NTNU – Trondheim
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Modelling Tele-economics systems using Business Dynamics

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Problem Description

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Business dynamics is a well-established framework for analyzing feedback and relationships between actors in business environments. The framework applies system dynamics to business cases. The human mind is not equipped for fully understanding all the consequences and reactions when changing parts of complex systems. Whereas we may think of systems in an event-oriented way where everything is a chain of causes and effects, complex systems may behave in a circular fashion with feedbacks, unanticipated side effects and interventions by others. Business dynamics tries to model such systems in order to gain further insight and allow for better decision making when faced with a complex system.

In this assignment, business dynamics will be used to model tele-economic systems. Systems modeled can be e.g. scenarios from the FTTH industry, mobile telephone, VoIP.
In particular, the following will be covered:
• A background study of business dynamics
• Identify business scenarios in the telecommunication industry
• Model the identified scenarios using business dynamics

Assignment given: 16.01.2012

Supervisor: Harald Øverby

Sammendrag

Det har vært en kraftig utvikling i mobiltelefonindustrien de siste årene. Mobiltelefonen har gått fra å være en enkel enhet som kunne ringe og sende tekstmeldinger til dagens smarttelefoner som er like kraftige som en datamaskin, og har et bredt spekter av funksjoner. I løpet av denne utviklingen har mobile operativsystem blitt stadig mer avansert og begynner å nærme seg operativsystemene vi er vant til fra ordinære datamaskiner. Dette har skapt et nytt marked for tredjeparts programvareutviklere og tjenestetilbydere.

Formålet med denne avhandlingene er å øke forståelsen for det mobile operativsystemmarkedet, og å undersøke de dynamiske effektene i økosystemet som omfavner disse operativsystemene.

Seks av de største aktørene i dette markedet har blitt undersøkt og analysert med fokus på forskjellige konkurransestrategier og –tilnærminger. I tillegg er det utviklet en dynamisk modell basert på John D. Stermans business dynamics-rammeverk. Modellen fungerer som en basis for et utvalg simuleringer for å undersøke effektene av forskjellige karakteristikker i en konkurransesituasjon.

Basert på analysen og simuleringene, foreslås følgende:

1. Kontroll over app-distribusjon og å tilby tilleggstjenester er viktige faktorer i det mobile OS-markedet av tre grunner: økt omsetning, økt kontroll over kundene og at det er en nødvendig egenskap i konkurransen mot andre aktører.
2. Å oppnå en fordel i en av tre karakteristikker – tilleggstjenester, apps eller utvalg av smarttelefoner – er nok til å påvirke utfallet av konkurransen.
3. Hvis utvalget av smarttelefoner med et gitt OS er lite, er viktigheten av å være markedsledende på apps og tilleggstjenester desto større.
4. For å oppnå en vesentlig ledelse i forhold til markedsandel er et stort utvalg av smarttelefoner som kjører aktørens OS viktig.

Abstract

There has been a major development in the industry of mobile phone devices during the last few years. From being only a device which could make phone calls and send text messages, the smartphones of today have become just as powerful as a computer with a wide range of functionality. With this development, the mobile operating systems have become far more advanced and are now similar to what we have in the desktop computer environment, creating a market for 3rd party software developers and service providers.

The aim of this thesis is to gain an understanding of the market of mobile operating systems for smartphones, and to investigate the dynamics in the ecosystem surrounding these operating systems.

An exploratory research of six major actors in this market and an analysis of the different competitive strategies and approaches have been conducted. In addition, a dynamic model using John D. Sterman's business dynamics framework has been developed. The model serves as a basis for a set of simulation runs in order to examine the effect of different characteristics in a competitive setting.

Based on the analysis and the model simulations, the following is proposed:

1. Controlling app distribution and providing additional services are found to be important factors in the mobile OS market based on three reasons: increased revenue, increased control over customers and as a necessary competitive feature.
2. Gaining an advantage in one of three characteristics – additional services, apps or device selection – is enough to affect the outcome of the competition.
3. With a low selection of devices, it is important to become a market leader in terms of additional services or apps.
4. In order to gain a significant lead in market share compared to a competitor, a large selection of devices is important.

Preface

This paper serves as a master thesis in the 10th semester of my Master of Science degree in Communication Technology at the Norwegian University of Science and Technology.

I would like to thank Harald Øverby, Associate Professor at the Department of Telematics (ITEM), for valuable guidance and feedback throughout this process.

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Trondheim, Norway
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1 Introduction

1.1 Background

The market for smartphones with advanced operating systems has grown significantly over the last few years. A smartphone has in many cases replaced the laptop when carrying out “on-the-go” tasks, both in a professional and personal setting. Mobile operating systems support many tasks such as e-mail and calendar synchronization, document processing, taking photographs, listening to music and watching videos.

Apple’s catchphrase “There’s an App for That” captures an important feature of the product development on the software side. Small-screen, touch-based applications tailored for mobile operating systems have become big business, and has contributed largely to the wide range of needs a smartphone covers today.

Prior to the expansion of complex tasks a cell phone is able to conduct, the devices were primarily differentiated by hardware specifications and design. Customers chose their cell phones based on criteria mainly concerned with the device manufacturers’ design decisions. With the introduction of smartphones, customers now need to assess not only the device itself but also the entire ecosystem surrounding the smartphone.

This development has resulted in a need of understanding driving forces behind the mobile operating system competition. In the past five years we have seen several new entrants in this competition, and previous power houses in the cell phone industry have been forced to change their strategies. This thesis attempts to investigate some of the aspects and approaches to achieve competitive advantage in this market.

1.2 Problem definition

The aim of this thesis is to gain an understanding of the market of mobile operating systems for smartphones. Through a qualitative analysis of the current actors in the market and a business dynamics model, the following research questions are the basis for the thesis research:

RQ 1: Which characteristics are important to exhibit in the mobile OS market competition?

RQ 2: What are the effects of these characteristics in a competitive setting?

1.3 Contributions

The contributions in this thesis are:

1. A qualitative analysis of the actors in today's mobile OS market with main focus on how the actors approach the market competition in different ways.
2. A business dynamics model of a competitive market setting where the effects of three different aspects – namely additional services, apps and device selection – are examined through a number of simulations.

1.4 Structure

Chapter 2 introduces relevant theory used as background for the analysis and discussion in this thesis. The framework used for modeling is also presented.

Chapter 3 presents the research process and the tools used for modeling and simulation.

Chapter 4 provides a description of the six major actors in the mobile OS market, and an analysis of their competitive strategies.

Chapter 5 describes the model, the included parameters and their equations and initial values.

Chapter 6 presents the results from the simulation.

Chapter 7 provides a discussion based on the analysis in chapter 4 and the results from the simulation.

Chapter 8 summarizes the findings and presents possibilities for further research.

2 Theory

This chapter provides a theoretical background for the work done in this thesis. First, a description of the modeling framework used when developing a model of the mobile OS ecosystem is provided, namely the business dynamics framework. Second, a general description of mobile operating systems is presented. Third, the roles of actors around the mobile OS are described in the concept of an ecosystem. A typology for describing the ecosystem is also presented, which is used when describing the six major mobile operating systems in section 4.1. Fourth, a four-part typology used to describe different strategies for platform competition is presented. This typology is also used to describe the six major mobile operating systems in section 4.1. Last, characteristics of this competitive network market are described, namely network externalities, switching costs and lock-in.

2.1 Business dynamics

We live in a world of heavily interconnected systems which are difficult to grasp for a human mind. Wikipedia defines a system as “a set of elements and relationships which are different from relationships of the set or its elements to other elements and sets” (Wikipedia). In order to gain a better understanding of such systems and the underlying dynamics, modeling may be used. In his book “Business Dynamics – Systems Thinking and Modeling for a Complex World” (Sterman, 2000), John Sterman describes principles for modeling complex dynamic systems which are used as a basis for the modeling process in this thesis.

2.1.1 From event-oriented to feedback view

Even though most of our decisions, being decisions about world politics, production rate in a supply chain or when to pass another car while driving on the freeway, are made to counter an effect of an earlier cause, most of us fail to see the bigger picture when making decisions and realize what the consequences of our decisions lead to in the rest of the system. From early on, we are taught that every event has a cause which is an effect of an earlier cause. This leads to an event-oriented worldview which is the base of our problem solving (Sterman, 2000). Figure 1 illustrates this approach to problem solving.

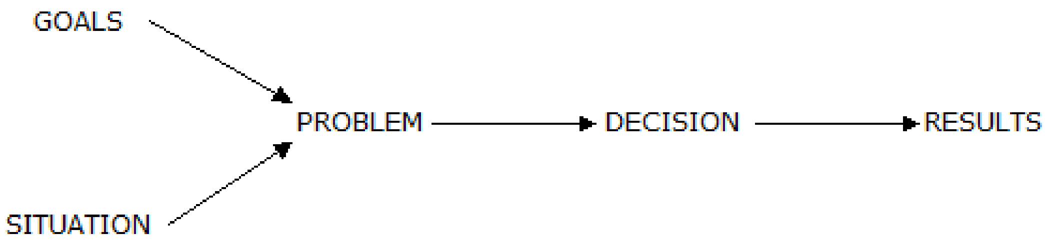

Figure 1 - Event-oriented world view. Source: (Sterman, 2000)

One example to illustrate further: suppose you are the CEO of a mobile network operator with a target of having a market share of 15% (goal). Your current market share is only 10% (situation). In order to reach your goal, an increase of 5% is needed (problem). In cooperation with the product development team you come up with a new subscription plan, including more minutes per month at a lower price than your competitors (decision). After some time you evaluate and observe that your market share has indeed increased (results). The "problem" however, is that you are of course not the only network operator in the market, and your competitors will probably go through the same chain of events in order to respond to your actions and try to win the customers back. Your company is now facing a new situation where there may be a gap between the current situation and your market share goal, creating new problems which need to be addressed.

As this example illustrates, the decision process is better described with a circular and iterative model as shown in Figure 2. This model captures the notion that our decisions affect other parts of the system, and especially that based on our decisions other actors in the system will react accordingly, leading to yet another change in the environment (situation). This change in the environment leads to another problem the decision maker needs to deal with. Based on this loop, Sterman names this model the feedback view: "the results of our actions define the situation we face in the future" (Sterman, 2000). Feedback loops are covered in section 2.1.2.2.

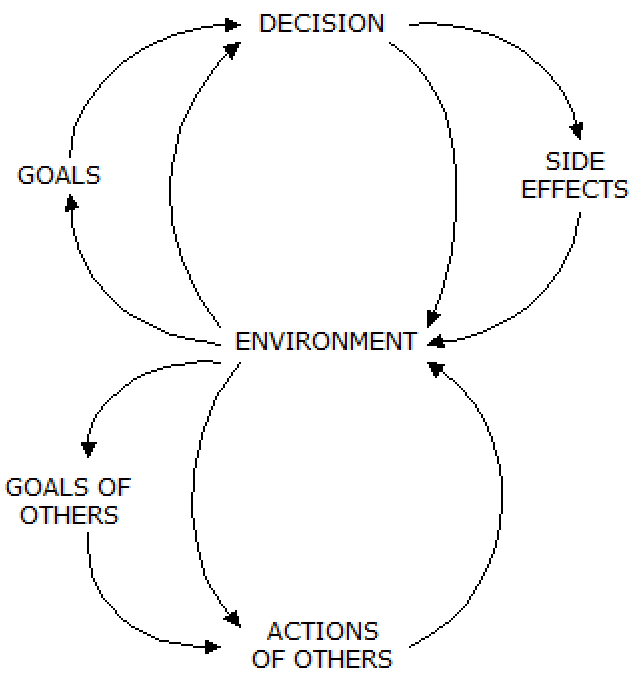

Figure 2 - Feedback view. Source: (Sterman, 2000)

2.1.2 Causal loop diagrams

One important tool to represent feedback structure in systems is causal loop diagrams (Sterman, 2000). The causal loop diagram consists of variables connected with links (arrows) showing the causal influences between the variables. While the causal loop diagram itself is not sufficient in order to simulate a complex system, it provides an overview over the system, shows what variables are connected with each other and how changes in parts of the system may affect other parts.

2.1.2.1 Link polarity

The links are assigned either a positive polarity represented with a '+' sign or a negative polarity represented with a '-' sign. Figure 3 shows an example of a positive link polarity. If the variable 'Sales' is increased, the variable 'Profit' will also increase. The positive polarity does not only represent increase, but means that the change in one variable will lead to a change in the same direction in the other variable. In this example, this also means that when 'Sales' decreases, 'Profit' will also decrease.

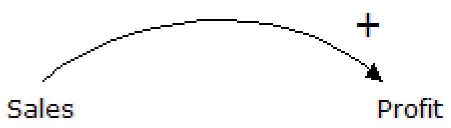

Figure 3 - Positive link polarity

Figure 4 shows an example with a negative link polarity. The negative link polarity represents a change in the opposite direction, leading us to read that an increase in the 'Price' variable will result in a decrease in the 'Sales' variable. Equally, if the 'Price' variable decreases, we expect to see an increase in the 'Sales' variable.

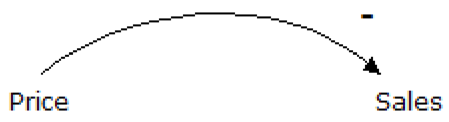

Figure 4 - Negative link polarity

It is important to note that the link polarity does not tell us what *will* happen, but rather what the effect of a change in the first variable is *if* the variable either increases or decreases (Sterman, 2000).

2.1.2.2 Feedback loops

The two previous examples are very simple and do not capture much of the behavior in a system. In Figure 5 we introduce links going either way between variables, creating loops.

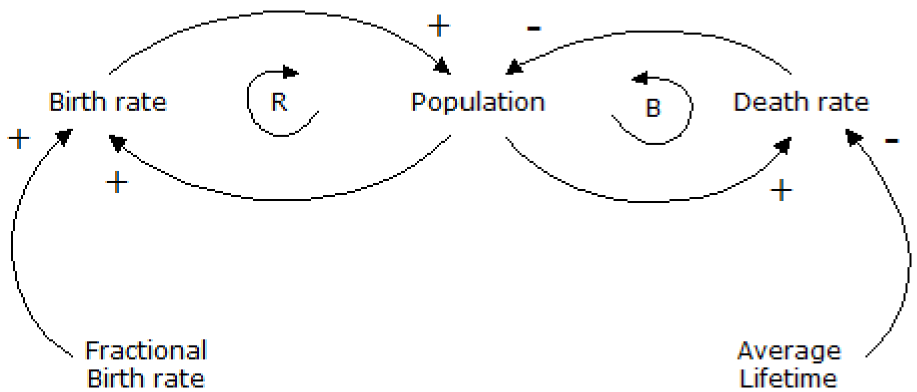

Figure 5 - Population model with loops. Source: (Sterman, 2000)

The loop created between 'Birth rate' and 'Population' consists of two links with positive link polarity. This represents a positive or reinforcing loop, marked with a capital letter R. The loop tells us something about the feedback effect between the variables, and a reinforcing loop will amplify or reinforce the change in one of the variables (Morecroft, 2007). In this particular example, an increase in the birth rate will (naturally) lead to an increase in the population. Because of the reinforcing loop, the effect of the population increase will be fed back and lead to an even larger increase in the birth rate. The reinforcing loop would work in a similar way if the first change was a decrease in birth rate (but now the decrease would be reinforced throughout the loop).

The loop between population and death rate is marked with a capital letter B for balancing loop. In this loop, a change in one of the variables will lead to a counteracting, or balancing, change when the effect is traced around the loop (Morecroft, 2007). In our particular example an increase in the population will lead to a higher death rate (e.g. deaths per day). The death rate has a negative effect on the size of the population, so the population growth will be balanced by the increase in death rate.

2.1.2.3 Invisible feedback

Although the feedback loops in Figure 5 are straight forward and relatively easy to grasp, not all feedback processes in a system is visible to the actors in the system. Complex system models with many feedback loops may consist of feedback processes that are felt through unanticipated side effects and surprising outcomes (Morecroft, 2007). One of the examples is the challenge of the bullwhip effect, which is a well-known issue in supply chain management. The bullwhip effect refers (within the field of supply chain management) to the case when change in orders or rate of production is higher than the change in actual sales to the customer. The effect has several reasons, but the main problem is that the distortion of demand propagates upstream in the supply chain in an amplified form (Lee, Padmanabhan, & Whang, 1997).

2.1.3 Stocks and flows

As mentioned in section 2.1.2, causal loop diagrams do have limitations when designing models for simulation purposes. Most importantly, causal loop diagrams fail to represent accumulated levels and the rate of which these levels change. These limitations are overcome by introducing the concept of stocks and flows.

Stocks are the accumulated levels, and characterize the state of the system at any given point in time (Sterman, 2000). Examples of stocks include the number of cars a car dealership have for sale in its lot, the number of subscribers to a cable TV service or the number of students enrolled at a university. The unit of a stock is the quantity of what the level is supposed to represent, such as cars, subscribers or students. In a diagram, the stock is represented with a simple rectangle. One important characteristic with stocks is that the level of a stock is only changed through either an inflow or an outflow (Sterman, 2000).

A flow (either into or out from a stock) represents the rate of which the stock level changes. Graphically, the flows are represented with arrows leading to or from the stock rectangle. When defining the flow, the unit must be the same as the associated stock but measured per time period (Sterman, 2000). Returning to the example with the stock of cable TV subscribers from the previous paragraph, the associated inflow could be “new subscribers” and measured as subscribers per day (or week, month or year).

Figure 6 shows a simple stock and flow structure based on the causal loop diagram representing the population in Figure 5. The stock, represented by a rectangle, keeps track of the size of the population and is measured by the number of people at any given point in time. In this simplified model, the only ways of changing the population is either by births or deaths which are the inflow and outflow, respectively. Both flows (birth rate and death rate) are measured in e.g. people per year.

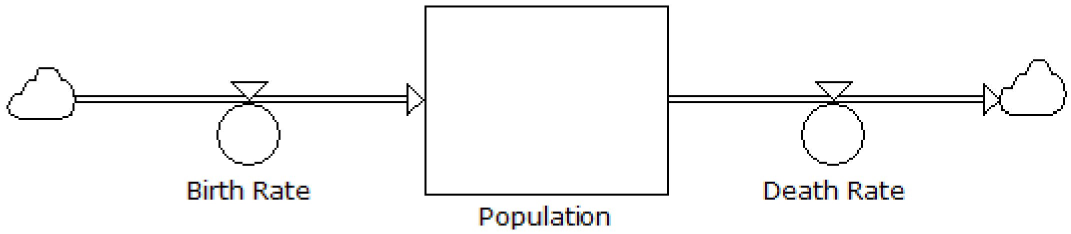

Figure 6 - Population model with stock and flows

One important property in the relationship between stocks and flows is the concept of equilibrium. A stock is in equilibrium when the level of which it represents is not changing. To achieve equilibrium, the net flow (net flow = outflow – inflow) has to be zero. There are two ways of achieving this, and hence two types of equilibrium. Relating to the population example in Figure 6, *dynamic equilibrium* is the case when people die at the same rate as babies are born. The magnitude of the population is still the same, but the population consists of different individuals, hence the prefix *dynamic*. In the other case, *static equilibrium* is when zero babies are born and zero people are dying. The magnitude of the population stays the same, and the population consists of exactly the same individuals. (Sterman, 2000)

2.2 Mobile operating systems

An operating system (or OS for short) is the software that operates between the hardware in a device and the programs or applications running on the device (TechTerms, 2012). Mobile operating systems are designed specifically for smaller, handheld devices such as smartphones and tablets, and for the last few years these operating systems have been designed around touchscreen input. Examples of some of today's most popular mobile operating systems include Google's Android[1], Apple's iOS[2], Microsoft's Windows Phone[3] and RIM's Blackberry OS[4].

Although one might feel that these operating systems have much in common when looking at the user interfaces, applications need to be developed differently if they are to be run on more than one of the platforms. The reason for this is that the different operating systems communicate with the hardware in different ways (TechTerms, 2012). The resulting effect is that most mobile applications – apps – are non-transferrable between phones running different operating systems.

2.3 Ecosystems

In order to better understand the competitive environment mobile OS companies operate in and the different strategies they choose, we need to look at the surrounding actors which all affect the market in their own way. To describe this environment, the concept of ecosystem is used. Campbell & Ahmed define the software ecosystem related to mobile operating systems as "a cluster of actors (individuals or organizations) employed in the development of services or software for a common market and sharing a common technological framework" (Campbell & Ahmed, 2011). A successful surrounding ecosystem is thought of being a crucial factor of success for a new mobile OS through the ability to develop a large and wide selection of supported applications rapidly (Campbell & Ahmed, 2011).

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[1] http://www.android.com
[2] http://www.apple.com/ios/
[3] http://www.microsoft.com/windowsphone/
[4] http://www.blackberryos.com/

Campbell & Ahmed focus primarily on the software part of the surrounding ecosystem, and assess the app marketplaces of four major players in the market. The environment does however include several other important actors, of which an understanding is important to establish. In (Lin & Ye, 2009), a framework based on the concept of a food web from ecology is proposed to gain a better understanding of the ecosystem surrounding mobile operating systems. This framework is presented graphically in Figure 7.

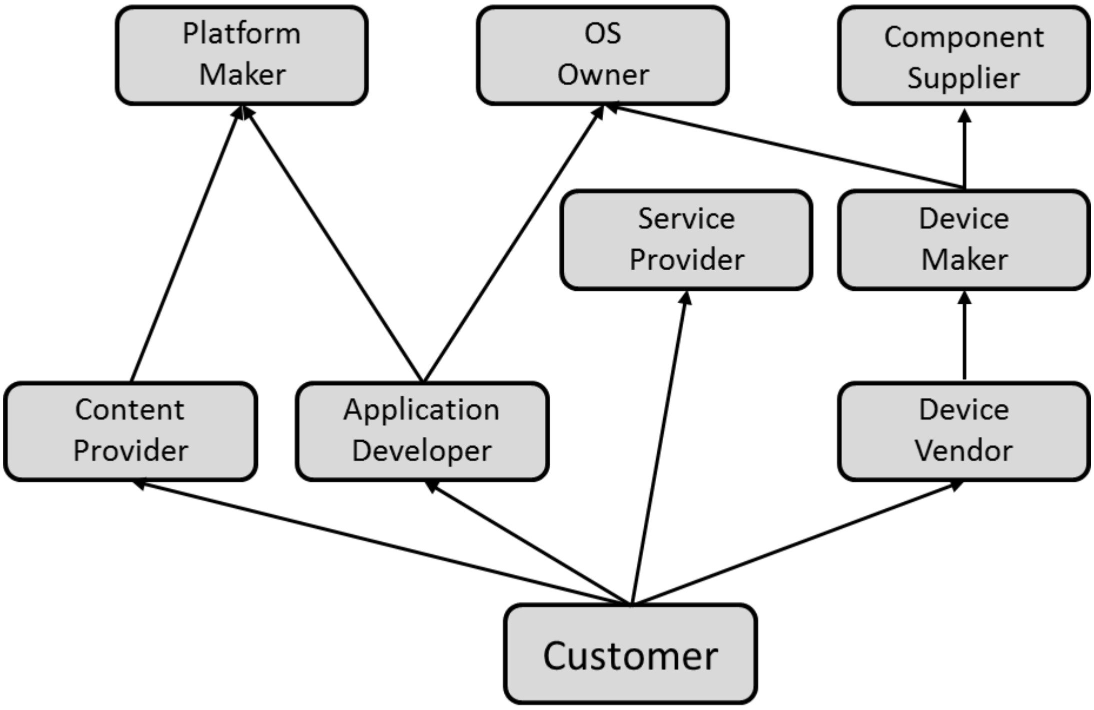

Figure 7 - The ecosystem surrounding a mobile OS. Source: (Lin & Ye, 2009)

The revenue streams in the ecosystem are initially provided by the customers, and the arrows represent the revenue flow from customer to the different actors in the ecosystem (Lin & Ye, 2009). Different strategies are used by the different OS owners, differentiated by how many of the roles in this system the OS owner control. As one example, a company may be the developer of the OS (OS owner) and sell devices running their OS only through their own brand stores (device vendor). This particular example does not necessarily refer to any of the existing actors in today's market, but the purpose is only to demonstrate how an OS owner may control different parts of the ecosystem. A detailed description of current mobile operating systems and their role in the market is presented in chapter 4.

2.4 Platform competition strategies

The mobile service domain has in the recent years seen a stronger focus on developing a platform around the services which has been a successful strategy for hardware manufacturers and software developers (Gonçalves, Walravens, & Ballon, 2010). Platform in this sense is referring to the ecosystem around e.g. Apple's iPhone and Google's Android. In (Gonçalves, Walravens, & Ballon, 2010) the term platform is described as mediating between different sides of the market (as in developers, advertisers and customers) and attempting to control roles within the ecosystem.

They present a four-part platform typology with focus on characteristics and the difference between platform strategies, which are summarized in Table 1 and described in further detail in the following sections.

	No control over customers	**Control over customers**
Control over assets	**Enabler Platform**	**System Integrator Platform**
No control over assets	**Neutral Platform**	**Broker Platform**

Table 1 - Platform typology. Source: (Gonçalves, Walravens, & Ballon, 2010)

2.4.1 Enabler platform

An enabler platform controls important assets contributing to the value proposition, and has the knowledge and experience to establish a successful platform for both value creators (software companies and developers) and for customers willing to pay for the value creators' products. The platform owner does not have control over the customers, so there is no direct link between the platform owner and the end-user, and in most cases the end-users do not pay directly to the platform owner for the services they buy. As this type of platform aims at enabling customer relationships between end-users and 3rd party service providers, the platform itself is rarely specifically branded in a sales setting. One example is smartphones running Android, where the main advertising focuses on the device itself with hardware specifications and not necessarily details about which operating system the device is running. (Gonçalves, Walravens, & Ballon, 2010)

In order for an enabler platform to be successful, the platform owner needs to focus on making the platform attractive for both 3rd party service providers (the developers) and the end-users. In a developer's perspective, several characteristics are important, namely how the profit from selling their services is split between the platform owner and the developer, a large customer base, and the ease of developing for the particular platform including available APIs[5], testing procedures and ease of submission of the final product. On the other hand, measures need to be taken to make the platform attractive to the end-users through the quality and availability of the services in order to keep the end-user locked in to the particular platform. (Gonçalves, Walravens, & Ballon, 2010)

The concept of lock-in is further explained in section 2.6.

2.4.2 System integrator platform

The system integrator platform approach is similar to the enabler platform in the sense that the platform owner controls value-adding assets on the software side. In addition, the platform owner also controls the hardware assets and has control over customers by a direct relationship through charging and billing. By controlling both software and hardware, a system integrator platform owner may also allow 3rd party service providers to publish and sell their services. One example of a system integrator platform is Apple's mobile initiative, which includes the device iPhone, their operating system iOS and the marketplace App Store. (Gonçalves, Walravens, & Ballon, 2010)

Success factors are similar to those described in the previous section, where the concern is about attracting developers and end-users to the platform. In addition, the platform owner needs to make sure that end-users experience the payment process as easy to use. (Gonçalves, Walravens, & Ballon, 2010)

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[5] Application Programming Interface

2.4.3 Neutral platform

In a neutral platform strategy, the platform owner offers a basic set of tools to create services for end-users. However, the platform owner asserts no control over the final service creation and hence do not have control over the value-adding assets. In addition, neutral platforms do not have a direct relationship with the customers, as opposed to the system integrator platform. A neutral platform is usually implemented as a cooperating organization or a consortium of different actors in the industry, working together to develop standards or technological advancement. (Gonçalves, Walravens, & Ballon, 2010)

Crucial success factors for a neutral platform are associated with controlling and facilitating cooperation between the companies involved in the consortium. A shared philosophy of how the consortium is to operate is important, and prospective members of such platform need to have a clear idea of how participating in the cooperation benefits them. (Gonçalves, Walravens, & Ballon, 2010)

One example of a neutral platform consortium is the Tizen[6] project, who works to create an open, hardware-independent Linux-based mobile operating system (The Linux Foundation, 2011).

2.4.4 Broker platform

As in the neutral platform strategy, a broker platform owner does not assert control over the final service creation and hence have no control over the value-adding assets. Nor does the platform owner control any of the hardware assets. However, the platform owner controls the customer relationships because the end-users use the platform owner's website or marketplace to browse and pay for products. The most common model for revenue sharing is a split of the revenue between the platform owner and the service developer, where the platform owner keeps one smaller part and pays out the rest to the developer. (Gonçalves, Walravens, & Ballon, 2010)

The success factors involved in a broker platform is generally related to operating the marketplace, and similar to the other platforms described the platform owner

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[6] http://www.tizenassociation.org/en/tizen

needs to make the marketplace attractive to both a large customer base and the developers. One of the key challenges is that a broker platform's marketplace is not necessarily limited to one particular operating system and is therefore required to provide support for a larger amount of different devices and operating systems. (Gonçalves, Walravens, & Ballon, 2010)

One example is the mobile application marketplace Handango[7], which supports multiple operating systems such as BlackBerry OS, Windows Mobile, Android and Symbian.

2.5 Network externalities

The term network externalities (or network effects) is used to describe the concept where the value of connecting to a network depends on how many other customers or users are currently connected to this network (Shapiro & Varian, Networks and positive feedback, 1999). The term network is not limited to physical network infrastructure, but may also be used as the network of your professional acquaintances connected to your LinkedIn[8] profile, the group of consumers choosing the Blu-ray technology over HD DVD when buying an optical disc player or an airline's flight route network.

Your professional network may externally be viewed as more valuable - that is more profitable to join for other professionals – if you are connected to a large number of other professionals. The value in this case also depends on several other factors, e.g. which industries your connections work in, which position they have in their firm and so on, but for now we only focus on the magnitude of the network when considering value.

The choice a consumer was faced with when deciding between optical disc players (prior to 2008 when Toshiba discontinued their HD DVD format (Patel, 2008)) also depended on the network size, and hence network value for the consumer. In this case network externalities played out on two levels. The first was the availability of

[7] http://www.handango.com/
[8] http://www.linkedin.com

movies and TV series in each format. Publishers made their titles available in the different formats depending on how many consumers already owned a compatible disc player. The second level depended on how many in the consumer's personal network who owned a disc player with one of the technologies. Based on this a consumer may choose the technology of which most of his friends own in order to borrow and lend compatible discs.

In a slightly different way, the flight route network of an airline may also be affected by network externalities. A consumer chooses (among other factors) to fly with an airline based on whether the airline offers service to this consumer's destination. As the number of flights increase, more customers are likely to choose this particular airline, and as the customer base of the airline increases, the company is more likely to offer a larger number of flights to more destinations.

2.5.1 Properties of network externalities

Positive externalities arise when the utility a consumer experiences from using a service or consuming a good increases as the number of other consumers using the same service or good increases (Katz & Shapiro, 1985). One example may be described with the forming of a study group. Starting out with one student, if a potential new member shares the same motivation and grade goal, both students may profit from working together. The value of this particular study group may increase to all its members if more students join until a certain point, which leads to the next property:

Negative externalities work as the opposite of the former property. For each new member in a network, the value of being part of the network decreases. In (Liebowitz & Margolis, 1994), Liebowitz and Margolis describe the effect as "if (…) a network becomes overloaded, the effect on an individual subscriber will be negative." In the study group example, based on experience it should be easy to acknowledge that after a certain point the group becomes too large to manage, and productivity and the benefit to each student decreases.

Direct externalities are considered as "those generated through a direct physical effect of the number of purchasers on the quality of the product" (Katz & Shapiro, 1985). Looking back to the aforementioned example of the LinkedIn professional network, an additional member to one’s professional network leads directly to an increase in the network value in the sense of new career opportunities or the possibility of striking business deals with new connections.

Indirect externalities or market-mediated effects may be described as when a complementary good or service becomes cheaper and more readily available the greater the extent of the market (Farrell & Saloner, 1985). Relating this to the example of Blu-ray and HD DVD technologies, indirect network externalities describe the effect that the choice of an optical disc player compatible with one of the formats has on the magnitude of available movies and TV series in the same format.

2.5.2 Critical mass

Network externalities play a more important role in the startup of e.g. new telecommunication services compared to a mature service (Allen, 1988), whereas the marginal value of one additional subscriber to the existing subscribers to the service is higher when the network size is small. The social networking service Facebook[9] may serve as an example: Facebook was first launched and limited to students at Harvard university in 2004 (Facebook Inc.). As a relatively small community, the value of one additional member from the Harvard student body would most likely be recognized by many of the existing members, seeing as the probability that existing members knew this particular student was relatively high. However, when a new member joins the Facebook network today, an extremely low fraction of existing members will recognize a value of connecting to this particular person because the network now consists of over 901 million active users (Facebook Inc., 2012).

One of the key challenges when introducing a new service where part of the value is connecting with other people or utilizing network externalities – either directly or indirectly – is establishing a critical mass of initial subscribers so prospective new subscribers recognize the value of subscribing to such service. Critical mass in this sense is defined as “the minimal number of adopters of an interactive innovation for

[9] http://www.facebook.com

the further rate of adoption to be self-sustaining" (Lim, Choi, & Park, 2003). In (Mahler & Rogers, 1999), it is argued that "the value of the innovation for the individual depends on how many others have adopted" [the innovation].

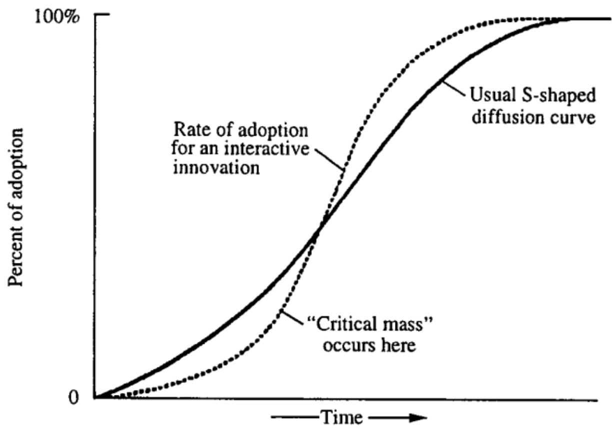

Figure 8 - The S-curve. Source: (Mahler & Rogers, 1999)

Reaching the critical mass is hence vital in order to spur fast growth in the adoption rate of the new service. The S-curve (Figure 8) is a well-known graphical representation of the rate of adoption of an innovation, and shows that a new service grows slow until the critical mass of adopters is reached. Following is a fast growth, where the market share is increased at a faster rate until the majority has adopted the service and the adoption rate decreases.

2.6 Switching costs and lock-in

Many products and services consumers are using today are developed and made with different standards and degrees of compatibility. One example is mobile apps, small applications designed to run on advanced cellular phones – smartphones – or tablets such as Apple's iPad. In most cases, an app is developed for one certain mobile operating system and the consumer may only run this app on supported devices, e.g. an iPhone running Apple's mobile operating system iOS or a smartphone running Google's mobile operating system Android. Once the consumer invests an amount of money into buying an app for his iPhone, he is not able to run this app on any other devices than those supporting Apple's iOS. When the time comes for this consumer to decide which new smartphone to buy next, the amount of money invested in non-transferable apps may impact his choice of whether to buy another smartphone which supports his current portfolio of iOS apps or starting over with a new smartphone with a different app standard.

Another example is the choice of music streaming service. In Norway, two of the most popular alternatives are the Swedish service Spotify[10] and the Norwegian service WiMP[11]. Both offers monthly subscriptions which give the consumer unlimited access to their digital music available through a desktop or mobile client. Both services enable the consumers to create playlists of favorite tracks. Seeing as there is no contract period, the consumer has a choice every month whether to continue or terminate the subscription and possibly change supplier. The price for the premium subscription is the same for both services, so the major obstacle of switching is most often the time invested in building a library of playlists seeing as this library must be transferred or recreated in order to experience the same value when switching to the other service.

In the previous examples either money or time is invested in using the service, and both these costs need to be part of the decision when switching technology. When the costs of switching from one brand of technology to another are substantial, users face lock-in (Shapiro & Varian, 1999). Shapiro & Varian classifies different types of lock-in, and 6 of the types are summarized in Table 2.

Type of lock-in	**Description**
Contracts	Contracts binding a consumer to certain commitments, e.g. using the service or product for a given period of time or committing to buying a certain amount of complementary products and services
Durable purchases	A product may last for a long time, hence locking a consumer to a certain provider for this period. Switching costs usually decline as the product gets closer to the end of its life-cycle.
Brand-specific training	Both time and money may need to be invested into learning how to operate a new machine or mastering a new software program. Switching costs arise when

[10] http://www.spotify.com
[11] http://www.wimp.no

	changing the product and new training is needed.
Information and databases	Applies to the situation when information or files need to be either transferred or converted to a new system or standard/format. Switching costs often increase with the size of data.
Search costs	Concerns the process of finding an alternative to the existing product or service, and includes both searching for and evaluating alternative solutions.
Loyalty programs	Services or products giving the consumers benefits for using it over time, e.g. airline frequent flyer programs. Switching costs are associated with the benefits lost when changing to another service.

Table 2 - Types of lock-in

3 Methodology

This chapter consists of two parts. First, a description of the methods used when acquiring and processing relevant data for the qualitative analysis is provided. Second, a background for the modeling and simulation process is given. A description of the software used for modeling is also provided in the second part.

3.1 Qualitative analysis – the mobile OS market

In chapter 4, a qualitative analysis of the mobile OS market is given. The analysis process consisted of two steps, namely data acquisition and data processing.

3.1.1 Data acquisition

Data was gathered for two main purposes, the first was to construct a description of the different mobile operating systems and the second was to prepare an overview of the development of market share during the last 5 years.

In order to describe the largest mobile OS actors, Wikipedia was used as an entry point in order to gain a brief overview of each of the chosen operating systems. The choice of which operating systems to include in the analysis was made based on their present market share, and today's six largest operating systems in terms of number of users were chosen. Additional information was acquired from the actors' respective web sites, primarily press releases from their web sites' media sections.

Information regarding historical development of market share was found in published articles from the IT research firm Gartner. Gartner release quarterly worldwide smartphone sales numbers based on vendor and operating systems. These numbers are, however, only estimates, and the way Gartner estimates these numbers are not publicly known.

3.1.2 Data processing

Based on the data acquisition, descriptions of the six included operating systems were written, with regards to a brief history from each operating system's initial launch until today, a short overview of how 3rd party apps are distributed in each case and an overview over supported devices. Further, each operating system was evaluated and categorized based on the theory presented in sections 2.3 and 2.4. This categorization serves as a background for the qualitative analysis in section 4.3, where the most important equalities and differences are discussed as properties of the competition in the mobile OS market.

Based on Gartner's estimates of smartphone sales by OS in the period 2007-2011, five graphical representations of the market share in each year was made and these are presented in section 4.2. As noted in the introduction of section 4.2, the numbers are presented as a percentage of the total sales numbers each year, and since the market for smartphones has grown substantially in the period 2007-2011, a decrease in market share does not necessarily correspond to a drop in total sales for a given actor. It does however show how dynamic this particular market is, in terms of how the positions of the market leaders have changed in a relatively short period of time.

3.2 Quantitative analysis – business dynamics model

In order to gain a better understanding of how the dynamics in the ecosystem surrounding a mobile OS affect the competitive market for smartphones, a model is developed and used to simulate several different scenarios. The software suite, modeling phase and simulation phase are described in the following sections.

3.2.1 Powersim Studio

The software chosen for modeling and simulation in this thesis is Powersim Studio 9, used with an academic license. Powersim is a program which lets the user develop dynamic models with a graphical user interface with drag-and-drop functionality. The main components that may be used are levels (to model stocks), flows with a related rate, auxiliary variables and constants.

The levels are defined with a unit (in this thesis the unit "customer" is defined) and an initial value which will change during simulation. The flow rates are defined as an equation of related parameters, and is measured in a given unit per time (in this thesis, a rate is measured in customers/day). An auxiliary variable is defined with an equation of related parameters, and its initial value depends on the related parameters. During a simulation, the auxiliary variables will change according to the change in the related parameters. A constant is defined with an initial value, which remains constant throughout the simulation.

Powersim also lets the user configure the simulation settings with respect to start and end time, and time steps. When a simulation is carried out, Powersim keeps the final values of levels, rates and variables. A result view may be set up, where the user is given the choice of representing the results with graphs, charts and tables.

In addition, Powersim supports optimization and risk analysis features. Figure 9 shows a screenshot of Powersim.

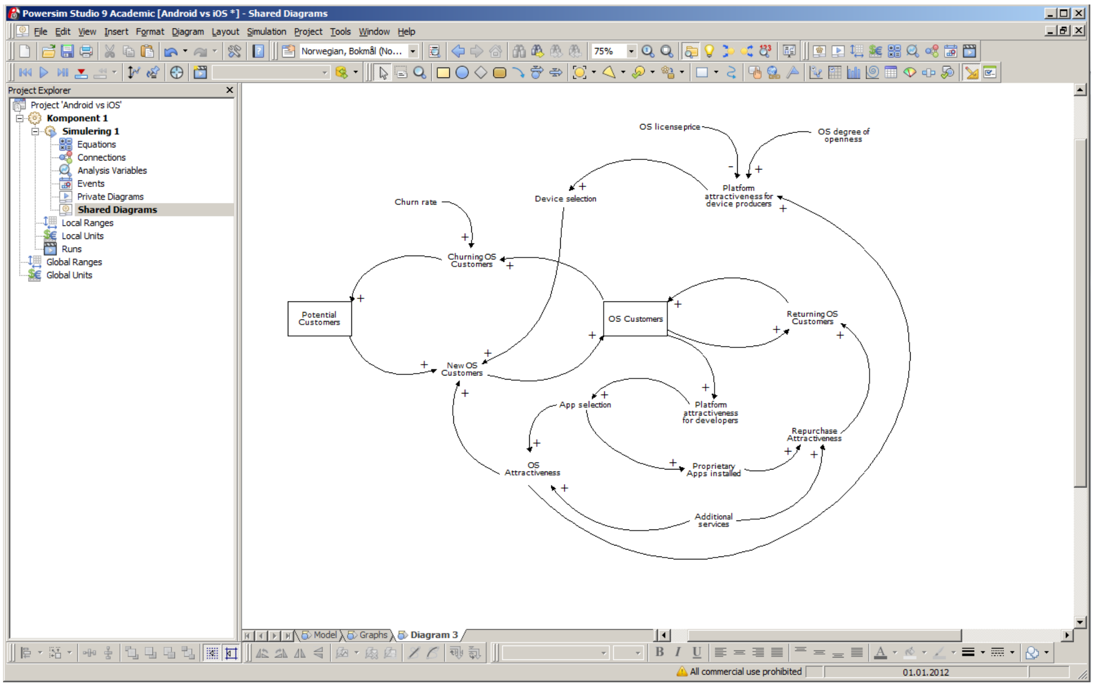

Figure 9 - Screenshot of Powersim

3.2.2 Modeling phase

The development of the model used in this thesis was done in two steps. First, a causal loop diagram of a single OS and its surrounding parameters was made. Based on the analysis in chapter 4, three main aspects were chosen to be included in the model, namely apps, devices and additional services. These aspects are further discussed in chapter 7. The purpose of developing the causal loop diagram was to obtain an overview of the system which was going to serve as a basis for the stock and flow model. In addition, link polarities were assigned in to order to capture the effect of changes throughout the model.

The next step was to expand the model and add stocks and flows in order to capture the accumulated levels of customers. The purpose was to set up a model which examined the effects of a competition between two actors, competing for the same stock of customers. This was an iterative process which started with only three levels and the connecting flows. When the initial rate equations were deemed satisfactory, more auxiliary variables and constants were added, resulting in more complexity. The rate equations were updated to include the newly added variables, and the process led to the final model, presented in chapter 5.

The competition model does only consist of two actors, which clearly is a rather significant simplification of the real world market. However, the purpose was not to model the entire market, but to examine some of the characteristics that may result in a competitive advantage. To model a complete market was considered to be too complex within the time frame of this thesis, so this two-sided competition model may be seen as the first step which may serve as a basis for a future expansion.

3.2.3 Simulation phase

After developing the model, several simulation runs were carried out using the built-in simulation feature in Powersim. Three main scenarios were used as a basis in the simulation phase, and these scenarios correspond to the three aspects mentioned in the previous section – apps, devices and additional services. Detailed descriptions of the different scenarios are provided in chapter 6, with the corresponding results.

The results of the simulation were recorded using Powersim's graphing tools, where the development of important parameters and levels were shown as time graphs. In chapter 6, graphs showing the market shares are provided for each simulation run. In addition, graphs showing selected parameters relevant for each simulation run are shown.

In these simulation runs, the flow of customers between the actors is approximated as a continuous stream rather than a discrete representation of customers moving at discrete points in time. Since the purpose of the model is not to track individual customers, but rather observe the accumulated levels of customers, it is considered adequate to use a continuous approximation (Sterman, 2000).

4 The mobile OS market

As additional background for the model presented in chapter 5, a description of current mobile operating systems is provided in this chapter. Following this overview, the development of market shares in the mobile OS market in the period 2007-2011 is presented. Last, characteristics of this competitive market are discussed, based on the mobile OS actors' different approaches to gain competitive advantages with respect to platform strategies and roles in the ecosystems.

4.1 Overview of current mobile OS

In this section an overview of today's largest mobile OS actors in terms of market share is given. The operating systems included are Android, iOS, BlackBerry OS, Symbian, Windows Phone and bada.

A brief historical development for each OS is provided, as well as a description of their app distribution channels and a summary of the largest device manufacturers that make smartphones with the different operating systems. In addition, the implementation of platform type and the OS owners' roles in the surrounding ecosystem are described in terms of the typology presented in section 2.3 and 2.4.

4.1.1 Android

Android is an operating system for smartphones and tablets based on a Linux kernel. Google acquired the startup company Android Inc. in 2005 (Elgin, 2005), and developed the software further through the consortium Open Handset Alliance[12]. The first commercial version of the operating system was released with the handset HTC Dream G1 on September 23 2008 (Aamoth, 2008).

Android's main distribution channel for apps is Google Play[13] (previously named Android Market). As of February 2012, the marketplace offered over 450 000 apps to Android users (Rubin, 2012) and during spring 2012 Google Play reached the milestone of 15 billion apps downloaded since the marketplace launched in 2008 (Lunden, 2012).

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[12] http://www.openhandsetalliance.com/
[13] https://play.google.com/store

Android is used on a wide range of smartphone devices from several device manufacturers. Device manufacturers shipping smartphones with Android include among others LG, Huawei, HTC, Samsung, Acer, Motorola, Sharp and Sony (Google, 2012).

4.1.1.1 Platform type

As the Android platform owner, Google controls the value asset of the operating system. They do not, however, control the hardware part of the package that is sold to the customers, and the device manufacturers advertise their own brand when selling devices running Android. Focus is on creating an attractive distribution channel for 3rd party developers in order to offer a wide selection of apps and services for Android users, and maintaining a large customer base to keep the platform attractive for developers. Android is here categorized as an Enabler Platform.

4.1.1.2 Role in ecosystem

Google currently control 3 of the roles around Android OS as depicted in Figure 10:

1. Platform maker: Google owns the marketplace (Google Play) where content providers and application developers may distribute their products to Android users. Revenue is shared between Google and the publisher, where Google keeps 30% of the revenue generated by an app.
2. OS owner: Google controls development and release of the OS.
3. Service provider: additional services that may be used within the Android ecosystem are also provided by Google, such as e-mail (Gmail), calendar service, cloud-based file storage (Drive) and navigation (Google Maps) to name a few. These services are not limited to Android users, but contribute to keeping users locked in to Google’s product line.

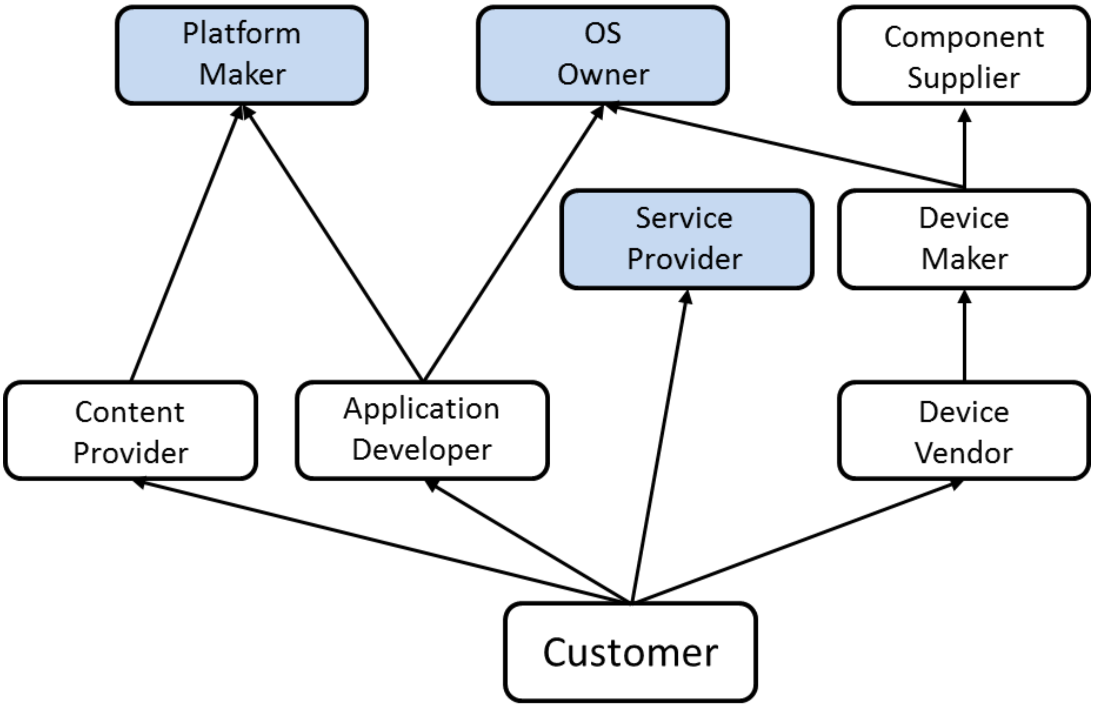

Figure 10 - Google's role in the ecosystem

Google has also had a short run as a device vendor, when they sold the first Google smartphone Nexus One (made by HTC) through their online store but the strategy was abandoned after a few months.

4.1.2 iOS

iOS is Apple's operating system for their mobile devices such as iPhone, iPod and iPad. Apple released the first device running iOS (then named iPhone OS) June 29, 2007 (Apple, 2007). Before the launch of iPhone other smartphones also had touch sensitive screens, but Apple changed the smartphone environment with their focus on usability and finger-based touch instead of having to use a stylus to navigate in the menu system.

Apple's distribution channel for apps to devices running iOS is App Store[14]. App Store was released in July 2008, and started out with an initial number of 500 apps available for download (Apple, 2008). In March 2012, Apple announced that the App Store offered more than 550 000 apps and that more than 25 billion apps have been downloaded since the release in 2008 (Apple, 2012).

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[14] http://itunes.apple.com/us/genre/ios/id36?mt=8

Apple does not license iOS to any other device manufacturer, and has so far released five different versions of the iPhone running iOS: iPhone (2007), iPhone 3G (2008), iPhone 3GS (2009), iPhone 4 (2010) and iPhone 4S (2011) (Wikipedia).

4.1.2.1 Platform type

Apple controls both the software and hardware assets regarding their mobile initiative. They also have a direct customer relationship through the sale of their own branded device through their web store and Apple brand stores. Similar to the Android ecosystem, Apple also needs to focus on maintaining the attractiveness of their ecosystem through attracting app developers and maintaining a large customer base for their app marketplace. Apple’s mobile ecosystem, including the iPhone and iOS, is here categorized as a System Integrator Platform.

4.1.2.2 Role in ecosystem

Apple controls a larger part of the iOS ecosystem with a total of five different roles as depicted in Figure 11:

1. Platform maker: just like Google, Apple controls the content and app distribution through their marketplace App Store.
2. OS owner: Apple controls development and release of iOS.
3. Service provider: Apple also offers additional services through the media portal iTunes, such as music, TV shows and movies. In addition, the iCloud service provides synchronization of documents, contacts, apps, pictures and more between the user’s Apple devices.
4. Device maker: the iPhone is an Apple branded device. Although Apple does not own the factories that produce the devices, Apple is in control of the design and the brand that iPhone is released under.
5. Device vendor: Apple also sells their own devices through their web site and their own retail store chain.

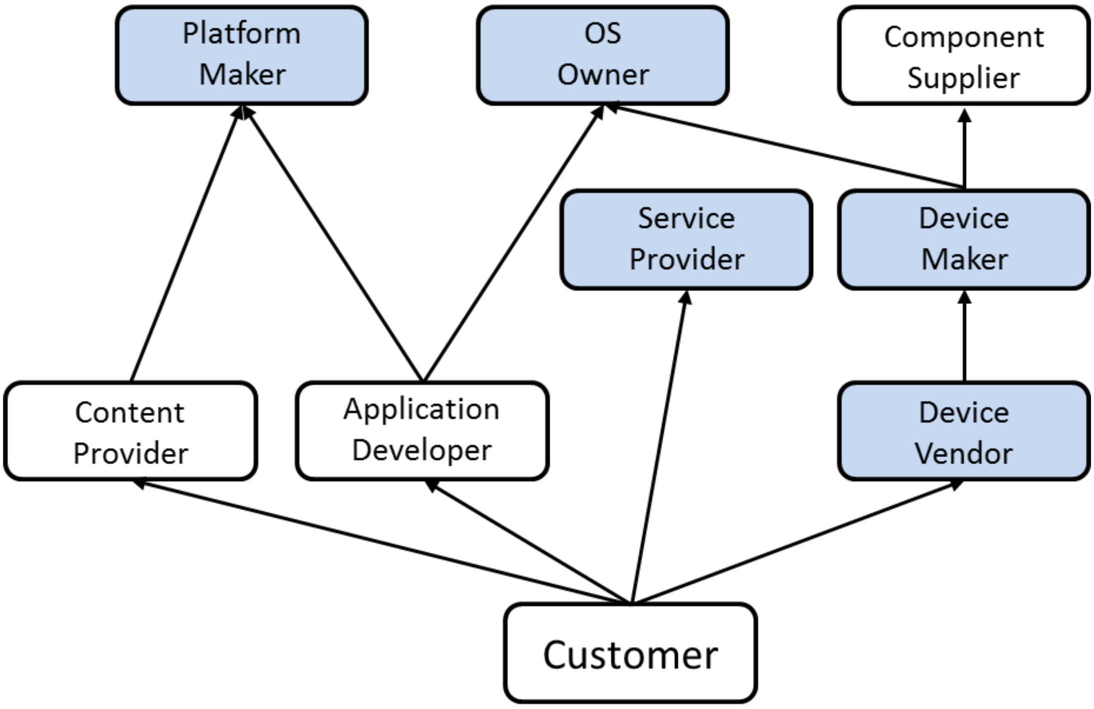

Figure 11 - Apple's role in the ecosystem

4.1.3 BlackBerry OS

BlackBerry OS is developed by the Canadian telecommunications company Research In Motion (RIM) for their smartphone device line BlackBerry. RIM first released a BlackBerry OS version for smartphone in March 2002 (Research In Motion, 2002).

RIM operates the app distribution channel, BlackBerry App World[15], released on April 1, 2009 (Research In Motion, 2009). BlackBerry App World reached the milestone of 2 billion downloads in January 2012 (Zeis, 2012) and in May 2012, RIM announced that there were 99 500 apps available in BlackBerry App World (Halvey, 2012).

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[15] http://appworld.blackberry.com

Similar to Apple, RIM does not allow other device manufacturers to make smartphones running BlackBerry OS. RIM offers a wide range of smartphones, both with touchscreens and QWERTY keyboards.

4.1.3.1 Platform type

RIM controls both the hardware and software assets in their ecosystem, and the products they advertise are BlackBerry devices running BlackBerry OS. As with Android and iOS, there is a critical need for attracting 3rd party developers and hence maintaining a large customer base. RIM's mobile ecosystem is here categorized as a System Integrator Platform.

4.1.3.2 Role in ecosystem

RIM controls four roles in the ecosystem surround their devices running BlackBerry OS as depicted in Figure 12:

1. Platform maker: apps are distributed through the RIM controlled BlackBerry App World.
2. OS owner: RIM develops their own OS, BlackBerry OS.
3. Service provider: RIM offers a line of services primarily focusing on corporate needs, with extended e-mail services, cloud service built around Microsoft Office 365 and a proprietary instant messaging client. In addition, RIM offers a music service, BBM Music.
4. Device maker: RIM offers a wide range of smartphones with their BlackBerry line.

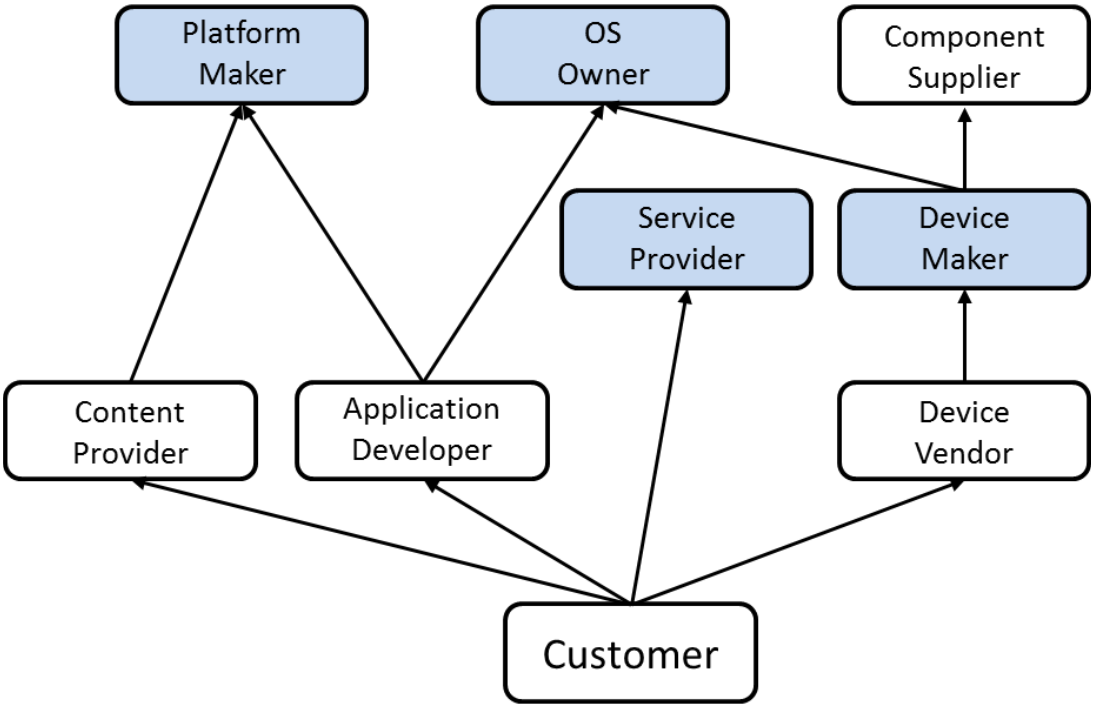

Figure 12 - RIM's role in the ecosystem

4.1.4 Symbian

Symbian Ltd. was formed in 1998 as a joint venture between the former developer of the OS, Psion, and major device manufacturers Ericsson, Motorola and Nokia (Rossen, 2004). In 2000, Nokia announced that their model 9210, the first smartphone with a Symbian OS, were to be launched in 2001 (Nokia, 2000). Nokia acquired Symbian Ltd. in 2008, becoming the sole owner of the mobile OS (Nokia, 2008). In 2009, the Symbian Foundation was formed by Nokia, Sony Ericsson, Motorola and several other big players in the telecommunication industry, with the purpose of making Symbian available open source (Nokia, 2008). Due to the lack of support from its members, the Symbian Foundation transitioned to a licensing operation only, leaving Nokia to step up their control over Symbian again (Nokia, 2010). In February 2011, Nokia announced that they would adopt Microsoft's Windows Phone as their primary smartphone strategy, reducing the commitment to Symbian as their smartphone OS (Nokia, 2011). A few months after Nokia's announcement regarding the transition to Windows Phone, Nokia released a statement regarding the outsourcing of Symbian to the consulting firm Accenture who are to provide updates and services until 2016 (Nokia, 2011).

The distribution channel for 3rd party apps to Symbian devices, Ovi Store[16], is owned and operated by Nokia.

Several device manufacturers, including LG, Motorola and Sony Ericsson, have released devices with Symbian OS. Nokia has however been the largest device manufacturer for Symbian supported devices.

Even though Accenture is the current developer of the OS, the description in 4.1.4.1 and 4.1.4.2 is based on the period where Nokia was the primary company behind Symbian OS. This provides part of the background for the discussion in 4.2 and 4.3 which takes the market share in 2007-2011 into consideration, and hence the period before Accenture assumed control.

4.1.4.1 Platform type

Until the transfer of development responsibility to Accenture in the fall of 2011, Nokia remained in control over the software assets. Nokia also established direct relationships with customers by controlling the hardware assets and selling Nokia branded devices. Nokia is here categorized as a System Integrator Platform.

4.1.4.2 Role in ecosystem

Until the fall of 2011, Nokia controlled four roles surrounding the Symbian ecosystem as depicted in Figure 13:

1. Platform maker: apps to Symbian devices are distributed through Nokia's mobile marketplace Ovi Store.
2. OS owner: Nokia was the main controller and developer of the OS.
3. Service Provider: Nokia offers additional services as well, including navigation (Nokia Maps) and a music store (Nokia Music).
4. Device Maker: Nokia controls designing and manufacturing of their devices.

[16] http://store.ovi.com/

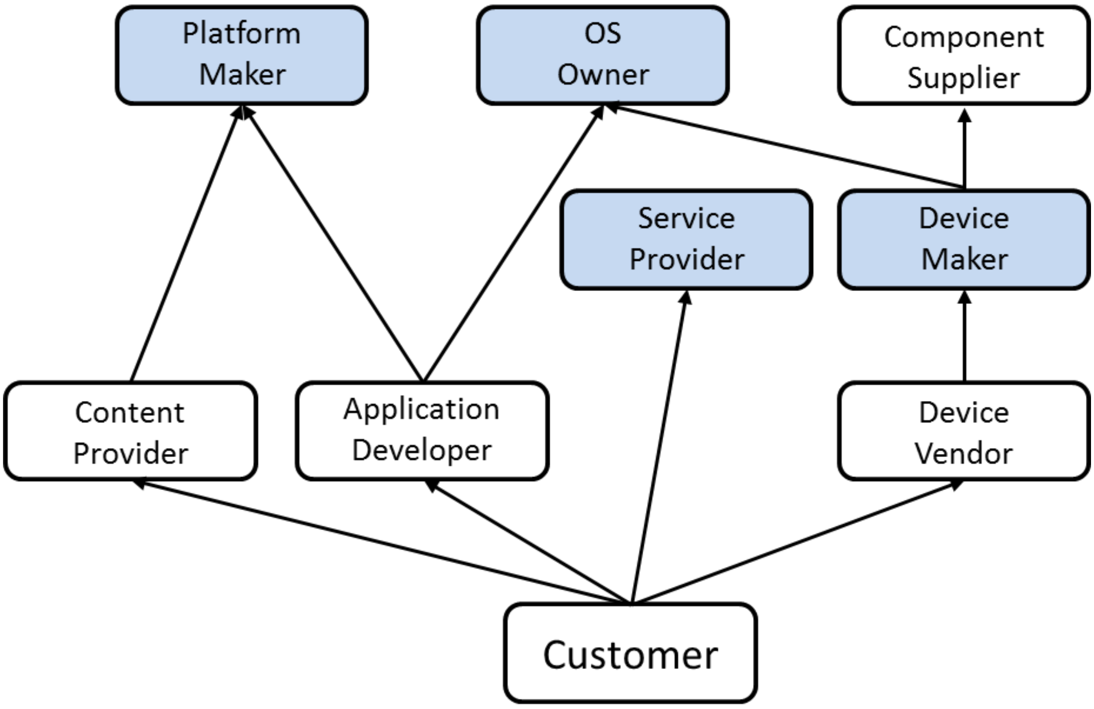

Figure 13 - Nokia's role in the ecosystem

4.1.5 Windows Phone

Microsoft announced their new mobile operating system, Windows Phone, in February 2010 (Microsoft, 2010), and devices made by HTC, Dell, LG and Samsung were shipped with Windows Phone 7 during the fall of 2010. Windows Phone replaced Microsoft's former mobile initiative, Windows Mobile, which was released in several different versions during the period 2000-2010.

The main app distribution channel is Microsoft's Windows Phone Marketplace[17], released shortly after the release of the Windows Phone OS. During the spring of 2012, the Windows Phone Marketplace reached 80 000 available apps (Blandford, 2012).

Microsoft does not make their own devices, but Windows Phone is in use by several major device manufacturers. In addition to devices from HTC, Dell, LG and Samsung, Microsoft announced in 2011 plans for a partnership with Nokia where

[17] http://www.windowsphone.com/marketplace

Nokia is planning on adopting Windows Phone as their main smartphone strategy (Microsoft, 2011).

4.1.5.1 Platform type

As mentioned in the last section, Microsoft does not assert direct control over hardware assets, but do possess the software assets. Seeing as they do not manufacture devices and hence have no direct relationships with their customers, they adopt an Enabler Platform strategy.

4.1.5.2 Role in ecosystem

Similar to Google, Microsoft possesses three roles in the ecosystem surrounding the Windows Phone OS as depicted in Figure 14:

1. Platform maker: 3rd party apps are distributed to Windows Phone users through the Microsoft controlled market place Windows Phone Marketplace.
2. OS owner: as a software development company, Microsoft controls the development of their OS, Windows Phone.
3. Service provider: additional services include music and video through Microsoft’s Zune platform, games through the Xbox Live platform, and synchronization of contacts, e-mail and documents through the Microsoft Office Mobile suite.

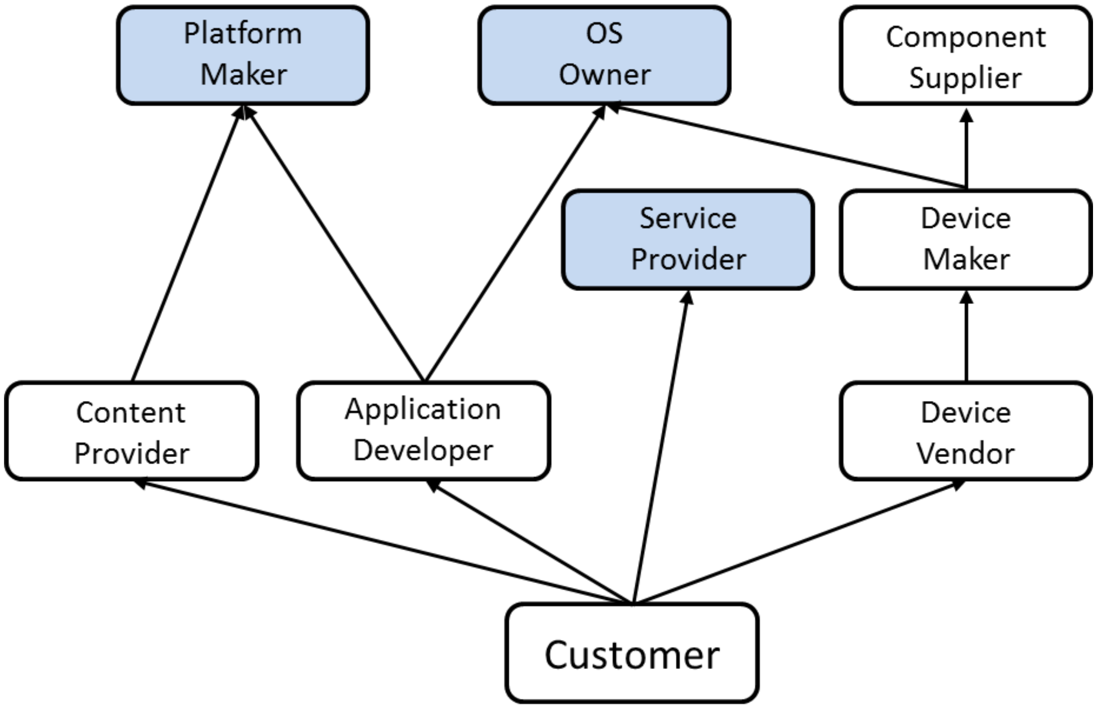

Figure 14 - Microsoft's role in the ecosystem

4.1.6 bada

bada is a mobile operating system developed by Samsung, and their first device shipped with bada – Samsung Wave S8500 - was announced in 2010 (Samsung, 2010).

Samsung opened their bada app distribution channel Samsung Apps[18] with the release of the first Samsung Wave phone in June 2010 (Manninen, 2011). In addition to bada apps, Samsung Apps also distribute Android apps. Samsung's latest official app statistics reveal that as of March 2011, over 13 000 apps were available and the milestone of 100 million downloads had been reached (Samsung, 2011).

bada is only shipped with Samsung devices, and Samsung have named their bada product line Samsung Wave.

4.1.6.1 Platform type

Samsung controls both the hardware and software assets surrounding their bada platform, and is hence categorized as a System Integrator Platform.

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[18] http://www.samsungapps.com/

4.1.6.2 Role in ecosystem

Samsung controls three roles in the bada ecosystem, as depicted in Figure 15:

1. Platform maker: apps are distributed through Samsung's marketplace Samsung Apps.
2. OS owner: bada is developed solely by Samsung.
3. Device maker: Samsung is one of the major smartphone device manufacturers, and makes all smartphones running bada OS.

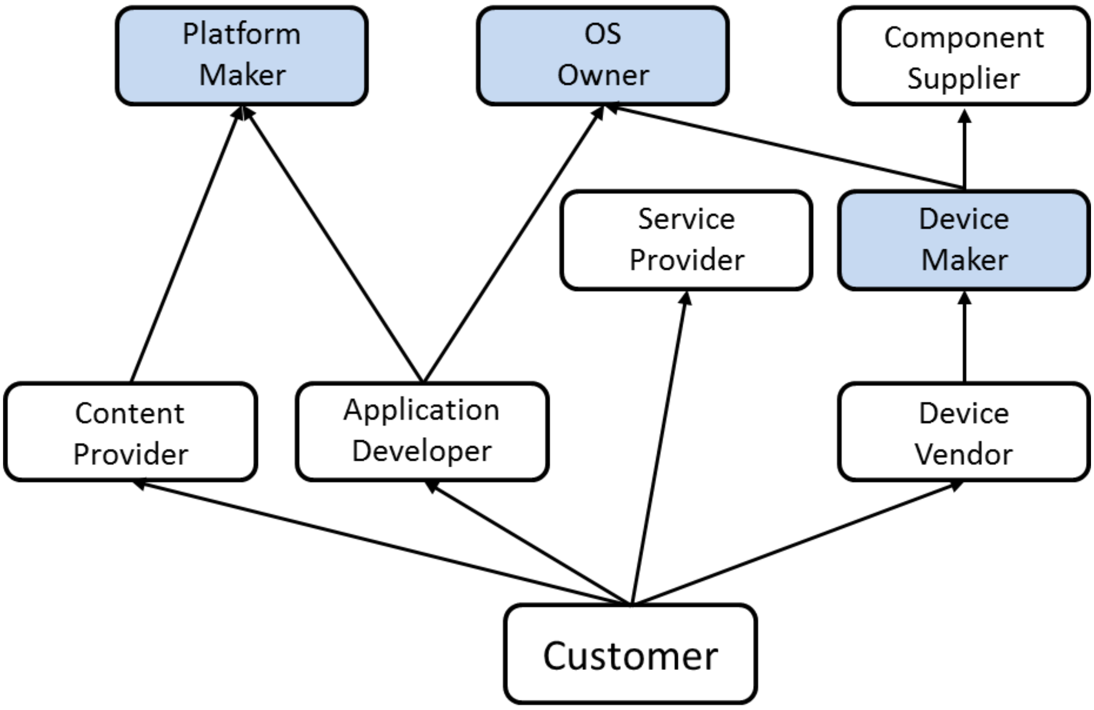

Figure 15 - Samsung's role in the ecosystem

4.2 Market shares in the period 2007-2011

The market for smartphones running advanced operating systems is relatively new, but during the period since Apple launched their first iPhone in 2007 (Honan, 2007) there has been several major changes. The changes include both global annual sale numbers of smartphones and the market leaders of the mobile OS competition. Annual sales numbers have risen from 122 million in 2007 (Gartner, 2009) to 296 million in 2010 (Gartner, 2011).

Figure 16 through Figure 20 summarize the change in market share in the period 2007-2011. The largest single impact in the variety of market leaders has been Google's launch of their mobile OS Android, increasing from a market share of ~4% in 2009 to become the largest smartphone OS in 2011 with a market share of ~51%. Apple has also had a stabile increase in their market share with 3%, 8%, 14%, 16% and 24% in 2007, 2008, 2009, 2010 and 2011 respectively.

Other significant changes to note are Symbian's decline from the superior market leader in 2007 with 63% to getting close to RIM's market share with about 10% in 2011. Microsoft has also seen a significant decline in their market position, decreasing from 12% in 2007 to 2% in 2011.

There are important considerations to note while reading these graphs: since the total sales of smartphones have increased more than 142% during this period, a decrease in market share for one actor does not necessarily mean that their sales numbers have decreased from one year to the next. In addition, the numbers show the market share based on sales each year and consequently does not represent the total market with older devices.

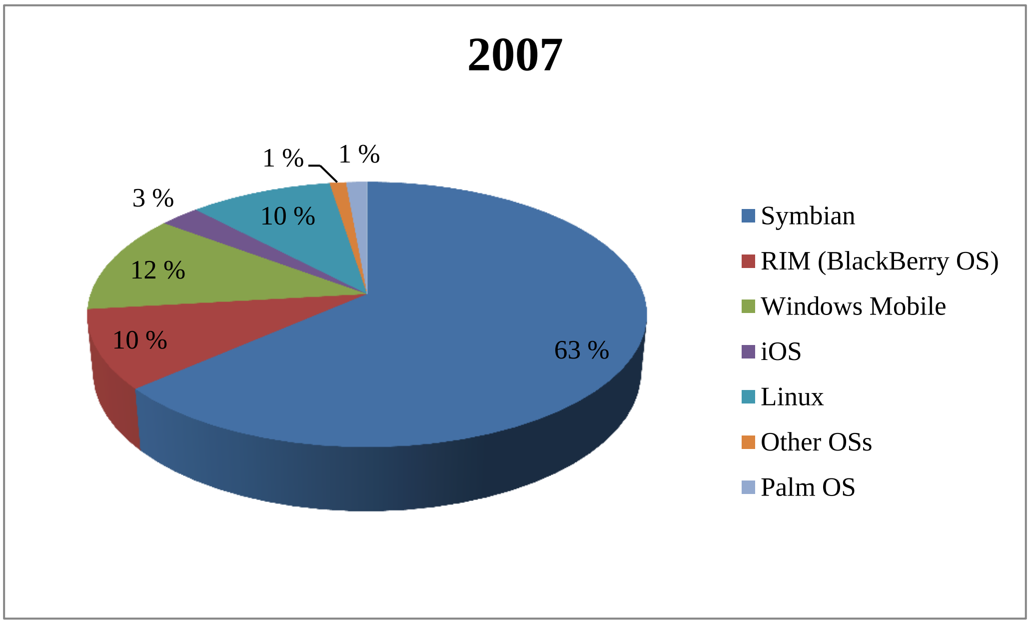

Figure 16 - Market share by OS in 2007. Source: (Gartner, 2009)

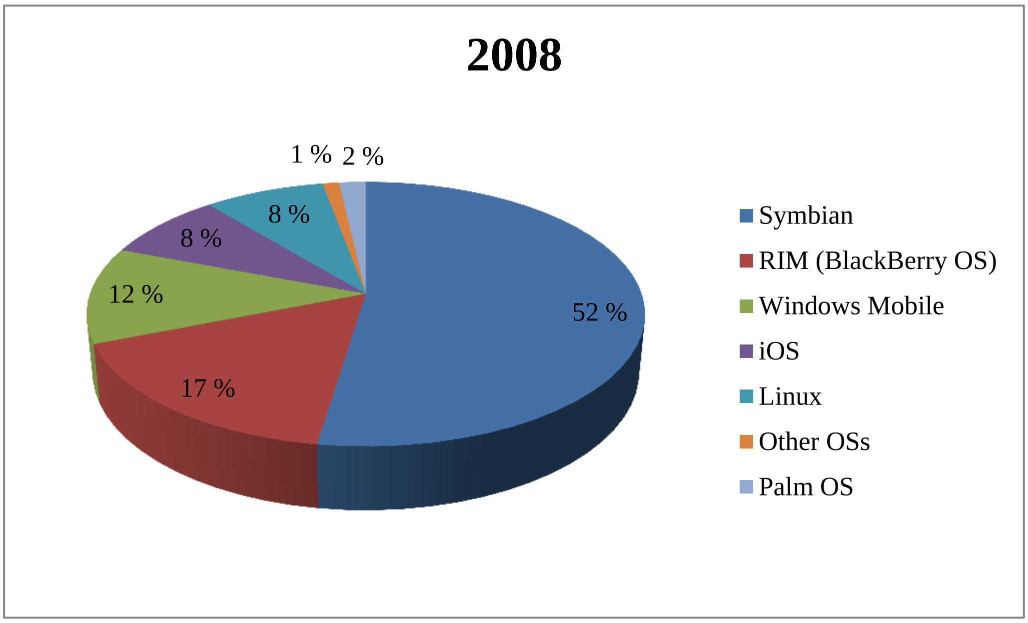

Figure 17 - Market share by OS in 2008. Source: (Gartner, 2009)

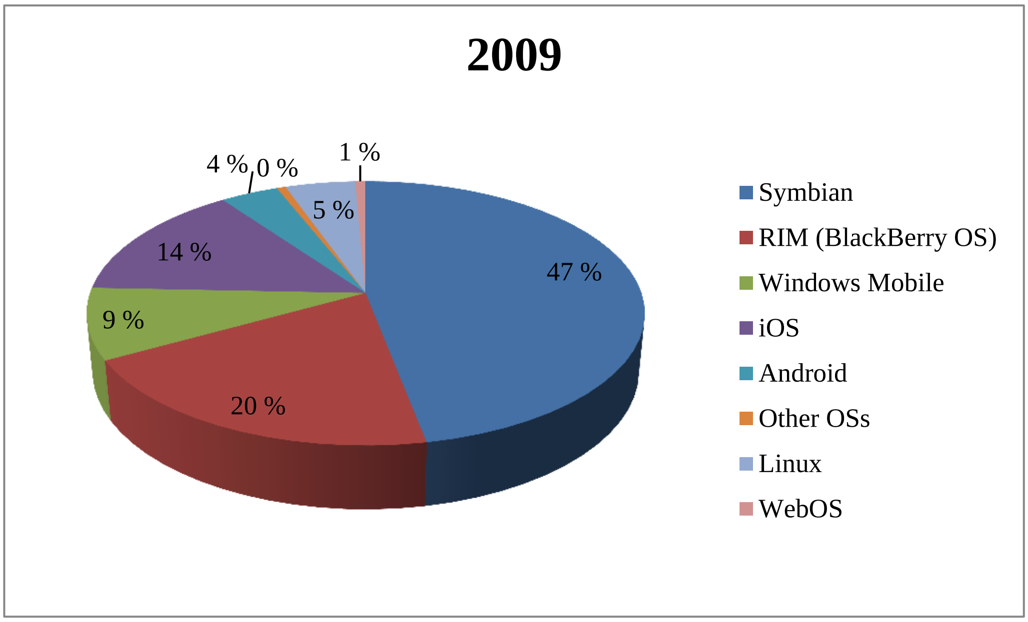

Figure 18 - Market share by OS in 2009. Source: (Gartner, 2010)

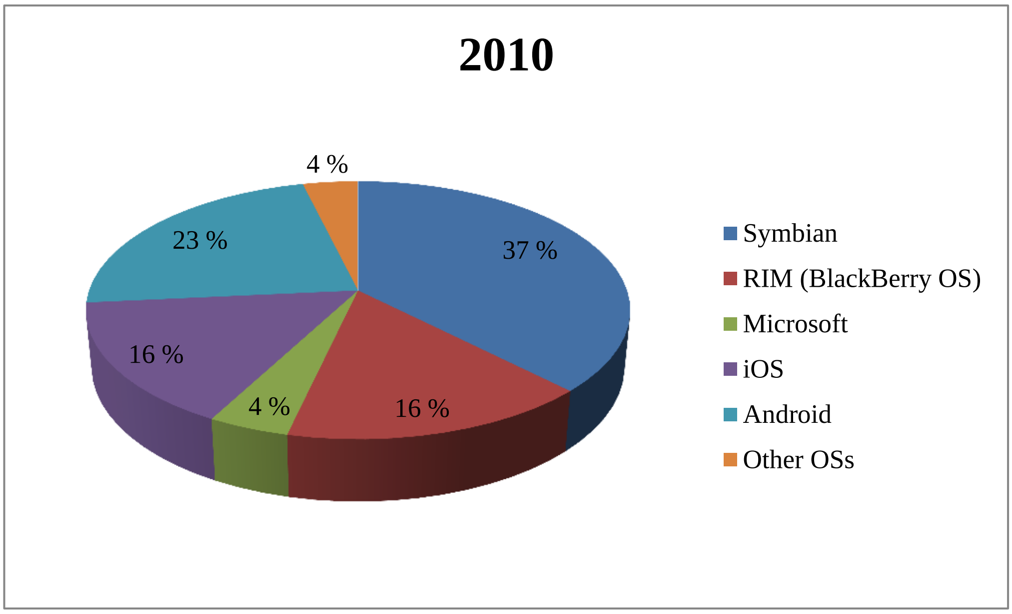

Figure 19 - Market share by OS in 2010. Source: (Gartner, 2011)

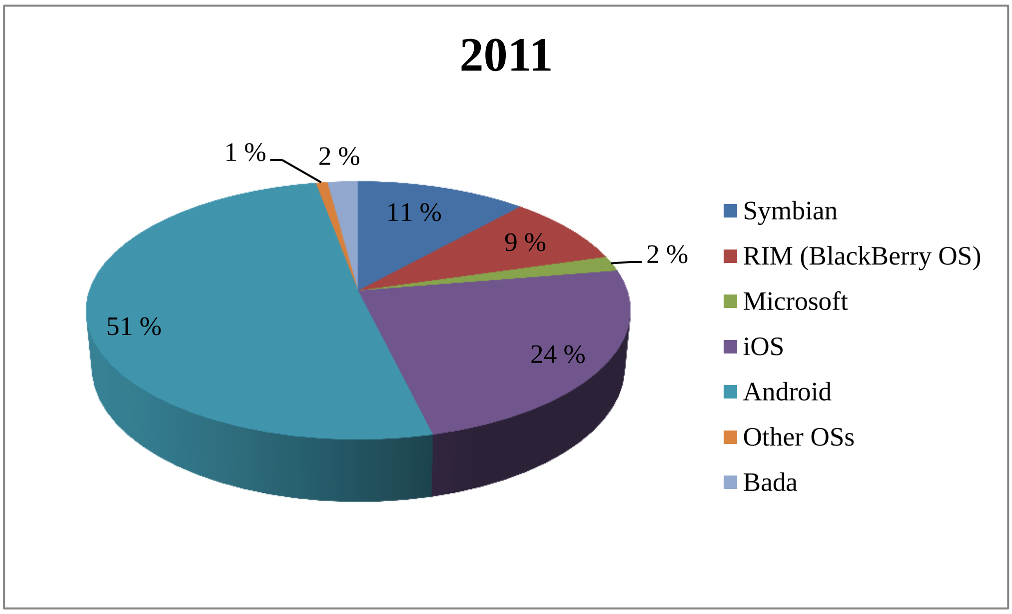

Figure 20 - Market share by OS in Q4 2011. Source: (Gartner, 2012)

4.3 Competition characteristics

Following the description of each mobile OS, their platform strategy and roles in the ecosystem, this section provides a discussion of the different approaches to gain competitive advantages in this market. The platform strategies are discussed first, followed by comments regarding the ecosystem roles taken by the actors.

4.3.1 Platform strategy

In section 4.1, six of the major actors in the mobile device and OS industry were described and their choices of platform strategy were categorized. The categorization is summarized in Table 3.

	Google Android	Apple iOS	RIM BlackBerry OS	Nokia Symbian	Microsoft Windows Phone	Samsung bada
Enabler	✓				✓	
System Integrator		✓	✓	✓		✓
Neutral						
Broker						

Table 3 - Summary of platform strategies

None of the actors were categorized as a neutral or broker platform, which follows naturally from the fact that these two strategies require the platform owner to have no control over value adding assets such as the OS or additional software.

There is however a difference in the choice of platform strategy. Two of the actors have adopted an enabler platform and four actors have adopted a system integrator platform. What differentiates the actors in this sense is mainly their involvement in device design and production. Google and Microsoft, the two enabler platforms, do not take part in the device market and are primarily software companies. They face different challenges than the other actors, because they need to make their platforms attractive to device manufacturers and compete against each other in addition to some of the device manufacturers’ own operating systems.

Google’s Android has obtained a very attractive position as the mobile OS with the largest network size in the market. In addition to a well-developed ecosystem with the markets second largest application marketplace that has emerged with the increase of potential app customers, Android is open source and is licensed for free to device manufacturers. Android is consequently probably viewed as a safe choice when device manufacturers decide which OS to support as new models are designed and released.

As a late entrant with their new smartphone OS, Microsoft is faced with challenges to increase their network size in order to attract developers, customers and device manufacturers. The relatively newly formed partnership with Nokia is one of the strategic moves by Microsoft to gain a larger market share, and it remains to be seen if this partnership will spur success.

4.3.2 Ecosystem roles

In addition to their platform strategy, the mobile OS actors' roles in the ecosystems surrounding their mobile initiatives were presented using a food web model typology. A summary of the actors' roles is provided in Table 4. Based on this, some comments regarding the actors' choice of roles and possible implications for competition between the actors are provided in this section.

	Google Android	Apple iOS	RIM BlackBerry OS	Nokia Symbian	Microsoft Windows Phone	Samsung bada
OS owner	✓	✓	✓	✓	✓	✓
Platform owner	✓	✓	✓	✓	✓	✓
Service provider	✓	✓	✓	✓	✓	
Device maker		✓	✓	✓		✓
Device vendor		✓				

Table 4 - Summary of ecosystem roles

4.3.2.1 Platform ownership and app distribution

All actors play the obvious role of OS owner, although both Google and Nokia are (or in Nokia's case, have been) part of different consortiums supporting the development of Android and Symbian. In addition, all actors possess the role as platform owner, controlling important platform aspects such as the marketplaces for 3rd party apps. Seeing as all actors have chosen this strategy, it is assumed that apps and the control over the app distribution channels are of major importance in the competition to survive in the mobile OS market. Apple was the first major company to release such a marketplace, and competitors soon rushed to copy the approach.

Three possible explanations of the reasoning behind controlling the app distribution are proposed:

1. Increased revenue. Most of the marketplace owners operate with a 70% (developer) / 30% (marketplace owner) split of the revenue from sold apps which contributes to increased revenue for the platform owner.
2. Increased control over the customers. By controlling distribution of proprietary apps to customers, the platform owner facilitates the process of getting the customers to invest time and money into products that are non-transferrable between platforms. As the theory of lock-in and switching costs explains, more time and money invested into complementary products leads to a higher commitment to the platform (increased switching costs), and as a consequence customers are less tempted to switch to another platform.
3. A necessary competitive feature. An operating system without any compatible software is destined to become a failure. Quality software and a wide selection of such are crucial in order to survive in a highly competitive market, and an OS owner has to be the facilitator and the driving force to attract developers to their ecosystem. OS owners without a well-run app initiative will not likely have a great chance of succeeding.

4.3.2.2 Providing services

All but one (Samsung) of the analyzed actors are also involved in providing additional services to their users, ranging from e-mail and calendar services to file storage and music, movies and game portals. As service providing is a strategy implemented by the majority of the actors, it is here proposed that service providing is one of the important factors along with platform ownership in the mobile OS market competition.

Along with the reasoning behind the strategy of controlling app distribution, the same three explanations as provided in the previous section are proposed, with special emphasis on number two – increased control over customers. Both time and money are also invested into the usage of these additional services and the switching costs increase with the commitment to additional services.

Consider for example Google’s e-mail service Gmail. Most people have one e-mail address that they use for personal purposes, and that address is handed out to all of the user’s acquaintances. In addition, the user will spend time gradually building up the built-in contact list. An average e-mail inbox will also hold a significant amount of useful information, ranging from receipts from online shopping to (in the case of Gmail) logs from instant messaging conversations with friends and family. Also, almost every type of online service nowadays, ranging from shopping sites to social networking sites, use your e-mail address as log-in username when creating an account. In those cases where e-mail addresses are not used as username, you will in most cases need access to the address used when registering if you forget username and/or password. All these aspects need to be taken into consideration when switching to another e-mail service provider and many users will probably deem the switching costs to be too high and continue to use the same service. Although the example of an e-mail service might not be specific to the mobile OS sphere, it serves as a general example of a complementary service provided by major actors in the mobile OS market.

4.3.2.3 Device makers

Four of the actors possess the role of device maker, namely Apple, RIM, Nokia and Samsung. As manufacturing devices is a primary activity for most of these companies, development of their mobile operating systems may be seen as a complementary product strategy in order to either control a larger part of the value chain or participate in development and license the OS to other device manufacturers.

In the case of Apple, the strategy may be seen a little different. Based on the vision of co-founder Steve Jobs, Apple has always strived to keep their products closed in order to offer a strictly tailored user experience with tight connection between software and hardware. Seeing as the different versions of the iPhone never have had revolutionary hardware specifications compared to smartphones in the same price range, Apple sells a complete user experience where the usability of the OS and its applications, and the streamlined interaction between software and hardware, may be seen as one of the most important features of the iPhone package.

4.3.2.4 Device vendors

Only one of the actors, Apple, sells their devices through a brand specific retail store chain. Since the Apple Store chain was founded before Apple started their smartphone initiative, it is given less focus in this analysis. It is, however, a part of the strategy behind one of the major actors and hence contributes to differentiate the Apple brand from the other mobile OS actors.

5 Model

Using the theory of business dynamics as presented in section 2.1 and the Powersim software suite as presented in section 3.2, a model concerning some of the parameters and characteristics of the ecosystem surrounding a mobile OS has been developed. The model is developed in order to gain a better understanding of which impact changes in characteristics and parameters have in the competition between different operating systems in terms of market share and the rate of new customers.

The model is presented in two parts. First, a causal loop model of a non-specific OS is provided. The purpose of this is to show an overview of the model structure, and to show how changes in one part of the system may affect other parts, represented by the link polarity assigned to each link.

Second, the model is expanded with the stock and flow notation in order to quantitatively capture the accumulated levels of customers and the rate of which these levels changes. The expansion also includes a competitive angle, where two different operating systems are competing over the same customers. This stock and flow model is the basis for the simulation results presented in the next chapter.

5.1 Causal loop diagram

Figure 21 shows the causal loop diagram of the single OS model.

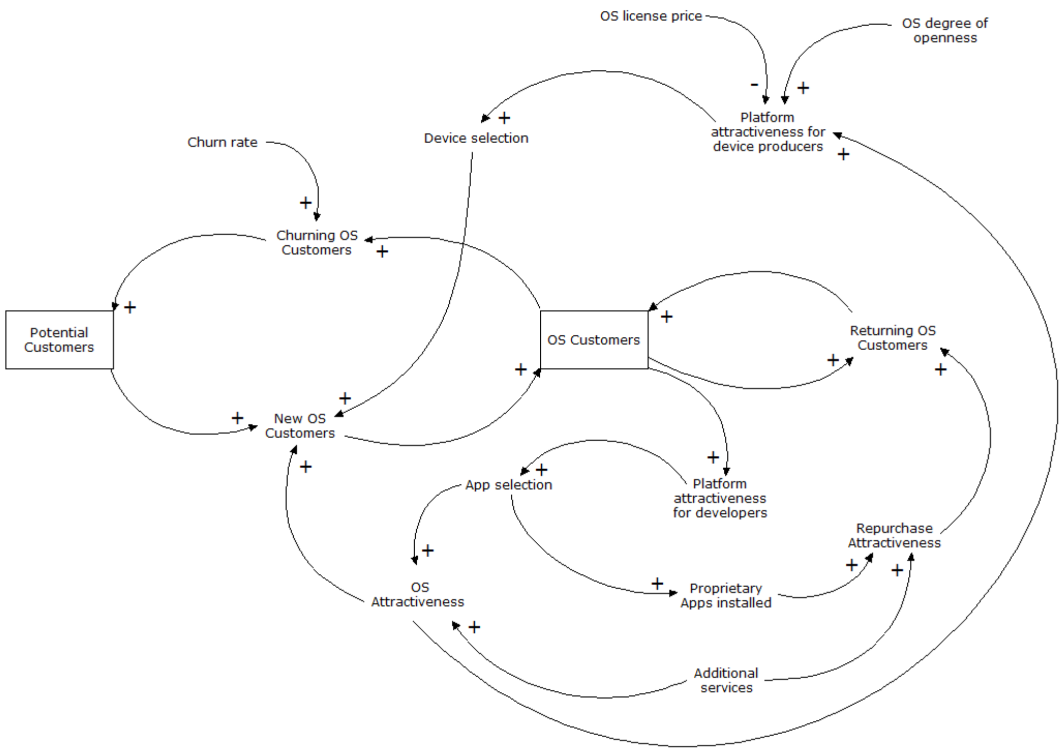

Figure 21 - Causal loop diagram of single OS model

The two main components in the model are **Potential customers** and **OS customers**. These two components represent the amount of potential buyers of a smartphone with a specific mobile OS and those customers who have already bought a smartphone with the given OS, respectively.

Next, there are three parameters which affect the number of customers in each of the two aforementioned levels:

1. **New OS Customers**: this parameter represents the rate of potential customers who decide to buy a smartphone with the given OS. The positive link from this rate to the component OS customers means that an increase in the rate leads to an increase of OS customers (and likewise, a decrease in the rate leads to a lower amount of customers than it would have been with a constant rate).
2. **Churning OS Customers**: represents the rate of which customers choose to leave the OS ecosystem, either by stopping to use a smartphone or buying a smartphone with an OS from another provider.

3. **Returning OS Customers**: represents the rate of which customers faced with the decision of buying a new smartphone choose to buy a device running the same OS.

These three rates are in turn affected by a web of other parameters which are described below.

Platform attractiveness for developers: a measurement of how attractive this platform is perceived by 3rd party app developers. The attractiveness grows with an increase in the market of potential buyers of apps from the developers – the OS customers.

App Selection: as the platform attractiveness for developers for a given OS increases, more developers will choose to develop apps for this platform and the selection of available apps in the marketplace is also considered as increasing.

Proprietary apps installed: this parameter measures how committed a customer is to the platform in terms of time and money invested in installing apps specific to the platform.

Additional services: this parameter represents the selection of additional services provided by the platform owner that in turn may lead to a higher degree of loyalty or lock-in for the customers. Examples of such services that exhibit increasing switching costs over time are Apple's iCloud synchronization service, or Google's Gmail client.

Repurchase attractiveness: based on the degree of commitment to the platform through proprietary apps installed and additional services used, this parameter represents the likeliness that an existing customer will continue to be a user of the same platform when buying a new smartphone.

OS attractiveness: this parameter represents the perceived attractiveness of the OS to potential customers, and is affected by the network size through app selection and the selection of available additional services. An increase in this attractiveness parameter leads to an increase in the rate of new customers.

Platform attractiveness for device producers: in the case where the OS owner licenses their operating system to other device manufacturers, this parameter measures how attractive the OS is for these manufacturers. The parameter depends directly on the perceived attractiveness for potential customers, and the reasoning behind this is that device manufacturers choose an OS based on the value added to their product in a marketing setting. In addition, price and openness affect the platform attractiveness.

OS license price: this parameter measures how costly an OS is to use on a new device made by a device manufacturer. A high license price has a negative effect on the platform attractiveness for device producers.

OS degree of openness: a measurement which represents how available the source code of an OS is, in terms of how much a device manufacturer may alter or add features to an OS.

Device selection: affected by the platform attractiveness for device producers, this parameter represents the selection of devices running a certain OS. If the platform attractiveness for device producers increases, it is assumed that the selection of supported devices increases.

Churn rate: the churn rate is the percentage of users that decide to abandon this specific OS ecosystem. When the churn rate increases, the number of Churning OS customers increases and hence the level of OS customers decreases.

As mentioned at the beginning of this chapter, the causal loop diagram shows an overview of the model structure. In order to capture changes in the accumulated levels, stocks and flows need to be introduced in the model. This expansion is covered in the section 5.2.

5.1.1 Feedback loops

Feedback loops are introduced in section 2.1.2.2, and the causal loop diagram in Figure 21 consists of several feedback loops. Five feedback loops are observed, of which four are reinforcing loops and one is a balancing loop. The reinforcing loops are explained with examples of increase, but as the theory explains, a negative effect (decrease) would also be reinforced in a similar way.

1. The loop OS Customers → Returning OS Customers → OS Customers is a reinforcing loop. When the amount of OS customers increases, the amount of returning customers increases which in turn contributes to an increase in the amount of OS customers.
2. The loop OS Customers → Platform attractiveness for developers → App selection → Proprietary apps installed → Repurchase Attractiveness → Returning OS Customers → OS Customers is a reinforcing loop. An increase in the amount of OS customers is followed by increase in the intermediate parameters leading to an even larger increase in the amount of OS customers.
3. The loop OS Customers → Platform attractiveness for developers → App selection → OS Attractiveness → New OS Customers → OS Customers is a reinforcing loop. Again, an increase in the amount of OS customers is propagated through the loop leading to further increase in OS customers.
4. The loop OS Customers → Platform attractiveness for developers → App selection → OS Attractiveness → Platform attractiveness for device producers → Device selection → New OS Customers → OS customers is a reinforcing loop based on the reasoning behind the three previous examples.
5. The loop Potential Customers → New OS Customers → OS Customers → Churning OS Customers → Potential customers is a balancing loop. The amount of potential customers decreases as customers become OS customers. However, when more customers become OS customers, the amount of churning customers increases, which in turn increases the amount of potential customers and slows down the growth of OS customers.

5.2 Stock and flow diagram

With the causal loop diagram presented in the previous section as a basis, the model is expanded to a market setting with competition between two operating systems. The model is presented in Figure 22.

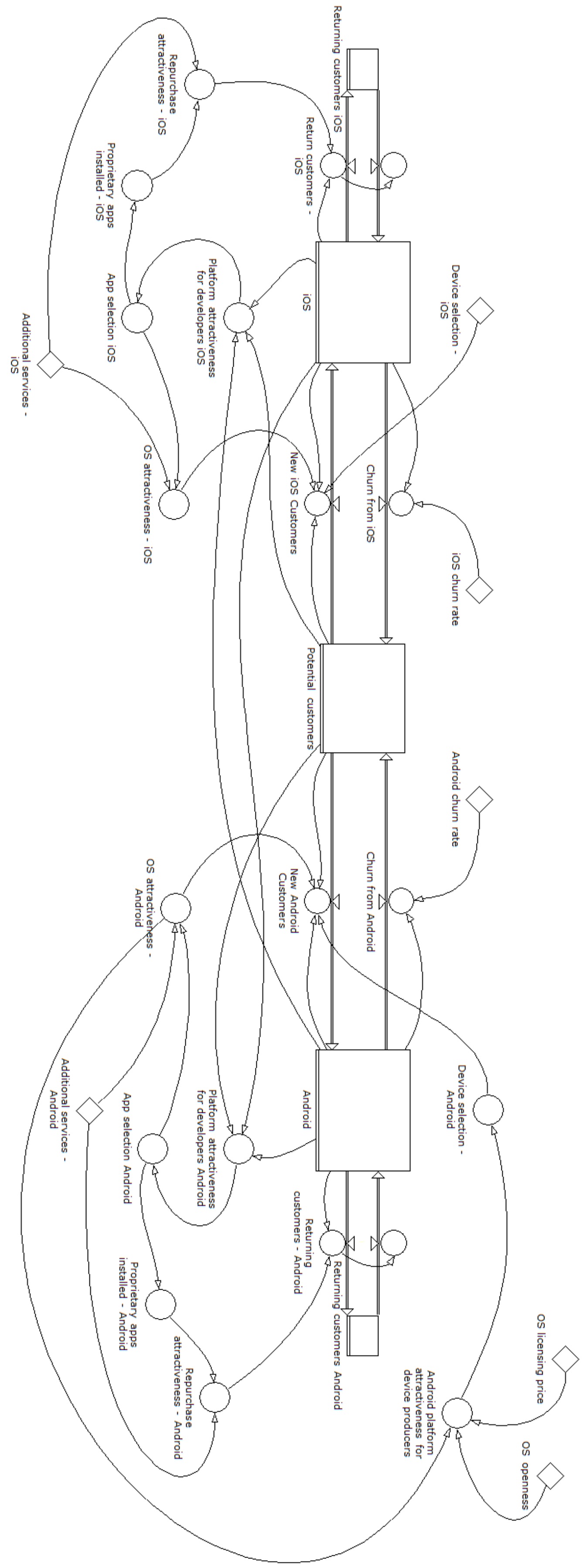

Figure 22 - Competition model

This model is developed around three main stocks, namely Potential customers, iOS and Android, where the two latter stocks represent the number of customers who own a smartphone running one of these operating systems.

Each of the stocks has one or more inflows and outflows which cause changes in the accumulated levels. Each flow has a corresponding rate, which is represented in terms of customers/day. As described in section 5.1, each rate is affected by a number of dynamic parameters, represented by the arrows pointing to the rate symbols. Most of these parameters were described in section 5.1. There are, however, a few differences:

1. In the single OS causal loop diagram, platform attractiveness for developers was solely based on the number of OS users. In this expanded competition model, attractiveness for developers is based on the magnitude of the market share. That is, the percentage of customers of one OS compared the total number of potential customers and customers of the other OS. Hence, the platform/OS with the largest market share is more attractive to the developers compared to the OS with a smaller market share.
2. Device selection is different for the two operating systems involved in the competition. Apple has a very small selection of smartphones available in the market at any given time, and for modeling purposes this is represented by a single constant “Device selection – iOS”. Android on the other hand, sees a more dynamic selection where new models from many different manufacturers are launched throughout the year. In addition, iOS is only available on devices from the OS owner, where the market share of Android depends on Google’s effort to attract device manufacturers to produce devices running on their platform.

This competition model is used to simulate the dynamics of market competition between two actors, and the results of the simulations are presented in chapter 6.

5.2.1 Equations and values

Each of the components in the stock and flow diagram, including stocks, flow rates, auxiliary variables and constants are defined with an equation or an initial value. These equations and initial values are provided in Table 5 (stocks), Table 6 (constants), Table 7 (flow rates) and Table 8 (auxiliary variables).

Parameter	Equation / initial value
Android	300 [customers]
iOS	200 [customers]
Potential customers	1000 [customers]
Returning customers – Android	0 [customers]
Returning customers - iOS	0 [customers]

Table 5 - Stock definitions

Parameter	Equation / initial value
Additional services – Android	0,4
Additional services – iOS	0,6
Android churn rate	0,0005
Device selection – iOS	1
iOS churn rate	0,0005
OS licensing price	0
OS openness	0,9

Table 6 - Constant definitions

Parameter	Equation / initial value
Churn from Android	$Android * Android\ churn\ rate$ [customers/day]
Churn from iOS	$iOS * iOS\ churn\ rate$ [customers/day]
New Android customers	$\frac{Android}{Android + Potential\ customers} * \left(1 - \frac{Android}{Android + Potential\ customers}\right) * OS\ attractiveness\ Android * Device\ selection\ Android * 2$ [customers/day]
New iOS customers	$\frac{iOS}{iOS + Potential\ customers} * \left(1 - \frac{iOS}{iOS + Potential\ customers}\right) * OS\ attractiveness\ iOS * Device\ selection\ iOS * 2$ [customers/day]
Returning customers – Android	$0{,}00025 * Repurchase\ attractiveness\ Android * Android$ [customers/day]
Returning customers – iOS	$0{,}00025 * Repurchase\ attractiveness\ iOS * iOS$ [customers/day]

Table 7 - Flow rate definitions

Parameter	Equation / initial value
Android platform attractiveness for device producers	$OS\ attractiveness\ Android * (1 - OS\ licensing\ price) * OS\ openness$
App selection Android	$4{,}5 * Platform\ attractiveness\ for\ developers\ Android$
App selection iOS	$6{,}5 * Platform\ attractiveness\ for\ developers\ iOS$
Device selection – Android	$Android\ platform\ attractiveness\ for\ device\ producers$
OS attractiveness – Android	$App\ selection\ Android * (1 + \frac{Additional\ services\ Android}{2})$
OS attractiveness – iOS	$App\ selection * (1 + \frac{Additional\ services\ iOS}{2})$
Platform attractiveness for developers Android	$\frac{Android}{Android + iOS + Potential\ customers}$
Platform attractiveness for developers iOS	$\frac{iOS}{Android + iOS + Potential\ customers}$
Proprietary apps installed – Android	$10 * App\ selection\ Android$
Proprietary apps installed – iOS	$15 * App\ selection\ iOS$
Repurchase attractiveness – Android	$\frac{Proprietary\ apps\ installed\ Android}{40} * (1 + Additional\ services\ Android)$
Repurchase attractiveness – iOS	$\frac{Proprietary\ apps\ installed\ iOS}{40} * (1 + Additional\ services\ iOS)$

Table 8 - Auxiliary variable definitions

6 Results

Using the model presented in chapter 5, simulation runs are set up with the Powersim software suite. Three different main scenarios are carried out, in order to examine the effect on the development of market share from three different parts of the model. These scenarios concern the additional services, the role of apps and the device selection, respectively. The three main scenarios have three “sub scenarios” each, where the main parameters for each scenario are given different initial values to examine the effects. The three main scenarios, their sub scenarios and the initial values are described in the following sections.

All simulation runs have some characteristics in common:

- The simulation runs are set up to go from 01.01.2012 to 01.01.2014, giving the model two years of maturity. The time period of two years gives the model enough time to “settle”, that is, to overcome the initial unstable dynamics and provide a close to stable equilibrium. One exception is the first simulation run in the device selection scenario, where the simulation needs four years to become stable.
- The model takes into consideration today’s market share, where Android has gained a dominant market position compared to iOS.

6.1 Additional services

In this scenario, the effect of providing additional services to customers is examined. As described in section 5.1, additional services may be e.g. a synchronization service or an e-mail service, contributing to make customers invest time and increase loyalty to the platform they have chosen to use. The effects are examined through change in total market share, change in perceived OS attractiveness for new customers and lastly, change in repurchase attractiveness in order to measure loyalty and the degree of lock-in.

Three sub scenarios are simulated in the case of additional services, where the degree of the additional services parameter is given different weight in each scenario:

1. In the first sub scenario, additional services are given equal weight for the two actors involved in the competition.
2. In the second sub scenario, iOS has a high degree of additional services while Android has a low degree.
3. In the third sub scenario, Android is given the higher degree leaving iOS with a low degree of additional services.

6.1.1 Equal values

Figure 23 shows the market share development when both actors have an equal degree of additional services. Both actors see an S-shaped growth, and Android, which has the initial largest market share, keeps its position as market leader and captures a larger portion of the potential customers compared to iOS.

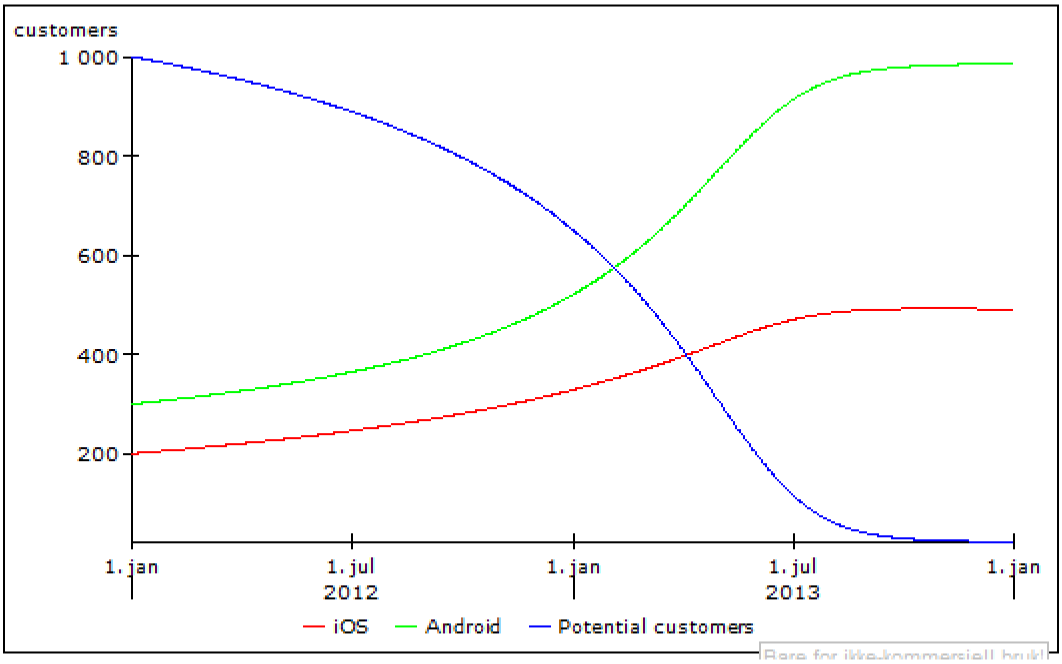

Figure 23 - Market Share - Additional Services 1

Figure 24 and Figure 25 show the changes in the parameters repurchase attractiveness and OS attractiveness, respectively.

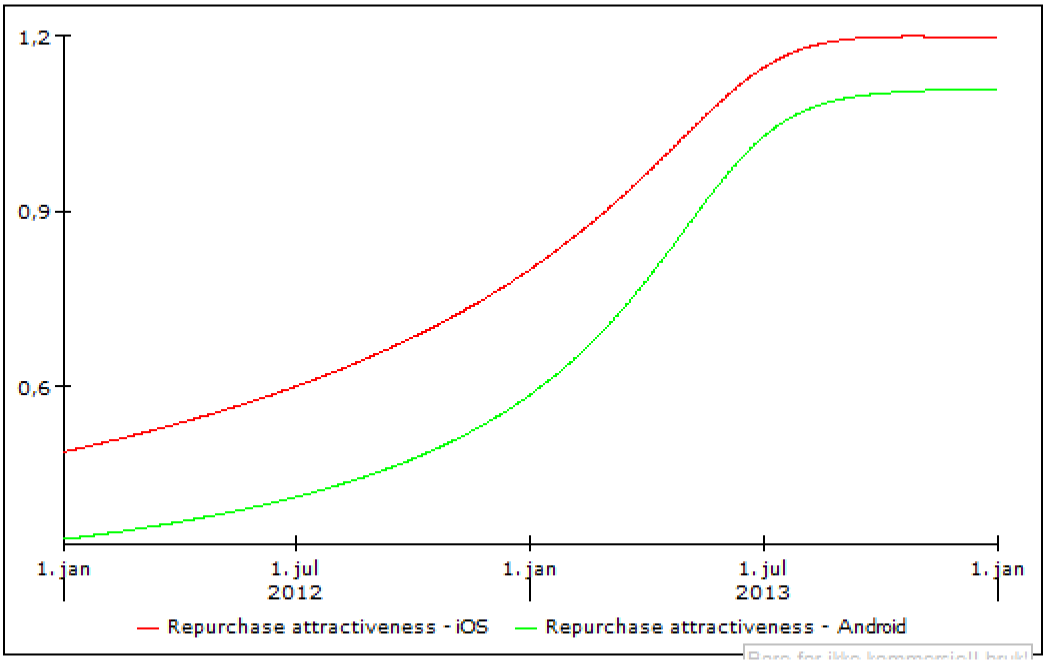

Figure 24 - Repurchase attractiveness - Additional Services 1

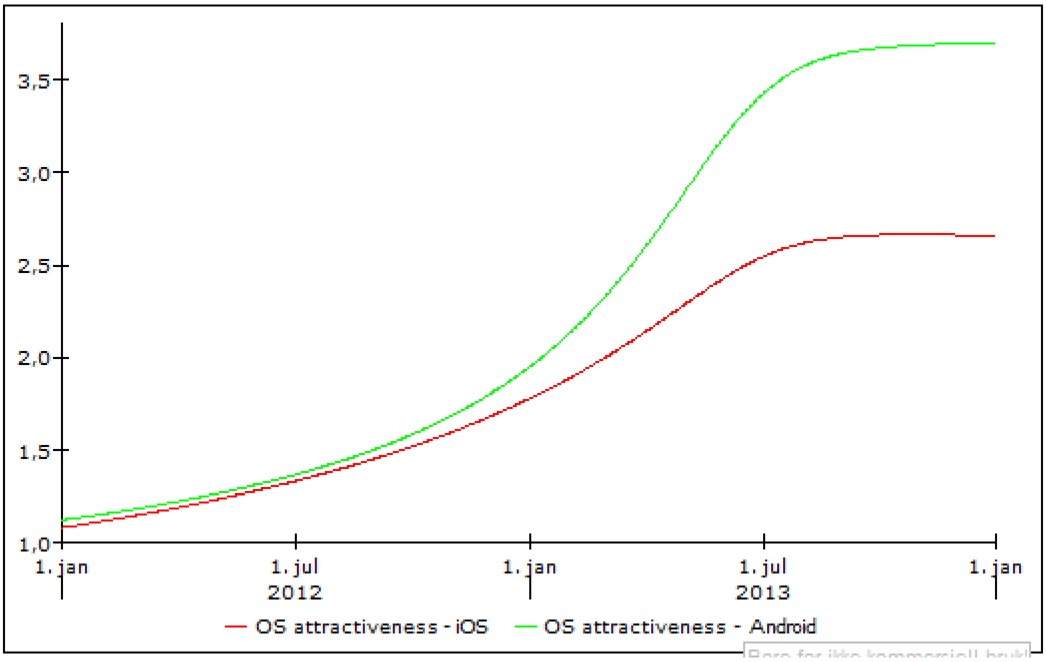

Figure 25 - OS attractiveness - Additional Services 1

6.1.2 iOS high / Android low

In the second sub scenario, iOS has the higher degree of additional services. Figure 26 shows the market share development in this case. Both actors have a period of about the same growth, until iOS catches up with Android and they end up with a close to even split of the market of potential customers.

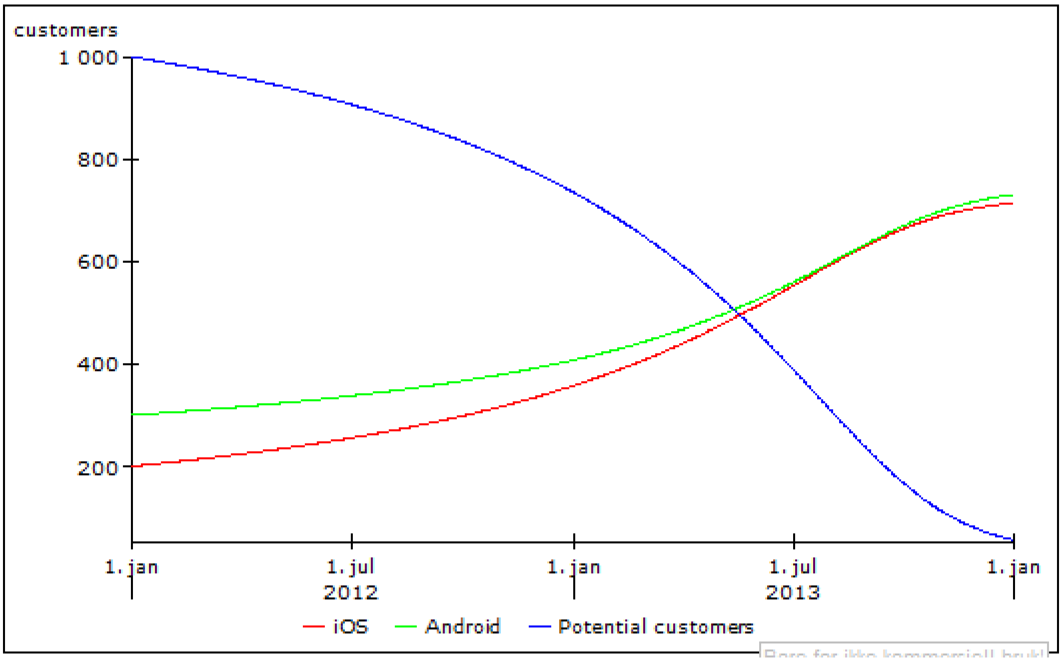

Figure 26 - Market share - Additional Services 2

Figure 27 and Figure 28 show the changes in the parameters OS attractiveness and repurchase attractiveness, respectively.

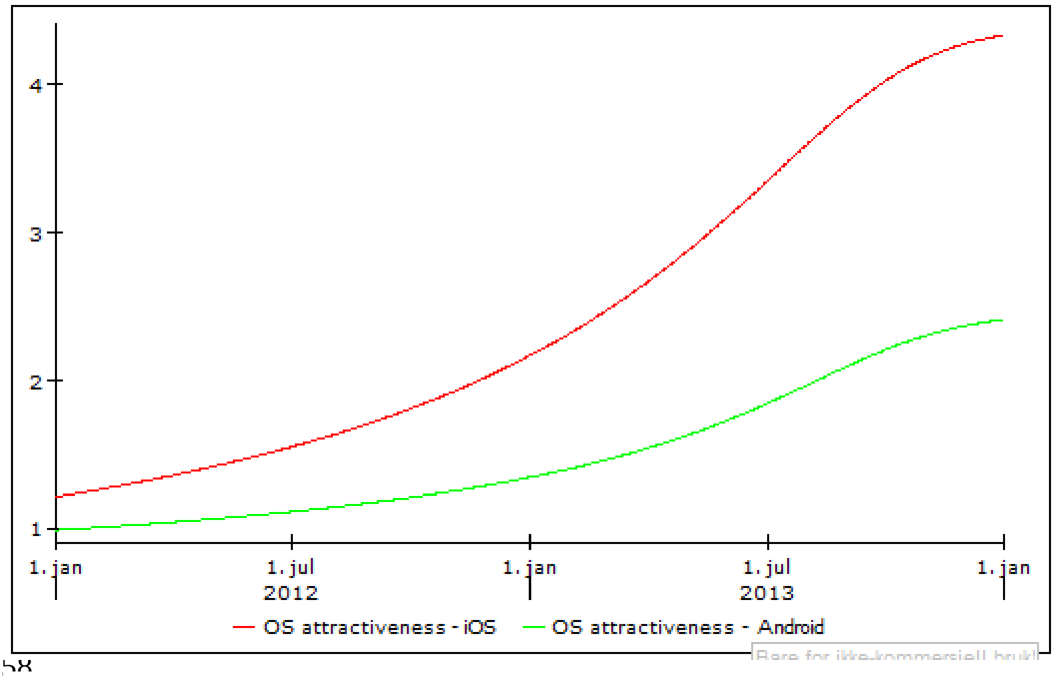

Figure 27 - OS attractiveness - Additional Services 2

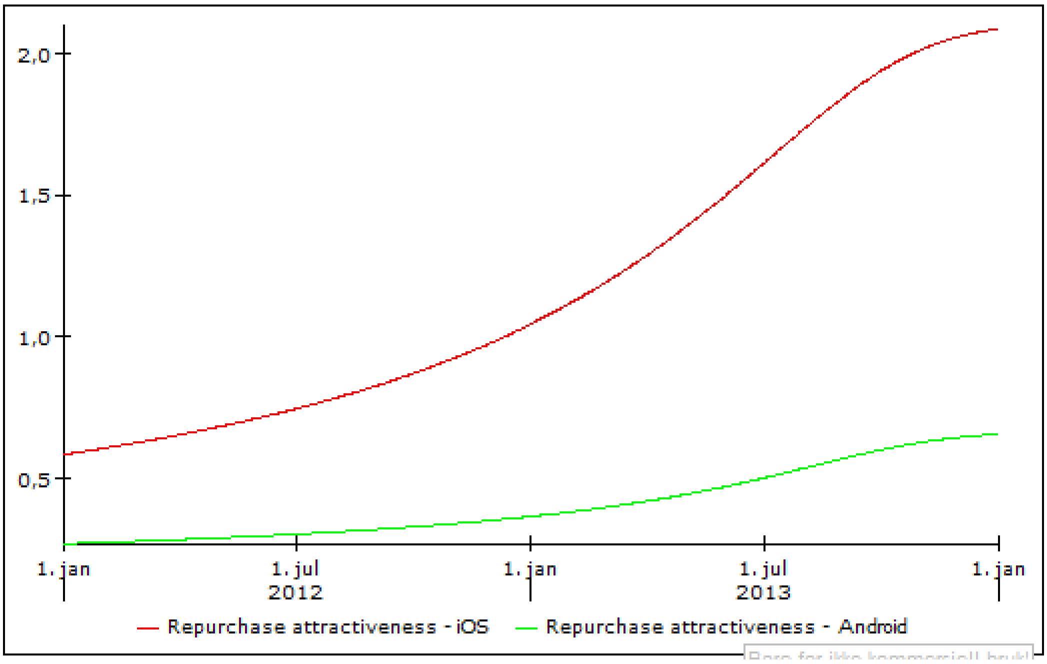

Figure 28 - Repurchase attractiveness - Additional Services 2

6.1.3 iOS low / Android high

In the last sub scenario, Android has the higher degree of additional services. As expected, Android keeps its position as the largest actor and sees a faster growth compared to the previous scenarios. iOS does also experience growth, although at a much slower rate. The gap in market share between the two actors is most prominent in this case, as shown in Figure 29.

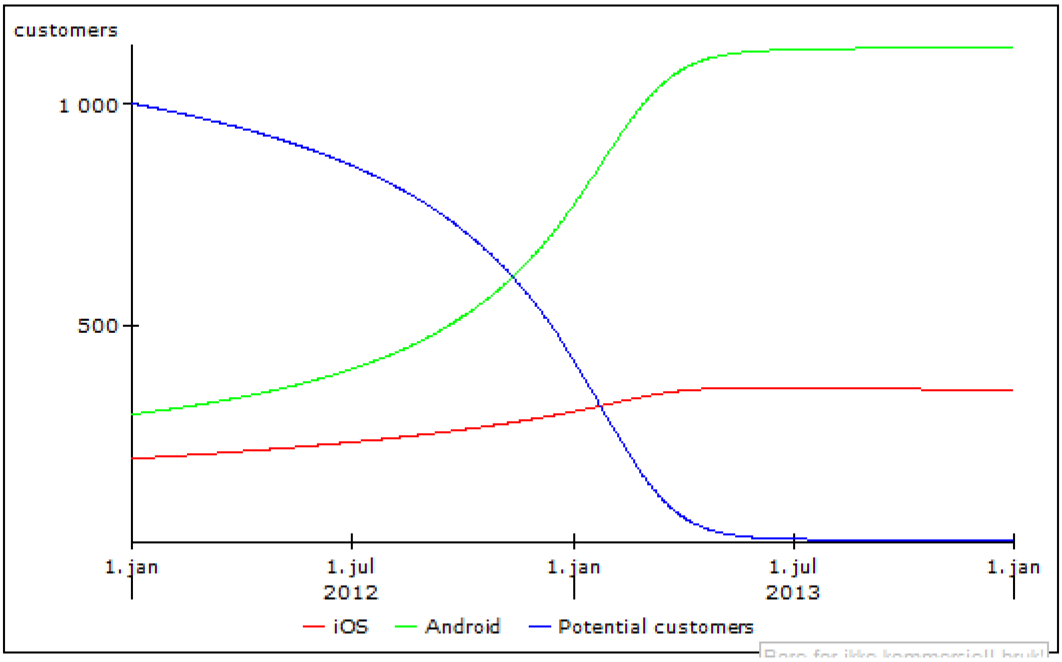

Figure 29 - Market Share - Additional Services 3

Figure 30 and Figure 31 show the changes in the parameters OS attractiveness and repurchase attractiveness, respectively.

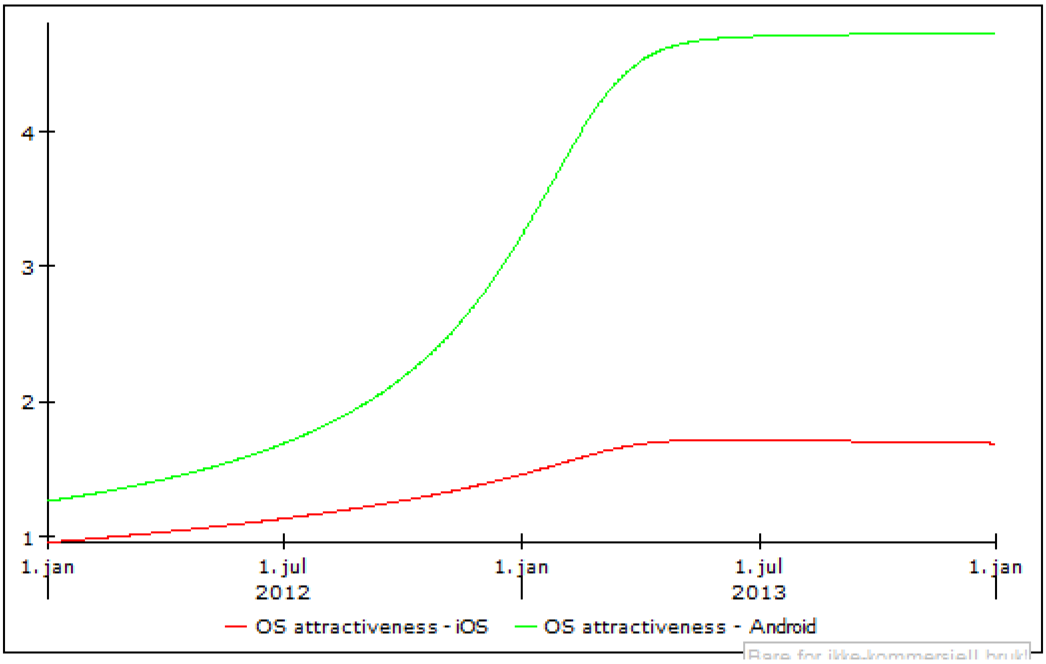

Figure 30 - OS attractiveness - Additional Services 3

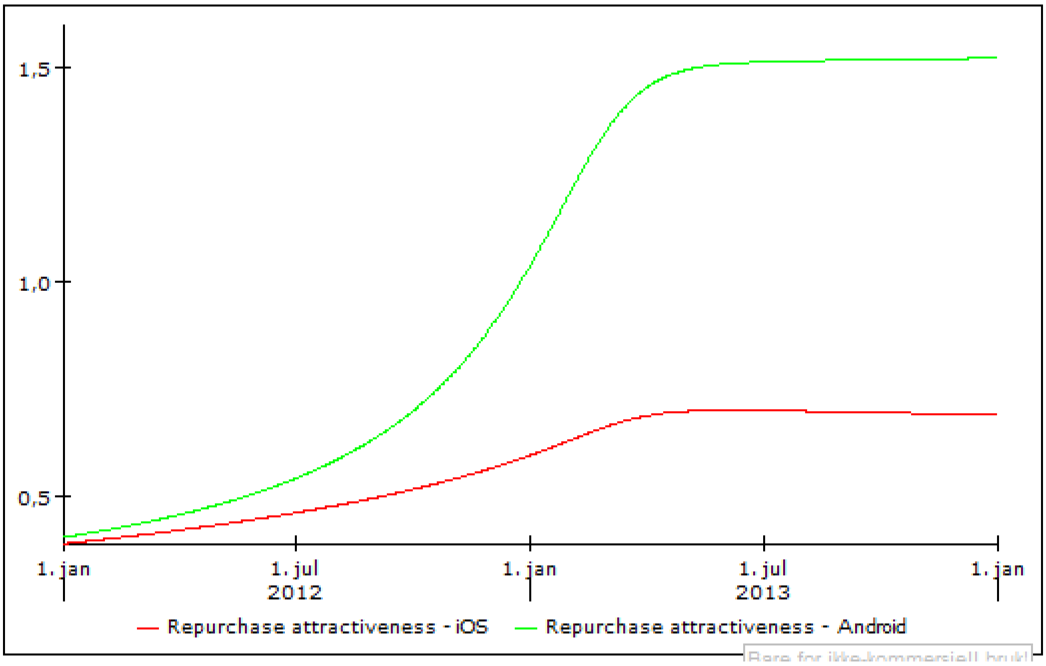

Figure 31 - Repurchase attractiveness - Additional Services 3

6.2 Apps

In the second main scenario, the role of apps and the effects of having growth in the app development environment are examined. There are two different parameters that are subject to change in the simulations under this main scenario. The first is the magnitude of change in app selection based on change in the platform attractiveness for developers, and the second is the magnitude of change in proprietary apps installed based on change in app selection.

Similar to the additional service simulations, three sub scenarios are carried out in order to observe changes in market share, OS attractiveness and repurchase attractiveness:

1. In the first sub scenario, both actors are assigned equal values.
2. In the second sub scenario, the app selection of iOS responds stronger to an increase in platform attractiveness for developers compared to Android. In addition, the parameter proprietary apps installed does also respond stronger to an increase in app selection.
3. The third sub scenario is similar to the previous, except that Android is given the advantages that iOS had in sub scenario 2.

6.2.1 Equal values

The market share development in this case is represented in Figure 32. Similar to the first sub scenario with additional services, Android's initial leading position is kept throughout the simulation. As Android's customer base is growing, the growth is fed back to the new customer rate, resulting in an increasing gap between Android and iOS.

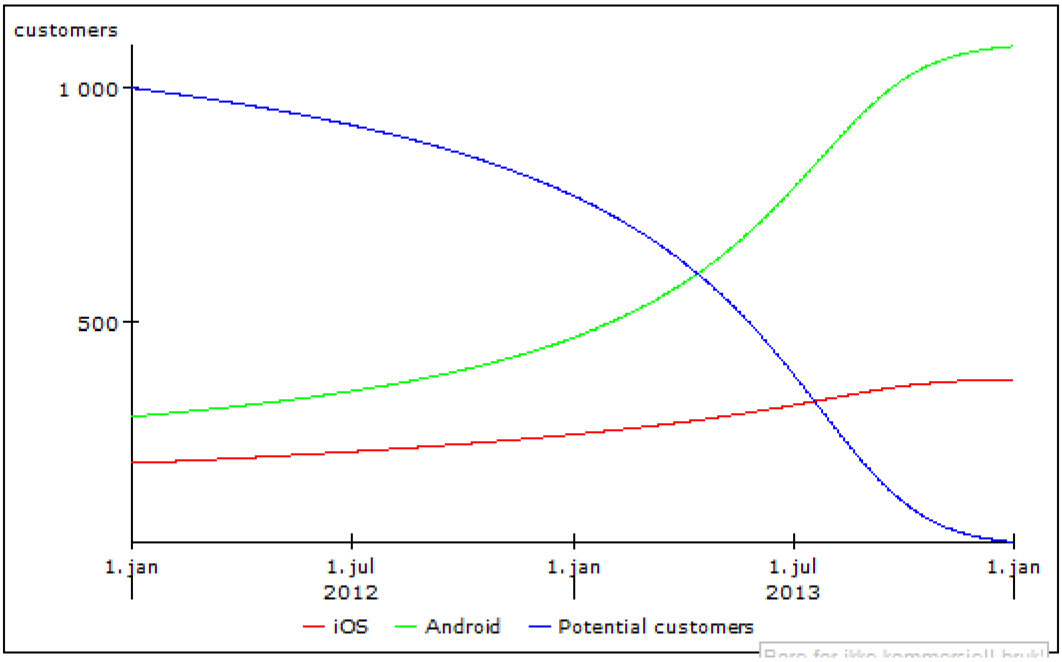

Figure 32 - Market share – Apps 1

In Figure 33 and Figure 34, the resulting effects in repurchase attractiveness and OS attractiveness are shown.

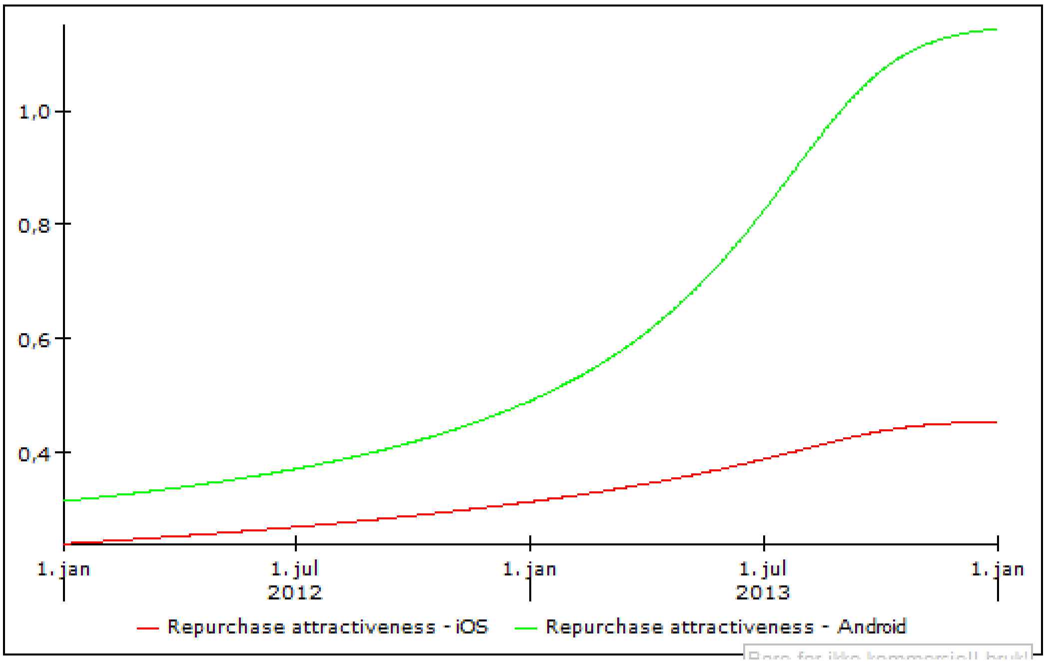

Figure 33 - Repurchase attractiveness – Apps 1

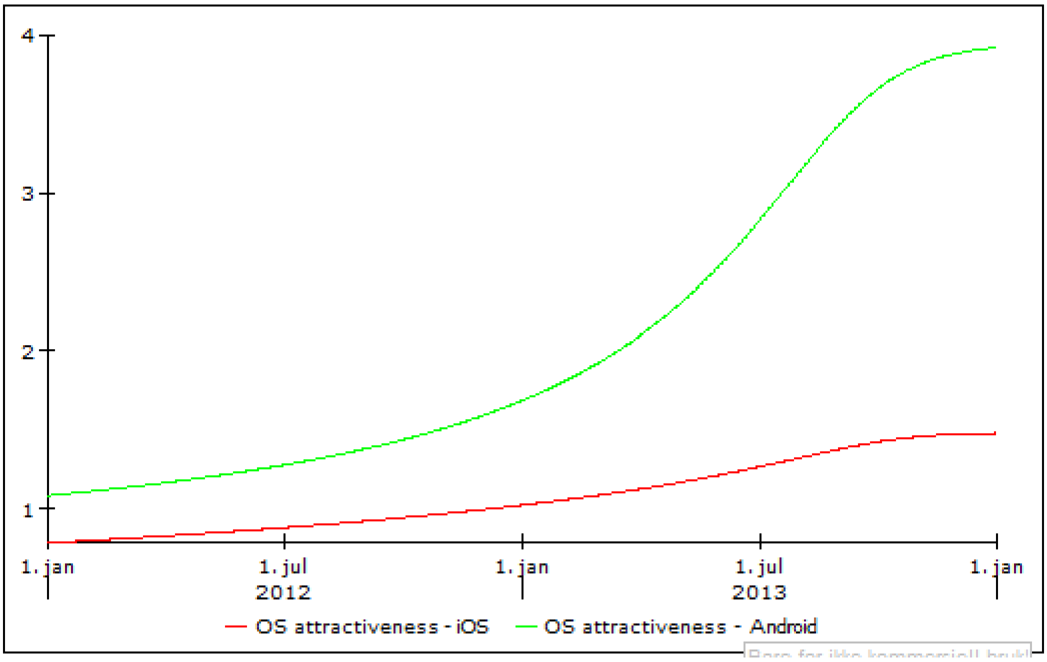

Figure 34 - OS attractiveness – Apps 1

6.2.2 iOS high / Android low

iOS is given the advantage with a higher magnitude of change in app selection when the platform attractiveness for developers increases. In addition, the iOS customers have a higher degree of proprietary apps installed. Both of these aspects are most realistic compared to real life numbers, where the iOS platform has the largest app selection and iOS customers install more apps each than users of other platforms. Android is still the market leader in this simulation (Figure 35), but iOS sees a larger increase in market share compared to the previous simulation.

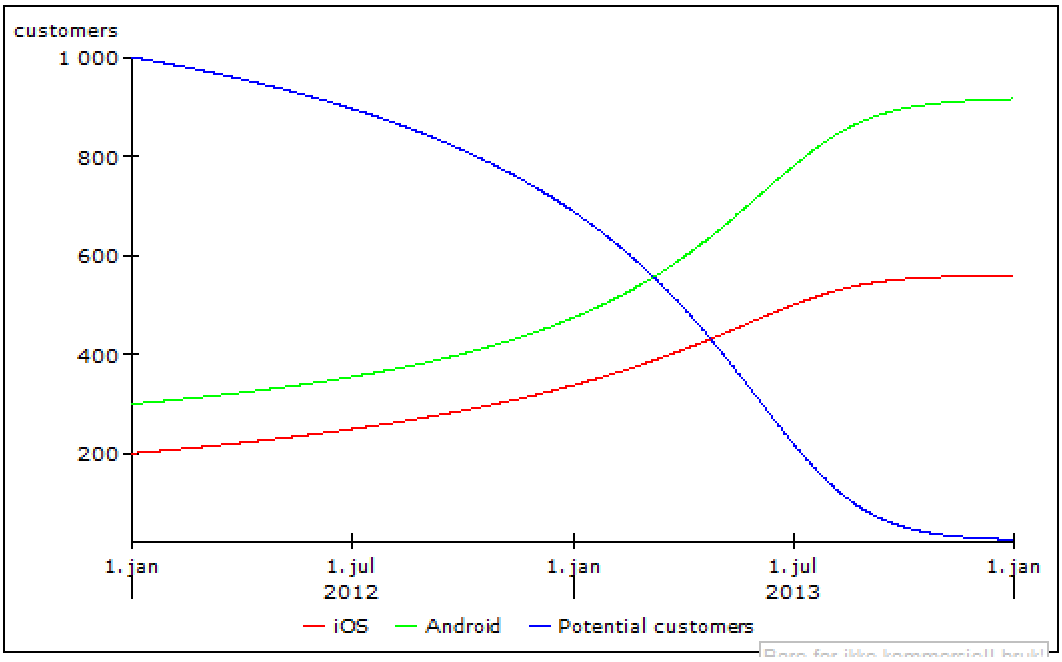

Figure 35 - Market Share - Apps 2

The corresponding changes in OS attractiveness and repurchase attractiveness is shown in Figure 36 and Figure 37.

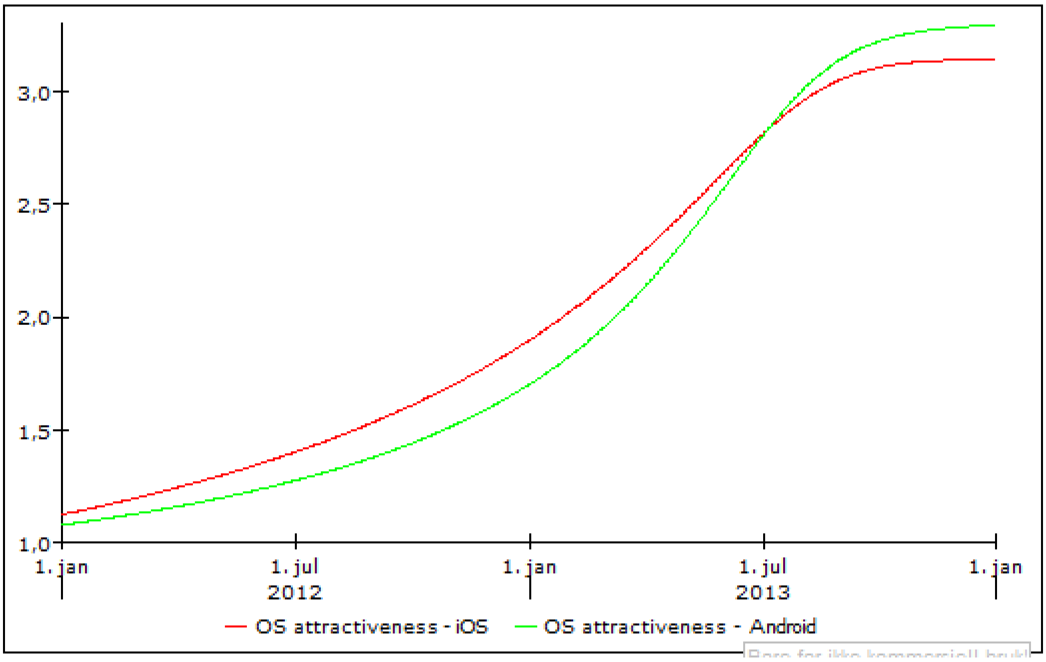

Figure 36 - OS attractiveness - Apps 2

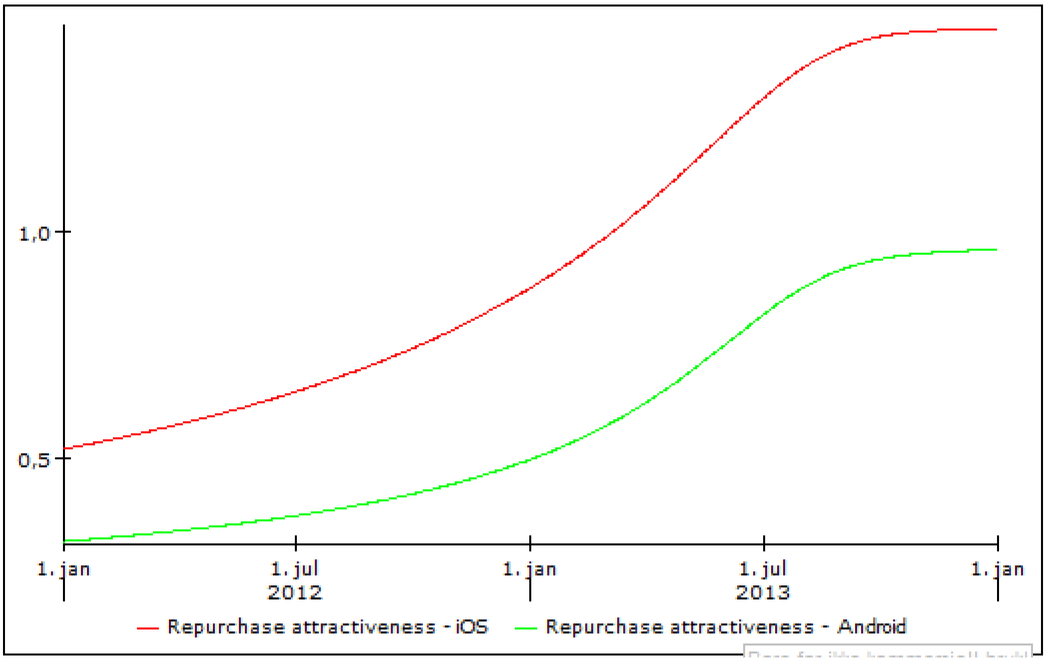

Figure 37 - Repurchase attractiveness - Apps 2

6.2.3 iOS low / Android high

In the last simulation run which examines effects of the role of apps, Android is given the advantages that iOS was given in the previous simulation. The app selection available for Android customers responds with a higher magnitude when platform attractiveness for developers increases and Android customers install a higher degree of proprietary apps compared to the iOS customers. The market share development is shown in Figure 38. As a result, Android takes a dominating market position after a short period of time, leaving iOS with small initial growth which shifts to a decrease in market share half way into the simulation.

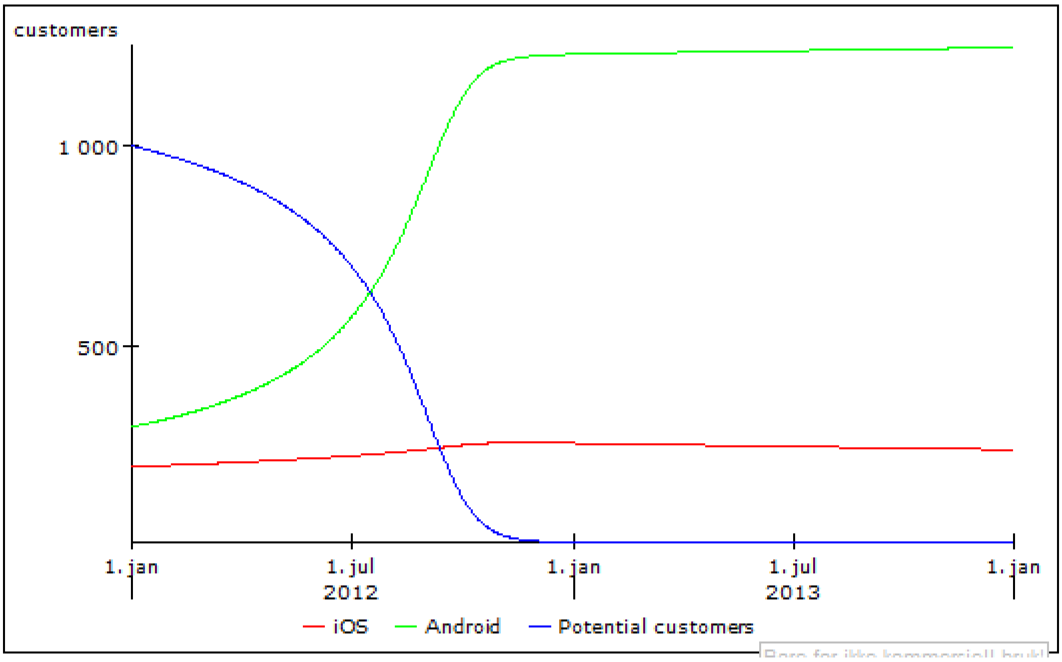

Figure 38 - Market Share - Apps 3

The corresponding changes in repurchase attractiveness and OS attractiveness are shown in Figure 39 and Figure 40.

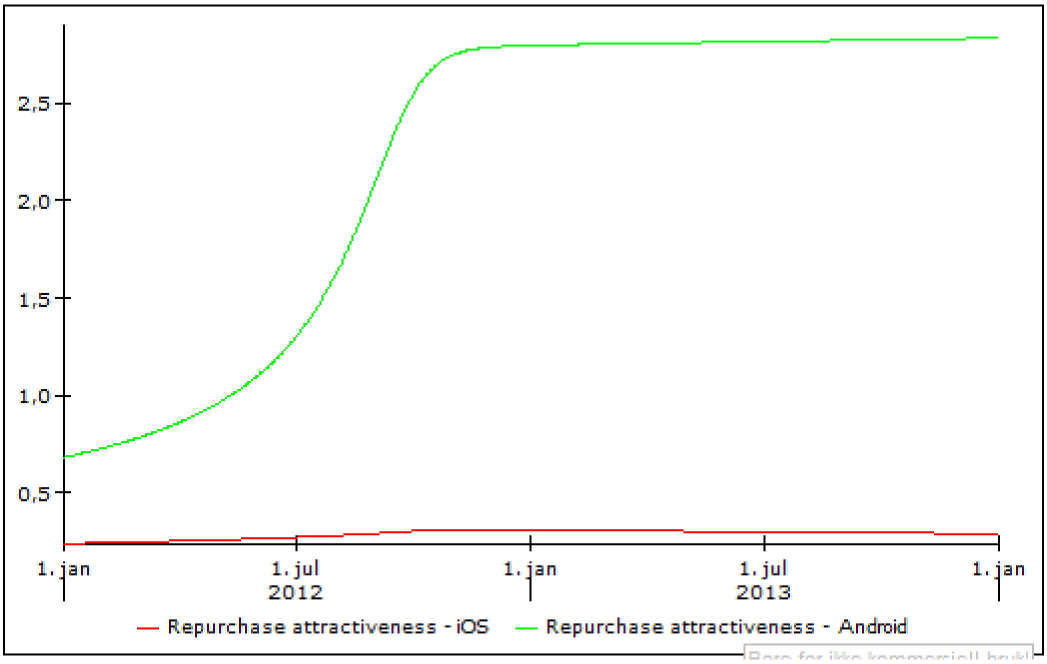

Figure 39 - Repurchase attractiveness - Apps 3

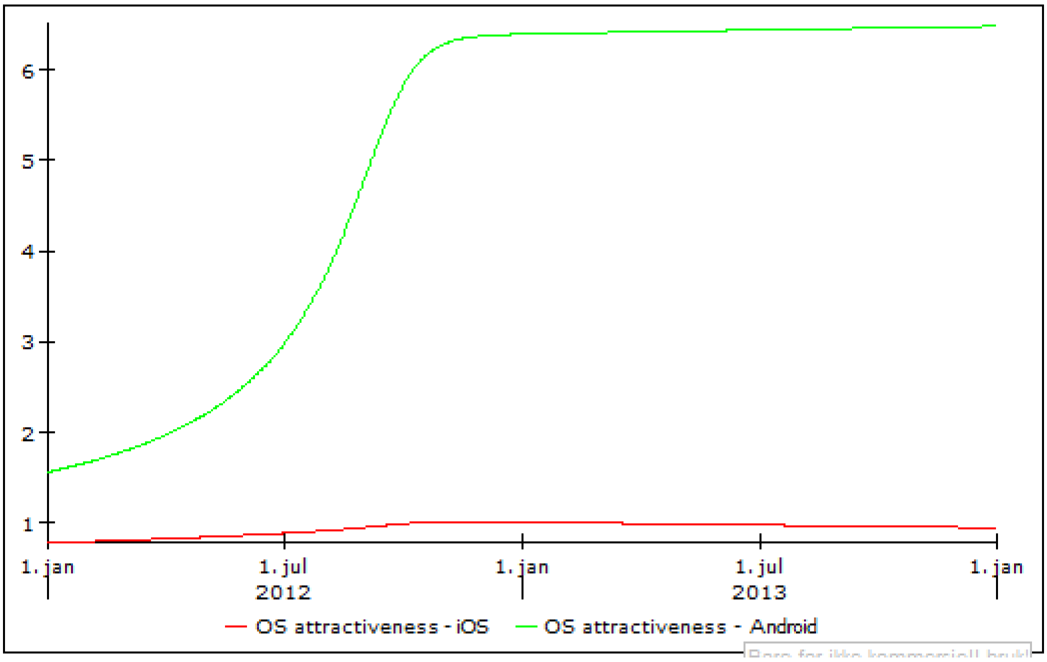

Figure 40 - OS attractiveness - Apps 3

6.3 Device selection

In the last main scenario, the effect of different degrees of device selection is examined. As explained in section 5, the device selection in the iOS ecosystem is considered constant seeing as Apple only sells a small variety of their iPhone at any given time. Also, since Apple is the device maker and OS owner, their choice of making a new device does not necessarily depend on the perceived attractiveness/size of the platform network. Android's market share, on the other hand, is dependent on being attractive for device manufacturers as the OS owner Google is not involved in manufacturing devices with their OS.

Similar to the other main scenarios, the device selection scenario is also divided into three different simulation configurations:

1. Low – where the parameter device selection is given a smaller impact on a customer's choice of buying a smartphone with an Android OS.
2. Middle – where the parameter device selection is not weighted differently than iOS's device selection parameter when a customer chooses platform.
3. High – where the parameter Android device selection is weighted with a larger impact on the customer's choice.

The effects in the different simulations in this scenario is shown through the development of market share and changes in the New OS customer rates.

6.3.1 Low

When device selection is given a small impact on a customer's choice, the market shares end up as shown in Figure 41. In this simulation, iOS ends up as the dominant market leader despite its starting point behind Android. Both OS attractiveness and repurchase attractiveness end up in largely in iOS's favor. The gap between iOS and Android grows to be significant during the simulation period of two years, leaving Android only slightly better off than its initial amount of customers. The differences in the New customers rates (measured in customers/day) shown in Figure 42 emphasize the growth leading to the large gap between iOS and Android.

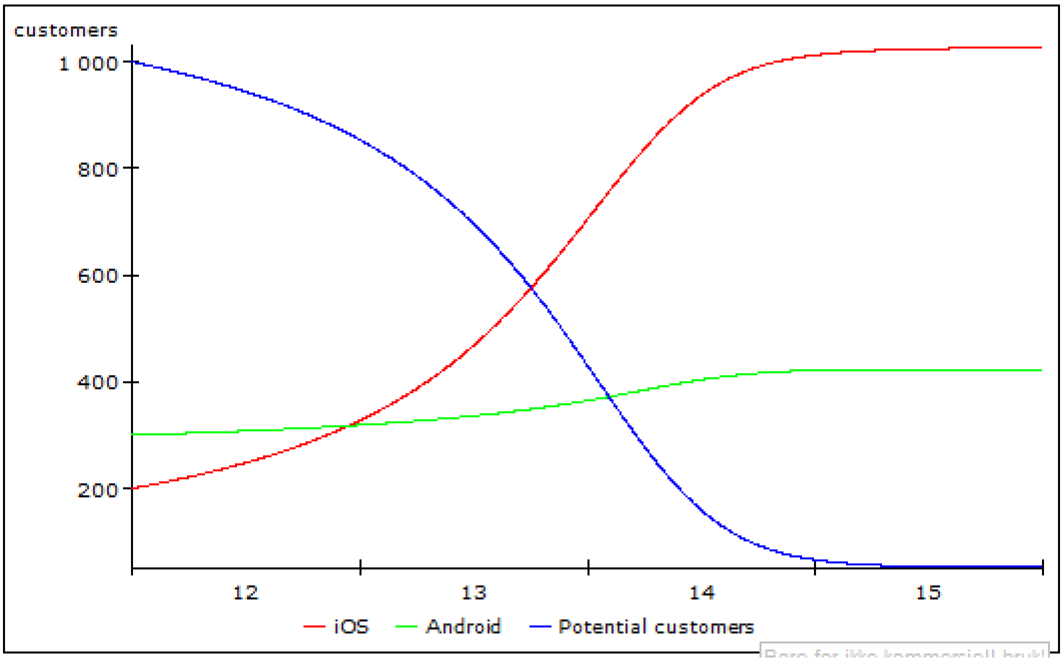

Figure 41 - Market Share - Device Selection 1

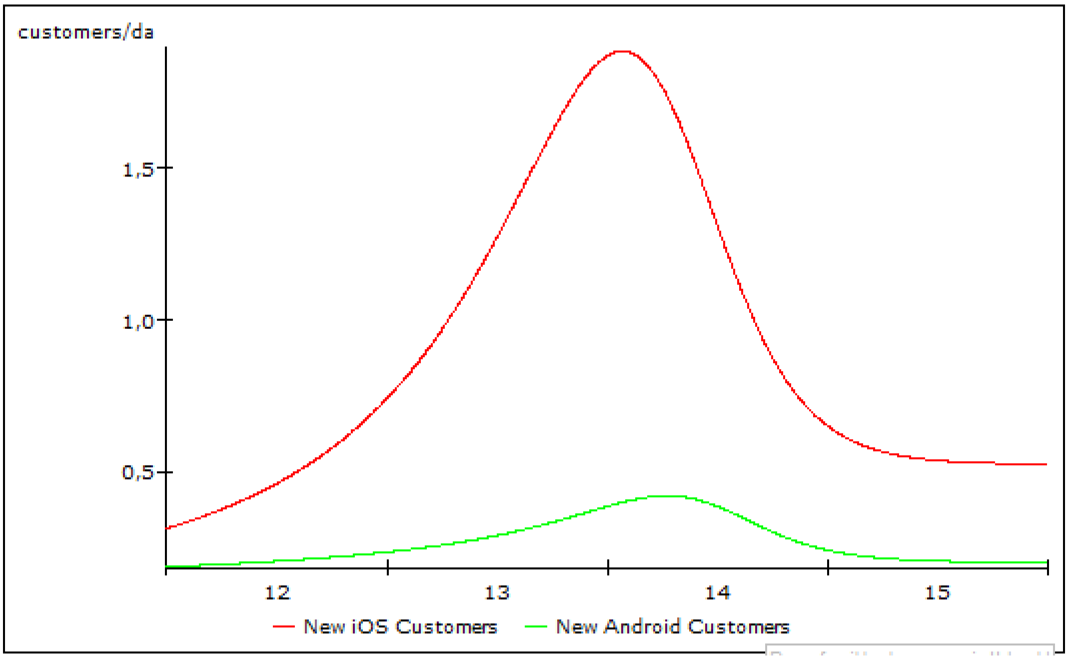

Figure 42 - New Customers rates - Device selection 1

6.3.2 Middle

When device selection is given equal weight for both iOS and Android customers, the market shares develop as shown in Figure 43. This configuration is also used in the other simulations described in this chapter. As expected, Android keeps its position as market leader throughout the simulation. The changes in new customer rates are shown in Figure 44.

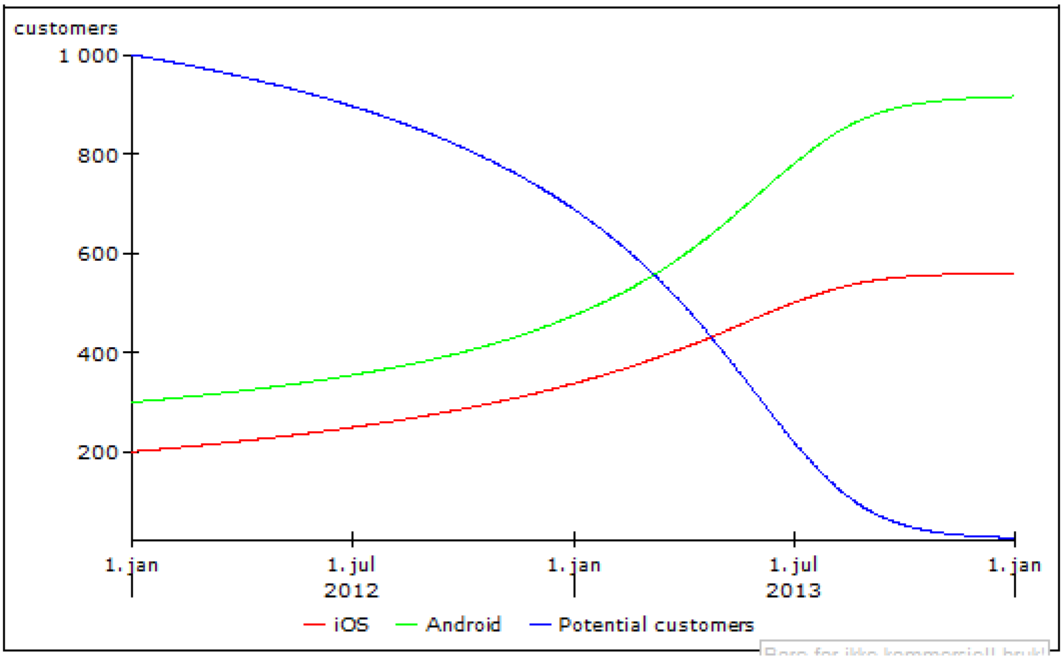

Figure 43 - Market Share - Device selection 2

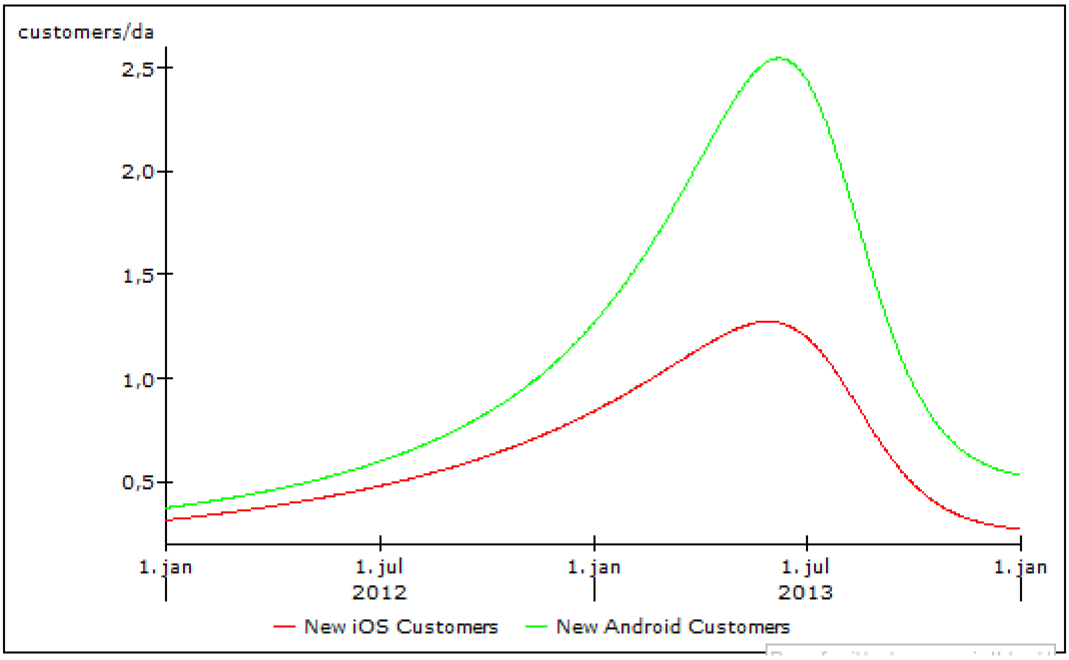

Figure 44 - New Customers rates - Device selection 2

6.3.3 High

In the last simulation run, device selection is given a higher weight in a customer's choice of buying an Android device. As expected, this configuration yields a fast development of market shares, where Android experiences a large growth already after six months and ends up as the dominant market leader. Figure 45 shows the market share development, and the growth rates are shown in Figure 46.

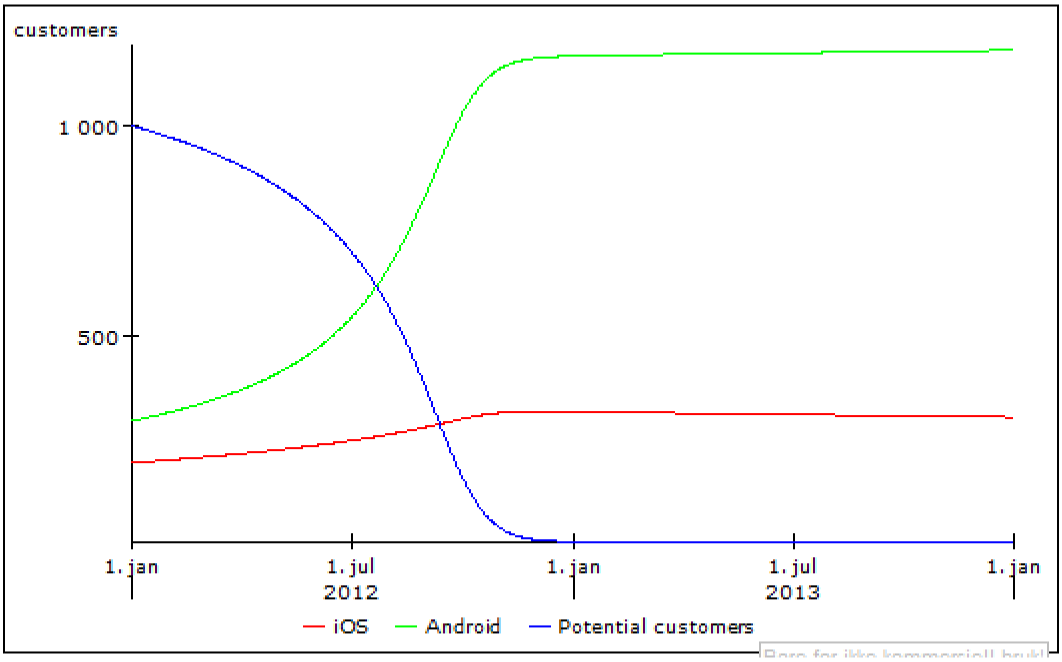

Figure 45 - Market Share - Device selection 3

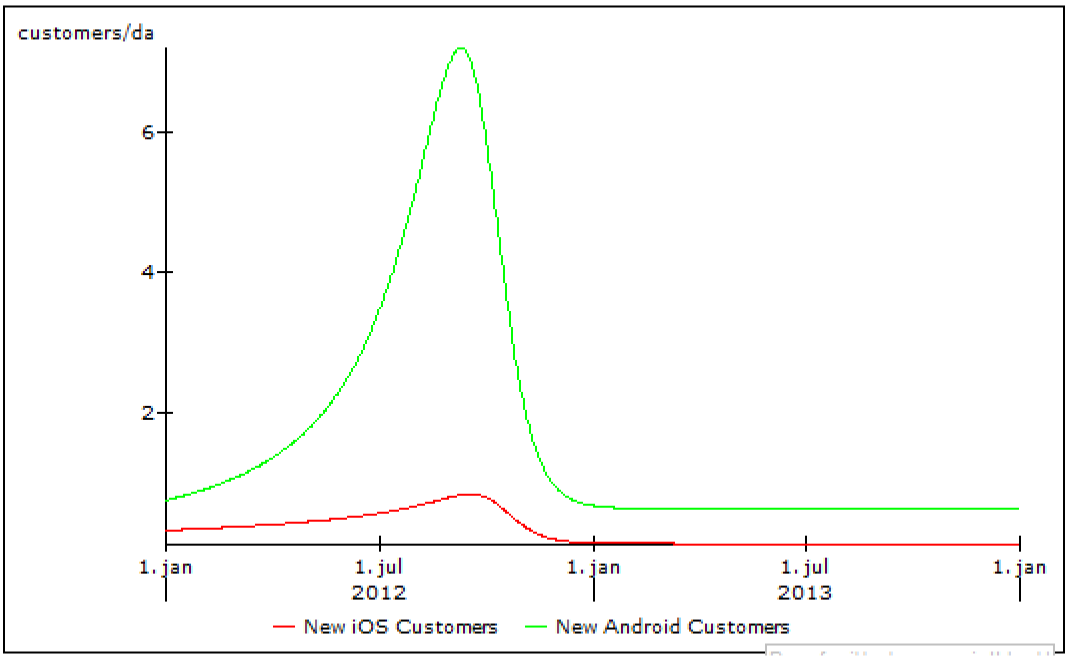

Figure 46 - New Customers rates - Device selection 3

7 Discussion

In this chapter, results from the work presented in this thesis are discussed. Section 7.1 continues the discussion from chapter 4. Section 7.2 provides a discussion based on the results from the simulations presented in chapter 6.

7.1 Competition approaches

As the analysis in chapter 4 shows, the market for mobile operating systems is mainly dominated by six major actors. The market shares have been in constant development the last few years, as the sales of smartphones have rocketed globally. One of the interesting features of this market is how the actors have taken different approaches in order to attract customers to their system. The actors themselves are also from very different backgrounds, ranging from Samsung with subsidiaries in electronics, ship building, insurance and construction industries, via Microsoft as a powerhouse in the computer operating system industry to Google, which started out mainly as an Internet search engine company.

This variety of backgrounds has led to various approaches to the mobile OS competition, such as a pure operating system developer (Microsoft), a complementary product to increase use of other services such as e-mail and search (Google) and a complementary product to increase sales of smartphone devices (e.g. RIM and Samsung).

The variation of approach in developing the platform surrounding the different mobile operating systems does also suggest that the actors in some way address different customer segments. RIM, with their strong focus on corporate services, is seen as an actor mainly attracting business users. Apple has focus on a high-end market, with a more expensive, tightly knit package of a well-designed device and a tailored OS. Android is on the other hand available on wide range of devices, both with respect to price, brands and hardware specifications.

This variation and focus on different customer segments suggest that there is room for several mobile OS actors. Even though the app marketplaces contribute to network externalities and positive feedback, the market has so far not been, and will probably not end up as, a winner takes all market.

7.2 Simulation results

Following the same structure as the presentation of results from the simulation, the results from the three main scenarios - additional services, apps and device selection - are discussed in the next sections.

7.2.1 Additional services

The role of additional services is examined in the first main group of simulation runs. When the two actors are assigned equal values of the degree of additional services, the effect of network externalities with regards to the initial amount of customers dominates. The perceived attractiveness for potential customers develops accordingly, since the effect of having more customers in the case of Android is fed back to the rate of new customers when the gap between the two actors starts to increase after about 12 months.

The next sub scenario is interesting in the sense that this is one of only two cases where the outcome in terms of market share is not given by Android's initial lead. A slight advantage in the terms of having a larger degree of additional services allows iOS to catch up and tie with Android. The effect is especially strong in terms of repurchase attractiveness, which suggests that the increased switching costs as a consequence of the use of additional services result in a significant degree of lock-in experienced by the iOS-customers.

When Android has the advantage of more additional services, as well as the initial larger market share, iOS does not gain momentum fast enough to attract a significant amount of new customers. In this head-on race, Android's advantages are strong enough to prevent iOS from reaching the critical mass necessary to experience the positive feedback leading to faster growth.

7.2.2 Apps

When the effects of app selection and the app purchasing behavior are examined, Android's initial market lead is kept throughout the three simulation runs. Even in the case where iOS has the advantage, Android ends up with a significantly larger market share. In this case, it does however boost the repurchase attractiveness for iOS to a higher level than Android, again suggesting the existence of strong lock-in effects.

In the third simulation run, app advantages combined with the initial market share lead result in an extremely fast growth for Android, leaving iOS with approximately the same amount of customers as the initial value.

This suggests that apps play an important role in the ecosystem up to a certain point. For an actor with a smaller market share, having a well-run app initiative is crucial in order to be able to capture customers. However, the effects of increasing the app initiative do not contribute enough in order to catch up or overtake the market leader position.

This may be explained with diminishing marginal returns from the selection of available apps. Every customer has a limited amount of apps that they need or desire in order to enjoy using a smartphone, e.g. a calendar app, a calculator app, a flashlight app, a few games and a bus schedule app to mention some examples. Obviously, the set of necessary apps is not equal for every customer, but chances are that most needs are met when a marketplace reach a certain selection of apps. After this point (which is not quantified in this thesis), every additional app published is either not wanted by a large percentage of the customers or is just a variation of an existing app. Consequently, it should not matter for a potential (or existing) customer whether a platform has 50 000 or 500 000 available apps as long as his needs are met.

7.2.3 Device selection

The second of two situations where iOS gain a significant market share is when the magnitude of device selection is given a smaller impact on a customer's choice of platform. In the first simulation run in the device scenario, iOS manages to neutralize Android's growth and surpass Android's market share after one year. Critical mass for further growth is reached, and iOS ends up with about 2/3 of the customers in the market.

When no corrective measures are taken with regards to device selection, both actors experience growth and Android keeps its market leader position with a slight increase in the gap between the two actors. When giving the magnitude of device selection an artificially high impact on the customer's choice, Android is able to capture most of the potential customers, leaving iOS with a very small growth.

The significant differences in the three simulation runs suggest that device selection is a crucial part of Android's market potential. Relating this to the market shares presented in section 4.2, it is proposed that customers do value having a larger selection of devices available which may appeal to different customer segments.

8 Conclusion

This thesis has looked into the competitive market of mobile operating systems. A qualitative analysis of the six major actors in the market has been conducted. The analysis focused on the difference in the actors' platform competition strategies and the different roles each actor has decided to control in the ecosystem surrounding the operating systems. This analysis serves as a background for the first research question:

> *RQ 1: Which characteristics are important to exhibit in the mobile OS market competition?*

Based on the findings in this analysis, a model was developed in Powersim using the business dynamics framework. The purpose of the model was to gain insights in order to find answers to the second research question:

> *RQ 2: What are the effects of these characteristics in a competitive setting?*

The model was developed as a competitive market with two actors competing for a certain amount of potential customers. Using a set of simulation runs with different initial configurations, the effects were examined and discussed in chapter 7. The main findings are summarized in the following section.

8.1 Findings

Even though the actors have different approaches to the competition, chapter 4 shows that two characteristics were found to be implemented by the majority of the actors. As a consequence, control over app distribution and providing additional services are proposed as two important factors in order to succeed in the mobile OS market. Three reasons are proposed in order to explain this:

1. Increased revenue
2. Increased control over customers
3. Necessary competitive feature

The three reasons are proposed for both app distribution and additional services, where the second reason is given most weight in the case of providing additional services.

Based on the simulation results, the following is proposed:

1. Gaining an advantage in one of the characteristics – additional services, apps or device selection – is enough to affect the outcome of the competition with respect to market share.
2. With a low selection of devices, it is even more important to become a market leader in terms of additional services and apps. This is especially important in order to increase the switching costs for a customer, and hence increase the repurchase willingness, that is to make the choice of buying a smartphone within the same ecosystem more obvious for a customer.
3. In order to gain a significant lead in market share compared to a competitor, a large selection of devices is important. This is explained with the increased ability of addressing several different market segments in terms of price and different needs of hardware specifications.

8.2 Future work

This thesis has a limited scope, and may be used as a basis for further research. A handful of possible topics that may be investigated further are proposed in the following sections.

8.2.1 Security perspective

As cellular phones have become more advanced, the operating systems have approached desktop operating systems in terms of complexity and consequently more vulnerable to malicious software. A security perspective may be added to the model in order to measure effects of the magnitude of malicious software written for a platform, the perceived level of security and an OS owner's measures against such problems.

8.2.2 App marketplace size

It is suggested in this thesis that the network size of the app marketplaces gives diminishing marginal return in terms of value for the customers after a certain point. A study may be conducted in order to quantify the point of which the network size is obtained in terms having a large enough app selection to attract new customers and keep the existing customers locked in to the platform.

8.2.3 Expansion of the three main characteristics

The three main concepts – additional services, apps and device selection – are modeled with a limited depth in terms of underlying effects and other influencing factors. A study may be conducted where each of these concepts are investigated in further detail and supported by real-world data in order to obtain a more fine-grained model.

8.2.4 A complete model

The model in this thesis does only involve two actors in a competitive market, which obviously is a significant simplification of the real world. An attempt may be made to expand the model with all actors described in section 4.1. Equipped with real-world data, such model may be used in an attempt to forecast the development in market shares in the years to come.

8.2.5 New entrants

As a continuation of the complete model suggested in the previous section, a study may be conducted where a new entrant is introduced in the model. Areas of interest may include what characteristics are needed to make a successful entry, what the necessary critical mass of customers is and how this critical mass may be reached.

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