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An Assessment Of Mobile Operating Systems: Know Your Mobile Operating System

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Abstract: Use of Mobile or handheld devices is very common today. When plan to buy a mobile whether it is new or preowned people are going through certain parameters like color, size, features, quality of camera, processor and memory. But, the most ignored or less cared part is operating system. This research paper highlights upon the existing and obsolete operating systems as well as their features and limitations. Paper compares the various mobile operating systems w.r.t. different crucial parameters like, basic features, browser, communication and connectivity, language and inputs, maps and navigation and privacy and security issues with most popular mobile operating systems.

Keywords: Mobile Operating System, smartphone, handheld operating system, Android, iOS, Symbian, Windows, Blackberry

1. Introduction

A mobile operating system serves as an interface between the end user device i.e. hardware and the application i.e. software. In its transitional role, it provides an unvarying access to resources and controls access to them. A mobile operating system, also known as a mobile OS, a mobile platform, or a handheld operating system, is the operating system that controls a mobile device similar in principle to an operating system such as Mac OS, Linux or Windows that controls a desktop computer or laptop. [1] A mobile operating system is an operating system for mobile phones, tablets, smartwatches, 2-in-1 PCs, smart speakers, or other mobile devices. Furthermore, they are a mixture of computer OS with some additional features for mobiles. Also, they are comparatively light and simple. [2]

Modern mobile operating systems combine the features of a personal computer operating system with touchscreen, cellular, Bluetooth, WiFi, GPS mobile navigation, camera, video camera, speech recognition, voice recorder, music player, Near field communication, personal digital assistant (PDA) and other features. [3] Selection of best OS for your pre-owned smartphone is depends on the services provided by the different OS developers. Apple offers a seamless consumer experience, while Android offers flexibility. Customer may

prefer the familiarity of Windows, or be a die-hard Blackberry fan. No matter what they are looking for, however, chances are at least one OS has what they need.

Mobile devices, with mobile communications capabilities, comprise two mobile operating systems the main user-facing software platform is supplemented by a second low-level proprietary real-time operating system which operates the radio and other hardware. Research has shown that these low-level systems may contain a range of security vulnerabilities permitting malicious base stations to gain high levels of control over the mobile device. [4]

2. Objectives:

1. To take the overview of existing and obsolete mobile operating systems.
2. To understand the features and limitations of selected operating systems.
3. To identify the parameters to compare the mobile operating systems.
4. To find privacy and security issues with most popular mobile operating systems.

3. Mobile Operating Systems that matters right now

These days everyone including grandparents in the family have smartphones though they are almost all run on one of two operating systems. However, there are large number of mobile operating systems available as shown in the following table below.

Table 1: Existing Mobile Operating Systems

Sr.	Mobile OS	Sr.	Mobile OS	Sr.	Mobile OS
1	AMAZFIT OS	15	GridOS	29	OxygenOS
2	Android	16	HTC Sense	30	Plasma Mobile
3	Android One	17	Indus OS	31	PostmarketOS
4	AliOS/YunOS	18	iOS	32	PureOS
5	BlackBerry 10	19	iPodLinux	33	QNX OS
6	Blackberry Playbook	20	Kai OS	34	Replicant OS
7	Chrome OS	21	LG UX	35	RockBox
8	ColorOS	22	LineageOS	36	Sailfish OS
9	/e/	23	LiteOS	37	Samsung One
10	EMUI	24	Lune OS	38	SHR
11	Fire OS	25	Maruos	39	Tizen
12	Flyme OS	26	Maemo OS	40	Ubuntu Touch
13	Fuchsia	27	Mer Project	41	watchOS
14	Funtouch OS	28	MIUI	42	webOS
				43	ZenUI

4. Obsolete Mobile Operating System

Mobile operating systems have been around since long before most people knew what a mobile operating system was. So there has been plenty of time for some of the big names to hit peak heights & then burn out.
Like all software, operating systems (OS) have a life cycle. Eventually vendors end their support for a version of an operating system. Once support ends, additional security updates are no longer provided rendering the OS insecure at that point. This applies to all operating systems. Following table shows the list of such

Table 2: Obsolete Mobile Operating Systems

Sr.	Mobile OS	Sr.	Mobile OS	Sr.	Mobile OS
1	Access Linux Platform	10	LiMo 4	19	OpenZaurus
2	Bada OS	11	Magic Cap	20	Palm OS
3	BlackBerry 10	12	MeeGo	21	PenPoint OS
4	Boot to Gecko	13	Moblin	22	Qt Extended
5	CyanogenMod	14	MotoMagx	23	Samsung Experience
6	Cyanogen OS	15	Newton OS	24	Symbian OS
7	Danger OS	16	Nokia S40	25	Windows Mobile OS
8	EPOC	17	Nokia Asha	26	Windows Phone OS
9	Firefox OS	18	Openmoko Linux	27	Windows RT

5. Types of Mobile Operating Systems and their features and limitations

Mobile phones especially smartphones are the technologically revolutionary offspring which has redefined and taken the digital world by storm. Today, we cannot live without smartphones since they are playing a significant role in redefining the way we get information and communicate with others. And smartphones are completely useless trash with no proper mobile OS, mobile operating system. As the specifically-designed software that runs on smartphones and other mobile devices, mobile OS has a great place in the proper functioning of any mobile device. And much like PCs that have scores of different types of operating systems, smartphones can run different operating systems or different versions.

When in the market for a new mobile phone, many people pay less attention to the mobile OS but more to other factors like price, screen, RAM, battery life and camera. But in fact, selecting which one to buy has much to with the mobile OS that runs the phone. In the current market, there exists almost more than 100 mobile operating systems to choose between. But in what follows, we'll explore the top 5 major ones that currently rule the kingdom and make a comparison among them in several different factors. Top 5 mobile operating systems viz. Android OS, Apple iOS, Windows Mobile OS, Blackberry Mobile OS, Sailfish OS.

The mobile operating system provides various interfaces of communication between the software components at the application layer middleware layers and hardware devices. The

OS manages the hardware and software resources within a device. It performs and manages basic tasks such as the recognition of input from the device keyboard and generation of output to the device's screen. OS also ensures that different programs running at the same time do not interfere with each other. It is responsible for the memory management and for communication within the device. OS can be extended to add additional complexity and functionality to the code.

Mobile OS supports the important UI (User Interface) function. The OS is purposely hidden from the user. It's, a base onto which the applications required by the user are loaded. The OS is not only a key element in terms of the tasks it performs but the choice of OS will constrain or enable the functionality of the end device in two key respects; firstly, that which is technically possible with any given OS and secondly that which is available, i.e. what applications have been developed for that OS. The OS also provides a consistent interface for applications, regardless of the hardware it is loaded on. Communication between the OS and the applications is done through an Application Program Interface which allows a software developer to write an application for one device and have a high level of confidence that it will be running on another running the same OS. Table 1.3 focus on few important operating systems w.r.t. their features and limitation

Table 3: Mobile Operating Systems and their features and limitations

Sr.	Mobile OS	Features	Limitations
1	**Symbian OS**[5][6]	▪ Provides open platform to enable independent technology and s/w vendors to develop third party app. ▪ Impressive battery life. ▪ Lower hardware requirements.	▪ Dependent on Nokia ▪ Provided a late response as compared to ios and Android. ▪ The touch of Symbian use devices are not as smooth as compared to ios and android devices.
2	**Android OS**[7]	▪ Flexible UI ▪ Ubiquity on a range of mobile phones ▪ Incomparable Apps in terms of sheer volume ▪ High-customizing capability ▪ Cost-wise devices	▪ Delayed updates ▪ Less secure
3	**iPhone OS (iOS)**[8]	▪ Beautiful UI ▪ Great quality of apps ▪ Regular Updates ▪ Excellent Security	▪ Closed-source and locked-down mobile OS ▪ Limited Customizability ▪ Costly devices
4	**BlackBerry OS**[9][10]	▪ Unique UI ▪ Excellent Security ▪ Excellent option for business people	▪ Not customizable ▪ Lack of Compatibility ▪ Limited Targeted Users
5	**Windows Phone 7 (Windows Mobile)**[11]	▪ Smooth to operate and easy to control ▪ Colorful UI ▪ Microsoft Office suite ▪ Secure	▪ Support Limited Apps
6	**Palm OS (Garnet OS)[**[12]	▪ Becoming windows-styled ▪ Much more software ▪ Lower price	▪ Percent share of market is lessening ▪ Not strong enough in multimedia

Table 3: Mobile Operating Systems and their features and limitations

Sr.	Mobile OS	Features	Limitations
7	**Palm webOS**[13][14]	▪ Free SDK and frameworks ▪ Free distribution of code ▪ "Homebrew" friendly	▪ If apps sold, must be distributed through Palm store ▪ Limited device support now ▪ Relatively small market share for Palm devices
8	**Bada**[15]	▪ Stable OS ▪ Has many of the features of Android and iOS ▪ Performance has been significantly improved with 1.2	▪ lack of Apps. ▪ Most of the good apps are paid and horribly priced compared to the counterparts. ▪ Lack of Good free Apps ▪ Does not support multitasking
9	**Maemo OS**[16]	▪ Multitasking features ▪ Good GUI	▪ Only One set N900 ▪ Lack of Support. ▪ less Applications
10	**Tizen**[17]	▪ Lightweight environment and user friendly interface ▪ It consumes less battery and is well-optimized. ▪ Offers seamless smartphone casting. ▪ Supports all devices.	▪ It can be difficult for non-tech-savvy people as it may require a lot of customization. ▪ No app store is available which may limit access to users' favorite content.
11	**Sailfish OS**[18]	▪ Independent and flexible ▪ Excellent security ▪ More Affordable	▪ Very few apps installed
12	**Ubuntu Touch**[19]	▪ Fast OS Switching (Shared Kernal) and fast processing ▪ Desktop & Mobile Integration ▪ Virus Free (Very less Prone to Virus) ▪ Nice Gestures (Sleek & Simple Gestures) ▪ Nice GUI (Great OS Graphical Design)	▪ No support for Low Configured Devices

Table 3: Mobile Operating Systems and their features and limitations

Sr.	Mobile OS	Features	Limitations
13	**Plasma Mobile**[20]	▪ Fractional scaling is available ▪ Plasmoids and workflow should be familiar to Android users ▪ Free software	▪ Minimal functionality so far ▪ Quite rough around the edges, with obvious quality of life bugs ▪ Fractional scaling still has issues
14	**PureOS**[21][22]	▪ Safe to use	▪ Pure OS is a bit out of date and it's a bit more complex to use in other distros ▪ When integrated with other software it faces some issues
15	**PostmarketOS**[23][24]	▪ Each phone has only one unique package ▪ Open Source ▪ Suitable for older devices	▪ No persistent flashing is supported at the moment ▪ Some drivers necessary for the operation of the device may not be available
16	**KaiOS**[25]	▪ Inexpensive hardware ▪ Simple UI ▪ Smart features ▪ Built in google assistance.	▪ The library of third-party apps is extremely limited. ▪ Google's own applications are just links to the mobile web versions.

6. Comparison of key mobile operating systems with important parameters

There can be various parameters to compare different operating systems which includes [26];

- Kernel
- Shell
- Security
- Architecture
- User friendliness.
- Operating system
- Integrated Development Environment
- SDK platform
- License
- Programming language used to write the OS
- Initial release
- Application store
- Graphical user interface
- Future prospect

Table 4: Comparison of mobile operating systems with specific parameters

Parameter	Android	iOS	System	Blackberry	Windows Phone	WebOS	Ubuntu	Firefox
OS Family	Linux	Darwin	RTOS	QNX	Window CE-7 Window NT-8	Linux	Linux	Linux
Vendor	Open Handset Alliance, Google	Apple, Inc	Accenture on behalf of Nokia (historically Symbian Ltd. And Symbian Foundation)	Blackberry Ltd.	Microsoft	Open WebOS community contributors, LG Electronics, Previously HP (Hewlett-Packard) & Palm	Canonical Ltd. Ubuntu community	Mozilla Foundation
Environment (IDE)	Eclipse (Google)	XCode (Apple), AppCode	QT, Carbide.C++, Vistamax, Eclipse	Eclipse, BlackBerry JDE	Visual Studio	Eclipse	Ubuntu SDK	WebIDE
SDK Platform	Linux, Mac OS X and Windows	Mac OS X using iOS SDK	Windows XP Professional SP2; Vista & 7 for some SDKs	Linux, Windows, Mac OS X	Windows	OS X, Ubuntu, Windows	Ubuntu Desktop using Ubuntu SDK	All where Firefox is available
License	Free and opensource, but usually bundled with proprietary apps and drivers	Proprietary EULA except for open source components	Proprietary, previously licensed under EPL	proprietary	Proprietary	Apache License	Free and open-source, mainly the GPL	Free and open-source, mainly the MPL; apache
Written In	C, C++, Java	C, C++, Objective-C, Swift	C, C++, Java ME, Python, Ruby, Flash Lite	C, C++, HTML5, Java script, CSS, Action Script, Java	C#, VB.NET, F#, C++, Jscript	JavaScript, CSS, HTML, C and C++	HTML5, QML, C, C++	HTML5, CSS, JavaScript, C++
Initial Release	September 23, 2008	June 29, 2007	1997	January, 1999	October 21, 2010	June, 2009	October 20, 2004	April 23, 2013
Runs on	Smartphones, Tablet, Computers, TVs, Cars and wearable devices	iPhone, iPad, iPod Touch	Smartphones	Smartphones	Personal Computers, Smartphones, Server Computers and Embedded Devices	TVs and Smart Watches	Personal Computers, Servers, Smartphones, Table computers (Ubuntu Touch), Smart TVs (Ubuntu TV)	Smartphones, Tablet and Computers
Application Store	Google Play	App Store	Nokia Ovi Store	BlackBerry World	Windows Phone Store	Palm App Catalog	Ubuntu Store	Firefox Marketplace, Web URL
GUI	Android	Cocoa Touch	Avkon	Cascades	Visual Studio	Graphical (Luna)	Ubuntu SDK	Firefox browser, Firebug
Future Prospect	Very High	High	Low	Low	Medium	Low	Low	Low

7. Security concerns associated with mobile operating systems

Major business risks commonly associated with mobility include:

- Unauthorized access to business data, networks and applications by lost or stolen devices;
- Breaches of confidential data when mobile devices fall into the wrong hands, even temporarily;
- Compromised devices as a vector for intrusion into or attack against enterprise assets; and
- Inadequate visibility into activity and security posture to prove regulatory compliance.

Fortunately, these risks can be managed by requiring mobile security controls. However, the controls available vary by mobile device type, OS and make/model, so a mobility assessment should cover the risks posed by all devices identified in your workplace and permitted by your mobility policy.

Smartphones, tablets and many other mobile devices often run one of four mobile operating systems: Apple iOS, Google Android, RIM BlackBerry OS or Windows Phone [27]

In terms of security features, different OSs have different mechanisms for securing the mobile phones. There are different types of security concerns present today [28]. These problems are occurring in the operating systems due to less attention when designing the operating system of mobile device. Some of the people find out the loopholes, and attack on the mobile devices for different purposes. Some attacks for the stealing information, network information, personal data, logins (saved in mobile) etc. There are some of the applications which are designed for specific type of attack on operating systems of handheld devices. Usually these are third party applications. Sometimes, these applications change the system files or systems default settings which is playing a vital role in our mobile phone security [29]. This paper also compare the security concerns of different operating systems in mobile phones. The detailed comparison is given in the table 5.

Table 5: Privacy and security issues with key mobile operating systems

Security Feature	Android	iOS	Tizen	Sailfish OS	Ubuntu Touch
1. Proxy server	▪ 3.1+ ▪ Only global ▪ Not per connection ▪ Only works for the browser ▪ 3rd party apps available	Yes	Yes	Yes	No
2. On-device encryption	▪ 3+ ▪ Insecure on Qualcomm devices	Yes (3rd party software may attempt brute-force attacks on password)	No	3.3.0+	No
3. External storage encryption	6+	External storage not available	No	Yes	No
4. Zero knowledge encryption	▪ No ▪ Data is accessible by Google ▪ Shared with the American PRISM surveillance program.	▪ No ▪ Data stored on iCloud is accessible by Apple ▪ Shared with the American PRISM surveillance program.	NA	NA	No
5. Privacy of synchronization	3rd party software like own Cloud	When synchronizing locally and not using iCloud	NA	NA	NA
6. Sync to cloud communication encryption	2.3.4+	Yes	NA	NA	NA
7. Wireless anti-tracking	Developer Options (9+)	8+	No	NA	No
8. Remote device location tracking	Yes	Yes	NA	NA	No
9. Remote device locking and/or data wipe	2.2+	Yes	NA	NA	No
10. End-to-end encrypted push notifications	Possible notifications are handled by the app that can decrypt it	▪ Possible since iOS 7, where the app can handle the notification and decrypt it	NA	NA	Yes
11. SSH Client	Yes	Yes	NA	Yes	Yes
12. VPN	Yes	Yes	NA	Yes	Yes
13. OpenVPN	▪ No ▪ Possible with 3rd party firmware	Yes	NA	Yes	Yes
14. WPA PEAP	Yes	Yes	NA	In developer mode	Yes

8. Conclusion

After studying various operating systems, their features and limitations, different parameters and security concerns, performance of popular operating systems like android, windows and iOS is evaluated. Security concerns of different operating systems as well as their performance in terms of running the processes is also compared. Performance of each OS is analyzed security issues. After thorough review, it is clearly observed that Android and iOS was better when compare to other mobile operating systems.

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