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User Experience of Mobile internet – Analysis and Recommendations

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ABSTRACT
Mobile access to the Internet with handheld devices has been technically possible for quite a while and consumers are aware of the services but not so ready to use them. A central reason for the low usage is that user experience of the mobile internet is not yet sufficiently good. This paper analyses the mobile internet from the end-user perspective, identifying factors and solutions that would make Internet usage on a mobile device an enjoyable experience. User experience can be improved by a better understanding of users and usage contexts, by developing mobile services that better serve the needs of mobile users, easing service discovery and by developing the infrastructure needed for the mobile internet. This paper discusses all these aspects and gives development recommendations. Multidisciplinary and multicultural cooperation between the various actors in the field is needed to improve user experience.

Keywords
Mobile internet, user experience, mobile services.

INTRODUCTION

Internet access on mobile devices not only changes the way the Internet is used but also some of its characteristics. In addition to enabling personal mobile devices to access existing Internet content, mobilizing the Internet enables totally new kinds of Internet content and services. Mobile internet services can be made topical and personal by utilizing location and other contextual data. Mobile users may play an important role in uploading topical content to web services. We have already seen the first steps in this direction. User experience of the mobile internet is affected by device hardware and software, connection, gateway, services, and the seamless flow between these (Roto, 2006). All of these should work smoothly together to facilitate positive user experiences. There is still a lot to do to improve mobile internet user experience as recent user acceptance studies from different parts of the world show that consumers are aware of mobile internet services but not yet so ready to use them (Chu & Pan, 2008; Lopez-Nicolas et al., 2008; Lu et al., 2008).

A major change in Internet usage is predicted for developing countries, where mobile phones may provide the primary way to access the Internet (Ipsos Insight, 2006). The entire Internet infrastructure will be different there, and the infrastructure should be built to provide the best possible user experience with the given resources. Internet access may affect the development of the whole society.

This paper is based on two Mobile Internet User Experience (MIUX) workshops held in conjunction with Mobile HCI 2007 and 2008 conferences (Roto & Kaasinen, 2007; 2008). The international workshops

gathered viewpoints and experiences from different cultures and stakeholders. Together with the participants we identified four aspects where mobile internet user experience can be improved: 1) understanding the users and usages of the mobile internet better; 2) improving services and service discovery; 3) improving device hardware and software, and 4) improving infrastructures such as connectivity, network proxies, pricing policies, guidelines and standards.

This paper analyzes issues that affect user experience of the mobile internet. First, in the next section we define what is meant by user experience. Then we discuss who are potential mobile internet users, why they are potential users and where the usage may take place. Next we discuss individual mobile internet services and suggest services that would be valued by mobile users. The following section discusses how people can be helped in discovering relevant services. Finally, infrastructure-level enablers for successful user experience are discussed in the last section.

USER EXPERIENCE

User experience is a term that describes a user's feelings towards a specific technology, system, or object during and after interacting with it. Various aspects influence the feelings, such as the user's expectations, the conditions in which the interaction takes place, and the system's ability to serve the user's current needs.

Taking the mobile internet into use proceeds via the intention to use to the actual adoption. The Technology Acceptance Model for Mobile Services, TAMM (Kaasinen, 2005), states that the perceived value, perceived ease of use, and trust towards the mobile internet all trigger the intention to use. If the adoption phase is also seen as being easy, people will start using the mobile internet (Figure 1).

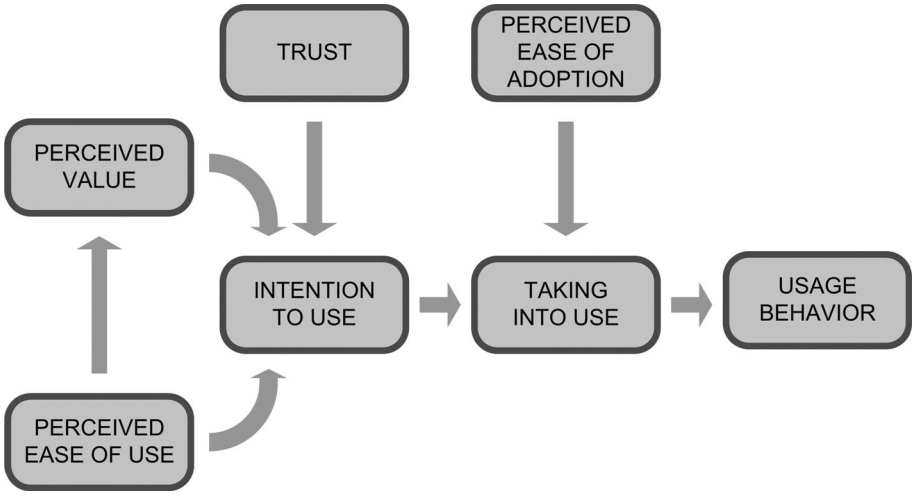

Figure 1. Technology Acceptance Model for Mobile Services, TAMM (Kaasinen, 2005).

By the time the user starts to use the mobile internet, s/he has certain expectations of it. If the expectations are low, user experience may be good even if the system is not perfect. People also evaluate the value they experienced with the mobile internet, and that may overcome the possible difficulties and thereby make the user experience positive. So, although the mobile internet system might not be perfect yet, it does not mean that the user experience has to be poor.

There are many elements that affect the user experience, and the user experience is often determined by the weakest link among these. According to Hassenzahl and Tractinsky (2006), the three main elements are the user's internal state, the context of use, and the actual mobile internet system. The system, in turn, consists of four main components in the case of the mobile Internet: the device, the software needed to use the Internet on the device, the network to transfer the packages, and finally the services available through the Internet (Figure 2). All these system components may come from different parties, making it challenging to provide a seamless user experience.

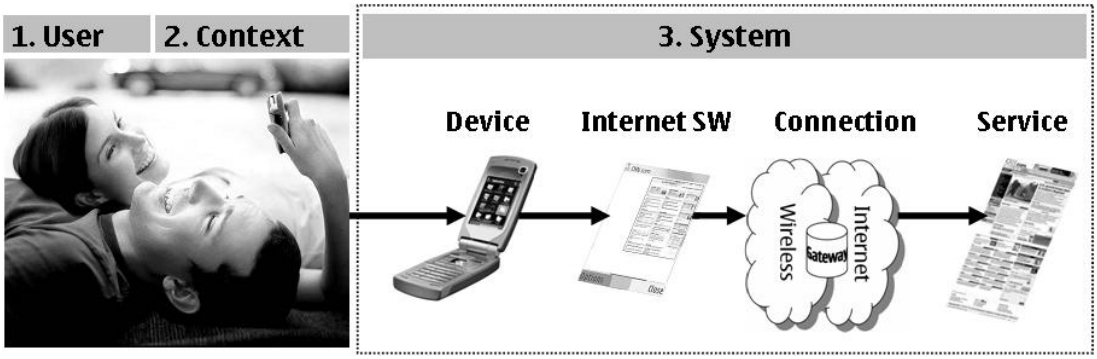

Figure 2. Elements affecting user experience of the mobile internet (adapted from Roto, 2006).

The user's internal state affects user experience, as each user has a specific need, motivation, and expectation for the Internet on a mobile device. Even the current mood of the user may affect user experience. The situation where mobile internet use takes place is more influential than with PC Internet use, which typically happens in a stationary context. In the case of the mobile internet, we should understand the physical, social and temporal context, and how the mobile internet use relates to the overall goal that the user wants to achieve.

Closest to the user is the mobile device with many aspects affecting user experience: display size, keyboard, memory space, processing power, user interface style, and the general attractiveness of the device. The Internet software on the device may either be preinstalled on the device or the user can install it afterwards, in the same way that (s)he can install web browsers on PCs. The browser, feed reader, e-mail client, and any Internet software on the device have different levels of usability, content support, and functionality, which influence user experience. In addition, in order to connect the various devices, and to the various services, an infrastructure of connections and gateways is needed (Roto, 2006).

At the other end of the mobile internet system, there are Internet services that the user wants to access with the device. The value and usability of the service in the mobile context affect user experience, but less obvious aspects of user experience are trust and the way in which the service provider can serve the user outside the Internet, e.g. informing about available services and easing access to them.

WHY, WHERE AND HOW PEOPLE USE THE MOBILE INTERNET

Understanding current users and usages of the mobile internet is crucial for improving user experience for the future. In the following we will give an overview of current knowledge about the market, the users and usage contexts.

Mobile internet Market Development

The mobile internet has undergone huge developments in the early years of this millennium, and the improvements in technology have led to better user experience and higher market penetration. Whereas in

2001 less than 1% of Western Europeans used the mobile internet at least once a month, by 2008 the user base had grown to 28%, and is estimated to reach 40% by 2011 (Strategy Analytics, 2008). The highest mobile Internet penetration is in Japan, where more than 75% of the population use a web browser on their mobile device at least once a month (Strategy Analytics, 2008). According to Comscore (2007a), in January 2007 5.7 million people used a mobile device to access the web in the UK alone, compared with the 30 million UK people who accessed the Internet from a PC. It is noteworthy that people under 35 accounted for 67% of the overall users. Gender is also an influencing factor, as 63% of mobile internet users in the UK are male, compared with 54% of PC Internet users (Comscore, 2007a). Mobile internet usage answers a variety of user needs and usage situations. Internet sites accessed via mobile terminals are most often related to news (both "serious" and gossip-type news), real-time messaging, searching, gaming, blogs and weather information (Comscore 2007a; 2007b).

A study by Comscore (2007b) in Japan reveals that despite the significant usage numbers, only 12.6% of the respondents stated that they were very satisfied or satisfied with accessing the Internet over a mobile device. This poses immense design challenges for the developers of both mobile terminals and mobile internet sites.

User acceptance of the mobile internet

Kuo and Yen (2008) have studied user acceptance of the mobile internet in Taiwan. Their studies showed that users with high personal innovativeness (willingness to adopt new technologies) perceived higher ease of use of the services than other users. Their results show that the most important factor in increasing consumer behavioral intention to use 3G mobile value-added services was attitude, followed by perceived ease of use, perceived costs and perceived usefulness. Perceived usefulness had the strongest effect on attitude. Lopez-Nicolas et al. (2008) have studied user acceptance of mobile services in the Netherlands. They also found that innovative people have a more positive perception of usefulness and are more likely to start using advanced services. Their results show that social factors exert an important influence on people's decision to adopt advanced mobile services. The opinions of friends and relatives had a significant impact, and perceived benefits were related to flexibility and status.

Koivumäki et al. (2008) found that the duration of service usage did not affect consumer perceptions of mobile services but familiarity with the device and user skills had an impact on the perceptions of the services. The tolerance of service imperfections decreased with device familiarity, i.e. people who were familiar with mobile devices were more demanding of the services. Koivumäki et al. (2008) emphasize the importance of enhancing the technology skills of the general public and potential mobile service users. They claim that skills can be enhanced by tutoring workshops, easily accessible user aids and providing hands-on user guidance in situations where new mobile phones are purchased.

Lee et al. (2007) indicate four factors in the relationship between the user's cultural profiles and post-adoption beliefs about the mobile internet. They concluded that uncertainty avoidance, individualism, contextuality, and time perception have a significant influence on the user's perceptions of mobile internet services and that the cultural characteristics of users have a strong effect on how services are adopted and used later on.

Fang et al. (2006) present a study of task technology fit by classifying the effects of task type on wireless technology acceptance. They argue that in the mobile context, when a user is performing general tasks, perceived usefulness and perceived ease of use are emphasized, but when s(he) is playing games, perceived playfulness is important. Furthermore, when the task is transactional, perceived usefulness and perceived security are emphasized.

The mobile internet is increasingly being used also in work-related services. The users may be of very varying ages, educational levels and technology-adaptation readiness. Their usage motivation may not

always be strong, as it is often for the company's benefit – and not necessarily that of the individual worker – that the mobile service is taken into efficient usage (Väänänen-Vainio-Mattila et al., 2007).

Contexts of use

Mobile internet usage takes place in different places and even while on the move. The context of use influences both the user's intrinsic state and the way the system may work and can be interacted with. The design for different contexts of use should take into account not only the physical context (lighting, temperature, unstable usage positions, noise levels, etc.) and environmental factors (moving surroundings, network coverage, technology compatibility, etc.) but also the social context, i.e. people around the user and other, wirelessly connected people (Väänänen-Vainio-Mattila & Ruuska, 2000).

The context of use includes also temporal and activity-related dimensions (Maehr, 2007). The temporal context denotes how important time is for the user at that moment. The user may be highly stressed as the goal of going online is to find time-critical information such as the fastest connection to some place. In contrast, in some other situations the mobile internet may provide entertainment to kill time. In terms of activity, the browsing may take place as a secondary task when the user's main attention is on some other primary task, e.g. walking downtown.

The context of use may change rapidly in mobile use, even in the middle of a usage session (Kaasinen, 2009). Short attention spans are typical in mobile use (Roto, 2006, p. 55), requiring good glanceability of the contents. Especially in work environments mobile internet usage is often embedded in the context of a counterproductive superordinate chain of tasks. These tasks may interrupt the browsing session and force the user to continue it at a later time. Such incidents may be incoming calls, unexpected traffic situations or the lack of pen and paper to jot down the discovered information.

In everyday life users typically adapt themselves to widely changing usage contexts. Suri's book "Thoughtless Acts" (2005) presents a range of examples such as holding a finger in the other ear while phoning, moving to the shade to read the phone display or moving to the sides of a room to talk on the phone. The mobile internet should support this kind of adaptation to the context.

Usage Patterns

For some users, the mobile internet is their first and only Internet experience as they may have never accessed the Internet from a desktop computer. Other users may by default use desktop internet but have to rely on the mobile internet as an additional means of access when a desktop computer is not available. While in the first usage pattern the mobile internet user experience is the standard experience, the second usage pattern introduces comparison and specific characteristics of mobile usage. This prior expectation creates a need for a positive user experience with the major advantage of mobile access coming from the mobility and flexibility of the handheld device; the user can access the full Internet anywhere at any time (Maehr, 2007).

Hinman et al. (2008) studied mobile internet usage with eight test users who were obliged to use only the mobile internet for four days. They found that during the trial the test users were accessing only familiar sites. With the mobile internet a high investment of time often returned a low value of accessed content. High investment of time was related to difficulty in inputting text and bandwidth constraints. Content had a high mobile value when it addressed a special need or when information was time- or context-sensitive.

In terms of usage scenarios, two scenarios are specifically of interest (Maehr, 2007, p. 31): The first scenario is the query for information where the user looks for a specific piece of information *right now*. Often only a few information channels are available and the time pressure is high. In this scenario the user's motivation and satisfaction of success will be high but it also carries high stakes as the cost of failure is high, temptation to take any easier route is big and contextual factors are likely to be

adversarial. The second scenario is the *killing-time* scenario where the user looks for entertainment or tries to complete tasks (e.g. answer an e-mail) because time is available. In this scenario the motivation for use is low and the user is likely to change to other entertainment sources or activities if problems are encountered. These two usage modes are also reported elsewhere, e.g. in Hassenzahl (2003).

Cultural Issues and Developing Countries

In developing countries the mobile phone may be the first wave of the information society. Unlike the developed world, which has experienced a rich, high bandwidth Internet with a desktop, large parts of the developing world are experiencing the Internet for the first time on a mobile phone.

Culture plays an important role in how the mobile internet-based services are used. For example, the perception of trust is different in developed nations than in developing ones. Furthermore, in developed economies, transactions tend to be performed in a more predictable manner by both involved parties. There is often also access to better redress, such as an efficient judiciary, efficient arbitration and reliable enforcement of redress decisions in the case of failed transactions (Bajaj & Leonard, 2004). This is not the same in developing countries. Such factors will decide the acceptance and/or failure rates of mobile services especially those involving some form of financial transaction.

Adoption and use of the mobile internet is highly dependent on the language and the literacy level in developing countries. Studies carried out in India show that the majority of the mobile phones are available in English only; however, most of the people know only basic English. Also, it was found that there was a clear dependence on younger people for any help regarding the operation and use of mobile phones (Joshi, 2006).

In developing countries, the need for and consumption of mobile internet (or Internet-like) services also depend on the economic status of the user population. For example, small farmers worldwide have traditionally been at the mercy of middlemen and have been victims of their own lack of timely information. A private firm, Kenya Agricultural Commodities Exchange (KACE), has contracted with the African mobile provider Safaricom Limited to sell timely market information and intelligence via SMS. Although farmers who can pay for SMS services are not among the poorest of the poor, many of them aren't very much richer (Rheingold, 2005).

Lu et al. (2008) have studied the adoption of the mobile internet in China. They point out that a strong current trend in China is internet data services delivered via mobile phones because the wireless telecommunication infrastructure is more completely developed than its fixed-line counterpart and mobile phones are more affordable.

The design of mobile internet-based services should be sensitive to the social, economic and cultural situations of the users. The design should address issues such as what is the ‘perceived reliability’ and trust in services among the target users, how much does the service cost, and are the services available in the local language or in basic English.

MOBILE SERVICES

Each service provider can improve the user experience of his/her service by considering mobile users when designing the main site or by implementing a separate version of the site for mobile users. In the following we will analyze the motivations for implementing unique mobile services and give recommendations of future service possibilities based on mobile values.

Mobile Version of Existing Service vs. Unique Mobile Service

An important decision regarding the implementation of individual services is whether to provide mobile users access to the existing web service or whether to provide a separate mobile service. Services specifically designed for mobile use can take into account the limitations of the mobile devices and

networks. The services can even utilize special facilities of the mobile device and contextual information such as location or tag-based information in the environment. With ordinary web content mobile user experience is not always good. The layout of the site may be too complex to be easily navigated, the site may be slow and it may include elements that do not work on the mobile device. Sites specifically designed for mobile devices can offer content that is easier and quicker to access but maintaining it may not be affordable for the service provider unless mobile usage is a significant part of the usage. Figure 3. illustrates the difference between accessing the main web site and accessing a site specially designed for mobile use.

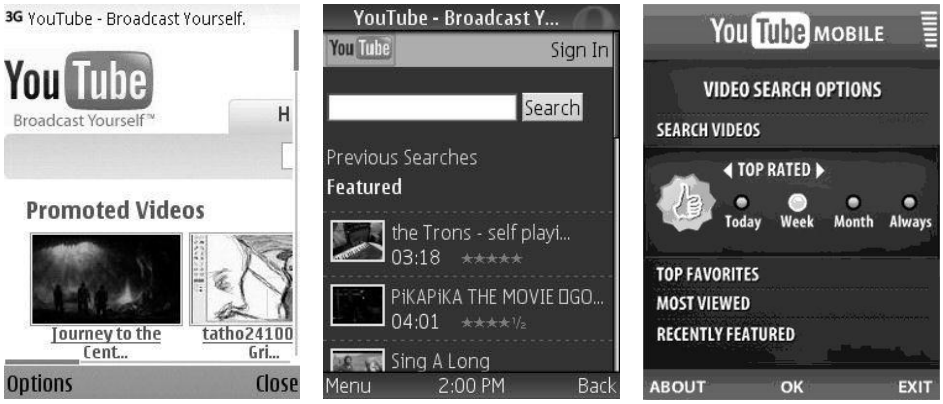

Figure 3. Left: Mobile access to YouTube web service, Middle: mobile version of YouTube service and Right: The same service as an experimental Internet-connected application (Zuverink, 2008. Used with permission).

In his recent Alertbox article, Jakob Nielsen (2009) proposes that for the best user performance, you should design different websites for each mobile device class — regular cellphones, smartphones and full screen phones (iPhone). The smaller the screen, the fewer features, and a more scaled-back design is needed. Nielsen proposes as the very best option to go beyond browsing and offer a specialized downloadable mobile application for the most devoted users. In practice, however, he admits that only the biggest and richest sites can afford all this extra work on top of their desktop-optimized website.

Recommendations for future services

Mobile Web Best Practices by W3C (2008a) defines key guidelines to follow to provide an appropriate user experience on mobile devices. Mobile Web Application Best Practices by W3C (2009) extend the guidance to taking advantage of the capabilities of each device. These two guidelines provide practical guidance with which to design mobile internet services, taking into account the restrictions of mobile devices and the fact that user goals for mobile use are different than those for desktop browsing (Daoust & Hazaël-Massieux, 2008). Key issues include relying on standards, taking into account device limitations, optimizing navigation, checking graphics and colors, keeping it small, using the network sparingly, helping and guiding user input as well as giving consideration to users on the go (Daoust & Hazaël-Massieux, 2008). Hinman et al. (2008) suggest designing mobile services for "skimming the surface". They point out that valuable mobile experiences are not immersive but mobile services have to be designed with interruptions in mind. Trust becomes increasingly important as mobile services get and more embedded in people's personal lives (Kaasinen, 2009). The most important issue, however, is provide value to the mobile user. The following subsections highlight some promising service

based on mobile values.

From Mostly to Always Online

The change from mostly online to always online may be the biggest effect of the mobile internet. Having a portable device that is continuously connected to the Internet enables continuous activities that may even span across different devices. This means that users may for instance start an activity such as reading e-mails or news feeds on their mobile phones on the way from work to then continue reading and answering them on their TV or desktop. In this way the mobile service extends the usage of the original service.

The always-on nature of mobile devices makes them an ideal choice for brief activities where long start-up and shutdown time is an overhead. Such activities can be checking to-do list items (i.e. grocery lists), looking up addresses and reading news and sports results. In the business world, the mobile internet can provide fieldworkers with direct form input functionality. This facilitates reporting in-place with customers and the problem at hand, thus improving quality and productivity of work.

Context awareness

Context awareness in mobile services has been studied a lot but actual implementations are still rare. Time and location data are relatively easily available for context-aware services, but the other relevant elements of context are more difficult to detect. Location-based services are promising in providing the user with situationally relevant and topical data (Kaasinen, 2009). Applications based on the mobility and location of the user can provide new functionalities such as pedestrian navigation systems, transport coordination or local service guides. Context recognition does not to need to be fully automatic. For example, in tag-based context recognition the user him/herself updates context information by touching contextually relevant objects in the environment (Kaasinen et al., 2006). The user may also update context data based on his/her current mode (Kaasinen, 2009). The location of the mobile device can be utilized in sampling of real-time data for better traffic reports, travel plans and other self-learning systems. Such systems would lead towards Kindbergh and Barton's (2000) Real-World Wide Web vision. Add-on services connected to a certain mobile TV programme also represent an approach to context-aware services. These services can provide the user with situationally relevant service that enhances the viewing experience (Kaasinen et al., 2008).

Internet-connected applications and widgets

Access to the Internet can be embedded in mobile applications. Mobile applications can offer graphically rich, branded, and highly interactive experiences (Zuverink, 2008). As a browser is not needed, the usability of the application can be developed without browser constraints. As the main application is stored locally on the phone, the user gets access to the application immediately, even if (s)he needs to wait for the actual content from the Internet (Zuverink, 2008). Mobile applications with embedded Internet connections can utilize phone features, e.g. a finder service can give the user information about the caller of a missed call and a navigation service can utilize GPS data and search maps and other topical information from the Internet. Figure 3 illustrates how the same service (YouTube) looks when accessing the main site, the site designed for mobile use and as an experimental Internet-connected application.

Access to the mobile internet may also take place via specialized widgets. These small mobile applications with embedded internet access can provide quick access to timely information chunks, e.g. weather or traffic information, whereas the browser allows access to in-depth information. Glanceability of the interface facilitates utilizing the widget even when the usage session is very short. If the user needs further information, the widget can allow seamless transition to the browser (Mihalic, 2008).

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From General to Personal

People would like to have and would benefit from personalized content but many studies have revealed that personalization is a major effort even in a desktop environment. In mobile contexts and with mobile devices that include many limitations regarding usability, the obstacles to personalization are even greater. Also, as typically mobile services are used only occasionally, the motivation for personalizing individual services is not very high (Kaasinen, 2009). The mobile context introduces the possibility and challenge of context-awareness: the user should be provided not only with personally relevant content but with both personally and contextually relevant content. Personalizing each individual service for different contexts of use may be overwhelming for the user. It would be beneficial to be able to use the same user profile with different services. On the other hand, location awareness as such makes access to services easier and makes the mobile internet feel more personal (Kaasinen, 2009).

User-generated content is increasing and it is making the mobile internet more personal. Internet and mobile communities such as Jaiku (www.jaiku.com), Facebook (www.facebook.com) and Myspace (www.myspace.com) are modern ways to communicate with close friends and others globally. Mobility is important in these as they are based on continuous connectivity to friends. Blogs and mash-ups provide new channels with which to share and express content by combining data from multiple sources into a single integrated service. These services can rely on low-effort user input (e.g. taking pictures, entering brief messages, etc.) while providing connectivity and quick entertainment. This makes them highly interesting for mobile use. This GEMS (get, enjoy, maintain, share) life cycle (Lehikoinen et al., 2007) enabled by cheap omnipresent connectivity can be the next step towards a sharing lifestyle spanning geographical distances.

From Expensive to Cheap Internet

While mobile internet data transfer is typically far more expensive than traditional Internet access, the prices for the mobile internet are dropping. This will broaden the market reach of the mobile internet and also enable other devices to cheaply connect to the Internet using the mobile phone as a hub. Just as it is possible to directly download music on the mobile phone and then sync it back to a computer, the mobile internet brings devices closer to the Internet's vast information repository. Especially for emerging markets where desktop computers are expensive, this enables cheap bi-directional communication such as e-mail, mobile blogging, electronic voting, bank access or information sharing (Maunder et al., 2007).

From Semi-private to Private Internet

The mobile phone is for many - in contrast to the *semi-private* desktop computer - a genuinely *private* device (McGuire, 2007). It is private and is usually treated like one of the most personal items. This enables a mobile phone not only to be a personal hub that collects data (pictures, activity organizer, health records, etc.) but also to function as a key, identification token or digital wallet for booking and payment.

Novel Interaction Possibilities

Although the mobile user interface is often a constraint to service design, the development of multimodal mobile user interaction technologies may facilitate novel interaction paradigms and even new activities. The Nintendo DS gaming system (www.nintendo.com/systemsds) gives a peek into future interaction possibilities taking advantage of touch screens, accelerometers, GPS receivers and specialized sensors. These sensors can be utilized in novel types of web applications where besides positioning, sensors can be used to track, analyze and support user habits and activities. Such self-learning systems could also provide quite accurate cues about the usage context.

Work-Related Services

In addition to the consumer segment, a remarkable but perhaps an undervalued user group is the segment of work- or business-related mobile service users. Mobile services designed specifically for certain work practices may increase both productivity and satisfaction of employees, as well as advance the functioning of entire business networks. Thus work-related services should be seen as an essential part of the development of the mobile internet. The development of mobile internet services has introduced great potential for benefiting businesses in different fields (Alahuhta et al., 2005). For example, health care, the construction business, and logistics are fields where mobility is a crucial part of the work. Work-related services can support both white-collar (office) and blue-collar work, e.g. on construction sites, forestry and passenger transport.

In work-related situations, loss of data, mistakes in input of business information and general difficulties in interaction with the service may occur. These issues can cause intense frustration in mobile service usage for the individuals and economic losses for the user's company. Thus, context-sensitive design is required throughout the mobile business value chain to support mobile internet service development (Väänänen-Vainio-Mattila et al., 2007).

SERVICE DISCOVERY

Easy service discovery is an important part of mobile internet user experience as the value of the mobile internet is in the wide selection of services rather than in any individual service (Kaasinen, 2009). A major obstacle in adopting commercial mobile services has been user unawareness of available services, as well as problems anticipated in taking services into use. Furthermore, as usage needs are typically quite occasional, people often do not have enough motivation to find out about these issues (Kaasinen, 2009). Increasing public awareness of available services as suggested by International Usability Partners (IUP, 2008) is important but technical solutions can also ease service discovery.

The following subsections suggest solutions to ease discovering mobile internet services.

Predictable Content

When accessing Internet content users would benefit from differentiating between mobile-optimized and ordinary sites. .mobi is a domain name that indicates mobile sites that are designed for small mobile devices. These domain names have been available since September 2006. In search results or as a link a .mobi link name directly indicates to the user that the site is mobile friendly. Mobile search engines may also look especially for .mobi sites. Moreover, popular sites can have mobile versions that the users can easily find just by changing the domain name (Haumont & Siren, 2007).

W3C (World Wide Web Consortium) has developed the "mobileOK" trust mark. mobileOK conformance tests (W3C, 2008b) provide the basis for making a claim of W3C® mobileOK™ Basic conformance and are based on W3C Mobile Web Best Practices. Passing these tests indicates that providers of the service have taken some steps to provide a functional user experience for users of basic mobile devices. Work on the mobileOK trust mark includes provision of machine-readable and human-readable forms of the mark, as well as discoverability of the mark (Hoschka & Smith, 2007). There are already some implementations of automatic mobileOK checkers (Daoust & Hazaël-Massieux, 2008). Once a service is mobileOK, it can be further developed by improving user experience on specific classes of devices ((Daoust & Hazaël-Massieux, 2008).

Service portals

One approach, familiar from the early days of the mobile internet, is to make mobile portals that provide only content targeted at mobile devices. These portals provided, e.g., by mobile operators still have an important role in the mobile internet. Operator portals, local portals and generic portals that include

thematically organized selections of services typically needed in mobile use help users to acquaint themselves with available services. Links to or offline versions of the portals can even be preinstalled on the device to ease getting started with the mobile internet.

Mobile users may benefit from personalized context-aware portals that provide easy access to services that the individual user would need or typically uses in that context. As configuration is a major effort for the user, it is often made available on the desktop. Some mobile operators provide desktop tools that facilitate updating bookmarks on the mobile. The desktop service gives a simple snapshot of titles available for the mobile user to choose. The user can then save the ones (s)he wants to get onto his/her mobile. The configuration is automatically synchronized on the phone.

It has to be kept in mind that portals are only starting points and the users should have ways to access other sites as well. Walled gardens, i.e. portals that do not allow users access other websites, are very likely to frustrate users in the long run. Since user experience with walled gardens is poor, most walled-garden portals have already torn down the walls and let users access any web sites.

Sharing information of services

In addition to commercial information of services, word of mouth is also important in informing users about new services. The success of the Japanese i-mode was partially based on users sharing web links via e-mail and personal home pages (Funk, 2004). In the field study by Arter at al. (2007), users appreciated incidental, location-based information that they got in the form of local queries made by other users. Providing users with technical enablers to copy applications from each other would also be beneficial (Roto & Kaasinen, 2008).

Local services

In mobile use, the need for local services is emphasized, for instance when visiting a strange city. In an unfamiliar environment mobile users need guidance services but find it difficult to get information on what is available, and what it costs to use those services. Tag technology provides interesting tools to ease taking local services into use by touching or pointing tags embedded in environmental objects (Kaasinen et al., 2006). Besides exploration ("what potentially interesting services are in my vicinity"), technologies such as Bluetooth messaging can be used to deliver content and services and enable proximity services (Jones, 2007).

Search services

Search has emerged as a key enabling technology to facilitate access to information for general Internet users (White & Drucker, 2007). In the mobile world, search can also be expected to become the main means for users to discover sites and content (Escofet, 2007). Based on a large-scale study of wireless search behavior, Kamvar and Baluja (2006) approximate that inputting a search query with a mobile phone takes approximately 60 seconds. In their studies of mobile internet use, direct links were preferred to search. Internet search providers such as Google, Yahoo or MSN already propose solutions suitable for mobile use, giving the user the possibility to search for mobile-optimized sites such as .mobi domains. Even if these search services facilitate searching only mobile websites, going through the list of results may be overwhelming in mobile use.

Church et al. (2008) have carried out an extensive study of mobile internet search requests with searches by 260 000 individual European users. Their results point out that only 8-10% of mobile internet users use regularly search services. Queries are short and users tend to focus on the first few search results. The vast majority of searches (over 90%) failed to attract result selections from the searcher. This is a strong indicator that people failed to find relevant information from the search results.

There is a clear need to improve mobile search services and there are actually quite a few research activities that aim to develop search technologies. Heimonen and Käki (2007) propose automatic categorization of search results to facilitate going through the results. Startups such as *kannuu* already offer search solutions that actively predict and match the most likely search selections, letting users quickly create search phrases (Communications Direct, 2007). Search can also be augmented by new techniques such as proactive notification based on needs and location (Jones, 2007). Kamvar and Baluja (2007) propose using contextual signals such as application in use, location and time to complete queries in mobile use. A local search that utilizes location data is useful in searching points of interest in a certain district or its environs. Simon and Fröhlich (2007) propose a framework for spatial selection of content based on the user's field of view.

MOBILE INTERNET DEVICES AND INFRASTRUCTURES

To give the user access to mobile services requires a mobile handset with a browser and a mobile network. The number of choices available of any one of these brings in the challenge of numerous different combinations of devices, browsers and networks. The infrastructure may also include proxies that adapt contents to different browsers and devices. Also pricing policies can be seen as part of this infrastructure. These elements of the mobile internet infrastructure and their influence on user experience are discussed below.

Mobile Devices

When Swisscom Mobile asked mobile users how important different phone features were for them when buying a new mobile phone on a scale from 1 (not at all important) to 10 (very important), 77% of users rated mobile internet access between 1 and 5, with a total average of 3.5 (for comparison: camera scored 5.5) (Swisscom, 2007). When purchasing a mobile device, consumers consider external attributes such as price, size, robustness or design of a mobile handset rather than Internet access. In some developing countries, the situation may be different. In South Africa, for example, the ability to go online was the second most important feature after camera when buying a mobile phone (Kreutzer, 2008)

Mobility is a fashion-driven consumer market, and unlike PCs, there are fewer drivers for technical consolidation. Consequently, leading handset vendors maintain complex customer segmentations and large device portfolios. Although many of these devices will increasingly use common platforms and web standards, there will still be large variations in all kind of features influencing the mobile internet user experience, i.e. implementation details, display sizes, processor power, storage capacity, power consumption, navigation tools, text input interface, broadband bearers and many variants of web tools, such as browsers, media players, application viewers or positioning tools (Jones, 2007).

Mobile devices are increasingly equipped with facilities that assist in connecting the physical world to the mobile internet. Device features such as cameras that read bar codes and preinstalled applications on phones let users get directly to online content and services (Browne, 2007). Similarly, radio frequency tags embedded in everyday objects can give access to Internet services related to the object in question (Kaasinen et al., 2006). An embedded GPS system in a mobile device facilitates services that are connected to the actual physical location of the user. However, services utilizing these new technical facilities have been suffering from 'chicken-egg' problems: because only some devices include these technical facilities, service providers are reluctant to provide services that utilize these unique features. On the other hand, as service selection is modest, users are not willing to invest in the devices and device manufactures hesitate about including the features in new devices.

Internet players such as Yahoo and Google, by providing their own devices, may take the advantage of integrating hardware and services to deliver an optimized user experience and understand the user's interests better (Jones, 2007). The Apple's iPhone has shown how successful integrated hardware and services may be.

Forrester Research suggests that a new category of consumer devices that blend the best of the PC, wireless, and web to deliver a superior mobile internet experience is needed (Jackson, 2007). Gartner predicts that although cellular handsets will dominate through 2011, the mobile web will extend onto devices such as Ultra Mobile PCs (Jones, 2007).

Networks

In the fixed network world consumers have got used to xDSL download speeds with up to 16 Mbit/s. Where mobile networks run on GPRS technology they merely reach 56 kbit/s which not only results in a slow service but moreover is not sufficient for a lot of applications, such as streaming video. While in some rural areas EDGE (up to 384 kbit/s) might remain the maximum broadband mobile network, in regions with a higher population density there will be more and more 3G and 3.5G (HSPA) networks available with 7.2 Mbit/s downstream capability since operators are continuously adding bandwidth to enable new services. In regions where the spectrum is limited, capacity will moreover be increased with additional metro-area wireless networks, such as WiMAX (70 Mbit/s for up to 50 km distance), a further development of WLAN (Jones, 2007).

In a focus group study carried out in China and in six European countries (IUP, 2008), current users of the mobile internet mentioned unreliable connections as well as network security as obstacles for using transaction services in China, Italy and France. Also non-users were concerned about unreliable connections and security issues. This study points out the importance of extending geographical coverage of 3G networks and improving speed and reliability of connections. Lu et al. (2008) have studied mobile internet adoption in China. They also found data security concerns and they emphasize mobile trust as a key factor affecting user adoption of mobile services.

Apart from bandwidth aspects, mobile networks can also add to a better mobile internet user experience by providing enabling services such as payment platforms or location information to 3rd parties.

Browsers and Proxies

The number of different mobile browsers may decrease via standardization efforts but on the other hand the number of browsers may increase as the number of internet-capable devices increases. The variety of browsers is a challenge for service providers who should provide content accessible by all the different browsers.

Quite a few mobile web browsers can access standard web content that was originally designed for large-screen viewing. The browsers adapt the content to make it more suitable for handheld access (Jones & Marsden, 2006). Adaptation can be implemented as server-side, client-side or intermediate adaptation (Laakko & Hiltunen, 2005). Algorithms used to transform the content of web pages into smaller units making it suitable for viewing on small-screen mobile devices typically fall into four categories (Schilit et al., 2002): Scaling, Manual Authoring, Transducing and Transforming. Web page transformation, whether at the site or at the browser level, can be grouped into three broad transformation categories: Direct Migration, Linear and Overview (MacKay et al., 2004) (Figure 4).

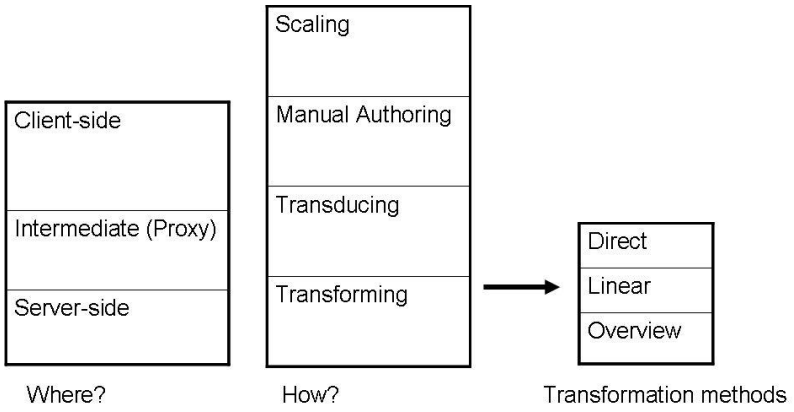

Figure4. Mobile Adaptation Techniques.

These technologies face challenges due to increasing website complexity, use of JavaScript, browser differences, lack of useful device data and failing compliance with standards (Moore, 2007). Each transformation technique has navigational advantages and constraints (MacKay & Watters, 2003) as well. Many current automated transformation options do not consider features such as user task, familiarly with information, web-page layout and mobility of the user, and their impact on the usability of the resultant transformed page (MacKay et al., 2004). Further research to improve these solutions and user experience will be required.

Pricing

With respect to paying for the mobile internet, consumers want predictability, simplicity, and affordability (van Veen, 2007). When Forrester asked European regular Internet users why they did not use the mobile internet, 55% stated that it was too expensive (Forrester Research, 2006).

In a focus group study in China and six European countries (IUP, 2008), non-users of the mobile internet were assuming mobile internet costs to be high, and they did not know how much they would be charged for mobile services nor the pricing policies. In this study, flat rates were of interest to many participants as they were familiar with this kind of pricing from their home and work broadband charges. Kuo and Yen (2008) suggest, based on their user studies in Taiwan, that if service tariffs cannot be reduced, service providers should develop more valuable and special services.

To improve user experience, users need to be able to understand, follow, and control the mobile Internet costs (Roto et al., 2006). Affordable usage costs should be accompanied with clear pricing structures. One option is time-based tariffs where the user pays for each minute, 15 minutes or by the hour. The interviewed Swiss customers clearly preferred such time-based tariff models to volume-based ones (van Veen, 2006). Another option is bundling a small package of mobile internet usage with another

subscription or even giving it away for free and thus letting the customer have a risk-free entry to mobile internet usage.

CONCLUSIONS

The mobile internet has great potential in providing users with personal access to topical information and services. There is still a lot to do to improve user experience of the mobile internet, however. Service providers can improve user experience by providing services specifically designed for mobile use and even utilizing location and other contextual information in the services. To make this affordable, the service has to provide clear value for mobile users.

The motivation to use the mobile internet may be based on the usage situation where no other alternative is available. It may also be the quickest and easiest way to access the Internet. In some cultures, the mobile internet may become the primary means of accessing the Internet because PC penetration is low. This introduces totally different requirements for mobile services than in cultures where mobile access is an alternative to desktop web access.

User experience of the mobile internet is affected not only by the mobile service properties but also by many infrastructure-level solutions related to wireless connections, various device types, browsers, proxies, and service discovery. Standardization efforts and guidelines are needed to support service providers in designing mobile-friendly services and in labeling those services so that users can recognize them.

The users will need more support in finding mobile internet services. Search engines are important but for mobile use they will need improved hit rate and efficiency. Novice users would benefit from readymade service packages and portals, while expert users might appreciate context-sensitivity and personalization to help service discovery.

Mobile internet research has mainly been carried out in the context of individual services or techniques. This paper has outlined an overview of the wide body of issues that affect user experience of the mobile internet. The authors see this holistic view as being very beneficial for improving the mobile internet user experience, since pleasing and engaging the user will require multidisciplinary and multicultural cooperation between the different actors in the field.

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REFERENCES

Alahuhta, P., Ahola, J. & Hakala, H. (2005). *Mobilizing Business Applications – A survey about the opportunities and challenges of mobile business applications and services in Finland.* Technology Review 167/2005. Helsinki, Finland: Tekes.

Arter, D., Buchanan, G., Jones, M. & Harper, R. (2007). Incidental Information and Mobile Search. In *Mobile HCI 2007 Proceedings* (pp. 129-136).

Bajaj, A. & Leonard, N. (2004). The CPT Framework: Understanding the Roles of Culture, Policy and Technology in Promoting Ecommerce Readiness. *Problems and Perspectives in Management,* 3(2004), 242-252.

Browne, J. 2007. *How Japanese Companies Guide Their Customers To Mobile internet Experiences.* Forrester Research.

Chu, C. & Pan, J-G. (2008). The forecasting of the mobile Internet in Taiwan by diffusion model. *Technological Forecasting & Social Change 75* (2008), 1054-1067.

Church, K, Smyth, B., Bradley, K. & Cotter, P. (2008). A Large Scale Study of European Mobile Search Behaviour. In *Proceedings of MobileHCI 2008* (pp. 13-22). ACM.

CommunicationsDirect. (2007). Searching for a Better Mobile Search Solution, October 22, 2007. Retrieved October 22, 2007, from http://www.communicationsdirectnews.com/do.php/100/27206

Comscore (2007a). Press release. Retrieved October 25, 2007, from http://www.comscore.com/press/release.asp? press=1432

Comscore (2007b). Press release. Retrieved October 25, 2007, from http://www.comscore.com/press/release.asp?press=1742

Daoust, F. & Hazaël-Massieux, D. (2008). From pages to applications: Mobile Web Best Practices. In *Mobile Internet User Experience Workshop, 2008. http://wiki.research.nokia.com/images/b/b6/Daoust-HazaëlMassieux.pdf*

Escofet, G. (2007). SMS-based WAP push to wither away once mobile search services get their act together. *Mobile Media 19(8).*

Fang, X., Chan, S. Brzezinski, J., Xu, S. (2006). Moderating Effects of Task Type on Wireless Technology Acceptance. *Journal of Management Information Systems* 3(22).

Forrester Research. (2006). *European Consumer Technology Adoption Study (ECTAS) Q4 2006 Survey*.

Funk, J. L. 2004. *Mobile disruption. The technologies and applications driving the mobile internet.* Wiley-Interscience.

Hassenzahl, M. & Tractinsky, N. (2006). User Experience – a Research Agenda. *Behaviour and Information Technology*, 2(25),. 91-97.

Hassenzahl, M. (2003). The Thing and I: Understanding the Relationship Between User and Product. In M. A. Blythe, K.Overbeeke, A. F. Monk & P. C. Wright, P.C. (Eds), *Funology: From usability to user enjoyment*. Kluwer Academic Publishers.

Haumont, S. & Siren, R. (2007). dotMobi, a Key Enabler for the Mobile Internet. In *Mobile Internet User Experience Workshop, 2007.* http://research.nokia.com/events/miux.html

Heimonen, T. & Käki, M. (2007). Mobile Findex – Supporting Mobile Web Search with Automatic Result Categories. In *Mobile HCI 2007 Proceedings* (pp. 113-120).

Hinman, R., Spasojevic, M. & Isomursu, P. (2008). They Call It "Surfing" for a Reason: Identifying mobile Internet needs through PC deprivation. In *CHI 2008 Proceedings. Case Studies* (pp. 2195-2207).

Hoschka, P & Smith, M. (2007). Best Practices: Making Mobile Browsing Better. In *Mobile internet User Experience Workshop, 2007.* http://research.nokia.com/events/miux.html

Ipsos Insight. (2006). Mobile Phones Could Soon Rival the PC As World's Dominant Internet Platform. In The Face of the Web. http://www.ipsos-na.com/news/pressrelease.cfm?id=3049

IUP - International Usability Partners. (2008). *IUP Mobile Transactions Report – 2008.* http://www.amber-light.co.uk/iup/IUP-MobileTransactionsReport.ppt

Jackson, P. (2007). *Defining Mobile internet Devices*. Forrester Research.

Jones, M. & Marsden, G. (2006). *Mobile Interaction Design*. England: John Wiley and Sons Ltd.

Jones, N. (2007). *Mobile Web Trends 2007 to 2011. Gartner ID Number: G00148175*. Gartner Research.

Joshi, D. (2006). *Mobility as an extension of Man.* Post Graduate Dissertation, National Institute of Design / Motorola India Research Labs, India.

Kaasinen, E. (2005). *User acceptance of mobile services - value, ease of use, trust and ease of adoption*. Doctoral dissertation. Finland : VTT Publications 566. http://www.vtt.fi/inf/pdf/publications/2005/P566.pdf

Kaasinen, E. (2009). User Acceptance of Mobile Services. *International Journal of Mobile Human Computer Interaction.* 1(1), 79-97.

Kaasinen, E., Ermolov, V., Niemelä, M., Tuomisto, T. & Välkkynen, P. (2006). Identifying User Requirements for a Mobile Terminal Centric Ubiquitous Computing Architecture. In Proceedings of FUMCA 2006: System Support for Future Mobile Computing Applications. http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=4021039

Kaasinen, E., Kivinen, T., Kulju, M., Lindroos, L., Oksman, V., Kronlund, J. & Uronen, M. (2008). *User Acceptance of Mobile TV Services- Finpilot2 Final report.* Helsinki, Finland: Forum Virium Helsinki. www.finnishmobiletv.com/finpilot2

Kamvar, M. & Baluja, S. A (2006). Large Scale Study of Wireless Search Behaviour: Google Mobile Search. In *CHI 2006 Proceeding.* (pp. 701-709).

Kamvar, M. & Baluja, S. The Role of context in Query Input: Using contextual signals to complete queries on mobile devices. In Mobile HCI 2007 Proceedings, 121-128, 2007.

Kindberg, T. & Barton, J. (2000). Towards a real-world wide web. In *Proceedings of the 9th Workshop on ACM SIGOPS European Workshop* (pp. 195-200). ACM Press. http://doi.acm.org/10.1145/566726.566766

Koivumäki, T., Ristola, A. & Kesti, M. (2008). The perceptions towards mobile services: an empirical analysis of the role of use facilitators. *Personal and Ubiquitous Computing 12*(2008), 67-75.

Kreutzer, T. (2008). Assessing Cell Phone Usage in a South African Township School. In *Proceedings of e/merge 2008 conference, 7-18 July, 2008*, online.

Kuo, Y-f. & Yen, S-N. (2008). Towards an understanding of the behavioural intention to use 3G mobile value-added services. *Computers in Human Behavior 1*(25), 103-110.

Laakko, T. & Hiltunen, T. (2005). Adapting Web Content to Mobile User Agents. *IEEE Internet Computing* 2(9), 46-53.

Lee, I, Choi, B., Kim, J. & Hong, S-J. (2007). Culture-Technology Fit: Effects of Cultural Characteristics on the Post-Adoption Beliefs of Mobile Internet Users. *International Journal of Electronic Commerce* 4(11), 11-51.

Lehikoinen, J. Salminen, I. & Aaltonen, A. (2007). *Personal Content Experience, Managing Digital Life in the Mobile Age.* Wiley-Interscience,.

López-Nicolás, C., Molina-Castello, F. J. & Bouwman, H. (2008). An assessment of advanced mobile services acceptance: Contributions from TAM and diffusion theory models. *Information & Management 45*(2008), 359-364.

Lu, J., Liu, C., Yu, C-S. & Wang, K. (2008). Determinants of accepting wireless mobile data services in China. *Information & Management 45* (2008), 52-64.

MacKay, B. & Watters, C. (2003). The Impact of Migration of Data to Small Screens on Navigation. *IT&Society 3(1)*, 90-101.

MacKay, B., Watters, C. & Duffy, J. (2004). Web Page Transformation When Switching Devices. In *Proceedings Mobile HCI'04* (pp. 228-239). LNCS, vol. 3160.

Maehr, W. (2007). User Experience of the Mobile Internet. Unpublished master thesis, Chalmers TH, Gothenburg, Sweden, 2007. www.t2i.se.

Maunder, A., Marsen, G. & Harper, R. (2007). Creating and Sharing Multi-media Packages Using Large Situated Public Displays and Mobile Phones. In *Proceedings of the MobileHCI 2007 Conference* (pp. 188-191). ACM Press.

McGuire, R. (2007). On Kelly Goto's Gotomobile. http:// www.gotomobile.com/archives/mobile-20-fireside-chat

Mihalic, K. (2008). Widgetization of Mobile Internet Experience. In *Mobile Internet User Experience Workshop, 2008. http://wiki.research.nokia.com/images/7/71/Mihalic.pdf*

Moore, E. (2007). Content Transformation [OpenWave]. Retrieved October 22, 2007, from http://mobilemonday.org.uk/ [accessed 2007, 10/22]

Nielsen, Jakob. (2009). Alertbot February 17, 2009. Mobile Web 2009 = Desktop Web 1998. http://www.useit.com/alertbox/mobile-usability.html

Rheingold, H. (2005). Farmers, Phones and Markets: Mobile Technology In Rural Development. Retrieved October 24, 2007 from http://www.thefeaturearchives.com/topic/Technology/Farmers__Phones_and_Markets__Mobile_Technology_In_Rural_Development.html

Roto, V. & Kaasinen, E. (2007). Workshop on Mobile Internet User Experience. Retrieved February 24, 2009, from http://wiki.research.nokia.com/index.php/MobileInternetUX-2007.

Roto, V. & Kaasinen, E. (2008). 2nd International Workshop on Mobile Internet User eXperience (MIUX'08). Retrieved February 24, 2009, from http://wiki.research.nokia.com/index.php/MobileInternetUX-2008.

Roto, V. (2006). *Web Browsing on Mobile Phones - Characteristics of User Experience.* Doctoral dissertation, TKK Dissertations 49, Helsinki University of Technology, Finland. http://research.nokia.com/people/virpi_roto/ dissertation.html

Roto, V., Geisler, R., Kaikkonen, A., Popescu, A. & Vartiainen, E. (2006). Data Traffic Costs and Mobile Browsing User Experience. In *MobEA IV workshop on Empowering the Mobile Web.*

Schilit, B., Trevor, J., Hilbert, D., Res, I. & Seattle, W. (2002). Web interaction using very small Internet devices. *Computer,* 10(35), 37-45.

Simon, R. & Fröhlich, P. A (2007). Mobile Application Framework for the Geospatial Web. In *Proceedings WWW2007 (pp.* 381-389).

Strategy Analytics. (2008). *Mobile Internet: Global Market Forecast, November 2008.*

Suri, J. F. (2005). *Thoughtless Acts.* San Francisco, USA: Chronicle Books.

Swisscom. (2007). *Mobile market research, December 2007.*

W3C. (2008a). *Mobile Web Best Practices 1.0. Basic Guidelines.* W3C Recommendation 29 July 2008. Retrieved February 28, 2009, from http://www.w3.org/TR/mobile-bp/

W3C. (2008b). *W3C mobileOK Basic Tests 1.0*. W3C Recommendation 08 December 2008. Retrieved February 28, 2009, from http://www.w3.org/TR/mobileOK-basic10-tests/

W3C. (2009). *Mobile Web Application Best Practices*. Editors' Draft 01 January 2009. Retrieved February 28, 2009, from http://www.w3.org/2005/MWI/BPWG/Group/Drafts/BestPractices-2.0/ED-mobile-bp2-20090101

van Veen, N. (2006). Breaking The Mobile internet's Low Adoption Spell, Forrester Research.

van Veen, N. (2007). Mobile internet Pricing Strategies Mature, Forrester Research.

White, R.W. & Drucker, S.M. (2007). Investigating Behavioral Variability in Web Search. In *Proceedings WWW2007* (pp.21-30).

Väänänen-Vainio-Mattila, K. & Ruuska,S. (2000). Designing Mobile Phones and Communicators for Consumers' Needs at Nokia. In E. Bergman (Ed.), *Information Appliances and Beyond: Interaction Design for Consumer Products* (pp. 169-204). Morgan Kaufmann.

Väänänen-Vainio-Mattila, K., Oksman, V. & Vainio, T. (2007). Exploring the User Experience Factors in Designing Successful Mobile internet Services for Business Use. In *Mobile Internet User Experience Workshop, 2007.* http://research.nokia.com/events/miux.html

Zuverink, D. (2008). Beyond Browsers: Taking Mobile Applications Online. In *Mobile Internet User Experience Workshop, 2008.* http://wiki.research.nokia.com/images/9/92/Zuverink.pdf