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Mobile Operating System in Today's Era

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Abstract: *Earlier mobile communication technologies were dominated by vertically integrated service provision which are highly bounded mainly to voice and short message services that are organized in a monopolistic competition between few mobile virtual network operators, service providers and enhanced service providers. In the recent years, however, radical change driven by advancements in technology, witnessed the introduction and further development of smartphones where the user can get access to new applications and services by connecting to the device manufactures' application stores and the like. These smartphones have added many features of a full-fledged computer: high speed processors, large storage space, multitasking, high-resolution screens and cameras, multipurpose communication hardware, and so on. However, these devices market is dominated by a number of different technological platforms, including different operating systems (OS) and application development platforms, resulting in a variety of different competing solutions on the market driven by different actors. This paper detailed a review and comparative analysis of the features of these technological platforms.*

Keywords: *Mobile OS, Android, iOS, Windows Phone, Black-Berry OS, webOS and Symbian.*

I. Introduction

Mobile communication devices have been the most adopted means of communication both in the developed and developing countries with its penetration more than all other electronic devices put together. Every mobile communication device needs some type of mobile operating system to run its services: voice calls, short message service, camera functionality, and so on. The earlier mobile operating systems were fairly simple, since the capabilities of the phones they supported were limited. However, modern smartphones have added many of the features of a full-fledged computer which includes high speed central processing units (CPU) and graphics processing unit (GPU), large storage space, multitasking, high-resolution screens and cameras, multipurpose communication hardware and so on. Modern mobile operating systems combine the features of a personal computer operating system with other features, including a touch screen, cellular, Bluetooth, Wi-Fi, global positioning system (GPS) mobile navigation, video camera, speech recognition, voice recorder, music player, near field communication and infrared blaster. Mobile operating systems have had to grow in sophistication to support these features.

Furthermore, modern smartphones are designed to allow external developers to write software for these devices. With this feature, users can get access to new applications and services by connecting to the device manufactures' applications stores e.g. Apple's 'App Store', Google's 'Android Market', Blackberry's 'App World', Nokia's 'OVI Store', Palm's 'Palm App Catalogue', Windows Mobile's 'Windows Market place' and so on. This has enabled these mobile devices to reap the advantages of the convergence process and brought advanced internet applications and services to these mobile devices.

However, the device market is dominated by a number of different technological platforms, including different operating systems and applications development platforms, resulting in a variety of different competing solutions on the market driven by different actors. This fragmentation of technological platforms and standards are seen as a barrier for development of contents and services, which locks the users to specific technologies or puts an immense load to the content and service provides to adopt their content /services to all these platforms.

In today's world, everybody from a lay man to an industrialist is using a mobile phone. Therefore, it becomes a challenging factor for the mobile industries to provide best features and easy to use interface to its customer. Due to rapid advancement of the technology, the mobile industry is also continuously growing. There are many mobile phones operating systems available in the market. The aim of this paper is to give a review and comparative analysis of the features of the six most popular mobile operating systems (Android OS, iOS, Windows Phone, Blackberry OS, webOS and Symbian OS) and user interface toolkits most frequently used to develop client applications (Qt, Java 2 Micro Edition, and Silverlight).

II. Mobile Operating Systems

A mobile operating system (Mobile OS) is a software platform on top of which other programs called application programs, can run on mobile devices such as personal digital assistant (PDA) , tablets, cellular phones, smartphones and so on . Over the years, Mobile OS design has experienced a three-phase evolution: from the PC-based operating system to an embedded operating system to the current smartphone-oriented operating system in the past decade. Throughout the process, Mobile OS architecture has gone from complex to simple to something in-between. The evolution process is naturally driven by the technology advancements in hardware, software, and the Internet.

Hardware: The industry has been reducing the factor size of microprocessors and peripherals to design actual mobile devices. Before the form factor size was reduced enough, the mobile device could not achieve both small size and processing capability at the same time. We had either a PC-sized laptop computer or a much weaker personal data assistant (PDA) in phone size. Mobile operating systems for PDAs usually did not have full multitasking or 3D graphics support. Features like sensors, such as accelerometers, and capacitor-based touch screens were not available in the past mobile operating systems.

Software: With a laptop computer, the software is mainly focused on the user's productivity, where support for keyboard and mouse that have precise inputs are essential. The software for a personal data assistant, as its name implies, helps the user to manage personal data such as contacts information, email, and so on. The mobile operating systems were not designed for good responsiveness or smoothness with a rich user interface (UI) including both touch screen and other sensors.

Internet: Along with Internet development, especially after Web 2.0, there is abundant information in the network waiting to be searched, organized, mined, and brought to users. People are increasingly living with the Internet instead of just browsing the Web. More and more people are involved in the development, including information contribution, application development, and social interactions. The mobile operating systems cannot be self-contained, but have to be open systems. The aforementioned technological advancements have resulted in a variety of different competing mobile operating system solutions on the market driven by different actors. Some of these actors includes Google's Android, Apples' iOS, Nokia's Symbian, RIM's BlackBerry OS, Samsung's Bada, Microsoft's Windows Phone, Hewlett-Packard's webOS, and embedded Linux distributions such as Maemo and MeeGo to mention but a few. The following sub-sections review six of the mostpopular mobile operating systems.

III. Android OS

Android OS for mobile devices is developed by theOpen Handset Alliance, which is led by Google. Googleunveiled the Android distribution in November 2007.Most of the Android core is released under the opensourceApache License but a large amount of software on Android devices (such as such as Play Store, Google Search, Google Play Services, Google Music, and so on) are proprietary and licensed .As of 2011, Android has the largest installed base ofany mobile OS and as of 2013, its devices also sell morethan Windows, iOS and Mac OS devices combined .As of July 2013 the Google Play store has had over 1million Android apps published, and over 50 billion appsdownloaded (PHONEARENA, 2014). A developer surveyconducted between April and May 2013 found that 71% ofmobile developers develop for Android [4].Android uses a Linux kernel with higher-level APIswritten in C and applications are normally programmed inJava and run with the Dalvik virtual machine (DVM)using just-in-time compilation to translate Java byte code into Dalvikdex-code. This combination brings upsome secure features, like efficient shared memorymanagement, preemptive multitasking, Unix user identifiers (UIDs) and file permissions with the type safeconcept of Java. Every Android application runs in aseparate process under a unique UID with distinctpermissions, which means that applications can typicallynot read or write each other's data or code. The kernelsandboxes applications from each, so that resource anddata must be share explicitly. To make a resource sharebetween applications possible, the permissions which arerequired must be declare statically at the time theapplication is installed. The Android system prompts theuser for consent at this time; a mechanism for grantingpermission dynamically at runtime is not possible and would lead to an increase of security transparency.

The Android platform contains the following layers :

Linux Kernel: Android relies on Linux for core system services such as security, memory management, process management and so on.

Android Runtime: It provides a set of core libraries which supports most of the functionality in the core libraries of Java. The Android Virtual Machine known as Dalvik VM relies on the Linux kernel for some underlying functionality.

Libraries: Android includes a set of C/C++ libraries. These libraries are exposed to developers through the Android application framework. They include media libraries, system C libraries, surface manager, 3D libraries, SQLite and so on.

Application Framework: It provides an access layer to the framework APIs used by the coreapplications. It allows components to be used bythe developers.

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 below:

- Linux Kernel- heart of whole system
- Libraries and Android Runtime
- Application Framework
- Android Applications.

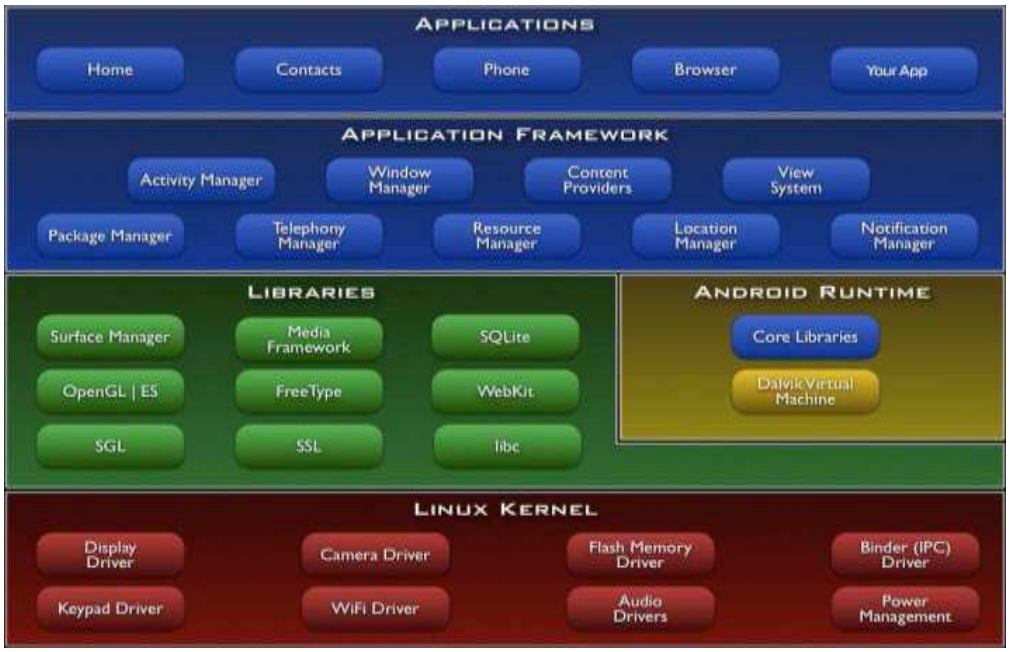

Figure 1: *Software stack of android*

IV. iOS Operating System

iOS (previously iPhone OS) is a mobile operating system developed by Apple Inc. and distributed exclusively for Apple hardware . In iPhone, Hardware refers to the physical chips soldered to the iPhone's circuitry. The actual processor falls under this layer, but the instruction set and in-memory descriptor tables are contained within the "processor" layer . Firmware refers to the chip-specific code that is either contained with memory in/around the peripheral itself, or within the drive for said peripherals. iPhone OS is the kernel, drivers, and services that comprise of the iPhone Operating System. It sits between the user space and hardware. Objective-C runtime is comprised of both the Objective-C dynamically-linked runtime libraries, as well as the underlying C libraries. Frameworks/API layer has API calls which are Apple-distributed headers with the iPhone SDK, with some dynamic linking occurring at runtime. These reside on top of the Objective-C runtime, as many of these are written in Objective-C [9]. The application stored in iPhone has to be purchased through the application store . This application was compiled to native code by the Apple-distributed iPhone compiler, and linked with the Objective-C runtime and C library by the linker. The application also runs entirely within

the user space environment set up by the iPhone OS. iOS is an operating system that powers iPhone, iPad, iPod Touch, and Apple TV. It is closed source and proprietary and built on open source Darwin core OS. iOS promoted a new style of user interaction for small screen, limited input devices, specifically, direct manipulation. Touch-based gestures like swipe, tap, tap and hold, and pinch are used to control on-screen interface elements, and to perform interface operations. Accelerometers support additional physical gestures like shaking and rotating the orientation of thedevice .iOS is derived from Mac OS X, and shares its basic Darwin foundation, an open source POSIX-compliant UNIX OS. In this sense iOS can be considered a variant of UNIX. iOS is made up of four abstraction layers: Core OS, Core Services, Media, and Cocoa Touch :

i. Core OS: The kernel of the operating system, which includes basic low-level features: system support—threads, sockets, IO, DNS, math, memory—general security services—certificates, private/public keys, encryption—externalhardware management, bluetooth, and sound and image processing.

ii. Core Services: Fundamental system-services, which are subdivided in different frameworks and based on C and Objective C. It includes basic application services, including accounts, contacts, networking, data management, location, calendar events, store purchasing, SQLite, and XML support.

iii. Media Layer: Considers the high-level frameworks, which are responsible for using graphic (support for 2d and 3d graphics), audioand video technologies.

iv. Cocoa Touch: The UIKIT, which is an Objective- C based framework and provides a number of functionalities, which are necessary for the development of an iOS Application like the User Interface Management. It also includesAPIs for building applications—multitasking, touch input, notifications, interface views, and access to device data.

Unlike Android applications, iOS applications can only be signed with an official certification.

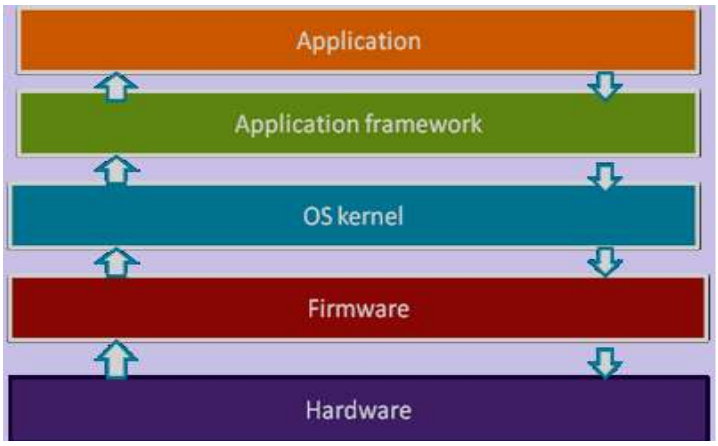

Figure 2: *Architecture of iOS mobile OS*

V. Windows Opearting System

Windows Phone is a proprietary smartphone operating system developed by Microsoft . It is the successor to Windows Mobile, although it is incompatible with the earlier platform . It was launched in 2010 under the name Windows Phone 7. Various hardware manufacturers including HTC, Samsung, LG, and Nokia are developing Windows Phone devices. In February 2011 Nokia and Microsoft announced that Windows Phone 7 would be theprimary OS for all future Nokia smartphones. Windows Phone 7 received a major upgrade (7.5 Mango) in February 2011, adding features that had been missing in the original release. The second generation Windows Phone 8 was released in October 2012 .Windows Phone 7's architecture required a hardware layer that meets Microsoft's minimum system requirements: an ARM7 CPU, a DirectX 9-capable GPU, 256MB RAM and 8GB of flash memory, a 5-megapixel camera, a multi-touch capacitive display, an A-GPS, an accelerometer, a compass, proximity and light sensors, and six physical buttons: back, start, and search; camera, power/sleep, and volume.

The Windows Phone kernel handles low-level device driver access as well as basic security, networking, and storage. Three libraries: An App Model for application management, a UI model for userinterface management, and a Cloud Integration module for web search via Bing, location services, push

notifications, and so on sit above the kernel . Application-facing APIs include Sliverlight, XNA, HTML/JavaScript and the Common Language Runtime (CLR) that supports C# or VB .Net applications. The kernel itself is a proprietary Windows OS design for embedded devices that combines Windows Embedded CE 6.0 R3 and Windows Embedded Compact 77. Windows Phone 8 replaced the Windows CE kernel with one based on Windows NT. This is meant in part to mimic the Windows 8 desktop OS, allowing for easier porting of applications between the two operating systems.

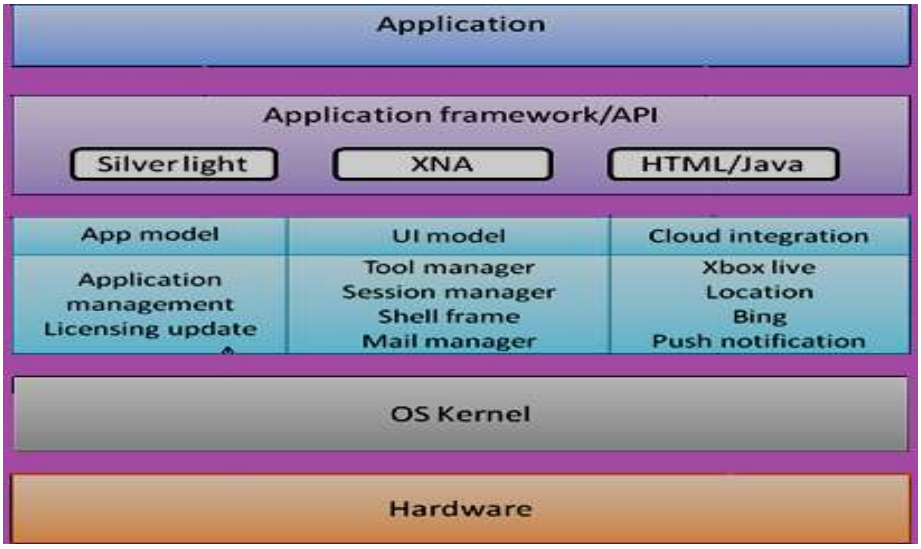

Figure 3: *Architecture of windows mobile OS*

VI. Blackberry Operating System

BlackBerry OS is developed by Research in Motion (RIM) for their BlackBerry smart phones and tabletdevices. BlackBerry OS 1.0 debuted in January 1999 as part of BlackBerry's pager/email devices. One of the main strengths of BlackBerry devices is their ability to handle corporate email. BlackBerry OS supports the Java Mobile Information Device Profile (MIDP) and the Wireless Application Profile (WAP). These protocols are used to synchronize through a BlackBerry Enterprise Server (BES) with push-based calendar, task, contact, email, and note exchange. BES provides the capacity, security, remote wipe, and other features that corporations require for mobile devices that access internal networks and/or corporate data. BlackBerry OS also provides the BlackBerry Internet Service (BIS), a client-specific method to allow Internet access for individual users .

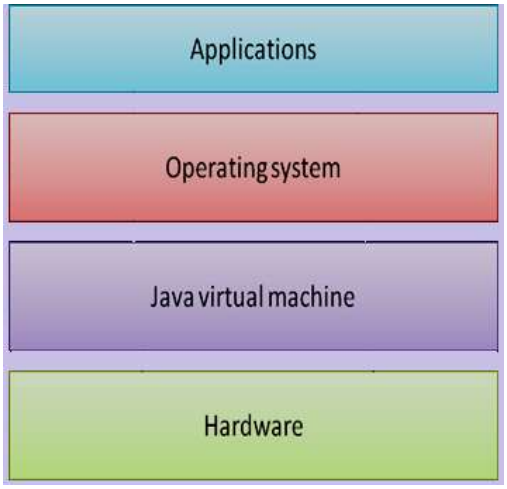

Figure 4: *Architecture of blackberry mobile OS*

This allows consumer customers to access personal email, browse the web, and so on. BlackBerry OS originally supported applications written in C++. One type of application is a Mobile Data Services (MDS) runtime, which is a container for processing and display data, usually pushed from a user's corporate system. Java ME was also supported, and was used to build applicationswith access to OS APIs that provide access to

standard UI widgets and different OS services. Both BlackBerryOS 6 and OS 7 were designed to encourage application development. Programming is now done in Java for phones, and in C++ or web-based languages for the PlayBook tablet. OS-supported APIs include browsing, mail, phone, PDA apps, LDAP, UI, http, math, cryptography, and so on. A C++ Native Development Kit was recently made available to support development on BlackBerry's PlayBook tablet OS. BlackBerry PlayBook OS 1.0, which is available only on the PlayBook, switched to be QNX-based. QNX is a UNIX microkernel that was originally developed in the 1980s and later re-purposed for embedded devices. RIM purchased QNX in April 2010, with plans to transition its upcoming smartphones to OS 10 and QNX. Blackberry 10, together with the Z10 and Q10 Blackberry smartphones, were released in January 2013.

VII. Symbian Operating System

Symbian is a mobile device OS developed by Nokia. It was originally the EPOC graphical operating system for PSION portable devices [12]. In 1998 PSION, Nokia, Ericsson, and Motorola formed Symbian OS. Currently, however, the Symbian Foundation is run and maintained by Nokia alone, providing access to Symbian throughstandard licensing agreements. The original Symbian OS was divided into two parts: a core OS that supported a Device Family Reference Design (DFRD) and a UI built on the DFRD. This allowed different UIs to be built for different types of devices, or for different manufacturers' handsets, but with a common OS core. Examples included the Pearl UI used by Nokia and the Quartz UI used by Ericsson. This strategy was later abandoned and different UIs were spun off to different companies. The latest version of Symbian is Symbian OS 9.5, released in March 2007. Follow on versions include Symbianˆ1, Symbianˆ2, and Symbianˆ3, which was released in 2010. Symbianˆ3 includes modern mobile OS technologies like 2D and 3D graphics acceleration, touch based interaction, and UI widgets. In May 2011, an update for Symbianˆ3, Symbian Anna, was officially announced, followed by Nokia Belle (previously Symbian Belle) in August 2011. Symbian OS follows a familiar architecture. It is built on a nanokernel/microkernel core with basic localization and screen drivers. Base services sit above the kernel, and include low-level libraries, media frameworks, XML, file system management, and hardware abstraction. OS services provide communication, telephony, networking, multimedia, and graphics. These support an Application Services layer with application-facing APIs for development and an interface layer to manage the UI. A JVM (Java ME) is also included above the OS services layer. Nokia provides SDKs for Symbian development that supports a variety of languages, including C++ and Java.

Symbian mobile operating system with libraries, UI frames works and common tools. It is descendant of Psions EPOC and run exclusively on ARM processors. Symbian OS was built to follow three design rules in order to support extended always on operation.

- The integration and security of user data is important.
- User time must not be wasted.

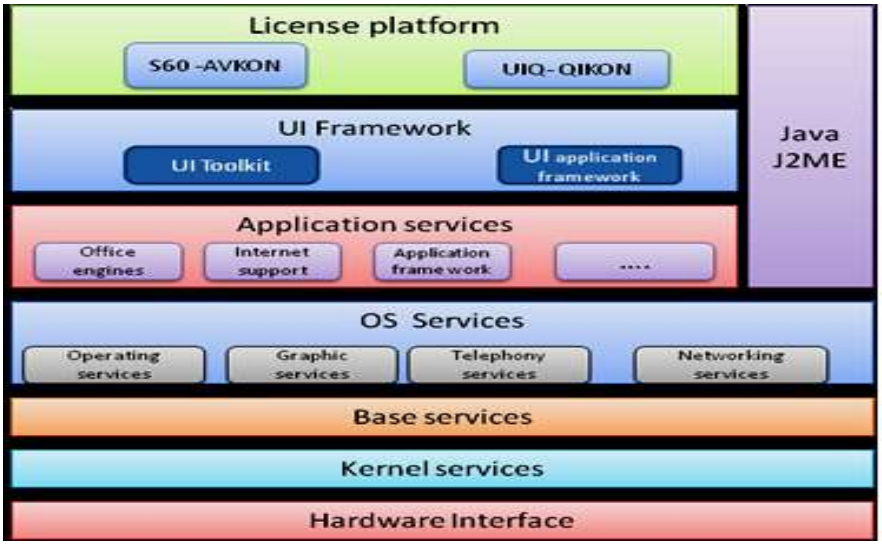

Figure 5: *Architecture of Symbian mobile OS*

VIII. Comparision Of Different Mobile Operating Systems

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 [15]-[19], the authors basically make comparison between smartphone based operating system like Android, iOS, Symbian, Windows and Blackberry.

The below tabular presentation will help to easily differentiate among different operating systems. Some characteristics of different smartphones OS have been evaluated.

Table1: Comparison of different mobile operating systems

Parameters	Android	iOS	Symbian	Windows	Blackberry
OS Family	Linux	Darwin	RTOS	Window CE-7 Window NT-8	QNX
Vender	Open Handset Alliance, Google	Apple, Inc	Accenture on behalf of Nokia (historically Symbian Ltd. And Symbian Foundation)	Microsoft	Blackberry Ltd.
Environment (IDE)	Eclipse (Google)	XCode (Apple), Appcode	QT, Carbide.C++, Vistamax, Eclipse	Visual Studio	Eclipse, Blackberry JDE
CPU Architecture	ARM, x86, MIPS	ARM, ARM 64	ARM, x86	ARM	ARM
Source Model	Open Source and in most devices with proprietary components	Closed Source	Closed Source, Previously open source	Closed Source	Closed Source
License	Free and open source, but usually bundled with proprietary apps and drivers	Proprietary ULA except for open source components	Proprietary, Previously licensed under EPL	Proprietary	Proprietary
Written In	C, C++, Java	C, C++, Objective C, Swift	C, C++, ME, Python, Ruby, Flash Lite	C#, VB.NET, F#, C++, JScript	C, C++, HTML 5, Java script, CSS, Action script, Java
Market Share	48.8%	17.2%	0.1%	19.5%	11.1%
Market Size	Very High	High	Very low	Medium	Low
Application Store	Google Play	App Store	Nokia Ovi Store	Windows Phone Store	Blackberry World
Cross Platforming	Android supports cross platforming	iOS don't support cross platforming	Symbian supports cross plat forming	Windows support cross platforming	Blackberry don't support cross platforming
Memory Utilization	Paging, Memory Map, No Swapping	Automatic Reference Counting, No Garbage Collection	Memory management Unit and Cache resides on a SOC (System on Chip)	ROM/RAM is flash memory used for Virtual Memory storage. Programs can only run from main memory.	Contain slot for external memory supports 32GB Micro SD card at the time of full memory.
Security	Multi layer security. Most secure and usable OS	Low level software hardware and farm ware security	Gate keeper type of security every time ask for user permission	Windows OS does data encryption, leak prevention and	Blackberry provides two methods data encryption

Reference

[1]. Apple1, (2014): "The Application Runtime Environment." Available: http://developer.apple. com/library /ios/#documentation/iphone/conceptual/iphoneosprogrammingguide/ Runtime Environment/RuntimeEnvironment.html

[2]. Apple2, (2014): "iphone in Business Security Overview." Available: http:// images. apple. com /iphone/business/docs/iPhone Security.pdf

[3]. CMER, (2014): "Mobile Operating System" Centre for Mobile Education and Research

[4]. DEVECO, (2013) "Developer Economics Q3 2013 Analyst Report" available at http://www.visionmobile.com/DevEcon3Q13

[5]. Fitzek F. and Reichert F. (2007): "Mobile PhoneProgramming and its Application to Wireless Networking" available at http://www.springerlink. com/content/978-1-4020-5968-1

[6]. Gartner (2010): "Gartner Says Worldwide Mobile PhoneSales Grew 35 Percent in Third Quarter 2010; Smartphone Sales Increased 96 Percent" Gartner, Inc. available at http://www.gartner.com/it/ page.jsp?id=1466313

[7]. Holwerda T., (2013): 'The Second Operating SystemHiding in Every Mobile Phone" available at http://www.osnews.com /story/27416/ The_second_operating_system_ hiding_ in_every_mobile_phone

[8]. HP, (2010): "HP Confirms Discussions with AutonomyCorporation plc Regarding Possible BusinessCombination; Makes Other Announcements." Availableat http://www.hp.com/ hpinfo/newsroom/ press/2011/110818b.html?mtxs=rss-corp-news.

[9]. Java, (2014): "Java 2 Platform, Micro Edition" Java 2Platform, Micro Edition Datasheet. Available atwww.sun.com/software

[10]. Koh, D., (2010): "Q&A: Microsoft on Windows Phone7" CNET Asia, CBS Interactive.

[11]. Li X., Wang Y., Wu J., Jiang K. and Liu B., (2012):"Mobile OS Architecture Trends" Intel Technology Journal, volume 16, issue 4, pp 178-198.

[12]. Lunden, I. (2011): "Symbian Now Officially No LongerUnder The Wing of Nokia," Available atwww.moconews.net.

[13]. Mahapatra, L. (2013): "Android Vs. iOS: What's theMost Popular Mobile Operating System in YourCountry?" available at http://www.ibtimes.com/ androidvs-ios-whats-most-popular-mobile-operating-systemyour-country-1464892.

[14]. Microsoft, (2014): "Silverlight 5 System Requirements- Compatible Operating Systems and Browsers".Available at http://www.microsoft.com/ getsilverlight/locale/en-us/html/ installation-win-SL5.html.

[15]. NCSU, (2014): "Mobile Operating System" available athttp://www.csc.ncsu.edu/ faculty/ healey/csc563/notes/ch-06.pdf

[16]. Okediran O. O., Omidiora E. O., Olabiyisi S. O. AndGaniyu R. A. (2013): " An M-voting System Frameworkfor Electronic Voting", Proceedings of the SecondInternational Conference on Engineering andTechnology Research., 2:241-245.

[17]. Palm, (2014): "Overview of webOS - Palm webOSArchitecture" available at https://developer.palm.com/content/resources/develop/overview_of_webos/overview_of_ webos_palm_webos_architecture.html

[18]. PHONEARENA, (2014): "Android's Google Play beatsApp Store with over 1 million apps, now officiallylargest" available at http://www.phonearena.com/news/Androids-Google-Play-beats-App-Store-with-over-1-million-apps-now-officiallylargest_id45680

[19]. QT, (2009): "Qt 4.4 Whitepaper" available athttp://qt.nokia.com/files/pdf/qt-4.4-whitepaper

[20]. Renner T. (2014): "Mobile OS - Features, Concepts andChallenges for Enterprise Environments" SNET ProjectTechnischeUniversit¨at Berlin

[21]. SDDP, (2014): "An Overview of Mobile Developmentin the Context of Current Technology" SoftwareDevelopment Discussion Paper, available at http://www.bbconsult.co.uk/Mobile- Web-Software-Development.aspx

[22]. Silverlight, (2008): "FAQ: Silverlight for Mobile". Available at http://silverlight.net/learn/ mobile. Aspx

[23]. Windows, (2011): "Windows Phone 7 PlatformIntroduced to iPhone Application Developers", availableat http://windowsphone.interoperabilitybridges.com/articles/chapter-1-windowsphone-7-platform-introduced-to-iphone-application-developers.

[24]. [24]. compatibility". Engadget, AOL.

[25]. Zubarev P. and Krinkin K. (2010): "QtMobility: Qt API Extensions for Mobile Development" 7th Conference of Open Innovations Framework Program FRUCT. Saint- Petersburg, Russia, available at http://osll.spb.ru/repositories/entry/osll/events/fruct7/fruct7_qtmobility .odp?rev=68