Quality Attributes in mobile Web Application Development

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Abstract: This paper deals with a quality model for mobile web applications. The paper describes typical challenges in the development of mobile web application and decomposes the challenges into the quality of the ISO 9126 quality standard. This leads to an adjusted ISO model that focuses on those quality features that are important in order to assure the quality of mobile web applications. The proposed model may be used for analyzing the quality factors of mobile web applications, expert evaluation checklists and may be used for quality based content adaptation. Finally, the paper shows that challenges in mobile web application development may be solved by applying quality insurance methods to the development of those applications.

Introduction

The mobile Internet promised comparable flexibility and cost efficiency to the normal web. However, experiences indicate that the development of mobile web applications needs to consider special challenges in the areas of usability, development efficiency and runtime consideration.

The major challenge of mobile application development is the heterogeneity of mobile devices and web browsers installed on the devices. The differences in the form factors and input capabilities strongly influence the usability of an application. In addition the pre-installed browsers differ between the devices. Currently most mobile devices, either support WML or subset of (X)HTML. The different markup languages pose threats to application development that are either automatically or manually adapted to the different languages. Finally the wireless network connection causes additional threats, such as higher network delay, limited bandwidth or dropped connections. These challenges will be investigated in depth in the "Challenges for Mobile Application Development" section.

These problems may be considered as quality problems. However, while several studies on quality for e-commerce systems have been done (i.e. [StXe01]) there are no such studies for mobile applications. An adapted quality model that investigates special issues in quality assurance is helpful in two ways. First the consideration of special quality features help implementers in creasing the quality of their applica-

tions and leverage the acceptance of mobile web applications. Therefore quality assurance methods contribute in overcoming some of today's challenges in mobile application development. Second a quality model will support researchers in comparing their approaches in mobile web applications development and device independence.
This paper describes the major challenges to application development when building mobile web applications and maps the challenges to the well known ISO 9126 quality attributes to the special needs of mobile web applications. The paper is organized as follows: the first chapter introduces the ISO 9126 norm. The second chapter describes the major challenges of mobile web applications development and links those challenges to the affected quality features. Chapter three summarises the findings of chapter two and indicates the parts of the ISO 9126 norm that are especially affected. The paper concludes with an outlook on future work that is required in order to archive the described goals.

Quality Attributes according to ISO 9126

The ISO 9126 is part of the ISO 9000 standard, which is the most important standard for quality assurance. The ISO 9126 defines a set of the quality attributes to be used in a quality assurance process. An overview of the defined attributes is shown in the figure below.

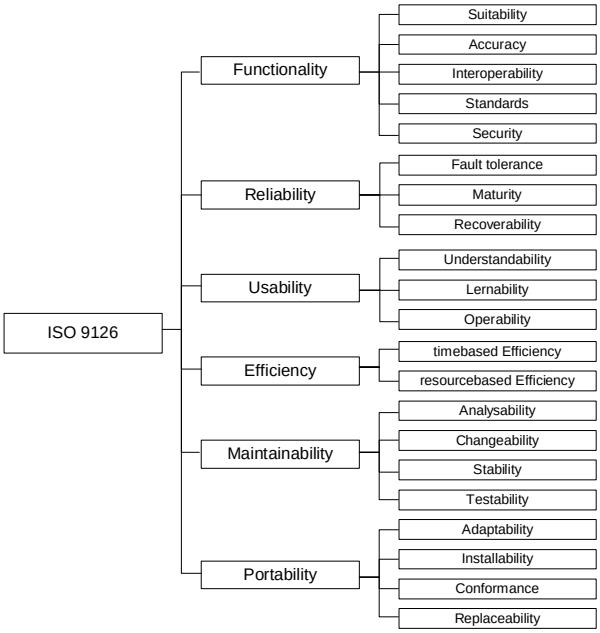

Figure 1 Overview ISO 9126

The main factors are *Functionality*, *Reliability*, *Usability*, *Efficiency*, *Maintainability* and *Portability* that are further divided into a set of sub- factors.

Functionality

Functionality is "a set of attributes that bear on the existence of a set of functions and their specified properties. The functions are those that satisfy stated or implied needs." *(ISO 9126: 1991, 4.1)*. This factor consists of five sub- factors: *Suitability* means that the functionality of the application fits the needs of a user to fulfil a certain task without overwhelming the user. *Accuracy* means that the results or application's behaviour is correct. *Interoperability* means that the application is able to interact with the specified systems. *Compliance* means that the application is compliant with standards, conventions or regulations in laws and similar prescriptions. *Security* is the ability to prevent unauthorized access, whether accidental or deliberate, to programs and data.

Reliability

Reliability is "a set of attributes that bear on the capability of software to maintain its level of performance under stated conditions for a stated period of time" (ISO 9126:

1991, 4.2). Reliability consists of three sub-factors: *Maturity* is the frequency of software faults. *Fault tolerance* is the ability of software to deal with of software faults or infringement of its specified interface. *Recoverability* is the capability to recover data affected in case of a failure and measured by the time and effort needed for it.

Usability

Usability is „a set of attributes that bear on the effort needed for use, and on the individual assessment of such use, by a stated or implied set of users" (ISO 9126: 1991, 4.3). The quality factor consists of three sub- factors: *Understandability* describes the users' effort for recognizing the logical concept of an application and the applicability of that logical concept. *Learnability* is the users' effort for learning the application as for example, operation control, input and output and finally *Operability* - the users' effort for operation and operation control.

Efficiency

Efficiency is "a set of attributes that bear on the relationship between the level of performance of the software and the amount of resources used, under stated conditions" (ISO 9126: 1991, 4.4). The efficiency of the *time* and *resource* behaviour are distinguished. The time behaviour describes for instance processing times and throughput rates while resource behaviour means the amount of resources used and the duration of use.

Maintainability

Maintainability is "a set of attributes that bear on the effort needed to make specified modifications" (ISO 9126: 1991, 4.5). The factor consists of four sub- factors: *Analysability*, the effort needed for the diagnosis of deficiencies or failures and for the identification of parts to be modified. *Changeability* is effort needed for modification, fault removal or for environmental change. *Stability* is the tolerance of the application towards unexpected effects of modifications. *Testability* is the effort for validating modification.

Portability

Portabiltiy is "a set of attributes that bear on the ability of software to be transferred from one environment to another" (ISO 9126: 1991, 4.6). The factor consists of four sub- factors: *Adaptability* is the opportunity for adapting the application to different environments without additional effort. *Installability* is the effort for installing the software. *Conformance* means the conformance of an application to standards or

conventions relating to portability. *Replaceability* is the opportunity and effort to use an application as a replacement for another application.

Challenges for Mobile Application Development

This chapter describes the typical challenges for the development of mobile web applications and relates them to the quality features described in the last chapter.

Usability

There are implied restrictions on interfaces for user interaction on mobile devices compared to a normal desktop browser. Porting an application from a desktop to a mobile version therefore requires adaptations with respect to output, input and navigation.

The output capabilities of mobile device are determined by their screen, which can range from small monochrome to VGA/SVGA size displays. The screen limits the amount of information for simultaneous display and therefore the bandwidth for user interaction. Applications need to consider this limitation, for example by distributing information across multiple pages or adapting the content of the application (e.g. [MaVe02], [KePl02]).

The limited input capabilities are due to size constraints of mobile devices that are usually not equipped with a full size QWERTY keyboard. The performance for data input is therefore comprimised. This must must be taken into consideration by applications which limit data input to the minimal required data. In addition, applications should select input widgets that are appropriate to the input hardware. For example, when designing a date entry field, an application should use numeric input widgets (i.e. an input field) instead of selection widgets (i.e. a DropDown Box) since mobile phones are usually equipped with a numeric keyboard that supports numeric input best.

The following example shows the effects the selection of different widgets when using a device with limited input capabilities. We evaluated multiple versions of a UI widget for specifying a date on a Motorola Timeport mobile phone. Figure 2 and Figure 3 below show two alternative versions: one using input fields, the other one using selection boxes. For the first version the user has to use the numeric keypad to input the date, for the latter version the restricted navigation facilities of such keyboards come into play.

Figure 2 Date Input - Keypad version

Figure 3 Date Input - Select version

During the user trial we found that on the average the users needed 18.3 seconds to complete version one while they needed 23.7 seconds for version 2. This indicates that for the selected phone numeric input methods should be used in favour to selection based methods. Similar results for the Nokia 7110 indicate that this is the general trend for devices with numeric keypads.

Another important observation is that the navigation concept needs to be adapted to a device. For instance, devices equipped with a touch screen should support a hypertext navigation concept, while other devices equipped with selects buttons should use menu based navigation.

Generally, the functionality of desktop applications is too complex for a direct transformation to mobile devices. Mobile web applications should be focused and simplistic in order to minimize the required interaction. Therefore, not only the individual user interface widget needs to be adapted, the overall complexity of the application should not overwhelm the user. Functionality that is not required to fulfil a certain task should be left out for those devices with restricted user interfaces.

In addition the operability is influenced by mobility for interactive tasks - data input and navigation. The hardware limitations (i.e. smaller keyboards) require more user attention to operate the application when inserting data or navigating. Additionally, the surrounding environment has an impact on the interaction. A user may be distracted and in motion when using his mobile device, so the accuracy, speed and correctness of his input may be lower.

In conclusion, usability and functionality are important and currently a major threat for the success of mobile web applications. Therefore quality factors such as usability, operability and especially suitability need special consideration when designing and implementing mobile applications. Quality assurance methods should be applied during the development process to assure that an application meets the required quality features and thus the success of the application.

Technology impact

Technology is no longer a guarantee for commercial success. Economics is an important factor for the success of mobile web applications. The costs – network and application - for using the applications need to be considered and a service needs to provide an added value to the user, which he's willing to pay for. Currently, the costs for using a service consist of a service fee and network costs. We focus on the network costs, which currently have a greater impact compared to non wireless networks. In GSM networks the network costs are either time or volume based. Mobile applications should therefore try to minimize the time a user needs to complete a task and the amount for data send to the client. This contributes to an application's suitability as well as a time and resource based efficiency.

Mobility and context changes

Suitability and costs have another effect on mobile applications. The applications are more focused and the usage time is reduced. The time invested for understanding and learning about the application should be reduced as well. Otherwise, the users could reject the application. This goal may be reached by a common applications design or by using use patterns. However learnability and understandability need special consideration.

As mobile web applications are used in very different environments and the user is often travelling, the user accesses the application whenever and wherever required to fulfil a certain task. A mobile web application is subject to continuous context changes. The context influences the application, which needs to adapt to those context changes. For example, the location is irrelevant to an office situation – the location does usually not change everyday. For a mobile web application this situation is different. When used on the road the location is very important, information that may be used increases the suitability of an application. For example [SpVo03] describes an approach that uses a user's location to replace certain location dependent user inputs. The decreased interactivity decreases the usage times that contributes to the suitability of the application.

A changing context is the nature of mobile web applications that must adapt to those context changes. Context changes have a strong influence on the software engineering process ([FiSa01]) of an application as well as quality engineering. The quality factor suitability is especially affected.

Wireless network

In the early day of mobile internet access, technology problems, such as network stability and networks delays, were identified as a major issue, communication technologies (e.g. devices, networks) have nowadays reached a certain level of maturity. However, the differences in the quality of service of mobile networks still differs from the QoS of fixed networks and therefore needs consideration in the develop-

ment process of mobile applications. The latency and the limited bandwidth have an impact on application development. For example, the delay in loading pictures on a mobile, requires by far more text oriented mobile web applications in order to be suitable.
Another challenge for wireless network access is security. Tampering a wireless connection is much easier compared to fixed lines. In addition the limited processing power also limits the level of the supported security standards. For example WTLS encryption that is used for WAP devices is less robust compared SSL, used in the normal web. The differences require special consideration in requirements engineering and quality assurance - especially the quality factor security.

Device heterogeneity

The heterogeneity of devices is causing an increased development effort for mobile web applications. There is a lack of accepted application level models for user interaction and content presentation (UICP) which satisfies the needs of efficient application development and device specific factors. In addition, maintaining multiple device dependent versions is labor intensive, compared to the a few common alternatives, which have to be maintained for non-mobile web-applications. Various approaches are being considered stressing different constraints and expectations.
The mechanisms of the World Wide Web have set the standard for UICP based on PC browsers. A large number of existing HTML pages induced efforts to achieve automatic transformation into representations which can be rendered on handheld devices with considerably smaller screen sizes. Such approaches (e.g. [BiSc97]) target page transformations based on syntactical analysis of a given HTML page, element type specific reductions (e.g. image rescaling) or exclusions of content parts based on assumptions about the semantics of HTML content parts. Experiments with such systems have shown that, while generated presentations are legible, the aesthetical quality of achieved presentations is rather low ([BiSc97]).
A second school of thought advocates the development of distinct UICP models to be used in the context of distinct devices. Providing a dedicated UICP model for every possible device ensures maximal UICP adaptation, at the expense of development cost ([UnwPla]). To alleviate this situation, approaches such as [UnwPla], [CoSh95] consider the provision of UICP models for a number different device classes. Still, UICP definition needs to be done several times.
Regarding implementation efficiency, defining and implementing a UICP model which can be reused for every possible end user device is an ideal approach.
To support such device independent authoring various techniques have been considered including:

- abstract user interfaces mapped onto a concrete UI representation of an employed device ([UIML], [XIML], [EiVa01])
- content elision and transcoding techniques (e.g. [BiSc97], [MaVe02])
- presentation structure adaptations such as for dynamic layouting and pagination (e.g. [MaVe02], [KePl02]).

The challenge common to all approaches is finding an optimal tradeoff between the quality and the development effort. The need for automation requires a high level of adaptability of applications as well as the supporting environment. In an ideal case an automated transformation system requires no additional modifications of the application are necessary. However, such a maturity level is difficult to reach –an evolutionary development approach [GeGa99] that starts with an application for a smaller set of devices which is extended to new devices is much more likely. The author of device independent applications is required to partially port or at least add additional meta-information for an adaptation engine for new devices. The frequent changes require a maintainable application. Changeability and stability are especially important for mobile web applications. In an ideal case an author is able to invest the minimal effort required to archive the predefined quality level.

Summary

The challenges for the development of mobile web applications are partially quality challenges. The fact that a software project is developing for a mobile client needs to be considered in requirement analysis and quality assurance. Table 1 summarizes the relationships between mobile challenges and quality factors according to the ISO 9126 norm.

Characteristics of mobile web application	Related Quality Factor
Usability – Output / Form factor consideration	Usability Suitability
Usability – Input / Form design	Usability Suitability Operability
Usability – Navigation	Usability Suitability Operability
Network limitations	Resource based Efficiency Time based Efficiency
Wireless connection	Security Suitability
Context changes	Suitability
Short usage times	Understandability Learnability
Application development for heterogeneous devices	Portability Adaptability Changeability Stability

Table 1 Impact of mobility on ISO 9126

Challenges Mobile Application Development – A Quality Problem?

As described in the last section a couple of challenges in mobile web applications and the development of such are related to quality issues. The most urgent challenges for mobile web applications concern increasing the usability and the suitability of mobile applications. Both are important quality factors listed in the ISO 9126 standard. A second challenge is on increasing the efficiency of mobile web application development. The heterogeneity of devices requires porting and adapting the application to new devices with new requirements towards the applications. Increasing the quality of the development processes and products/program code in the areas of portability and maintainability will help to lower the cost when adding a new target platform.

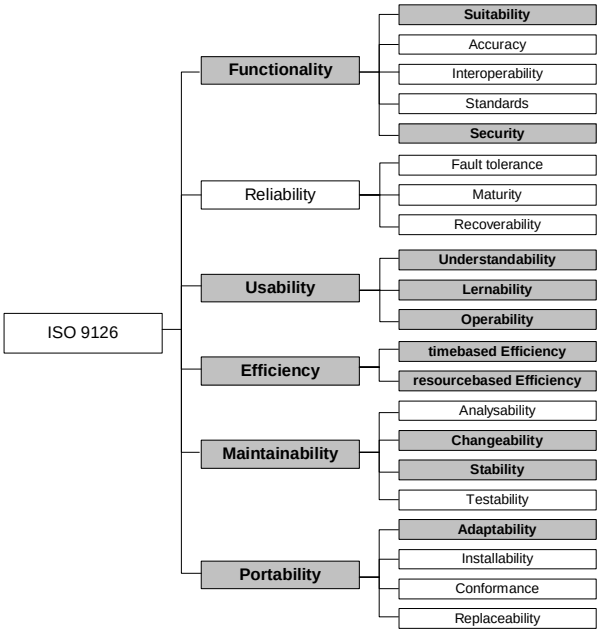

Figure 4 ISO 9126 - Effects of mobile web applications

Finally, the limited processing and network resources require efficient use of the available resources. An overview of the impacts of mobile web applications on the ISO 9126 standard is shown in Figure 4. The areas that are of special interest are marked bold.

The adapted ISO standard may be used to support the development in tracking the most important quality factors for mobile web applications. The attributes should be especially considered in the requirement phase. Applying software and quality engineering methods to the development should then lead to increased quality of mobile web applications and therefore better acceptance of future generation of mobile web applications.

Conclusion & Future work

The paper has discussed the ISO 9126 norm with respect to the development of mobile web applications. We introduced the standards, explained typical challenges in mobile web application development and linked those challenges to quality features. The result is a list of quality features that require special attention for those development projects. The final goal of the research is applying quality assurance to help improving mobility challenges.

The next steps for our research is a deeper investigation on the core quality attributes and on methods for measuring those under the requirements imposed by mobile web development, namely the heterogeneity of device that may be too labor intensive, for quality assurance comparable to effort for the development of applications. This may also imply changes to the general development approaches such as HORIZON process that is used within SAP.

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