



Choosing the Smart Phone Operating System For Developing Mobile Applications

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ABSTRACT

Technological advancements and market competition in the smart phone business are becoming more evident. In this article, we examine the decisional deliberation of the mobile application operating system (OS), to epitomize the development of the smart phone technology and its market. Specifically, we consider the OS vendor's market strategy, the preferences of individual and corporate buyers and the inclinations of mobile application developers in general when making decisional choices for OS adoption. It is through this analysis of the various factors and their current developments that we seek to inform organizational managers and/or individual developers on choosing the appropriate smart phone OSs. In order to evaluate the smart phone OSs we present a benchmark method based on six dimensions, namely: security, individual and organization buyer choice, market growth, ease of implementation and net revenue.

Categories and Subject Descriptors

K.6.3 [Management of Computing and Information Systems]: Software Management – software selection.

D.2.9 [Software Engineering]: Management – cost estimation, productivity, copyrights.

General Terms

Management, Human Factors, Legal Aspects.

Keywords

Smart phone, operating systems, market development, mobile commerce, buyer's choice, market growth potential, security

1. INTRODUCTION

Having researched on and developed mobile applications for several years, we are fortunate to have witnessed the emergence and growth of the smart phone and the competition among the smart phone manufacturers and advocates in competing for market dominance. What is a smart phone? The smart phone is a handheld device that offers advanced capabilities like e-mail and

Internet access beyond a typical mobile phone. Smart phones, as defined by the CTIA (Cellular Telecommunication Industry Association), are “wireless phones with advanced data features, and often, keyboards. What makes the phone ‘smart’ is its ability to manage and transmit data in addition to voice calls.”[3]. For instance, a smart phone today could be used to locate an individual and navigate through unfamiliar terrains and places using the Global Positioning System (GPS) service. In this article, we seek to make sense of the different types of smart phone operating systems (OSs) available so as to offer informed considerations for and recommendations to smart phone application developers keen to enter this market, and researchers who are interested to study this technology. A smart phone application developer could be the manufacturer of the device, the network operator, or any other third-party software developer.

Previous research (Chang and Chen 2005[1] and Keijzers et. al. 2008[2]) in smart phone client platform evaluations highlighted the need to provide a list of requirements and recommendations in order to benchmark the available solutions. It is through this lens that we seek to inform Information Systems (IS) researchers on the development of the smart phone industry by analyzing the market evolution, the available mobile application development frameworks; and by reviewing multiple consumer surveys, we seek to extract common dimensions allowing the comparison and benchmarking of the smart phone operating systems.

The smart phone is becoming increasingly available in the market. It is rather popular with demanding consumers who expect greater functionalities. Indeed, the smart phone market is expanding rapidly and new devices are constantly appearing on the market. According to a Gartner Inc. report, the worldwide sales of smart phones reached 32.2 million units in the second quarter of 2008, marking a 15.7% increase from the second quarter of 2007[4].

A smart phone has at least two “processors”, one dedicated for voice and data transfer (sms/IP/etc.) over the cellular network and the other one assigned to run the smart phone's operating system (OS). The operating system is the core software running on the smart phone. Its task is to manage the phone hardware and resources. The operating system also provides an interface called Application Programming Interface allowing third parties to develop native applications to run on the smart phone. Most of the smart phone OSs offer the ability to dynamically and easily (one click operation) install new native applications in contrast to regular phones that may only support sandboxed or middleware applications. Mobile phone manufacturers are introducing their respective smart phone OSs, e.g., Symbian by Nokia or iPhone OS by Apple, and so are the new players entering the market, e.g., Android from the Open Handset Alliance.

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The rest of this article is organized as follows. First, we seek to gain a good understanding of the history and evolution of the smart phone market (Section 2) and of the various types of applications running in a smart phone (Section 3). Next, we examine the dynamics of the smart phone OS market by triangulating from the perspectives of the vendors, the buyers and the developers (Section 4). Lastly, we build on the cumulated knowledge about the market dynamics to propose an approach to evaluate a smart phone OS. It is our goal that, through this evaluation approach, we can assist developers to make information decisions and researchers to draw inferences based on our evaluation of the mobile application research opportunities.

2. THREE PERIODS OF GROWTH

The evolution of the smart phone market can be characterized by three periods. From the 1990s until 2007, several key international mobile companies set the foundations for the development of the modern smart phones. For instance, in 1996, Nokia launched the Communicator and brought many innovations in this field, such as color screens, cameras, WiFi, and the integrated global positioning system (GPS) chip. In 2002, RIM released the first smart phone optimized for wireless e-mail. One year later, Microsoft released a smart phone OS. Despite these technological initiations, the smart phone market was predominantly for the corporate users and less for the end-consumers, i.e., the market was quite contained until 2007.

In 2007, Apple launched the first generation of the now well-known iPhone. The iPhone is designed for the mass market, i.e., for both private as well as corporate users (till version 3.0 iPhone OS was more adequate for private than corporate customers). It defined the new quality standard in smart phones, such as the high resolution touch screen. Shortly after the launch of the iPhone, other manufacturers followed suit and the smart phone market peaked. The OSs of the smart phones were and are still however relatively incompatible with one another, i.e., there is no standard of interoperability across OSs.

An exciting breakthrough was the emergence of the Google Android in October 2008. By virtue of being free and open source software, Android can be adopted by any smart phone manufacturer (e.g. Motorola). Does this mean organizations and individual developers of smart phone applications should aim to develop their applications for Android? Or should applications be developed for the OS of each and every smart phone? We argue that there is a need to target the OS of a particular smart phone and in order to make such a decision, it is important to understand the implications of the smart phone OSs in the present and future contexts.

3. THE NEED TO TARGET A SMART PHONE OS

There are three distinct types of smart phone applications: web-based, middleware-based and native-based applications.

A web-based application consists of a local web engine (a web browser) and a web page with a look-and-feel similar to the smart phone user interface. Web applications can easily be implemented and are very portable across devices. However they can only profit from a very limited set of features since they do not use the local resources of the smart phone, such as the GPS, Bluetooth access, and etc. It has to be noted that in the future with the

introduction of the new HTML standards new features will be introduced such as geo APIs.

A middleware application is slightly more advanced. Like web-based applications, middleware such as JavaFX[5] allows users to instantly port the applications in a variety of smart phones as soon as they are developed. However in order to execute these applications in various smart phone devices, the JavaFX middleware has to be present on the OS of the smart phone. It is also important to note that applications developed for middleware can only profit from the standard set of features (i.e., the common features available in various smart phones). Some very specific and recent features of the OS of a particular smart phone might only be used by native applications. In respect to this claim we cite here an extract of a April 2010 Steve Jobs's letter: "We know ... that letting a third party layer of software come between the platform and the developer ultimately results in sub-standard apps ... developers ... can only take advantage of platform enhancements if and when the third party chooses to adopt the new features."

Native applications are the most powerful among the three types of applications. They are directly linked to the Application Programming Interface (API) of the OS of a smart phone. The OS, (e.g., Nokia's Symbian), is the core software running on the smart phone. It provides an interface, i.e., the API, which allows developers to develop applications that can natively run and interact with the smart phone OS. The API of one OS differs from other OSs, causing a smart phone application natively running on one OS to be non-executable in another OS. Owing to this limitation, an organization or an individual developer often needs to decide for which OS an application has to be developed. Developing an application for all available OSs would be too expensive and time consuming and eventually decrease the potential value of a smart phone application resulting from the rampant introduction of smart phone applications. Here, we seek to facilitate the decision-making process by highlighting three pertinent considerations, namely, the OS vendor's market strategy, the individual and corporate buyers' preferences, and the inclination of the mobile application developers in general.

4. MARKET DYNAMICS OF THE SMART PHONE OS

Our review of the market suggests that there are six dominating OSs, namely, Symbian, iPhone OS, RIM OS, Window Mobile, Linux (Android is included in the Linux set), and Palm OS. Competition among the OS vendors is keen, notably the intense competition between Apple and Nokia [6]. Among the six dominating OSs, Apple's shipment share only accounted for 3.6% back in the third-quarter of 2007. However, the shipment share of Apple soared to 17.3% one year later. The relatively late newcomer appears to have commanded a significant marginal increment in market share within a very short time span.

Behind the apparently stiff competition in the smart phone market, there seems to be a new ecosystem. The smart phone OS producers allow third party software developers to profit from selling applications especially developed for the phone. The OS producers will then benefit by making the smart phone more attractive for customers by providing a multitude of native applications. This new ecosystem has allowed marginal actors such as third party application developers to participate in the mobile communication market.

Apple has been very successful and has been able to amass impressive outcome from this ecosystem. More than 100,000 applications have been developed for the iPhone with new features and capabilities added regularly. On the other hand, application developers have consistently gained from the ecosystem by selling applications in a euphoric market. An example of a company that has benefited from this market dynamics is Smule[7], a start-up company. Smule launched Ocarina, the first musical instrument created for iPhone. According to Dr. Ge Wang, the founder of Smule, "The product made hundreds of thousands of dollars in its first month." In the first five months, nearly 700,000 people bought the Ocarina application [8]. However, even if the ecosystem has proven to work well, Smule is an exception in a plethora of third party application developers trying to make a fortune. Thus, while the market dynamics of the smart phone OSs introduced a new ecosystem to allow third party application developers to access the market, being successful in a highly competitive market is a difficult achievement. In the next section, we highlight three important factors to consider in order to increase the chances of success.

4.1 Factor 1 – OS vendor's software market strategy

From a developer's perspective, the OS vendor's business and software marketing strategy largely determines 1) the interoperability possibilities of the application between different proprietary solutions, 2) the ease of developing and testing, and 3) the hardware market availability. To better understand these concerns, we review three examples.

The unique characteristic of the Android OS being an open source is that any smart phone manufacturer can openly adopt the Android OS. Furthermore the Open Handset Alliance that supports the Android OS provides a free software development kit (SDK) to developers to encourage them to create applications for Android. While in 2008, only one smart phone was running the Android OS, (the T-Mobile G1) [9], one year later, more than five smart phone models with the Android OS were available in the market. Consequently, testing the applications for the Android OS in every smart phone adopting the OS is critical. The Android SDK provides a generic Android equipped smart phone emulator. While a developer for example, could adjust the look-and-feel of his/her application according to the emulator screen size, some real smart phone devices may have different screen sizes, resulting in the poor display of the application in a real scenario.

Apple has adopted a vertical software market strategy because Apple OS only runs on the Apple smart phone, i.e., the iPhone[10]. While limiting the possibility of collaboration with other smart phone manufacturers, it enables Apple to maintain a more stable and reliable framework since the OS is conceived to run on a precisely defined hardware. To the application developers, this means that they do not need to be concerned about the hardware thus simplifying the development and testing processes. The simulator provided by Apple is very similar to the iPhone, which is manufactured by Apple, especially for the look-and-feel. If a new iPhone model with a different screen size is launched, the emulator would be adapted accordingly and in advance.

In contrast to Apple, Symbian adopts a horizontal software market strategy where Symbian Foundation produces the OS to be ported

to any compatible smart phones, which are manufactured by third party manufacturers such as Nokia, Sony-Ericsson, etc. The OS however is not an open-source system. Nevertheless, the advantage of this strategy is that the Symbian OS is available on different types of hardware and has enormous potential for market growth. The disadvantage is that the developer has to check the availability of the required features in various Symbian devices. It is important to note here that not all hardware fully supports the Symbian OS potential, e.g. although the Symbian OS provides an API for GPS, not all Symbian equipped smart phones have GPS chips.

It is important to note at this point that there are three main software market strategies: open source, horizontal, and vertical. To illustrate these strategies, we choose three main mobile OS vendor companies as concrete examples to highlight the differences between the OS market strategies. While an open source platform principle offers the greatest flexibility and the widest possibility of integration and collaboration, a vertical market strategy could reduce the application developer's overheads because the developer does not need to manage the 'heterogeneity' of the hardware. In other words, although the smart phone OS that adopts horizontal or open source platform principles has the highest market growth potential because the OSs are available in more than one smart phone, the developer's overhead is the highest because of the need to adapt the applications to multiple hardware devices. Testing and profiling phases have to be administered on multiple hardware devices and a list of compatibility issues has to be dealt with.

4.2 Factor 2 – Buyer's choice

Besides understanding the market strategy of the OS vendors, the developers should also be aware of the type of smart phone device that is of the greatest interest to their target buyers. There are two main categories of target buyers, i.e. the individual end-consumer and the corporate consumer.

The individual end-consumer's choice: The individual end-consumer is a person who wants to buy a smart phone for his personal use, e.g., for storing personal information or for entertainment. For application developers developing applications (such as gaming applications) for individual end-consumers, the end-consumer's perception of the smart phone is important because if he or she is not interested in the smart phone device, they will not even take a look at the available applications of the particular device. In November 2008, J.D. Power and Associates surveyed 1388 wireless customers [11] and observed the following ranking of importance (in descending order): 1) Internet capability, 2) ability to use email, 3) overall design, 4) Bluetooth, and 5) keyboard style. The association also stressed that the end-consumers were most satisfied with the iPhone[10], followed by the BlackBerry[12]. As satisfied consumers beget more consumers, this is another important indication of the type of smart phone device that the developers may want to focus on when developing applications for end-consumers. It is important to note here that however, these findings may not be applicable if the target buyers of the applications are corporate consumers.

Corporate buyer's choice: A corporate consumer is an organization who wants to buy a smart phone for its employees as a working tool. The company's perspective and concern in choosing the smart phone device for its employees are important for developers who intend to develop applications, such as mobile

intranet applications, for corporate buyers. Security is of the utmost importance when a corporate consumer is selecting a smart phone device for its employees. This is especially crucial if the smart phone device needs to be integrated with the IT infrastructure of the company. A survey distributed by the InformationWeek journal to 250 IT experts confirmed the security concern of the corporate consumers as well as revealing four other concerns in selecting a smart phone device for corporate use [13]. Specifically, in the report, it ranked the importance of the concerns thus (in descending order): 1) security, 2) IT manageability, 3) easy integration, 4) applications available, and 5) wireless email. The implication of these results for developers of corporate applications is that when choosing a smart phone OS, they must at the very least focus on the overall OS security as well as the basic security features made available by the OS, such as cryptography and secured protocols like https or the ability to remotely lock or erase the content of the device. In addition, one needs to be concerned about the ease of managing and integrating the smart phone device so that it is compatible with the firm's IT infrastructure. For instance, the widespread adoption of BlackBerry by corporate consumers was the result of BlackBerry being the first device that integrated the Microsoft Exchange emailing system and enabled pushed e-mail.

4.3 Factor 3 – Other Developers' inclinations

Having discussed the OS vendor's software market strategy and the individual and corporate buyers' preferences, we next discuss the inclination of the mobile application developers in general. Regardless of the market strategy and the target buyers' inclinations, other developers have several concerns when selecting a smart phone OS to develop. First, the quality of the SDK, which is the development framework of the smart phone OS. The SDK is as a set of development tools that allows a developer to create applications for a certain software package and hardware platform. SDKs differ in terms of their programming code languages, their libraries and API support. Provided libraries should be carefully inspected, not all OSs provide the same bunch of functionalities and this may limit or even makes the implementation of an application not possible. As concrete example we mention "Credit Card Terminal"[14] a mobile commerce application that allows transforming a smart phone into a credit card terminal. For such a kind of application security is the utmost important feature. In order to guarantee a minimum-security level the OS has to provide security libraries in order to perform secured transactions and store sensitive data in a protected end encrypted environment.

SDK also differ in terms of their tools such as hardware emulators, as well as tracing and profiling instruments. Each SDK comes with an attached license, which could limit the development and licensing freedom of the applications built with the SDK. The SDK also provides built-in libraries, code examples, and documentation. When selecting a smart phone OS to develop for, it is important that the organization or individual developer agrees with the SDK licensing rules which may limit the application design, creativity and the future net revenue.

It must be noted that application developers are concerned with the revenue model. This aspect is especially related to independent developers who aim to profit from their developed applications. The most common features of revenue models are:

- The offering of online advertisement spaces and the generating of revenue from the advertisers
- The building of an application for a third party and the earning of a commission
- The selling of services to users through the application

• The licensing for application usage. In 2008, the licensing revenue model gained popularity due to the advent of application stores such as the Apple App Store. Smart phone OS vendors introduced their application stores to entice independent developers to develop applications for their OSs. This application store is an easy way for developers to license their developed applications and earn revenue from the licensing fees. The following are four currently available OS vendors' application stores:

The Android's application store platform is known as the *Market* [15]. Applications developed for Android can be licensed through this platform with a registration fee of \$25 and a transaction fee corresponding to 30% of every license sold.

The Apple iPhone's application deployment framework is known as *App Store* [16]. A developer needs a license to upload his application in App Store. The developer's license costs \$99 per year. Similar to Android's Market, Apple's App Store earns 30% of every license sold.

RIM's BlackBerry *App World* [17] which was launched in April 2009, is the latest application store. In contrast to Android's Market and Apple's App Store, developers need to pay an administration fee of \$200 in order to submit as many as ten applications to BlackBerry's App World.

Nokia's *Ovi* [18] application store offers a 70% revenue share and requires a 50€ registration fee.

With the exception of the BlackBerry App World, the revenue models of the application stores are similar, and based on shared revenue of 70/30% between the application developer and the store owner. Each store has its terms and conditions. These do affect the developers' net revenue and also the acceptance or declination of publishing an application on the store. For example, the Skype iPhone application is limited to allowing phone calls only over the wifi networks [19] because consumers: "May not have Voice over Internet Protocol (VoIP) functionality using the cellular network"

5. EVALUATING THE SMART PHONE OS – THE SIX DIMENSIONS

Building on the three-factor analysis, we next propose a tool that could be used to assess an OS. We conceive a "fitness" (or "attractiveness") of an OS to manifest in six distinct dimensions. They are 1) the corporate buyer's choice, 2) the individual consumer buyer's choice, 3) the OS vendor's market growth potential, 4) ease of implementation, 5) application store net revenue, and 6) security. The dimensions are gradients with values ranging from 0 (lowest) to 6 (highest). Figure 1 depicts a radar chart used to graphically represent the six dimensions (see Figure 1). Each candidate (i.e., smart phone OS) is evaluated and a radar chart is computed. The same dimensions are also used to represent the application developments needed in order to compute the "requirement chart". The OSs charts are then compared with the requirement chart to establish the best fit.

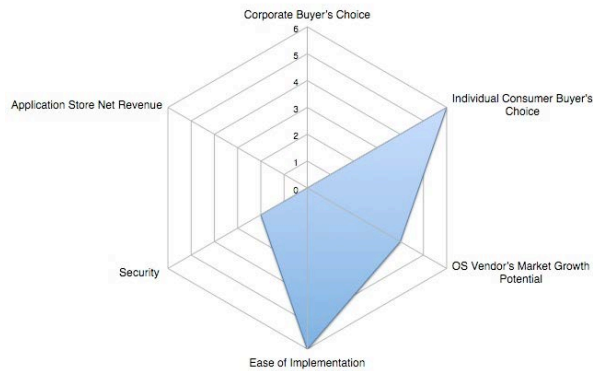


Figure 1. Six dimensions, example of requirement chart

The first two dimensions, i.e., the corporate buyer's choice and the individual consumer buyer's choice, are related to the buyer's choice (i.e., Factor 2). The buyer's inclination to choose a smart phone is quantifiable through the cross comparisons of the buyer's wants and the device's feature provisions. The greater the match between the feature demanded and supplied will lead to a higher scored value.

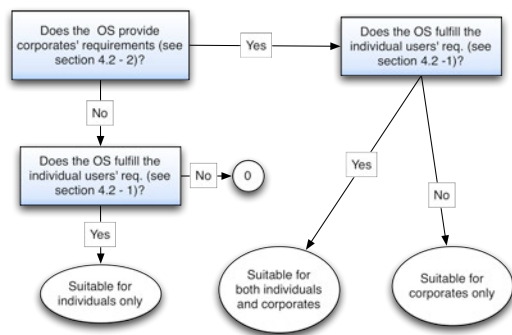


Figure 2. Individual consumers and corporate customers' choice dimensions

The assessment of the third dimension, i.e., the OS vendor's market growth potential, is based on the actual and future availability of the product on the market (see Figure 3). If an OS is not present on the targeted market and/or no future launch is anticipated or planned, the growth potential dimension value will clearly be relatively low. On the other hand if the OS has already acquired a large market share and/or its vendor software market strategy implies a large growth potential, the dimensional value should be very high.

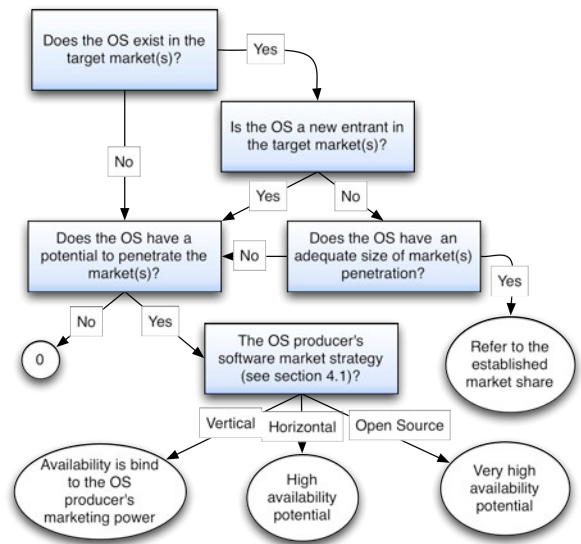


Figure 3. OS vendor's market growth potential

The ease of implementation, the fourth dimension, is related to the developer's inclinations as well as the terms and conditions associated with the Software Development Kit (SDK). Terms and conditions can limit the freedom of development by restricting the domain of application or variety of functionality (hence, the dimensional value of zero). Being familiar with the SDK would be important, especially in the situation where the development team is large. It is also to be noted that the vendor software market strategy also plays a role in the complexity of evaluating the performances of a developed application on a device with a single or more candidates. A vertical market strategy combined with a very well known smart phone OS SDK should be interpreted as the one with the highest value for the ease of implementation dimension (Figure 4).

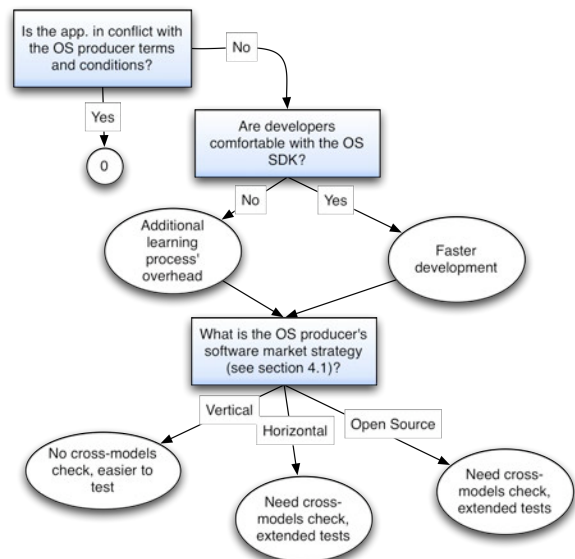


Figure 4. Ease of implementation dimension

The application store's net revenue, the fifth dimension, does not evaluate the future revenue of the application but the ratio between the licensing gross income and the final net revenue. The most common method of generating income with mobile application development is by selling the applications in the application stores. This mode of selling often results in the revenue being shared between the developer and the store-holder (with 30-70 sharing in most cases), or the developer enjoying only publishing costs. When selling costly applications that involve a long maturation process, the shared revenue models could dramatically reduce the sustainability of the future development of the applications. This dimension identifies how profitable (expected) an application developed for a specific OS would be (Figure 5).

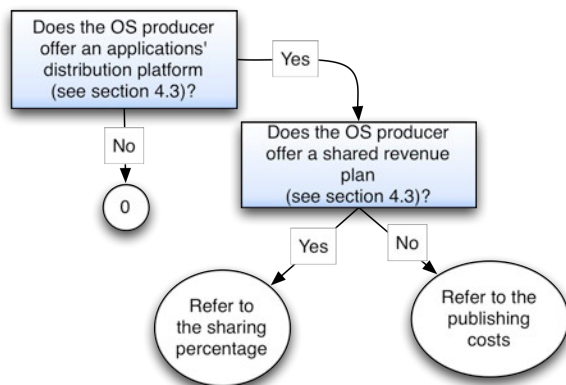


Figure 5. Application store net revenue dimension

The OS's security mechanisms are the sixth dimension. APIs and features available on the OS in order to secure local data or transactions operated by the smart phone. This dimension is mostly relevant for corporate applications, but not only. Also security sensitive applications for individual customers such as mobile payment applications should consider and benchmark this last dimension (Figure 6).

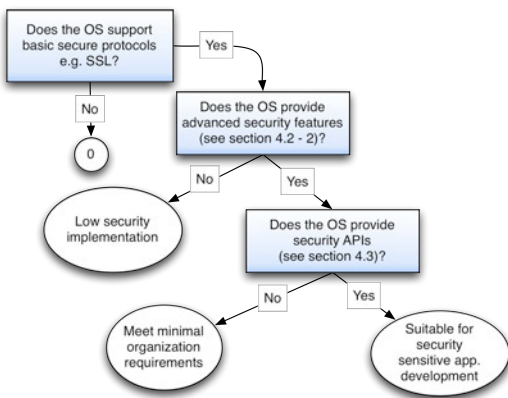


Figure 6. Security dimension

To understand the six dimensions and how to evaluate them in order to produce the "requirement chart", we describe the following real scenario:

"A grocery store chain wants to launch a pilot study to determine if a mobile application can enrich its customer

experience. The mobile application will offer an additional service to the merchant's customers. The application will allow them to distribute mobile coupon discounts to customers and inform them of the most attractive offers."

Considering the scenario, we estimate the dimensions as follows: The application is obviously more suitable for private than corporate consumers (corporate choice = 0) (consumer choice = 6). It has to be swiftly and easily implemented to avoid investing in too many resources in a prototype development. However, the quality of the software has to be controlled in order to get a representative evaluation of the application potential (ease of implementation = 6). The net revenue is negligible since usually such an application is distributed without charge (net revenue = 0). The security dimension is secondary since no sensitive data are treated, however we want to ensure that our application is retrieving the discounts from an authenticated server (security = 2). By evaluating the six dimensions correspondently to the future application needs the "requirement chart" (Figure 1) can be computed. It is to be noted that a better fit is achieved when there is more overlapping between the requirement chart and the evaluation chart of a specific smart phone OS.

6. CONCLUSION

This article provides guidelines to developers of mobile applications in selecting the smart phone OS for developing their applications. We propose to consider the OS vendor's market strategy, the choices of individual or corporate buyers; and the inclination of the mobile application developers in general. It is to be emphasized here that although there could be many other factors that a developer could consider, we believe that the three factors presented, followed by the six dimensions, are the most critical ones. We successfully tested our benchmark scheme by applying it to our accumulated know-how (e.g. previously developed mobile applications). We believe a comprehensive and up-to-date analysis of the proposed three critical factors coupled with a careful evaluation process following the proposed schemes could inform a decision on the appropriate smart phone OS for developing an application. Toward this end, we hope this article will generate interest in this field of investigation.

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