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ANDROID THE MOBILE OPERATING SYSTEM AND ARCHITECTURE

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Abstract: The Android operating unit is a mobile phone operating body built through Google primarily for touchscreen tools, smartphones, and tablet computers. It will undoubtedly begin with Android Architecture, which consists of five degrees: the Linux piece, Libraries, Application structure, Android runtime, and System apps. The Android operating unit is a multi-user Linux device in which each application is a various customer. Mobile applications have transformed interaction from conventional antiqued methods and fast-forwarded. Mobile applications have delivered more significant than social networking sites functionalities. Mobile applications have entirely altered the point of view and the process of working. Ordering food items, inspecting profile harmony, and creating a grocery store checklist are achievable utilizing mobile phone requests. Apple and Google have carried out significant improvements in the industry of mobile phones. Mobile uses have made our lifestyles less complicated, yet it has also unfavorably affected our lifestyles. Current researches state that making use of a mobile phone the entire time may lead to anxiety. Mobile applications denote a turning point in the primary creations and also developments. They aid organizations to interact much better along with their clients via flash message, offer on-demand solutions utilizing area sharing, and give prolonged assistance with document sharing, video recording conferencing, and a lot more. This paper describes the information about the android operating system and its components, how they interconnected with each other, and in today's era, it can change the way of communication.

Keywords- Operating system, mobile application, library, Linux Kernel, Dalvik virtual machine, memory, security, privacy, Android boot process, Android runtime

1. INTRODUCTION

In modern times technology has been widely adopted and employed by human beings in all fields. The use of technology has numerous advancements. It allows the people to keep in touch without gathering at one location. The growth of mobile technology has drawn people's attention from all walks of life, facilitating globalization by making the world look like a global village. With the number of mobile users increasing exponentially, the different firms operating in the technology industry are also not relenting to expand to meet the evolving demands of the consumers. As a result, multiple digital devices and gadgets continue to be developed with phones that were initially designed for calls only have a wide range of uses as they become part of people's lives and transform it.

Mobile phone users can access the internet, send and receive messages, or even video conference, serving like portable computers, apart from making and receiving calls. However, this could not have been possible were it not for developing a natural operating system. With only three operating procedures for the handheld devices; Windows by Windows incorporation, iOS by Apple incorporation, and Android by Google, the latter dominates the market by holding a significant market share in the number of users and units shipped worldwide. With each Android version release improving users' experience by bringing better features. Android smartphones pose a significant threat to the iPhone market. It is because Google was targeting the same consumers targeted by iPhone and has managed to secure both the hearts and minds of the mobile app developers making Android a success. With the development of smartphones and more mobile applications, there has been a complete turn in the usage of mobile phones, making them become part of the users' everyday life.

The android operating system was based on the Linux kernel and was unveiled in 2007 after Google purchased the functional system developer in 2005. Since then, Android has kept updating, bringing in new features to improve user experience and fix bugs. Through the development of Android, the world experienced the most extensive phone use not only by the millennials but across all demographics as people showed a willingness to do away with the conventional internet-accessible devices such as desktops and laptops. They are now comfortably embraced handheld technology ditching the traditional forms as outdated. Since then, the mobile landscape has experienced tremendous changes, including the emergence of new areas where smartphones are applied with the help of the Android Real-Time System. This paper discusses how the Android operating system has changed the mobile landscape.

2. BACKGROUND AND HISTORY:

Android is depicted as a mobile operating system. At the beginning improved by Android, Inc. Android was sold to Google in 2005. Android centered on a restricted Linux 2.6 kernel. Google and other representatives of the Open Handset Alliance (OHA) collaborated on Android (design, development, distribution). The Android Open Source Project (AOSP) governs the Android maintenance and development cycle. The android operating system is based on a revised Linux 2.6 kernel. Measure up to a Linux 2.6 environment. However, numerous drivers and libraries have been altered or recently established to allow Android to run as effectively and essentially potential on mobile devices such as smartphones or internet tablets. A few of these collections come up with their origins in open-source developments. Due to some authorizing issues, the Android community decided to implement their c library (Bionic) and build an Android-specific Java runtime engine (Dalvik Virtual Machine – DVM).

Along with Android, emphasis has always been on enhancing infrastructure based on the limited resources available on mobile devices. On the way to balance the working world, and Android-specific application framework was designed and implemented. Hence, Android can best be described as a complete solution stack, incorporating the OS, center-wear components, and applications. In Android, the altered Linux 2.6 kernel acts out as the hardware abstraction layer (HAL). The evaluation of the Android operating environment can be labeled as:

- An accessible platform for mobile expansion
- A hardware source pattern intended for mobile devices
- A modified Linux 2.6 kernel drives a system
- An application and user interface (UI) framework
- A run time environment

3. ANDROID PHONE MARKET GROWTH

In today's world, smartphones have grown extensively, with the larger population owning different types of smartphones with varying features. With a substantial portion of the people using smartphones in various capacities, it has made a relatively significant impact on the economic activities making use of the handheld technology in one way or another. However, the main factor distinguishing the smartphone industry in terms of the units shipped across the world. The number of users is the type of operating system among the three which dominate the industry. As figures from the international data corporation reveal, the smartphone industry has been growing at the rate of 1.1%. With the number of units shipped amounting to 350 million by the third percentile of the year, the Android has maintained a leading position in the market share. The requirement of Android phones has been on the rise, with the consumers only. Choosing from the wide range of Android phones meets their needs and is within their budget.

However, even the vendors in the smartphone market are capitalizing on the wide acceptance of the Android operation system, making competition stiff in the business environment, with each vendor trying to be maximizing profits. The volatility of the technology industry has made Android production keep growing as they make efforts to ensure the operating system is compatible with a majority of hardware and have features that improve users' experience. Multiple companies producing android phones struggle to ensure they meet quality standards and improve features, especially data security, which has become a significant challenge in the technology realm. The smartphone revolution is believed to be geared by the Android process. However, it would take an optimistic tech seer could have predicted that the Android operating system would acquire such a significant market share when Google bought the Android developer in 2005. Later on, in 2007 iPhone was introduced, giving Google a hard time penetrating the market with their open-source mobile operating system, making them try even to have the OS available to the phone manufacturers at no direct costs. A comparison of the major players in the smartphone operating system industry reveals that a relatively high number of smartphones have an Android operating system, as shown below.

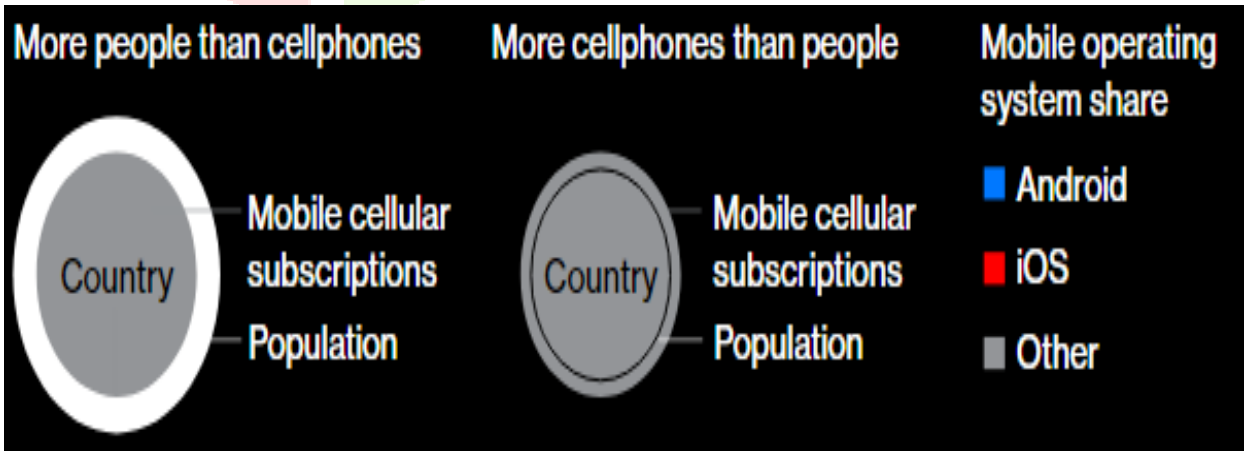

fig 3.1 phone market growth

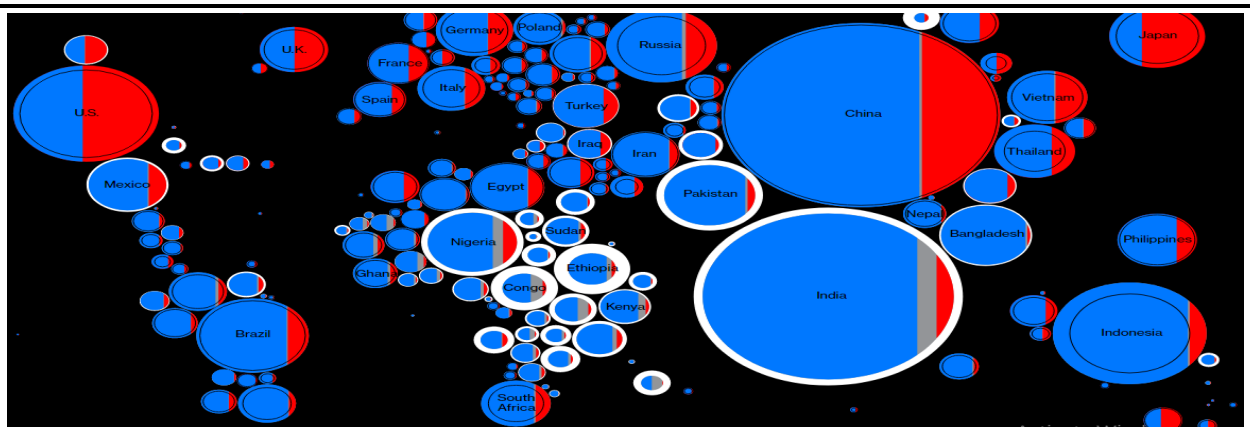

fig 3.2 phones of the world

With the increased internet connectivity facilitating users going online, research shows that most online users use their smartphones rather than personal computers. China, the most crowded nation in the world, failed to produce a whole generation of personal computers to venture into smartphones when only 10% of its population used the internet from the statistics of the United Nations in 2005. However, in 12 years, the figures had escalated to 54%, with close to 1 billion people of China's population going online with smartphones and despite Apple being successful in the same market Android run smartphones were more purchased as only 1 out of 10 of those purchased had an iOS. Besides, the counterpoint research in India revealed that among all the smartphones sold in the country, 99% were Android phones, and the government had the fastest-growing smartphone market. It has become a familiar pattern in different countries globally. Despite the iPhone being launched first, Android came later and has grabbed the highest number of users and contributed to making the smartphone the primary tool.

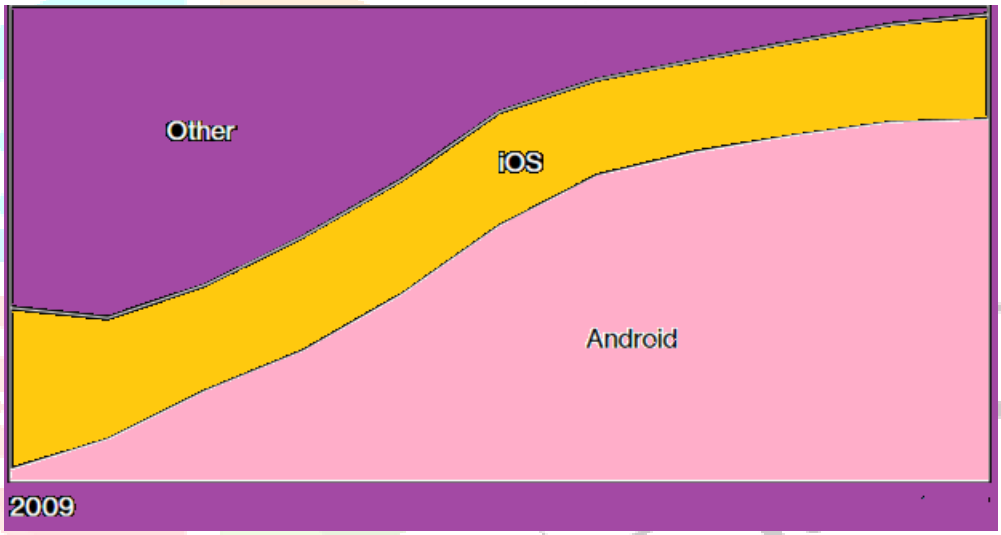

fig 3.3 mobile operating system market share

4. THE ANDROID SOFTWARE PLATFORM

The increasing usage of mobile phones is approximately 3.5 times that of personal computers, with handheld technology offering more services than initially developed. Smartphones are in today's world being used for entertainment and information, especially with the launching of the android operating system. An android is an open-source software for mobile devices that comprises an operating system, middleware, and critical applications. Since the software platform was launched, it has undergone multiple improvements in various dimensions, such as features and compatible hardware, to improve users' experience.

Besides, the software platform had also extended to other types of devices apart from the mobile ones it targeted when it entered the market by launching a mobile platform. It runs multiple applications that allow users to choose among the wide range of applications and their carriers as an operating system. Android has attracted significant attention in the mobile industry and other industries due to its open-source nature and architectural model. Based on the Linux kernel architectural model, the Android platform consists of several layers providing a complete software stack, as shown below.

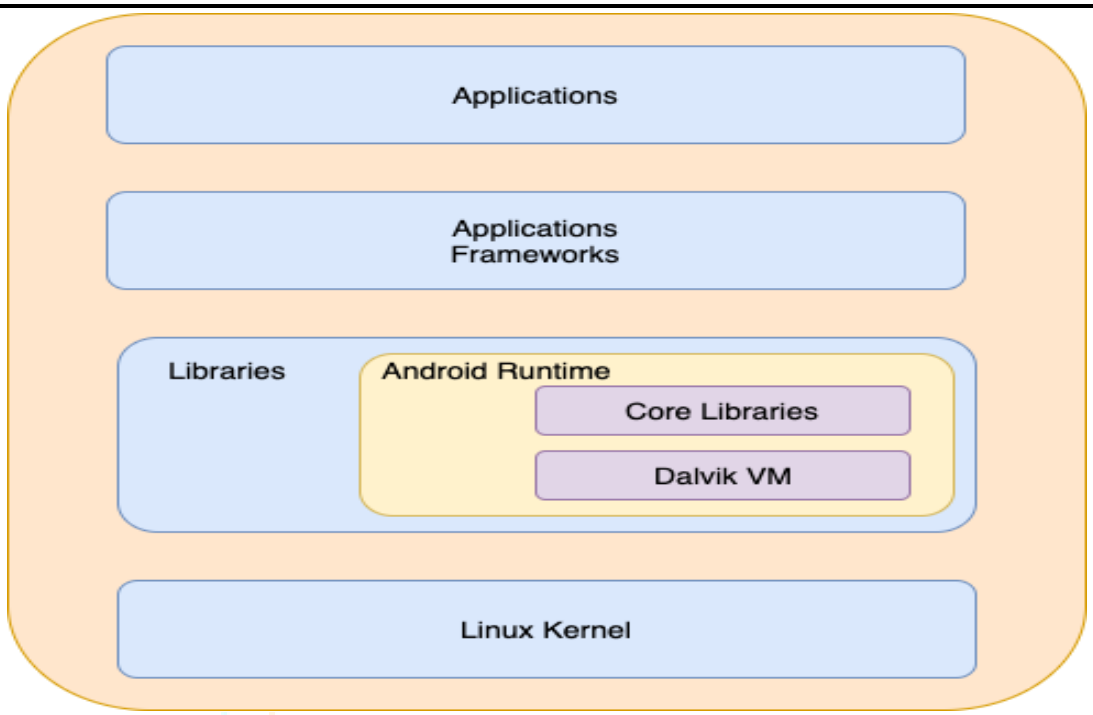

fig 4.1 android software platform

In the Android architecture, the application layer is the outermost with core applications written in Java programing language such as contacts, email, and SMS, all of which can be run simultaneously. One can be reading an SMS and listening to music at the same time. The open-source design is reflected in replacing an application downloaded from the Google market or directly from the developer's site allowing the user to customize the mobile device.

fig 4.2 architecture diagram of android system

Android is an extensive operating setting that is based upon Linux. The piece, along with some variations like V2.6, is additionally a split device. The style of Android body has received this photo, as the account is revealing various levels of Android. That is, Application level, Application structure work level, Library coating, Android Run opportunity level, and Kernel level. Each class is gotten in touch with the other. Android OS is a pile of program parts broken down into five segments and four principal coatings as pre-coating as presented below in the design.

Application layer:

It is the site of all Android applications, including an email client, SMS program, maps, browser, contacts, etc. All the mentioned applications are written using the Java programming language.

4.1 APPLICATION FRAMEWORK LAYER

- It is the layer that defines the Android application framework. All Android applications are established on the application framework. The Android application framework includes:
- A rich and extensive set of views can build an application with a beautiful user interface. To our knowledge, the outlook may constitute lists, grids, text boxes, buttons, and even an embeddable web browser.
- Content providers are responsible for enabling applications to access data from other applications such as Contacts or share their data.
- A Resource Manager responsible to provides access to non-core resources such as localized strings, graphics, and layout files.
- A Notification Manager is responsible to enables all applications to display custom alerts in the status bar.

- An Activity Manager is responsible for managing the lifecycle of applications and provides a standard navigation back stack. The location manager is responsible for fires alerts when a user enters or leaves a specified geographical location.
    - Package manager: It is liable to retrieve the data about installed packages on the device.
    - Window manager: It is responsible for creating views and layouts.
    - Telephony manager: It is responsible for handling settings of network connection and all information about services on the device

4.2 APPLICATION LIBRARY

GNU libs (Glibc) are complex and very large for cellphones; thus, Android applies its unique model of libc, Bionic libc, which resides in a smaller dimension - 200Kin. Several components bit out some complex C++ functions, one of the most substantial ones no C++ exemption, Small and exclusive string execution, highly based upon kernel futexes. Bionic libc carries out certainly not sustain POSIX as well as is certainly not suitable along with Glibc. Collection's level features a collection of C/C++ groups utilized through numerous parts of the Android unit and assists with the user platform.

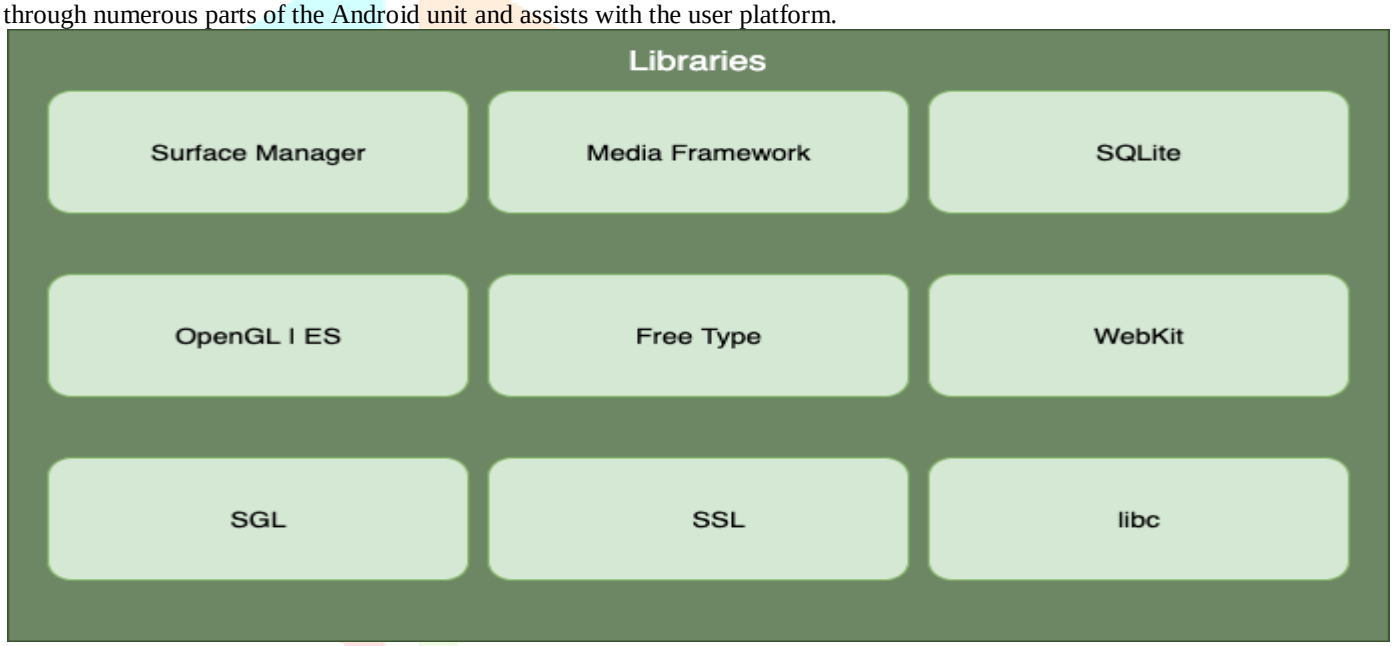

fig 4.2.1 libraries

4.3 ANDROID RUNTIME

It features a collection of center collections and also Java online equipment (Dalvik online equipment). That has been revamped as well as improved through Google to become ideal for the Android system. Linux bit lies at a lower level of the Android body and also functions as an absorption coating. The components bridge of the software application pile delivers center device solutions like surveillance, moment monitoring, procedure administration, system pile, and chauffeur version. Moreover, some lower functionalities including the administration of strings of Dalvik. The online device additionally depends on the Linux piece.

4.3.1 ANDROID APPLICATION RUN TIME ENVIRONMENT

Each Android use operates in a distinct method and the Dalvik Virtual Machine (VM) based upon the Java VM. The Dalvik layout has been maximized for smartphones. The Dalvik VM possesses a little moment impact, as well as various cases of the Dalvik VM, may operate simultaneously on the mobile phone

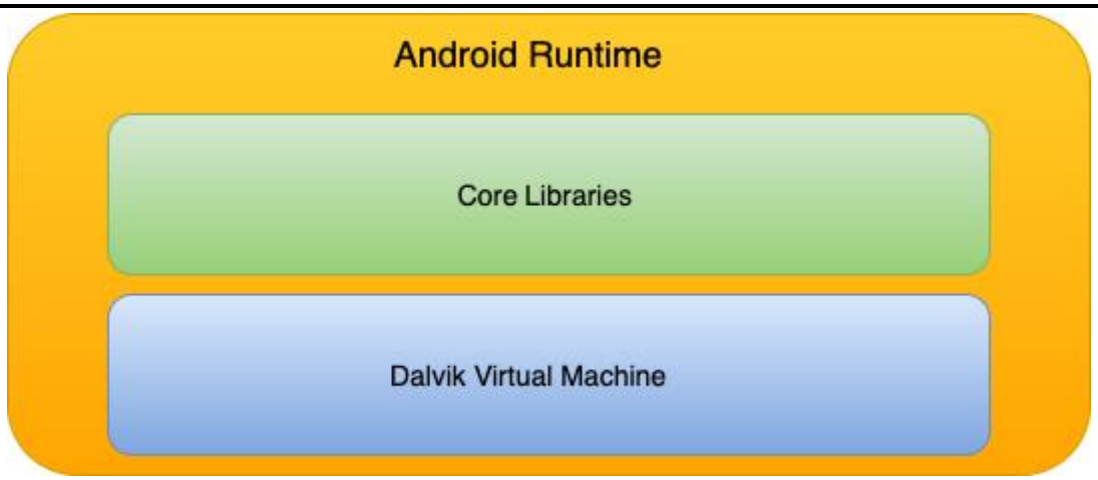

fig 4.3.1.1 android runtime

4.4 LINUX KERNEL

At the end of the levels is Linux. Linux 2.6, along with around 115 patches, supplies essential body capabilities like method control, mind administration, tool monitoring, video camera, keyboard, feature, etc. The bit manages all the factors that Linux is excellent at, such as media and a substantial assortment of gadget vehicle drivers. It takes throbbing away from interfacing to outer equipment.

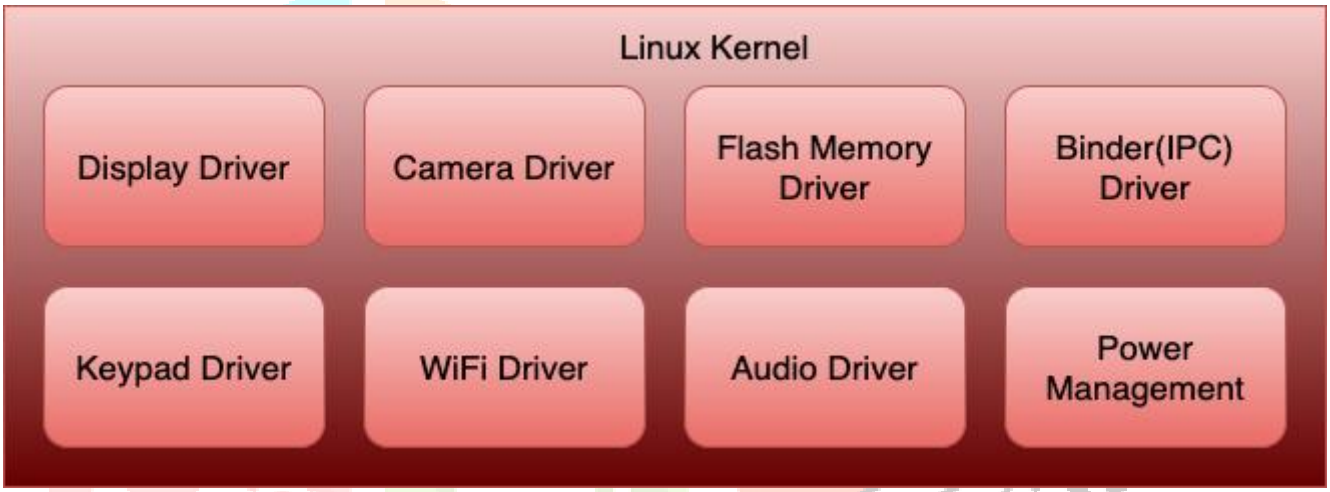

fig 4.4.1 Linux kernel

5. DALVIK VIRTUAL MACHINE (VM)

Android treatments and rooting structures are recorded rather than utilizing a primary Java digital maker. Android uses its personal VM. This online device is not suitable for the essential Java online equipment. Java ME is focused and improved for tiny bodies. These minor units typically offer small RAM, an idle CPU, apart from many PCs, no swap room to repay the tiny volume of Android operating on the Linux piece. Its apps are created through Java shows foreign languages. Thus Android apps are working on a Java Online equipment is called Dalvik online device. Dalvik digital equipment has been upgraded and also improved through Google for the components of mobile phones. The influential byte code linguist of the online equipment is referred to as Dalvik. Rather than utilizing regular byte code, Dalvik possesses is personal byte code style which is gotten used to the demands of Android aim at tools. The byte code is a lot smaller than standard Java byte code as well as the generated.dex documents are tiny. In an Android device, there is a resource named.dex, consisting of Android SDK, improves the Java Class data (collected through a frequent Java compiler).dex layout. The. Dex style data incorporate all Java lesson data and remove repetitive relevant information in every Java lesson document.

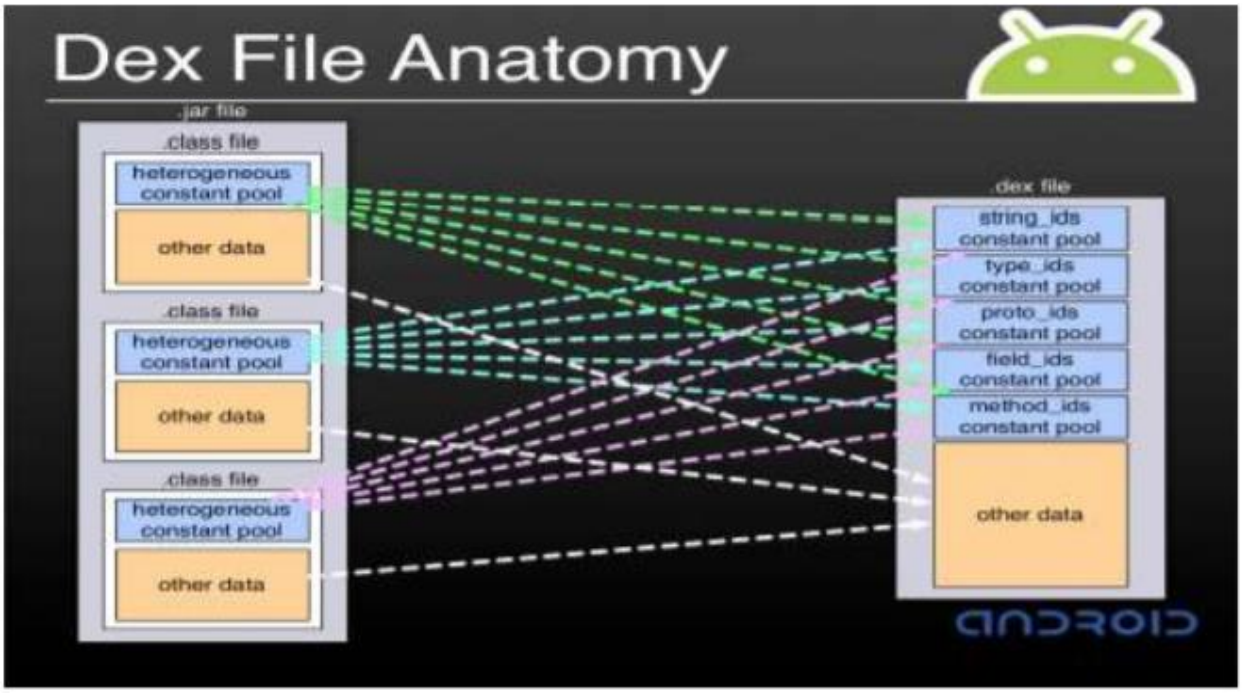

fig 5.1 .dex file format in android

5.1 MEMORY IN DVM

In Dalvik VM, there are four moments to set apart that could be organized to clean or dirty and shared or private. Regular information dwelling in either discussed or even exclusive well-maintained moments are public libraries and app particular documents similar .dex reports. Clean up mind is supported through data or other resources and could be trimmed due to the piece without information reduction. The exclusive grubby moment is typically composed of the requests ton and writeable command information frameworks like those needed in. dex data. These three types of various minds are pretty typical and also not specialized of Dalvik.

5.2 FEATURES OF DVM

Discussed grimy mind is feasible with a location of Dalvik phoned Zygote. The method begins at shoe opportunity and parents of all Dalvik VMs in the body. The Zygote initializes and bunches training classes intended to be utilized typically through requests right into a load. In familiar grimy moments lives, e.g., the dex information framework of collections. After the start-up of the Zygote, it pays attention to demands on an outlet. , if a brand-new function begins, the request is delivered to the Zygote, which does a rudimentary fork (). The recently forked method comes to be a complete Dalvik VM operating the begun use. The discussed grimy mind is a "copy-on-write" moment to decrease attention usage.

- Dalvik's online device possesses several occurrences or instances on one tool. Every case also functions in a particular Linux procedure; an Android use operates in circumstances of a Dalvik digital device.
- Dalvik online equipment relies on the rooting system software (Linux bit) for seclusion, mind control, and threading help.
- Dalvik's online equipment is register-based.

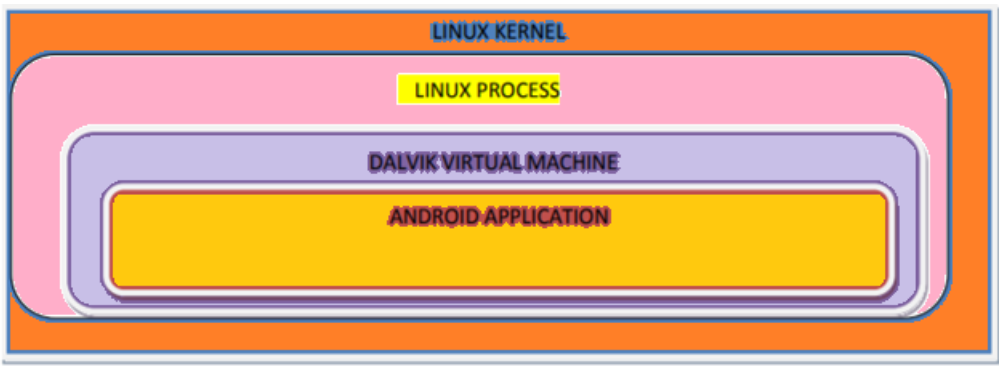

fig 5.2.1 position of dvm in android machine

6. APPLICATIONS AND DEVELOPERS

In modern times, people's experiences in computing and mobile devices have drastically changed due to the richness and quality of mobile applications. A few years back, mobile phones were only used for calls and small tasks such as storing contacts and calendars. At the same time, personal computers executed more advanced tasks such as reading emails, editing documents, and accessing the internet. However, today smartphones have equivalent computing power as personal computers. They can execute the same tasks due to the availability of a wide range of mobile applications. Nowadays, smartphones have become part of our lives and central to both our communication and information needs.

The iPhone's success and growth in market value have resulted from the many applications in its App Store. However, Android has had relatively high growth in its app market, recording over two billion app downloads, with its applications development rate being relatively high. However, the development of new applications in both phones comes out almost simultaneously. The difference between the two applications stores exists in the ease and authority of publishing a new application. The Android market is openly sourced such that app developers can publish an app in the market by themselves. At the same time, there are restrictions in the Apple app store requiring an app developer to seek approval for publication from Apple. Nevertheless, some advantages and disadvantages accrue from Google Android being an open-source software. The Android software will have a host of benefits that will enable it to gain a competitive advantage over the other operating systems in the market.

First, it will provide an open field for all app developers to publish their applications to help the consumers. They will have a wide variety of mobile applications, as Android will break the monopoly. Secondly, it will allow the customization of mobile phones with different features, although this will depend on the carrier. Third, the Android market will expand the number of mobile phones running the Android OS, making the phone manufacturing companies innovative and providing additional features that improve users' experience, such as location awareness services and real-timer multiplier games. On the contrary, the Google Android market is bound to face multiple problems such as rejection by carriers who charge a fee for the other web-based applications. Besides, it will face security challenges by increasing the risks of having the mobile devices hacked as the open-source platform can run all the Android phones.

7. SECURITY AND PRIVACY

The architectural model of the Android operating system makes its applications safer than those in the iPhone app store since explicit permission is required from the user for an application to access data from other applications as they are run in different spaces. In addition, Android application users have control of their security and privacy since they control which services the applications can access. Unlike iPhone applications with access to a wide range of system resources, users rely on Apple to evaluate an app before publication. However, although users of the Android OS have control of their security and privacy on their hands, they are not fully protected from malicious applications which can disclose or communicate personal information to a website. Additionally, Google sometimes removes malicious applications from the market if the users prove they are malware with the potential to cause harm. Still, as of now, not a single malware has been reported. The Android security features include

- **App sandbox:** This uses the Linux user-based protection and assigns each application a unique user ID, and the Android OS uses the ID to identify and isolate application resources.
- **Authentication:** Android devices use cryptography keys which the user must provide their credentials. Besides, some devices have a fingerprint sensor, and the user only needs to register one or more fingerprints which will be used to unlock the devices and allow execution of other tasks.
- **Encryption:** This technique involves encoding the plaintext using a secret code to hide the true meaning of the information. Encryption ensures the message cannot be read by anyone, not the authorized recipient, even if the message is intercepted while in transit over a network. An encrypted data has all the user's data encrypted automatically, and no unauthorized party can read the data even if they access it.
- **Security enhanced Linux:** It is one of the pillars of the Android security model, which is used to enforce all the mandatory access controls not only for Linux capabilities and all other processes.
- **Verified boot:** This is a security feature in the Android operating system that ensures all the executed codes come from a trusted source, and if there are any corrupt codes, they are blocked. It works on establishing trust for all the verified partitions.

8. BOOT SEQUENCE AND PROCESS

Android footwear series is thus explained in layout, which illustrates that it is hooked up along with in-app structure and its own whenever request prefers to operate supervisor. Afterward, it is joined with indigenous public libraries to its indigenous public library and later in operating opportunity Dalvik Virtual equipment filled through Zygote via bit. It is triggered that use the associated training class in the piece.

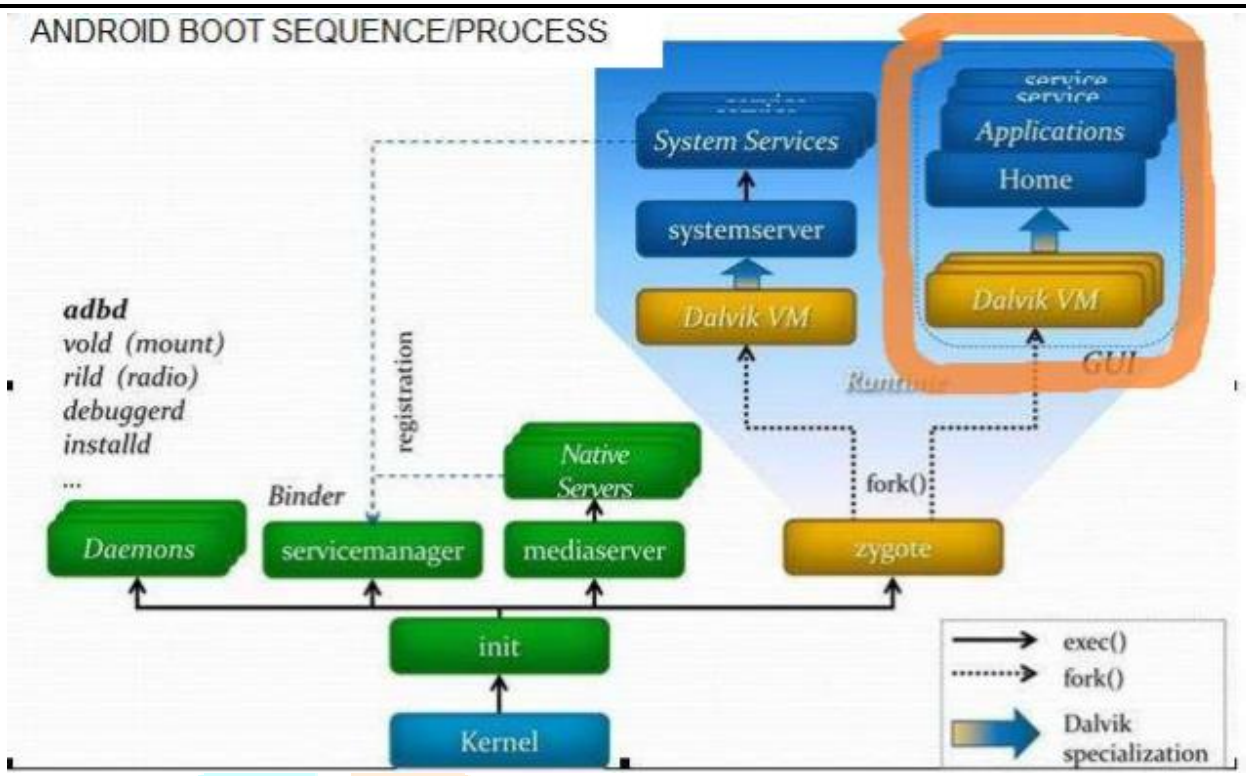

fig 8.1 android boot sequence process

8.1. AN MUSIC PLAYER AS AN EXAMPLE FOR BOOT SEQUENCE

Right here, there is an easy popular music gamer; the four parts of Android have been determined within this instance. Popular Music Main Activity is a thing of Activity style. It offers a user interface to consumers in application coating and connects with a service utilized to participate in popular music in history through a broadcast receiver. Songs player service is an item of extensional solution style generally functions to participate in songs in history and come back participate in statuaries to main music activity through the show. MusicInfo Manager is a custom-made training class; it stuffs content providers supplied through the unit to obtain relevant songs from a flash memory card.

Due to the above parts, accept one another can quickly notice the functionality of play songs on the android system. The Music Player Service operates in history profits all participate in condition to the MusicMainActivity work in the foreground through the program. A broadcast receiver has signed up in MusicMainActivity to obtain all shows coming from Music Player Service. The acquired program will undoubtedly be settled through MusicMainActivity. Depending on the program's web content, MusicMainActivity will carry out activities to display the action standing to consumers. After the song's gamer catapulted, the MusicMainActivity will deliver notifications to MusicInfoManager for songs data. The MusicInfoManager is going to trigger a Content Provider that is supplied through the unit. After that, acquire the song, submits a listing, and profit it to the MusicMainActivity

8.2. ANDROID BOOT PROCESS

Zygote initializes and also preloads primary collection training class. These are composed of both indigenous and coffee. The system is hosting servers in JAVA. When it is shifted on, as shown in the figure below, it can easily observe the Android information of these procedures.

Phase 1: Electrical power on as well as system startup: When energy begins, Boot ROM regulation beginning completion coming from a pre-defined place, i.e., is hardwired on ROM. It fills Bootloader into RAM as well as begins implementation.

Phase 2: Bootloader: Bootloader is the little plan which operates before the Android operating device is working. The Bootloader is the first system to function. Thus, It specifies for panel and also processor chip. Bootloader executes implementation in the second phase. The initial stage is to recognize external RAM and a bunch plan that assists in the second phase. In this phase, bootloader arrangement system, moment, and so on, which demands to operate piece, Bootloader manages to give arrangement inputs or even guidelines for specific functions.

Phase 3: Kernel: Android bit begins identical method as Linux as a piece launch it start arrangement store, secured mind, organizing, lots of motorists. When bit surfaces device configuration, it first seeks to "init" in device reports and launch its origin method or initial procedure.

Phase 4: init procedure: it quite to begin with the method; our experts can easily claim it is the original procedure or even grandma of all forms. Init method possesses two accountabilities.

- Mount directory sites like/ sys, /dev, /proc.
- Operate init.rc text.

Phase 5: Zygote and Dalvik: The distinct Virtual Machine (VMs) occasion will turn up in the moment for every application in JAVA; however, Android applications need to release quickly as achievable. At that point, if Android Operating System launches various cases of Dalvik VM for every application to beat this trouble, Android Operating System possesses " Zygote." Zygote allows communal code throughout Dalvik VM, lesser mind impact as well as marginal start-up opportunity. A zygote is a VM method that begins at body footwear opportunity, as experts have gone over in the previous action. Zygote initializes as well as preloads primary collection courses. These are three center lessons that are read-only and aspects of Android SDK or even core structures.

Phase 6: Element Service: After finalizing all measures runtime, ask Zygote to introduce body hosting servers. These are filled in both indigenous as well as caffeine. The system web servers in JAVA can quickly look at as a method as the same unit web server is actually on call as System Services in Android SDK. Zygote fork brand new procedure to release unit solutions, and experts may find resource regulation in Zygote init training class and "Start System Server" system.

Phase 7: Boot Completed: As System Services launches and functions, Android has finished the loading method, and "ACTION_BOOT_COMPLETED" criterion program activity will undoubtedly.

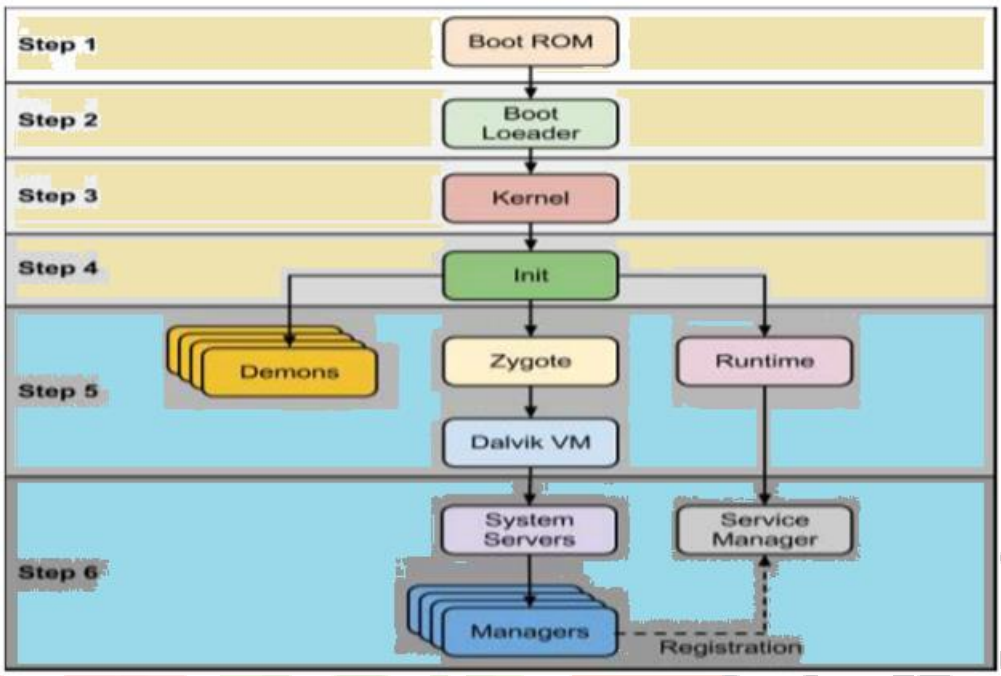

fig 8.2.1 android boot process

9. FEATURES OF ANDROID OPERATING SYSTEM

- **Storage:** In this significant data era, storage in digital devices is a critical component, and the Android OS has SQLite, which is a relational database with a relatively big storage capacity to meet the storage needs of Android mobile devices. It has attracted significant attention on Android devices in the market, especially for consumers who require the devices for storage purposes.
- **Connectivity:** One of the critical requirements of users in this digital era is a device that has access to the internet. An android smartphone or tablet supports connectivity technologies ranging from EDGE to Wi-Fi, ensuring users can access the internet at any place using the Android mobile devices.
- **Messaging-** Android operating system supports two forms of messaging; people widely use SMS and MMS to send text messages and share information relatively quickly. The OS is also developing other versions, such as the Google Cloud Message, which has tremendously improved users' experience in the Android Push Messaging service.
- **Multiple language support:** Android applications are written in different programming languages, supported by the Android operating system, making them compatible with most carriers. It is an advantage to the users as they can have a wide range of applications to choose from without worrying about the programming language used by developers.
- **Web browser:** A browser used in Android OS has a Web kit layout engine alongside others such as Chrome which provides a reliable platform for users to access the internet. Besides, the platform has a user-friendly interface making it easy to browse the different sites online.
- **Java support:** With most of the applications in the Android market written in the Java programming language, it is essential to have an operating system that can execute all the java byte codes. Besides, the operating system has Dalvik executables comprising all the Java classes, which are run on Dalvik, a machine designed for Android mobile devices.
- **Bluetooth:** It provides an application for sharing files between files or even enabling access to the files from a personal computer. Users of mobile devices face no challenges sharing contacts between phones or even music playlists.
- **Tethering:** This is an essential feature for online users. The Android OS allows a mobile phone to be used either as a wireless or wired WI-FI hotpot which third parties previously offered before the Android 2.2 version.

- **Video calling:** Some customized versions of the Android support video calling, which supports multiple applications used for video calling, such as Skype. Besides, users can video chat through hangouts with those using the Google+ Android app.
- **Screen capture:** Android allows a user to screenshot when two buttons are pressed simultaneously using the power and volume down button. It started after Android 4.0 versions as previously. It could only be done through third-party customization.

10. CONCLUSION:

In conclusion, from the research, it is apparent that the Android operating system is diverse and more advanced than the iPhone and Windows operating systems. Android operating system by Google dominates the market by holding a significant market share both in the number of users and units shipped across the world. With each Android version release improving users' experience by bringing better features, Android smartphones pose a significant threat to the iPhone market. Google was targeting the same consumers targeted by iPhone and has managed to win together with the mobile app developers' hearts and minds, making Android a success. The Android is open-source software for mobile devices that comprises an operating system, middleware, and critical applications. Since the software platform was launched, it has undergone multiple improvements in various dimensions, such as features and compatible hardware, to improve users' experience. Besides, the software platform had also extended to other types of devices apart from the mobile ones it targeted when it entered the market by launching a mobile platform. It is important to note that in modern times, people's experiences in computing and mobile devices have drastically changed due to the richness and quality of mobile applications. It is no longer when mobile phones were used for calls only because smartphones have an equivalent computing power as personal computers. They can execute the same tasks due to the availability of a wide range of mobile applications. The android operating system runs multiple applications that allow users to choose among the wide range of applications and their carriers. Android has attracted significant attention in the mobile industry and other industries due to its open-source nature and architectural model.

11. REFERENCES

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