An Empirical Study of the Use Contexts and Usability Problems in Mobile Internet

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Abstract

Mobile Internet, which is a combination of the Internet with mobile devices, has become popular recently. Mobile Internet is primarily different from stationary Internet in that it may be used in various contexts, whereas stationary Internet is mostly used in predetermined environments. However, it is far from clear in what places and situations Mobile Internet has been used frequently and what the impact of the contexts has been on the ease of use.

This paper proposes a framework for studying the use context relevant to Mobile Internet. It then presents the results of an empirical study of the use context and service usability for Mobile Internet by using monitoring methods. The results indicate the use contexts of Mobile Internet are of a concentrated type rather than being widely diverse. Moreover, the different contexts present unique usability problems. The paper concludes by discussing the theoretical and practical implications of the results.

1. Introduction

Mobile Internet, which is defined as the use of the Internet via hand-held devices such as mobile phones or personal digital assistants (PDA), is growing at an astonishing rate worldwide and is expected to surpass the stationary Internet in a few years according to Merrill Lynch report [14]. For example, Ministry of Information and Communication reported that more than ten million people in Korea (25% of the total population in 2000) possess their own mobile Internet phones [15].

Mobile Internet is considered to be significantly different from the stationary Internet in two important aspects [3]. First, Mobile Internet can be used in various contexts, whereas stationary Internet is mostly used in predetermined environments. For example, because of its portability and intimate connectivity, Mobile Internet can be readily used on the road while in one's car. In contrast, the stationary Internet has been used mostly in limited contexts such as in an office or home [1,16]. Therefore, it is important to study the contexts in which people use Mobile Internet and also how

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often people use Mobile Internet in each specific context [6]. However, not much research has been conducted to define the numerous contexts relevant to Mobile Internet or to identify the key contexts in which people use Mobile Internet most frequently. Second, Mobile Internet usually comes with more limited system resources than the stationary Internet [3]. For example, Mobile Internet has much smaller screens, less convenient input devices, and much slower networks. The limited resources tend to make Mobile Internet more difficult to use, and, therefore, it is commonly stated that Mobile Internet will only become successful after these usability problems have been overcome (2000). However, little is known about the major types of usability problems in mobile contexts and about the impact of the user's context on the major usability problems.

This study attempts to identify the key contexts and the impact of each context on Mobile Internet's usability problems. We first propose a comprehensive framework for analyzing mobile contexts and mobile usability problems in the next section. The following section explains monitoring methods that were employed to capture the mobile contexts and usability problems faithfully in our study. The next section presents results from the monitoring study, and then the final section describes the implications and limitations of the study's results.

2. Mobile Contexts and Usability Problems

2.1. Mobile Context

We define *mobile context* as, 'any *personal and environmental* information that may influence the *person* when he/she is using Mobile Internet'. Our definition of context has two characteristics. First, our definition focuses on the contextual information from the user's perspective even though information about contexts can be theoretically limitless [7]. We are primarily interested in the information that may influence user behavior because our study attempts to identify usability problems that people often experience while using Mobile Internet. This definition is consistent with prior studies on contexts, in which contextual information focuses on what is important to the target users, such as user tasks, user action, and the specific situations of the users[7,8]. Second, our definition includes not only personal contexts but also environmental contexts. The personal contexts refer to information about the people who are currently using Mobile Internet [13]. For example, the emotional (joyful or depressed) and physical (moving or standing) states of the users are considered as personal contexts [16]. On the other hand, the environmental contexts describe the outer circumstances of Mobile Internet users [5]. For example, the user's location as well as the number of people in close physical proximity to the user is considered as environmental contexts [2]. Based on the definition of mobile context we propose a structure of contexts of Mobile Internet as shown in Figure 1.

At the top level in Figure 1, we divided contextual information into two categories: personal context and environmental context. The personal context consists of the internal and external context [2]. The internal context refers to intrinsic aspects in the user's minds, that is,

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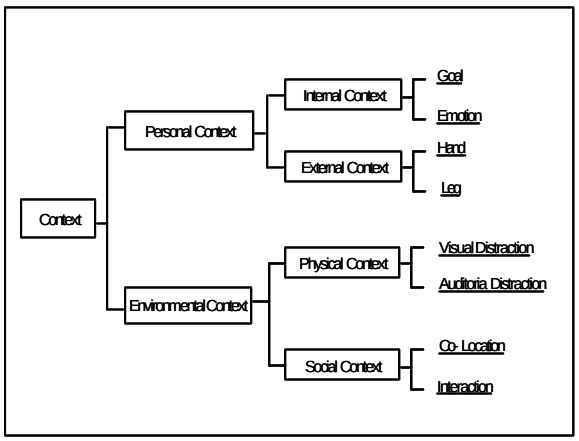

Figure 1.
The Structure of Context of Mobile Internet

why he/she uses Mobile Internet and how he/she is feeling while using it [9]. Therefore, the subcomponents of internal context include the purpose of using Mobile Internet (Goal) and the state of feeling (Emotion). External context is related to the physical body of the user and consist of two subcomponents: Hand and Leg. The Hand indicates the use of the user's hands, such as whether two hands or one hand is used to manipulate keypads of mobile devices [10]. The Leg indicates the movement of the user's legs, such as whether he/she is moving or not moving [11].

The environmental context is composed of both the physical and social environments surrounding the user. The physical context describes how distractive are the circumstances in which the user finds him/herself. Distraction here consists of both visual and auditory elements. The visual distraction indicates how much visual information is presented to the user, whereas the auditory distraction refers to the degree of noise in the environment while he/she is using Mobile Internet [2]. On the other hand, the social context refers to how many people are around the user (Co-location) and how much interaction he/she has with them (Interaction) while using Mobile Internet.

2.2. Mobile Information Architecture

One of the main goals of this study is to investigate the impact of diverse contexts on the usability problems people experience while using Mobile Internet. We expect that different contexts may cause different kinds of usability problems. In order to investigate this hypothesis, we first need a comprehensive framework to classify different usability problems into appropriate categories. In this study, we apply the framework of Information Architecture, which means the overall structure of the Internet systems that are important to the ease of use [12]. The Information Architecture has been known as an effective framework to enrich customers' experiences on the stationary Internet [12]. We extended this conceptual framework into Mobile Information Architecture in order to reflect the characteristics of Mobile Internet.

Mobile Information Architecture consists of four elements: Representation, Structure, Navigation, and Content. First, Representation refers to the visual presentation of information [17]. It consists of several aspects such as how efficiently the information is shown on the LCD panel of mobile devices, how easy it is to read the presented information, and how densely the information is presented to the users. Second, Structure means how well Mobile Internet service is organized. It includes sub-components such as the relevance of menu categorization, the appropriateness of menu labels, and the adequate order of menu sequence. Third, Navigation indicates how efficiently the procedures of

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Mobile Internet service are designed. The subcomponents of Navigation include how easy it is to learn the procedure, how easy it is to move between different sub-services, and how many different ways are provided to move to other than current services. Finally, Content indicates how relevantly the information is provided under particular contexts. Sub-components of Content include how effectively the information is given, how reliable the information is, and how often the information is updated.

In summary, Mobile Internet can be used in various contexts in terms of eight elements of the context structure (Goal, Emotion, Hand, Leg, Visual, Auditory, Co-location, and Interaction), and different contexts may cause different kinds of usability problems that can be classified into four groups based on Mobile Information Architecture (Representation, Structure, Navigation, and Content).

3. An Empirical Study

3.1. Study Procedure

The participants were recruited through an advertisement listed on several web sites, and they were rewarded with monetary compensation for participation. More than 200 people applied for the study, and 40 people were selected initially based on two criteria. First, all the participants were required to have sufficient experience in using Mobile Internet (more than two hundred minutes per month) prior to the study. Second, they were asked if they were able to use the stationary Internet during the entire study period.

Then, we held a training session in which a brand-new mobile Internet phone was distributed to participants. At the training session, we explained the tasks that the participants were required to do in keeping a log of their usage. We also asked for and received a signed consent form from the participants, and with the consent form, we were allowed to access their usage data saved in the gateway servers in the telecommunication companies. Following the training session, we conducted a three-day warm-up session in which three participants who could not follow the instructions were excluded from the study. Consequently, thirty-seven people participated in the study. Their ages ranged from fifteen to forty, and the average age of the participants was 23.1 years. Their gender was nearly evenly distributed, with 57.8% of the participants being female. They also had diverse occupations ranging from student to lawyer to other types of professionals. The composition of the participant pool was well balanced in terms of age, gender, and occupation, and thus matches well with the general characteristics of user population.

The main part of the study was conducted for two weeks in the middle of the year 2000. During this period, participants were encouraged to use Mobile Internet whenever they liked, and their usage fees were reimbursed. In addition to using Mobile Internet, the respondents were asked to complete two more tasks. First, they were asked to carry a pocket diary and fill in the forms whenever they used Mobile Internet. The form was designed to be used as a mnemonic aid and to provide maximum convenience for the participant. For example, the size of the form is similar to that of the mobile phone distributed to each participant, and the number of questions in

the form was limited to the most key topics. Second, the participants were asked to connect to our web site at least once a day, and to input what they had written in the pocket diary into the web diary. The form in the web diary is the same as those in the pocket diary, except that the participants were also asked to write in detail about any usability problems they may have experienced during the specific session on the stationary Internet.

At the end of each day during the main part of the study, independent inspectors examined the web diary of each participant with the server log data in the telecommunication companies. If any inconsistency was observed between the web diary and server log, the inspectors sent a text message to the corresponding participants and requested modification. At the end of the main part of the study, pocket diaries were collected and the contents in the pocket diaries were compared with those in the web diaries and any discrepancies between the two were reconciled by the authors.

3.2. Analysis Procedure

The contents of web diaries were analyzed in two parts: use contexts and usability problems. To investigate the use contexts of Mobile Internet, the participants were asked directly about the eight context components. In terms of Goal, participants were to choose either Utilitarian or Hedonic according to their purpose of use. If they used Mobile Internet for pleasure (such as for killing time), they would select Hedonic. On the other hand, if they had specific goals in their minds, they would select Utilitarian. In terms of Emotion, they were asked to select either High when they felt joyful or Low when they felt depressed. In terms of Hand, they were asked to select either Two if both hands were employed in using Mobile Internet or One if only one hand was used at that time. In terms of Leg, they were asked to select either Move if their legs were moving while using Mobile Internet or Stop otherwise. In terms of Visual distraction, they were to select either High if they observed lots of visual stimuli or Low otherwise. In terms of Auditory distraction, they were asked to select either High if they heard loud noises around them or Low if their surrounding environment was quiet. In terms of Co-location, they were asked to select either Many if they were surrounded by many people, or Few otherwise. In terms of Interaction, they were asked to select High if they communicated with other people or Low otherwise. In summary, each of the eight context factors was coded in a bipolar manner, and this coding produced a total set of 256 unique contexts (2^8).

In terms of coding usability problems, two coders were recruited to classify the written comments of participants into the four groups of Mobile Information Architecture. For example, one of our participants commented, "*I was trying to find the location of Hyundai department store, but strangely enough it was under the wrong menu category of Chatting.*" This comment was coded into the usability problem of Structure because the information was categorized into the wrong group. In order to ensure the inter-coder reliability of encoding usability problems, the Kappa ratio was calculated as 0.79, which is sufficient for conducting further analyses. The discrepancies between the two independent coders were reconciled under the moderation of

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the authors because they fully understood the constructs of the study.

4. Results and Discussions

4.1. General Results

For two weeks, participants used Mobile Internet 61 minutes on average every day. The usage time ranged from the minimum of 7 minutes to the maximum of 132 minutes per day. During the main study period, participants reported a total of 1552 effective sessions through the web diary, excluding 50 sessions due to their incompleteness. The number of sessions varied between the minimum of 23 sessions to the maximum of 132 sessions, and each participant completed 42 sessions of diaries on average. In total 1505 usability problems were reported, which meant 41 problems by each participant on average.

4.2. Use Contexts

The entire set of 1552 sessions was classified according to the 256 different contexts, whose results are shown in Figure 2. The most important fact that we can infer from Figure 2 is that the use of Mobile Internet was highly concentrated in a few key contexts. This is contrary to the general belief that Mobile Internet would be used widely in diverse contexts. Two aspects of Figure 2 support the fact that Mobile Internet is used heavily only in a few key contexts.

First, Figure 2 shows that participants used Mobile Internet the most frequently in two specific contexts. The most frequently experienced context accounts for 222 sessions (14.6%), and the second most frequently experienced contexts accounts for 109 sessions (7.1%) among the entire 1552 sessions. Therefore, the two contexts, which is only 0.4% of the entire 256 contexts, covered more than 20% of the entire sessions. Furthermore, only 14 of the 256 (2.8%) contexts could explain more than 50% of the entire 1552 sessions. The most frequently experienced context was when participants had a Hedonic goal, their emotional state was Joyful, only One hand was used, their legs were not Moving, visual and auditory distractions were Low, Few people were around them, and their interaction was Low. The second most frequently experienced context was the same as the first one except that their Goal was Utilitarian rather than Hedonic. Therefore, people used Mobile Internet most frequently when they felt joyful, when they were in a calm and quiet environment, and when they used one hand. This often describes the context of an office or a bedroom, which is counter to the widely held belief that Mobile Internet would be used often while outdoors and on the move.

Second, Figure 2 indicates that there are many contexts (99 out of 256 contexts, which is 38.7% of the entire set) in which participants never used Mobile Internet during the entire study period.

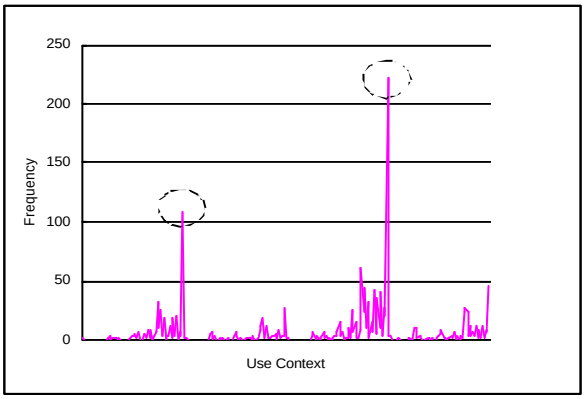

Figure 2.
Frequently Experienced Mobile Contexts

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This means that none of the 1552 sessions occurred in those contexts. Table 1 presents the relative percentage of contexts where Mobile Internet was either used at least once or never used at all else. For each of the eight context factors, a standard t-test was conducted to identify which context factor was significant in determining the use or non-use of Mobile Internet.

As shown in Table 1, context factors such as Goal, Hand, Leg, and Auditory had a significant impact on the usage of Mobile Internet. For example, participants used Mobile Internet at least once in 109 out of 128 contexts (85.9%) while they were not moving. On the other hand, they used Mobile Internet in only 46 out of 128 contexts (36.7%) while they were moving. In fact, the result that participants were more likely to use Mobile Internet when they were not moving is statistically significant. Likewise, participants used Mobile Internet more often when they had hedonic goals (69.5%) rather than utilitarian goals (53.1%), when they used only one hand (76.6%) rather than with both hands (41.1%), and when they were in a noisy (68.8%) rather than a quiet environment (53.9%). These results indicate that not all eight factors are important in terms of determining whether to use or not to use Mobile Internet.

Table 1.
Mobile Internet Case Ratio

Context Factor		Used at Least Once	Never Used
Goal**	Hedonic	69.5%	30.5%
	Utilitarian	53.1%	46.9%
Emotion	Low	60.2%	39.8%
	High	62.5%	37.5%
Hand***	One	76.6%	23.4%
	Two	46.1%	53.9%
Leg***	Stop	85.9%	14.1%
	Moving	36.7%	63.3%
Visual	Low	57.8%	42.2%
	High	64.8%	35.2%
Auditory*	Low	53.9%	46.1%
	High	68.8%	31.2%
Co-location	Low	61.7%	38.3%
	High	60.9%	39.1%
Interaction	Low	68.0%	32.0%
	High	62.5%	37.5%

(*, $p<0.05$; **, $p<0.01$;***, $p<0.001$)

In summary, Mobile Internet has been used heavily in a few key contexts, and these contexts are different from the ones that we predicted before we conducted the study. Four out of the eight context factors were found to have a significant impact on the usage of Mobile Internet.

4.3. Mobile Internet Usability Problems

We adopted the Mobile Information Architecture framework in order to comprehensively study the usability problems endemic to Mobile Internet. For the analysis of usability problems, we selected 38 out of 256 contexts in which the participants used Mobile Internet more than ten times during the main study. We selected these contexts because they represented 75% of the entire data set and in order to minimize the bias from extreme data. We then calculated the average probability of specific usability problem types for each of the eight context factors, and the results are shown in Table 2 below. For example, 18% in the upper left cell (Hedonic-Representation) in Table 2 means that 18% of all the usability problems that occurred when participants used Mobile Internet with a Hedonic goal were Representation problems.

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The results in Table 2 indicate two interesting facts regarding the usability problems of Mobile Internet. First, each of the four different usability problems had a much different probability of occurrence (F =40.44, p<0.001). Usability problems related to the Content of Mobile Internet occurred most frequently (37.2%), followed by those related to Navigation (28.7%), Representation (19.7%), and Structure (14.6%). The highest rate of Content problems indicate that the most serious problem of the current Mobile Internet services is the lack of appropriate contents that take into account key characteristics of Mobile Internet. This might be because of the current trends of deploying contents in the stationary Internet carelessly to the Mobile Internet environment. Navigation problems might also occur relatively more often because the small display and awkward input devices make browsing on Mobile Internet more difficult.

Second, a standard *t*-test was conducted for each of the eight context factors to investigate the impact of context on the occurrence of specific types of usability problems. The results indicate that the usability problems were significantly affected by three context factors: Hand, Leg, and Co-location. In terms of Hand, Structure problems were more likely to occur when participants used Mobile Internet with one hand (7.4%), compared to two hands (16.5%) (t (30)= 2.16, p<0.05). This result may seem to be plausible because scrolling the menu bar or changing pages by pushing small buttons in mobile devices would be difficult with one hand. Therefore, a simple menu categorization and labeling system might be needed for easy control and navigation. In terms of Leg, Representation problems occurred more often when participants were moving (35.1%) rather than stopping (17.4%) (t (35)= 2.63, p<0.05). This result may be because it is more difficult to read or see what was represented on the small display of mobile phone, especially when people were moving. On the other hand, Content problems occurred more often when participants were stopping (39.3%) rather than moving (19.6%) (t (35) =2.47, p<0.05). This might be because most current Mobile Internet services developed focusing on mobility, whereas too few services were available to provide participants with enough value when they are not moving. Finally, in terms of Co-location, the participants experienced Content problems more often when they were alone (43.6%) rather than when many people were around them (30.9%). (t (22)= 3.11, p<0.01). These results indicate that there may not be

Table 2.
Mobile Internet Usage and Problem Ratio

Context Factor		Representation	Structure	Navigation	Content
Goal	Hedonic	18.0%	14.0%	27.0%	40.0%
	Utilitarian	19.0%	16.0%	31.0%	34.0%
Emotion	Low	19.0%	15.0%	26.9%	38.7%
	High	17.9%	14.6%	29.5%	38.0%
Hand	One	17.9%	16.5%*	28.5%	37.3%
	Two	20.4%	7.4 %*	29.6%	42.6%
Leg	Stop	17.4%**	14.8%	28.6%	39.3%*
	Moving	35.1%**	14.9%	30.4%	19.6%*
Visual	Low	16.9%	14.3%	30.0%	38.9%
	High	19.6%	15.1%	28.5%	38.4%
Auditory	Low	19.4%	13.7%	28.6%	38.1%
	High	17.7%	15.4%	28.7%	38.2%
Colocation	Low	16.6%	13.5%	26.5%	43.6%**
	High	20.8%	16.6%	31.7%	30.9%*
Interaction	Low	17.5%	14.3%	30.2%	38.0%
	High	21.5%	16.6%	22.9%	39.0%
Average***		19.7%	14.6%	28.7%	37.2%

(*, p<0.05; **, p<0.01;***, p<0.001)

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sufficient mobile contents, which areadequate to use alone in a remote place.

In summary, people experienced different usability problems more often according to different contexts. They experienced more Structure problems when they used Mobile Internet with one hand, more Representation problems when they were moving, and finally more Content problems when they were standing alone in a remote place.

5. Conclusions

This study focused on the user contexts of Mobile Internet and their impact on usability problems. The results of the study indicate three important findings in terms of mobile context and usability problems. First, people do not use Mobile Internet evenly in every possible context. Instead, their usage is heavily clustered around a few critical contexts, such as when they are not moving with only one hand available. Second, the type of goals that people have in their mind, the availability of hands, the movement of legs, and the level of auditory distraction have a significant impact on the usage of Mobile Internet. Finally, different usability problems are experienced more often according to different use contexts. Especially, availability of hands, movement of legs and the number of people around the user are found to have significant impacts on the kinds of usability problems.

The results of this study have several limitations. First, participants in this study were asked to describe their user contexts in a bipolar method. We used the bipolar measures in order to limit the total set of mobile contexts to a manageable number and to provide the participants with the simplest way to answer context-related questions. However, in order to provide more concrete suggestions to the developers of Mobile Internet services, future studies should be followed to focus on a few context factors with more refined numeric measures and more specific usability problems of Mobile Internet.

The second limitation of this study comes from the characteristics of the study method. Even though we could infer relations between context and usability problems, we cannot explain why certain usability problems occurred more frequently in certain contexts. In order to provide causal explanations, more controlled experimental studies focusing on key usability problems should be conducted in the future.

Finally, the study's results cannot be applied directly to other countries because all participants in the study were recruited from Korea. Moreover, the experience of 37 people over a two-week period may not be enough to collect comprehensive data on Mobile Internet contexts and usability problems, even though we balanced the participants in terms of age, gender and occupations. A future study may be conducted with more people in different cultures for a longer time to verify the external validity of the study's results.

Despite these limitations, the results of this study have several implications both from a theoretical and practical perspective. From the theoretical perspective, this study provides a framework of use contexts and usability problems in Mobile Internet. It also presents a data collection method that can collect reliable data about contexts and usability problems in Mobile Internet. From the practical perspective, the

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study's results indicate that Mobile Internet is used heavily in a few contexts. The result implies that Mobile Internet service providers do not have to take into account all possible contexts, but should focus on the key contexts through developing specialized applications. Moreover, people turn out to experience different usability problems in different contexts. Therefore, Mobile Internet services that are developed specifically for a specific context should pay extra attention to those factors that are closely related to the usability problems experienced by users in that context.

Acknowledgement

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