BRNO UNIVERSITY OF TECHNOLOGY
VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ

FACULTY OF ELECTRICAL ENGINEERING AND COMMUNICATION
FAKULTA ELEKTROTECHNIKY
A KOMUNIKAČNÍCH TECHNOLOGIÍ

DEPARTMENT OF FOREIGN LANGUAGES
ÚSTAV JAZYKŮ

Android vs iOS: A Comparative Study
Android vs iOS: srovnávací studie

BACHELOR'S THESIS
BAKALÁŘSKÁ PRÁCE

AUTHOR Faruk Pršeš
AUTOR PRÁCE

SUPERVISOR Mgr. Ing. Eva Ellederová
VEDOUCÍ PRÁCE

BRNO 2020

VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ

FAKULTA ELEKTROTECHNIKY A KOMUNIKAČNÍCH TECHNOLOGIÍ

Bakalářská práce

bakalářský studijní obor **Angličtina v elektrotechnice a informatice**

Ústav jazyků

Student: Faruk Pršeš   *ID:* 195246
Ročník: 3   *Akademický rok:* 2019/20

NÁZEV TÉMATU:

Android vs iOS: srovnávací studie

POKYNY PRO VYPRACOVÁNÍ:

Popište a srovnejte různé vlastnosti mobilních operačních systému Android a iOS. Zvažte výhody a nevýhody obou operačních systémů a navrhněte budoucí trendy v jejich využití.

DOPORUČENÁ LITERATURA:

1) Hoog, A. (2011). Android forensics: Investigation, analysis and mobile security for Google Android. Amsterdam: Elsevier.

2) Matthew, D. (2011). Flash mobile: Developing Android and iOS applications. Oxford: Focal Press.

3) Iversen, J., & Eierman, M. (2013). Learning mobile app development: A hands-on guide to building apps with iOS and Android. Boston: Addison-Wesley.

Termín zadání: 6.2.2020   *Termín odevzdání:* 12.6.2020

Vedoucí práce: Mgr. Ing. Eva Ellederová

doc. PhDr. Milena Krhutová, Ph.D.
předseda oborové rady

Abstract

This bachelor's thesis compares two most popular operating systems in a modern smartphone age. iOS and Android are well known for their rivalry. Therefore, the aim of this thesis is to provide a detailed analysis of these two operating systems and to discuss their advantages and disadvantages. The first part of this work frames the concept of mobile/smartphone operating systems and traces the historical development of the smartphone operating systems. Afterwards, it moves on to the history of Apple and Google systems and compares their origin, features, user-interface, hardware requirements, application development and, in general, their way to become the most stable and popular smartphone systems in the world. The second part of this work is focused on analysing survey results. The goal of the survey was to compare preferences of Android and iOS users.

Key words

iOS, Android, smartphones, iPhone, Apple, Google, updates, hardware, software, comparison, applications, Samsung, survey

Abstrakt

Tato bakalářská práce srovnává dva nejpopulárnější operační systémy v moderní době chytrých telefonů. iOS a Android jsou operační systémy známé pro svoji rivalitu. Cílem této práce tedy je poskytnout detailní analýzu těchto dvou operačních systémů a diskutovat jejich výhody a nevýhody. Práce nejdříve vymezuje samotný koncept mobilních operačních systémů a seznámí čtenáře s historickým vývojem operačních systémů chytrých telefonů. Poté se zaměří na historii operačních systémů společností Apple a Google a srovná jejich původ, funkce, uživatelské rozhraní, hardwarové požadavky, vývoj aplikací a jejich obecnou cestu k tomu, aby se staly nejstabilnějšími a nejpopulárnějšími operační systémy chytrých telefonů na světě. Praktická část práce je převážně zaměřena na rozbor výsledků dotazníku. Hlavním cílem tohoto dotazníku bylo porovnat preference uživatelů Android a iOS.

Klíčová slova

iOS, Android, chytrý telefon, iPhone, Apple, Google, aktualizace, hardware, software, srovnání, aplikace, Samsung, dotazník

Rozšířený abstrakt

Bakalářská práce *Android vs iOS: A Comparative Study* srovnává dva nejpopulárnější operační systémy v moderní době chytrých telefonů. Cílem této práce je vymezit koncept mobilních operačních systémů, srovnat mobilní OS Android a Apple, seznámit čtenáře s historii těchto dvou systémů a jejích vývojem. Bakalářská práce je rozdělena na dvě hlavní části, teoretickou a praktickou. Cílem teoretické části je porovnat tyto operační systémy z hlediska technických specifikací, poskytnout historické pozadí Androidu a iOS a podrobně oba systémy srovnat z teoretické stránky. Dále se zde čtenář dozví, proč právě tyto dva OS jsou těmi nejlepšími, nejstabilnějšími a nejpopulárnějšími na celém světě. Cílem praktické části je analyzovat odpovědi z dotazníku a zjistit na základě čeho respondenti preferují Android anebo iOS.

Práce začíná krátkým úvodem do řešené problematiky včetně motivačních faktorů, které mě vedly k výběru tohoto tématu. Teoretická část je rozdělena na čtyři hlavní kapitoly. První kapitola vymezuje samotný koncept mobilních operačních systémů. Dále jsou zde detailně představeny oba již zmíněné operační systémy – Android a iOS. Druhá kapitola je zaměřena na popis funkcí Androidu a iOS na základě hlavních aktualizací těchto operačních systémů. Další kapitola je poté zaměřena na hardwarové srovnání těchto operačních systémů. Apple používá vlastní A13 procesor, zatímco Android spoléhá na procesor vyrobený firmou Qualcomm. Tyto procesory jsou detailně porovnány v tabulkách. Dále se v této kapitole čtenář dostane ke srovnání dvou nejlepších chytrých telefonů, které tyto čipy mají. Poslední kapitola teoretické části se zabývá rozdílným vývojem aplikací pro Android a iOS. Čtenář se zde dozví, co je potřeba udělat při vývoji aplikace pro iOS a co pro Android.

Praktická část práce je zaměřená na analýzu a interpretaci výsledků dotazníkového šetření, ve kterém jsem se pokusil pokládat otázky, které odhalí, z jakých důvodů se respondenti rozhodli používat Android a z jakých naopak iOS. Výsledky zobrazené v grafech jsou následně okomentovány a diskutovány včetně zdůvodnění různých trendů u každého z analyzovaných operačních systémů.

PRŠEŠ, Faruk. (2020). *Android vs OS: srovnávací studie*. Brno: Vysoké učení technické v Brně, Fakulta elektrotechniky a komunikačních technologií. 50 s.
Vedoucí bakalářské práce: Mgr. Ing. Eva Ellederová.

Prohlášení

Prohlašuji, že bakalářskou práci na téma *Android vs iOS: srovnávací studie* jsem vypracoval samostatně pod vedením vedoucí bakalářské práce a s použitím odborné literatury a dalších informačních zdrojů, které jsou všechny citovány v práci a uvedeny v seznamu literatury na konci práce.

Jako autor uvedené bakalářské práce dále prohlašuji, že v souvislosti s vytvořením této práce jsem neporušil autorská práva třetích osob, zejména jsem nezasáhl nedovoleným způsobem do cizích autorských práv osobnostních a/nebo majetkových a jsem si plně vědom následků porušení ustanovení § 11 a následujících zákona č. 121/2000 Sb., o právu autorském, o právech souvisejících s právem autorským a o změně některých zákonů (autorský zákon), ve znění pozdějších předpisů, včetně možných trestněprávních důsledků vyplývajících z ustanovení části druhé, hlavy VI. díl 4 Trestního zákoníku č. 40/2009 Sb.

V Brně dne ....

Faruk Pršeš

Acknowledgements

I wish to express my sincere gratitude to my thesis supervisor Mgr. Ing. Eva Ellederová for providing me with all the necessary consultations and for her valuable guidance and encouragement extended to me during the preparation of my bachelor's thesis. This accomplishment would not have ever been possible without her.

Table of Contents

Introduction

Mobile phones are a very trendy topic nowadays and it is arguably one of the most used and fast developing technological inventions. With the rapid growth and success of mobile phones, we have been slowly introduced to smartphones, the modern era mobile phones, which use combination of powerful processors and artificial intelligence to compute all sorts of complicated tasks. However, all of this would be useless if it were not for the operating systems that these smartphones use together with its computational power. Two such systems are Android and iOS. This bachelor's thesis will review both operating systems thoroughly and compare them to each other from a historic perspective as well as a hardware and software perspective in four chapters of the theoretical part followed by the quantitative research focused on the mobile users' preferences.

The thesis consists of a theoretical part and a practical part. Firstly, it explains how smartphone operating systems are different from the basic computer operating systems (henceforth OS) and what smartphone OS concept is. The reason for cell phones and PDAs descent is explained with statistical facts and two most popular operating systems are introduced. Then, both operating systems are thoroughly introduced to the reader. The reader gets to know how each system works and history of each system.

Comparison of both operating systems is available in terms of their programming language, history, and major updates. Next, features of both operating systems are analysed and compared to each other. Both operating systems are analysed from its very first version to the most recent one. The reader can easily tell which features one system lacked while the other was faster to adapt to changes in technology and vice versa. In the final two chapters of the theoretical part, both operating systems are compared from a hardware perspective. Then, the application development for both Android and iOS is analysed and described.

In the practical part of this thesis, I will analyse all results from the questionnaire survey, in which I tried to find out why people prefer either Android or iOS, what they would change on directly competing OS and what their previous experience with Android/iOS was like.

The goal of this thesis is to familiarize the reader with different characteristics of both operating systems and possibly help the reader decide which one suits them better between

the two. This was also one of the main reasons I chose this topic. This paper is not supposed to decide which operating system is overall better, it only serves as a pure comparison between two best operating systems available on the market at the moment.

1 Concept of Smartphone Operating Systems

It is astonishing to realize how important operating systems are to computers. According to Jipping (2007), operating systems support access and innovation; they allow the complicated internal processes to be handled at ease. An operating system is a software program. It does not matter where it is stored (on a hard drive, a compact flash storage, or ROM) because it eventually loads into computer memory and executes instructions just like any other software program. The need for a pocketable OS was inevitable. Therefore, the major phone manufacturers started to develop mobile operating systems.

A mobile OS is an operating system that is made to run on mobile devices such as cell phones, PDAs, smartphones, tablet computers, smartwatches, and many other handheld devices. However, nowadays cell phones and PDAs are not very popular because of the increasing popularity of smartphones and wearables[1]. Due to this trend of smartphones becoming popular, old ordinary cell phones and PDAs have been left behind and made obsolete. For instance, the report from the Pew Research Center (2019) claims that only 15 % of US residents own a cell phone but not a smartphone, while 81 % of them own a smartphone. With this huge growth of smartphone industry, manufacturers had to figure out what mobile OS their device would run on.

There are many types of smartphone operating systems – some are already discontinued like Windows Phone and some belong among the most popular smartphone OSs like Android or iOS (formerly iPhone OS) and are still actively used.

---

[1] Wearables are electronic technology or devices, such as smart watches, fitness trackers, smart jewellery, and smart clothing, incorporated into items that can be comfortably worn on the human body. They are used for tracking information on real time basis due to motion sensors that synchronize a person's activity with mobile devices or computers. (Happiest Minds, n.d.)

1.1 Android OS

Android is a mobile OS developed by Google after Android Inc. was bought by Google in 2005. It is based on a version of Linux kernel and other open source software[2] and is made mainly for touchscreen mobile devices like tablet computers and smartphones. It is written in Java (UI), C (core), C++ and some other programming languages (Team AA, 2019, December 3). Unlike the other mobile OSs, Android is known for being very customizable since it is based on open source software. This means that not only the user can customize this OS but also developers and smartphone manufacturers can make their very own version of the Android user interface (UI) for their smartphone. Android is very often associated with proprietary software made by Google that is known as Google Mobile Services (GMS). These services usually come pre-installed on Android running devices and they include core applications, such as Gmail, the application store called Google Play and usually Google Chrome web browser and Google Search application (Android, n.d.).

1.1.1 History of Android OS

In October 2003, the company Android Inc. was founded in Palo Alto, California. There were four founders – Chris White, Rich Miner, Nick Sears, and Andy Rubin. At the time of public founding of Android Inc, Rubin believed that Android Inc would make smarter mobile devices that are more aware of its owner's location and preferences (Callaham, 2019, August 18).

This seems to be a perfect description for smartphones nowadays. Even though Android is a mobile OS today, its purpose was supposed to be different in the beginning. According to PCWorld (Alabaster, 2013, April 16), in 2013 Rubin revealed on stage during his speech in Tokyo that the Android OS was originally developed to improve an OS in digital cameras. It seems that the founders of Android Inc. initially did not think that their OS would be used in smartphones but due to the rapid decline of digital cameras back then, Android Inc. decided to change its direction and started to focus on using their OS inside mobile phones. Rubin (as cited by Alabaster, 2013, April 16) also adds, "the exact same platform, the exact same operating system we built for cameras, that became Android for cell phones".

---

[2] Open source software is software with source code that anyone can inspect, modify, and enhance. (Opensource.com, n.d.)

In 2005, the original company (Android Inc.) was acquired by Google, which was a big breakthrough in Android's history (Callaham, 2018, July 11). The founding members continued developing their OS under their new owner, Google. Eventually Google and Rubin's team decided to base Android on Linux kernel, which also meant that they would have to offer their OS to the third-party manufacturers for free. However, that is when the original creators and Google felt they could make money and profit from offering services and applications that used the OS.

In 2019, an updated Android logo was launched (see Figure 1). The logo had undergone the three major changes, in the font, colour and shapes of the Bugdroid mark. The word "Bugdroid" refers to the Android mascot. According to Hill (2018, October 31) the original Bugdroid Android logo was created by Irina Blok, a Silicon Valley-based designer working for Google, whose idea was to create an open source logo for the developer community.

Figure 1. Android logo since 2019. Reprinted from https://www.android.com/.

1.1.2 Major Versions of Android OS

The beginning of the Android version history dates all the way back to November 5, 2007 when the first Android beta was released to the public. The very first official release of Android was on September 23, 2008. Since its initial launch Android has been gradually developed by Google and has seen many updates to its operating system.

There has been over 25 updates to Android over the years, but Table 1 provides only major updates to Android and some key features of each update.

Table 1. *A brief survey of major versions of Android OS.*

Name and version	Release date	Key features
Android 1.0	September 23,2008	• Android Market allowed application downloads and updates through the Market application • Camera support • Wi-Fi and Bluetooth support • Instant messaging, text messaging and MMS
Android 1.5 Cupcake	April 27, 2009	• Video recording and playback in MPEG-4 and 3GP formats • Auto-rotation option
Android 2.0 Éclair	October 26, 2009	• Bluetooth 2.1 support • Numerous new camera features • Ability to tap a Contacts photo and select to call, SMS, or email the person
Android 3.0 Honeycomb	February 22, 2011	• Optimized tablet support with a new "holographic" user interface • Hardware acceleration • Support for multi-core processors
Android 4.0 Ice Cream Sandwich	October 18, 2011	• Face Unlock – a feature that allows users to unlock handsets using facial recognition software • 1080p video recording for stock Android devices • Improved camera application
Android 5.0 Lollipop	November 12, 2014	• Support for 64-bit CPUs • Refreshed lock screen, no supporting widgets • Refreshed notification tray and quick settings pull-down
Android 6.0 Marshmallow	October 5, 2015	• App Standby feature • USB-C support • 4K display mode for apps • Native fingerprint reader support • Experimental multi-window feature
Android 7.0 Nougat	August 22, 2016	• Support for file-based encryption • Multi-window support, which supports floating apps on a desktop layout • New Data Saver mode, which can force apps to reduce bandwidth usage
8.0 Oreo	August 21, 2017	• Picture-in-picture support • Notification improvements • Downloadable fonts • Wi-Fi Assistant
9.0 Pie	August 6, 2018	• New user interface for quick settings menu • Support for display cut-outs • Battery percentage now shown in Always-On-Display • A new "Lockdown" mode which disables biometric authentication once activated
Android 10	September 3, 2019	• Support for WPA3 Wi-Fi security protocol • Support for foldable phones • Better support for biometric authentication in apps • Dynamic depth format for photos, which allow changing background blur after taking a photo

Note: Adapted from https://www.androidauthority.com.

10

1.2 iOS

iOS is a mobile OS created and developed by Apple Inc. This operating system is exclusively made only for products released and made by Apple. There are many devices running iOS such as iPhone, iPod Touch and iPad (prior to 2019 – introduction of iPadOS). iOS is the second most popular mobile operating system in the world right after Android. It is written in C, C++, Objective C and Swift. iOS is a very closed operating system (Computer Business Review, n.d.). Unlike Android users, iOS users are very limited about what is customizable and changeable. Its market for applications is called the iOS App Store.

1.2.1 History of iOS

iOS was unveiled along with iPhone at the Macworld Conference and Expo on January 9, 2007 (Clover, 2020, January 9). It was later released in June of the same year. When iPhone was about to be released, the name of Apple's OS was iPhone OS (Royal, 2017, January 13). It was not until 4th version of Apple's OS in 2010 when Apple finally dropped "iPhone" from the name and went with simple "iOS" – at that time it was iOS 4.

Silver (2018, July 5) points out that in the first version of iOS, third-party native applications were not supported because of the missing App Store. However, later Apple announced iPhone SDK on March 6, 2008 (Krazit, 2008, March 12). The iOS App Store was introduced to the world on July 10, 2008 (the day before the iPhone 3G was released) with 500 applications available at launch. This very quickly grew over the years and as of the end of 2018 there are 2 million apps available on the App Store (Silver, 2018, July 5).

According to 1000logos (n.d.), the iOS visual identity was redesigned almost every year with new system update to iOS. The one shown below (see Figure 2) is from 2013 and it remained almost the same till today with only some minor changes applied to it. In this logo, in 2013 Apple started using Myriad font to make it thin and elegant.

Figure 2. iOS logo since 2013-today. Reprinted from
https://worldvectorlogo.com/logo/apple-ios

1.2.2 Major Versions of iOS

Major new iOS releases are always announced at the annual Apple Worldwide Developers Conference (WWDC) and are usually released in September of the same year. Updates for iOS are released through the iTunes software and, since iOS 5, via over-the-air software updates – enables the user to update using only Wi-Fi connection and the user's iOS device. In Table 2, you will find only major updates to iOS and some key features of each update.

Table 2. *A brief survey of major versions of iOS.*

Name and version	Release date	Key features
iPhone OS 1	June 29, 2007	- Phone: Call people, add people to favourites, group chat - Switch between EDGE and Wi-Fi - Apps like Texting, Photos, Safari, Mail, Maps, Stocks, Weather - iPod: Create playlists, listen to songs etc.
iPhone OS 2	July 11, 2008	- Added language support - Ability to import to SIM contacts - App Store - Ability to turn on and off location services
iPhone OS 3	June 17, 2009	- Ability to cut, copy and paste added - Video recording in Camera app - SMS applications renamed to Messages - Right to left support
iOS 4	June 21, 2010	- Multitasking - Camera supports up to 5x digital zoom - Tap to focus during video - Cellular data toggle (on or off)
iOS 5	October 12, 2011	- Notification Center - iMessage introduced - Siri voice control (personal assistant) - iTunes/USB no longer needed to activate device - PC-Free
iOS 6	September 19, 2012	- Siri available on iPad - Music app gets a new UI - Added a "Do Not Disturb" mode - Maps are Apple-sourced instead of using Google sources - App Store and iTunes get a new UI
iOS 7	September 18, 2013	- Brand new UI design "New" banner on newly installed apps have been replaced with blue dots - Control center - AirDrop – integration of Apple's ad-hoc Wi-Fi sharing feature
iOS 8	September 17, 2014	- iCloud (iCloud library and iCloud drive) - UI Changes in Control Center - When plugged into power the user can say "Hey, Siri" and Siri will be automatically activated - Wi-Fi calling
iOS 9	September 16, 2015	- Carplay support - Added video recording settings - New Wallet app replacing Passbook

iOS 10	September 13, 2016	• New sounds (locking device, keyboard clicks) • Lock screen features – swipe left to open camera, swipe right for Today view, press home button to unlock device
iOS 11	September 19, 2017	• ARKit (Augmented Reality kit) • Do Not Disturb While Driving • Brand new Control Center
iOS 12	September 17, 2018	• The new app Measure – using ARKit 2.0 • Screen Time feature • Battery Health finally out of beta testing • Battery Statistics Chart
iOS 13	September 19, 2019	• Dark Mode – when enabled the UI, native apps and supported third-party apps go darker • Apps launch up to twice as fast as on iOS 12 • Face ID is up to 30% faster • Introduction of Apple Arcade – a gaming subscription service by Apple

Note: Adapted from www.lifewire.com.

1.3 Goal of Smartphone Operating Systems

The whole purpose of a smartphone OS is to make working with one's mobile device possible and easier. When one starts up a mobile device, a screen of icons or tiles can be seen. They are placed there by the operating system. Without an OS, the device would not even start.

According to Viswanathan (2019, April 20), the mobile operating system is a set of data and programs that runs on a mobile device. It manages the hardware and makes it possible for smartphones, tablets, and wearables to run apps. It also manages mobile multimedia functions, mobile and internet connectivity, the touch screen, Bluetooth connectivity, GPS navigation, cameras, speech recognition, and many more features of each smartphone.

This definition sums up the purpose of smartphone operating systems perfectly. In order to use a smartphone, work with it, watch a movie on it, play games on it, surf the web, we need a suitable operating system for it. Otherwise, the mobile device is useless without OS.

2 Features of Android and iOS

To understand what a mobile feature means, firstly, one needs to understand what exactly a feature is. The definition of the word "feature" is as follows: a typical quality or an important part of something (Cambridge Dictionary, n.d.). Therefore, a mobile feature is a specific function, quality, and capability that a given phone has.

Android and iOS have been fighting for years to surpass each other in the category of features. For this reason, this chapter focuses on a feature comparison between Android and iOS.

2.1 Android Features

From its initial release up to the present day, Android has transformed visually, conceptually, and functionally. The following subchapter 3.1.1, describes the features introduced to Android from the very beginning (Android 1.0) to the most recent ones implemented in Android 10. Only major updates will be covered.

2.1.1 Features Sorted by an Update Version

Android 1.0 made its official public debut in 2008. This release of Android did not even have its own codename, just a version number. It came with multiple Google apps such as Gmail, Maps, Calendar, and YouTube; all of which were already implemented into the operating system (Raphael, 2019, September 13). It came with a camera, Bluetooth, and Wi-Fi support. It also enabled users to use instant messaging via SMS and MMS. Users could also download an application and application updates from Android Market (something that iOS lacked in its initial release).

Later in 2009, Android 1.5 was released with its first codename "Cupcake". This is the first time Android introduced codenames for each update of its OS. It enabled users to use Auto-rotation option. Users could also use video-recording and play videos in MPEG-4 and 3GP formats for the first time. Cupcake introduced plenty of refinements to the interface. An example of such an interface change was the first on-screen keyboard; a feature that would be necessary as smartphones moved away from the physical keyboards (Raphael, 2019, September 13).

The next version was Android 2.0 Eclair. It was a very simple release. It came with Bluetooth 2.1 support, many new camera features, a speech-to-text mechanism, and ground-breaking addition of voice-guided turn-by-turn navigation and real-time traffic information (Raphael, 2019, September 13).

Android 3.0 Honeycomb (released in 2011) came with an optimized user interface for Android tablets. It was a tablet-only release to support the launch of the Motorola Xoom tablet (Raphael, 2019, September 13). It also came with support for multi-core processors as those were necessary for tablets to run smoothly. Throughout update versions 3.1 and 3.2, Honeycomb remained a tablet-exclusive update.

Android 4.0 was named "Ice Cream Sandwich" and it entered the era of modern design in mobile OS. The release refined the Honeycomb visual concept and it brought together tablets and phones with a unified user-interface (Raphael, 2019, September 13). Once again, the 4.0 release added new camera features. It started to support Face Unlock which enabled users to unlock the phone using facial recognition software, 1080p video-recording for stock Android devices.

Android 5.0, codenamed Lollipop, once again reinvented Android in the autumn of 2014. Android brought support for 64- bit CPUs, revamped the lock screen and notification screen. It also introduced hands-free voice control via voice command "OK, Google" which enabled the user to assign a task to the OS and a few seconds later it would give them the result. For example, being given the command "OK, Google, open Gmail," Android proceeds and opens the Gmail app for the user, or another command "OK, Google, show me my calendar" results in opening the calendar app (Cipriani, 2016, July 1). Unfortunately, with all these new features, it also introduced many software bugs[3] which had not been ironed out until the next release of Android (5.1) (Raphael, 2019, September 13).

2015's Android 6.0 release named Marshmallow turned out to be a minor update in terms of features over the last year's Android 5.0 Lollipop release. It brought fingerprint reader support, USB-C support. Probably the most notable feature in Marshmallow was the fact that the user could search for anything online right on the home screen by tapping on "Google

---

[3]   A software bug is a problem causing a program to crash or produce invalid output. A bug can be an error, mistake, defect, or fault, which may cause failure or deviation from expected results. (Techopedia, n.d.)

Now on Tap" and afterwards typing/speaking (Cervantes, 2017, June 14). Unfortunately, Google never perfected the feature and it ended up quietly abandoning the feature in years to come (Raphael, 2019, September 13).

Google's 2016 Android 7.0 Nougat release provided Android with a native split-screen mode, a brand-new Data Saver feature, and Google Assistant (Raphael, 2019, September 13). A split-screen mode enabled the user to have more apps on the screen and hence provided them with better multitasking capabilities. The Data Saver feature (when enabled) saved data to browse the Internet provided by a carrier. However, the most pivotal feature of Nougat was the implementation of Google Assistant. It offered voice commands, voice searching, and voice-activated device control which let users complete a number of tasks after they said "OK, Google" or "Hey, Google" wake words (Tillman & O'Boyle, 2019, October 8). It is designed to give you conversational interactions. The Google Assistant would go on to become a critical component of both Android and most other Google products.

Android 8.0 Oreo was released in March 2017 and brought some refinements and adjustments considering Wi-Fi, notification settings. Now, the user could snooze notifications. It also introduced the all new Picture-in-Picture (PiP), new autofill APIs for better management of passwords and fill data. Android Oreo is available to download via Google's Android Open Source Project. It is also downloadable as an over-the-air update for Google's older Nexus and Pixel devices (Callaham, 2019, August 18).

Google's Android 9.0 Pie included new features made to preserve and extend smartphone's battery life. It used its artificial intelligence (AI) and machine learning to find out which apps you are more prone to using at a certain time of the day. It also comes with a feature called Shush; the feature that automatically puts the user's phone in Do Not Disturb mode as soon as they place the smartphone screen-down on a flat surface (Callaham, 2019, August 18).

Google released Android 10 in 2019, September. It is the first Android that does not have any dessert name as its codename. It completely revamped the user-interface by relying only on a swiping mechanism (Android gestures) to get around the system (Raphael, 2019, September 13). It also came with support for biometric authentication in applications, and support for foldable phones; a new piece of technology coming into the smartphone industry.

2.2 iOS Features

Apple's OS has always been known for its simplicity and easy-to-use interface ever since iPhone OS 1. While its grid-like home screen has not changed much in terms of interface, iOS as a whole has changed in functionality a lot, especially when it comes to features. Below in subchapter 3.2.1, one will be familiarized with history and features of each major version of the iOS.

2.2.1 Features Sorted by an Update Version

iPhone OS 1 (released in 2007) was the very first version of Apple's OS. It came pre-installed on the original iPhone. While majority knows this operating system as iOS, from versions 1 to 3 it was called iPhone OS. iPhone OS 1 was a truly remarkable breakthrough in mobile operating systems. It provided features such as a multitouch screen, Visual Voicemail, iTunes integration, Music app, and Safari browser (Costello, 2019, November 12).

One year later, Apple released iPhone OS 2 which brought some refinements of the first version. It was released together with the iPhone 3G. The biggest change/feature in this version of iOS was added support for App Store. This virtual market enabled users to download any applications out of 500 available at launch (Costello, 2020, January 10).

2009's release of iPhone OS came together with the release of iPhone 3GS.The third version of iPhone OS introduced new basic features such as copy and paste, Spotlight search, MMS support in the Messages app, and users were for the first time able to record video using the Camera app (Costello, 2019, November 12).

The fourth edition of iOS was the first one to finally officially get rid of the long naming "iPhone OS" and go with the simple "iOS 4". The concept for modern iOS was set in iOS 4. The features that are nowadays extensively used, once debuted in iOS 4 and in its various versions (iOS 4.x.x). The popular features were FaceTime, AirPlay, AirPrint, multitasking, and application management on the home screen (Costello, 2019, November 12).

iOS 5 was released in 2011 and it was the update that finally brought wireless capabilities to iPhone such as being able to update iPhone via over-the-air, and iCloud storage. Features

such as iMessage, Notification Centre, and personal assistant Siri were added in this edition of iOS (Costello, 2019, November 12). Apple's personal assistant was very important for iOS and its further development as Apple tried to enhance Siri's AI with every iOS release ever since.

iOS 6 was quite a hard time for Apple as it faced difficulties because of the removal of native pre-installed Google Maps and YouTube applications. Apple released their own Apple Maps which had a horrible start due to plenty software bugs present in the beginning (Costello, 2019, November 12). The other new features were Do Not Disturb mode, or Passbook (nowadays called Wallet) which enabled the user to save plane tickets or hotel reservation right into iPhone and use it as authentication later at the airport or hotel.

iOS 7 was the very first edition of iOS that brought a huge design and user-interface overhaul to make it look more modern. It was the first iOS that was designed by Jony Ive, Apple's head of design. Touch ID was one of the most interesting features of iOS 7. It enabled users to unlock their iPhone with their fingerprint. The other important features were AirDrop and CarPlay support (Costello, 2019, November 12).

While iOS 7 had brought the biggest visual overhaul since iPhone OS 1, iOS 8 was mainly focused on refining the established design from iOS 7. Apple focused on improving workflow and adding a large number of new tools for developers to make their apps run even smoother and better than ever before (The Verge, 2013, September 16). It also brought many new exciting features such as Apple Music, Apple Pay, Wi-Fi calling, Hey Siri, and others (Costello, 2019, November 12).

iOS 9 was released in 2015 and it brought major refinements and improvements in stability and speed. For the first time ever, users were able to participate in Public Beta Program which enabled users to test Apple's newest and greatest creation before the final public release. iOS 9 also introduced Low Power mode which helped preserve a battery when the user felt it was draining fast. Another new feature was Night Shift which changed the colour of the display to the warmer one at night, hence giving less harm to a human eye (Costello, 2019, November 12).

iOS 10 was released in 2016. It was a summarization of the best features of an iPhone

brought to perfection. Moreover, iOS 10 enabled Siri (personal assistant) to have access to third-party applications and work with the information received from them. iMessage received a third-party application support. The user was also finally able to remove pre-installed applications such as Music app, Stocks app, Compass, and many more (Costello, 2019, November 12).

2017's iOS 11 was mainly focused on iPads (tablets produced by Apple). It did contain several new features for iPhone such as Do Not Disturb While Driving, a brand-new Notification Centre and Augmented Reality kit (AR kit). However, iPad received a lot more improvements such as drag and drop support, a file browser app, split screen support, and Apple Pencil support (Costello, 2019, November 12).

iOS 12's key features were improvements to Siri, a brand-new version of Augmented Reality (AR Kit 2), and a way to monitor user's activity on iPhone and iPad using Screen Time in the Settings app (Costello, 2019, November 12). Users were also given a battery statistics chart and a battery health category which helped users to understand how their battery aged. Apple explained to users that batteries are, just like any other rechargeable battery, consumable components that become less effective as they age (Apple, n.d.).

Finally, iOS 13 was released in 2019. It was a very important update to an iOS because of the fact that iPad stopped running on iOS and it got separated into running its own brand-new operating system called iPadOS, beginning from version 13 (just like iOS 13). Due to this update to iPad, it became clear that Apple is trying to make iPad a perfect laptop replacement. Going back to iOS 13, it introduces many new features such as being able to unlock iPhone 30% faster with Face ID, apps launching twice as fast as on iOS 12, and visual overhaul of Stocks app, Remainders app, Notes app (Costello, 2019, November 12). The main feature of iOS 13 was the newly introduced system-wide Dark mode which enabled users to set all screens, menus, views, and controls to a darker palette. Dark mode perfectly utilizes the Super Retina XDR display (OLED[4] panel) which helps save the battery since it does light up every pixel of the display individually. For this reason, pixels stay turned off on every black surface displayed on iPhone.

---

[4] OLED (Organic Light Emitting Diode) is a flat light emitting technology, made by placing a series of organic thin films between two conductors. When electrical current is applied, a bright light is emitted. (OLED-info, 2019, March 28)

3 Latest Hardware Comparison

While the newest high-end Android processor is very powerful, chips located in the newest iOS devices are even better at executing all sorts of tasks (McKane, 2017, July 2).

Android's best processor chip available at the time of writing this thesis is Snapdragon 865 chipset. It is manufactured by company called Qualcomm and comes with 5G capabilities. It was unveiled at its annual Snapdragon Tech Summit in Hawaii late last year. Majority of the new 2020 Android phones is expected to have this processor. Snapdragon 865's features are mainly focused on 5G connectivity speeds, doubling down gaming performance, and improving photo and video quality through computational power available in this chip (Swider & Knapp, 2020, February 25).

iOS's best chip available at the time of writing this thesis is called A13 Bionic. It is manufactured by Apple and can be currently found only in following Apple smartphones: iPhone 11, iPhone 11 Pro, iPhone 11 Pro Max and iPhone SE2 (Wikichip, n.d.). The A13 chip easily outperforms last year's A12 processor also manufactured by Apple. It is estimated that A13 Bionic has 20% performance gain over the A12. The A13 has six CPU cores, a graphics processor and the neural engine. For a processor on already a very high-performing level, it is unbelievable to see another performance boost in A13 Bionic chip. To compare these figures to a real-life example, it is like watching the fastest athlete beat himself in a sprint (Malik, 2019, September 19).

In Table 3, you will find benchmark comparison between Android's Snapdragon 865 and Apple's A13 Bionic tested through popular Geekbench 5 application. Geekbench 5 application stresses only the central processing unit, abbreviated CPU (UserBenchmark, n.d.).

Table 3. *Geekbench 5 benchmark comparison between Snapdragon 865 and A13 Bionic*

Processor	Single-Core performance	Multi-Core performance
Snapdragon 865	932	3513
A13 Bionic	1335	3530

Note: Adapted from https://nanoreview.net/.

As can be read from Table 3, A13 Bionic outperforms Snapdragon 865 by approximately 43 % in Single-Core performance. When it comes to Multi-Core performance, both processors have about the same amount of computational power. These numbers clearly show that A13 Bionic processor is a more powerful chip regarding a processor's power (Nanoreview, n.d.).

The next test is performed through AnTuTu Benchmark 8 application. This application computes the user experience score (UX), random access memory score (RAM), central processing unit score (CPU), graphics processing unit score (GPU) and input/output score (IO) all together and the final result gives the overall score (Hoffman, 2014, June 6). Unlike Geekbench 5 application, AnTuTu stresses more components to get the overall score.

In Table 4, you will find benchmark comparison between Android's Snapdragon 865 and Apple's A13 Bionic chip tested through popular AnTuTu Benchmark 8 application.

Table 4. *AnTuTu Benchmark 8 comparison between Snapdragon 865 and A13 Bionic*

Processor	Overall score
Snapdragon 865	550243
A13 Bionic	480884

Note: Adapted from https://nanoreview.net/.

Table 4 shows that Snapdragon 865 outperforms A13 Bionic by approximately 14 %. Android's latest processor is a clearly more efficient unit when working with every relevant component (Nanoreview, n.d.).

A detailed comparison of these two processors would require a thesis on its own. Analysing it thoroughly would make this thesis digress from its original topic. Instead, this thesis will only analyse hardware of the two most popular and powerful Android and iOS smartphones available on the market right now: Samsung Galaxy S20 Ultra and iPhone 11 Pro Max.

3.1 Samsung Galaxy S20 Ultra

As "ultra" naming suggests, the Samsung Galaxy S20 Ultra is a top-of-the-line Android phone available on the market at the time of writing this thesis. It is powered by earlier mentioned Snapdragon 865 processor. This smartphone comes with 12 GB of RAM (buyers can opt for up to 16 GB). Combined with these technical specifications, Samsung Galaxy

S20 Ultra handles the newest version of Android with ease and it should support future versions of Android for the next approximately two to three years (Zeman, 2020, May 4).

Samsung Galaxy S20 Ultra runs edited version of Android 10. Android phone manufacturers very often take a stock Android OS and change its user-interface (UI) settings up to their liking and then ship their smartphone with their own version of Android. In this case, Samsung made their own version of Android 10, called One UI 2.0. The software experience on this combination of hardware offers everything that user could ever want from an Android smartphone (Zachary, 2020, May 2).

According to Bohn (2020, February 27), Samsung Galaxy S20 Ultra also comes with built in 120 Hz OLED panel. The refresh rate is set to 60 Hz out of the box, but users can change that to 120 Hz in the settings app. This high refresh rate makes experience of using Android so much better and smoother. Samsung Galaxy S20 Ultra's display supports resolution up to 3200x1440 and shines with its vibrant and accurate colours (see Figure 3).

Figure 3. Samsung Galaxy S20 Ultra. Reprinted from https://theverge.com/2020/2/27/21155012/samsung-galaxy-s20-ultra-review-5g-screen-camera-space-zoom-price.

3.2 iPhone 11 Pro Max

Apple's best smartphone running iOS is currently iPhone 11 Pro Max. A buyer can choose between 3 models: iPhone 11, iPhone 11 Pro or iPhone 11 Pro Max. The latter is the fastest and best performing Apple device available on the market as of writing this thesis. It is powered by Apple's newest A13 Bionic processor. As mentioned before, this processor is extremely powerful with amazing computational capabilities. The smartphone also comes with 4 GB of RAM and is aimed for a very specific category of users – professionals. Taking in account these technical specification, iPhone 11 Pro Max is expected to support future versions of iOS for the next 5 to 6 years. The fact that Apple managed to make the chip that can be supported for 5 to 6 years to come, makes this smartphone stand out in many people's eyes (GSMArena team, 2019, September 25).

iPhone 11 Pro Max runs iOS 13 (the newest iOS released by Apple). Unlike Android, Apple's iOS is not editable by smartphone manufacturers, simply because Apple is the only smartphone manufacturer that runs their devices on iOS. Therefore, engineers and developers at Apple managed to completely adjust iOS 13 to run perfectly smooth and fast on iPhone 11 Pro Max. Therefore, iPhone 11 Pro Max because of its A13 Bionic processor and iOS 13 architecture is the fastest and best performing smartphone right now (GSMArena team, 2019, September 25).

According to Spoonauer (2020, May 1), iPhone 11 Pro Max's camera design is very intimidating. With its 3 huge camera lenses in the back (see Figure 4), many people believe this design does not look very pleasant. However, these lenses allow user to take one of the best-looking pictures and videos matching the professional cameras.

Figure 4. iPhone 11 Pro Max's 3 cameras. Reprinted from
https://tomsguide.com/uk/reviews/iphone-11-pro-max.

4 Application Development

According to Iversen and Eierman (2013), the app development for mobile devices is, in many ways, similar to the development for other platforms. However, in other ways, mobile development requires attention to items that are not even present in traditional development. Mobile devices have different approach to apps. For example, mobile devices have access to environmental sensors such as accelerometer, gyroscope, GPS, or magnetometer. Mobile devices also have a much smaller screen and a very limited power supply as opposed to desktops or laptops.

App design is also a very important aspect when developing an app for a smartphone. Applications that run well on a traditional computer could be a complete failure when ported to a smaller form factor like smartphones. A poorly designed smartphone app will likely result in a decline in popularity. There is a high chance that another developer will try to visualize the same idea as yours in an app with one difference, theirs will be better designed. Therefore, your app is destined to fall short to competition if poorly designed (Iversen & Eierman, 2013).

Iversen and Eierman (2013) claim that Android devices and iOS devices have each a different unique set of hardware and software capabilities that make the way the user interacts with the device different for each. This means that in order to make the app complete with no shortage of the user's experience, the developer has to thoroughly learn all the different characteristics of each mentioned OS. The developer should always expect users to do things that the app is not designed for, even if those things make no sense at all. If the user does something unexpected with the app and it crashes and loses data, it is always the developer's fault for not covering that risk in developing stages of the app.

Matthew (2011) states that there are many design considerations the developers always want to take into account as they work on their apps, such as different hardware, hardware acceleration, and touch interaction.

In the following two subchapters, this thesis will discuss some basic characteristics of Android and iOS operating systems that developer should always be aware of when designing and developing an app.

4.1 Android App Development

In general, to begin creating an Android app, the developer needs the Software Developer Kit (known as SDK), Integrated Development Environment (IDE) such as Android Studio or Eclipse, the Java Software Development Kit (JDK) and essentially a virtual device to test an app on. All of these are required before even considering specific characteristics of Android devices (such as screen sizes, user-interface), and Google Play Services (Sinicki, 2015, November 28).

Android allows developers to provide different resources for different Android devices. For example, developers can create different layouts for different screen sizes. As Android Developers (n.d.) point out, the system then takes care of the process by determining which layout to use based on the screen size of the current device.

If the developer decides to make use of specific hardware on the device, say camera, then they need to make sure to make a compatible devices list. They can specify their app requires specific hardware so that Google Play will not allow the app to be installed on devices without them (Android Developers, n.d.).

If we are to consider characteristics of Android smartphones, then for example, we need to pay attention to four hardware buttons (see Figure 5). These buttons were specifically designed to support the user's use of device. These buttons were the Home button, the Menu button, the Search button, and the Back button. The user could press any of these four buttons at any given time in app, which would impact what the app would do afterwards. However, two of those four buttons already had a function preassigned to them. For example, the Home and Back buttons always worked independently of developer's code. On the other hand, the Search and Menu buttons would work in-app only if developer wrote a code for their functionality (Iversen & Eierman, 2013).

Figure 5. Android hardware buttons. Reprinted from Iversen and Eierman (2013, p. 85).

However, with the release of Android 10 version, Android Gestures were introduced, replacing four hardware buttons. These are touch gestures that allow user to interact your app using touch (see Figure 6). Android supports a range of touch gestures, including tap, double tap, pinch, swipe, scroll, long press, drag and fling. Although drag and fling are similar, drag is the type of scrolling that occurs when a user drags their finger across the touchscreen, while a fling gesture occurs when the user drags and then lifts their finger quickly. Gesture navigation is a big deal in Android 10; therefore, developers must be careful not to cause any conflicts when adding their own (Thornsby, 2019, October 13).
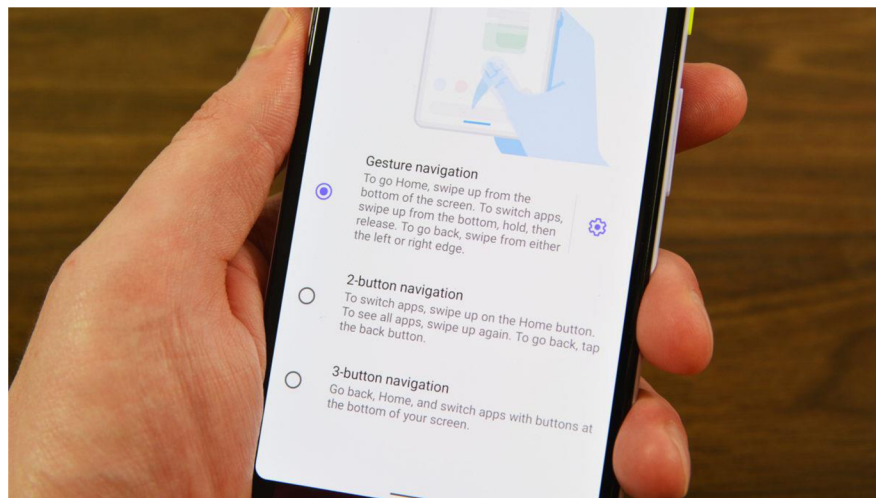
Figure 6. Gesture navigation in settings app. Reprinted from Thornsby (2019).

4.2 iOS App Development

iOS runs on iPhone, iPad, and iPod Touch hardware. Apple provides all the necessary tools, accessories, and resources to create iOS apps for these devices. An iOS developer can choose to program in native languages such as Swift or Objective-C. There is also an option to build a cross-platform native applications using React Native[5] or Xamarin[6] (Amazon, 2004).

In order to develop iOS apps, the developer needs a Mac computer that has the latest version of Xcode. This is currently the only way to develop apps for iOS. Xcode is Apple's IDE for Mac and iOS apps. It is a graphical interface where the developer writes codes for their iOS applications. It also has the built-in iOS SDK, tools, compilers, and frameworks that the

---

[5] React Native is a JavaScript framework for writing real, natively rendering mobile applications for iOS and Android. It is based on React, Facebook's JavaScript library for building user interfaces, but instead of targeting the browser, it targets mobile platforms (O'Reilly Online Learning, n.d.).

[6] Xamarin is an open-source platform for building modern and performant applications for iOS, Android, and Windows with .NET (Microsoft Docs, 2019, September 16).

developer needs specifically to design, develop, write code, and debug an app for iOS. Apple suggests using their modern programming language Swift for developing native mobile apps on iOS (Amazon, 2004).

Contrary to the development of an app for Android, Apple made it easier for developers to perfect and design their apps on iOS. There are many Android smartphones, and therefore developers must design their apps to fit many different UIs, screen sizes and technical specifications. However, Apple has a simple line-up with just a few iPhone models with different specs. For example, according to Iversen and Eierman (2013), the primary hardware button of concern on iOS devices is the Home button (see Figure 7). This button immediately moves any app presently running to the background and OS goes back to home screen. An app should be designed so this action will not cause any problems.

Figure 7. The Home button located on Apple iPhone. Reprinted from https://www.muj-ipad.cz/nahradi-apple-home-tlacitko-ios-zarizeni-kapacitnim-snimacem.

However, the hardware Home button is not the only way to navigate in iOS. With introduction of iPhone X and iOS 11, Apple removed the hardware Home button and implemented gestures as a way of navigating throughout their OS (see Figure 8). For example, Sync Store (2019, December 5) claims that swiping up from the bottom of the iPhone X's screen would cause the same reaction just like pressing the hardware Home button on older versions of iPhone (with exception to iPhone SE 2nd Generation – the only new iPhone model supporting the hardware Home button).

Figure 8. Absence of the Home button on iPhone X. Reprinted from
https://www.wearesync.co.uk/latest-news/our-favourite-iphone-touch-and-gestures/

According to Apple Developer's page (n.d.), people interact with an iOS device by performing gestures on the touchscreen. These gestures elicit a close personal connection with content and enhance the sense of direct manipulation of onscreen objects.

Both Android and iOS have a button that puts the device to sleep or reboots it. This action also must be handled. Fortunately, the same commands that put the app in the background for other actions are executed so no additional programming is required to prepare for this (Iversen & Eierman, 2013).

In conclusion to the theoretical part of this thesis, it is important to realize that both operating systems are designed to be the best version of OS for their hardware. Also, it is quite apparent that while Android was slow at the beginning, nowadays it is very close to overtaking Apple's iOS as the best smartphone OS in the world. iOS is odd due to being completely closed off and very little is customizable and accessible even for developers. On the other hand, Android is open source software and almost anything can be changed by developers, smartphone manufacturers or users. Both systems are made to last, however, Apple might be a little bit better since it provides users with about 5-year OS support from the launch day of a device before eventually stopping the support for that given device.

In the practical part of this thesis, I will analyse results from the questionnaire survey in which I tried to find out why a random sample of respondents prefers either Android or iOS.

5 Practical Part

From February to March 2020, I conducted a survey in which 116 people participated, mostly from the southern part of the Czech Republic. The main goal of the conducted survey was to establish what smartphone operating system is preferred among a random sample (the age of the respondents was mostly between 18 and 30), and why. Some of the questions focused on only Android users, while others focused on only iOS users. All collected data were visualised in graphs, and consequently the reasons for each OS were analysed. A close iOS and Android comparison based on an opinion of various types of people seems to be an interesting and topical issue.

5.1 Methodology

I divided the questionnaire (see Appendix) into several sections. The first section aimed at collecting data about the respondents' gender, and in the following two sections, I collected data related to the research topic.

In the first section of the questionnaire, I tried to find out how choice of an OS changes depending on gender and explain the probable reasoning behind the results.

The second section focused on what the respondents prefer about their OS and what it would take for them to change directly to a competing OS (from Android to iOS and vice versa). The answers regarding only iOS users and only Android users were compared to each other and analysed. It also presented a question whether any Android users had ever owned an iOS smartphone and vice versa. Based on their answer, the respondents were either redirected to the end of the questionnaire or were asked the last question that was discussed in the third section of the questionnaire.

The third section focused on experience of each respondent that owned a competing OS at some point in the past. It provided a comparison of different results based on answers from Android users owning an iOS smartphone before, and answers from iOS users owning an Android smartphone before.

The second overall question that ended the questionnaire asked if the respondents claimed they owned a smartphone with any other OS that was not Android or iOS. The last question

of the second section of the questionnaire was also based on the answer of the respondents and its result either ended the questionnaire for the respondents or presented one last question. Due to this measure, the second section of the questionnaire contained 115 respondents and the third section contained 78 out of 116 respondents in total.

It is important to note that sections in the practical part are different from the sections in the questionnaire in Appendix. In order to redirect Android and iOS users to their set of questions, I had to make separate sections for Android users, iOS users, Android users with iOS experience, and iOS users with Android experience. For example, choosing the option c) Other (Windows Phone etc.) in the second section of the questionnaire in Appendix would redirect respondent to the very end of the whole questionnaire as this practical part analyses preference of only Android and iOS users.

5.2 Data Presentation and Interpretation

5.2.1 First Section: OS Preference Based on Gender

Out of 116 respondents, 77 were males and the remaining 39 were females. The universal question for every respondent asked what OS the respondents used on their main smartphone.
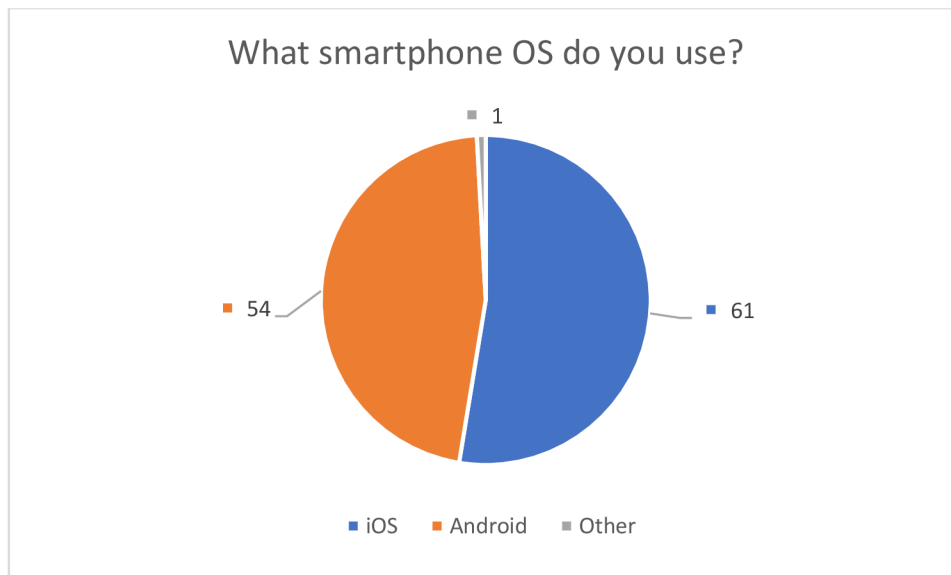
Figure 9. What smartphone OS do you use?

The results between iOS and Android were about the same with 54 respondents that stated they used Android and 61 of them claimed they used iOS in their main smartphone. Only 1

respondent stated they used different OS than Android or iOS (see Figure 9). These results are not surprising because of the fact that other operating systems started to decline as iOS and Android rapidly increased in popularity. For example, nowadays it is very rare to see a person with Windows Phone OS.

The survey shows that women are more likely to be using iOS rather than Android powered smartphone. This could be simply explained as most of the questioned respondents were aged between 18 and 30 years old, and therefore they usually tend to prefer trendy and more prestigious brands such as Apple. This statement is particularly valid for the young women who tend to care more about trends, product popularity and prestige.
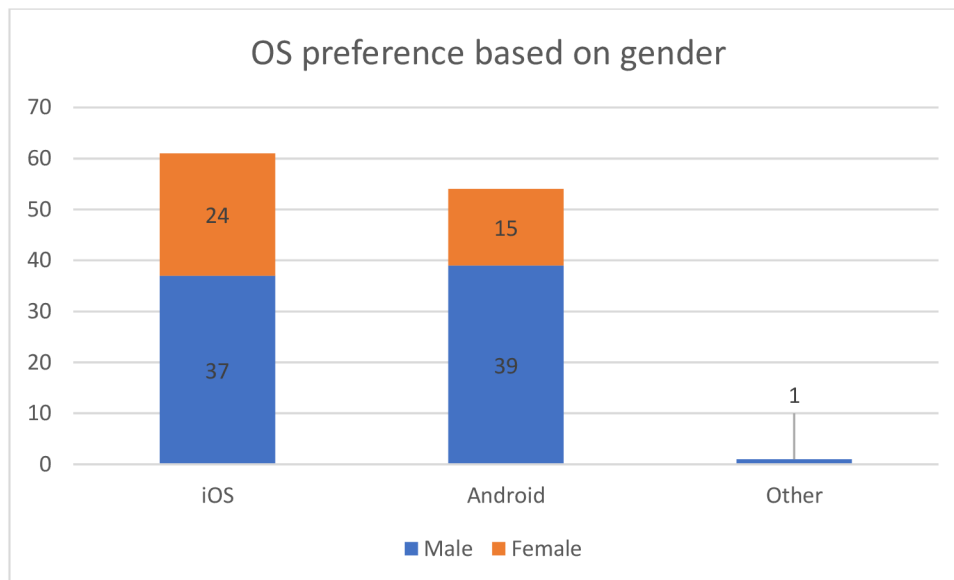
Figure 10. OS preference based on gender

Looking at men's OS preference, the results are quite different from women's results. As can be seen from Figure 10, the results show that men's preference for Android or iOS is about the same, with 37 respondents preferring iOS, 39 of them prefer Android, and 1 respondent uses completely different OS.

5.2.2 Second Section: Reasons for Choosing the Particular OS

In the second section, I wanted to compare results from questions aimed at Android users with the results from the questions aimed at iOS users. Both groups were given the same questions with almost the same answers. I questioned both groups why they prefer the OS

of their choice, whether they plan on staying with their OS, what it would take for them to change to competition, and whether they have ever owned a directly competing OS.

The very first question asked the respondents why they preferred the OS of their choice. It is important to note this was a multiple-choice kind of question. The main selling point for iOS users seems to be performance (25 % of respondents) of the OS and easy-to-use user interface (25 % of respondents). Secondary reasons for owning an iOS are design of iOS devices (21 % of respondents), popularity and prestige of Apple products (11 % of respondents). Lastly, 8 % of respondents preferred the battery life. Most of the remaining answers were written and submitted by the respondents and did not get a large number of votes (see Figure 11).
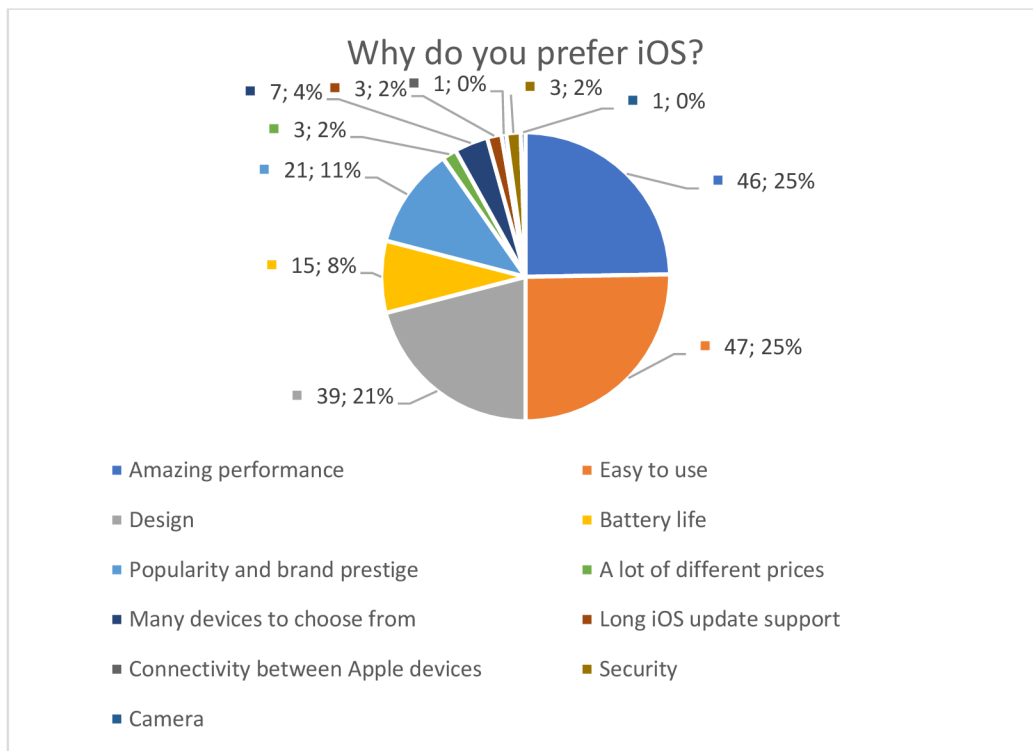
Figure 11. Why do you prefer iOS?

Contrary to iOS, the main selling points for Android users were a variety of different prices (from budget smartphones to flagship ones) and a variety of different brands offering many different prices. This is a completely understandable outcome. iOS is only available on Apple devices while Android is open source OS and any smartphone manufacturer can choose to have Android as its OS. Furthermore, Apple is known for being a very premium company with higher starting prices for their devices. These facts are interconnected together and therefore the results were not surprising to see. On the other hand, the difference between

iOS prestige and Android prestige was huge. iOS lead in a popularity category with 11 % against Android's 3 % of all respondents. Secondary reasons for owning an Android device were easy-to-use user interface (16 % of respondents), performance (15 % of respondents), battery life (11 % of respondents), and lastly design (10 % of respondents) (see Figure 12). The remaining categories were mostly written and submitted by the respondents in "Other" category.
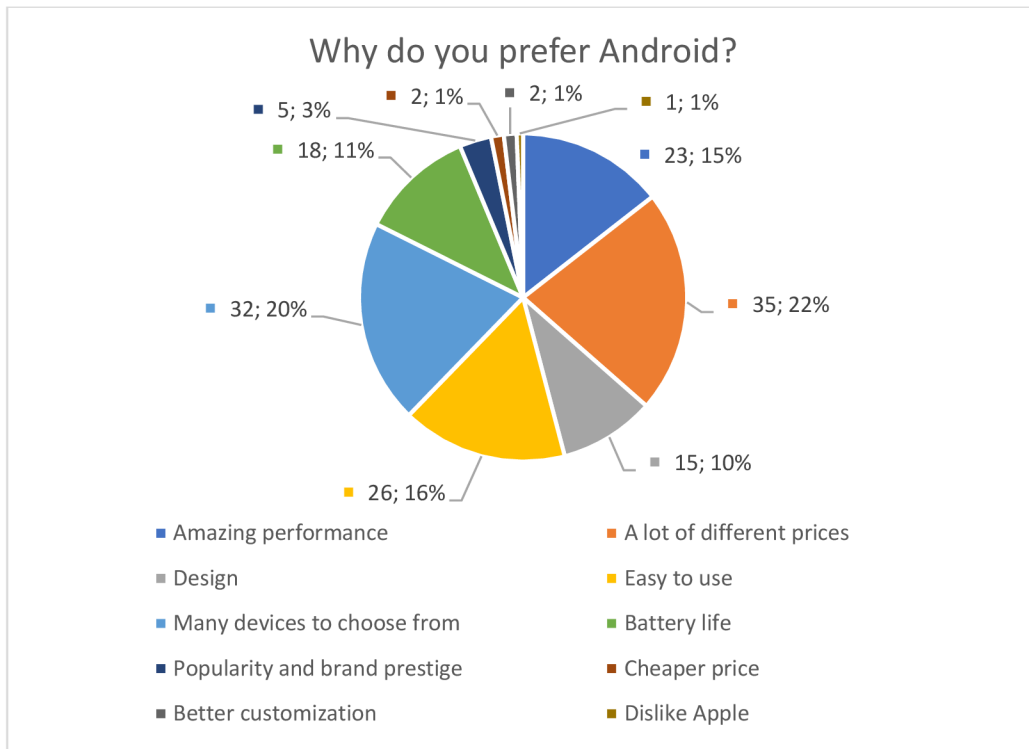
Figure 12. Why do you prefer Android?

On the question of what it would take for iOS users to switch to Android, 20 % of respondents belong to faster and better performance, 13 % of respondents goes to security and safety. "Easier usage", "Better design", and "More functions and features" all received 12 % of votes. Lastly, 10 % of votes belong to "Longer OS support". Then there are votes for categories such as "More applications", "Popularity and brand prestige", "iMessage on Android", and "Nothing", all of which received 5 % of votes (see Figure 13).
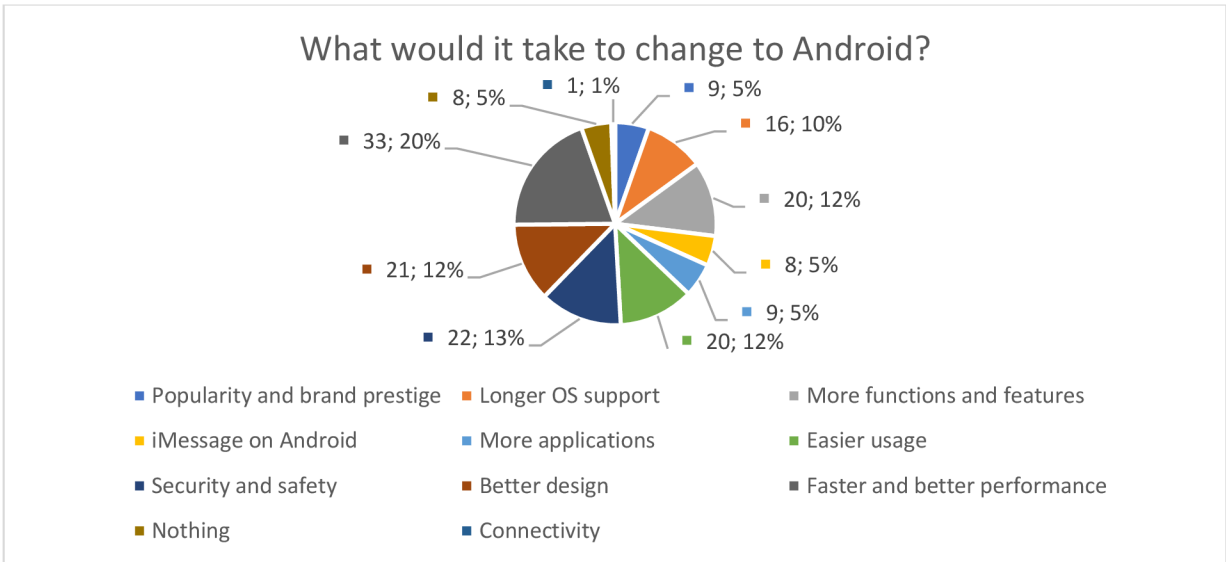
Figure 13. What would it take to change to Android?

From an Android user's perspective, the most voted category was "Lower Apple prices" with 19 % of all respondents. This makes sense since there are many people who would love to own an iOS device but due to high prices set by Apple, they are usually left with Android, which has many device options with many different price tags. The second most voted category was "More customizable" category with 13 % of all respondents (see Figure 14). The reason for that is quite obvious – Android is an open source OS that allows users to change and tweak many settings while Apple closed off its inner workings of iOS, allowing users to only change some fundamental settings. It seems like iOS users prioritize performance and less customization, and Android users tend to care more about pricing of their device, price-performance ratio (more devices to choose from and less emphasis on product popularity and brand prestige) and customization. This question was again a multiple-choice type.
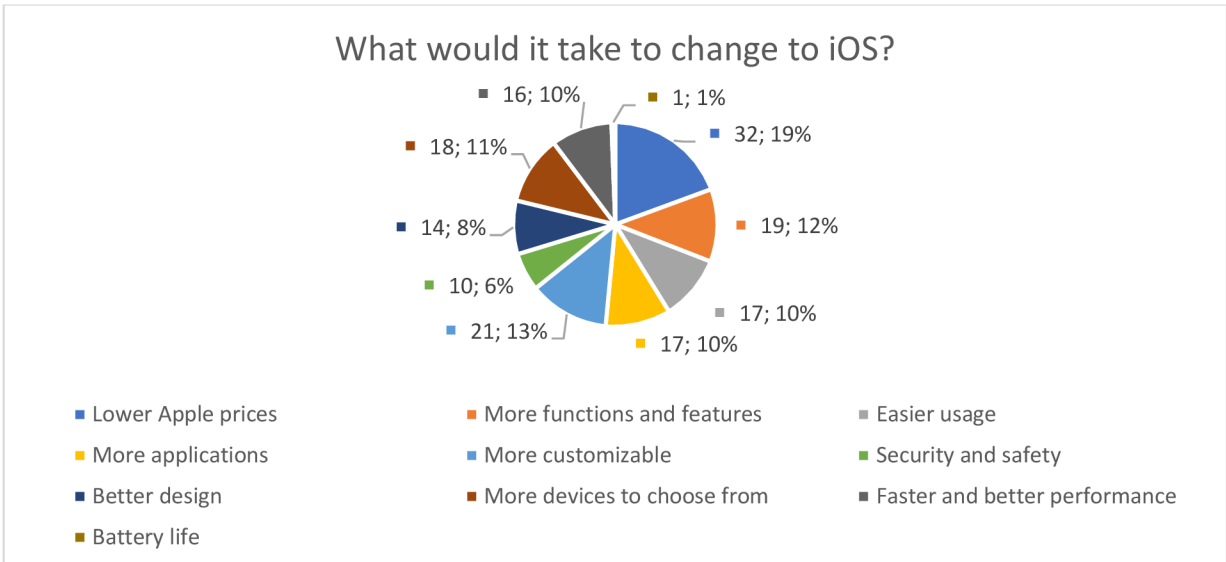
Figure 14. What would it take to change to iOS?

a)   b)
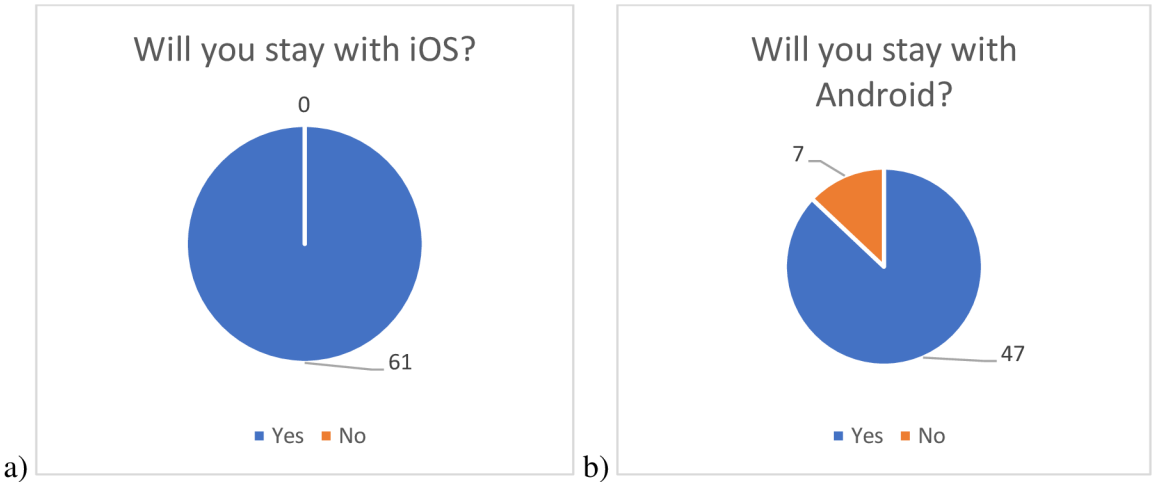
Figure 15. a) Will you stay with iOS? b) Will you stay with Android?

When the respondents were questioned whether they would be staying with their current OS when it was time to change their smartphone for a new one, all 61 iOS users replied they would be staying. However, out of 54 Android users, 7 of them replied they would be changing their OS as soon as they bought a new smartphone (see Figure 15). The most probable explanation is likely to be the complexity of Android. It is a very customizable OS and not everyone will enjoy it. There are certain people who enjoy simple and straightforward settings and manipulation with their smartphone. Also, some of those 7 users maybe had had iOS device before and decided to try Android, but then realized they miss iOS.
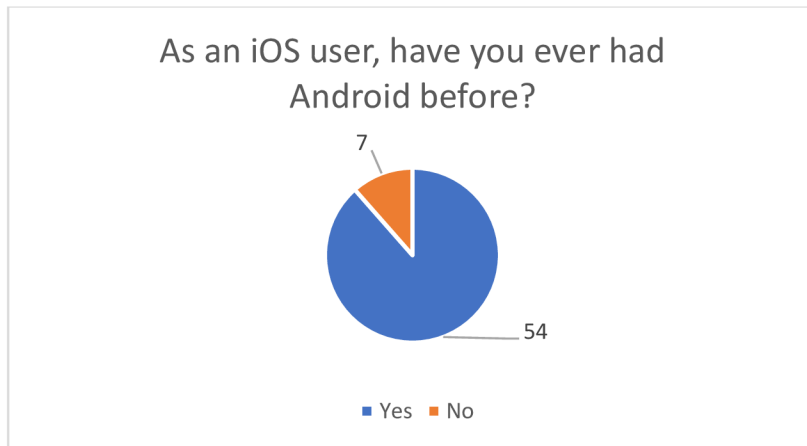
Figure 16. As an iOS user, have you ever had Android before?

In the last question for both, iOS and Android users, in the second section of the practical part, I questioned the respondents whether they had ever had a directly competing OS before. Depending on their answer, the survey either asked the respondents to submit their answers or redirected them to the last question of the whole survey for a further analysis. As can be seen from the chart in Figure 16, 54 out of 61 iOS users have had Android device at some point in the past. Only a small fraction of iOS users have never owned an Android device of some kind before. This is not surprising due to the fact that many people find iOS devices to be too expensive but once they persuade themselves to buy one and try it out, they realize it usually fits their preferences perfectly. After their answer, 54 iOS users were redirected to the last question of the survey.
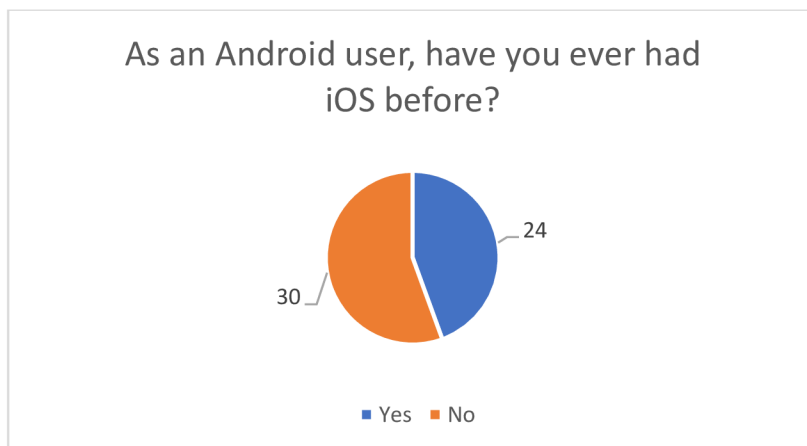
Figure 17. As an Android user, have you ever had iOS before?

On the other hand, answers from Android users were very different when asked whether they had ever owned an iOS device before. 30 out of 54 respondents answered that they had never had iOS device before. Only 24 of them said they had had one before owning an Android

device, which is less than half of Android respondents (see Figure 17). Again, the reason for this is most likely a low starting price for many Android devices and therefore, people tend to stay more with Android rather than try iOS. Also, some people simply like the fact they can customize, tweak and root their smartphone, which is something that iOS lacks.

5.2.3 Third Section: Experience with the Particular OS

In the third section of this practical part, I analysed answers from the last question that only some respondents answered (depending on their answer in the previous question). Both groups (Android and iOS users) were given a question asking them to describe their previous experience with competing OS. They were given 5 possible answers to describe their experience – excellent; good; not great, not terrible; bad; horrible.
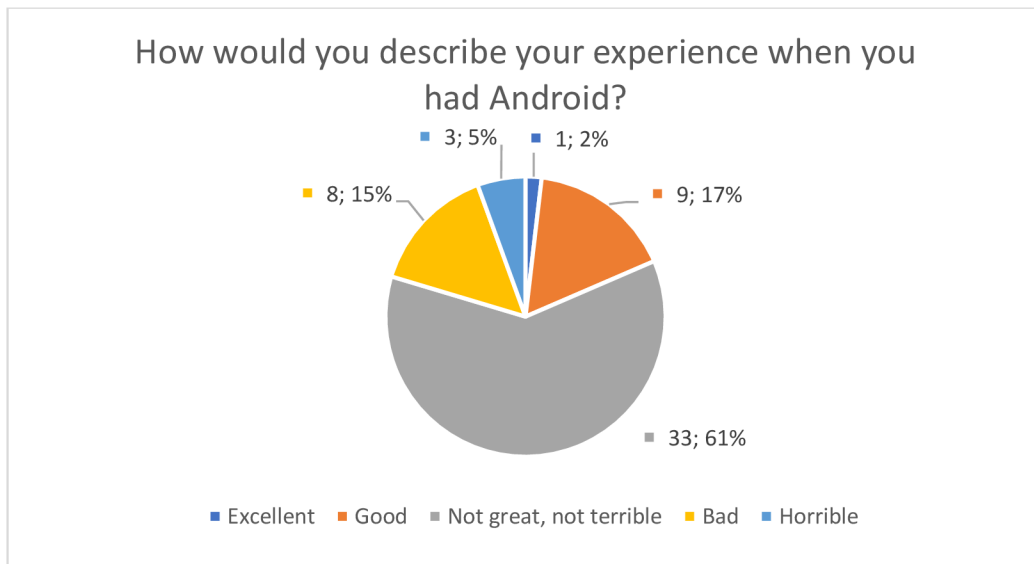
Figure 18. How would you describe your experience when you had Android?

From the chart in Figure 18, we can see that 61 % of iOS users who had owned an Android device before, answered that their experience had been rather neutral with some ups and downs. 17 % of respondents said their experience with an Android device had been good, while 15 % said their experience had been bad. 5 % of respondents described their experience as horrible. The real anomaly in these results is "Excellent", which was chosen by only 1 respondent (2 % of respondents). The reason for these results is probably the fact that many people tend to buy low budget Android phones that are very unreliable and start to lag soon after the purchase. This is not the case with iOS devices as Apple makes mostly only premium fast-performing smartphones that come with premium price tags.
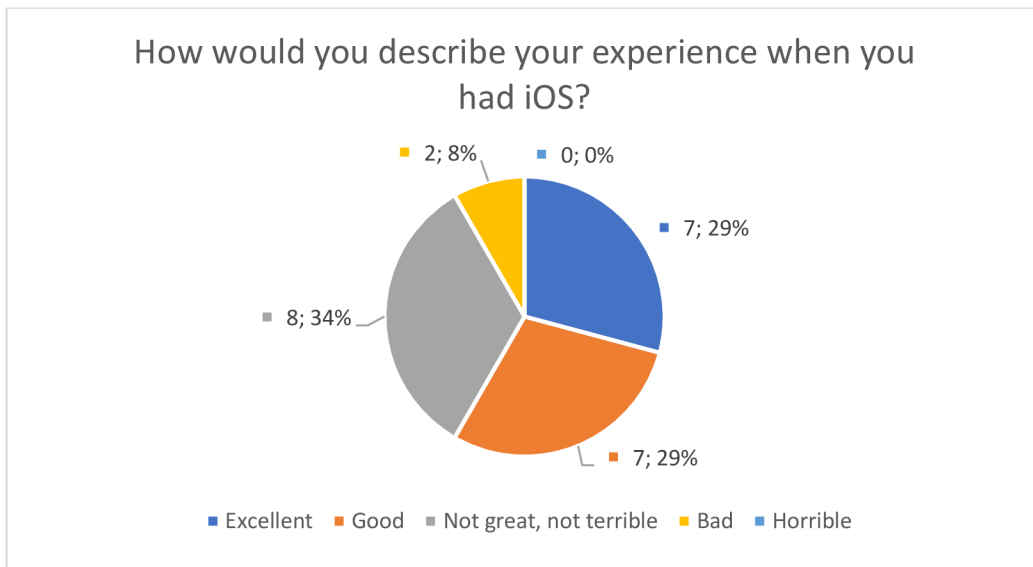
Figure 19. How would you describe your experience when you had iOS?

As can be seen from the last chart in Figure 19, Android users had mostly excellent and good experience, with 59 % of respondents combined together claiming they had either good or even excellent experience when they owned an iOS device in the past. 34 % of all respondents stated that their experience using an iOS device had been rather neutral with some advantages and disadvantages. The real anomalies in this chart are "Bad" experience (only 2 respondents) and "Horrible" experience (no respondents). The reason for these anomalies is most likely the fact that iOS devices, unlike most Android devices, usually do not slow down or degrade with time. These respondents are now Android users, however, when they primarily had an iOS device, they probably did not change their OS because of lack of performance but most likely because they needed some other features that iOS lacked while Android did not, such as for example previously mentioned ability to customize and tailor the user experience to the user's liking.

5.3 Discussion

One of the insights analysed in the first section of the practical part shows that women are more likely to own an iOS device rather than Android one, while men own both operating systems about equally.

As the second section revealed, iOS leads in categories such as "popularity and brand prestige" and "amazing performance". On the other hand, Android users prefer their operating system due to it being available on all kinds of smartphone devices. This is a huge advantage for Android on the smartphone market as potential customers can get an Android powered device for low prices as well as high ones. Android users can either opt to buy a budget Android device or flagship one. While Apple offers their own budget iPhone options, the price-performance ratio is not quite as good as it is regarding budget Android devices. Again, this is due to Apple being a very popular brand with its logo being considered extremely premium – hence the higher price. Also, many Android users would consider switching to iOS if Apple lowered their price tags (19 % of all votes by Android users).

The third section of the practical part shows that iOS users that had previously owned an Android device, were mostly neutral about their Android powered device in the past (61 % of respondents). 17 % of respondents said their past experience with Android device had been good and only 2 % of respondents said it had been excellent. The rest of the answers belong to "Bad" and "Horrible" categories (20 % combined together). However, Android users that had owned an iOS powered device sometime in the past, said they had been mostly satisfied with their past iOS device (58 % of respondents answered either "Good" or even "Excellent"). 34 % percent of respondents said their experience with iOS had been rather neutral. Finally, only 8 % of respondents said their experience had been bad. No respondent claimed their experience had been unpleasant.

Conclusion

This bachelor's thesis was intended to focus on the comparison of Android and iOS operating systems. The terms regarding operating systems were defined, the detailed information about their historical development was provided, and hardware comparison was made. I conducted a literature review of a variety of articles and books and described every major version of both systems since both systems are very complex and different from each other in terms of history, features, application development and ideologies.

Android has always been a very open operating system due to its open source software origin, enabling developers and users to customize every little detail. However, Apple's iOS has taken a completely different approach to this matter. Apple decided to completely close off the inner workings of iOS and developers could not access its code. For this reason, Apple managed to make their own ecosystem, where every Apple device works seamlessly with each other. There are many Apple products that are to a certain extent dependent on iOS and iPhone; for example, Apple's wearable Apple Watch, the moment one gets rid of iPhone, Apple Watch becomes useless without information from paired iPhone.

Android has been making faster progress in terms of new features, but on the other hand, it feels much less secure and stable than iOS. Its complexity and open source make it customizable and developers and phone manufacturers very often take advantage of this fact. They make their own version of Android and hence also slowing it down a bit. In order to get the best performance out of Android, users should always use a stock version of Android made only by Google.

According to the studies presented in this thesis, developers adopt different approaches when developing an application for each of these operating systems. Android used to have multiple physical buttons that had to be taken care of when programming an app. The same applies for iOS with one slight difference – it had only one physical button that had to be considered. Both operating systems later adapted a new way of navigating the system – gestures.

The practical part of this thesis revealed that iOS users mostly care about performance, design, easy usage, and brand popularity and prestige. On the other hand, Android users prefer customizability, easy usage, battery life, variety of different Android devices available

and different price range. Eventually, iOS users and Android users are probably two different psychological types of people and it would be interesting to conduct a research study that would focus on psychological differences between these two types of people.

In conclusion, both operating systems are different from each other in many aspects and both are made for different kind of users. Eventually, it all comes down to users' preferences and expectations from the smartphone operating system.

List of References

Alabaster, J. (2013, April 16). Android founder: We aimed to make a camera OS. Retrieved from https://www.pcworld.com/article/2034723/android-founder-we-aimed-to-make-a-camera-os.html

Amazon. (2004). Getting Started with iOS App Development. Retrieved from https://aws.amazon.com/mobile/mobile-application-development/native/ios/

Android. (n.d.). Android – Google Mobile Services. Retrieved from https://www.android.com/gms/

Android Developers. (n.d.). Build your first app. Retrieved from https://developer.android.com/training/basics/firstapp

Apple.com. (n.d.). Batteries. Retrieved from https://www.apple.com/batteries/

Apple Developer (n.d.). Gestures. Retrieved from https://developer.apple.com/design/human-interface-guidelines/ios/user-interaction/gestures/

Bohn, D. (2020, February 27). Samsung Galaxy S20 Ultra Review: Shutter Bug. Retrieved from https://www.theverge.com/2020/2/27/21155012/samsung-galaxy-s20-ultra-review-5g-screen-camera-space-zoom-price

Callaham, J. (2018, July 11). Google made its best acquisition 13 years ago: Can you guess what is was? Retrieved from https://www.androidauthority.com/google-android-acquisition-884194/

Callaham, J. (2019, August 18). The history of Android OS: its name, origin and more. Retrieved from https://www.androidauthority.com/history-android-os-name-789433/

Cambridge Dictionary. (n.d.). Feature | Meaning in the Cambridge English Dictionary. Retrieved from https://dictionary.cambridge.org/dictionary/english/feature

Cervantes, E. (2017, June 14). Android 6.0 Marshmallow features. Retrieved from https://www.androidauthority.com/android-6-marshmallow-features-662856/

Cipriani, J. (2016, July 1). The complete list of "OK, Google" commands. Retrieved from https://www.cnet.com/how-to/complete-list-of-ok-google-commands/

Clover, J. (2020, January 9). Today Marks the 13th Anniversary of When Steve Jobs Unveiled the Original iPhone. Retrieved from https://www.macrumors.com/2020/01/09/original-iphone-unveiling-13th-anniversary/

Computer Business Review. (n.d.). What is iOS? Retrieved from https://www.cbronline.com/what-is/what-is-ios-4899783/

Costello, S. (2020, January 10). How Many Apps Are in the App Store? Retrieved from https://www.lifewire.com/how-many-apps-in-app-store-2000252

Costello, S. (2019, November 12). The history of iOS, from version 1.0 to 13.0. Retrieved from https://www.lifewire.com/ios-versions-4147730

GSMArena team. (2019, September 25). Apple iPhone 11 Pro and Pro Max review. Retrieved from https://www.gsmarena.com/apple_iphone_11_pro_max-review-1991p5.php

Hoffman, Ch. (2014, June 6). What Does AnTuTu Benchmark Actually Measure? Retrieved from https://www.makeuseof.com/tag/antutu-benchmark-measure/

Happiest Minds. (n.d.). Wearable technology. Retrieved from https://www.happiestminds.com/Insights/wearable-technology/

Hill, S. (2018, October 31). Who's Bugdroid? Meet the cute mascot of Android. Retrieved from https://www.digitaltrends.com/mobile/who-is-bugdroid-the-story-of-androids-mascot

Iversen, J., & Eierman, M. (2013). *Learning mobile app development: A hands-on guide to building apps with iOS and Android*. Boston: Addison-Wesley.

Jipping, M. J. (2007). *Smartphone operating system concepts with Symbian OS: A tutorial guide*. Chichester: Wiley.

Krazit, T. (2008, March 12). Live blog from Apple's iPhone SDK announcement. Retrieved from https://www.cnet.com/news/live-blog-from-apples-iphone-sdk-announcement/

Malik, O. (2019, September 19). An Exclusive Look Inside Apple's A13 Bionic Chip. Retrieved from https://www.wired.com/story/apple-a13-bionic-chip-iphone/

Matthew, D. (2011). *Flash mobile: Developing Android and iOS applications*. Oxford: Focal Press.

McKane, J. (2017, July 2). iOS vs Android – Smartphone hardware comparison. Retrieved from https://mybroadband.co.za/news/smartphones/216118-ios-vs-android-smartphone-hardware-comparison.html

Microsoft Docs (2019, September 16). What is Xamarin? – Xamarin. Retrieved from https://docs.microsoft.com/en-us/xamarin/get-started/what-is-xamarin

Nanoreview. (n.d.). Snapdragon 865 A13 Bionic: tests and benchmarks. Retrieved from https://nanoreview.net/en/soc-compare/qualcomm-snapdragon-865-vs-apple-a13-bionic

OLED-Info. (2019, March 28). An introduction to OLED displays. Retrieved from https://www.oled-info.com/oled-introduction

Opensource.com. (n.d.). What is open source software? Retrieved from https://opensource.com/resources/what-open-source

O'Reilly Online Learning. (n.d.). Learning React Native. Retrieved from https://www.oreilly.com/library/view/learning-react-native/9781491929049/ch01.html

Raphael, JR. (2019, September 13). Android versions: A living history from 1.0 to 10. Retrieved from https://www.computerworld.com/article/3235946/android-versions-a-living-history-from-1-0-to-today.html

Royal, S. (2017, January 13). iPhone OS 1: The Beginning of an Era. Retrieved from https://lowendmac.com/2017/iphone-os-1-the-beginning-of-an-era/

Silver, S. (2018, July 5). Apple details history of App Store on its 10th anniversary. Retrieved from https://appleinsider.com/articles/18/07/05/apple-details-history-of-app-store-on-its-10th-anniversary

Sinicki, A. (2015, November 28). How to start Android app development for complete beginners in 5 steps. Retrieved from https://www.androidauthority.com/android-app-development-complete-beginners-658469/

Spoonauer, M. (2020, May 1). iPhone 11 Pro Max Review. Retrieved from https://www.tomsguide.com/uk/reviews/iphone-11-pro-max

Swider, M., Knapp, M. (2020, February 25). Snapdragon 865: phones list, specs and 5G capabilities. Retrieved from https://www.techradar.com/news/snapdragon-865-phones-list-specs-and-5g-capabilities

Sync Store. (2019, December 5). Our favourite iPhone touch gestures and commands. Retrieved from https://www.wearesync.co.uk/latest-news/our-favourite-iphone-touch-and-gestures/

Team AA. (2019, December 2). What is Android? Here is everything you need to know. Retrieved from https://www.androidauthority.com/what-is-android-328076/

Techopedia. (n.d.). What is Software Bug? – Definition from Techopedia. Retrieved from https://www.techopedia.com/definition/24864/software-bug-

The Verge. (2013, September 16). iOS: a visual history. Retrieved from https://www.theverge.com/2011/12/13/2612736/ios-history-iphone-ipad

Thornsby, J. (2019, October 13). How to use gestures and gesture-based navigation in your Android app. Retrieved from https://www.androidauthority.com/android-gesture-tutorial-1032515/

Tillman, M., O'Boyle, B. (2019, October 8). What is Google Assistant and what can it do? Retrieved from https://www.pocket-lint.com/apps/news/google/137722-what-is-google-assistant-how-does-it-work-and-which-devices-offer-it

UserBenchmark. (n.d.). What is the Geekbench score?. Retrieved from https://cpu.userbenchmark.com/Faq/What-is-the-GeekBench-score/52

Viswanathan, P. (2019, April 20). What Is a Mobile Operating System? Retrieved from https://www.lifewire.com/what-is-a-mobile-operating-system-2373340

Wikichip. (n.d.). A13 Bionic – Apple. Retrieved from https://en.wikichip.org/wiki/apple/ax/a13

Zachary, K. (2020, May 2). The best 5 things about Samsung Galaxy S20 Ultra. Retrieved from https://www.androidpolice.com/2020/05/02/5-best-things-samsung-galaxy-s20-ultra/

Zeman, E. (2020, May 4). Samsung Galaxy S20 Ultra review: Too much of a good thing. Retrieved from https://www.androidauthority.com/samsung-galaxy-s20-ultra-review-1085702/

1000logos. (n.d.). IOS LOGO. Retrieved from https://1000logos.net/ios-logo/

List of Figures

List of Tables

Appendix

Questionnaire: Android vs iOS

Section 1

1. What gender are you?

    a) Male

    b) Female

Section 2

1. What operating system does your MAIN smartphone use?

    a) iOS

    b) Android

    c) Other (Windows Phone etc.)

Section 3

1. Why do you prefer iOS?

    a) Performance and functionality

    b) Wide range of prices

    c) Design

    d) Easy to use

    e) Wide range of devices to choose from

    f) Battery life

    g) Popularity and brand prestige

    h) Other

2. When you change your smartphone, will you choose to stay with iOS?

    a) Yes

    b) No

3. What would make you change operating system to Android?

    a) More popular and better prestige

    b) Longer OS support

    c) More functions and features

    d) iMessage on Android

    e) More applications

    f) Easier usage (more user-friendly)

    g) More secure and safe

    h) Better design

i) Faster and better performance

j) Other

4. As an iOS user, have you ever had Android before?

a) Yes

b) No

Section 4

1. How would you describe your experience when you had Android?

a) Excellent

b) Good

c) Not great, not terrible

d) Bad

e) Horrible

Section 5

1. Why do you prefer Android?

a) Performance and functionality

b) Wide range of prices

c) Design

d) Easy to use

e) Wide range of devices to choose from

f) Battery life

g) Popularity and brand prestige

h) Other

2. When you change your smartphone, will you choose to stay with Android?

a) Yes

b) No

3. What would make you change your operating system to iOS?

a) Lower Apple prices

b) More functions and features

c) Easier usage (more user-friendly)

d) More applications

e) More customizable

f) More secure and safe

g) Better design

h) More devices to choose from

i) Faster and better performance

j) Other

4. As an Android user, have you ever had iOS before?

    a) Yes

    b) No

Section 6

1. How would you describe your experience when you had iOS device?

    a) Excellent

    b) Good

    c) Not great, not terrible

    d) Bad

    e) Horrible