Mobile Device and Technology Characteristics' Impact on Mobile Application Testing

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Mobile technologies have a significant impact on processes in ICT, including software development. Within mobile technologies a new type of software has emerged: mobile applications. Nowadays, the concept of mobile applications is widely known and the development of mobile applications is more and more widespread. One of the most important parts of mobile application development is mobile applications testing. The testing process has always been very important and crucial in the software development cycle, which is why testing constitutes an important aspect of software development. An appropriate testing procedure significantly increases the quality level of the developed product. With mobile application development testing, new challenges associated with mobile technologies and device characteristics, have arisen. Some examples of these challenges are: connectivity, convenience, touch screen technology, context awareness, supported devices, etc. It is important that we adequately address these challenges and perform an appropriate mobile application testing process, resulting in a high quality product without critical defects that could cause quality issues or the unwanted waste of human or financial resources. In this paper, we will present a mobile application testing process. We will indicate the important parts and especially emphasize the challenges related to mobile devices and technology features and properties.

General Terms: Mobile applications testing

Additional Key Words and Phrases: testing, mobile applications, mobile technologies, quality

1. INTRODUCTION

Mobile devices and mobile applications play an important role in our everyday lives. Nowadays we are surrounded by mobile technology and cannot imagine running personal or business errands without them. This has been confirmed by numerous pieces of research. According to Gartner, the worldwide sale of mobile phones in the third quarter of 2012 reached almost 428 million units. Within this number, smartphone sales represent almost 40 percent of total mobile phone sales [Gartner 2012]. A similar thing is happening in the area of mobile subscriptions. At the end of 2012, there were approximately 6.8 billion mobile subscribers in the world, which is equal to 96 percent of the world population. Currently, global mobile-cellular penetration rates are 96 percent. In Europe the number is higher, at 126 percent [ITU 2013].

Closely related to mobile devices are mobile applications. By the end of 2012, there were approximately 1.1 million mobile applications users. According to forecasts, the number will grow rapidly – by nearly 30 percent per annum - to reach 4.4 billion by the end of 2017 [Whitfield 2013a]. Applications generated $12 billion in revenue in 2012 and a total of 46 billion applications were downloaded [Portio Research 2012]. This number is also expected to grow: in 2013 smartphone and tablet users will download a further 82 billion applications [Whitfield 2013b]. Mobile applications are currently represented in almost every possible personal or business domain. Although games still constitute the largest category in most of the major application stores [Whitfield 2013b], mobile applications can be seen in just about every industry. Some examples include: retail, media, travel, education, healthcare, finance, social, business applications, collaboration and more [uTest 2012]. Some of these applications within a specific

domain use more or less sensitive user data. Users frequently allow access to personal data in the context of mobile devices and also enter a lot of personal information. In this context, the issue of users' trust takes on an important role. It becomes important to provide quality mobile applications that are reliable and flawless [Hu and Neamtiu 2011]. Applications that are reliable and work flawlessly within expected functionalities can gain a user's trust and, more importantly, keep it. Users also often have high

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expectations about the quality of mobile applications. Applications that crash and lose users' personal data are not allowed [Bo et al. 2007]. One of most important mechanisms for providing reliable, flawless and quality mobile applications is an appropriate testing procedure. Testing during mobile application development is slightly different from testing procedures in traditional software and the process itself is also suited to the area of mobile applications and mobile technologies.

In this paper we will present a testing procedure for testing mobile applications. We will identify and describe specific characteristics for mobile devices, mobile applications and mobile technologies as a whole, which have a significant impact on the testing procedure. First, in Section 2, we will present the fundamentals of software testing and reveal some of the major differences between testing traditional and mobile software. We will also provide an introduction to mobile application testing. In Section 3, we will present some of the specific characteristics of mobile technologies that have an impact on testing and challenges in testing mobile applications. Everything will be cemented with a practical approach for mobile application testing procedures and gained experiences. In the Discussion, we will present the findings and results of our work.

2.   FUNDAMENTALS OF MOBILE APPLICATION TESTING

Mobile application development has specific characteristics that need to be addressed through the entire product's life cycle. According to a recent study [Wasserman 2010], there are important software engineering research issues linked to mobile application development. Some of these issues include: potential interaction with other applications, handling available sensors, the development of native or hybrid mobile applications, different families of hardware and software mobile platforms, problems of security, an adjusted user interface and the problem of power consumption.
Testing process plays an important role in the life cycle of a software product, whether in mobile or traditional desktop application. Therefore, it is crucial to address abovementioned issues in related mobile testing procedures.

A lot of research has dealt with the fundamentals of software testing, therefore there are many available definitions of testing. To summarize one of the definitions: testing is an activity performed for the purpose of evaluating product quality, and for improving the product by identifying potential defects and problems. Software testing is composed of the dynamic verification of the program behavior on a finite set of test cases against the expected program behavior [Bourque and Dupuis 2004].

Testing is not just an activity that starts after the coding phase is finished and is used to detect failures. Software testing is a procedure that should be active through the entire product life cycle, from the development and maintenance process to actual product construction. Also, the planning phase for testing should occur early in the product requirements process and test plans must be systematically and continuously developed, as the development of a product proceeds. Currently it is considered that the right strategy for quality is one of prevention. It is much better to avoid problems than to correct them. Therefore, testing must be viewed as a procedure for checking if prevention was successful and for identifying faults in cases where prevention was not effective [Bourque and Dupuis 2004].

An important aspect that makes mobile testing different is the complexity of testing, a point made by the authors of the aforementioned study [Wasserman 2010]. A challenge that they mention is the diversity of different available mobile devices, for example Android devices and others related to testing native mobile applications. There are also many other challenges related to mobile application testing. We will describe these challenges in detail in the subsection below.

2.1   Mobile application as testing object

If we want to properly understand the concept of mobile application testing, it is important that we understand what a mobile application is. We are all familiar with mobile applications, but what does the definition say? A mobile application is a type of software application designed to run on smart phones, tablets and other mobile devices and/or for taking in input information. Similarly, mobile applications in

the context of mobile computing is an application that runs on an electronic device that may move [Kirubakaran and Karthikeyani 2013].

The testing of mobile applications is an important and also very difficult task, according to various authors [Bo et al. 2007; She et al. 2009; Kirubakaran and Karthikeyani 2013; Franke and Weise 2011]. They all believe that testing mobile applications is a non-trivial process that takes a lot of time, effort and other resources. We have had the same experience with projects where we developed mobile applications for Android, iOS and BlackBerry. The experience is described in detail below in Section 3. As previously mentioned, as mobile applications become more and more complex and ubiquitous, users have higher and higher expectations with regard to mobile application quality. Users want an application that does not fail, lose data or harm the device's operability, as well as applications that are secure, reliable and easy to use. If we conduct the testing procedure properly, possible defects embedded in the application can be detected and removed and this can lead to greater confidence in an application [Bo et al. 2007; She et al. 2009].

The challenges encountered during mobile application testing were mostly related to the different characteristics of mobile devices or mobile technologies, which has a direct influence on mobile applications and the conducted testing procedure. In the existing literature we found many different described characteristics. As noted by [Kirubakaran and Karthikeyani 2013; Franke and Weise 2011] these characteristics are: connectivity, convenience, user interface, supported devices, touch screens, new programming languages, resource constraints, context awareness and data persistence. The mentioned characteristics are presented in Figure 1.
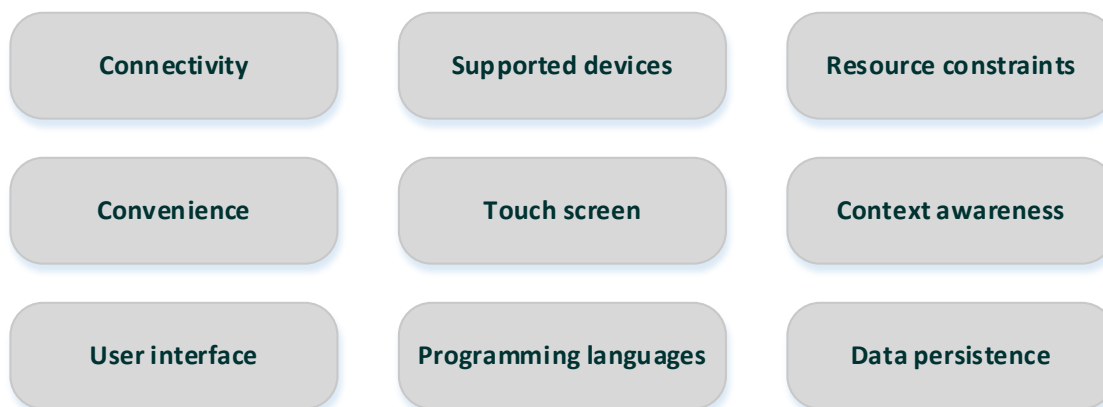
Connectivity	Supported devices	Resource constraints
Convenience	Touch screen	Context awareness
User interface	Programming languages	Data persistence

Fig. 1. Characteristics of mobile devices and technologies with their impact on the testing procedure

3.   CHALLENGES IN MOBILE APPLICATION TESTING

As previously mentioned, during mobile application testing we came across different challenges. Different authors have already investigated some of the challenges that have a significant influence on the testing procedure. We came across the same characteristics that consequently represent challenges in testing mobile applications. As mentioned, we developed mobile applications for the operating systems Android, iOS and BlackBerry in the context of a research and development project. Mobile applications are a part of the larger project, which also include a web application. Within the development process, we also perform mobile application testing. The process of application testing is a complex process, but for the needs of this article we will show a simplified version. The simplified testing process can be seen in Figure 2. The process starts with the release of a version of the mobile application for a specific platform for testing purposes. The Quality Assurance team receives aversion and starts the process of testing based on the recorded test scenarios. If they find an irregularity, an error or an unreliable function, they report the problem to the web-based bug tracking system. Bugs are seen by the development team and later fixed. We have to point out that within our project, we also performed different types of test cycles. The most

common was the weekly testing procedure. There is also testing for the purpose of the application's release on the belonging market.

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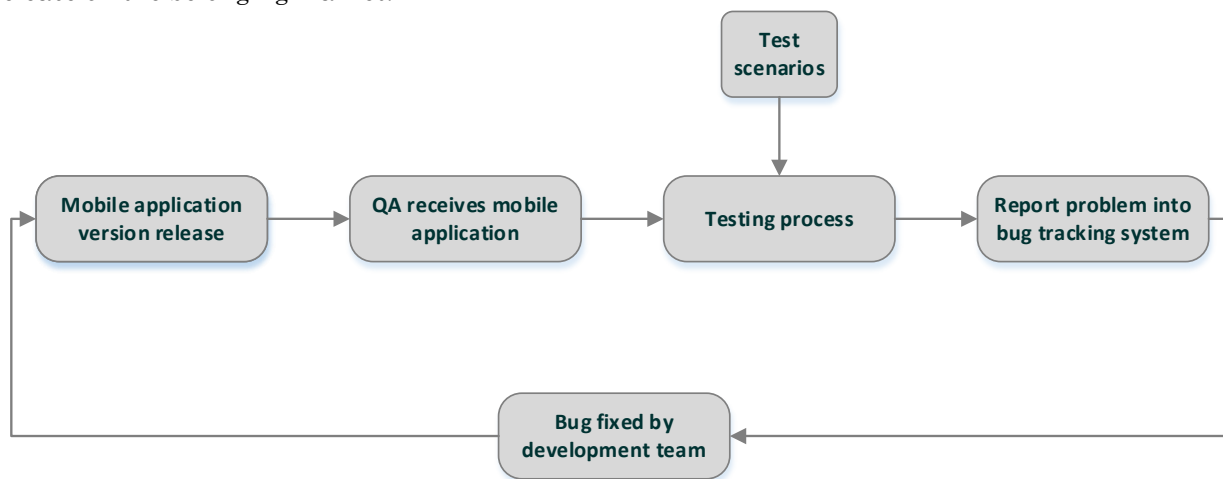
Fig. 2. Mobile application testing procedure

The most important part of the testing process is the execution of test scenarios, where specific characteristics of mobile devices are revealed. In fact, they also play an important part in writing testing scenarios, where we have to shape each test scenario in a way that it will consider and verify a specific characteristic. When we started to write and later execute specific test scenarios, we reviewed existing literature from the area of mobile application testing. Specific characteristics identified in different works were taken into account within our own testing procedure. The nature of these characteristics, what existing literature says, and how we dealt with them is discussed below.

The first property we came across and has an impact on many different types of testing is *connectivity*. Mobile applications have to be designed with the awareness that they will be always online, because mobile devices are always logged on to a mobile network. Networks can vary according to speed, reliability and security. Especially slow and unreliable wireless networks are a common obstacle for mobile applications. The described property has to be considered in functional testing, where different networks and connectivity scenarios have to be performed, with an emphasis on popular networks. Connectivity also has an effect on performance, security and reliability testing [Kirubakaran and Karthikeyani 2013; uTest 2012]. In practice, we consider the characteristic *connectivity* in such a way that we test our applications in different networks. We also perform test scenarios to test different internet connections. We use different Wi-Fi networks and cellular networks by different operators and in different places, like buildings, city centers or in nature. For our application, connectivity is very important because functions in mobile applications are supplemented with web applications, so the application uses the function of synchronization very often.

Another important property according to other studies is the *user interface*, which is related to the characteristic of *convenience*. This property is important because user interfaces in development need to follow specific guidelines based on the different platforms for which they are being developed. Different platforms have their own rules and guidelines about how a specific user interface should look, so if a product in development is being developed for different platforms we have to strongly focus on a specific design. Regardless, different platforms still present a big challenge in terms of designing the best possible use of limited screen space, so that the design of the user interface takes greater importance in the development process. The user interface looks different based on the mobile device's screen resolution and its dimensions. Some implications on testing are seen in the area of different devices that need to be used for testing procedure. It is recommended to test the user interface on as many different mobile device as possible. This is because different devices behave differently with the same application code [Hu and

Neamtiu 2011; Kirubakaran and Karthikeyani 2013; Wasserman 2010]. Within the development of mobile applications in our project, the developers followed specific rules and good practices for designing platform specific applications. These guidelines were also reviewed in the testing phase. We also developed our own Style guide document, which ensured that regardless of the platform, the application would look similar and reflect the fact that all applications are part of the same product family. With regard to the testing process, we tested the appearance on different mobile phones, with different resolution and different physical dimensions. We considered the minimal and optimal screen size, which was set within the Software requirements specification document.

Nowadays many different mobile devices are available. What is important is that applications work flawlessly on as many devices as possible. *Supported devices* represent one of the most difficult aspects of the testing process. Devices from different vendors have different software and hardware components. In particular, there are hundreds of different mobile devices that run the operating system Android, whereas the mentioned operating system has countless different versions. Different versions of operating systems are also a great challenge to cover within the testing process [Kirubakaran and Karthikeyani 2013]. Usually it is impossible to test every available device, so we group mobile devices in different categories, as proposed in [Kirubakaran and Karthikeyani 2013]. The focus of this challenge is on Android mobile devices. We tested our mobile applications on mobile devices from different vendors, with different hardware components and different versions of operating systems. We developed three groups: small, optimized and high quality mobile devices. The first group included mobile devices with a small screen size and low resources, while the last group included mobile devices with a high screen resolution and a lot of resources. Test scenarios were carried out on a few representatives of each group. However, iOS devices were a different story as there is not such a large variety of different mobile devices. The same testing strategy was used for testing the *touch screens* of mobile devices and their properties, which also represent an important challenge in mobile application testing. Touch screens are the main tool for inputting user data into a mobile application. An important aspect is the system response time to a touch, which depends on device resource utilization, and easily may become slow in some circumstances, such as in the case of a busy processor, a lack of memory or other problem. Thus, it is important to test the touch screen's abilities under different circumstances [Kirubakaran and Karthikeyani 2013]. We tested touch screen capabilities under different circumstances, as proposed. We burdened the processor and available memory by running multiple applications simultaneously, for the purpose of testing the behavior of different touch screen on different devices.

As many authors agree, mobile devices are becoming more and more powerful, but their *resources*, like processor power, RAM, and resolution are still facing restrictions [Kirubakaran and Karthikeyani 2013; She et al. 2009; Franke and Weise 2011; Portio Research 2012]. This characteristic is closely linked to some of the previously mentioned characteristics, like *supported devices* and *touch screens*. As proposed in [Kirubakaran and Karthikeyani 2013] mobile device resources have to be continuously monitored, to see what a specific mobile device is capable of and to verify what actions are taken if a device runs out of resources. A very similar characteristic is *data persistence*, because mobile applications that run out of memory shut down running applications, so we have to make sure user data is stored and saved adequately [Franke and Weise 2011]. We also test these two characteristics within specified groups of mobile device testing. We try to overload a specific mobile device and test the behavior of a mobile application. We check if it stored data properly and of course where the breaking limit for the mobile application is.

A very important characteristic that has a significant impact on testing our mobile application is *context awareness*. A lot of mobile applications also rely on sensed data, provided by context providers that monitor the surroundings and connectivity of devices. All these provide an enormous amount of data, which vary depending on the user's actions and the environment. It is important to test the application under a different environment and under any contextual input, if it is going to work correctly [Kirubakaran and Karthikeyani 2013]. Our application uses data provided by GPS sensors and via Bluetooth from heart rate sensors. We have to ensure that the data is provided correctly regardless of the mobile device and its operating systems. Different operating systems support different Bluetooth devices so we have to ensure that we test all available and supported devices properly.

The characteristic that is more involved in the developing process, but still part of the testing process, is related to new *programming languages* that are used for mobile application development. These programming languages were developed to support mobility, managing resource consumption and handling new GUIs [Kirubakaran and Karthikeyani 2013]. It is important that code during the development process is tested properly, according to the features and characteristics of programming languages.

DISCUSSION

All characteristics were, as mentioned, appropriately represented in the process of writing test scenarios, and later considered in the testing of developed mobile applications. The majority of characteristics are important after the development phase is finished and it is time to test the developed software for defects and irregularities. Software testing is an activity aimed at evaluating the quality of a program and also for improving it by identifying defects and problems, as claimed in [Kirubakaran and Karthikeyani 2013]. As we emphasized, some important characteristics that have a significant impact on mobile application testing are: connectivity, convenience, user interface, supported devices, touch screens, new programming languages, resource constraints, context awareness and data persistence. All characteristics found by different authors were appropriately considered while testing our mobile application for the operating systems Android, iOS and BlackBerry, developed within a research and development project. In the future, we would like to spread those characteristics into automatic testing and test management tools for the mobile application domain.

Testing mobile devices is different from testing a mobile application. We think that mobile application testing cannot be properly conducted if the characteristics specific to mobile devices and mobile technologies are ignored. If we test mobile application regardless mentioned characteristics we will find obvious defects, but irregularities specific to mobile application will not be discovered. And we will not be able to offer a quality product to potential users. The mentioned characteristics and guidelines have a significant impact on testing and consequently on mobile application quality. And as we know, a quality product means satisfied and loyal users.

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