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Title

CHALLENGES, METHODOLOGIES AND MANAGEMENT ISSUES IN THE USABILITY TESTING OF MOBILE APPLICATIONS

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Abstract:

Usability testing of software applications developed for mobile devices is an emerging research area that faces a variety of challenges due to unique features of mobile devices, limited bandwidth, unreliability of wireless networks, as well as the changing context (environmental factors). Traditional guidelines and methods used in usability testing of desktop applications may not be directly applicable to a mobile environment. Therefore, it is essential to develop and adopt appropriate research methodologies that can evaluate the usability of mobile applications. The contribution of this paper is to propose a generic framework for conducting usability tests for mobile applications through discussing research questions, methodologies, and usability attributes. The paper provides an overview of existing usability studies and discusses major research questions that have been investigated. Then, it proposes a generic framework and provides detailed guidelines on how to conduct such usability studies.

Keywords: Usability testing, mobile applications, mobile devices, evaluation, tools.

Introduction:

With the continuous advances in wireless technology and the widespread use of mobile devices such as cell phones, personal digital assistants (PDAs), palms, and pocket PCs, many innovative mobile applications are emerging, aiming to enhance wireless communication and provide users with ubiquitous access to information (Li & Liao, 2000). Many businesses have deployed mobile applications to gain competitive advantage. Such applications developed specifically for small mobile devices include daily news alert services, classified mobile advertising, restaurant and entertainment listings, wireless Web portals, and mobile commerce (m-commerce) applications (Varshney & Vetter, 2002).

The high demand and fast growth of mobile applications have attracted extensive research interests. Because developing mobile applications with an easy-to-use interface is critical for successful adoption and use of applications, one of the important research issues is regarding how to conduct an appropriate usability test using mobile devices in a wireless environment. Usability testing is an evaluation method used to measure how well users can use a specific

software system. It provides a third-party assessment of the ease with which end users view content or execute an application on a mobile device. An effective usability test has to be able to elicit feedback from users about whether they use an application without (or almost without) difficulty and how they like using the application, as well as evaluate levels of task performance achieved by users (Wichansky, 2000).

There are various guidelines for usability testing of desktop applications. However, those established concepts, methodologies, and approaches commonly used in traditional human-computer interaction research are not always applicable to mobile applications (Jones et al., 1999) due to mobility and the distinct features of mobile devices and wireless networks. Ideally, usability testing of mobile applications should be carefully designed to cover all or most possible situations of a mobile environment (Kim et al., 2002). In reality, however, this poses many challenges. For example, it is difficult to foresee the exact situations of the application use - users may be standing, walking, or sitting in a dark or bright environment while using an application. As a result, a usability test may have to concentrate only on certain aspects of a mobile application and sacrifice others. Furthermore, traditional research methodologies used in usability testing, including controlled laboratory experiments and field studies, have various limitations in a mobile environment, such as ignoring the mobile context or lack of sufficient procedural control. Therefore, it is essential to develop guidelines for usability testing of mobile applications. This paper is aimed to contribute to this important research area. Built upon the literature, it proposes a generic framework for usability testing of mobile applications, discusses several important issues in this field, and provides insights on how to conduct usability studies according to the nature of applications and usability attributes being evaluated.

1. Usability of Mobile Applications

a. Mobile applications

Mobile applications, referred to software systems operating on mobile devices, are evolving rapidly, making ubiquitous information access at any time and anywhere a true reality. For example, many mobile applications have brought Internet services to mobile devices (Kaasinen et al., 2000). In the business area, M-Commerce (Mobile e-Commerce) applications, such as mobile banking and advertising, extend electronic businesses to mobile devices. Customers can

check their bank account balances and carry out business transactions through their cell phones (Varshney & Vetter, 2002; Zhang, 2003).

There have been some usability studies for mobile applications. Some focus on Wireless Application Protocol (WAP) evaluation (Chittaro & Cin, 2002; Kassinen et al., 2000). In the field of mobile education, usability studies are conducted when mobile devices are used for collaborative learning or information access (Danesh et al., 2001; Luchini et al., 2002). In the entertainment industry, mobile users can enjoy watching video or playing interactive games on their mobile devices. Those advanced features of mobile applications enable users to carry out a variety of activities through mobile devices. Because achieving a high level of user satisfaction is critical to the success of mobile applications, usability testing is a mandatory process to ensure that a mobile application is practical, effective, and easy to use, especially from a user's perspective.

b. Challenges in usability testing of mobile applications

The unique features of mobile devices and wireless networks pose a number of significant challenges for examining usability of mobile applications, including mobile context, multimodality, connectivity, small screen size, different display resolutions, limited processing capability and power, and restrictive data entry methods.

- **Mobile context**

It can be defined as "any information that characterizes a situation related to the interaction between users, applications, and the surrounding environment (Dey & Abowd, 2001)." It typically includes the location, identities of nearby people, objects, as well as environmental elements that may distract users' attention. It is very difficult to select a methodology that can include all possibilities of mobile context in a single usability test (Longoria, 2001).

- **Connectivity**

The slow and unreliable wireless network connection with low bandwidth is a common hindrance for mobile applications (Longoria, 2001). This problem largely affects data downloading time and quality of streaming media (e.g., video and audio streams). Strength of signals and data transfer speed in a wireless network may vary at different time and locations,

compounded by user mobility (Sears & Jacko, 2000). Therefore, how to deal with various network conditions must be taken into consideration in a usability study.

- **Small screen size**

Physical constraints of mobile devices, especially small screen size, can significantly affect the usability of mobile applications (Jones et al., 1999; L. Kim & Albers, 2001). Direct presentation of most WWW pages on small mobile devices can be aesthetically unpleasant, un-navigable, and in the worst case, completely illegible (Bickmore, 1997).

- **Different Display Resolutions**

The display capability of mobile devices supports much less display resolution (normally 640*480 pixels or below) in comparison with desktops. Low resolution can degrade the quality of multimedia information displayed on the screen of a mobile device. As a result, different levels of display resolution on different mobile devices may cause different usability test results (Jones et al., 1999).

- **Limited Processing Capability and Power**

Computational power and memory capacity of mobile devices lag far behind desktop computers. Some applications that require a large amount of memory for graphic support or fast processing speed, such as an application of 3D city maps for PDAs (Rakkolainen & Vainio, 2001), may not be practical for mobile devices. Because of limited processing capability of mobile devices, developers may have to disable some functions (e.g., high resolution images and dynamic frame movement).

- **Data Entry Methods**

Providing input to small devices is difficult and requires a certain level of proficiency Longoria, 2001). Small buttons and labels limit users' effectiveness and efficiency in entering data, which may reduce the input speed and increase errors. Results of a usability study can be affected by the use of different data entry methods (e.g., soft versus physical keyboards) (MacKenzie & Zhang, 1999; Soukoreff & MacKenzie, 1995; Zhang, 1998). Different user status (e.g., sitting versus walking; holding a device in hand or putting it on a table) while using a mobile device can further exacerbate the data entry problem.

There are also some other challenges. Today, multimodal mobile applications are emerging. Multimodality combines voice and touch (via a keypad or stylus) as input with relevant spoken output (e.g., users are able to hear synthesized, pre-recorded streaming or live instructions, sounds and music on their mobile devices) and onscreen visual displays in order to enhance the mobile user experience and expand network operator service offerings. Blending multiple access channels provides new avenues of interaction to users, but it poses dramatic challenges to usability testing as well. The above problems caused by physical restrictions of mobile devices and wireless networks imply that while designing and conducting usability studies for mobile applications, these issues must be carefully examined in order to select an appropriate research methodology and minimize the potential effect of contextual factors on perceived usability when they are not the focus of studies.

2. Research methodologies for usability testing of mobile applications

Two major methodologies that have been applied to usability testing of mobile applications are laboratory experiments and field studies. In a laboratory experiment, human participants are required to accomplish specific tasks using a mobile application in a controlled laboratory setting, while a field study allows users to use mobile applications in the real environment. Both methodologies have pros and cons. Therefore, selection of an appropriate methodology for a usability study depends on its objectives and usability attributes.

Laboratory experiments

There are several advantages of performing usability testing of mobile applications through controlled laboratory experiments (e.g., Bautsch-Vtense et al., 2001; Buchanan et al., 2001; Buyukkokten et al., 2002). First, a tester has full control over an experiment. He/She can define particular tasks and procedures that match the goal of a usability study, and ensure that participants follow experimental instructions. For example, if the objective of a study is to investigate the effectiveness of a data entry method while a user is moving around, then a laboratory experiment is more appropriate than a field study, because testers can explicitly require and ensure participants to use a mobile device while moving. Second, it is easy to measure usability attributes and interpret results through controlling other irrelevant variables in a laboratory environment. As a result, the laboratory experiment approach is very helpful to

usability studies that focus on comparing multiple interface designs or data input mechanisms for mobile devices. Third, it makes it possible to use video or audio recording to capture participants' reaction (including emotions) when using an application (Dumas & Redish, 1999).

A major limitation of the laboratory testing method is that it ignores mobile context and unreliable connection of wireless networks. A mobile application tested in a real environment may not work as well as it does in a controlled laboratory setting due to the changing and unpredictable network conditions and other environmental factors. In a lab, participants may not experience the potential adverse effects of those contextual factors.

Field studies

A major advantage of conducting usability tests through field studies is that it takes dynamic mobile context and unreliable wireless networks into consideration, which are difficult to simulate in laboratory experiments. The perceived usability of a mobile application is derived based on participants' experience in a real environment, which is potentially more reliable and realistic compared to laboratory experiments (Kjeldskov & Stage, 2003; Palen & Salzman, 2002a; Sharples, Corlett, & Westmancott, 2002).

However, performing field studies for mobile applications is far from trivial. A major challenge of this methodology lies in the lack of sufficient control over participants in a study. There are three fundamental difficulties reported in the literature (Beck, Christiansen & Kjeldskov, 2003). First, it can be complicated to establish realistic environments that capture the richness of the mobile context. Second, it is not easy to apply established evaluation techniques such as observation and verbal protocol when a test is conducted in a field. Third, because users will physically move around in a dynamically changing environment, it is challenging for data collection and condition control. Therefore, in a field study, testers must define the scope of mobile contexts (e.g., physical body movement such as walking, standing, or sitting, and environment such as home/office, quiet/noisy, bright/dark) and use effective methods to collect data in the field.

3. Tools used in usability testing of mobile applications

Real mobile devices are used in field studies. Usability tests of mobile applications in laboratories can be carried out on either emulators or actual mobile devices. Both approaches have their pros and cons (Longoria, 2001). Using an emulator on a desktop computer enables testers to thoroughly capture user behavior such as the number of button clicks via software tools (Buyukkokten et al., 2002; Chittaro & Cin,2002; Jones et al., 1999). The captured data are generally informative and useful for analyzing user performance and finding faulty designs of applications that frustrate users. However, using emulators omits some important aspects of actual mobile devices and mobile context. For example, it alleviates the problems of long transmission latency caused by limited bandwidth in real wireless networks, inefficient input mechanisms, and the changing wireless environment, potentially leading to untruthful user perception and satisfaction. We argue that emulators are more suitable to be used for improving the interface design of applications such as the layout of menu structures during the development process.

Testing an application on real mobile devices allows testers to collect more realistic information than testing on emulators, because users can test the application in a real environment. In comparison with the emulator testing, however, this approach has difficulty in capturing sufficient details of user behavior while users use a mobile application

Mobile devices themselves, due to their unique, heterogeneous characteristics and physical constraints, may play a much more influential role in usability testing of mobile applications than desktop computers do in usability testing of desktop applications. Therefore, real mobile devices should be used whenever possible. Emulators may only be suitable for examining the usability of some device-related issues (e.g., interface design), while real mobile devices are more appropriate for finding usability problems involving mobile context. For example, a usability study of evaluating menu and link structure design for three different mobile phones (i.e., Nokia 3210, Siemens C35i, and Motorola P7389) was conducted in a laboratory experiment (Zifle, 2002). Emulators of three mobile phones running on a desktop were used. Participants were asked to solve six predefined tasks using three mobile phones within a time period. Usability attributes such as effectiveness (measured by the percentage of tasks solved), efficiency (measured by time used to solve tasks and number of clicks used to reach a destination page), and learnability (measured by the improvement in task performance in the second trial) were used to evaluate the menu and link structure design for each mobile phone. Results indicate that

the basic principle of menu and link structure design for mobile applications is to minimize the number of clicks by users to reach destination pages.

4. Conclusion and Future Research

With the rapid advances of mobile technology and applications, effective usability testing becomes increasingly important for the design, development, and deployment of successful mobile applications. However, due to unique features of mobile devices, limited bandwidth, unreliability of wireless networks, as well as other changing mobile context (e.g., location), traditional guidelines and methods used in usability testing of desktop applications may not be directly applicable to mobile applications. Therefore, it is essential to develop and adopt appropriate research methodologies and tools to evaluate the usability of mobile applications. This paper highlights major research questions and issues in this field, and proposes a generic framework built upon the past literature to guide the selection of research methodologies, usability attributes, mobile tools, and data collection methods for usability testing of mobile applications. The latest advance of mobile technology and increasing wireless network bandwidth makes it a reality for users to gain access to multimedia information (combines several communication media such as text, graphics, video, animation and sound) available on the Internet or other sources from mobile devices. However, the constraints of mobile devices and wireless communication pose a variety of challenges for mobile devices to handle mobile multimedia applications (Smith, Mohan, & Li, 1999). For example, low wireless network bandwidth may cause significant transmission delay, which can affect both user perception and performance while using mobile applications. Although many mobile multimedia applications have used audio or video compression techniques to compress multimedia content in order to reduce the file size and shorten the transmission delay (Brachtl, Slajs, & Slavik, 2001; Smith et al., 1999), such data compression can result in reduced quality of multimedia content presented on mobile devices. So far, most usability studies of mobile applications deal with either traditional database data or textual documents. Few studies have focused on usability testing of multimedia applications. This raises an interesting and even more challenging research question: *how can usability of mobile multimedia applications be evaluated effectively?* Based on previous studies of traditional multimedia applications in wired environments (Garzotto et al., 1993; 1994;

1995; 1998, Peterson, 1998), we suggest that usability testing of mobile multimedia applications should be planned from a QoS (quality of service) perspective. Researchers can adopt evaluation principles for usability of multimedia applications such as discipline, interactivity, quality, usefulness, and aesthetics (Heller et al., 2001).

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