The smartphone revolution and importance of mobile computing to stay relevant on smart device market:

An analysis of user priorities when choosing a new smartphone and prototyping of an online performance comparison service

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Abstract

This master thesis in media technology depicts the development on the smartphone market globally but with focus on Swedish users. It underlines the importance of performance and processing power of smartphones on the Swedish market. In this study, user priorities when choosing a new smartphone are examined as well as user habits and user experience.

The study proves that users value performance as the second most important factor, after the operating system when choosing a new smartphone and that the majority are comparing prices of smartphones before purchase, which is why this thesis proposes an online service presenting smartphone performance comparisons. For this, a web prototype is developed incorporating already documented performance benchmark results for the majority of smartphones on the Swedish market. The way of measuring performance through benchmark applications is discussed in this thesis but the specific test procedures for the documented results are not. Recommendations on functionality and approach for further development and implementation of the online service are made in this thesis.

Keywords: Smartphone usage, Benchmarking, Mobile computing, User experience, User habits, Web prototyping, CMS, Performance comparison, SOC

Referat

Detta examensarbete inom medieteknik skildrar utveckling på smartphone-marknaden globalt men med fokus på Svenska användare. Arbetet framhäver vikten av prestanda och beräkningskraft för smartphones på den Svenska marknaden. I detta arbete undersöks vilka egenskaper som prioriteras vid val av ny smartphone samt vad användare gör med sina telefoner och hur nöjda de är med användarupplevelsen. Undersökningen visar att användare värderar prestanda som den näst viktigaste faktorn, efter operativsystem vid val av ny smartphone samtidigt som en majoritet aktivt jämför priser på smartphones innan köp. På dessa grunder föreslås en tjänst för att presentera jämförande prestandaresultat för smartphones. För detta tas en webbprototyp fram, innehållandes redan dokumenterade prestandamätningar för majoriteten av alla smartphones på den Svenska marknaden. Att använda benchmarkapplikationer för prestandamätningar diskuteras i detta arbete men det specifika tillvägagångssättet för de redan dokumenterade prestandaresultaten behandlas inte. Rekommendationer för ytterligare funktionalitet och utveckling av en prestandajämförelsetjänst på nätet görs i slutet av arbetet.

Keywords: Smartphone-användning, Benchmarking, Mobil datoranvändning, Användbarhet, Användarvanor, Webbprototyp, CMS, Prestandajämförelse, SOC

Preface

I would like to thank my supervisor Björn Thuresson (KTH) and Marlène Sellebråten (Mobil) for their contributing expertise as well as their time, resources and guidance during this research.

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1. Introduction

This first chapter will introduce the subject discussed and the problem definition of this thesis.

1.1 Background

The smart device industry is fast changing with big players in both the hardware and software business seeing market shares shifting quickly. It's important, maybe now more than ever to stay competitive by giving the customers what they want and have the leading edge in development by knowing what the next big market changer might be.

The fact of the matter is that shipments of smartphones globally have reached all-time high and are predicted to continue to grow 71.1% from 2013 till 2017 in unit shipments. 2013 saw a recorded growth of 38.4% compared to 2012), passing one billion units shipped in just 2013. (IDC, 2013), (IDC, 2014) Furthermore, the global market share for smartphones among smart devices, which comprises desktop PC's, portable PC's, tablets and smartphones, is estimated to grow from 65.1% to 70.5% within that same period.

The growth in the smartphone market is according to IDC, fueled by strong emerging market demand and declining prices. In the more developed markets additional reasons might be that smartphones are becoming more capable of replacing traditional PC's and other gadgets regarding functionality and performance. (Hammershoj et al., 2010) Even global tablet shipment is estimated to have topped total PC shipments for the first time in the fourth quarter of 2013. (IDC, 2013) Hence the smart device market has been, and still is undergoing a significant change and it is clear that mobile computing is becoming even more relevant.

Sweden is clearly at the forefront in terms of market penetration for smartphones as 86 % of the Swedish population between 15 and 64 years of age has a smartphone according to a study done by Flurry. Sweden thereby has the third greatest smartphone penetration in the world only trumped by Singapore and Hong Kong with 92% and 87% respectively. (Reed, 2013)

The most popular smartphones on the Swedish market is generally highly specced devices at high price points, so called flagship devices from various manufacturers according to the price comparison service Prisjakt. (Prisjakt Sverige AB, 2014) Although there are several services for comparing price and specification of smartphones, services presenting comparisons of actual performance and processing power of smartphones on the Swedish market are rare but seems particularly relevant to the Swedish performance oriented smartphone market.

There are several benchmark applications for smartphones where consumers can test the performance of their own smartphone but there is arguably a shortage of services for presenting comparisons regarding the performance and processing power of the majority of smartphones on the Swedish market.

Consequently, this thesis is done in cooperation with www.mobil.se; the leading Swedish magazine and website for mobile IT in Sweden (Mobil, 2014), in order to examine the interest and demand for smartphone performance. The task to create a concept and a prototype for an online comparison service regarding performance and processing power of smartphones for the Swedish market is also set accordingly.

1.2 Problem definition

On the grounds described in the background section of this thesis, especially that there supposedly would be a demand for comparing the performance of smartphones on the Swedish market and that high performing smartphones in particular are very popular among Swedish customers and users, the main question for this thesis is as follows:

Is there a great demand and interest for comparing performance between smartphones and if so, how can it be presented on Sweden's leading website for mobile IT to make it easier for consumers to compare smartphone performance?

1.3 Purpose and target audience

The purposes of this thesis is to depict how the industry for mobile smart devices is doing in its path to achieve the production of devices with higher performance, and how in turn the higher performance levels are paving the way for new functionality and also new types of devices. Accordingly, this thesis also aims to determine whether there is a demand for performance comparisons between smartphones within the target audience. To examine this, a survey was conducted which form the basis for developing a concept and a web prototype for presenting smartphone performance comparisons, consequently intended for Mobil to implement on their website www.mobil.se.

The survey carried out in the form of an online questionnaire also has the purpose of showing what the respondents actually use their smartphones for, how long the actual life span of their smartphones is and what the most important factor is when choosing a new smartphone to thereby determine how performance oriented the users are, in which case indicating further that there is a need for presenting performance comparisons online.

This thesis aims to describe the recent development on the mobile smart device market and how it has been formed by both innovative manufacturers and the user's needs, to possibly try to summarize and conclude what changes could be seen in the future.

The intentions besides offering people performance comparisons that are in the market for a new smartphone and giving Mobil a foundation for presenting these smartphone performance comparisons is to also address companies within the smartphone- and accordingly marketing industry, mobile smart device industry and mobile business sector to give strategic advices as to product development and marketing.

1.4 The magazine and website Mobil, mobil.se

Mobil and www.mobil.se is the leading Swedish magazine and website in the mobile communications area. Mobil is addressed to everyone looking to buy new mobile gadgets or services. Mobil also publishes web TV via Youtube on their channel "mobilmagazine" as well as a daily newsletter via subscription that keeps you updated on what's happening in the industry. (Mobil, 2014)

The magazine and website are also read by those who want to keep track of what's happening in the mobile world and those working in the mobile industry; IT and telecom managers, marketers, business developers and developers.

The reason this company was contacted for this thesis is because they test and review the majority of smartphones on the Swedish market. And what's particularly interesting for this thesis is that Mobil is carrying out performance testing through benchmark applications and that they also do actual battery testing. These are two areas of testing that give quantified, measured and comparable performance data that the price comparison websites do not provide.

When it comes to battery testing, the numbers for how long the battery life is per charge are published by Mobil as new phones are tested, both on the website www.mobil.se and in the printed version of the magazine Mobil. However, there isn't yet an easy way for consumers to view comparisons in terms of actual battery life tests. Mobil have also for long done rigorous performance testing including many of the most popular benchmark applications and the performance figures have been well documented for each device tested by Mobil.

This means that they have a good potential for presenting performance figures and make it easier for their readers to compare performance between smartphones but it has not yet been published to the readers neither on the website www.mobil.se nor in the magazine Mobil.

Mobil, which is a trademark, owned by the company South Square Publishing AB is then the employer and client for this master thesis. (Mobil, 2014)

The thesis will hereby examine the interest among the readers of Mobil for an online service presenting smartphone performance comparisons on the website www.mobil.se. It will also result in an online prototype for presenting performance comparisons of smartphones.

1.5 Delimitations

The performance measurements of smartphones used in the prototype is done by Mobil, thus those testing processes are not included as a part of this thesis aside from the extracted values from the performance testing.

The thesis will give a macro perspective on the development of the mobile smart device market but also focus on the Swedish smartphone market, its devices and users. It is primarily the Swedish smartphone market that will be analyzed and discussed as Mobil which this thesis is done in cooperation with operates in the Swedish market and also to make the content more in depth.

The target groups for the survey in form of a questionnaire in this thesis, is delimited to readers of the website www.mobil.se and Media Technology students at The Royal Institute of Technology respectively.

The online prototype developed in this thesis is not intended for end users but for the internal staff and developers of www.mobil.se. It is therefore not undergoing any user testing in this thesis.

2. Theory

In this section, development of the smartphone as a connected smart device will be examined as well as the adoption rate and usage,, focusing on the Swedish market. This chapter will also explain the fundamental definition of a smartphone, hardware and software wise and how this is about to change, to try and give an insight as to where the development is headed.

The thesis will in the theory section also elucidate the major companies driving the smartphone development in terms of devices and platforms globally and also examine trends in the Swedish smartphone market.

Previous research and the pursuit of performance in today's smartphones will also be discussed.

2.1 Definitions

SOC:

SOC stands for "system on a chip". The SOC is what carries out the instructions of any software such as kernels, OS's and apps run on a smartphone. The SOC normally integrates hardware enabling many different types of functionality, such as; CPU (central processing unit), GPU (graphical processing unit), GPS, WAN (wide area network: telecommunication circuitry), WLAN, PAN (Such as Bluetooth, IrDA) and determines the limitations of what other types of hardware is supported and can be connected to the SOC to make up a smartphone, such as RAM memory, screen resolution, camera resolution, connectivity such as USB version, USB OTG (on the go), MHL, HDMI, and so forth. (Carroll et al., 2010)

As the manufacturing processes gets more refined or in other words as the SOC manufacturers is able to produce smaller transistors that primarily make up the circuitry of the SOC:s, the SOC can be made more powerful in terms of processing power, but at the same time consume less power and critically also be made smaller. So as essential this development is to improve performance, it is also fundamental for SOC manufacturers to be able to include more functionality into the SOC so that devices can be more capable but at the same time cheaper to manufacture. (Mack, 2011)

2.2 The beginning of the smartphone revolution (and thereby the hunt for smartphone performance)

There is no denying that the launch of the first iPhone marked the beginning of the smartphone revolution in the early 2007 followed by Google later that year launching Android, Google's operating system for smartphones used by several smartphone manufacturers such as Samsung, HTC, LG and Sony among several others. (Hall et al., 2009)

This began to redefine the term "mobile computing" as the new era of smartphones offered more PC-computer like functionality in a much smaller form factor than before thanks to the new software platforms iOS and Android.

Of course, Apple was not the first company making smartphones as the term had existed for quite a while back with the former market share leading OS for smartphones being Symbian which was first released in 2000. Symbian was the world's most widely used smartphone OS until 2010. (Hall et al., 2009)

But as the new era for smartphones rose with iOS and Android being the two leading OS's platforms for smartphones, a significant trend in the traditional PC market could also be seen as portable PC's for the first time in 2008 outsold desktop PC's globally. (Magnusson, 2008)

And ever since, the whole smart device market has seen a shift towards mobile computing.

So while the traditional PC is transforming into more portable and new types of devices with functionality derived from smartphones like touch screens, smartphones are closing in on traditional PC's with ever more functionality as one of the main competitive factors.

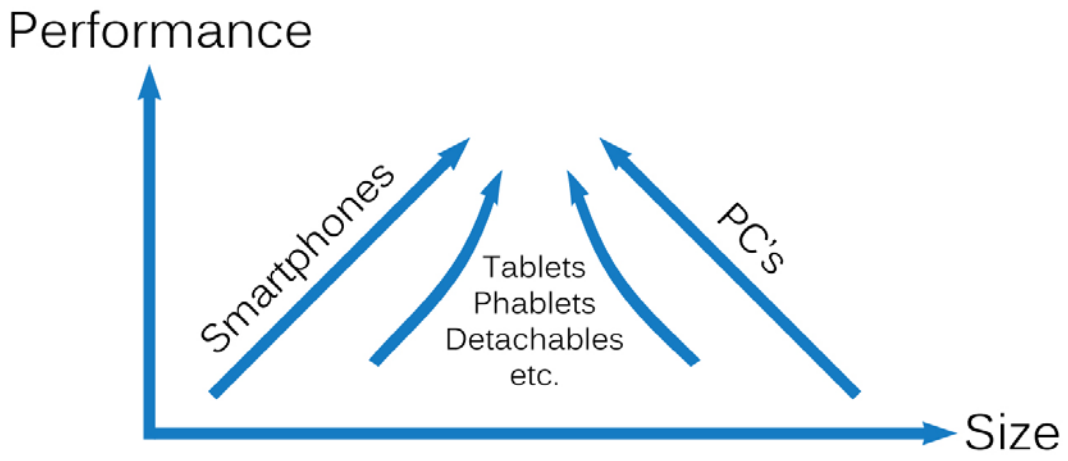


Figure 1: General development of smart devices over time

However, another recurrent factor for smartphone manufacturers since the first iPhone, have been to achieve higher performance and processing power for every new incarnation of their latest smartphones, for them to be able to run more compute intense applications and being able to support other types of hardware functionality like screens with higher resolution, cameras and so on, giving the customers what they want. (Shimpi, 2013)

The key reason why these new platforms, mainly iOS and Android, quickly made a big impact on the smartphone marked is however that they offered a far more usable environment for both developers and consumers to customize the functionality of the smartphone and utilize the hardware within it.

And it was the progress made in hardware development that made the iPhone and any other device running iOS or Android possible. The performance level of the SOC's had risen to an acceptable level within performance, power efficiency and thermal envelope for the size of a smartphone. This made it possible to develop and run these sophisticated operating systems, which also paved the way for new types of devices such as tablets. (Shimpi, 2009)

To describe this in more detail the next sections are going to depict and emphasize the pursuit of mobile performance among the players in the smart device market, to justify the relevance of this thesis survey and the online performance comparison prototype.

2.3 The big players in the smart device industry

As stated previous in Figure 1 the two product categories; PC's and smartphones, are approaching one another in terms of performance, functionality and also mobility. Thus smartphones are getting continuously more qualified as replacements for the traditional PC in many user areas. Development in the whole smart device market therefore becomes relevant for the development in the smartphone market alone.

To explain the concept of performance in the smart device market and especially the smartphone segment, this section is going to give a description of what a smartphone is in general but also how it can be defined in terms of hardware architecture and in terms of the ability to run different types of operating systems, together with a walkthrough of the major operating companies, to describe the shift towards mobile in the smart device market and the relations among them.

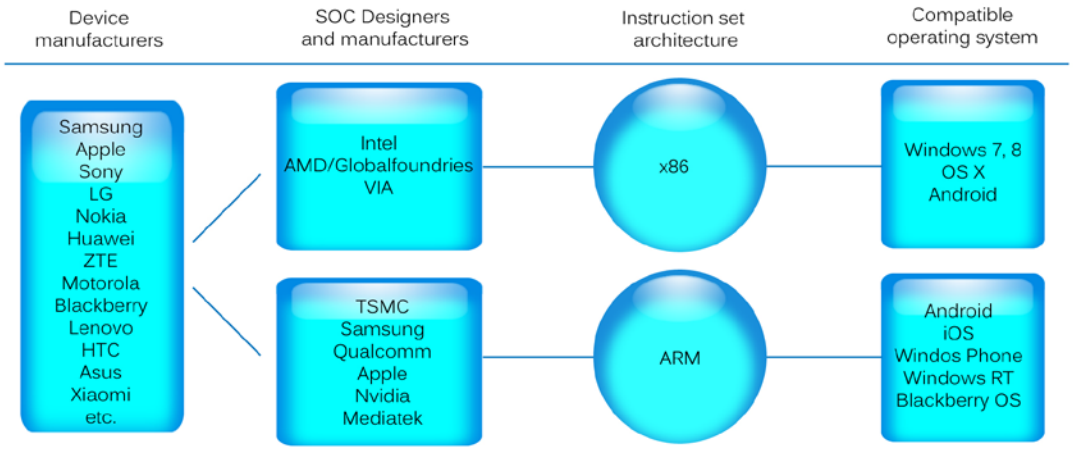


Figure 2: Simplified flowchart over the smart device industry with some of the key players as of November 2013

2.3.1 The smart device market behind the scenes

The smartphone market is strongly defined by Google and Apple and their operating systems for smartphones. As of the third quarter in 2013, Android based devices accounted for 81, 9% of smartphone sales worldwide and iOS accounted for 12, 1% respectively. (Gartner, 2013) These two operating system are most commonly used (solely for iOS) in smartphones based around the ARM instruction set architecture which is the leading instruction set used in 90% of smartphones. (Torres et al., 2013) Every SOC produced for smartphones commercially uses either the ARM or the x86 instruction set architecture.

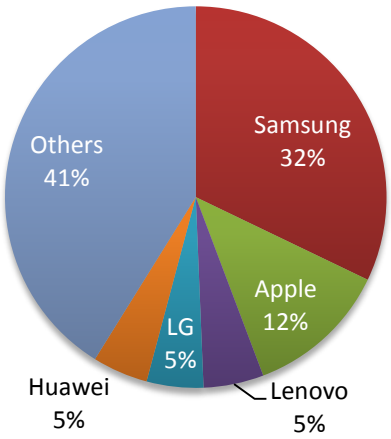


Figure 3: Smartphone sales by manufacturers 3Q13

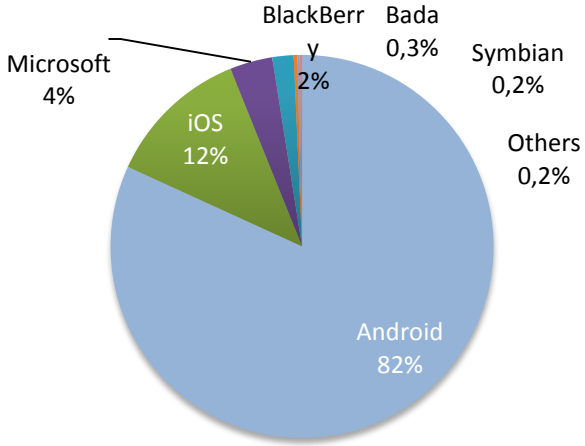


Figure 4: Smartphone sales by OS 3Q13

The instruction set architecture is related to programming and defines what data types, instructions, memory architectures and exception handling can be used. Certain operating systems are thereby designed after a certain instruction set architecture. (Faut et al., 1995)

ARM is a RISC (reduced instruction set computing) instruction set architecture which means ARM based processors requires significantly fewer transistors than x86 based processors. This is favorable regarding heat generation and power usage which makes ARM processors suitable for use in portable, battery powered devices such as smartphones and tablets. (Furber, 2000) The x86 instruction set architecture has primarily been used for more powerful processors designed for larger devices such as desktop and portable PC's. However, as manufacturing processes are being refined and ever made smaller it becomes possible to add more transistors into the SOC's chips making it eligible to manufacture x86 based SOC's in a smaller form factor suitable for smartphones. (Bourzac et al., 2013)

Leading MPU Suppliers ($M)

2012 Rank	Company	2011	2012	Percent Change	Percent Marketshare	Main Product Lines
1	Intel	37,435	36,892	-1%	65.3%	x86 PC, server MPUs
2	Qualcomm	4,152	5,322	28%	9.4%	ARM mobile app processors
3	Samsung (+Apple)*	2,614	4,664	78%	8.2%	ARM mobile app processors
4	AMD	4,552	3,605	-21%	6.4%	x86 PC, server MPUs
5	Freescale	1,210	1,070	-12%	1.9%	ARM and embedded MPUs
6	Nvidia	591	764	29%	1.4%	ARM mobile app processors
7	TI	510	565	11%	1.0%	ARM mobile app processors
8	ST-Ericsson**	660	540	-18%	1.0%	ARM mobile app processors
9	Broadcom	295	345	17%	0.6%	ARM mobile app processors
10	MediaTek	280	325	16%	0.6%	ARM mobile app processors

*Includes Apple's custom processors made by Samsung's foundry business.
Source: IC Insights **Cellphone IC joint venture to be dissovled by STMicroelectronics and Ericsson by 3Q13.

Figure 5: Leading microprocessor suppliers 2012. Image courtesy of IC Insights Inc.
(Lineback, 2013)

2.3.2 Instruction set architecture inventors

2.3.2.1 ARM; ARM Holdings plc.

The ARM instruction set architecture is owned by ARM Holdings plc. and is licensed together with chip designs to other micro architecture designers and manufacturers which many of them design their own SOC's incorporating memory, radios etc. based on the ARM instruction set architecture. ARM stands for Advance RISC Machines. (Shimpi, 2013)

Companies that produce ARM SOC's include Qualcomm, Samsung, Apple, Nvidia and many more, some of which both design and manufacture the SOC's and some which design the SOC's but uses contracted manufacturers such as the world's largest semiconductor foundry TSMC (Taiwan Semiconductor Manufacturing Company) for manufacturing.
(ARM Ltd, 2014)

2.3.2.2 x86; Intel Corporation

Intel is the world's largest semiconductor chip maker based on revenue, making CPU's and SOC's among other types of componentry for every kind of smart devices. In 1971 Intel created the world's first commercial microprocessor and has since then been best known for its PC processors. (Moore, 1996) More recently, Intel also has begun focusing on mobile computing, with one of the first big leaps towards a more mobile smart device market being the introduction in 2011 at the hardware fair Computex, of a new category in the segment for portable PC's called Ultrabooks. (Huang, 2011) Intel created a fund with 300 million dollars to subsidize computers built by manufacturers according to the new Ultrabook concept which incorporated a slim form factor and Intel's CULV (Consumer Ultra-Low Voltage) platform with energy efficient chips in order to fit into the new slim form factor where heat output and battery consumption is critical, yet with reasonably high performance levels.

Intel had even prior to the introduction of the Ultrabook concept been making CPU's with even lower power consumption called Intel Atom, since 2009. These CPU's were primarily intended for use in so called netbooks, which like the Ultrabook concept had a very small, slim form factor but without focus on performance and high processing power. (Magee, 2011)

The netbook segment saw a dramatic decrease in 2010 coinciding with the appearance of the Apple iPad and in 2011 with the introduction of Ultrabooks. (Arthur, 2011)

As there was no longer a strong market for the Intel Atom platform that made up the netbook segment, it was dramatically reinvented in 2013 with a heavily redesigned micro architecture called Silvermont, making it more suitable for smaller devices such as tablets and smartphones. This can be seen as the first major step in making smartphones x86 compatible, with the theoretical possibility of running x86 compatible software and OS's former developed for PC's. However, the performance issue is still evident as the Atom processors are not as powerful as CPU's designed for PC-computers and therefore not as suitable to run computer like software. (Shimpi, 2013) However, in 2011-09-13 Intel announced that it was going to cooperate with

Google in making it possible to run Android on devices based on Intel's Atom platform making it the first bond of x86 hardware and Android. (Antaranews, 2011)

Intel is both the owner of most patents associated with the x86 instruction set architecture and is also a semiconductor designer and manufacturer.

2.3.3 SOC designers and manufacturers

Besides Intel, there are other major corporations with big influence on the development of SOC's for smartphones, such as TSMC; the world's largest semiconductor foundry. It manufactures SOC's and other type of circuitry designed by architect designers such as Qualcomm, Apple and Nvidia among others. Although TSMC's budget for research is less than that of both Intel and Samsung, in 2013 TSMC was spending more than ever on research in order to keep the development rate high to reach smaller production nodes. (Hugosson, 2013) This can be seen as a clear sign of the performance race going on between SOC designers and also between manufacturers striving to offer the users more processing power and performance in relation to power consumption. (TSMC, 2014)

Because of the rapid growth of the smartphone market, the smartphone out of all of the smart devices has arguably seen the most noticeable evolution in recent years, and still is, with even the two largest x86 manufacturer and designers Intel and AMD shifting focus towards more efficient processors and SOC's for smaller devices such as tablets and smartphones. (Hugosson, 2013)

It is clear that the big players in the PC industry want a piece of the market already dominated by the established companies in the smartphone industry like Samsung, Qualcomm, Apple and Nvidia with many more. (Gartner, 2013)

One reason why Qualcomm is the worlds largest ARM microprocessor supplier is their strong partnership with Samsung; the world's largest smartphone manufacturer. The reason why Samsung uses Qualcomm SOC's in practically all of their premium smartphones for the international market including Sweden ought to be that Qualcomm had an early integration of 4G / LTE in their SOC's and also leading performance in processing power and graphics. The early and now wide integration of 4G / LTE in their SOC's is well suited for more developed markets with the 4g infrastructure in place. (McQueen, 2009)

In less developed markets, like big parts of China for instance, where 4G isn't yet the standard for mobile networks, the price/performance ratio is more important as Mediatek, a SOC designer of mid-level performance SOC's dominates the market. (Sangani, 2011)

2.3.3.1 Moore's law

The manufacturing process is the premise on which chip designers have to base their architectures on. Smaller manufacturing nodes makes the basis for performance increases of a chip as more complex architectures can be designed and implemented using more and smaller, thereby faster switching and more efficient transistors in the same physical area to increase the computational capacity and in the long term make them cheaper as less material is used.

The observation that the number of transistors in integrated circuits doubles roughly every 24 months is called Moore's Law and was first stated by and named after Intel co-founder Gordon E. Moore. (Mack, 2011)

2.3.4 Smartphone manufacturers

Regardless of what hardware specification and what SOC the device manufacturers use, it is ultimately the smartphones with their functionality and user experience that is being marketed to the customer. And the user experience and functionality of the smartphone is ought to be what matters to users regardless of hardware specification. But it is likely no coincidence that Samsung, the world's largest smartphone maker uses high performing, top of the class SOC's developed by themselves but also SOC's from Qualcomm in its best-selling smartphones. (Mick, 2012)

But performance, such as processing power and graphics performance is in many cases used as a strong marketing incentive, as Apple often highlights the performance increase of the chip used in every new incarnation of their iPhone and iPad. (Shimpi, 2013)

Regarding performance increases, the same is of course true for every other smartphone manufacturer but one of the most palpable recent incremental features on smartphones is the increase in screen size. Samsung has for instance implemented a larger screen for every new flagship device both in their Galaxy S series and their Galaxy Note Series of smartphones. In this case, additional graphical processing power is a necessity to manage the larger number of pixels on the larger displays. (Culpan, 2013)

2.3.5 Smartphone operating system platforms

It is evident that Android currently is the dominating OS for smartphones but the recent sales figures of course don't necessarily correspond to the actual current number of users or the established user base. (Arthur, 2013) This could especially be true for the Swedish smartphone market, as Telia, one of the major network operators in Sweden reported that the iPhone 5s was their bestselling smartphone in both October and November 2013 after the launch of the new model from Apple. This is a recurrent trend as the same thing happened with the iPhone 5 in 2012 after its launch. This is an indication of that iOS indeed has a strong position on the smartphone OS market in Sweden compared to the global sales statistics. (Sellebråten, 2013), (Gartner, 2013) This could be explained by the fact that iOS devices are relatively high priced compared to the average selling price of Android devices making the representation of iOS devise higher in developed countries than in developing countries. However, despite this, Telia said that Android smartphones where selling better than iOS smartphones for the rest of the year making it highly likely that Android is the most commonly used smartphone OS also in Sweden as it is globally.

The fact that ever more software is run in the web browser makes the conditions for software development and support more equal regardless of OS. Google have even launched an OS entirely based on their web browser Chrome with associated cloud based apps, called Chrome OS, intended for small notebooks. (Geer, 2009)

Microsoft currently has three OS's for consumers; Windows 8.1 intended for x86 based PC's, Windows RT intended for ARM based tablets and Windows Phone for smartphones. However, Microsoft is saying that they want to reduce the number of operating systems in the future, making the experience more unified regardless of the device. (Foley, 2013)

The fact that the performance and functionality of smartphone and tablets are increasing rapidly makes it viable to run the same apps and programs and even OS's regardless of the device itself. This might suggest that it matters less for the user experience what type of device is used as long as it satisfies the intended function. This progress has several advantages for users and even in corporate environments as the mobility and flexibility increases and thereby also the productivity. (Osterman Research, 2013)

2.4 Further definition of a smartphone

We now know who the leading hard- and software developers in the smart device market are and also some operative relations between them. We will now take a look at the definitions of smartphones and PC's respectively to possibly be able to augur the future development of smartphones.

2.4.1 Defining smartphones by hardware and software

There are many ways one can define the terms computer and smartphone respectively. The obvious difference between a computer and a smartphone has traditionally been the physical form factor. Another way of defining the difference between them is the specific hardware they use as computers typically are running X86 based hardware and software whereas smartphones are running ARM based hardware and software. As stated previously in this thesis, aside from Intel, every other SOC manufacturer is producing ARM SOC's. As the majority of smartphones are running ARM based hardware, computers and smartphones have for long also been definable by their OS's. But as x86 based SOC's are entering smartphones and former so called mobile OS's like Google Android with others are being ported and optimized for running on x86 based SOC's, it gets harder to define smartphones, both hardware and software wise. A smartphone can however more widely be defined as a mobile phone running an OS such as

Google's Andriod, Apple's iOS or Microsoft's Windows Phone, with the possibility to alter or add features and functionality such as apps and user interface. (Peiper, 2011)

2.4.2 Functionality further blurring the line between smartphone and PC

2.4.2.1 USB OTG (on the go)

USB on the go is a proprietary solution which makes it possible to connect USB devices to the smartphone. The interface is a mobile version of the regular USB interface typically found on computers. It opens up for more computer like functionality for smartphones such as mouse and keyboard as well as connecting storage devices such as external hard drives, flash memory and many other things. (Keys, 2013)

2.4.2.2 MHL, WiDi, Miracast

MHL is one of the standard interfaces for connecting secondary screens to smartphones. The interface uses the USB connection which sends out a digital mirrored picture of what the smartphone is showing on its screen. WiDi and Miracast are two other, of many technologies practically doing the same thing but operate wirelessly. (Maxwell, 2013)

2.4.3 Smartphone replaces ever more devices

Smartphones are in many cases capable of replacing other types of devices, such as compact cameras, portable gaming consoles, TV remotes and so on. And with ever more performance and functionality, taking advantage of cloud based services and applications; it is often seen as a replacement for traditional PC's as well. And it is true that while global shipment of smartphones is increasing, global shipment of traditional PC's decreased with 10% in the whole of 2013 compared to 2012. (Gartner, 2014) But one part of the PC industry that is still growing apparently, is gamers and enthusiasts as the sales of PC hardware for gamers and enthusiast is expected to grow 3 % annually until 2016. (Jon Peddie Research, 2013) As there still is a considerable performance gap and of course because of the difference in physical- and screen-size, there are several types of devices filling the gap between Smartphones and PC's.

2.5 Tablets, phablets, detachables and hybrids

Tablets were first introduced with the launch of the iPad in 2010. And in the fourt quarter of 2013, global tablet shipment surpassed global PC shipment. (IDC, 2013) With close enough performance, tablets can replace laptops in some respects today. But it is primarily because of the lower average selling price compared to laptops that tablet shipment has spiked. (IDC, 2013) Additional advantages besides the obvious portable form factor are that they're often specified with better battery life, dual cameras and with more sensors than a regular laptop. And in the higher price segment, tablets with Windows 8.1 often feature the same sort of connectivity for external hardware as a laptop. So in some respects, tablets can already be seen as a full replacement to laptops. (Dimestam, 2013)

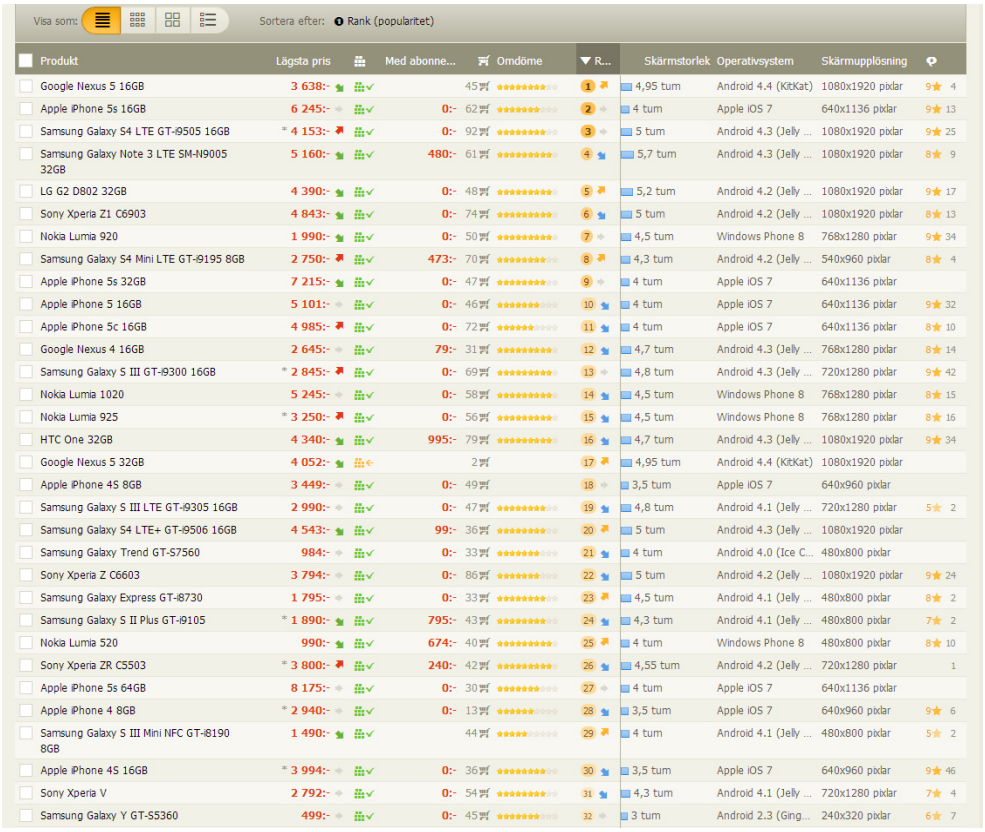
Even the line between tablets and smartphones are being blurred by so called phablets, basically smartphones with a screen size larger than 5, 5 inches. The phablet segment is growing rapidly as 20 million phablets were shipped in 2013. And it is predicted to grow to 120 million shipped units in 2018. (Juniper Research, 2014)

2.6 Smartphone comparison websites

The two most prominent price comparison sites on the Swedish market for comparing smartphones is www.prisjakt.se and www.pricerunner.se. They provide national price comparisons of gadgets and services along with specification comparisons for gadgets. One can also sort the gadgets, in this case smartphones, on certain aspects such as lowest price, screen size, OS, screen resolution and popularity. And what's interesting here for this thesis is that the most popular smartphones in Sweden seems to be highly priced and thereby high specced, high performing devices. The fact that it seems as there is a high correlation between popularity and

performance on the Swedish smartphone market indicates that the Swedish smartphone market is performance orientated or at least that there is a big interest for high performing smartphones.

However, the reason why these price comparison websites like Prisjakt and others don't view actual comparable performance such as processing power and actual battery life is naturally because they don't have access to the smartphones and therefore can't do any actual testing on them, something that www.mobil.se on the contrary do.



Visa som: Sortera efter: Rank (popularitet)

Produkt	Lägsta pris	Med abonne...	Omdöme	R...	Skärmstorlek	Operativsystem	Skärmupplösning
Google Nexus 5 16GB	3 638:-		45	1	4,95 tum	Android 4.4 (KitKat)	1080x1920 pixlar
Apple iPhone 5s 16GB	6 245:-	0:-	62	2	4 tum	Apple iOS 7	640x1136 pixlar
Samsung Galaxy S4 LTE GT-i9505 16GB	* 4 153:-	0:-	92	3	5 tum	Android 4.3 (Jelly ...	1080x1920 pixlar
Samsung Galaxy Note 3 LTE SM-N9005 32GB	5 160:-	480:-	61	4	5,7 tum	Android 4.3 (Jelly ...	1080x1920 pixlar
LG G2 D802 32GB	4 390:-	0:-	48	5	5,2 tum	Android 4.2 (Jelly ...	1080x1920 pixlar
Sony Xperia Z1 C6903	4 843:-	0:-	74	6	5 tum	Android 4.2 (Jelly ...	1080x1920 pixlar
Nokia Lumia 920	1 990:-	0:-	50	7	4,5 tum	Windows Phone 8	768x1280 pixlar
Samsung Galaxy S4 Mini LTE GT-i9195 8GB	2 750:-	473:-	70	8	4,3 tum	Android 4.2 (Jelly ...	540x960 pixlar
Apple iPhone 5s 32GB	7 215:-	0:-	47	9	4 tum	Apple iOS 7	640x1136 pixlar
Apple iPhone 5 16GB	5 101:-	0:-	46	10	4 tum	Apple iOS 7	640x1136 pixlar
Apple iPhone 5c 16GB	4 985:-	0:-	72	11	4 tum	Apple iOS 7	640x1136 pixlar
Google Nexus 4 16GB	2 645:-	79:-	31	12	4,7 tum	Android 4.3 (Jelly ...	768x1280 pixlar
Samsung Galaxy S III GT-i9300 16GB	* 2 845:-	0:-	69	13	4,8 tum	Android 4.3 (Jelly ...	720x1280 pixlar
Nokia Lumia 1020	5 245:-	0:-	58	14	4,5 tum	Windows Phone 8	768x1280 pixlar
Nokia Lumia 925	* 3 250:-	0:-	56	15	4,5 tum	Windows Phone 8	768x1280 pixlar
HTC One 32GB	4 340:-	995:-	79	16	4,7 tum	Android 4.3 (Jelly ...	1080x1920 pixlar
Google Nexus 5 32GB	4 052:-		2	17	4,95 tum	Android 4.4 (KitKat)	1080x1920 pixlar
Apple iPhone 4S 8GB	3 449:-	0:-	49	18	3,5 tum	Apple iOS 7	640x960 pixlar
Samsung Galaxy S III LTE GT-i9305 16GB	2 990:-	0:-	47	19	4,8 tum	Android 4.1 (Jelly ...	720x1280 pixlar
Samsung Galaxy S4 LTE+ GT-i9506 16GB	4 543:-	99:-	36	20	5 tum	Android 4.3 (Jelly ...	1080x1920 pixlar
Samsung Galaxy Trend GT-S7560	984:-	0:-	33	21	4 tum	Android 4.0 (Ice C...	480x800 pixlar
Sony Xperia Z C6603	3 794:-	0:-	86	22	5 tum	Android 4.2 (Jelly ...	1080x1920 pixlar
Samsung Galaxy Express GT-i8730	1 795:-	0:-	33	23	4,5 tum	Android 4.1 (Jelly ...	480x800 pixlar
Samsung Galaxy S II Plus GT-i9105	* 1 890:-	795:-	43	24	4,3 tum	Android 4.1 (Jelly ...	480x800 pixlar
Nokia Lumia 520	990:-	674:-	40	25	4 tum	Windows Phone 8	480x800 pixlar
Sony Xperia ZR C5503	* 3 800:-	240:-	42	26	4,55 tum	Android 4.2 (Jelly ...	720x1280 pixlar
Apple iPhone 5s 64GB	8 175:-	0:-	30	27	4 tum	Apple iOS 7	640x1136 pixlar
Apple iPhone 4 8GB	* 2 940:-	0:-	13	28	3,5 tum	Apple iOS 7	640x960 pixlar
Samsung Galaxy S III Mini NFC GT-i8190 8GB	1 490:-		44	29	4 tum	Android 4.1 (Jelly ...	480x800 pixlar
Apple iPhone 4S 16GB	* 3 994:-	0:-	36	30	3,5 tum	Apple iOS 7	640x960 pixlar
Sony Xperia V	2 792:-	0:-	54	31	4,3 tum	Android 4.1 (Jelly ...	720x1280 pixlar
Samsung Galaxy Y GT-S5360	499:-	0:-	45	32	3 tum	Android 2.3 (Ging...	240x320 pixlar

Figure 6: The most popular smartphones according to www.prisjakt.se as of 2013-11-18

2.7 How to measure smartphone performance; benchmark applications

Performance in this matter means how good a device does in certain areas or within certain aspects of use. In this thesis performance is primarily related to the actual processing power, how well smartphones can view graphical content on the screen, how long the actual battery life is and so on. There are several applications for measuring performance in many aspects and quantifying it into comparable numbers. In most cases these performance tests gives a good reference as to how well the smartphone performs and this will of course also correlate as to what the user experience is going to be like within the operating system and applications. The primary purpose of benchmark applications is then naturally to reflect the real performance in regular use. Applications made for testing a smart device's performance are called benchmark applications and has for long existed for traditional computers but as the performance levels of smartphones increases, similar benchmark applications have also become more relevant for mobile platforms. (Shimpi, 2013)

One can argue that as the hardware in a smartphone is so closely coupled together and that the parts are not interchangeable as they might be in a PC, the most relevant would be to measure overall system performance and it probably is but there are applications for testing each component of the SOC separately, such as the CPU, GPU, RAM etc.

Graphical performance of a smartphone is directly related to both the GPU and the screen of the device. But other parts of the SOC can also affect graphics performance as the CPU and RAM has to match the performance of the GPU in order to not be bottlenecks in the system. (Shimpi, 2013)

The SOC as a whole is naturally the most critical piece of hardware aside from the screen when it comes to power drawn from the battery. Thereby the power usage of the SOC and other hardware in combination with the capacity of the battery gives the basis for how long the battery life will be of the device. But of course it then depends on how the smartphone is used and what software is run. (Carrol et al., 2010)

As many benchmark applications there are, as few services are there presenting actual performance figures from these kinds of benchmark applications for smartphones. Tests of new smartphones are often published online including performance tests. But it's hard to find a complete performance comparison of the majority of the smartphones, especially on the Swedish market.

Examples of popular benchmark applications for mobile platforms are Antutu, 3DMark, Quadrant, RealPi, Vellamo, Passmark, Google Octane and many more.

2.7.1 Deficiencies and shortcomings with using benchmark applications for performance comparisons.

Benchmarking is the most concrete way of getting a comparable measurement of a smartphones performance but there are some deficiencies with using benchmark applications for performance comparisons.

Several third party smartphone reviewers has concluded that some manufacturers let the SOC expose a certain performance mode, raising the operating frequencies of the CPU and GPU only in certain benchmark applications in order to attain higher scores. It can be argued that this then doesn't reflect the actual performance of the smartphone when used for other types of applications and everyday use. This can also make comparisons somewhat unfair if this is just implemented for some of the smartphones on the market. Anandtech has investigated this further and even made a list of affected smartphones and benchmark applications and it is clear that several manufacturers include these types of optimization when running certain benchmarks. (Shimpi, 2013)

Futuremark which is the creator of the benchmark app 3DMark has even publicly delisted specific smartphone models that they suspect are cheating. Futuremark says that the smartphones in question fail to adhere to the fairness policy which requires that the 3DMark app is treated by the smartphone as any other app.

Thermal throttling is another issue that can affect performance levels. When the CPU or GPU are experiencing a heavy workload for some time they tend to produce a lot of heat and as a consequence of that the frequencies can be reduced in order for the SOC to not overheat. This is typically not evident when benchmarking as the duration of the tests usually isn't long enough to raise the temperatures that much. Some SOC's even raise the thermal limit as to what temperature thermal throttling should be enabled when running certain benchmarks. (Shimpi, 2013) Thermal throttling is not as common but could be evident on high end SOC's for instance when playing demanding 3D games for a long period of time.

Yet another issue is that all the benchmark applications are not available for every OS, making it somewhat hard to compare smartphones with different OS's with each other. This is true for some of the benchmarks but not all, web based benchmarks can for instance be run independent of OS.

Although there are some issues with measuring performance of the SOC, these benchmarking methods is still regarded as being the most relevant way of comparing performance between smartphones.

2.8 Smartphone usage in Sweden

It's apparent that smartphone usage has dramatically increased over the last years. Even though the adoption rate of smartphones has increased and still is increasing, the most prominent aspect regarding smartphones in Sweden is that they are taking over the connected smart device market. In 2009 the vast majority of people in Sweden had a mobile phone with the ability to connect to the internet but only 18% was using it to do so. According to .SE, 65% of the population over 12 years old is now using their mobile phones to connect to internet. (Figure 7)

And for the age group 26-35 years old 85% are using internet in their mobile phone on a daily basis. (Findahl, 2013)

Smartphone usage has especially increased among younger people where it went from 22% to 62% between 2011 and 2012 among 12-15 year olds. In 2013, 93% of them had a smartphone and 78% was using it on a daily basis for connecting to the internet. It is clear that young people are driving this development. (Figure 8)

In total 90% of the Swedish population between 12-45 years old are using a smartphone occasionally and 75% are using it on a daily basis. For the Swedish population 12+, those figures are 67% and 47% respectively. 53% in total have had their latest mobile phone less than a year.

The PC-computer is still the most commonly used smart device for connecting to the Internet in Sweden although new purchases of smart devices are more leaning towards mobile devices such as smartphones and tablets. (Findahl, 2013)

Out of all of the daily Swedish smartphones users more people are using their smartphone than their computer to read emails and the evening news and almost as many are using their smartphone as opposed to their computer for playing games online; (38% vs. 48%), reading daily news on the web; (45% vs. 56%).

Even though the computer is still the main smart device on the Swedish market for some activities on the internet, like watching streaming television and writing emails, the increasing mobile trend is clear regarding online usage of smartphones.

The survey done by the .SE foundation shows that Sweden is a highly developed country regarding the adoption rate and usage of smartphones.

Regarding the actual smartphone devices, both of the Swedish price comparison web sites www.prisjakt.se and www.pricerunner.se generally lists the most popular smartphones by users as being in the higher price range with new hardware specifications as well as supporting the latest versions of OS's. This coupled with the fact that the majority (53% from the survey done by .SE) of the Swedish population has had their current mobile phone for less than one year indicates that the Swedish smartphone market in particular is focused around high performing smartphones.

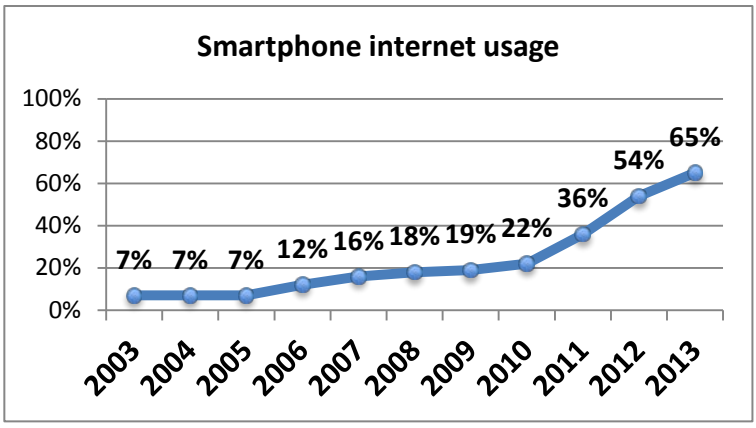


Figure 7: Percentage of Swedish population using internet in their smartphone

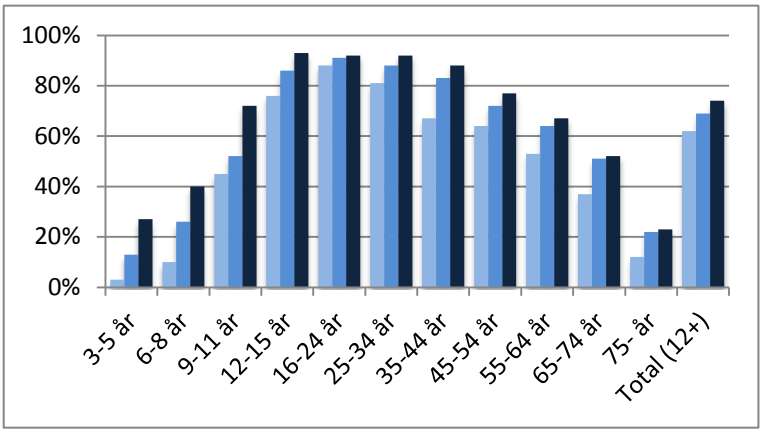


Figure 8: Percentage of different age groups among the Swedish population who uses internet in their smartphone daily(dark blue) and occasionally(light blue).

3. Method

This part describes the survey method that is used, with the purpose of answering the main problem definition of the thesis.

3.1 Choosing the target audience

The primary target audience for this thesis is readers of the website www.mobil.se. Readers of www.mobil.se as target audience is an obvious choice for this thesis as its purpose is to investigate the smartphone usage and what's important when choosing new smartphone together with creating a concept and prototype for the website. The target audience was attained directly from www.mobil.se and in addition to being suitable for the purpose of investigating if there is an interest for performance comparisons of smartphones on the website, the target audience is a potential large quantity of people which gives the opportunity to get a high number of responses on the survey to give a good basis for analysis.

In addition to the target audience attained from www.mobil.se, a reference group consisting of students and alumni from the media technology program at KTH was chosen. The idea with this reference group is that they're not necessarily visitors and readers of the website but that they rather fall in the category of potential new users of the website as they supposedly have technical interest and expertise in this area. The purpose here is first and foremost to see if the reference group shows interest for a smartphone performance comparison service as Mobil is of course aiming to get as many visitors as possible on their website and thereof new users such as this reference group.

3.2 Choice of research method

In order to answer the main question for this thesis, there was needed additionally support for that performance comparisons of smartphones is relevant for people who are interested in smartphones and especially for the readers and potential readers of the website www.mobil.se. To examine this, statistics from a quite large group within the target audience was needed for determining the relevance of comparing performance for smartphones. For this, a survey in the form of an internet based questionnaire was chosen as the main research method on the grounds that it is easy to publish and reaches out to many people in a short period of time. This also gives the opportunity to gather both quantitative and qualitative data in digital form which facilitates the summary of results and analysis. (Arnkvist et al., 2012)

3.3 Internet based questionnaire

A survey in the form of an internet based questionnaire was made to help determine user habits and what's important for the target group when choosing a new smartphone. The questionnaire intended to help determine the need and interest for comparing performance of smartphones and also help decide the content and functionality of the web prototype for comparisons of smartphones.

The questionnaire was designed mostly with closed questions, with the possibility to choose a given answer. This was done in order to give a clear summary as the responses don't have to be read and interpreted as opened questions do. It also gives clear statistics and minimizes the time taken to fill out the questionnaire which thereby increases the odds for a high response rate.

The questions in this survey were formulated as follows, with the stated purpose specified all with remembrance to answer the thesis main question.

Question number 1 and 2 about gender and age:

Intended to present the target group clearer and possibly see differentiations in it.

3. What type of phone do you use as your primary mobile phone?

Intended to see the share of smartphone users, which the survey is most relevant for.

4. Is your primary smartphone a private phone or a work phone? (Who is paying for it?)

Intended to see if the respondents have chosen their smartphone themselves or gotten it from the employer.

5. What type of operating system does your primary mobile phone have?

If the operating system was not included in the survey list, the respondent could enter it manually.

This question makes further categorizing possible. Intended to show how performance orientated (interest and knowledge) and satisfied users are depending on operating system used.

6. What brand is your primary mobile phone?

The selection of brands that the respondents were able to choose as answer for this question was the 13 most popular smartphone brands according to prisjakt.se as of 2013-11-16. This was done under the assumption that people have smartphones from the most popular brands on the Swedish market. If the brand of the respondents' phone wasn't in the list, they could enter the name of the brand manually.

A categorizing question intended to show satisfaction, usage, popularity by brand but also maybe determine emphasize on what brands should be performance tested and included for Mobil.

7. What is the model name of your mobile phone?

(The selection of smartphones that the respondents were able to choose as answer for this question was the 17 most popular smartphones from each manufacturer according to prisjakt.se as of 2013-11-16. This was done under the assumption that people have those smartphones that are most popular on the Swedish market. If the device was not included in the list, the respondent could enter the name of the device manually.)

Intended to determine if the target group generally has high performing, high priced smartphones and to compare the popularity ratings for smartphones on prisjakt.se with what people actually use or to see if a specific device stands out in any way. The answers here could also be compared to Mobil's data base with what models are already tested.

8. For how long have you had your current mobile phone?

Intended to determine the typical life span of smartphones, maybe if so called flagship devices are kept longer and if the ones having high performing devices are more performance orientated. Also intended for determining how many and what models would be relevant to include in a smartphone performance comparison service.

9. Are you satisfied with the user experience of your mobile phone?

Categorizing question to see if users are more satisfied whether they value smartphone performance. Also to be able to generalize what operating systems are the most satisfying in terms of user experience. If the respondent answered that they were unsatisfied with the user experience, they were asked to describe the user experience in an open text field.

10. What is important to you when choosing a new smartphone?

Intended to see what aspects out of affordability, performance, battery life, storage capacity, camera, design, OS, hardware specification, 4G/LTE, and screen size are most important for comparisons when choosing smartphone, thus indicating what comparative characteristics would be suitable for including in a prototype for performance comparisons. Also intended to determine if a performance comparison service is relevant.

11. What is the most important factor when choosing a new smartphone?

The respondents were able to choose one of the categories in question number 10 as the most important factor when choosing a new smartphone.

This question was included in order to single out what single aspect is most important and what people are most interested in when choosing a new smartphone. It was also included as a backup question to question number 10 if the respondents should have put in the same answers for all the different categories.

12. Have you ever visited pricerunner.se or prisjakt.se to compare smartphones?

Intended to show if the target group are familiar with comparing smartphones online. If so, that would be an incentive to why they would also want to also compare actual performance of smartphones which Prisjakt and Pricerunner can't do but what the prototype of this thesis is aiming to address.

13. Have you ever used any benchmark application for smartphones?

Shows if there are any interest in testing performance of smartphones by the target group and if so, are they regular visitors of www.mobil.se or not?

14. Do you look for performance tests online before choosing a new smartphone?

Performance such as processing power, graphics performance, memory performance, battery life.

Maybe the most concrete question to whether there is a demand for a performance comparison of smartphones by the target audience.

15. What do you use your smartphone for?

Intended to what types of performance test would be relevant and best suited for smartphone performance comparisons.

16. How often do you visit the website www.mobil.se?

Intended to see how often the target audience visits the website mobil.se which is the site where a service for smartphone performance comparisons is intended. This could also give an indication of what the most dedicated readers of mobil.se are interested in and how well the respondents represent the imagined target group.

Also intended for the reference group to see if the target audience is familiar with Sweden's leading website for mobile IT which is the site where performance comparisons of smartphones are thought to be presented if some sort of implementation of the prototype of this thesis would be carried out.

3.4 Execution

The questionnaire was created using Google Forms and the questions were further refined by first sending out the questionnaire internally to the editorial staff of www.mobil.se as well as my supervisor at KTH for feedback. The questionnaire was written in and published in Swedish for the website www.mobil.se because of the target audience being Swedish as the website www.mobil.se is in Swedish. The questionnaire was distributed on www.mobil.se and was published 2013-11-29.

The publication can be found here: http://www.mobil.se/nyheter/vad-r-det-viktigaste-n-r-du-v-ljer-mobil#.Uv7PUvl5M43

A slightly adapted version of the questionnaire as well as translated into English was also sent out directly via email on 2013-11-11 to 501 engineering students and alumni from the media technology program at The Royal Institute of Technology (KTH).

The email addresses to the media technology students and alumni was retrieved at 2013-11-08 from www.bilda.kth.se under registered participants for the courses DM228X - thesis project, DM129X - bachelor thesis project and DM1578 – program integrating course.

3.5 Method criticism/survey errors

The decision of using mostly closed questions in the questionnaire survey was well suited for this thesis as it provided clear statistics which didn't need additional interpretation as open questions would have needed. But the risk with using only closed questions with given answers such as multiple choice questions, is that the respondent could accidentally choose the wrong answer that was not intended to choose, or that the respondent mechanistically selects the same answer for all the questions which for instance has a scale from 1 to 5. (Arnkvist et al., 2012) This could potentially have affected the result and is an error worth mentioning. But as the respondents for this survey was of large quantity and there is a reasonable spread in the results it is unlikely to have distorted the outcome to a large extent.

Another potential error with the survey could be that the same person could have responded several times and therefore affected the result. For instance, the question about smartphone OS usage shows a clear over representation of people using Windows Phone, compared to the actual market share which could be an indication of Windows Phone users being more engaged in the subject or that the same users have responded several times to distort the statistics.

3.6 Method analysis

The reliability of the survey may be considered high. As multiple choice questions were used, the responses will always be statistically distributed over the given choices. The distribution might of course vary over time as conditions on the smartphone market changes. The

distribution might also change if another target audience is selected such as a narrower, more niched group of people that doesn't use or don't have any interest in smartphones.

The validity of the survey is a possible source of error but as multiple choice questions were used there was little room for misinterpretation. However, the survey could arguably have included more direct questions with purpose to give a more direct answering to the thesis main problem. This would possibly have given the thesis an even clearer conclusion but at the expense of a more isolated answer not applicable in a larger context.

The method chosen for this thesis's survey has given rather satisfactory results in order to answer the thesis main question and give a comprehensive view on the subject.

4. Results

The questions and results from the questionnaire is presented in English in favor of this thesis and a complete English version of the questionnaire that was published and sent out can be found in the appendix section.

The questionnaire published on www.mobil.se was open for respondents between 2013-11-29 and 2013-12-13. In those two weeks it got 1363 responses which of 1282 where from Android-, iOS- and Windows Phone-users.

The questionnaire that was sent out via email to KTH media technology students was open for respondents between 2013-11-11 and 2013-11-20. 121 out of 501 people responded to the survey which gives a response rate of 24, 1%.

The results from the primary target audience, namely the readers of www.mobil.se is being presented with the exception of question 1 about gender, question 2 about age, question 6 about smartphone brand and question 7 about smartphone model. The results from these 4 questions is not presented due to discretion and of competitive reasons, thus those results are only presented internally to the editorial staff of www.mobil.se.

The results for question 9, 10 and 11 are divided into sub groups for user of Android, iOS and Windows Phone respectively. This is done for several reasons. Firstly, these are the three major operating systems both on the global market and on the Swedish market and they represent 94,2 % of respondents in this survey. Furthermore, there are not as many benchmark applications for other platforms, making performance comparisons for these other platforms difficult to realize. Android-, iOS- and Windows Phone-users also represent the primary target group for the website and magazine Mobil and www.mobil.se. All this makes users of the three leading smartphone operating systems relevant and the sectioning of these three also makes for a more interesting presentation.

Results from some of the questions in the questionnaire that was sent out to the KTH reference group is discoursed along with the results from the same question for the primary target group; readers of www.mobil.se in those cases that the question and the results are found especially relevant for this thesis. In those cases, the difference in results between the two target audiences is discussed in the analysis section.

4.1 What type of mobile phone do the respondents use?

Figure 9:

What type of phone do you use as your primary mobile phone?

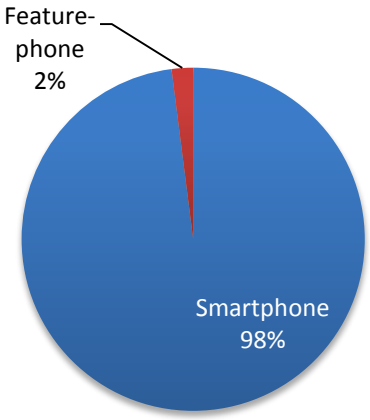


Figure 10:

Is your primary mobile phone a private- or a work-phone? (Who is paying for it?)

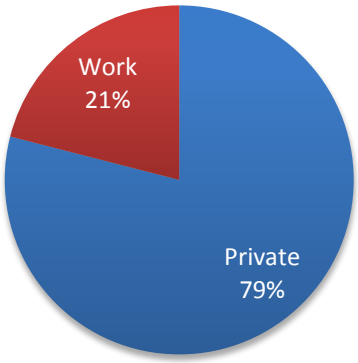


Figure 11:

What operating system does your mobile phone have?

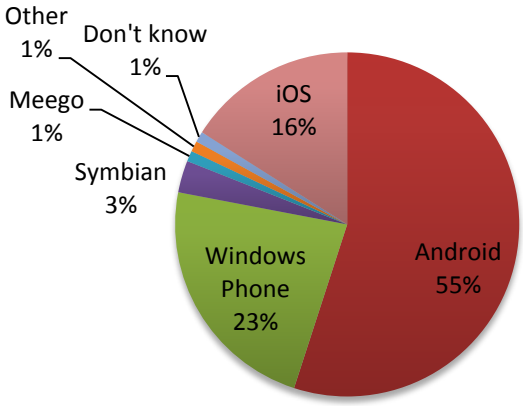
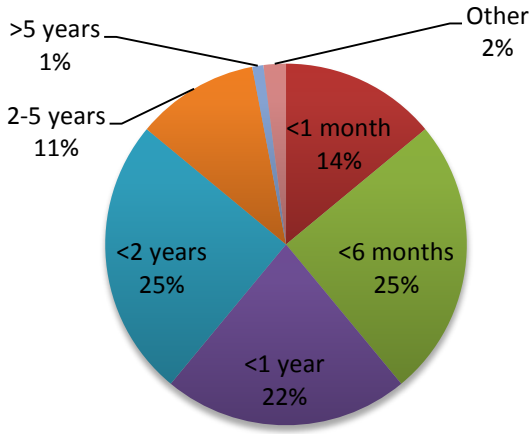


Figure 12:

For how long have you had your current mobile phone?



98 % of the respondents in this survey use a smartphone as their primary mobile phone which makes the rest of the results relevant for this thesis' main subject as it is difficult to measure performance levels on feature phones. The division between private phone owners and work phone owners shows that 79 % in this survey has paid for their phones themselves which makes the latter questions about prioritizing factors when choosing a new mobile phone interesting.

The proportions regarding operating system shows a clear representation of the three largest operating systems for smartphones and somewhat confirms their domination on the market. However, these proportions do not necessarily show a nationwide representation nor can they be said to be corresponding to the readers of www.mobil.se. It rather gives an indication of what technology interested Swedes that visits www.mobil.se thinks. There is a slight over representation of Windows Phone users in this survey compared to what could be expected, which indicates that Windows Phone users might be more eager to answer these types of surveys or particularly committed to their OS.

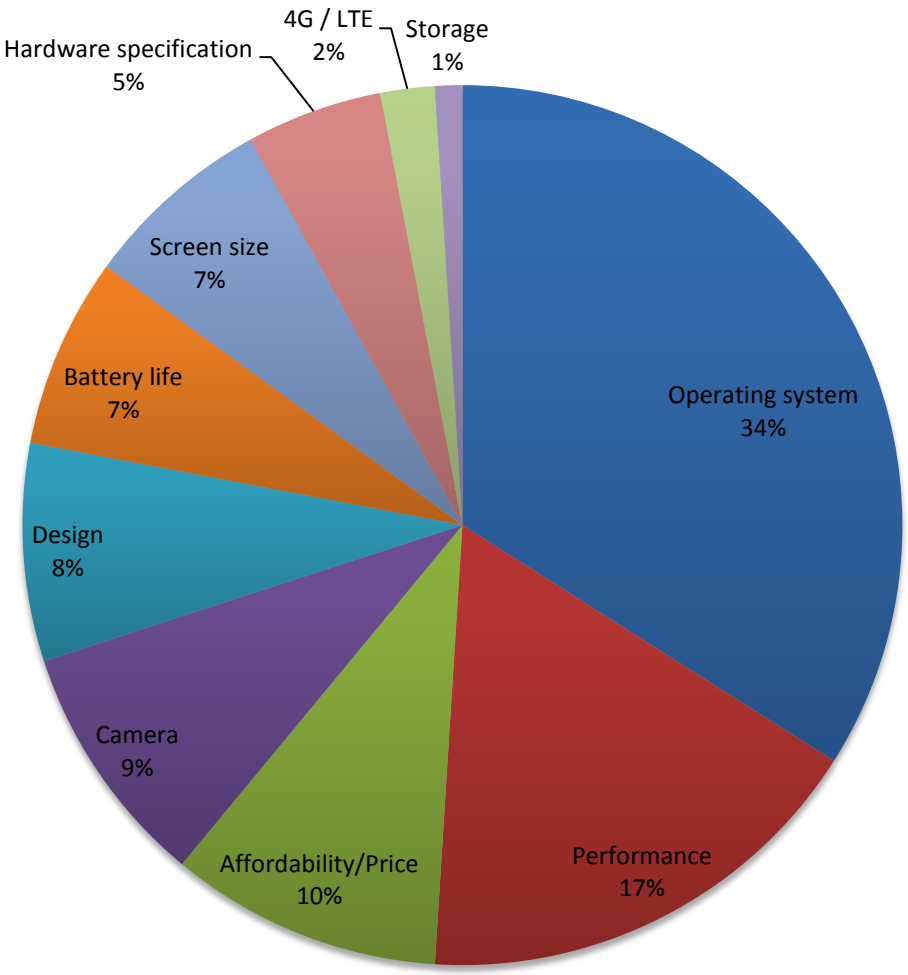
There is a large group of people who have got a new phone in <6 months or less and the majority of the respondents seems to change phone at least every year, with a vast minority keeping their phone for more than 2 years. *Read more about these results in the analysis, chapter 5.2.*

Figure 9, 10, 11 and 12 shows the results on question 3, 4, 5 and 8 in the questionnaire.

4.2 The most important factor when choosing a new smartphone

Figure 13:

What is the most important factor when choosing a new smartphone?
Android, iOS and Windows Phone-users
(Question 11)



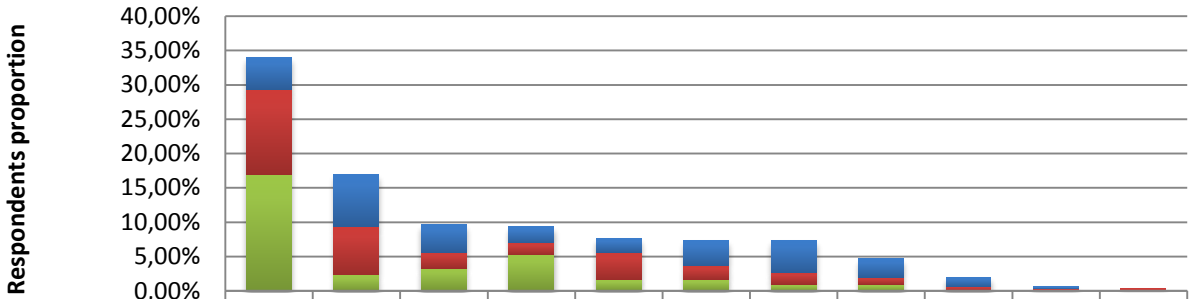
The results (Figure 13) shows which are the most important factors and of highest priority by users when choosing a new smartphone. In the operating system category it can be assumed that the range of applications from the app stores respectively is included. The category "performance" refers to processing power, graphics performance and memory performance as stated in the questionnaire. Of course, there could be several other important factors like for instance contract conditions but this survey focuses on the properties of the devices themselves.

It is no doubt the operating system and then the performance are the two factors that matters most for the respondents in both target audiences when choosing new smartphone.

Read more about these results in the analysis, chapter 5.3.

Figure 14:

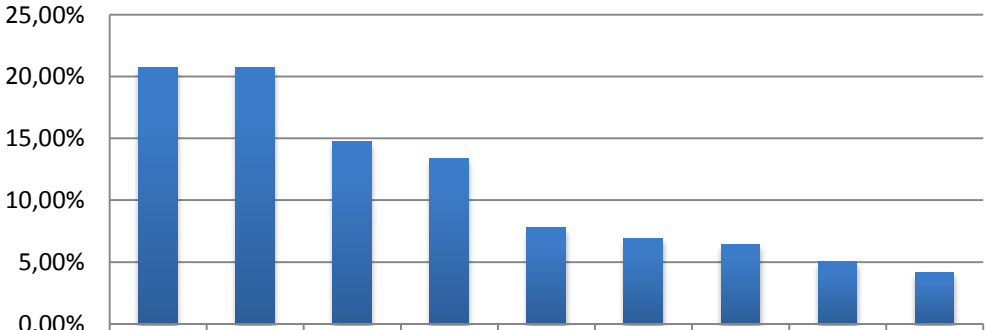
What is the most important factor when choosing a new smartphone?
Divided in Android-, iOS- and Windows Phone-users
(Question 11)



	Operating system	Performance	Affordability/Price	Camera	Design	Battery life	Screen size	Hardware specification	4G / LTE	Storage	Don't know
Android	4,66%	7,67%	4,00%	2,33%	2,00%	3,67%	4,67%	2,67%	1,33%	0,33%	0,00%
iOS	12,33%	7,00%	2,33%	1,67%	4,00%	2,00%	1,67%	1,00%	0,67%	0,33%	0,33%
Windows Phone	17,00%	2,33%	3,33%	5,33%	1,67%	1,67%	1,00%	1,00%	0,00%	0,00%	0,00%

Figure 15:

What is the most important factor when choosing a new smartphone?
KTH Reference group
(Question 11)



	Operating system	Performance	Battery life	Camera	4G / LTE	Affordability/Price	Screen size	Storage	Hardware specification
Respondents proportion	20,74%	20,74%	14,75%	13,36%	7,83%	6,91%	6,45%	5,07%	4,15%

For users of the three major operating systems; Android, iOS and Windows Phone, the opinions differ as to what is the most important factor. (Figure 14)

Android users put performance as the most important factor, with operating system and screen size tied on second place. iOS and Windows Phone-users agree on that the choice of operating system is most important. iOS users put performance on second place and design on third. Windows Phone users value the camera as the second most important factor while performance comes third.

The priorities for the KTH reference group (Figure 15) are showing to be a bit different from what the respondents form www.mobil.se states. Particularly performance and battery life seems to be of higher value for the KTH students than to the readers of Mobil.

Read more about these results in the analysis, chapter 5.3.

4.3 The most important factor when choosing a new smartphone categorized by Android-, iOS and Windows Phone-users. (Question 11)

Figure 16:
Android

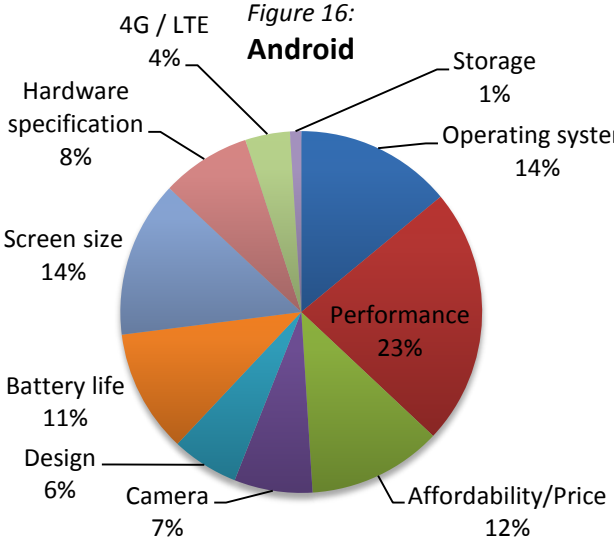


Figure 17:
iOS

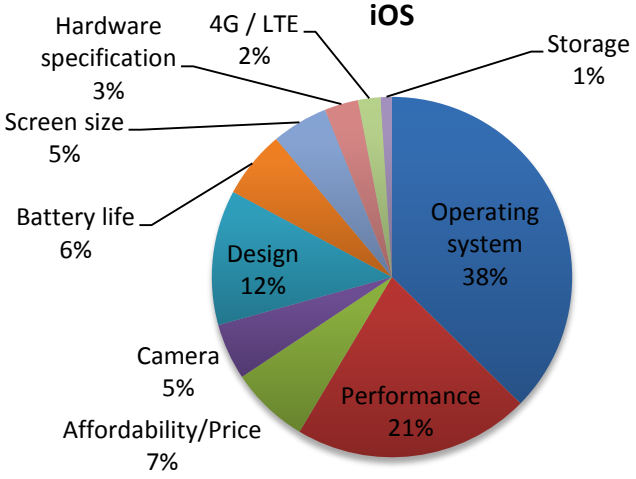
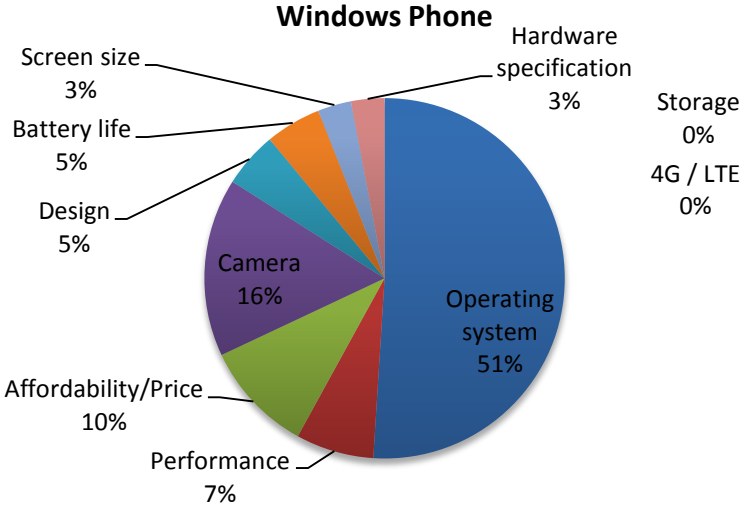


Figure 18:
Windows Phone

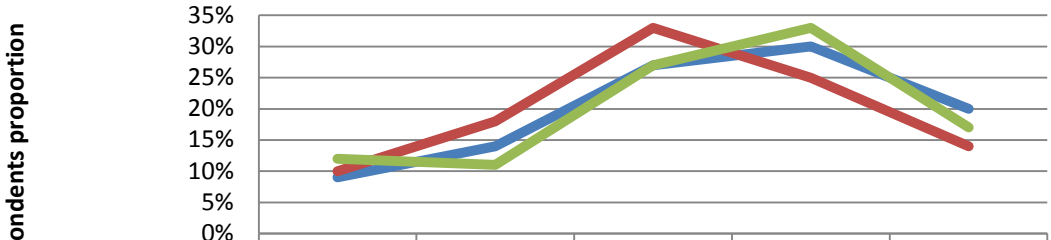


Read more about these results in the analysis, chapter 5.3.

4.4 Important factors when choosing a new smartphone rated by Android, iOS and Windows Phone-users. (Question 10)

Figure 19:

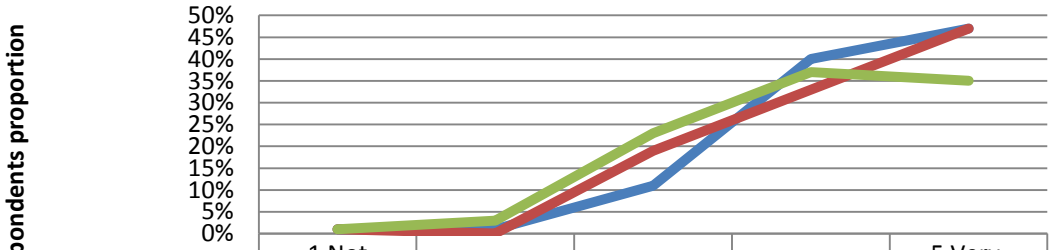
Price and affordabillity



	1 Not important	2	3	4	5 Very important
Android	9%	14%	27%	30%	20%
iOS	10%	18%	33%	25%	14%
Windows Phone	12%	11%	27%	33%	17%

Figure 20:

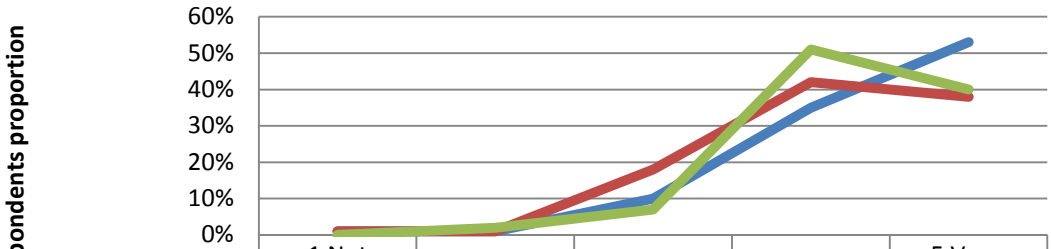
Performance



	1 Not important	2	3	4	5 Very important
Android	1%	1%	11%	40%	47%
iOS	1%	0%	19%	33%	47%
Windows Phone	1%	3%	23%	37%	35%

Figure 21:

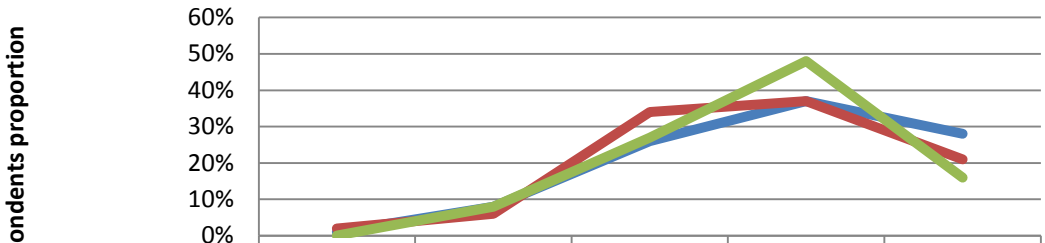
Battery life



	1 Not important	2	3	4	5 Very important
Android	1%	1%	10%	35%	53%
iOS	1%	1%	18%	42%	38%
Windows Phone	0%	2%	7%	51%	40%

Figure 22:

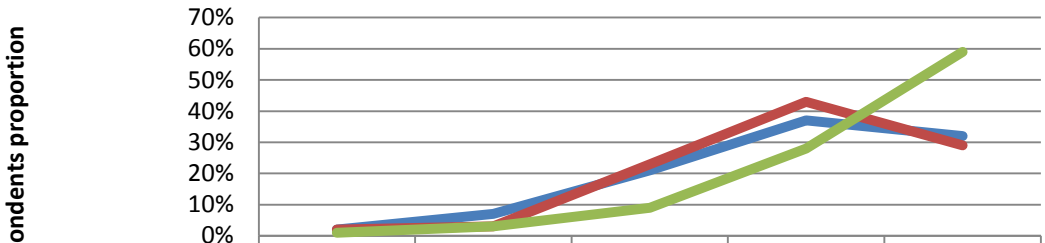
Storage



	1 Not important	2	3	4	5 Very important
Android	1%	8%	26%	37%	28%
iOS	2%	6%	34%	37%	21%
Windows Phone	0%	8%	27%	48%	16%

Figure 23:

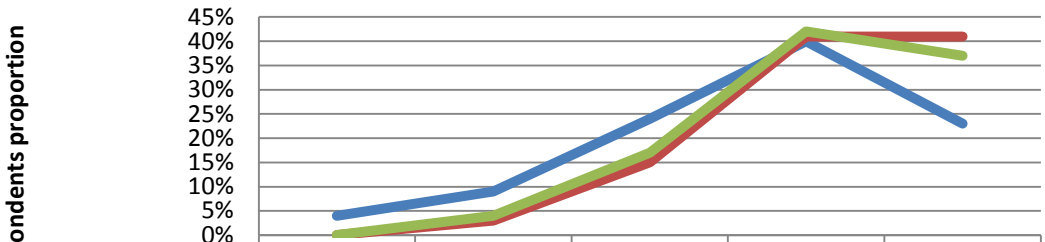
Camera



	1 Not important	2	3	4	5 Very important
Android	2%	7%	21%	37%	32%
iOS	2%	3%	23%	43%	29%
Windows Phone	1%	3%	9%	28%	59%

Figure 24:

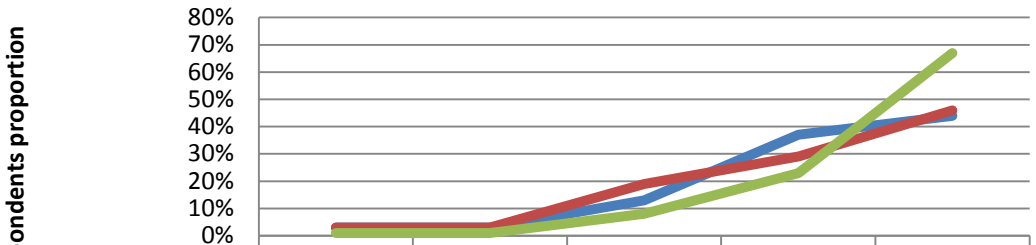
Design



	1 Not important	2	3	4	5 Very important
Android	4%	9%	24%	40%	23%
iOS	0%	3%	15%	41%	41%
Windows Phone	0%	4%	17%	42%	37%

Figure 25:

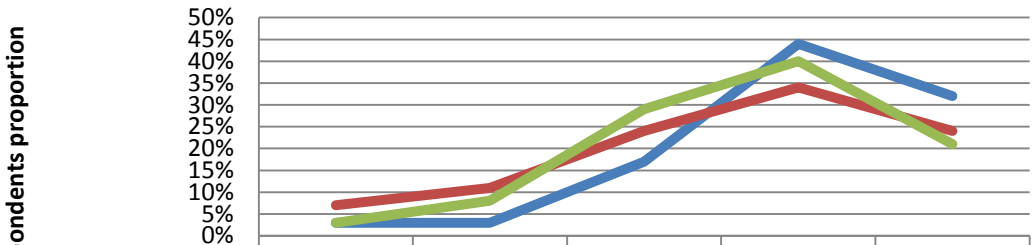
Operating system



	1 Not important	2	3	4	5 Very important
Android	3%	3%	13%	37%	44%
iOS	3%	3%	19%	29%	46%
Windows Phone	1%	1%	8%	23%	67%

Figure 26:

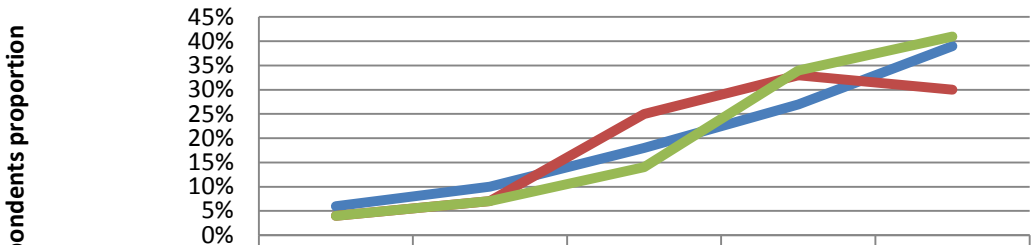
Hardware specification



	1 Not important	2	3	4	5 Very important
Android	3%	3%	17%	44%	32%
iOS	7%	11%	24%	34%	24%
Windows Phone	3%	8%	29%	40%	21%

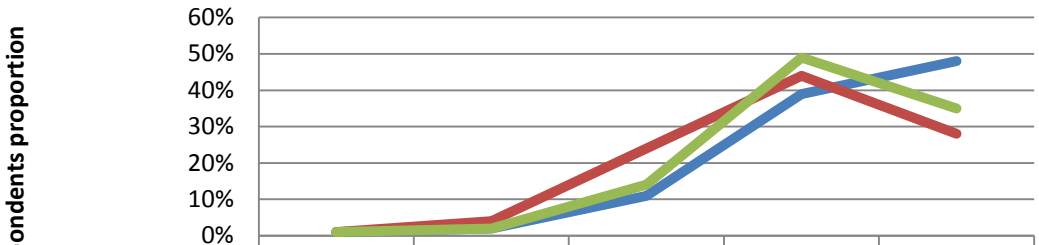
Figure 27:

4G / LTE support



	1 Not important	2	3	4	5 Very important
Android	6%	10%	18%	27%	39%
iOS	4%	7%	25%	33%	30%
Windows Phone	4%	7%	14%	34%	41%

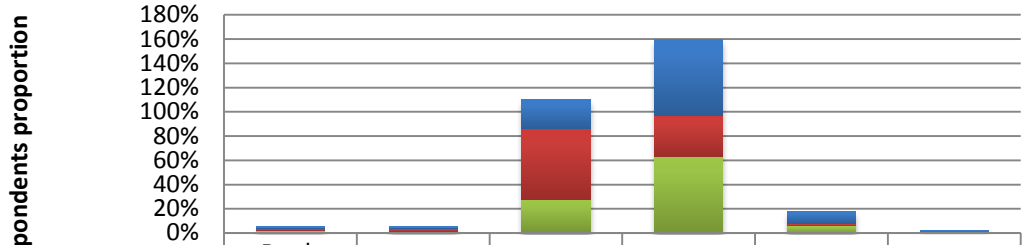
Figure 28:



	1 Not important	2	3	4	5 Very important
Android	1%	2%	11%	39%	48%
iOS	1%	4%	24%	44%	28%
Windows Phone	1%	2%	14%	49%	35%

The charts 19 to 28 are the results for question 10. They show the difference in valuation for certain factors that Android-, iOS and Windows Phone-users have when they are choosing a new smartphone. The overall result is that users of the three leading smartphone operating systems seem to value all of the given factors quite high. But there are some differences to be found in what users value depending on which OS they are using.

Figure 29:



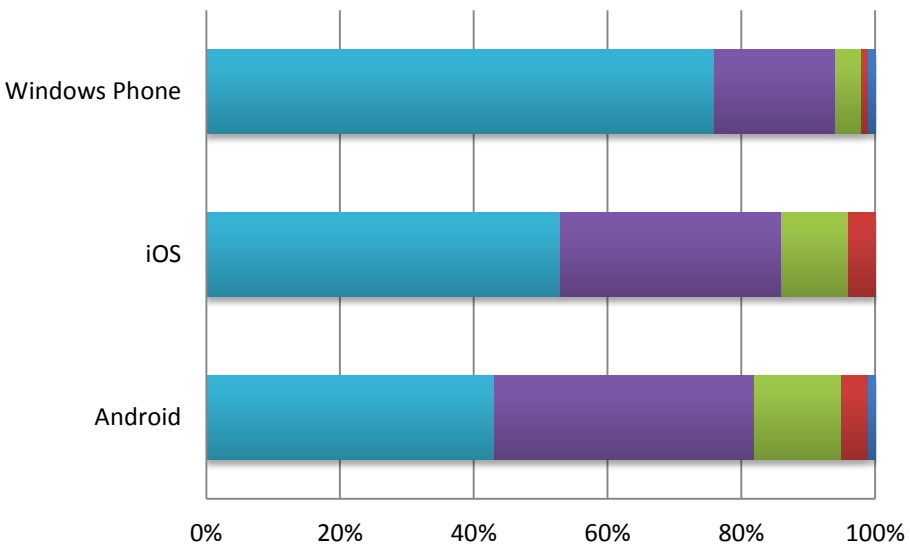
	Don't know	3"	4"	5"	6"	7"
Android	1%	1%	24%	63%	10%	1%
iOS	2%	3%	58%	34%	2%	1%
Windows Phone	2%	1%	28%	63%	6%	0%

5” Seems to be the most popular screen size for smartphones overall. However, naturally the majority of iOS users prefer 4” as all the iPhones since the iPhone 5 has a 4” screen. What’s interesting is that 34% of iOS users would prefer a 5” screen rather than 4” which could be seen as an indication that there is a demand for an iPhone whit larger display, something Apple might launch in the coming future.

Read more about these results in the analysis, chapter 5.4.

4.5 What do users of the major operating systems think of the user experience? (Question 9)

Figure 30:



	Android	iOS	Windows Phone
5 Very satisfied	43%	53%	76%
4	39%	33%	18%
3	13%	10%	4%
2	4%	4%	1%
1 Unsatisfied	1%	0%	1%

It seems like users of Windows Phone are most satisfied with their user experience. Despite it not having the same range of apps as Android and iOS, the actual users seems quite satisfied. The results could however be an indication of that most Windows Phone users have made a more conscious, deliberate choice of smartphone since Windows Phone arguably, does not yet appeal to a broader audience in the same way Android and iOS does.

Read more about these results in the analysis, chapter 5.5.

Figure 30 shows the results on question 9 in the questionnaire.

4.5.1 How could the user experience be made better?

If the respondents answered that they were unsatisfied, they were asked to describe the user experience in an open text field. Here is a summarized view of the number of people that answered the open part of question 9 and what properties or categories these users of smartphones with the three different OS's were unsatisfied with:

Please describe your user experience if you are not very satisfied (open part of question 9):

Figure 31:

Properties	Android	iOS	WP	Tot
Low performance, slow	25	5	1	31
Batterylife	18	5	3	26
OS related, openness, apps	8	6	11	25
Software bugs	12	2	1	15
Small screen	10	3	1	14
Camera	11	2		13
Missing functionality, HW & SW	6		4	10
OS addons by manufacurers	9			9
Storage management, no SD card slot	5	2	1	8
Poor call quality, reception	4	2		6
Build quality	5			5
High price		1		1

The most prominent cause to a bad user experience seems to be that the phone feels slow, sluggish and has long response time when using the touch screen and the UI. Short battery life seems to bother people too. A common complaint among Android users was that smartphone manufacturers often install additional apps that are annoying, takes up storage and can't be removed. Complaints from Windows Phone users were that there weren't enough apps and some iOS-users thinks the OS is too closed for customization.

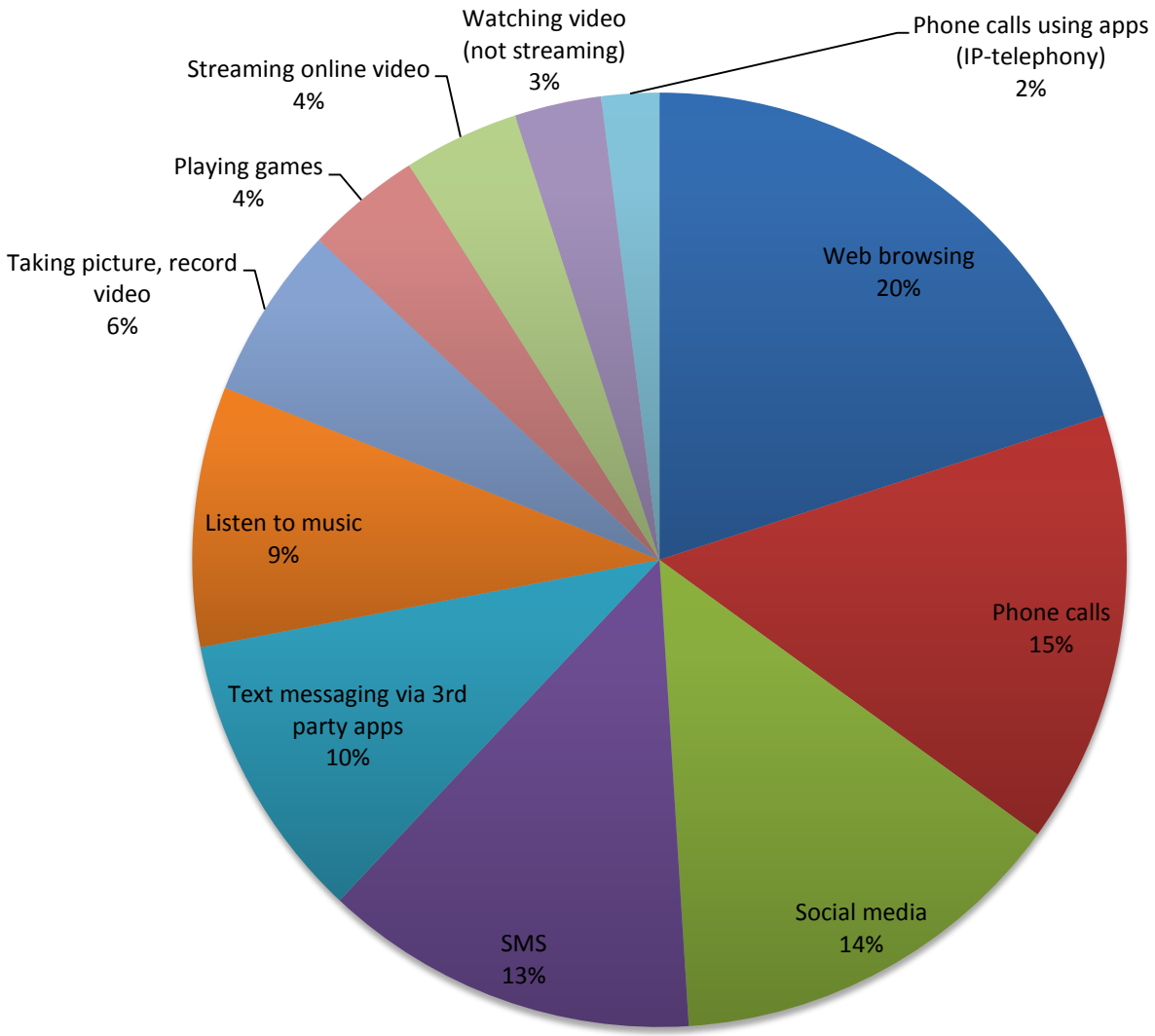
Read more about these results in the analysis chapter 5.5.1.

4.6 What do the respondents use their mobile phone for? (Question 15)

Figure 32:

Activities that the respondents use their phones for several times a day

Android-, iOS- and Windows Phone-users



This pie chart shows what users of the three major smartphone operating systems most commonly use their mobile phone for several times a day. The original primary function of the mobile phone gets beaten by the activity web browsing which 20% state they use their phone for several times a day. 15% make phone calls as often.

Based on this survey, traditional mobile operators may not be particularly worried that users no longer make normal phone calls as IP telephony is the activity used the least. Only 2 % said they use IP telephony several times a day while 36 % say they never use it. Comparing the use of standard SMS and text messages using other apps gives a more even distribution where 13 % say they use SMS several times a day and 10 % states they use apps such as iMessage, Hangouts, Messenger, Rebtel, WhatsApp, Kik or alike for messaging.

Read more about these results in the analysis, chapter 5.6.

4.7 Comparisons and awareness before choosing smartphone.

Figure 33:
Have you ever visited pricerunner.se or prisjakt.se to compare smartphones?
(Question 12)

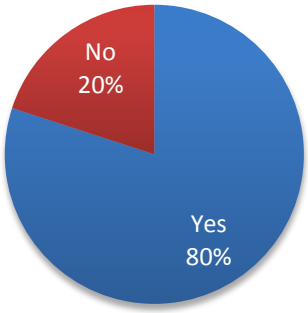


Figure 34:
Have you ever used any benchmark application for smartphones?
(Question 13)

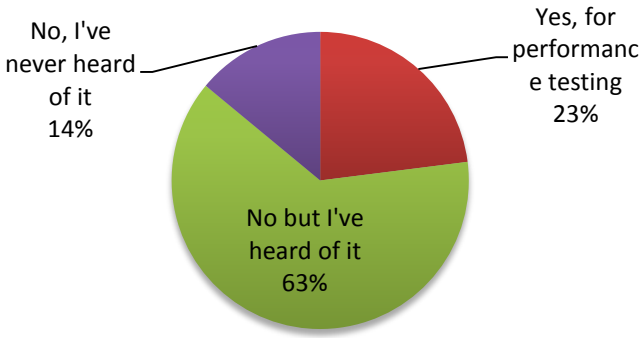


Figure 35:
Do you look for performance tests online before choosing a new smartphone?
(Question 14)

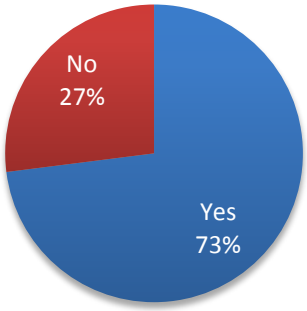


Figure 36:
How often do you visit the website www.mobil.se?
(Question 16)

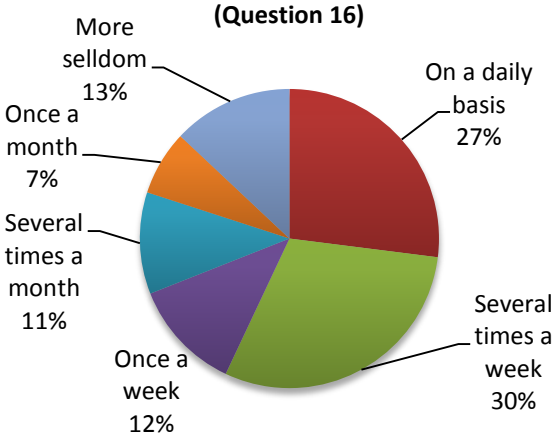
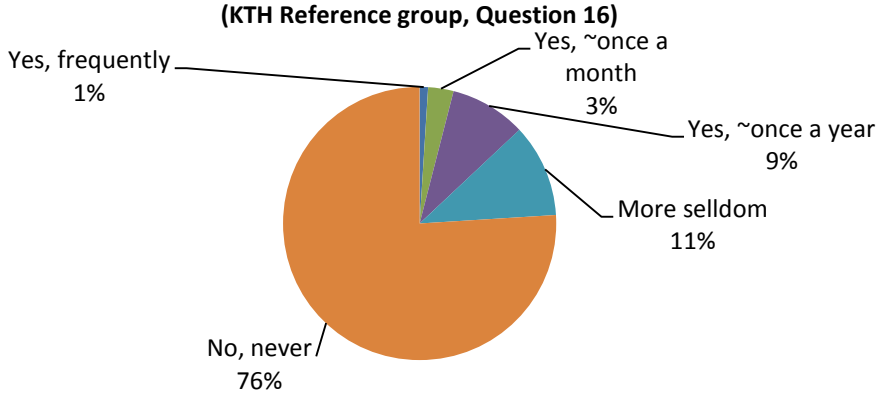


Figure 37:
Have you ever visited the website www.mobil.se?
(KTH Reference group, Question 16)



As much as 80 % say they have used any of the websites www.prisjakt.se or www.pricerunner.se to compare specifications or prices of smartphones. This shows that the respondents probably are interested in comparing smartphones and also making a conscious choice when choosing a new smartphone. (Figure 33)

Further, 23 % of the respondents have used a benchmark application on a smartphone with the purpose of testing its performance. An additional 63 % say they have heard of benchmark applications and only 14 % states they haven't. (Figure 34)

73 % of the respondents also look for performance tests online before choosing a new smartphone which means that the interest for performance comparisons of smartphones is particularly high. (Figure 35)

The vast majority of the respondents visit the website www.mobil.se several times a week or more often which shows that the respondents represents the target audience well. (Figure 36)

The fact that 76 % of the respondents from the reference group aren't readers of www.mobil.se but still seems to have a high interest in smartphone performance makes them a crowd of potential new users of the website. (Figure 37)

Read more about these results in the analysis, chapter 5.7.

5. Analysis and interpretation of the questionnaire results

5.1 Background

The questionnaire survey was carried out with the purpose of answering the thesis main question, which is: "*Is there a great demand and interest for comparing performance between smartphones and if so, how can it be presented on Sweden's leading website for mobile IT to make it easier for consumers to compare smartphone performance?"*, in order to determine if there is a demand for a service presenting smartphone performance figures on the Swedish market and more specifically on the website www.mobil.se. The overall result shows that performance and battery life for smartphones indeed is of high interest and in some cases; performance seems to be of highest priority for people when choosing a new smartphone. The overall interest from the respondents to make a conscious choice when choosing a new smartphone also seems to be high. This confirms that there is a big interest for smartphone performance comparisons and gives a positive response to the main question of this thesis and can thereby also be seen as a motive for implementing such a service on the website www.mobil.se. In the next chapter, a prototype of such a service will be formed and further recommendations for such a service will also be given. But first, let's look at the questionnaire survey results more closely.

5.2 What type of mobile phone do the respondents use?

It turns out that 98 % of the respondents use a smartphone and only 2 % uses a feature phone as their primary mobile phone. (Figure 9) As the target audience was readers of www.mobil.se it is not strange to see that such a high proportion is using a smartphone. Because this study features a more niched target audience, these numbers well exceeds the previous study made by Flurry (Reed, 2013) which said 86 % of the Swedes between 15 and 64 years of age have a mobile phone. But the fact that such a vast majority of respondents uses a smartphone proves that the desired target audience in that matter is reached since the main purpose was to determine the interest and demand for a service presenting *smartphone* performance comparisons.

The results also show that 79 % of the respondents have a private phone rather than a work phone (Figure 10) which also is to be seen as an interesting outcome as performance comparisons is thought to primarily target individual people but such a service could also be of big potential interest to companies choosing smartphones, especially if a dynamic price comparison is implemented together with the performance comparisons.

The survey confirms the domination of the three leading OS's in the market with Android together with iOS and Windows Phone representing 94 % of the users (Figure 11). The proportion are not necessarily representative to what the Swedish population uses nor does they necessarily represent the proportions of the different OS users visiting www.mobil.se but the purpose with dividing these categories of users was also to see whether there were any differences in what people value when choosing smartphones and if the interest in performance was any different as there are few benchmark applications working across the three OS's. As 55 % of the respondents use Android and most of the benchmark applications tested by Mobil is compatible with Android it's a good fit (Figure 11).

In total 61 % of the respondents answered that they have had their mobile phone for less than 1 year, 25 % said they have had it for less than 2 years and only 14 % have had their phone for more than 2 years (Figure 12). As www.mobil.se started performance testing their reviewed phones and tablets about 1, 5 years ago, from when this survey ended, the potential target audience and the fact that most people seem to change phone less than every 2 years make it more than suitable to launch a smartphone performance comparison service on their website

based on the documented data from the benchmark applications. Furthermore, the fact that people change phones this frequent gives even more support for that the demand for this type of service would be high.

5.3 The most important factor when choosing a new smartphone

It is clear that the choice of operating system is what matters most to people when choosing a new smartphone as 34 % of the respondents put it as the number one factor (Figure 13). The reasons for this could be that the operating system is what most defines the user experience of a mobile phone including the range of apps and other types of software functionality. It is also likely that many of the users have been accustomed with the experience and usability of a certain operating system and has gotten used to it and is therefore loyal to it (Figure 13). The second most important factor with 17 % of respondents thinking it's the most important, shows to be performance, such as stated in the survey as processing power, graphics performance and memory performance which could equal the responsiveness of the device in situations like starting the device, loading apps or websites, the fluidness when playing 3D games or viewing high resolution content, multitasking abilities and so on. The fact that performance comes in as the second most valued factor for the primary target group in this survey shows that there is indeed a high interest in smartphone performance and that it is a very important factor for people choosing new smartphones which makes a service presenting comparable smartphone performance figures highly eligible.

The overall least important factor with barely 1 % of the votes turned out to be storage (Figure 13). The reasons for this could be that many phones have the ability of increasing the internal storage by installing a micro SD card. Another reason could be that cloud storage is getting more and more usual. Some phones even come bundled with extensive cloud storage solutions out of the box.

Comparing important categories for users of the three leading operating systems shows a slight difference in priorities. 23 % of Android users put performance as the most important factor (Figure 16). This could be because of the wide range of Android phones compared to devices running iOS or Windows Phone making the user experience quite different depending on the performance of the device. And as there are many different smartphone brands running Android, the release of new models is frequent, making the competition for performance among the different brands and models dense. The choice of operating system then naturally comes in second, for 14 % of Android users but screen size is apparently equally important to the respondents using Android as the OS (Figure 16). This is surely because of the wide range of Android phablets compared to the range of iOS and Windows Phone devices. What sets iOS users apart is that they value design more than the other with 12 % of iOS users marking it as the most important factor (Figure 17). Windows Phone users on the other hand values the camera more than other, with 16 % saying it is the most important factor (Figure 18). This also reflects the characteristics and marketing for the smartphones running the different operating systems respectively.

The media technology students that made up the KTH reference group shows an even higher interest for performance regarding smartphones as over 20 % mark performance as the most important factor when choosing a new smartphone, tied for the first place with operating system (Figure 15). This implies that there is an even higher interest in smartphone performance comparisons in this target group that can be seen as potential new visitor's readers of www.mobil.se. This further shows that presenting performance comparisons for smartphones seems relevant for www.mobil.se. Another category that is rated higher by the reference group is battery life (Figure 15) which is another property that Mobil has tested for their reviewed smartphones and documented, which could also be presented alongside the performance comparisons.

5.4 Important factors when choosing a new smartphone rated by Android-, iOS- and Windows Phone-users respectively

Figure 19-28 shows how users of the three different operating systems rated the importance of the factors when choosing a new smartphone, on a scale from "1: not important" to "5: very important". The key takeaway from this is that the lines often follow each other, meaning that users irrespective of operating system, many times value the factors equally as much. But what's interesting with these line charts is that they also show the delicate difference.

Worth mentioning here is that a greater proportion of Android users than iOS and Windows Phone users think the following factors are very important; "price and affordability" (Figure 19)," battery life" (Figure 21), "storage" (Figure 22), "hardware specification" (Figure 26) and "screen size" (Figure 28).

A greater proportion of iOS users than the others only marked the factor "design" as being very important (Figure 24).

A greater proportion of Windows Phone users than the others seem to think that the factors; "camera" (Figure 23), "operating system" (Figure 25) and "4G / LTE support" (Figure 27) are very important.

None of the groups of users seem to think that any of the given factors are particularly unimportant although many Android users have put the factor "design" (Figure 24) far down the scale and iOS users have marked the factor "price and affordability" (Figure 19) far down the priority scale while more Windows Phone users than the others have marked "performance" (Figure 20) closer to "not important".

Figure 29 is showing a complimentary question about the importance of the screen size, namely; "What screen size do you prefer?" The majority of both Android and Windows Phone users prefer 5" on their phones and the majority of iOS users prefer 4". But it's obvious that there is a big demand for larger screens on smartphones running iOS as a staggering 34 % of iOS users would rather prefer a 5" screen in contrary to the 4" screen that is fitted to the current iPhones on sale. (December 2013) This is something Apple hardly will ignore for the launch of the next iPhones.

5.5 What do users of the major operating systems think of the user experience?

76 % of Windows Phone users state they are very satisfied with the user experience of their mobile phones (Figure 30), even though only 7 % of those lists performance as the most important factor when choosing a new smartphone (Figure 18). There could be many explanations for this. Either Windows Phone users are already satisfied with the performance of their phones which could be explained by well optimized software for the hardware of the phones. Or maybe they consider the performance levels being insignificant as long as they get the functionality and appearance of the operating system and apps. Speaking of apps, the shortage of them available for the Windows Phone OS doesn't seem to have had a large negative effect on the result of user experience satisfaction in this survey.

53 % of iOS users are very satisfied with the user experience while only 43 % of Android users say they are very satisfied (Figure 30).

A natural explanation to that both Windows Phone- and iOS users are more satisfied with the user experience than Android users could be that the two former OS's are more optimized to a specific set of hardware whereas Android is used by many different smartphone manufacturers and on a larger variety of hardware including smartphones in the budget segment with low performance levels impairing the user experience of the OS.

5.5.1 What could be made better for an improved user experience?

If the respondents thought that they were unsatisfied with the user experience, they were asked to describe the user experience in a text field below question 9. Figure 31 shows a summary of what properties the respondents answered that they were particularly unsatisfied with.

The problem that the phone feels slow and unresponsive seems to bother Android users most, which might again be because iOS and Windows Phone have a closer relation between hardware and software whereas Android is free to use for every smartphone manufacturer and thus has to work on many types of different hardware. However, overall it is undeniably the performance levels and secondly battery life which users seem to care most about according to the responses on this question as 31 people said that they were in some way unsatisfied with the performance of the phone whereas 26 people stated they were unsatisfied with the battery capacity or battery life of their phones. There were complaints about the OS's and there seems to be some specific characteristics for the OS's respectively that bothers people. When it comes to Android people seems to have problems with software bugs and glitches, such as apps suddenly closing, that the phone is not responding on inputs etc. Another palpable matter seems to be the additional UI skins and preinstalled widgets or apps that phone manufacturers ad as a layer on top of Google's Android as people say that it makes the phone feel slow and sometimes unintuitive to use.. Some iOS users state that the OS is too limited for optimization and personalization and that they feel bound to the "Apple ecosystem". Complaints about the Windows Phone OS were mostly related to the shortage of 3rd party apps and functionality.

And although the factor "storage" doesn't seem to be of great importance to people when choosing a new phone (Figure 13), some people are unsatisfied with the storage management, particularly on Android as users claim to have problems moving apps between internal and external storage, whereas there were 2 iOS users missing the possibility to extend the internal storage with a micro SD card.

5.6 What do the respondents use their phones for?

Figure 32 shows that web browsing is the activity that most of the respondent's (20 %) use their mobile phones for several times a day. Most of the other activities in this survey also require internet connection, such as social media, streaming online video, text messaging via apps etc. The result here then is not totally unexpected since the survey from .SE clearly shows that 65 % of the Swedish population uses internet in their phones daily. (Findahl, 2013)

So, the most common usage of a smartphone seems to be web browsing out of all the activities listed in question 15 in this thesis´ survey. Therefore, it seems most relevant that smartphones should perform well when browsing the web from a user's standpoint, for a good user experience.

For testing the performance of web browsing, there are web based performance benchmark apps, such as Google Octane which then seems highly relevant to include in a service for presenting smartphone performance comparisons. Mobil has tested and documented web browsing performance for most of their review smartphones which is very appropriate.

Only 2 % state that they use IP telephony or voice-over IP several times a day. The low usage could be because the network operators mainly charge for the data used while a generous time for regular phone calls often is included in the subscription fee.

5.7 Comparisons and awareness before choosing smartphone

80 % in this survey (Figure 33) have used www.pricerunner.se or www.prisjakt.se to compare smartphones which shows that the interest in comparing smartphones before purchase, to make a conscious choice is high. 23 % of the respondents have used benchmark apps to test smartphone performance and additionally 63 % have knowledge about smartphone performance

benchmarking (Figure 34) which coincides well with the fact that Mobil tests and documents benchmark results for every reviewed smartphone.

73 % of the respondents (Figure 35) are already looking for performance tests online before choosing a new smartphone but smartphone performance comparisons is rare and hard to find, especially on the Swedish market, which shows that Mobil could benefit from having a smartphone performance comparison service on their website.

76 % of the respondents from the reference group aren't readers of www.mobil.se and yet they show an even greater interest in smartphone performance (Figure 14 and 15) which makes them a group of highly potential new users who would likely get more reasons to visit the website if smartphone performance comparisons were presented there.

6. Recommendations on content and functionality for the smartphone comparison service prototype

The analysis of the survey results showed, as described in the former chapter that a suitable suggestion for Mobil would be to implement some sort of service for presenting smartphone comparisons on their website www.mobil.se.

In order to exemplify what kind of functionality, usability and layout such a service could and should include on the basis of the analysis for the survey, a web prototype is hereby developed to realize the concept. The web prototype was created using mainly the CMS (content management system) “WIX” (www.wix.com), together with “Microsoft Excel” and “Adobe Photoshop” and incorporates the benchmark results documented by Mobil for their reviewed smartphones.

Note that this thesis does not include a final implementation of a smartphone comparison service on the website www.mobil.se but a visual and functional prototype for Mobil, with guidelines regarding functionality, design and usability for such a service.

To start with, a specification with desired functionality was established:

- Visualization of the documented performance benchmark results and battery life tested by Mobil using bar charts.
- The possibility of sorting the results on different categories such as device, performance benchmark or battery life.
- Linking the visualized results to the review on www.mobil.se, of the corresponding smartphone models.
- Links to the used benchmark applications respectively for explanation of the tests.
- Potential implementation visualized on www.mobil.se.

Propositions and recommendations on further implementation and realization will be raised in chapter 8.

7. Prototype for a smartphone comparison service on www.mobil.se

The purpose of the prototype is to develop a concept for an online performance comparison service on the website www.mobil.se. The prototype is therefore created according to the "self-design" decision style. (Spool, 2009) The prototype is not intended for end users but for the internal staff and developers of www.mobil.se

The prototype contains all the documented results from the benchmark applications: Antutu, Quadrant, Vellamo, Passmark and Google Octane, along with battery testing and boot up times for smartphones and tablets tested by Mobil from the beginning of 2012 till 2014-02-02.

Mobil has been testing smartphones in several benchmark applications and for this prototype, the most relevant benchmark results were chosen. As smartphone performance is in focus, benchmark results from Antutu, Quadrant and Passmark was included as they test the processing power, graphics performance and memory performance of the devices. To include all three of these increases the coverage of devices as for instance iOS is only compatible with Passmark out of three. And Windosw Phone is not compatible with Quadrant. Android supports all the featured benchmarks in this prototype which is appropriate as the majority of the respondents in the survey done in this thesis use Android. (Figure 11) Further the benchmark app Vellamo is included which measures HTML5 performance, relevant for browsing and online content. Google Octane is a web based benchmark application compatible with every OS and is run in the browser. The results from this benchmark should be highly relevant as web browsing turned out to be the most common activity for users in the survey. (Figure 32) As Mobil also tests the battery life and startup times for the devices, results with those parameters are also included. Battery life also showed to be a very important factor for people when choosing a new smartphone which also makes it interesting to include in this prototype. (Figure 21) So there are a variety of test results included in the prototype to increase the comparability of smartphones and tablets when it comes to performance and battery life.

The color coded rectangles is there to illustrate the corresponding description below the figure. A screenshot without the rectangles and with the inclusion of all the devices featured in the prototype can be found in the appendix section.

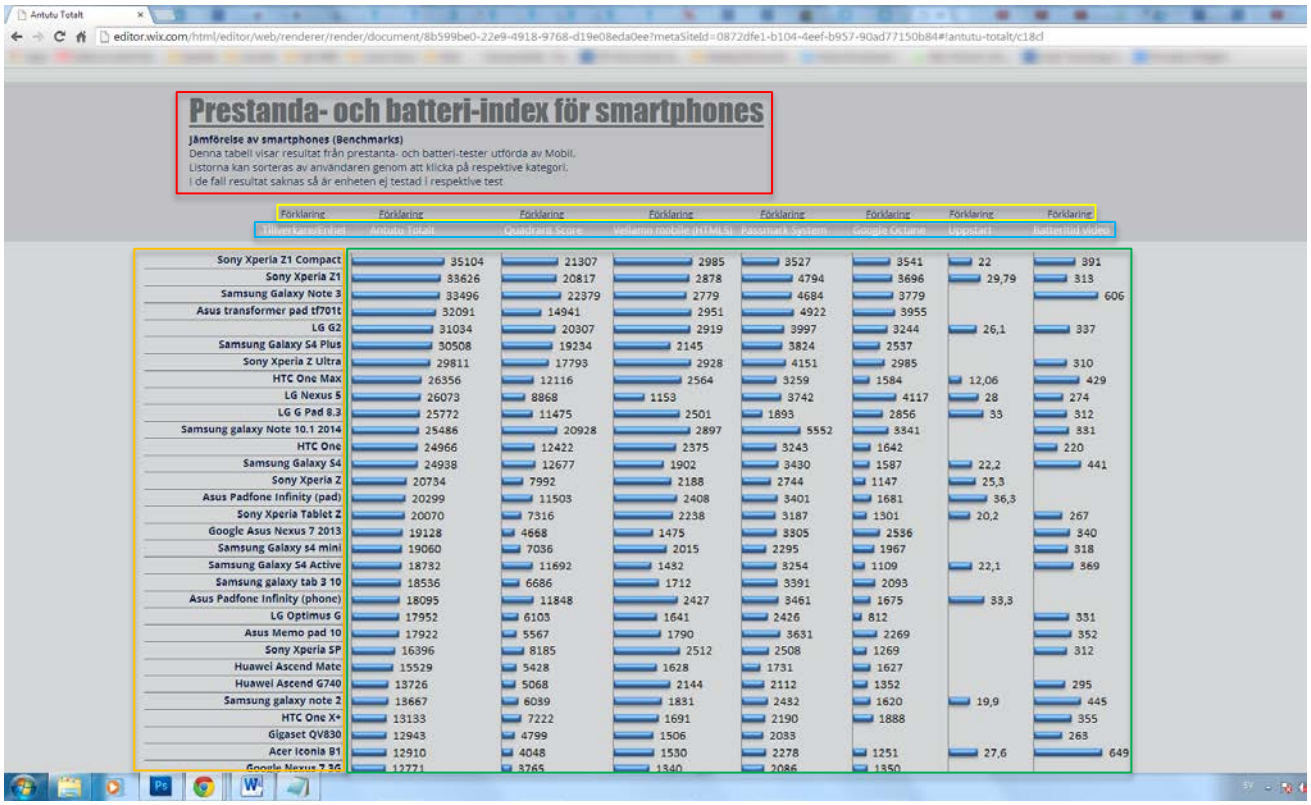


Figure 38: The Prototype

Color coded descriptions from figure 38:

Description of the service:
Performance- and battery-index for smartphones
Comparison of smartphones (Benchmark results)
This table shows results from performance and battery tests done by Mobil.
The results can be sorted by the user by clicking on the different categories.
If results in some category are missing, it means the device has not been tested in the corresponding test.

Links to external descriptions of the corresponding benchmark applications.

This is the categories on which the results in the table are to be sorted after. By clicking the different categories all the columns will be sorted after the desired category.

List of devices sorted and ranked accordingly, clicking a device in the list will open a new tab with the review on the corresponding device on www.mobil.se.

Results sorted and ranked accordingly to the corresponding devices.

7.1 Graphical suggestion for implementation on www.mobil.se

A graphical suggestion for implementation on Mobil's website is done with functionality described in chapter 8, such as a search field, the ability to choose which benchmark results should be displayed by ticking or un ticking check boxes. The addition of a checkbox for price comparison was also included as well as a new bar at the website called "performance testing" for potentially navigating to the service.

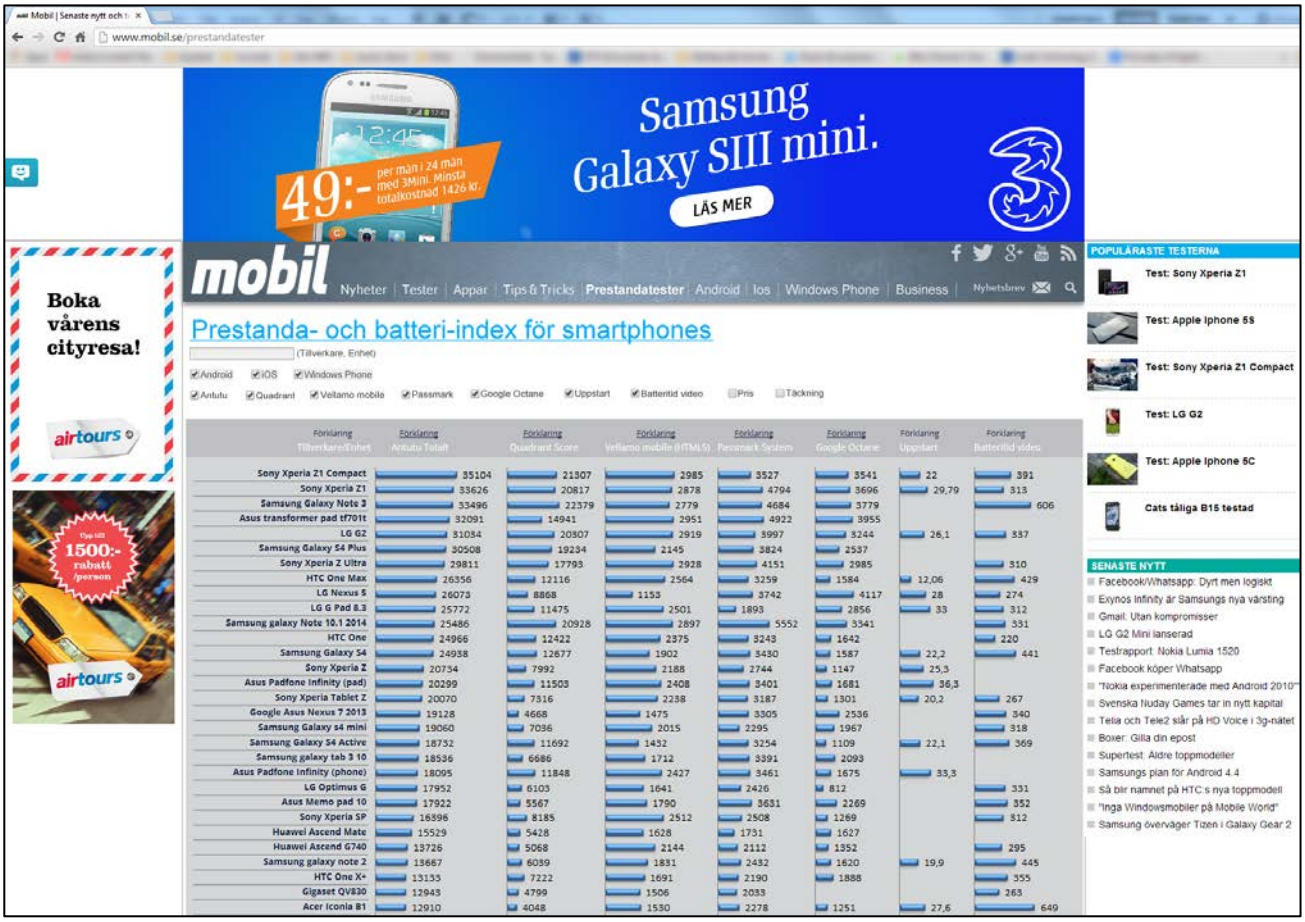


Figure 39: Graphical suggestion for implementation

8. Evaluation

This thesis set out to answer the question:

“Is there a great demand and interest for comparing performance between smartphones and if so, how can it be presented on Sweden’s leading website for mobile IT to make it easier for consumers to compare smartphone performance?”

This was accomplished by a rigorous questionnaire survey with over 1300 respondents.

The survey results show that there is potentially a great demand and a big interest for comparing performance between smartphones on the Swedish market. Upon this foundation, an online performance comparison prototype was created to show how such a service could look like on the website www.mobil.se. The survey gave the employer Mobil a bigger understanding of their users as well as an incentive to implement a smartphone comparison service. The prototype also gave Mobil a concept on which to develop such a service, which would aim to increase the number of visitors on www.mobil.se and potentially also its revenue.

Concerning the development on the smartphone market, we will likely see a more differentiated market with manufacturers trying to come up with unique functionality. There will also be room for different segments in different parts of the world for some time to come as different MPU’s apparently have success in different parts of the world compared to Intel’s almost monopolistic like status on the PC market. One can also expect that there will be an increased focus on energy efficiency as smartphones get more powerful. However, performance in terms of processing power, graphics performance and so on will likely be a popular yardstick for a long time to come. The key underlining explanation to why smartphone performance is of big interest and importance when choosing a new smartphone ought to be that it affects the user experience within the operating system and its apps.

One thing to note with the findings in this thesis is that the results and conclusions drawn are based on investigating a quite niched target audience, which should be taken into consideration when comparing other types of users or generalizing the results.

The market share for the leading OS’s for smartphones has of course to do with the sales of devices. And as Microsoft further opens up their Windows Phone platform for hardware manufacturers it is likely that Windows Phone will gain some market share. New iPhone’s with larger screen could also act as a catalyst for the iOS market share in the future. Android naturally has the biggest growth potential on developing markets primarily India and other parts of Asia. Since the first iPhone, the smartphone market has matured in the sense that it’s probably more lucrative to give the users what they want in different parts of the world respectively then it is trying to take the market by surprise, of the simple reason that it’s now a lot harder to do so.

9. Further recommendations on functionality and implementation

Propositions and recommendations on further implementation:

- Building a database using for instance MySQL, with entries that hold information about specifications for smartphones, such as operating system and hardware specification in order to be able to filter the results according to desired specifications.
- Both the price comparison services Prisjakt and Pricerunner have been contacted in regards of adding dynamic price comparisons of the listed devices in the prototype and Prisjakt have confirmed that they have an API where the dynamic lowest price from their service can be shown as a dynamic parameter on any other website which would make it possible to add another column including price.
- A natural addition would be to include a new potential monetization method for www.mobil.se using the API from www.prisjakt.se or www.pricerunner.se to include dynamic price comparison and earn royalty per click linked to www.prisjakt.se or www.pricerunner.se from the smartphone comparison service on www.mobil.se.
- Suggested additional functionality; the ability to filter results shown on specifications for the devices, such as OS, brand, screen size and so on.
- The ability to show only the results for chosen devices or devices searched for.
- Adding a similar smartphone comparison section, as suggested in the prototype, to the CMS system used by Mobil for www.mobil.se.

10. Suggestions on further related work

Besides usability testing for the prototype and an eventual implementation of an online service presenting smartphone performance comparisons, here are some suggestions on other related fields to examine further:

The relation between benchmark results and the user experience.

Put together a total score as a performance index from different benchmarks to show the total general performance of a device.

Look at differentiations in smartphone adoption, usage and priorities in other parts of the world such as emerging markets with major growth, like India.

Investigate the growth potential and maturation of the smartphone market.

To further examine the processing power of a smartphone in relation to a PC, look more closely on the “bring your own device” concept.

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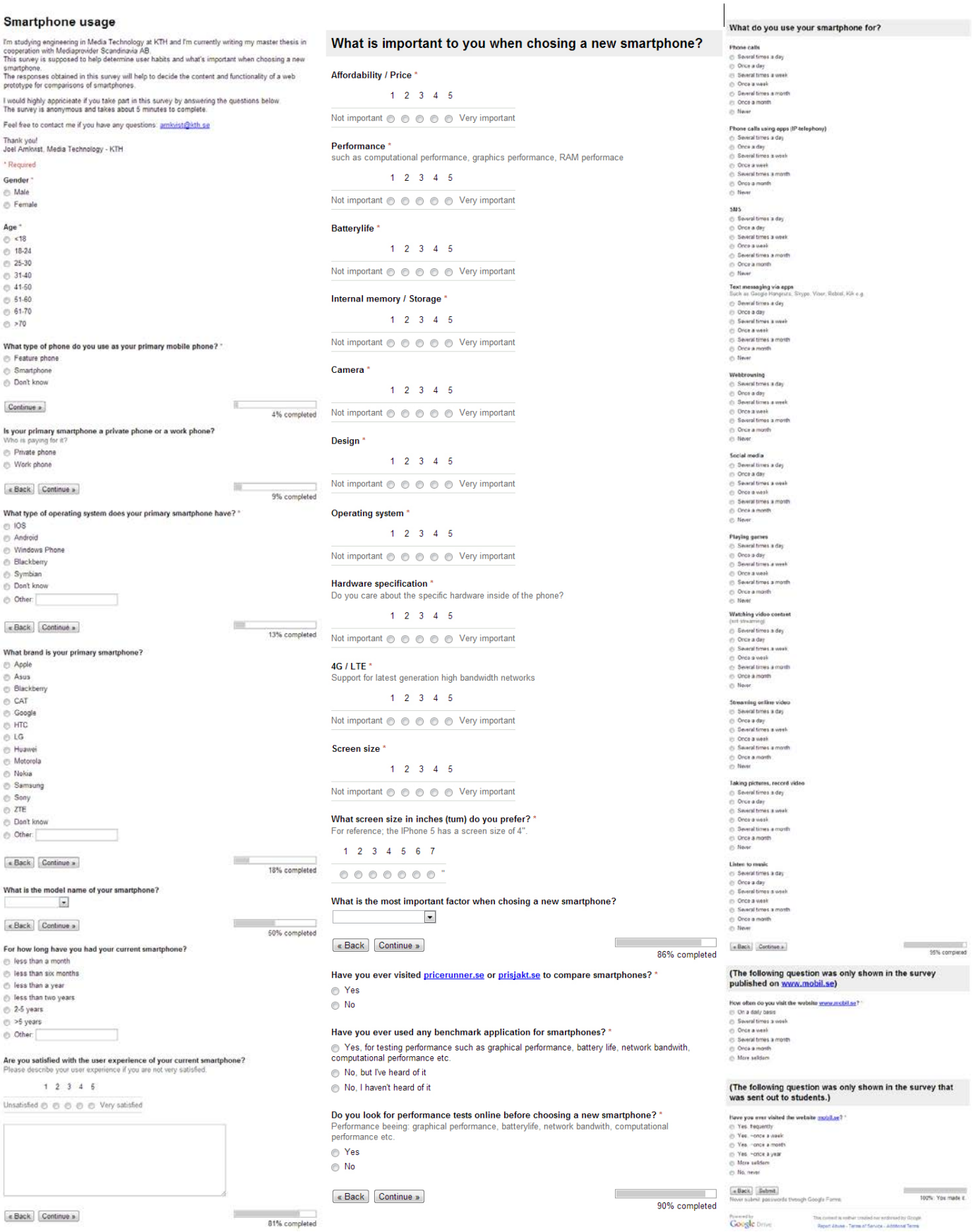
11. Appendix

11.1 Questionnaire survey



Smartphone usage

I'm studying engineering in Media Technology at KTH and I'm currently writing my master thesis in cooperation with Mediaprovider Scandinavia AB.
This survey is supposed to help determine user habits and what's important when choosing a new smartphone.
The responses obtained in this survey will help to decide the content and functionality of a web prototype for comparisons of smartphones.

I would highly appriciate if you take part in this survey by answering the questions below.
The survey is anonymous and takes about 5 minutes to complete.

Feel free to contact me if you have any questions: amkvist@kth.se

Thank you!
Joel Amkvist, Media Technology - KTH

* Required

Gender *
Male
Female

Age *
<18
18-24
25-30
31-40
41-50
51-60
61-70
>70

What type of phone do you use as your primary mobile phone? *
Feature phone
Smartphone
Don't know

Continue »
4% completed

Is your primary smartphone a private phone or a work phone?
Who is paying for it?
Private phone
Work phone

« Back Continue »
9% completed

What type of operating system does your primary smartphone have? *
IOS
Android
Windows Phone
Blackberry
Symbian
Don't know
Other:

« Back Continue »
13% completed

What brand is your primary smartphone?
Apple
Asus
Blackberry
CAT
Google
HTC
LG
Huawei
Motorola
Nokia
Samsung
Sony
ZTE
Don't know
Other:

« Back Continue »
18% completed

What is the model name of your smartphone?

« Back Continue »
50% completed

For how long have you had your current smartphone?
less than a month
less than six months
less than a year
less than two years
2-5 years
>5 years
Other:

Are you satisfied with the user experience of your current smartphone?
Please describe your user experience if you are not very satisfied.
1 2 3 4 5
Unsatisfied Very satisfied

« Back Continue »
81% completed

What is important to you when chosing a new smartphone?

Affordability / Price *
1 2 3 4 5
Not important Very important

Performance *
such as computational performance, graphics performance, RAM performace
1 2 3 4 5
Not important Very important

Batterylife *
1 2 3 4 5
Not important Very important

Internal memory / Storage *
1 2 3 4 5
Not important Very important

Camera *
1 2 3 4 5
Not important Very important

Design *
1 2 3 4 5
Not important Very important

Operating system *
1 2 3 4 5
Not important Very important

Hardware specification *
Do you care about the specific hardware inside of the phone?
1 2 3 4 5
Not important Very important

4G / LTE *
Support for latest generation high bandwidth networks
1 2 3 4 5
Not important Very important

Screen size *
1 2 3 4 5
Not important Very important

What screen size in inches (tum) do you prefer? *
For reference; the IPhone 5 has a screen size of 4".
1 2 3 4 5 6 7
"

What is the most important factor when chosing a new smartphone?

« Back Continue »
86% completed

Have you ever visited pricerunner.se or prisjakt.se to compare smartphones? *
Yes
No

Have you ever used any benchmark application for smartphones? *
Yes, for testing performance such as graphical performance, battery life, network bandwith, computational performance etc.
No, but I've heard of it
No, I haven't heard of it

Do you look for performance tests online before choosing a new smartphone? *
Performance beeing: graphical performance, batterylife, network bandwith, computational performance etc.
Yes
No

« Back Continue »
90% completed

What do you use your smartphone for?

Phone calls
Several times a day
Once a day
Several times a week
Once a week
Several times a month
Once a month
Never

Phone calls using apps (IP-telephony)
Several times a day
Once a day
Several times a week
Once a week
Several times a month
Once a month
Never

SMS
Several times a day
Once a day
Several times a week
Once a week
Several times a month
Once a month
Never

Text messaging via apps
Such as Google Hangouts, Skype, Viber, Rebtel, Kik e.g.
Several times a day
Once a day
Several times a week
Once a week
Several times a month
Once a month
Never

Webbrowsing
Several times a day
Once a day
Several times a week
Once a week
Several times a month
Once a month
Never

Social media
Several times a day
Once a day
Several times a week
Once a week
Several times a month
Once a month
Never

Playing games
Several times a day
Once a day
Several times a week
Once a week
Several times a month
Once a month
Never

Watching video content
(not streaming)
Several times a day
Once a day
Several times a week
Once a week
Several times a month
Once a month
Never

Streaming online video
Several times a day
Once a day
Several times a week
Once a week
Several times a month
Once a month
Never

Taking pictures, record video
Several times a day
Once a day
Several times a week
Once a week
Several times a month
Once a month
Never

Listen to music
Several times a day
Once a day
Several times a week
Once a week
Several times a month
Once a month
Never

« Back Continue »
95% completed

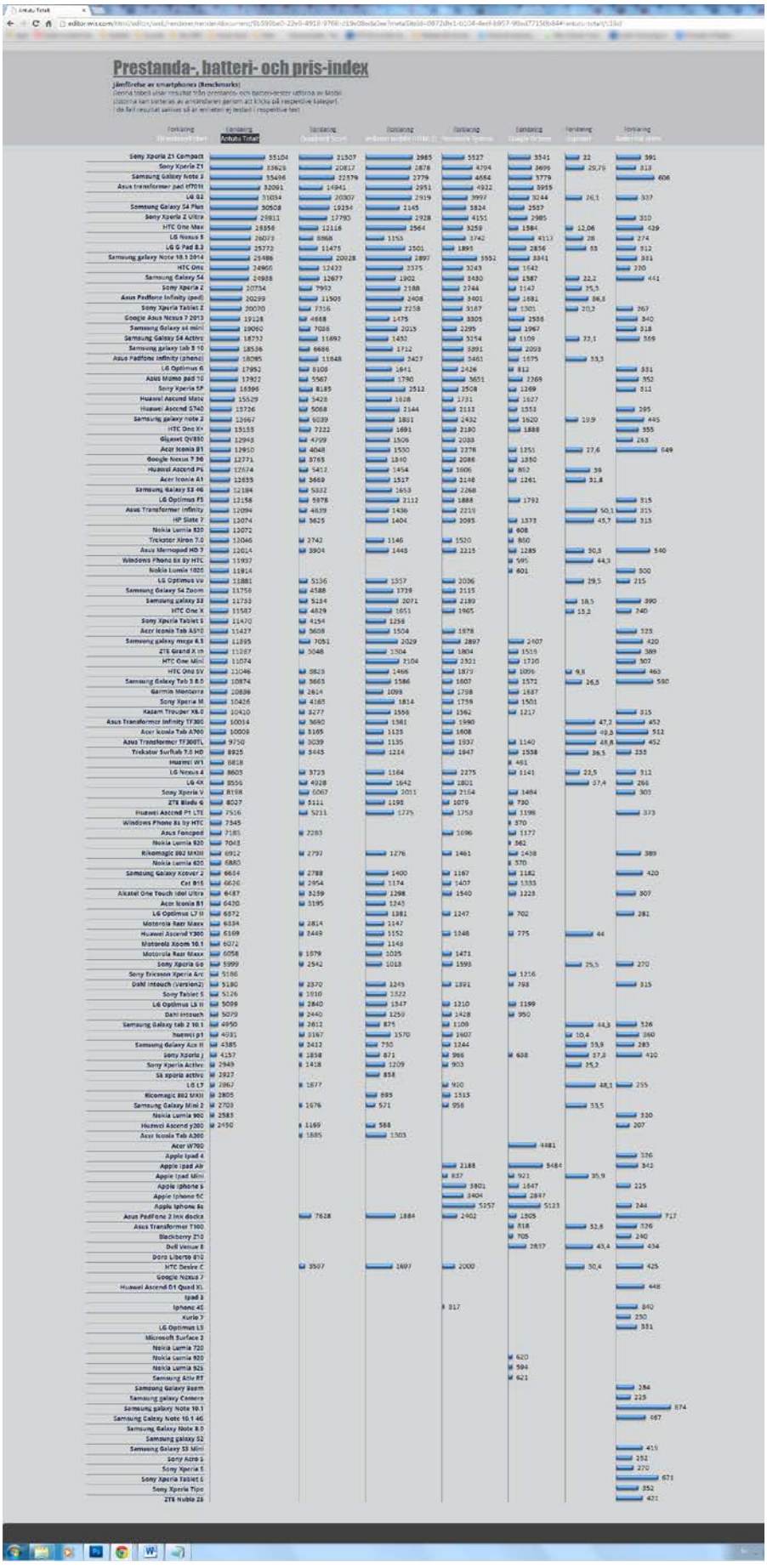
(The following question was only shown in the survey published on www.mobil.se)

How often do you visit the website www.mobil.se? *
On a daily basis
Several times a week
Once a week
Several times a month
Once a month
More seldom

(The following question was only shown in the survey that was sent out to students.)

Have you ever visited the website mobil.se? *
Yes, frequently
Yes, ~once a week
Yes, ~once a month
Yes, ~once a year
More seldom
No, never

« Back Submit
Never submit passwords through Google Forms.
100%. You made it.

Powered by Google Drive
This content is neither created nor endorsed by Google.
Report Abuse - Terms of Service - Additional Terms

11.2 Web prototype