

An Overview and Study of Android 5.0 Lollipop OS

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Abstract— Android is Linux based mobile OS which is being used by popular smart phone brands like Samsung, LG, HTC, Sony Xperia, and many other. Android 5.0 "Lollipop" is the latest version of the Android mobile operating system developed by Google. Unveiled on June 25, 2014 during Google I/O, it became available through official over-the-air (OTA) updates on November 12, 2014. This paper will contain detailed study of Android 5.0: Lollipop OS. It will cover stepwise development of android OS up to Lollipop. Contrast of Lollipop from old android OS, IOS and Windows Phone OS, details review of technical background of Lollipop OS.

Key words: Android, Lollipop 5.0, Smart phone.

Motorola, etc and many other mobile companies. Initially Android was developed by Android Inc which was later purchased by Google in 2005 and brought up with a project called Android Open Source Project. Android being an open source has large communities of developers writing applications developed primarily in java. Now apps are also developed in other languages such as C, C++, python, java script, flash etc. They are available to download from Google play or other third party sites. In February 2015 there are more than 6075,000 apps and games available on Google Play to keep users entertained, alongside millions of songs and books, and thousands of movies. Also the estimated number of downloads from Google play in billion.

I. INTRODUCTION

Android is a Linux based OS. 5.0 version of Android is popularly known as Lollipop OS. It is claimed to be the best android OS by Google and other intellectual groups who are working in smart phone companies like Google (Nexus), Samsung(Galaxy series), Sony (Xperia), HTC(One, Wildfire and many more). Hence we will study the good part of OS 5.0 Lollipop with comparisons to other Android OS with history and other many more features

II. ANDROID

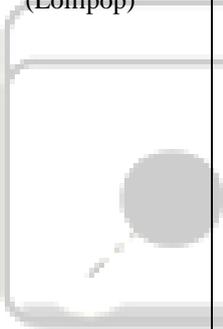
Android is a Linux-based operating system designed especially for Smartphone and tablets, developed by Google combining with other Open Handset Alliance (OHA). Android is now used in various Smartphone and tablets developed by Samsung, LG, Google, Htc, Sony Ericson,

III. DEVELOPMENT OF ALL ANDROID OS

Android Inc. was founded in Palo Alto in October 2003. One of the founders of Android Inc, Andy Rubin wanted to develop smarter mobile devices that are more aware of its owner's location and preferences. Later Google acquired Android Inc. on August 17, 2005 and Rubin started working with Google. At Google, the team led by Rubin developed a mobile device platform powered by the Linux kernel. And hence the android was developed. The first commercially available phone to run Android was the HTC Dream, released on October 22, 2008. Then Google collaborated with HTC to release a first Nexus phone, Nexus One. Later on various brands of mobiles like Samsung, LG, Motorola, Sony Ericson etc also collaborated with Google and started producing Android smart phones.

Android 1.0 (Alfa)	September 23, 2008	<ul style="list-style-type: none"> - GPS and Bluetooth (but not stereo Bluetooth) - Multitasking - Tight integration with Google Services like Gmail, Google Maps (With Street View), and Google Calendar - Apps: Amazon MP3 Store, YouTube - Android Market (about 35 apps at launch) - No Microsoft Exchange Server no camcorder
Android 1.1 (Beta)	February 9, 2009	<ul style="list-style-type: none"> - Universal search box (search had been limited to the Web) - Revamped Android Market: Browsing categories (Apps, Games, Downloads) and filters (Top Free, Top Paid, Just In) - Camera: Toggle between camera and video modes; integrated photo gallery and camera with bulk photo deleting - SDK expands support for gestures, voice-to-text
Android 1.5 (Cupcake)	April 30, 2009	<ul style="list-style-type: none"> - Virtual onscreen keyboard - Camcorder mode for recording & watching video - Stereo Bluetooth - Home screen widgets and folders - Direct upload to YouTube and Picasa
Android 1.6 (Donut)	July 18, 2009	<ul style="list-style-type: none"> - Multiple user accounts - Exchange support; universal e- mail inbox - Quick Contact pop-up widget to launch communications with friends in the address book - Search saved SMS and MMS Messages

		<ul style="list-style-type: none"> - Camera improvements include support for flash and digital zoom - Bluetooth 2.1 - Keyboard improvements: Adaptive dictionary that includes contact names in suggestions
Android 2.0 (Éclairs)	October 26, 2009	<ul style="list-style-type: none"> - Live wallpaper; five home Screens - Speech-to-text added to any text field; microphone icon for voice dictation in e-mails, texts, and so On
Android 2.2 (Froyo)	May 20, 2010	<ul style="list-style-type: none"> - Speedier OS - USB tethering and hot-spot Support - Android Market update: Batch and automatic updates; installing apps to the SD card - Adobe Flash 10.1 - File uploading in the browser - Improved Microsoft Exchange support: Security policies, global address lookup, calendar sync, remote wipe - Bluetooth support for voice dialing and contact sharing
Android 2.3 (Gingerbread)	December 6, 2010	<ul style="list-style-type: none"> - Redesigned copy/paste - Web M video compression Support - NFC (near-field communication Support) - Switch to front-facing camera from camera app - Virtual keyboard shortcuts
Android 3.0 (Honeycomb)	February 22, 2011	<ul style="list-style-type: none"> - 3D graphics support - Side-by-side browser tabs: private browsing - Dual-pane modes for address book, e-mail - Redesigned UI includes program Thumbnails - Video chatting with Google Talk - Full-screen-mode photo gallery - Bluetooth tethering
Android 4.0 (Ice cream Sandwich)	October 19, 2011	<ul style="list-style-type: none"> - Support for peripherals like keyboards and game pads - Resizable widgets - Pay as you go" support for 3G, 4G tablets - Various bug fixes and Enhancements
Android 4.1 (Jell Bean)	July 9, 2012	<ul style="list-style-type: none"> - Support for virtual buttons in addition to touch-sensitive Buttons - Create folders by dragging apps on top of each other - A new app tray tab for thumbing through widgets - Calendar app now supports pinch-to-zoom - Revamped Gmail user interface - New Chrome browser syncs with your bookmarks, saves pages offline, supports 16 browser tabs - More keyboard error correction, inline spell check - Customizable lock screen, - Launcher Recent applications icon - Roboto typeface - New swipe/delete behavior - Improved voice integration and copy and paste - Face Unlock security feature Data Usage tracking - Hide unwanted app icons - Shut down apps that are using background data
Android 4.4 (Kit Kat)	October 31, 2013	<ul style="list-style-type: none"> - Wireless printing capability - Native infrared blaster API - Browser text wrap is disabled - Wi-Fi and mobile data activity (TX/RX) indicators are moved to quick - Public API for developing and managing text messaging clients - Settings application no longer uses a multi-pane layout on devices with larger screens - Disabled access to battery statistics by third-party applications - Expanded accessibility APIs and system-level closed captioning settings - Audio tunneling, audio monitoring and loudness enhancer

		<ul style="list-style-type: none"> - New framework for UI transitions - Public API for developing and managing text messaging clients - Sensor batching, step detector and counter APIs - Bluetooth Message Access Profile (MAP) support - Settings application now makes it possible to select default text messaging and home (launcher) application - Android Runtime (ART) introduced as a new experimental application runtime environment, not enabled by default, as a replacement for the Dalvik virtual machine
<p>Android 5.0 (Lollipop)</p> 	<p>November 12, 2014</p>	<ul style="list-style-type: none"> - Android Runtime (ART) with a head-of-time (AOT) compilation and improved garbage collection (GC), replacing Dalvik that uses just-in-time (JIT) compilation - Support for 64-bit CPUs - OpenGL ES 3.1 and Android Extension Pack (AEP) on supported GPU configurations - Recent activities screen with tasks instead of applications, up to a configured maximum of tasks per application - Vector drawables, which scale without losing definition - Support for print previews - Material design, bringing a restyled user interface - Refreshed lock screen, no longer supporting widgets - Refreshed notification tray and quick settings pull-down - Project Volta, for battery life improvements - Searches can be performed within the system settings for quicker access to particular settings - Lock screen provides shortcuts to application and notification settings - Guest logins and multiple user account - Audio input and output through USB devices - Third-party applications regain the ability to read and modify data located anywhere on external storage, such as on SD cards - Pinning of an application's screen for restricted user activity. - Recently used applications are remembered even after restarting the device. - Web Views receive updates independently through Google Play for security reasons, instead of relying on system-wide vendor updates - Tap and Go allows users to quickly migrate to a new Android device, using NFC and 18. Bluetooth to transfer Google Account details, configuration settings, user data and installed applications. - A flashlight-style application is included, working on supported devices with a camera flash. - User-customizable priorities for application notifications.

IV. TECHNICAL BACKGROUND OF ANDROID 5.0 LOLLIPOP OS

Android 5.0 introduces a refreshed notification system. Individual notifications are now displayed on cards to adhere to the material design language, and batches of notifications can be grouped by the app that produced them. Notifications are now displayed on the lock screen as cards, and "heads up" notifications can also be displayed as large banners across the top of the screen, along with their respective action buttons. A do-not-disturb feature is also added for notifications. The recent apps menu was redesigned to use a three-dimensional stack of cards to represent open apps. Individual apps can also display multiple cards in the recent menu, rather than only one entry per app; for example, a web browser can show all of its open tabs as individual cards.

Lollipop also contains major new platform features for developers, with over 5,000 new APIs added for use by applications. For example, there is the possibility to save photos in a raw image format. Additionally, the Dalvik

virtual machine was officially replaced by Android Runtime (ART), which is a new runtime environment that was introduced as a technology preview in KitKat. ART is a cross-platform runtime which supports the x86, ARM, and MIPS architectures in both 32-bit and 64-bit environments. Unlike Dalvik, which uses just-in-time compilation (JIT), ART compiles apps upon installation, which are then run exclusively from the compiled version from then on. This technique removes the processing overhead associated with the JIT process, improving system performance.

Lollipop also aims to improve battery consumption through a series of optimizations known as "Project Volta". Among its changes are a new battery saver mode, job scheduling APIs which can restrict certain tasks to only occur over Wi-Fi, and batching of tasks to reduce the overall amount of time that internal radios are active. The new developer tool called "Battery Historian" can be used for tracking battery consumption by apps while in use. The Android Extension Pack APIs also provide graphics

functions such as new shaders, aiming to provide PC-level graphics for 3D games on Android devices.

A number of system-level, enterprise-oriented features were also introduced under the banner "Android for Work": Samsung contributed its Knox security framework for segregating personal and work-oriented data from each other on a device, along with accompanying APIs for managing the environment. Devices can also be configured so that users do not have to unlock their device with a PIN or pattern if it is within a trusted, physical location, or is in proximity to a user's Android Wear device. Device encryption will be enabled by default. Android 5.0 Lollipop—the largest and most ambitious release for Android y, This release is packed with new features for users and thousands of new APIs for developers. It extends Android even further, from phones, tablets, and wearable, to TVs and cars.

V. FEATURES OF ANDROID 5.0 LOLLIPOP

A. Screen Capturing and Sharing

Android 5.0 lets you add screen capturing and screen sharing capabilities to your app. With user permission, you can capture non-secure video from the display and deliver it over the network if you choose.

B. Material Design

Android 5.0 brings Material design to Android and gives you an expanded UI toolkit for integrating the new design patterns easily in your apps. New 3D views let you set a z-level to raise elements off of the view hierarchy and cast real time shadows, even as they move. Built-in activity transitions take the user seamlessly from one state to another with beautiful, animated motion. The material theme adds transitions for your activities, including the ability to use shared visual elements across activities. Ripple animations are available for buttons, checkboxes, and other touch controls in your app. You can also define vector drawables in XML and animate them in a variety of ways. Vector drawables scale without losing definition, so they are perfect for single-color in-app icons. A new system-managed processing thread called RenderThread keeps animations smooth even when there are delays in the main UI thread.

C. Performance Focus

Android 5.0 provides a faster, smoother and more powerful computing experience. Android now runs exclusively on the new ART runtime, built from the ground up to support a mix of ahead-of-time (AOT), just-in-time (JIT), and interpreted code. It's supported on ARM, x86, and MIPS architectures and is fully 64-bit compatible. ART improves app performance and responsiveness. Efficient garbage collection reduces the number and duration of pauses for GC events, which fit comfortably within the v-sync window so your app doesn't skip frames. ART also dynamically moves memory to optimize performance for foreground uses. Android 5.0 introduces platform support for 64-bit architectures—used by the Nexus 9's NVIDIA Tegra K1. Optimizations provide larger address space and improved performance for certain compute workloads. Apps written in the Java language run as 64-bit apps automatically—no modifications are needed. If your app uses native code,

we've extended the NDK to support new ABIs for ARM v8, and x86-64, and MIPS-64. Continuing the focus on smoother performance, Android 5.0 offers improved A/V sync. The audio and graphics pipelines have been instrumented for more accurate timestamps, enabling video apps and games to display smooth synchronized content.

D. Notifications

Notifications in Android 5.0 are more visible, accessible, and configurable. Varying notification details may appear on the lock screen if desired by the user. Users may elect to allow none, some, or all notification content to be shown on a secure lock screen. Key notification alerts such as incoming calls appear in a heads-up notification—a small floating window that allows the user to respond or dismiss without leaving the current app. You can now add new metadata to notifications to collect associated contacts (for ranking), category, and priority. A new media notification template provides consistent media controls for notifications with up to 6 action buttons, including custom controls such as "thumbs up"—no more need for Remote Views.

E. New types of Sensors

In Android 5.0, a new tilt detector sensor helps improve activity recognition on supported devices, and a heart rate sensor reports the heart rate of the person touching the device. New interaction composite sensors are now available to detect special interactions such as a wake up gesture, a pick up gesture, and a glance gesture

F. Your Apps on the Big Screen

Android TV provides a complete TV platform for your app's big screen experience. Android TV is centered around a simplified home screen experience that allows users to discover content easily, with personalized recommendations and voice search. With Android TV you can now create big, bold experiences for your app or game content and support interactions with game controllers and other input devices. To help you build cinematic, 10-foot UIs for television, Android provides a lean back UI framework in the v17 support library. The Android TV Input Framework (TIF) allows TV apps to handle video streams from sources such as HDMI inputs, TV tuners, and IPTV receivers. It also enables live TV search and recommendations via metadata published by the TV Input and includes an HDMI-CEC Control Service to handle multiple devices with a single remote. The TV Input Framework provides access to a wide variety of live TV input sources and brings them together in a single user interface for users to browse, view, and enjoy content. Building a TV input service for your content can help make your content more accessible on TV devices.

G. Document-Centric Apps

Android 5.0 introduces a redesigned Overview space (formerly called Recents) that's more versatile and useful for multitasking. New APIs allow you to show separate activities in your app as individual documents alongside other recent screens. You can take advantage of concurrent documents to provide users instant access to more of your content or services. For example, you might use concurrent documents to represent files in a productivity app, player matches in a game, or chats in a messaging app.

H. Advanced Connectivity

Android 5.0 adds new APIs that allow apps to perform concurrent operations with Bluetooth Low Energy (BLE), allowing both scanning (central mode) and advertising (peripheral mode). New multi-networking features allow apps to query available networks for available features such as whether they are Wi-Fi, cellular, metered, or provide certain network features. Then the app can request a connection and respond to connectivity loss or other network changes. NFC APIs now allow apps to register an NFC application ID (AID) dynamically. They can also set the preferred card emulation service per active service and create an NDEF record containing UTF-8 text data.

I. High-Performance Graphics

Support for Khronos OpenGL ES 3.1 now provides games and other apps the highest-performance 2D and 3D graphics capabilities on supported devices. OpenGL ES 3.1 adds compute shaders, stencil textures, accelerated visual effects, high quality ETC2/EAC texture compression, advanced texture rendering, standardized texture size and render-buffer formats, and more. Gameloft's Rival Knights uses ASTC (Adaptive Scalable Texture Compression) from AEP and Compute shaders from ES 3.1 to deliver HDR (High Dynamic Range) Bloom effects and provide more graphical detail. Android 5.0 also introduces the Android Extension Pack (AEP), a set of OpenGL ES extensions that give you access to features like tessellation shaders, geometry shaders, ASTC texture compression, per-sample interpolation and shading, and other advanced rendering capabilities. With AEP you can deliver high-performance graphics across a range of GPUs.

J. More Powerful Audio

A new audio-capture design offers low-latency audio input. The new design includes: a fast capture thread that never blocks except during a read; fast track capture clients at native sample rate, channel count, and bit depth; and normal capture clients offer re-sampling, up/down channel mix, and up/down bit depth. Multi-channel audio stream mixing allows professional audio apps to mix up to eight channels including 5.1 and 7.1 channels. Apps can expose their media content and browse media from other apps, then request playback. Content is exposed through a query able interface and does not need to reside on the device. Apps have finer-grain control over text-to-speech synthesis through voice profiles that are associated with specific locales, quality and latency rating. New APIs also improve support for synthesis error checking, network synthesis, language discovery, and network fallback. Android now includes support for standard USB audio peripherals, allowing users to connect USB headsets, speakers, microphones, or other high performance digital peripherals. Android 5.0 also adds support for Opus audio codecs. New Media Session APIs for controlling media playback now make it easier to provide consistent media controls across screens and other controllers.

K. Enhanced Camera & Video

Android 5.0 introduces all new camera APIs that let you capture raw formats such as YUV and Bayer RAW, and control parameters such as exposure time, ISO sensitivity,

and frame duration on a per-frame basis. The new fully-synchronized camera pipeline allows you to capture uncompressed full-resolution YUV images at 30 FPS on supported devices. In addition to giving greater control over image capture, the new APIs also expose detailed information about the camera's properties and capabilities and provide metadata that describes the capture settings of each frame. Apps sending video streams over the network can now take advantage of H.265 High Efficiency Video Coding (HEVC) for optimized encoding and decoding of video data. Android 5.0 also adds support for multimedia tunneling to provide the best experience for ultra-high definition (4K) content and the ability to play compressed audio and video data together. Users have a unified view of their personal and work apps, which are badged for easy identification.

L. Android in the Workplace

To enable bring-your-own-device for enterprise environments, a new managed provisioning process creates a secure work profile on the device. In the launcher, apps are shown with a Work badge to indicate that the app and its data are administered inside of the work profile by an IT administrator. Notifications for both the personal and work profile are visible in a unified view. The data for each profile is always kept separate and secure from each other, including when the same app is used by both profiles. For company-owned devices, IT administrators can start with a new device and configure it with a device owner. Employers can issue these devices with a device owner app already installed that can configure global device settings.

M. Chromium WebView

The initial release for Android 5.0 includes a version of Chromium for WebView based on the Chromium M37 release, adding support for Web RTC, Web Audio, and WebGL. Chromium M37 also includes native support for all of the Web Components specifications: Custom Elements, Shadow DOM, HTML Imports, and Templates. This means you can use Polymer and its material design elements in a WebView without needing polyfills. Although WebView has been based on Chromium since Android 4.4, the Chromium layer is now updatable from Google Play. As new versions of Chromium become available, users can update from Google Play to ensure they get the latest enhancements and bug fixes for WebView, providing the latest web APIs and bug fixes for apps using WebView on Android 5.0 and higher.

N. Accessibility & Input

New accessibility APIs can retrieve detailed information about the properties of windows on the screen that sighted users can interact with and define standard or customized input actions for UI elements. New Input method editor (IME) APIs enable faster switching to other IMEs directly from the input method.

VI. CONCLUSION

Android 5.0 Lollipop Operating System of Google have made it more advanced to compete with IOS and windows phone OS. They have shown true capability of android OS.

Android 5.0 Lollipop OS are very popular among the different OS and this is expected to increase in popularity and despite its popularity momentum.

In this paper, we are representing the Android 5.0 Lollipop stepwise development, and other all Android OS stepwise development, details of technical background and all features of the Android 5.0 Lollipop OS. That paper hence and we can see that Android 5.0 Lollipop OS is the best Android OS ever made.

REFERENCE

- [1] "About the Android open source project" <http://source.android.com/about/index.html>.
- [2] Android Developers. 21 July 2009, <http://developer.android.com/guide/basic/android.html>.
- [3] Cunningham, Andrew (June 27, 2012). Ars Technica. Retrieved 2012-09-15.
- [4] "Android: Be together. Not the same.". Official Google Blog. October 15, 2014. Retrieved October 23, 2014.
- [5] Android Lollipop hits AOSP; HTC sets the upgrade pace". SlashGear. Retrieved 24 December 2014.
- [6] "When and where to get Android 5.0 Lollipop". CNET. CBS Interactive. October 15, 2014. Retrieved October 16, 2014.
- [7] "Updated Android Lollipop Developer Preview image coming to Nexus devices in a couple of days". PhoneArena. Retrieved October 16, 2014.
- [8] Technical trends- smart phones, smart people by Harikumar P Travancore Analytics, Technopark-Trivandrum, kerala in CSI communication 11 april 2011. http://www.csi-india.org/c/document_library.
- [9] http://www.techradar.com/reviews/pc-mac/software/operating-systems/android-5-0-lollipop/1087230/review?artc_pg=5
- [10] <http://developer.android.com/about/versions/lollipop.html>
http://en.wikipedia.org/wiki/Android_Lollipop#cite_note-anandtech-lunveil-6
- [11] http://en.wikipedia.org/wiki/Android_Lollipop#cite_note-anandtech-lunveil-6.