

An Overview of Android Operating System and Its Versions

¹Mrs.M.Angelin Rosy, ²Mrs.M.Dukitha, ³Dr.M.Felix Xavier Muthu

^{1,2} Assistant Professor, ³ Associate Professor

^{1,2}Department of MCA, Er.Perumal Manimekalai College of Engineering, Hosur, India

³Department of Mechanical Engineering, St.Xavier's Catholic College of Engineering, Chunkankadai

Abstract-Android operating system is one of the most widely used operating system these days. Android Operating System is mainly divided into four main layers: the kernel, libraries, application framework and applications. Its kernel is based on Linux. Linux kernel is used to manage core system services such as virtual memory, networking, drivers, and power management. In these paper different features of architecture of Android OS as well security features of Android OS are discussed.

Keywords – Dalvik VM, Linux, Sandbox

I. INTRODUCTION

Android operating system is one of the most widely used mobile Operating System these days [1]. Android mobile operating system is based on the Linux kernel and is developed by Google. Android operating system is primarily designed for smartphones and tablets. Since Android is an open source it has become the fastest growing mobile operating system. Due to its open nature it has become favorite for many consumers and developers. Moreover software developers can easily modify and add enhanced feature in it to meet the latest requirements of the mobile technology [2]. Android users download more than 1.5 billion applications and games from Google Play each month. Due to Its Powerful development framework users as well software developers are able to create their own applications for wide range of devices [3]. Some of the key features of Android operating system are: Application Frame work, Dalvik virtual machine, Integrated browser, Optimized Graphics, SQLite, Media Support, GSM Technology, Bluetooth, Edge, 3G, Wi-Fi, Camera and GPS etc [1]. To help the developers for better software development Android provides Android Software development kit (SDK). It provides Java programming Language for application development [1]. The Android software development kit includes a debugger, libraries, a handset emulator based on QEMU (Quick Emulator), documentation, sample code, and tutorials [4].

II. ARCHITECTURE OF ANDROID OPERATING SYSTEM

Android operating system is a stack of software components. Main components of Android Operating system Architecture or Software Stack are Linux kernel, native libraries, Android Runtime, Application Framework and Applications.

A. Linux Kernel

Linux Kernel (Linux 2.6) is at the bottom layer of the software stack. Whole Android Operating System is built on this layer with some changes made by the Google [5]. Like main Operating System it provides the following functionalities: Process management, Memory Management, device management (ex. camera, keypad, display etc). Android operating system interacts with the hardware of the device with

this layer [6]. This layer also contains many important hardware device drivers. Linux kernel is also responsible for managing virtual memory, networking, drivers, and power management [7].

B Native Libraries Layer

On the top of the Linux Kernel layer is Android's native libraries. This layer enables the device to handle different types of data. Data is specific to hardware. All these libraries are written in c or c++ language. These libraries are called through java interface. Some important native libraries are:

Surface Manager: it is used to manage display of device. Surface Manager used for composing windows on the screen.

SQLite: SQLite is the database used in android for data storage. It is relational database and available to all applications.

WebKit: It is the browser engine used to display HTML content.

Media framework: Media framework provides playbacks and recording of various audio, video and picture formats.(for example MP3, AAC, AMR, JPG, MPEG4, H.264, and PNG).

Free Type: Bitmap and Font Rendering

OpenGL / ES: Used to render 2D or 3D graphics content to the screen

libc: It contains System related C libraries [5].

C. Android Runtime

Android Runtime consists of Dalvik Virtual machine and Core Java libraries. It is located on the same level as the library layer [5]. Dalvik Virtual Machine is a type of Java Virtual Machine used for running applications on Android device. The Dalvik VM enables every Android application to run in its own process, with its own instance of the Dalvik virtual machine. The Dalvik VM allows multiple instance of Virtual machine to be created simultaneously providing security, isolation, memory management and threading support [8]. Unlike Java VM which is process-based, Dalvik Virtual Machine is register-base. Dalvik Virtual Machine run .dex files which are created from .class file by dx tool. dx tool is included in Android SDK. DVM is optimized for low processing power and low memory environments. DVM is developed by Dan Bornstein from Google [9].

D. Application Framework

The Application Framework layer provides many higher-level services or major APIs to applications in the form of Java classes. Application developers are allowed to make use of these services in their applications [6]. These are the blocks with which developer's applications directly interact. Important blocks of Application framework are:

Activity Manager: It manages the life cycle of applications.
Content Providers: It is used to manage the data sharing between applications, manages how to access data from other applications.

Telephony Manager: it manages all voice call related functionalities.

Location Manager: It is used for Location management, using GPS or cell tower.

Resource Manager: Manage the various types of resources used in Application [8].

E Application Layer: The Applications Layer is the top layer in the Android architecture. Some applications come pre-installed with every device, such as: SMS client app, Dialer, Web browser and Contact manager. A developer can write his own application and can replace it with the existing application [8].

III. DIFFERENT SECURITY FEATURES OF ANDROID OS

Android Operating system should ensure the security of users, user's data, applications, the device, and the network. To achieve the security of these components Android provides these key security features [10]

- 1) Security at the Operating System level through the Linux kernel.
- 2) Application sandbox for all applications.
- 3) Secure interprocess communication.
- 4) Application - defined and user - granted permissions.

A Linux Kernel

Android operating system is based on Linux kernel. Due to its open source nature it is researched, attacked and fixed by many research developers. So Linux has become stable and secure kernel. Linux kernel provides Android with several key security features including:

A user-based permissions model

In the Linux file system each file and directories has three user based permissions. owner, group, other users. owner - The Owner permissions apply only the owner of the file or directory. group - The group permissions apply only to the group that has been assigned to the file or directory. other users - The other Users permissions apply to all other users on the system. Each file or directory has three basic permission types: read - The read permission means user's ability to read the contents of the file. write permissions mean's user's ability to write or edit a file or directory. execute - The execute permission means user's ability to execute a file or view the contents of a directory [11]. This permission model ensures that proper security is maintained while accessing android files.

Process isolation:

The Android operating system assigns a unique user ID (UID) to each Android application and runs it as a separate process. Extensible mechanism for secure IPC. The ability to remove unnecessary and insecure parts of the kernel [10]. code to harm the host device. With the help of sandbox untrusted program access only those resources of the device for which permission is granted. Permission is denied if it tries to access other resources of the device [12].

B. Secure inter-process communication

Some of the applications still use traditional Linux techniques such as network sockets, file system and shared files for inter-process communication. But android operating system also provides new mechanism for IPC such as Binder, Services, Intents and Content Providers. All these mechanism allows developers to verify the identity of application and also used to set the security policies [13].

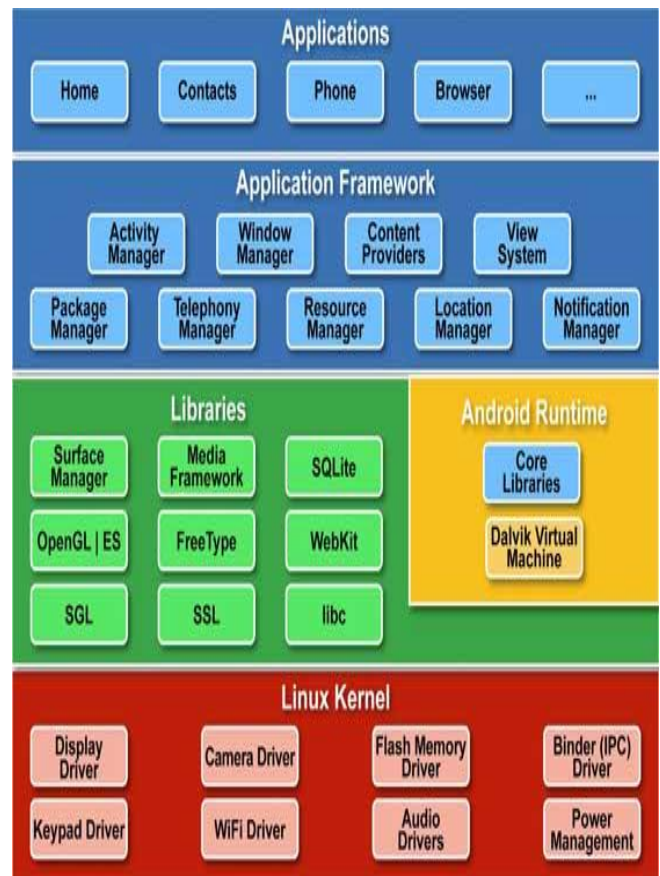


Figure.1 Architecture of Android

C. Application signing

In order to install and run applications on Android OS they must be digitally signed. With this mechanism Android OS identifies the author of an application. This feature is also used to establishing trust relationship between applications.

If an application is not signed properly then it cannot be installed on the emulator also. Some standard tools such as Keytool and Jarsigner are used to generate keys and sign application. apk files [15].

D. Application-defined and user-granted permissions

Permissions are an Android security mechanism to allow or restrict application access. By default, Android applications have no permissions granted, making them safe by not allowing them to gain access to protected APIs [14]. Some of the protected APIs include: Camera functions, Location data (GPS), Bluetooth functions, Telephony functions, SMS/MMS functions and Network or data connections. These resources are accessed only through the operating system [10].

IV. DALVIK VM

DALVIK VM A special Java virtual machine (VM) designed to run with limited system resource. Memory efficiency Register machine vs. Stack machine (modern JVM) fewer instructions, faster execution. Java class files are

converted into “.dex” files that Dalvik executes Java byte-code is converted into Dalvik byte-code during this process.

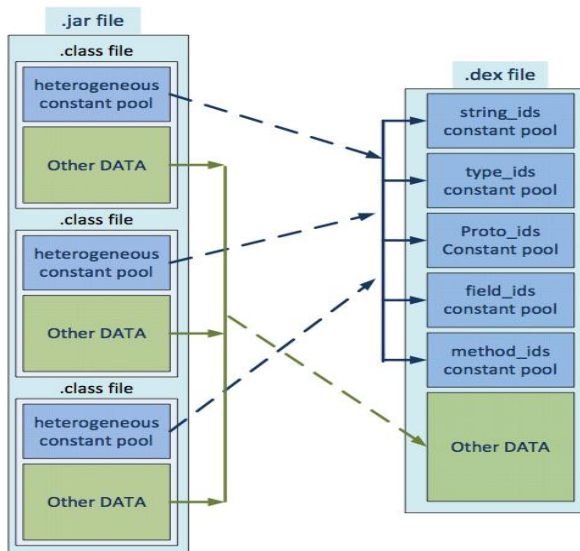


Figure.2 DALVIK VM

V. ANDROID OPERATING SYSTEM VERSIONS

Every Android version after 1.5 has been evolved with definite code names that have been chosen in an alphabetical manner. And no official explanation has ever been given for this peculiar naming convention, although it has garnered much media attention. However, Google did not attach any high-calorie code name to its initial versions 1.0 and 1.1 of the Android Operating System.

A Cupcake

Although not the very first version from Google after buying the company Android, Version 1.5 is considered as the first prominent version that highlighted the true power of its platform. With this version, in fact, Google kicked off the trend of naming its versions after yummy desserts. The many novel features associated with the Cupcake version include third-party keyboard and direct upload to YouTube.



Figure.3 Cupcake

B Donut

Released in 2009, Android Version 1.6 has been code named as “Donut,” after the tasty ring-shaped delicacy. Its specialties like enhanced user experience, text-to speech support, improved video aspects and refined search integration helped Google to get itself rooted firmly in the highly

competitive Smartphone market. Larger screen-size support and turn-by-turn navigation facilities were the other sweet coatings on the donut version.



Figure.4 Donut

C Éclair

Named after those oblong baked pastries with chocolate filling, Android 2.0 was released in October 2009. The bug fix version named as 2.0.1 soon followed a couple of months later in December 2009. Then in January 2010, out came Android 2.1 with added animation features. However, the three versions are often considered as a single release. Google map navigation is its highlighted feature. Other celebrated features of Version Éclair include flash and digital zoom options for camera, live wallpapers, multi-touch support mechanism and of course, Bluetooth 2.1 support.



Figure.5 Eclair

D Froyo

The next one in the queue, Android 2.2 is about sheer speed and nothing else. Short for Frozen Yoghurt, Google got this version’s speed technically enhanced. Yet another unique characteristic feature was its uniquely redesigned home screen. It ensured better functionality for the device, with the entire process streamlined.



Figure.6 Froyo

E Gingerbread

Named after the popular ginger-flavored cookies, Android version 2.3 looked new and fresh in various ways. A few of its unique features included several cameras, SIP internet calling, download manager, a few sensors like a barometer, gravimeter etc.



Figure.7 Gingerbread

F Honeycomb

Google introduced Android 3.0 in February 2011 and called it, Honeycomb. Made for tablets, versions 3.1 and 3.2 followed in rapid succession. Gingerbread was, in fact, Android's very first tablet-only update.



Figure.8 Honeycomb

G Ice Cream Sandwich

Version 4.0 was the outcome of Google's plan to get the tablet-only platform of Honeycomb synthesized with a mobile platform. Dubbed as Ice-cream Sandwich, enhanced functionality was not the only big change that it brought in. In terms of design too, there were drastic changes.

Introduction of default font was another highlight of Ice-cream Sandwich. From this version onwards, Google effectively brought all its services under the umbrella, 'Google Play'.



Figure.9 Cream Sandwich

H Jelly Bean

Although primarily meant to enhance functionality and improve user interface, "Google Now" was indeed the most innovative aspect of Version 4.1. Nicknamed as Jelly Bean, here was something that could correctly guess what you are up to search, before you actually go looking for it.

Apart from the predictive feature, highly interactive notifications too made Jelly Bean stand out from the rest. Version 4.1 was also noted for its unique in-built speech-to-text engine, popularly referred to as 'voice typing'. The outcome has been an overall performance enhancement that assured an absolutely buttery smooth user interface.



Figure.10 Jelly Bean

I KitKat

Google officially unveiled Android version 4.4, which it named as Kitkat, in 2013. Nestle offered full support and even kicked off a special ad campaign on its release. However, the code name that Google had initially associated with Android 4.4 was "Key Lime Pie". The name was later changed to Kitkat as they thought key lime pie was not a very popular dessert. Google wanted a dessert name that is known by all, and hence partnered with Nestle for the code name Kitkat. Version 4.4 debuted on Nexus 5, and can effectively run on quite many devices compared to earlier Android versions.

'Google Now' feature, introduced initially in Jelly Bean was taken even ahead with the introduction of Kitkat. Earlier, you had to touch the gadget to open up the smart artificial intelligence (AI) assistant. Now with Jelly Bean, all you got to do to initiate the search is to utter the required phrase to the gadget.

Another advantage of Version 4.4 was that now the operating system could run even on devices with lower RAM. 512 MB RAM was the recommended minimum. The introduction of Emoji on Google's keyboards was yet another unique aspect of Kitkat.



Figure.11 KitKat

J Lollipop

With Version 5.0, popularly referred to as Lollipop, Android could simply spread across a wide range of devices from smart phones to televisions and even to smart watches. Lollipop came out with a brand new runtime. Battery saving feature ensures excellent battery life on these various devices. It saves your phone from damage even while its battery is running low.



Figure.12 Lollipop

K Marshmallow

Android 6.0, named Marshmallow, has been released under the code name Android M. It has ushered in a fistful of welcome changes that are sure to make a major impact. Doze mode that cuts down the power consumption drastically when the device is idle, opt-in app permission, fully supported USB C, inbuilt fingerprint sensor support system is but a few of them. It even allows the user to get a MicroSD card formatted and use it as internal storage, enjoying the same security level.

Of course, all those versions that have been rolled out by Google till now have been sweet. Still sweeter ones are yet to come and steal the show. Android N, the next in line is already underway with its developer preview already released.



Figure.13 Marshmallow

L Nougat

Android Nougat is slowly drawing to a close as the latest and greatest version of Android. But as Nougat steadily creeps towards double digits in terms of Android version distribution, and with Android 7.1.2 now out for a number of devices, we thought it was time to revisit the Android N release. Nougat may not have delivered the same dramatic visual overhaul we were first treated to in Android Lollipop two versions ago, but Nougat does provide a lot of major improvements and refinements over Marshmallow, along with quite a few arguably more important usability changes. With that in mind, join us as we run through all the major Android

7.x features – both user-facing and behind-the-scenes – in our full Android Nougat review.



Figure.14 Nougat

M Oreo

Android 8.0 Oreo focuses primarily on speed and efficiency. Google's Pixel phones, for example, have seen boot times cut in half with Android 8.0 (another name for Oreo). Others are faster too, according to our testing. Pesky background activity that drains your battery and data plan have been restricted, another perk of Oreo. Android Oreo skimps on bold visual changes, but packs in useful design tweaks, like picture-in-picture (PiP) mode for multitasking with the likes of YouTube, Google Maps and Hangouts appearing in a small corner window when minimized. New notification dots on apps icons offer a colorful reminder to check out updates.

Android Oreo 8.1 has launched on even fewer devices, but packs in extras, mostly concentrated on Pixel phones. AR Stickers on Pixel phones inject even more fun into the stock camera app as we demoed in our in-depth article. The Pixel 2-exclusive Visual Core makes the best phone camera even better with improved HDR+ photos. Head to the next page to read more about the best features coming with the Android Oreo update. But first, check out which phones are compatible with the software.



Figure.15 Oreo

N Pie

Android "Pie" (codenamed Android P during development) is the ninth major update and the 16th version of the Android operating system. It was first announced by Google on March 7, 2018, and the first developer preview was released on the same day. The second preview, considered beta quality, was released on May 8, 2018. The third preview, called Beta 2, was released on June 6, 2018. The fourth preview, called Beta 3, was released on July 2, 2018. The final beta of Android P was released on July 25, 2018. Android "P" was officially released on August 6, 2018 as "Android 9 Pie" and is available for Google Pixel devices and

the Essential Phone. Google announced it will release Android 9 Pie (Go Edition), the lite version of Android Pie, in autumn.



Figure.16 Pie

CONCLUSION

From above discussion it is clear that Android Operating System follows a variety of security mechanism. When a developer install an application a new user profile with that application is created. Each application run with its own instance of Dalvik VM. So applications cannot access each other's data. If applications want to access shared data or resources then they require permissions. All Android applications are signed so users know that the application is authentic. The signing mechanism allows developer to control which applications can grant access to other application on the system.

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