phones. The added functionalities are backed by the plethora of both software and hardware capabilities and when put together make the smart phone a useful resource to anybody living in the current decade.

Technology has changed the way humans live. The things that people could only imagine have become reality. Smartphones contribute to one such innovation. We can now connect to anybody from anywhere in the world. We can also access the internet using these portable devices. There are plenty of smartphones available in the market today. Each one provides different functionalities to the user. All these use a unique Operating system to provide the user what they really want. The demands of the users keeps increasing every day and hence it becomes very important for the vendors to keep introducing additional features which could help them to stand out in the market for a long time. The most common

Operating systems which are present in the smartphones are Android OS, Apple iOS, and Windows OS. The most popular companies which deal with enhancing the user's experience with the smartphones are Google, Samsung, Microsoft, Apple, and Nokia. There are many other companies which perform a lot of research and develop Operating systems for the mobiles. This area in technology requires constant development and up-gradation for which a lot of efforts are being put up by several organizations. For a common man, it becomes important to know what's behind the smooth touch screen and how all this works. The operating system of a smart phone helps it to be unique and be consistent in the market for a long time.

The term smart Phone was coined by the corporate Ericsson [1] within the year 1997. The smart Phones were totally different from the opposite feature handsets thanks to the applying Programming Interfaces. The primary phone to own cellular and private Digital assistance was developed by IBM within the year 1992. This phone was named "Simon Personal Communicator". Within the year 1996, Nokia released "Nokia 9000" that had organizer with QWERTY data input device with it. In a while, the movable in operation systems were introduced. The mobile phones area unit currently classified on the premise of their in operation systems. Today [2], quite eightieth of the mobile market consists of sensible phones that area unit reliable and easier to use. Humanoid captures forty third of the smartphone market and iOS captures four-hundredth. These in operation systems offer a computer

programmed during which the users will perform their tasks in a very comfy atmosphere.

All the smart phones present today use a certain technology and provides several features. These features differ with respect to the operating systems used in the particular smartphone. Each smart phone application is developed using the various software development life cycle models based on the requirement of the client. The most basic stages involved in the development of the application are -

1. Communication
2. Planning
3. Modelling
4. Coding
5. Deployment

The smart phones consist of certain built in applications like Web Browser, Calendar, Email Client, etc. Other applications can be installed by the user with the app store. The Operating system is responsible to provide an interface between all the hardware and software components of the system and act as a platform with which the humans could interact with the mobile phone.

Mobile networks are devouring a lot of information so as to improve their correspondences and pack the information inclusion. Ceaselessly, improvement in Mobile phone innovation step by step has incredible effects on individual. Mobile phone clients are profiting profits by the quick expanding in improvement of portable telephone gadgets. We can see this fast change in cell phone innovation in our everyday life. In the past period [2], if somebody needed to mail important document, he/she needed to deliver from door to door, however these days with current headway of mobile phone innovation, individuals can without much of a stretch send the archives in delicate duplicate arrangement by means of a mobile phone. Improvement in cell phone innovation additionally impacts affects different fields of life.

For instance in business segment one can develop his business by means of a cell phone; there are numerous different precedents in our everyday life and mobile phones assume an imperative job in the life of individual.

The development of mobile phone operating system has quickly expanded to contain challengers, for example, Google, Android, Symbian, Apple, BlackBerry, Microsoft, Palm, and so on. Such working framework's stages have arrived in a long way on the grounds that no organization gives an operating system that is ideal for the cell phone clients. These organizations contend that their stages of working framework for cell phones execute best in all endeavors and furthermore these organizations definitely don't declare any powerless purpose of their frameworks. This circumstance makes trouble for the mobile phone clients that they don't realize which organization's stage is the most appropriate for their prerequisites. So as to explain this issue,

we play out an expansive examination of mainstream working frameworks of mobile phones so as to bring up their quality. After examination of such working frameworks for cell phones we can get a genuine thought which cell phone is the best reasonable for end clients, business application, gaming and furthermore for mixed media.

The operating systems used in smart phones enable the computing capabilities and maintain the functional state of the device it is dedicated to. They are designed to run applications which meet the hardware requirements of any device. Mobile operating systems are similar to that of operating systems. They are specifically designed for mobile phones and provision many portable devices to achieve the above said functionalities. The latest mobile phones have larger screens which are intended to enhance the experience of the user. They come with advanced and/or interactive user interfaces that compel the users to make utmost use of the phone, even for the silliest of reasons.

The latest operating systems namely Android and iOS along with other major operating systems for mobiles have changed the scenario in a horizon of ways. With open source operating systems began the era where developers can now make an application of their choice which can be made compatible with most of the mobile operating systems today. Building customized applications have been on the rise to meet specific requirements across different verticals as favorable. The latest features offered today are coupled with the basic functionalities of any regular mobile phone to achieve a dual benefit and yet remain portable. Some of the widely used features are namely Wi-Fi, social media sharing capabilities in one touch, or anything that can help increase productivity.

Adding to the context above, there has been an increase in the number of active smartphone users every year as a result of the limitless possibilities with open source software and the world of developers. In the recent years, it has been observed that there is exceptional importance given to the user interface and usability of smartphones which are completely OS-dependent. It is aimed towards achieving an enhanced user experience so that the phone continues to be used with satisfying outcomes. The mobile operating systems are sometimes programmed to support a specific task majorly and such operating systems may be released for select smartphones that qualify the minimum hardware requirements. Affordability, durability and satisfaction are yet major factors that continue to influence consumers and their choices to stick to a mobile operating system of their choice.

The success of a particular smartphone brand is not guaranteed in every continent. The stakeholders become opportunities depending on the priority given towards the quality of the products and services offered. Pricing is equally important as new manufacturers slog to make a presence in the industry for new releases. It is important to understand the social stratification of each continent to design a country-specific product including mobile operating systems. With continued reference to the same, it has been observed over the years that android has been leading the smartphone market

with every fiscal year due to the ease of developing suitable applications as necessary and the number of android users growing along with. Also, iOS is equally competent with its most easy to use operating system while at the same time is restricted to Apple's handheld devices only.

Some of the exceptional applications such as WhatsApp and Facebook [3] with endless possibilities of connectivity have brought forward a sharp increase in the total number of smartphone users due to its convenience and ability to connect across people sustainably. Nevertheless, not all mobile operating systems are safe to use and not all mobile operating systems that are safe to use can be used across all devices. The "End User License Agreement" of each manufacturer controls the terms of use of each of their products irrespective of whether it was initially developed by the parent company, its subsidiaries or a third party.

Some of the most commonly available operating systems are analyzed in this paper and an overview is provided about each of the mobile operating system. This paper focuses on Survey different mobile operating systems presently in use. The remainder of the paper as follows with 2. Analysis of various operating systems, Section 3. Success Defining Pointers for Mobile Operating Systems. Section 4 Comparison on Different Operating Systems and The last Section 7 show the conclusion of operating systems with comparison tables.

II. ANALYSIS OF VARIOUS OPERATING SYSTEMS

There are hundreds of operating systems present in the market today. A detailed description is provided here of a few of them.

A. Android

September twentieth, 2008 was the date when Google discharged the principal Android OS by the name of 'Astro'. After at some point next updated variants 'Drinking spree' and 'Cupcake' were likewise discharged [4]. Google at that point embraced the pattern of naming Android forms after any pastry or a sweet in alphabetical order. The other releases are Donut, Éclair, Froyo, Gingerbread, Honeycomb, Ice Cream Sandwich, Jelly Bean, Kitkat, Lollipop, Marshmallow, Nougat, and Oreo. Android Pie (Android 9.0) is so far the most recent Android adaptation from Google. Since the stage isn't closed like iOS, there are an excessive number of incredible Android applications worked by designers.

Android OS [20] is architected as various layers of stacked as programming that includes android applications, a working framework, android run-time, middleware, administrations and libraries. Each layer of the stack, and the comparing components inside each layer, are firmly incorporated and gives distinctive sort of administrations to the layer simply above it and also the ideal application advancement and execution condition for mobile phones.

Some of the smartphones operating on Android are HTC Desire, Samsung Galaxy Gio, Motorola Droid Razr, Samsung Galaxy S3 and HTC Wildfire.

B. Apple

iOS was introduced in 29th June 2007 when the first iPhone was developed. From that point forward iOS has been under gone numerous redesigns and as of now the most recent one is the iOS 9.

Apple has still not enabled some other producer to lay hands on its working framework. In contrast to Android, Apple has progressively focused on the execution alongside appearance. This is the reason [5, 6,7] that the essential appearance of iOS is nearly equivalent to it was in 2007. Generally it is extremely easy to use and is one of the versatile best working frameworks on the planet. So far iOS has been utilized in all iPhones, iPod and iPad.

C. Windows

Windows OS is utilized [21] in mobile phones, however typical cell phone clients discover it somewhat hard to work it and yet it was exceptionally well known among individuals who were utilized to it.

This was the situation until Nokia and Microsoft held hands to cooperate. The most recent Windows discharge by Microsoft is known as Windows 7 which has increased tremendous ubiquity among all sort of clients [6,8]. With its bright and easy to understand interface, it has given Windows OS another life and is right now sought after everywhere throughout the world. Another explanation for its prosperity is that this most recent OS is utilized in ground-breaking gadgets made by Nokia. The PC like look has completely vanished from the windows telephones with the arrival of Windows 7. Samsung and HTC likewise discharged a few Windows-based telephones, yet they couldn't numerous spots in the market.

Nokia Lumia series is totally windows based. Some of the most recent Windows Phones are Nokia Lumia 800, Nokia Lumia 900, Samsung Focus and HTC Titan 2.

D. Ubuntu touch

Ubuntu Touch offers a totally extraordinary approach to deal with utilizing our mobile phones or tablets than utilizing other standard working frameworks. The OS is based on Ubuntu, which gives us a protected and stable base framework utilized by a large number of individuals crosswise over PCs, servers, IoT gadgets and even the universal space station.

The intuitive user interface [7] enables us to get to the majority of your telephone's highlights by swiping from the edges of the screen to get to your applications, devices and settings all with one hand and no on-screen catches. It looks incredible and feels smooth.

The latest version was released in 16.04 OTA-5 / 12 October 2018. The marketing targets are Smartphones, tablets, mobile

devices. It uses the Unix-like OS family. UBports, Ubuntu community, previously Canonical Ltd. have developed the OS. It uses ARM platform. The default user interface in the OS is Graphical (Native and Web applications).

E. Blackberry

Blackberry OS is the property of RIM (Research in Motion) and was first released in 1999. RIM has developed this operating system for its Blackberry [16, 17] line of mobile phones. Blackberry is vastly different from other working frameworks. The interface style, and also the Smartphone configuration, is likewise unique having a trackball for proceeding onward the menu and a QWERTY keyboard.

Like Apple, Blackberry OS is a close source OS and isn't accessible for some other maker. As of now, the most recent arrival of this working framework is Blackberry OS 7.1 which was presented in May 2011 and is utilized in Blackberry Bold 9930. It is an entirely dependable OS and is immune to all the viruses.

A portion of the mobile phones working on Blackberry OS are Blackberry Bold, Blackberry Curve, Blackberry Torch and Blackberry 8520.

F. Tizen

Tizen is a mobile operating system created by the Linux Foundation that keeps running on an extensive variety of Samsung gadgets, including cell phones; tablets; in-vehicle infotainment (IVI) gadgets; shrewd TVs; brilliant cameras; smart watches; Blu-beam players; savvy home apparatuses (fridges, lighting, clothes washers, forced air systems, stoves/microwaves); and mechanical vacuum cleaners. Tizen can run Android applications utilizing Open Mobile ACL (application similarity layer), anyway applications must be introduced from an application store since straightforwardly introducing Android APK documents isn't upheld. Tizen is an open source and flexible operating system which is developed from the scratch to address the needs of all the stakeholders of the mobile and connected device ecosystem, including device manufacturers, mobile operators, application developers and independent software vendors (ISVs). Tizen is developed by a community of developers, under open source governance, and is open to all members who wish to participate.

III. SUCCESS DEFINING POINTERS FOR MOBILE OPERATING SYSTEMS

Some of the popular operating systems have a couple of common functionalities that make it lead the market [9]. Some of the necessary and must have abilities of a successful mobile operating system today (or an operating system in general) involve hardware and software working in sync that enable many functionalities. A few of such concrete necessities are discussed as below.

A. Hardware Limitations

The extent to which the hardware of a mobile phone can be scaled to use can be an equally [10,11] determining factor in terms of the functionality of a phone. This involves the memory and storage, both user available and that reserved for the operating system. Ports which can be used and relevant existing protocols linked to the same are expected to be of a latest standard to support multiple connectivity options available. Some of the latest changes in the hardware vital today involve dual cameras for crisp and clear images, upgradability of internal memory which is rare and other add on hardware components which qualify with the available hardware specifications such as support to on-the-go pen drives. Wearable accessories linked to the hardware are also known to extend the use of an existing hardware.

B. Software Limitations

Similar to hardware specifications, the example of a software limitation can be its inbuilt permission sets and restrictions that prevent a user or developer from performing extensive changes to the operating system or a specific application within the operating system [12]. This may or may not be from a third party distributor. The latest applications are expected to support the latest trends in terms of web services, synchronization across devices or applications, flash support, and other dynamic properties that lets a user appreciate the technology while being benefitted from the same. Many of the applications today are cloud based to reduce stress on hardware while at the same time safely authenticating the user. Other issues associated are the availability of the same applications and its subjection to cross platform support.

C. Other Correspondences

The combination of a hardware and another hardware or hardware with software built for each other can enable a high degree of reusability and generate revenue. A cutting edge example to define the same would be a retina scanner [13, 14]. A lately developed retina scanner for mobiles supports the latest mobile operating systems that are widely used today. It makes use of an add-on module that is to be plugged in to the phone and is ready for use. This particular combination can provision an eye scanning functionality to all the smartphone users at a highly reduced cost. Also, the population of active users can be made use of while at the same time the need to manufacture such eye scanning systems otherwise would cost millions for any organization. Nevertheless, there are continuous efforts today that drive the large population closer to technologies that can be made readily available to drive the economy.

With continued reference [18] to the above points, the mobile operating system and the hardware must qualify the minimum standards defined by their respective governing bodies to ensure the safety and security of its users. It is frequently observed that certain unfamiliar brands of electronic devices being alleged of sending user data in the background without the knowledge of the user. This can involve sensitive data,

transaction information and other valuable information that should not be known to the public. With the growing number of users and applications comes the growing number of associated risks involved. It is appreciated to update to the latest security patches and have steady hardware to ensure the smooth functioning of the devices without disappointment.

D. Future Scope

With the availability of cross-platform tools for developing a particular application or service, a single requirement can be fulfilled for multiple mobile operating systems using suitable services. [15,17] Certain frameworks have the excellent abilities to run an application the way it should on more than one type of mobile operating system without compromising on the service the application is intended to offer. However, when such services are not able to bypass certain frequent situations involving low memory or other ailments that affect the performance of an application, there is still a slight gap that is to be covered. The reliability on cloud based services offered in a secure environment is believed to continue offering promising results as long as the user has an internet connection which is a must in today's day and age.

IV. COMPARISON ON DIFFERENT OPERATING SYSTEMS

The leading operating systems for mobiles are discussed as below followed by a comparison of vital features in the sense of hardware and software offerings of leading manufacturers.

A. Android OS by Google

Developed by Google in the early 2007 and leading, it has made its way to the automobile industry [6] and growing. There are many versions released with date with incrementing API levels with each release. The app store supports millions of both free and paid applications for users to choose from. Being open source, there are large groups of developers and testers to drive the Android era [8]. Google along with its subsidiaries have always been successful in scaling this operating system across third party mobile phone manufacturers while still ensuring that the necessary standards are compiled for.

B. iOS by Apple

It is the first and yet most preferred and convenient operating systems for the iPhone in the world with a rich user interface [6]. Supporting its fellow line-up of products such as the iPod, it continues to scale multiple functionalities such as cross platform collaboration on the go with Mac systems.

C. Others

Some of the other operating systems involve Windows 10 Mobile [14] by Microsoft, Symbian by Nokia and BadaOS by Samsung. These operating systems are not as popular due to certain economic and social preferences but do have many of the services still supported by the parent organization(s). Compared to all the existing mobile operating systems, iOS has been and continues to be the most secure mobile

operating system with user privacy being one of the core values of Apple Inc.

TABLE I. SECURITY BASED COMPARISON OF TOP THREE MOBILE OPERATING SYSTEMS [9]

Aspect	Operating Systems and Concerns	
	Android	iOS
Mobile Eco-System	Does not have control	Has Control
Encryption	Not enabled by default	Enabled by default
Corporate Presence	Moderate (not more than 21%)	High (more than 30% and counting)
Third Party Support	Most of the times	Strong control over third party offerings
Ability to Hack	Very High	Negligible due to strong control

TABLE II. COMPARISON OF ANDROID, iOS AND WINDOWS OS' GENERAL SPECIFICATIONS [9]

Aspect	Operating Systems and Information		
	Android	iOS	Windows
License Type	Available as Open Source	Proprietary Software	Proprietary Software
Development Language	C/C++ and Java	Swift with Objective C	C#/F#, VB.NET, JavaScript
Market Share	Ranks Topmost	Ranks Moderate	Below Average
VM Support	Yes	No	Yes

TABLE III. COMPARING TABLE WITH SERVICES OFFERED BY THE THREE MOBILE OPERATING SYSTEMS.

	ANDROID 5.0	WINDOWS 8.1	iOS 8.2
USER INTERFACE	MATERIAL DESIGN / v17 LEANBACK	SILVERLIGHT /XAML	COCOA TOUCH
INSTALLATION MODE	MANY	MANY	RESTRICTED
GRAPHICS	OPENGL ED3.1	DIRECTX	METAL
CODING LANGUAGE	JAVA	C#	OBJECTIVE- C/SWIFT
DEVELOPMENT	YES	YES	RESTRICTED
VIRTUAL MACHINE	NONE	CLR	NONE

V. CONCLUSION

The mobile operating systems evaluated here offer several advantages. In this paper we have compared the Operating systems in 3 different categories. The First category is advantages and disadvantages of iOS, Android and windows and we find them have their advantages and disadvantages. IOS development requires a specific type of hardware that may be more difficult to obtain but that might encourage cross-departmental collaboration and expose us to another operating system. The second Category is based on Security Based Comparison of Top Three Mobile Operating Systems. The third category is Comparison of Android, iOS And Windows Os' General Specifications. And Final category is Comparison with Services Offered by the Three Mobile Operating Systems. The ever increasing dependence on smartphones is believed to always increase. However, Android and iOS are said to be the leading operating systems for mobiles as discussed throughout this paper due to their distinguishing offerings in every aspect.

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