A Comparative Review of Mobile Application Development Frameworks: Kotlin Vs Java

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Abstract- The place of mobile communication in the twenty first century cannot be overemphasized as it has impacted almost all known field of human endeavour. The revolution in telecommunication induced by the development of mobile devices and applications has greatly improved businesses and the dominance of the Google Android over Apple iOS applications with its open-source application development has made it much easier for third-party developer to create state-of the art applications to meet the customers need. This paper reviews the evolution of mobile devices and application development taking into consideration programming language tool like Java and Kotlin for developing Android applications with the view to examine their strength, weaknesses and areas comparable advantage as to ascertain the best tool for modern Android application development.

Indexed Terms- Android, DEX, DVM, iOS, JVM, Mobile Application

I. INTRODUCTION

The evolution in computers and information technology in the last few decades has brought about a breath of fresh air to businesses and organization across the globe with massive information processing and management tools that has drastically changed and impacted the global economic landscape in the positive direction. The miniaturization of computers and other data handling and processing devices from the large-scale computing equipment of the first generation to easy going hand-held and micro devices has also opened up new opportunities for hardware and software development to meet the growing demand of the everyday consumer of the product. Today a small device like a smart watch or phone has more processing and storage capacity than the computer of the 1960s and late 1980s respectively and this trend will continuously evolve with mid blowing innovations. The evolution in computers and information technology pervaded the telecommunication space with the introduction of cell phones and now mobile devices that have more computing and data processing power and the introduction of more ground breaking innovations like the iPhone and other hand-held mobile devices. Global obsession and dependency on mobile devices especially the smart phone has been on the increase since the late 2007 with the introduction of the Apple iPhones as more research and innovation into satisfaction of the consumer's needs in terms of technological development. The massive growth of wireless or cell phone from the late 1970s to date has shown that the wireless communication network has become more pervasive than anyone could imagine with an upsurge of mobile phone user and subscribers globally showing that mobile communication is a more viable and robust voice communication away from the traditional fixed telephone approach and this has led to a new mobile communication standard for other telecommunication services aside from the voice telephony [1]. With more than five billion estimated mobile phone users globally both for the voice and other multimedia functionality and internet access, it has emerge as one of the most accessed and utilized information and communication technology tool ever which most probably would overtake personal computer usage with time [2].

Dudley [3], asserts that the average mobile phone user touches their an estimated 2.617 time daily, stating that "more people in the world today have more access to a mobile phone than a toilet", this indeed is an incredible feat in technological advancement. With the average person spending an estimated 800 hours on the phone annually, this is an indication that human dependency on this piece of technology is on the rise and as more features and applications are deployed in the mobile technology domain businesses and organizations are tending towards mobile

technologies. Despite the fact that mobile phone were originally designed for making calls it has gradually evolved to becoming a viable tool for full business computing and a lifestyle enhancement for many users giving them the opportunity to leverage on the social media components for social interaction and business linkages [4]. This paper reviews the innovation in mobile application development and the similarities and differences application development tools like Java and Kotlin programming languages for android programming.

II. BRIEF HISTORY OF MOBILE DEVICES

Change is said to be the only thing that is constant in life and this cannot be overemphasized as the technology world is one with the constant emergence of new realities in terms of innovations. The computers and information technology world has been the most evolving discipline of the twenty first century, with landmark innovations that has affected all other domains, today the use of mobile gadgets or devices has been seen in education, healthcare, business, politics, research and development. One would say that this level of cross-discipline innovations has come to stay as there is no known field of endeavour that mobile devices and applications have not been deployed. From its inception, mobile or cell phones were designed for voice communication only before the mobile technology revolution which injected novel tools that has hitherto enhanced the once voice based tool to a multi-faceted utility tool. Mobile phones have since evolved from just making calls to carrying out short message services popularly known as SMS (Text Messaging), minor calculators to children games, internet connectivity and full multimedia and business functionalities and much more yet to be deployed [5]. From Motorola DynaTAC 8000X the first commercial mobile phone to the Apple iPhone and now the latest Samsung Galaxy fold launched in April 2019, the shape, size, weight, texture has been drastically reduced and improved to create a sense of fashion and style for the user. It has changed the face of modern day communication beyond voice to image and video processing including groups and multi-user communication where more than one person can communicate seamlessly at the same time also referred to as conference calls, this feat made it the use of

mobile device more interesting and engaging [6, 3]. The table 1 shows some of the distinct features of the different mobile devices from the inception to date [3]:

Table 1: Evolution of Mobile Devices from 1983 – 2019

S/No	Device name	Date/Year	Dimension/Size	Weight/Mass	Internal Memory	Operating System
1	Motorola Dynatac 8000X	1983	3300 x 898 x 445 mm	1kg	None	Vendor
2	Nokia 1011	1992	192 x 62 x 30 mm	475 g	None	Vendor
3	IBM SIMON	1994	200 x 64 x 38mm	510 g	1.8 MB	Zaurus
4	Nokia 9000 Communicator	1996	158 × 56 × 27 mm	386 g	8MB	GEO STM 3.0
5	Motorola Startac	1996	57 x 98 x 22 mm	88g	None	
6	Nokia 8110	1996	141 x 48 x 25 mm	152 g	None	
7	Siemens S10	1997	147 x 46 x 25 mm	185 g	None	
8	Blackberry (RIM) 850	1999	89 x 64 x 24 mm	133 g	2MB	RIM Black Berry 1.0
9	Nokia 7110	1999	125 x 53 x	141 g	None	Vendor

			24 mm			
10	Sharp J-Sh04	2000	27 × 39 × 17 mm	74g		
12	Nokia 3310	2000	113 x 48 x 22 mm	133 g	None	Vendor
13	Nokia 1100	2003	106 x 46 x 20 mm	93g	None	Vendor
14	Blackberry (RIM) 6210	2003	113 x 75 x 20 mm	136 g	16.0 MB	Blackberry OS
15	Motorola Razr V3	2004	98 x 53 x 13.9 mm	95g	5.5 MB	Vendor
16	Sony-Ericsson Walkman W800	2005	100 x 46 x 20.5 mm	99g	34.0 MB	Vendor
17	Nokia N95	2007	99 x 53 x 21 mm	128 g	8G B	Symbian 9.2
18	iPhone	2007	115 x 61 x 11.6 mm	135 g	128 MB	iOS
19	HTC (T-Mobile) Dream G1	2008	17.7 x 55.7 x 17.1 mm	158 g	256 MB	Android 1.6 (Donut)
20	iPhone 3G	2008	115.5 x 62.1 x 12.3 mm	133 g	16G B	iOS
21	Blackberry	2009	109 x 60 x	106 g	256 MB	Blackberry
	Curve 8520		13.9 mm			OS 5.0
22	Samsung Galaxy S	2010	122.4 x 64 x 10.9 mm	129 g	16G B	Android 2.2
23	Samsung Galaxy Note N7000	2011	146.9 x 83 x 9.7 mm	178 g	16G B	Android 2.3.5
24	iPhone 5	2012	123.8 x 58.6 x 7.6 mm	112 g	32G B	iOS
25	Samsung Galaxy S3	2012	136.6 x 70.6 x 8.6 mm	133 g	16G B	Android 4.3 Jelly Bean
26	iPhone 5C	2013	124.4 x 59.2 x 9 mm	132 g	32G B	iOS
27	iPhone 5S	2013	123.8 x 58.6 x 7.6 mm	112 g	32G B	iOS
28	Nokia Lumia 1020	2013	130.4 x 71.4 x 10.4 mm	158 g	32G B	Windows
29	iPhone 6 Plus	2014	158.1 x 77.8 x 7.1 mm	172 g	64G B	iOS
30	Samsung Galaxy S6 Edge	2015	142.1 x 70.1 x 7 mm	132 g	32G B	Android 6.0/7.0/8.0
31	Google (HUAWEI) Nexus 6p	2015	159.3 x 77.8 x 7.3 mm	178 g	32G B	Android 6.0/7.0/8.0
32	Google Pixel	2016	143.8 x 69.5	143 g	32G B	Android

			x 8.6 mm			7.1/8.0
33	Samsung Galaxy S8+	2017	159.5 x 73.4 x 8.1 mm	173 g	64GB	Android 7.0
34	iPhone X	2017	143.6 x 70.9 x 7.7 mm	174 g	64GB	iOS
35	One Plus 6T	2018	157.6 x 74.6 x 7.9 mm	183 g	64GB	Android 9.0
36	Samsung Galaxy Fold	2019	117.9 x 160.9 x 7.6mm	276 g	512 GB	Android 9.1

(Source: Dudley, 2018)

Fig. 1 Evolution of Mobile Devices from 1982 – 2007 (Source: Mayank, 2016)

The changes and evolution in mobile phones and device were made possible by research development in both the hardware and software architecture of the systems which has made it affordable, accessible and handy compared to the bulky nature of the foremost Motorola DynaTAC 8000X that weight almost a kilogram with a dimension of 3300 x 898 x 445 mm compared to the 2019 Samsung Galaxy fold which weighs 276g and the dimension of 117.9 x 160.9 x 7.6mm when unfolded and 62.8 x 160.9 x 17.1mm when folded. Secondly, the battery power has significantly improved as the earlier mobile phone's like the Motorola DynaTAC can only be used for 30 minutes of call time with a massive 10 hours required to recharge the battery [7], today mobile phone producers have competitively extended the battery life of their devices to now accommodate lesser charge time and longer battery life running into days. The internal memory also of these devices has also improved drastically to almost equal and in most cases surpassed that of the regular computer from 1.8MB on the IBM Simon to 512 GB on the Samsung Galaxy fold making the mobile device a data powerhouse of the twenty first century.

III. MOBILE APPLICATION DEVELOPMENT

The evolution in the mobile devices as stated earlier can be attributed to both the hardware and software components and how they have transited from one generation of mobile devices to another shaping and changing the face of voice and data communication. The software revolution of mobile technology is one of the driving force of this paper. Applications are programs that are designed to carry out or perform a specific purpose/ tasks and mobile applications are designed also for different purposes. From the operating systems to the mobile application programs also known as Mobile Apps there has been a remarkable transformation with innovative programs developed to meet both business needs and that of individual of different ages and preference. The process of creating software application programs that run on mobile devices utilizing network connectivity to work with isolated or remote resources is mobile application development. Thereby creating installable programs that implements backend services like data access with application program interface (API) for a mobile device [8]. Rajput [7] states that mobile applications are programs generated on computers designed to run on mobile devices just as the conventional software programs run on computer systems for specific operations and services, mobile applications run on mobile devices be they smart phone or tablets and other hand held devices and PDAs. One factor responsible for this level of advancement in mobile application over the last few decade was the synergy in research and development by various stakeholders in mobile communication like manufacturers, mobile service provides, mobile application developers, service providers to improve their product and service efficiency [9] and this effort has paid off with ground breaking services and

applications that is has met and still meeting the needs of businesses, organizations and individuals globally irrespective of age and gender disparity.

The emergence of Apple iPhone running on iOS operating system in 2007 and the subsequent release of Google HTC on Android 1.0/1.6 ushered a new era in mobile computing that kick started the mobile application revolution [10, 11]. Mayank [11] further opines that the visionary approach of Apple and Google in launching the App and Play Stores, a repository for iOS and Android applications in 2007 further revolutionized the mobile communication space giving mobile device users access to Mobile Apps on the go to meet their work and gamming needs, and also created opportunities for third party Mobile application developer to create and upload their mobile Apps in both store. Furthermore, mobile application download reached one billion between 2009 and 2010 creating a big market opportunities for both developer and users.

IV. ANDROID APPLICATION DEVELOPMENT

Irrespective of the fact that there were other mobile operating systems in the market like Symbian, Blackberry RIM (Research in Motion), IBM, Windows, Palms OS and web OS, the dominance of Apple iOS and Google Android OS as the base for mobile devices was unequalled as application development is ever on the increase. Android operating system is predicated on Linux kernel and has its own virtual machine or DVM (Dalvik Virtual Machine) which is used for the execution of Android applications and its constant review and evolution with enhanced internet access and connectivity accounts for its success over Apple iOS [12]. Furthermore the advantage of Google Android OS over Apple iOS can be related to the fact that the Android is open source [10]. Running on over 400 million devices across the globe as an open source technology stack, Android OS has empowered developers and device manufactures to work remotely to develop top class application and devices to meet changing consumer demands [13]. With an estimated 74.85% of the total market share as at April 2019, Android OS has distinguished and established itself as a one of the most popular, preferred and efficient mobile application

development platform as it allows for easy modification and enhancement of android applications by independent developer to meet user requirements, this also adds to its popularity of android as the number one software development platform for mobile devices [14]. Aside from the Dalvik virtual machine (DVM) which is a java specific runtime engine, the android operating system has other features like the graphic optimizer, integrated browser, SQlite database, GSM technology, Bluetooth, 3G and 4G, camera and lots more that makes for enhancement in mobile application development. Additionally the android software development kit (SDK) provide for java programming language to facilitate application development [15]. The application programs that extends the device functionalities are mostly written in Java programming language with access into the API in the Android SDK. The programming languages supported by the Android SDK includes C/C++ which can be combined with the Java and GO programming language though with few limitations on the Android API. Java programming appears to be one of the key programming languages for android application development though it has been in existence long before the advent of the Android OS [16].

In today's mobile application development, especially in the android programming domain, Java and Kotlin are the two dominant programming languages in use for world class mobile application development. Though Java has been one of the key programming language that drive android application development in the past but most recently "Kotlin" appears to be the new kid on the block in terms of programming language that has been incorporated in the android SDK and it has enhanced the application development process with lesser code as compared with the native java programming.

V. EVALUATION OF ANDROID DEVELOPMENT FRAMEWORKS

From the beginning of mobile application development and the emergence of Android programming for mobile applications there has been several development tools and frameworks used for the creation of state of the art, user friendly applications to meet the growing demand of users across different categories. These development tools

include Java, C/C++, C#, Visual Basic, Corona/LUA, PhoneGap, Utility and most recently Kotlin [14, 17]. The most preferred of these development frameworks are Java and Kotlin, with Java being the key fundamental and most widely used tool for android applications development [18].

VI.   JAVA FOR ANDROID

As a general purpose programming language underpinned by the object oriented programming paradigm developed by Sun Microsystem in 1995, Java is found on many devices ranging from the smallest mobile device to massive mainframe computers. For years in the mobile application revolution Java served as the most preferred language for developers due to the fact it was the official language supported by Google for android application development [19, 17]. Java depend on the Virtual Machine for its implementation and the Dalvik virtual machine (DVM) is the Java specific VM for android. Java is used in android development because it is easy to program, interoperable and common amongst developers. It does not need code recompilation due to the fact that it runs on the Dalvik virtual machine (DVM) and class file are compiled into the Dalvik Executable format (DEX) thereby eliminates complications of pointer arithmetic, bundling Android Packages (APK) with other resources. Irrespective of the fact that it is slow it in terms of speed it is still a key programming tool for developing android applications [19, 18]. Furthermore, to improve the performance of java, native codes are also required as the java source codes are compiled into bytecode and then translated into the Dalvik bytecode to be store into the .dex format which is a machine executable format [20].

VII.   KOTLIN FOR ANDROID

From the inception of mobile communication and programming many application framework has been developed to aid and facilitate the growth now enjoyed by users of mobile devices across the globe. Android application development has provided platform for third party developers to create their own customized applications for different uses. Java over the years serves as the key tool in android development despite its inherent limitation but with the emergence of Kotlin, there appears to be a shift in the android programming community towards this new tool for some obvious reasons. Kotlin was released in 2016, developed by JetBrains as a statically-type programming language that runs on Java Virtual Machine (JVM) and it can compile codes written in Java script. In 2018 Google adopted Kotlin as the official programming language for Android application development [14, 19]. As a programming language, Kotlin is extensively intuitive and easy to learn as most its syntax are Java-like and it can integrate easily in Java IDEs like NetBeans, IntelliJ. The amazing feat of this program is its interoperability with Java and code written in Kotlin can run with a Java program without any form of error syntactically or logically [21]. Coppola et al [14], asserts that most of the common limiting features of Java that has been addressed and tackled by Kotlin include; Nullability, Mandatory Cast, Long argument list and Data classes respectively and these criteria has informed the drift of developers towards it as a suitable alternative to Java though complementary in nature. One key advantage of Kotlin over Java is the use of shorter lines of codes for application development thereby reducing the time required to develop a standard Java program improving application development throughput [22]. Sommerhoff [23], argues that Kotlin is a programming language for Java Virtual Machine (JVM) and not a replacement for Java as most authors have proposed. And with the current move by JetBrains to integrate Kotlin in embedded systems and iOS, it is clear that it aims at becoming a platform for the integration of several application development tools and features that would be advantageous for large scale projects irrespective of the area. Shah [24], also agrees with Sommerhoff [23] that the end has not yet come for Java as an Android application development tool as its vast open source libraries and tools has continued to be of immense help to developers. However, Kotlin has provided the necessary remedy to the various challenges developer face in using Java for application development thereby enhancing the Java development ecosystem. Though most developer believe it has come to completely replace Java but the fact remains that they can complementarily coexist in the same program. With inherent limitation of Java in Android API development, the lightweight nature of Kotlin and other feature has indeed enhance the Android API development eliminating this Java setback. Secondly

the conciseness of Kotlin code eliminate the bulky nature of Java code that creates more bug in the program and make it difficult to read. This is one area that Kotlin has come to the rescue of Java developer as codes can now be written in a more direct and concise way eliminating this program development bottlenecks [24]. The code snippets below show a simple calculation program written in Java and Kotlin to carry out the same function:

Java code for calculating using Case Statement

```
public class ClearBridge {

public static double calculate (double a, String op, double b) throws Exception {

    switch (op) {
        case "add" :
                return a + b;
        case "subtract" :
                return a - b;
        case "multiply" :
                return a * b;
        case "divide" :
                return a / b;
        default:
                throw new Exception();
        }
    }
}
```

Kotlin code for solving the same calculation problem

```
fun calculate (a: Double, op: String, b: Double): Double {
    when (op) {
            "add" -> return a + b
            "subtract" -> return a - b
            "multiply" -> return a * b
            "divide" -> return a / b
            else -> throw Exception()
    }
}
```

From the code snippet we the conciseness of the Kotlin is such that if bugs are discovered it is easy to resolve while it could take much longer time to discover and resolve same in Java. This reduces time and boost the morale of development team.

Table 1: Comparison between Java and Kotlin

The Basis of Comparison	JAVA	KOTLIN
Null Safe	NullPointerExceptions is one of the major limitations of Java program as it permits developer to allot null variables and these can cause null pointer exception when accessing a referenced object that has a null value which a user must necessarily manage	Kotlin by default does not allow for the assignment of null values to any object or variable, here all variables are non-null in other word a null value will cause a system failure for Kotlin at compile time but the only way to implement a null variable is to declare it as: value num: Int?=null
Extension Function	Java does not have Extension function. Therefore to create extension function, a new class must be created to inherit a parent class to be able to extend the functionality of an existing Java class	Kotlin offers Extension function to users whereby an existing class can be extended with new functionalities by using the prefix of a class name to a new function name
Coroutine Support	Since by default Android is single threaded and Java is a multithread programming language it provides the ability to create a multithread to manage complex tasks for the android application at the background for CPU intensive operations.	Kotlin can create multithreads processes and provides coroutine support for long-running intensive operations which can suspend the execution of specific threads without inhibiting the thread as it execute CPU intensive operations
No check Exception	Java uses check exceptions to enable developers to declare and catch	In Kotlin there is no need to declare or catch exception because it does not have checked exceptions

	exceptions leading to robust codes good error handling.	
Data Classes	If we need a class to hold only data in Java, there is need to define the constructors, variables to store data, getter and setter methods, hashcode(), toString(), and equals() functions	In Kotlin, the compiler automatically creates constructors, getters and setter methods for field in the program if and when a Class is declared with the keyword "data" in the class definition.
Smart cast	Casting in Java is dependent on the variable type and the operation to be performed.	Kotlin handles smart cast with keywords which verifies absolute values and performs casting implicitly. The key word is "is-checks"
Type inference	Variable declaration is compulsory in Java as it is used to specify the type of each variable to be used in the program	It is not compulsory to specify a variable type to be used in Kotlin, but the developer are free to do so if they so desires.
Functional Programming	Functional programming is not supported in Java as it object oriented in nature but Java 8 have some subset of functional programming required for Android development	Kotlin is a combination of procedural and functional programming paradigm comprising of several useful methods and tools like lambda, operator overload, lazy evaluation, higher-order functions and more.

The table above reviews some of the notable comparisons of Java and Kotlin and how these programming languages have improved mobile application development with enhanced products that cuts across different spheres of human endeavour. Furthermore android application developed in Kotlin avails the developer of a number of features that enhances the programming experience and reduce the lengthy Java codes to the barest minimum.

CONCLUSION

The evolution in mobile application development has indeed enhance communication in voice and data compared to what was obtainable two decades ago, thanks to the emergence of programming languages that has brought about great ease in personal and commercial telephony. Mobile applications have been deployed in healthcare delivery services, banking operation, business, education, governance, research and development with apps that provides accurate and real-time analysis of events. Android application are everywhere today and their impact are astronomical therefore application development with enhance programming tool like Kotlin will not only boost the developers morale but will create sustainable application that meets user requirement in lesser time with more improved features unlike Java. Kotlin has come to stay as a reliable substitute and for Java in mobile application development to meet the ever growing android application users across the globe.

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