Usability Requirements for Mobile Service Scenarios

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Abstract

Mobile computing has been affecting our everyday lives by providing us with continuous interaction possibilities, thus moving computers from a localized tool to a constant presence. Users, then, need to be supported by a new sort of interface enabling interaction with services and people in a variety of contexts, provided across diverse devices, services and functions for different types of purposes. So that these new mobile scenarios are accepted, the understanding of users’ needs and the establishment of usability requirements are essential activities in the software design process. The traditional analysis and assessment frameworks might not cover the new issues raised by the emerging scenarios: these envision holistic experiences of interaction, thus implying users’ needs that are changeable in place and time and are strongly dependent on the context of the experience itself. This paper aims to point out the new issues to encounter in the usability requirements specification for mobile computing scenarios.

Keywords: usability, requirements, mobility, user centered design, context

1 Introduction

The development of mobile technology jets the bases for new patterns of interaction and communication: new users’ goals and behaviors emerge. In this sense the elicitation of users’ needs must rely on a deep understanding of the multi-faceted context of use of information systems, and on the way users perform their activities nowadays, in order to design scenarios and establish usability requirements for future systems. In this paper we point out the new issues that User Centered Design needs to take into account when dealing with mobile scenarios; to that respect in section 5 we claim the importance of the usage of a coherent, multi-dimensional framework for usability requirements specification, which can be used as a dynamic design tool during an iterative process. Relying on such a framework we point out in section 6 some usability goals that are typical for mobile scenarios and that need to be assessed in the usability requirements specification.

2 New challenges for Usability in Mobile Scenarios

The emerging mobile scenarios imply new challenges for user centered design approaches mostly due to the mutable settings in which usability analysis takes place. Gathering users’ needs and specifying usability requirements for mobile services need to adequately consider heterogeneous dynamic contexts of use, and ask for an analysis that goes beyond the simple task scenario of desktop environments. This may include different locations, time, goals, and people involved in

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the interaction. Therefore the users’ need is no longer solely a matter of addressing the practical and functional demands related to accomplish a specific task. E.g. a cognitive walkthrough conducted in usability labs may not cover the whole complexity of the mobile contexts. By taking into account the main steps of the iterative design process proposed by (Preece et al., 2002), the emerging issues that usability analysis requires to encounter can be mapped to the activities shown in Figure 1.

![User Centered Design Process](image)

**Figure 1:** User Centered Design Process according to (Preece et al., 2002)

With mobile service scenarios usability analysis encounters specific issues for each activity of this User Centered Design Process.

**Identify Needs/Establishing Requirements:**
- Context of use is highly mutable since users are mobile in time and place, and their goals are variable, thus it is hard to track their cognitive and operative workflows.
- Mobile services usually target very heterogeneous user groups, thus requiring extended understanding of user requirements, which can vary according to the user group.
- Mobile computing scenarios are often based on middle-long term horizons, for which technology is not yet available: users might not know the technological possibilities and it is therefore hard to envision needs for unfamiliar scenarios.

**Design:**
- Task analysis is more complex and holistic and linked to distributed activities, thus conceptual design needs to take into account a more heterogeneous context of use.
- Interfaces can migrate across different communication means, using different modalities, thus requiring an extended multi-platform interface design.
- User's familiarity with other applications influences the mental model and expectations users have for mobile applications (Holtzblatt, 2004).
- Users' mental models are highly affected by cultural and generational differences, and are strongly dependent on users’ acquaintance with the PC environment.
- The social and economic role of mobile communication is leading to more and more discussion about the best way to include the customer in the design process.

**Build an Interactive Version:**
- Prototyping for mobile computing often needs to rely on new technologies and protocols that are not yet mature and grounded, so that many assumptions about performance and reliability need to be done.
- Software and hardware in mobile computing are influencing much more each other’s usability than in the desktop environment, where standards are already available. To
this end the selection of a certain hardware and a certain technology is crucial and affects the prototype evaluation.

Evaluate:

- New aspects, such as outdoor setting, multi-tasking and intermittent activities, multi-user interaction, new business models and communication patterns, affect the whole usage experience and need to be assessed in different times and places;
- The holistic aspect of the experience requires an extended set of dimensions to be assessed, which are often dependent on subjective values.

Achieving a product which satisfies the users’ needs normally requires an iterative approach to software development with continuing feedback from users throughout the process (ISO/IEC 9126-1, 2002). The iterative aspect of the process aims to progressively specify requirements and measurements that allow for quality assessment in the evaluation phase. The present paper focuses on the “Identify needs/Establish Requirements” activity of the process, keeping in mind that its iterative nature implies strong interdependences among the phases: i.e. the issues identified in the other phases influence the usability requirements specification activity addressed in this paper.

3 Usability Requirements Definition

In a user centered design approach, requirements definition is one of the activities that need to take place at the beginning of the project and serves as a framework for evaluation in later phases of the system development process. There is actually a certain confusion in the usability discipline regarding the definition and the use of the terms functional requirements, user requirements, system requirements, usability requirements, usability goals, etc. In practice it is hard to be coherent when addressing factors dealing with the subjectivity of human experiences and definitions. In this sense, for instance, the user’s need for having the possibility of sending an SMS can be considered as functional requirement for the system (i.e. the system must provide the functionality to send an SMS), but also a usability requirement for assessing the criteria of effectiveness and satisfaction (the user can perform the desired task with a certain degree of satisfaction).

The separation of functional requirements and usability requirements is only possible to a limited extent. The main question to be asked for the usability requirements is: assumed the system would support the user by the functions xyz how are these functions to be designed to fulfill the criteria of usability, e.g., in which modality are the interactions provided, which implicit or explicit user input is expected, how much and in which sequence the content and the interaction steps are organized, etc. Both, the functions needed for the accomplishment of the task, and the environment in which the tasks are performed by users, can be described in terms of scenarios. Scenarios describe in realistic pieces of events and realistic episodes of interaction between people and between people and systems how the service can be delivered, tasks can be performed and system features should be working in a certain context. Based on scenarios, requirements specifications describe the functionality of the system and its usage. Usability requirements specification focuses on the usage behavior of the system derived from the analysis of the user tasks and user goals.

How to define a usability requirement then? Let’s say that given a certain context of use, it is important for the user that the system is easy to learn. Learnability is a usability goal, i.e. a measurable design objective for how usable a system needs to be. A meaningfully stated usability goal is one that succeeds in communicating a product team’s intent, with as little ambiguity as possible, to deliver a usable system (WM-data AB & Ericsson Radio Systems AB, 2003). Getting back to the example, the statement “first-time user X should be able to learn in 2 minutes time how to perform task Y” is a usability requirement for the learnability of the user interface. A goal
can have more than one corresponding requirement. For instance, learnability can also be assessed statistically: “At least 90% of a statistically valid sample of users should rate the application as being easy to learn on the following scale: very easy to learn, easy to learn, neutral, difficult to learn, very difficult to learn”.

Specifying usability requirements aims at quantifying the goals that are set for the usability of the system, and describes how the system should be designed to meet those goals. Usability requirements specification therefore describes three levels of understanding: what will be measured (usability goals, e.g. efficiency, learnability), how it will be measured (e.g. user tests, questionnaire) and what level of the measure is required for the goals to be fulfilled (e.g. time to complete task scenario, number of errors in completing the scenario, proportion of users to be able to complete the task successfully). The choice of which measurement to adopt and what tolerance value to set as requirement depends on multiple factors:

- the type of usability goal (whether objectively or subjectively measurable);
- the feature of the system (whether a mobile or desktop device, a personal or a sharable interface);
- the state of development of the system (whether a low or high fidelity prototype, or a ready to use product);
- the resources available for the usability evaluation (whether statistically relevant samples of users could be contacted);
- the physical and social environment of use of the system (whether outdoor, on the move, in an office, in a meeting).

This means that the same usability goals may require different measurement methods and tolerance values according to the specific context; the same goal could be measured differently when the system is used in an office room or at a bus station; different types of users might have different usability requirements; requirements may change their measures and shift in relevance ranking when moving from one situation to another. Usability requirements must be as tangible as possible, so that we are able to verify them and trace them during the development (Lauesen & Younessi, 1998).

4 Different Approaches to Usability Requirements Specification

The ISO 9241-11 (ISO 9241-11, 1998) serves as a guideline with the main considerations one should take while looking at usability, which includes not only requirements specification, but also testing, developing, etc. The referred ISO suggests that goals of use of a product should be described: these may be decomposed into sub-goals, which help identifying the criteria which would satisfy that goal. When specifying or measuring usability, the following information is needed: a description of the intended goals, a description of the components of the context of use including users, tasks, equipment, and environments, and the target or actual values of effectiveness, efficiency, and satisfaction for the intended contexts.

The approach defined by Preece (Preece et al., 2002) proposes the use of the following usability goals in order to classify usability requirements: effective to use, efficient to use, safe to use, have good utility, easy to learn and easy to remember how to use. These goals are respectively related to the characteristics the system should have to allow users to: carry out their tasks efficiently, obtain high level of productivity, prevent from serious errors, execute the tasks in the way they want, be easy to learn and to remember.

Another classical approach to deal with usability requirements is detailed in (Nielsen, 1993) where the author proposes a different, but related approach to classify usability goals, based on the following criteria: learnability, efficiency, memorability, error avoidance, and satisfaction.
Ben Shneiderman in (Shneiderman, 2000) defends the concept of “universal usability”, which involves understanding how users attempt to accomplish tasks using a variety of technologies in different organizational and social contexts. Universal usability will be met when affordable, useful, and usable technology accommodates the vast majority of the global population: this entails addressing challenges of technology variety, user diversity, and gaps in user knowledge in ways only beginning to be acknowledged by educational, corporate, and government agencies. Shneiderman does not focus his ideas on how to deal specifically with requirements, although his approach encompasses usability in a broader term, and can be very relevant in the context of mobile services that target a variety of users groups.

These approaches are valuable and rich to a certain extent, but two points remain open: how should one classify usability requirements since they use various goals names and explanations, and how to classify requirements which do not fit in one of these category or fit in more than one? This decision is very critical for the project and may depend on the context and on the stakeholders’ perspectives, thus potentially raising misunderstanding and lack of coherence.

Given the value of these classical approaches for dealing with usability requirements in general, we argue that they are not comprehensive enough to deal with the complexities of usability of mobile service scenarios in a consistent way. There are two main problems supporting our argumentation: (i) mobile tools raise new challenges for HCI research by making time, location, task and context important issues to be addressed during system development and (ii) the problem of bridging the gap between usability, user and system requirements, remains unsolved when we base our specification according to one of these proposals. As cited in (Ferre, 2003) one of the reasons why usability techniques are not regularly used in software development, despite how critical software usability is for the overall quality of the software product, is the lack of integration with software engineering concepts, terminology and process.

Because of the complexity of mobile contexts and of the issues highlighted in section 2, a more comprehensive framework to elaborate usability objectives is essential for a coherent project development. To this respect we propose and argument the adoption of the (ISO/IEC 9126-1, 2002) as framework for the usability requirements specification within the next section, in order to guarantee external and internal quality of use.

### 5 A Framework for Usability Requirements Specification in Mobile Contexts

In the ISO 9241-11 on “Ergonomic Requirements for Office Work with Visual Display Terminals -Guidance on Usability”, usability is defined as “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.” (ISO 9241-11, 1998).

It should be noted that usability as defined in (ISO 9241-11, 1998) also depends on software qualities which are distinct from usability as defined in (ISO/IEC 9126-1, 2002), such as functionality, reliability and computer efficiency. These software qualities all contribute to quality of the work system in use.

When considering the highly mutable context that are proper of usage of mobile services, the three parameters effectiveness, efficiency and satisfaction identified in the (ISO 9241-11, 1998), might therefore not suit such complex and changeable contexts, as the provided criteria have a too high level of definition granularity.

The context of use specifies the task goal, the functionality the software has to provide, the process of the task accomplishment including breaks, inclusion of other tools, reference to data and media and the split of work between teams and departments (ISO 9241-11, 1998). The spectrum of elements of the context of use makes clear that not only functional but also social and
organizational aspects have to be taken into account when specifying the context of use. Figure 2 illustrates the different dimensions of the context of use and their subcategories according to (Maguire & Bevan, 2002).

<table>
<thead>
<tr>
<th>User group</th>
<th>Tasks</th>
<th>Technical environment</th>
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<tbody>
<tr>
<td>• System skills and experience.</td>
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<td>• Task knowledge.</td>
<td>• Task list.</td>
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<td>• Training.</td>
<td>• Goal.</td>
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<td>• Qualifications.</td>
<td>• Output.</td>
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<td>• Language skills.</td>
<td>• Steps.</td>
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<td>• Age &amp; gender.</td>
<td>• Frequency.</td>
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<tr>
<td>• Physical and cognitive capabilities.</td>
<td>• Importance.</td>
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<td>• Attitudes and motivations.</td>
<td>• Duration.</td>
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<td>Physical environment</td>
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<td>• Auditory environment.</td>
<td>Organisational environment</td>
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<td>• Thermal environment.</td>
<td>• Work practices.</td>
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<td>• Visual environment.</td>
<td>• Assistance.</td>
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<td>• Vibration.</td>
<td>• Interruptions.</td>
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<tr>
<td>• Space and furniture.</td>
<td>• Management &amp; communications structure.</td>
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<td>• User posture.</td>
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<td>• Health hazards.</td>
<td>• Organisational aims.</td>
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<td>• Protective clothing &amp; equipment.</td>
<td>• Industrial relations.</td>
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<td>• Job characteristics.</td>
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**Figure 2:** Context of use factors (Maguire & Bevan, 2002)

As in (Bevan & MacLoed, 1994), “usability is a function of the context in which the product is used [...]. It is a property of the system: it is the quality of use in context”. While investigating the context of use in the usability analysis, we support the idea that it is necessary to point out the criteria, or quality factors, that would mostly affect the user experience with the system in a certain situation. This allows identifying the usability goals of higher relevance for mobile service scenarios that in the development of the project can be measured and assessed as requirements (Figure 3).

**Figure 3:** The terms and definitions taken from ISO /IEC 9216-1:2001 Software engineering - Product Quality – Part 1: Quality Model, figure 4, are reproduced with permission of the International Organization of standardization, ISO. This standard can be obtained from any ISO member and from the Web site of the ISO Central Secretariat at the following address: www.iso.org. Copyright remains with ISO.
6 Usability Goals and Quality Factors in Mobile Contexts

Adopting the (ISO/IEC 9126-1, 2002) as a framework for classifying usability goals and specifying requirements accordingly, responds to the goal of providing a solid and structured reference for the succeeding steps of the design and development processes, and to share a common vision among the project stakeholders, thus allowing for consistency and coherence when approaching the evaluation phases.

When talking about mobility, different dimensions can be identified. With a perspective on the device mobility, (Dix at al., 2000) propose a taxonomy of mobility that takes into account:

- level of mobility of the device: fixed, mobile or autonomous
- relation to other devices: free, embedded, pervasive

In the context of our analysis we look at mobility in a broader sense, encompassing other dimensions: (Roggenkamp, 2004):

- device mobility, the continued access to services with a device while moving;
- user mobility, apart from the mobility without physical constraints, this refers to location and device independent service access;
- service mobility, the capability to provide a certain service irrespective of device and user.

These dimensions concurrently affect the mobile experience as a whole. By relying on a review of related work and literature, and on the authors’ professional experience in the design, usability specification and evaluation of mobile services, the main usability goals to address in mobile service scenarios are here presented. We point out some of the quality factors that mostly influence mobile usability and differentiate it from the static one. It should to be mentioned, though, that the set of usability goals typical of mobile service scenarios here proposed can assume different aspects, according to the specific mobile service: different domains or service goals can imply different factors and ranking of importance.

**Portability**

Portability refers to the capability of the software to be transferred from one environment to another (ISO/IEC 9126-1, 2002). When referring to mobile computing, in particular, portability also suggests portability of the device, thus implying for characteristics of low weight, small screen sizes, but also limited power resources, limited disk capacity, limited input/output facilities. These factors heavily weigh on the usability of mobile services and require rethinking traditional approaches to information access. Scalability becomes a growing concern because of the distribution of mobile computing and networks. Data repositories become richer in content than traditional file systems or databases, thus requiring new information architecture.

**Adaptability**

The shift from an environment to another implies the capability of the system to adapt to changes in context, while at the same time making the interface predictable and consistent. In these varying contexts users perform multitasking activities that require adaptable suitable support. An efficient way of improving the usability of mobile services and applications is to adapt the contents and presentation of the services to the individual users and their current context of use. In this way the amount of user interaction can be minimized and allow for a quick access to the information or service that she needs in the current task of use (Kaasinen, 2003). A major challenge for context-aware systems though is to integrate changes of the context into the user interface that allow for transparency and controllability.

**Availability**
It is a sub-category of Portability and refers to the capability of the system to be in a state to perform a required function at a given point in time, under stated conditions of use (ISO/IEC 9126-1, 2002). The overcome of spatial and temporal limitations gives users an extended reach over their environment: this means that we are more reachable from others and at the same time we can reach more people. Furthermore the way we reach others is no longer mediated only by voice, but the meaning of SMS for instance lies in the possibility of reaching other people wherever and whenever in a new, more personal and unobtrusive way, which does not require necessarily for an immediate reply.

Real-time communication is also more spontaneous and the feeling of closeness is supported even though users are physically separated (Lindholm & Keinonen, 2003).

Learnability
Mobile users don't focus on their device in the same way as when they are sitting in front of their desktop computer. They have less attention and patience and simultaneously perform different cognitive tasks: a demanding and/or stressing environment can distract them. They have less "mental bandwidth" - capacity for absorbing and processing content - than a stationary user in front of a PC (Chincholle & Burden, 2002). While on the move, they tend to use services that allow both quick manipulation of the interface and a reduction in number of steps to access information. They look for pieces of information on the fly, so that they need a navigation structure that is easy to follow, consistent, and intuitive. The primary drivers to a mobile user are time, convenience, and communication: receiving only the information needed in a friendly, personalized manner is the ultimate objective. Therefore the information architecture should strive for a reduced amount of options, only the necessary – instead of quantity, the quality of the presented information is much more important.

Furthermore, to allow equal access to communication across society irrespective of individual differences in technical literacy and capabilities, ease of use and accessibility for disabled users become key issues for new communication tools.

Security
A first banal aspect affecting the security of mobile communication is due to the sizes of the mobile hardware. Portable computers are more vulnerable to loss or damage, both due to their physical features and to the contexts in which they are used. This is an aspect that additionally affects the privacy concern, e.g. what happens when the device in which we saved all our contacts, messages, pictures and other private valuable data is stolen?
Privacy problems occur in almost any interactive networked medium like the Internet or interactive television. But in the wireless medium this problem is even acuter for several reasons (Napchi, 2003):

- It is always on: it is always with the user and connected to the network (see also Availability)
- It is personal: the wireless medium enables each user to be identified by his mobile device, unlike the Internet, which on a desktop computer can generally be accessed by several individuals.
- It is location-aware.

Moreover, the ability of context-aware systems to infer revealing information from loosely related personal data has even more troubling implications for individual privacy. Even a few privacy violations could lead the user to distrust and abandon a context-aware system. To this end transparency and controllability are fundamental (see also Adaptability) (Satyanarayan, 2001).

Reliability
Mobile connectivity is highly variable in performance, thus affecting the reliability of mobile services: inside some buildings, a mobile element may have high-speed wireless LAN connectivity, while in other circumstances, it may only have modem or integrated services and
digital network connectivity. This aspects need to be evident for the user: user’s awareness of connection status can avoid frustrations due to mismatched expectations of service availability and performance.

**Attractiveness**

Mobile access cannot in itself be assumed to be a remarkable benefit for every category of service, because the benefits are perceived only when content is specifically tailored to fulfill needs in mobile usage situations and the added value of the service is sufficiently distinguishable from the one offered by other channels (Lindholm & Keinonen, 2003). The ability to access information on demand at any location confers competitive advantage on individuals in social and economic setting which is per se increasingly mobile.

**Interoperability**

Mobile contexts require for an increasing span of access of data across different systems and networks. This implies that data from shared file systems, relational databases, object-oriented databases, and other repositories must be accessible to programs running on mobile computers (Landay & Kauffmann, 1993). For example, in the circumstance of emergency medical response the responding personnel will need rapid access to the specific patient’s medical records to determine drug sensitivity.

According to (Groot & van Welie, 2002), although the industry likes to talk about “virtual services”, people with their millions of year of history of handling artifacts, will probably view the Mobile Internet as an “ecosystem of connected terminals”, where the interaction with each terminal is dependant on the context of use. Multi-channel services in this ecosystem should also try to take advantage of the specific context of use of each channel in such a way that the different channels reinforce each other.

7 Conclusion and Discussion

The main purpose of the usability requirements specification is to serve as a dynamic and re-definable tool for the succeeding development phases, with two complementary objectives: (i) guarantee that the usability requirements are being considered in the software development, in the conceptual design and in design of the user interfaces activities and (ii) help verify whether the usability goals are achieved during the evaluation.

In this paper we pointed out some aspects that a user centred design process needs to take into account when dealing with usability requirements specification for mobile scenarios. We suggest a holistic approach that looks at the context of use in a broader perspective, than the one of the three traditional usability categories of effectiveness, efficiency and satisfaction. To this respect (Preece et al., 2002) claim how “the emergence of new technologies offering increasing opportunities for supporting people in their everyday lives in a diversity of application areas (e.g. education, entertainment, home, public area) has brought about a much wider set of concerns”: these, identifiable as “experience goals”, such as engagement and motivation, are not so clearly defined and imply for new analysis approaches. The elicitation of requirements on the one hand, and the way in which requirements can be formalized and assessed on the other, are therefore activities that deserve to be looked at with particular concern and are likely to require innovative methods and frameworks. In this sense the involvement of users in the process, for an understanding of new aspects that were traditionally not addressed in the usability analysis, can support the creative design of these emerging mobile scenarios, and promises to offer a better foresight of their future acceptance.

**References**