

A Study on Smartphone based Operating System

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ABSTRACT

At present there are many mobile phones operating systems available in the market but mobile phones with android OS have now become domestic product which was once extravagant product. The reason towards this change is attributed to its varied functionality, ease of use and utility. There are number of tasks performed on it like making call, sending or receiving SMS, music, billing, online shopping, online booking, playing games, web browsing, using different apps like whatsapp, facebook or Applock etc. Hence a large amount of user sensitive data is stored within the devices [1]. Increased usage of smartphone has led towards higher concerns about security of user- private data. Due to android as an open source mobile platform, user can easily install third party applications from markets and even from unreliable sources [2]. Thus, Android devices are a soft target for privacy intrusion. Whenever the user wants to install any application, firstly it's the description and the application screenshots which provides an insight into its utility. The user reviews the description as well as a list of permission requests before its installation. As the types and rate of malicious attacks increases, the difficulty of examining in advance whether an app is malicious or not through its descriptions has increased manifolds. In this paper we have reviewed and examined android software stack and compared smartphone based operating system like android, iOS, blackberry, Symbian, windows phone, webOS, Ubuntu and firefox.

General Terms

Android, Operating System and Security

Keywords

Android software architecture; android; iOS; Symbian; blackberry; windows phone; webOS; Ubuntu; Firefox; Android Security.

1. INTRODUCTION

Smartphones are now participating nearly in each and every sphere of life like business, education, workplace and healthcare. The Worldwide Mobile Communications Device Open Operating System Sales (WMCDOOS) provides total market of 104,898 to End Users by OS [3]. There are over 1.3 million active applications [4] in Google Play App Store. Android is the first open source, Linux-based and modern mobile handset platform. Google developed it for handset manufacturers like T-Mobile, Sprint Nextel, Google, Intel, Samsung, etc. [1]. It offers to consumers a richer, less expensive, better mobile experience and various features like 3D, SQLite, Connectivity, WebKit, Dalvik and FreeType etc. Since android provides open source operating system; users

and developers can get source code but only under the rules and conditions [1].

Whenever the user wants to install any application, firstly its description as well as a list of permission requests is provided with an opportunity for review before its installation or cancel the installation if he or she finds that the permissions are too many or objectionable. The android operating system has its own well established android permission model, but intruders can supplements them by allowing the components to be changed within and across the applications through Intent communication mechanism due to which it has susceptibility for attacks by malwares [5].

Android open source platform requires strong and complex security architecture to ensure security of user private data, personal information, application and network, but it has few constraints for developers which raises the security risk for the end users [2].

This paper is to compare the latest smartphone operating system like android, iOS, blackberry, Symbian, windows phone, webOS, Ubuntu and firefox. The comparison between different smartphone operating system is done using different parameters like OS family, Environment and market share. After summing up findings through the comparison, the conclusion discuss which operating systems are in competition and draw some conclusions from it.

The rest of the paper is organized as follows: section 2 presents the android architecture diagram: software stack of android, section 3 presents the related work, section 4 show the comparison of different major operating system, section 5 includes conclusions and future scope of the research work.

2. SOFTWARE STACK OF ANDROID

Android OS is architected in the form of different layers of stacked as software that comprises android applications, an operating system, android run-time, middleware, services and libraries. Each layer of the stack, and the corresponding elements within each layer, are tightly integrated and provides different kind of services to the layer just above it as well as the optimal application development and execution environment for mobile devices.

The Software stack of android consists of different layers that provide different services to layer just above it are shown in figure 1.

1. Linux Kernel- heart of whole system
2. Libraries and Android Runtime
3. Application Framework
4. Android Applications.

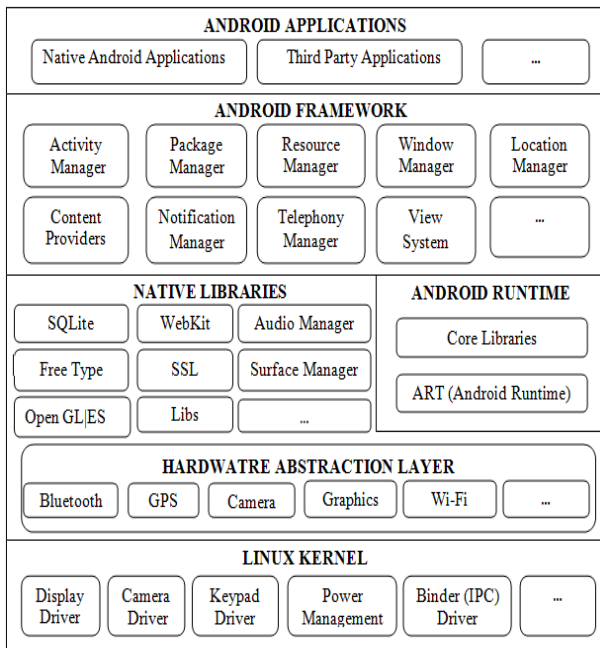


Fig 1: Software stack of android [1, 6]

2.1 Linux Kernel- the heart of the whole system

At bottom of the Software stack of Android, there is a Linux kernel. It acts as the heart of the whole system. It provides various functionalities like memory management, process management, device management, security settings etc. in android system and all the essential device drivers for the hardware with which it interacts [1].

2.2 Native Libraries

On the top of the kernel layer there is a set of libraries including surface manager that composes windows on the screen, Open GL/ES for 3D Library, SGL for 2D Graphics, Media Framework to play and recording of various audio, video and picture formats, Free Type for Font Rendering, WebKit Browser Engine, well known libc for System C libraries, SQLite relational database for storage, Open SSL internet security library etc. These native libraries are based upon c or c++ language.

2.3 Android Runtime

Located on the same level as the native libraries, the Android runtime is the third section of the architecture and available on the second layer from the bottom. It includes a set of core Java libraries that enables Android application developers to write Android applications using standard Java programming language. It also includes ART (Android Runtime) [7]. It is similar to DVM (Dalvik Virtual Machine) specially designed and optimized for Android. Each process is executed in a virtual machine separately. It operates on DEX files and running dex byte codes. It provides Ahead-of-Time (AOT) compilation, improved garbage collection, improved debugging and development, security, isolation, memory management, fast performance and threading support. It helps user to execute multiple applications at the same time

2.4 Application Framework

On the top of Native libraries and android runtime layer, there is application framework layer. It provides many packages of higher-level services to application that collectively form the environment within which they are constructed from reusable,

interchangeable and replaceable components. It provides the functions of phone like location management, data sharing, resource management etc.

The packages present are as given below:

2.4.1 Activity manager

It controls and manages the activity lifecycle of applications.

2.4.2 Resource manager

It manages and provides access to non-code embedded resources such as graphics, strings, color settings and user interface layouts.

2.4.3 Notification manager

It allows all applications to show custom alerts in status bar and notifications to the user.

2.4.4 Location manager

When user enters or leaves a particular geographical location, it triggers alerts about location changes using GPS or cell tower.

2.4.5 Package manager

The system by which applications are able to retrieve the data about other applications currently installed on the device.

2.4.6 Telephony manager

It manages and enables to access voice calls, network connection settings, status and subscriber information service in our application.

2.4.7 Window manager

An extensible set of creative views and layouts is used to create application user interfaces.

2.4.8 Content Provider

It is the system by which it enables and manages data sharing between applications [1].

2.5 Android applications

The android applications are at the topmost layer of the Android software stack. These comprise both the native applications and the third party applications. The native applications provide the basic Android implementation such as SMS client app, Dialer, Web browser and Contact manager. The third party applications are further installed by the developers, programmers while debugging/testing and user after purchasing the device.

3. RELATED WORK

As android usage are increasing day by day, so android have emerged as an outstanding area of research in recent past. Research activities are concentrated in areas such as reverse engineering, clustering, machine learning, operating system and security and they have received a lot of attention. Since the proposed work is focused on operating system and security, this survey covers the above two areas with respect to smartphones based operating system.

In 2014, Kaur et. al. [1], described the android architecture, android operating system and its key features. They also compared Android with different OS like iOS (Apple), Symbian (Nokia) & Blackberry OS (RIM). From their survey, they concluded that android is better than all other operating systems. However due to open source OS and unique features, android has some limitations which leads to malware attacks like virus, worms, spyware, adware and Trojan horse.

In 2014, Okediran et. al. [6], presented a review and comparative analysis of different technological platforms. They mainly reviewed six Smartphone based OSs like Android-Google, iOS-Apple, Windows Phone-Microsoft, Blackberry OS, webOS and Symbian OS-Nokia. They found that As android can run on all mobile devices becomes the most popular operating system all over the world/the world over.

In 2014, Dabhi et. al. [7], presented a detail review on latest and upcoming operating systems like IOS 7(Apple), Android 4.4 KitKat (Google) and windows 9 (Microsoft). They compared updated features, facilities, performance and verdict about these operating systems. From market share analysis during December 2013, They found that android got 81.3% and is the best Smartphone OS in the world today.

In 2014, Arshad et. al. [8], proposed a light weight taint analysis tool for android application named AT2. This tool performed static analysis on android applications (APKs) using reverse engineering techniques and taint-aware slicing. To analyze the structure of an application, it used program slicing technique for data flow analysis. It performed the program slicing on full class name and methods name of an android application. The information leakages were detected using taint analysis technique on sliced programs. At the end, it presented a user friendly detailed report of analysis performed on android applications (APKs); which helped to enhance the security of android applications.

In 2013, Ahmed et. al. [9], compared two most popular mobile operating system android and iOS in terms of security. They compared security features like Encryption, Data Storage Format, Application Sandboxing, Memory Randomization, and Built-in Antivirus in both Mobile OS. From comparison, they concluded that iOS is more secured than android OS. They also described some security points to keep the user- sensitive data safe on the respective Smartphones.

In 2013, Sharma et. al. [10], discussed about the various mobile technologies like 1G, 2G and 3G along with the different mobile phones based on different OS available in the market. They mainly compared Symbian OS, BlackBerry OS, Android OS, iOS and Windows Phone according to Vendor, Programming Language and Application Store. They also differentiated iPhone from blackberry and Symbian. From the difference, they found that iPhone has more features and require less code to write its application. Due to this, iPhone causes fewer bugs. At the end, they concluded that android and apple are growing at a fast pace in the market.

In 2013, Johnson et. al. [11] presented a framework for revealing the software security, functionality and accessibility risks for handheld devices. This framework executed all the possible execution paths without any kind of user input; as well as libraries using static as well as dynamic code analysis. The output of static code analysis was used as an input for the execution of dynamic code analysis. A large number of android applications are tested to display its functionality and feasibility. This approach can be used for other purposes like program confirmation, mnemonic execution, coactive debugger and deep exploration of an android application.

In 2012, Nosrati et. al. [12], presented a brief introduction of mobile computing including various mobile devices and operating systems. The devices like tablet, smartphone, personal digital assistant, ultra-mobile PC, and wearable computers are introduced. They also discussed about BlackBerry, iOS, Android, and Bada, Symbian, Windows, Palm OS. At the end, some general limitations of mobile computing devices are subjected.

In 2011, Becher et. al. [13], discussed about security of mobile devices. They differentiated security of handheld devices from computer system. They also classified attacks for smartphones in four categories hardware-related, device independence, software-related, and user-centric. They summarized that the smartphones are growing rapidly as compare to ordinary computer in terms of processing power, display size, and versatility of operating systems. As a result, mobile security becomes an interesting area.

In 2011, Jaeyeol et. al. [14], discussed that Smartphone using application like Android, BlackBerry, Linux and iPhone that fulfill the user requirements has become a prerequisite. They over-reviewed the related work about media player for audio-video files, Handler, SD card for storage and activity life cycle of android application. From survey, they proposed the class diagram for English tutoring application, handler function and Text-to-Speech. At the end, they proposed optimization function to develop English tutoring android application for user to learn English easily in a hope that it will help developers to write English applications.

In 2010, Wu et. al. [15], found that android platform can be extended as an educational tool. They described sheep framework for game development by extending android platform based on previous students' projects. From the discussion, they found that they can apply or expand a tool to grasp software architecture course using double simulation method that is to enable the second stimulus that rival the first stimulus.

In 2009, Lin et. al. [16], analyzed the smartphone OSs market under a uniform ecosystem framework. They first compared "food webs" of major companies like Nokia, Apple, RIM and Microsoft. From the comparison, they found that companies use smartphone OS just as a business unit and use it as a opportunity for new business. For competition among different OS device maker and application developer are two key factors and validate them with network effect theory.

CONCLUSION

The mobile operating system used for various handheld devices like smartphones, tablets, PDAs, or other mobile devices. In recent past, the research activities are concentrated in areas like comparison of various mobile operating systems, security of personal data, reverse engineering of mobile based application. The analysis show that android and iPhone are most popular operating system among all other smartphone OS. Most of the security techniques do not tolerant to malicious activities in smartphones.

4. COMPARISON OF DIFFERENT SMARTPHONES

Mobile Devices i.e. handheld devices have become an important part for communication purpose in human being's life. Due to change in technology and time, use of mobile devices shifted towards to Smartphones. In existing work, the authors basically make comparison between smartphone based operating system like android, iPhone, blackberry and Symbian. In addition to it, we also have discussed about other recent operating system like window phone, webOS, Ubuntu and firefox. We have presented the comparison in table 1. This graphical presentation will help to easily differentiate among different operating systems. Some characteristics of different smartphones OS have been evaluated. The comparison result helps to identify different results by comparing different smartphone based operating system that is shown in Table 1.

TABLE 1. Comparison of different smartphone operating system ^[1, 6, 8, 11, 13]

OS	Android	IOS	Symbian	Blackberry	Windows Phone	WebOS	Ubuntu	Firefox
Parameter								
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
CPU Architecture	ARM, x86, MIPS	ARM, ARM 64	ARM, x86	ARM	ARM	ARM	ARM and x86	ARM, x86
Source Model	Open source and in most devices with proprietary components	Closed source	Closed source, previously open source	Closed Source	Closed Source	Open Source	Open Source	Open source
License	Free and open-source, 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, JavaScript, CSS, ActionScript, 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
Latest Release	5.1 "Lollipop" / March 10, 2015;	iPhone 6 Plus / September 19, 2014;	Nokia Belle Feature Pack 2 / October 2, 2012	BlackBerry 9790/9900 / November 20 13;	Windows Phone 8.1 Update / December 5, 2014;	2.2.4 (Pre 3) (phone) / January 12, 2012;	14.10 Utopic Unicorn / 23 October 2014	1.4.0 / August 8, 2014

OS	Android	iOS	Symbian	Blackberry	Windows Phone	WebOS	Ubuntu	Firefox
Parameter								
Package Manager	Google Play, APK	iTunes	Nokia Store	BlackBerry Link	Zune Software (not since Windows 8)	OTA deployment, webOS through App store, Web URL, Precentral, .ipk	Ubuntu Touch through App store, Web URL	Firefox OS Packaged Apps
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, tablet computers (UbuntuTouch), smartTVs (Ubuntu TV)	Smartphones, Tablet and computers
Market Share^[3]	48.8%	17.2%	0.1%	11.1%	19.5%	--	--	--
Market Size^[4]	Very High	High	Very low	Low	Medium	Very low	Very low	Very low
Application Store	Google Play	App Store	Nokia Ovi Store	BlackBerry World	Windows Phone Store	Palm App Catalog	Ubuntu Store	Firefox Marketplace, Web URL
Non-English Language Support	Partial	Yes	Yes	Yes	Yes	Partial	Yes	Yes
Virtual Machine	Allowed	Not Allowed	Allowed	Allowed	Allowed	Allowed	Allowed	Not, Only simulator available.
Debugger	Debugger available	Debugger available	Debugger available	Debugger Available	Debugger available	Debugger available	Debugger Available	Debugger available
Cross-Platform Deployment	Android only	iPhone, iPad, iPod Touch	Compile per target	BlackBerry only	Windows Mobile, Windows FU, Windows CE	webOS, Palm only	HTML5 app to be available web browser.	Web browser on other platform
GUI	Android	Cocoa Touch	Avkon	Cascades	Visual Studio	Graphical (Luna)	Ubuntu SDK	Firefox browser, Firebug
Documentation Available At	www.android.com	www.apple.com/ios/	symbian.nokia.com	us.blackberry.com/apps-software/blackberry7/	www.windowphone.com	www.hpwebos.com www.openwebosproject.org	www.ubuntu.com	mozilla.org/firefox/os
Tool for Reverse Engineering of App	Apk tool, Dex2jar, JD-Compiler, XDA Auto tool	iRET Toolkit, Windows Explorer, oTool, iExplorer, Class-dump-z	Carbidge.c+, IDA Pro, APP Trk, SISWare, ARM assembler	JD-GUI, Notepad, VSMTTool, COD extractor	Decompressor, Visual Studio / Notepad, .Net Decompiler	Binwalk	Bokken	gdb-debugger, b2g-ps
Future Prospect	Very High	High	Low	Low	Medium	Low	Low	Low

5. CONCLUSIONS AND FUTURE SCOPE

Smartphones like personal computer provides various functionalities like use of application, usability, web browsing, running GPS, expendable memory; multitasking, multiprocessing, playing games, social networking etc. In this paper, we have presented a detail review and comparative analysis of different Smartphones operating systems. We have made comparison between android, iOS, Symbian, Blackberry, Windows Phone, WebOS, Ubuntu and Firefox.

For comparison, various parameters of existing work like OS family, IDE, GUI, SDK platform, CPU Architecture, etc. and some new parameters like Market Size, Market share, Debugger availability, Cross platform deployment, Reverse Engineering tool, future Scope etc. have been considered. Because these parameters provides new research trends of smartphone based operating systems.

From comparative analysis and market share analysis during fourth quarter of 2014, we have found that android and Windows Phones are superior to others OS. Android gets 80.7% and is the best Smartphone OS in the world today. We can also use it as an Educational tool. Due to android as an open source operating system, the user can easily install third party applications from markets and even from unreliable sources. Due to this, it has some limitations which lead to malware attacks like virus, worms, spyware, adware and Trojan horse. So, we propose detection of malware before installation of an application as well as comparison of android, iOS, Symbian, Blackberry, Windows Phone, WebOS, Ubuntu and Firefox Smartphones OS in terms of security.

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