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WEB BROWSING ON MOBILE PHONES - CHARACTERISTICS OF USER EXPERIENCE

Doctoral Dissertation

Virpi Roto

Helsinki University of Technology
Department of Computer Science and Engineering

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Espoo 2006

WEB BROWSING ON MOBILE PHONES - CHARACTERISTICS OF USER EXPERIENCE

Doctoral Dissertation

Virpi Roto

Dissertation for the degree of Doctor of Philosophy to be presented with due permission of the Department of Computer Science and Engineering for public examination and debate in Auditorium T1 at Helsinki University of Technology (Espoo, Finland) on the 8th of December, 2006, at 12 noon.

Helsinki University of Technology
Department of Computer Science and Engineering

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Software and Application Technologies Laboratory

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Author Virpi Roto

Name of the dissertation

Web Browsing on Mobile Phones – Characteristics of User Experience

Date of manuscript October 10, 2006	Date of the dissertation December 8, 2006
☐ Monograph	☒ Article dissertation (summary + original articles)

Department	Computer Science
Laboratory	Software Business and Engineering
Field of research	Usability
Opponent(s)	Prof. Matt Jones
Supervisor	Prof. Marko Nieminen

Abstract

The increasing importance of the web in people's daily life calls for device-independent access to existing web sites. More than two billion people have a mobile phone today, and for many of them, a mobile phone may be the only way to connect to the web. There is an order for full web access on mobile phones, but it faces several challenges and the user experience is often poor.

This dissertation has its focus in the area of human-computer interaction and user experience research. The overall goal of the research has been to improve the end user experience when browsing the web with a mobile phone. Previous research has identified that the user's internal state, context, and system affect the user experience, but product development needs a more concrete and comprehensive list of attributes. To understand the user experience building blocks in the case of mobile browsing, we ran several usability studies with mobile web browsers in both a laboratory and a mobile context. We also conducted 35 contextual inquiry interviews in Finland, United States, Japan, and the United Kingdom. The studies revealed that mobile browsing user experience is affected by the user's state, context, mobile device, browser application, network infrastructure, and web sites. Identifying these characteristics composes the main contribution of this dissertation.

The mobile browser development activity at Nokia serves as a case study, in which we have considered the identified attributes and aimed to create a browser that fits well into the mobile context. Our field study results and early feedback from the market have been encouraging, which shows that taking the user experience characteristics into account helps creating positive user experiences.

Finally, this dissertation adduces topics for future user experience research by discussing the difference between user experience and experience in general, the effects that pricing has on the user experience, and the role of a user's expectations in evaluating the user experience.

Keywords	Mobile internet, user experience, building blocks of user experience, user studies, mobile phone		
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VÄITÖSKIRJAN TIIVISTELMÄ

Tekijä Virpi Roto

Väitöskirjan nimi

Internet-selailu kännykällä – käyttäjäkokemuksen piirteitä

Käsikirjoituksen jättämispäivämäärä 10.10.2006 | Väitöstilaisuuden ajankohta 8.12.2006

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Vastaväittäjä(t) Prof. Matt Jones
Työn valvoja Marko Nieminen

Tiivistelmä

Internetin kasvava merkitys ihmisten päivittäisessä elämässä vaatii laiteriippumatonta pääsyä olemassa oleville Internet-sivustoille. Yli kahdella miljardilla ihmisellä on jo kännykkä, ja monille kännykkä saattaakin olla ainoa tapa päästä verkkopalveluihin. Webbi pitäisi tuoda kännykkään, mutta tehtävä on haasteellinen ja käyttäjäkokemus on vaarassa jäädä huonoksi.

Tämä väitöskirja kuuluu ihmisen ja koneen vuorovaikutuksen sekä käyttäjäkokemuksen tutkimusalaan. Tutkimuksen yleinen päämäärä on ollut parantaa kännykällä tapahtuvan Internet-selailun käyttäjäkokemusta. Aiempien tutkimusten mukaan käyttäjän sisäinen tila, konteksti ja käytettävä järjestelmä vaikuttavat käyttäjäkokemukseen, mutta tuote-kehityksessä tarvitaan konkreettisempaa ja täydellisempää listaa kokemukseen vaikuttavista osatekijöistä. Ymmärtääksemme mobiiliselailun käyttäjäkokemuksen rakennuspalikoita olemme tutkineet kännykkäselainten käytettävyyttä sekä laboratorio- että kenttäolosuhteissa. Olemme myös tehneet 35 kontekstuaalista haastattelua Suomessa, Yhdysvalloissa, Japanissa ja Isossa Britanniassa. Tutkimukset paljastivat, että kännykällä tapahtuvan Internet-selailun käyttäjäkokemukseen vaikuttavat käyttäjän tila, konteksti, mobiililaite, selain, verkkoinfrastruktuuri sekä webbisivustot. Näiden tekijöiden ja osatekijöiden tunnistaminen on tämän väitöstutkimuksen päätulos.

Nokian Internet-selainkehitys älypuhelimille on esimerkkitapaus, jossa otettiin huomioon tunnistamamme käyttäjäkokemukseen vaikuttavat tekijät ja pyrittiin luomaan selain, joka täyttäisi liikkuvan käyttäjän tarpeet. Kenttätestiemme tulokset sekä alustava julkinen palaute on ollut rohkaisevaa, mikä osoittaa, että tunnistamiemme tekijöiden huomiointi auttaa positiivisen käyttäjäkokemuksen luomisessa.

Lopuksi väitös käsittelee aiheita, joita käyttäjäkokemuksen tutkimus ei yleensä tuo esiin, vaikka tämän tutkimuksen perusteella ne olisi tärkeä ymmärtää: mikä ero on käyttäjäkokemuksella ja kokemuksella yleisesti, miten hinnoittelu vaikuttaa käyttäjäkokemukseen ja kuinka käyttäjän odotukset vaikuttavat käyttäjäkokemuksen arviointiin.

Asiasanat Mobiili internet, käyttäjäkokemus, käyttäjäkokemuksen tekijät, käyttäjätutkimus, kännykkä

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Preface

My background is in computer science, where I was interested especially in usability of software products. My master's thesis (1993) was about task analysis methods, that is, how to investigate users' work flows in detail when they are applying a PC application in their work. I joined Nokia 1995, and started soon usability consultancy work by evaluating usability of various kinds of Nokia products and by helping business units in developing their product creation processes to a more user-centred direction.

In 2002, my colleague Anne Kaikkonen and I were asked to help Wireless Access Protocol (WAP) developers out there to create usable WAP sites with XHTML Mobile Profile, the new markup language of WAP 2.0 (WAP Forum 2002). We created a WAP site in three different user interface (UI) styles and wanted to compare the usability of each style. After the tests, we analysed the origins of each usability problem, and realized that almost half of the problems did not originate from the site, but from the browser application or from the phone hardware. This was very different from the case of testing a web site with a Personal Computer (PC), where the hardware and browser is standardized and you seldomly see such a radical effect of them in the results of a usability study.

After this WAP 2.0 study, I realized we have to improve the usability of the Nokia XHTML browser, which was a prototype at the time of the study. We started to collaborate with the browser team in Nokia Research Center, and the focus of the usability tests of mine shifted from the site to the browser.

Whenever testing the different browsers, I saw that usability was not the only factor that made users happy or unhappy. Even if usability would be close to perfect, there are other factors that prohibit users from browsing on their mobile phones. I broadened the scope of my research from usability to user experience.

Good user experience is a common goal in designing technical products today inside and outside Nokia. Any self-respectful product development program has the term user experience on the product requirements list. Unfortunately, the project manager or any member in the team can decide what "superior user experience" means for a product. Why user experience is so important, and why even researchers cannot agree what it means in practice?

Because "user experience" is a buzzword, many researchers avoid using it. I think, however, that researchers need to undertake defining it. Without a definition, we cannot design and evaluate user experience, and the "superior user experience" promised for a product may mean, for example, a flashy welcome animation or a cool new algorithm to organize icons randomly. First, we need to define the elements that affect user experience in different cases, and after investigating several different types of cases, we will hopefully be able to derive an overall definition for the high-level user experience elements. In this dissertation, I try to define user experience in terms of characteristics affecting user experience in the case of mobile browsing. Hopefully researchers find this dissertation useful when further investigating user experience.

Acknowledgements

It is not always straighforward to conduct a solid piece of multi-year research in industry setting. I have been fortunate to be able to continue the research on mobile browsing over several years and to publish the results openly in international conferences. I owe this thesis to various people in Nokia, academia, and home.

First, I am very grateful for and impressed about the apt and constructive comments I always received for the dissertation from my supervisor, Prof. Marko Nieminen. It must have been hard to handle my immature, industry-driven views and arguments in the beginning of this work, but he never discouraged me by highlighting the flaws but concentrated in the improvements. It was a long but very enlightening journey from my first "I think this is ready now" statement to the final version of the dissertation. Not many professors would have been able to keep me efficient and motivated throughout this journey, but Marko somehow managed to do it. He turned me into a true scientist.

I was honoured to have Prof. Kaisa Väänänen-Vainio-Mattila from Tampere University of Technology and Jun.Prof. Marc Hassenzahl from the University of Koblenz-Landau, Germany, as the pre-examiners of my dissertation. I thank them for providing very insightful and valuable comments for finalizing my dissertation, which helped me to understand the fields of mobile HCI and user experience research more deeply.

Mika Rautava has been my closest colleague during the most hectic periods of writing this dissertation. Despite the workload that he had to bear while I was absent, he was always very supportive and participated the discussions about my thesis with interest. I truly appreciate his help, which has been vital in order to work on this dissertation. I also thank my other colleague and friend Salla Myllylä who teached me the user needs research methods and the philosophy of user-driven innovation. Her overnight thinking sessions brought new light to various user studies of ours.

I am truly grateful to the browsing project team in Nokia Research Center, led by Guido Grassel, and the whole Web Technologies program, headed by Barbara Heikkinen and later by Tuomas Tammi, for inviting me to work with them. Guido's innovative and inspiring team has motivated and encouraged me to take the deep dive into mobile browsing user needs that form the heart of this dissertation. My warm thanks to Guido and the team members Andrei Popescu, Antti Koivisto, Elina Vartiainen, and Janne Kaasalainen. It has been a pleasure to develop the browser prototypes with you!

I want to express special thanks to Franklin Davis from Nokia Technology Platforms who first saw the value in our browser usability studies and found the funding for our work through several years. He appreciated and advertised my work within Nokia and was a key person in enabling this research. Franklin Davis, Roland Geisler, Kimmo Vättö and Ari Laaja were among the elementary people who pushed our browser solution to S60 phones and enabled the success that our browser feature innovations have caught.

I want to thank my line managers Jaakko Lehikoinen, Mika Röykkee, and Jan Bosch, as well as the head of Nokia Research Center, Bob Iannucci, for the possibility to work on the dissertation during year 2006. All of them have been very supportive in this project of mine.

When I first started mobile browsing related activities, Anne Kaikkonen provided me her valuable knowledge about the usability and usefulness aspects of WAP sites. I will always remember the long evenings in Pisa editing our first accepted CHI paper with Anne. If she

had chosen the tourist attractions instead, the paper might have not been accepted and I might have never made the decision to pursue a PhD degree.

I am under an obligation also to all other people with whom I have had the pleasure to author scientific publications: Antti Oulasvirta from Helsinki Institute of Information Technology, Katri Laakso from Nokia Research Center, and Sakari Tamminen and Jaana Kuorelahti from Helsinki University of Technology. Working with you has been interesting and educative.

Barbara Hammond from Nokia Research Center Boston has been very kind to help me with the Boston user study and to check the language of many of my publications. I want to thank her very much for sacrificing countless hours of her free time for helping me.

I hardly remember the times ten years ago when I started the post-graduate studies, already working in Nokia Research Center. What I do remember was the working climate and the 10% time dedicated for studies that encouraged me to sign in as a post-graduate student. This must have been enabled by Juhani Kuusi, the former head of Nokia Research Center, and Pertti Lounamaaa, the head of Software Applications Laboratory at the time. Pertti also made it possible for me to move to Panu Korhonen's usability team. I enjoyed working in Panu's multidisciplinary group, which he turned into a recognized industrial HCI research team during the years. This time teached me a lot about usability and human-computer interaction and provided a solid foundation for this work.

I want to thank the old friends of mine from the University of Helsinki, department of Computer Science. I never planned to graduate from computer science, but failing the admission test to the department of architecture gave me a good reason to stay with my congenial souls. Without the lively student life that kept me with computer science this dissertation would have never seen the daylight.

I want to thank also other friends, relatives, and colleagues who have kept my feet on the ground and provided mental refreshment in a form or another during the years.

I am grateful to my parents who have raised me to enjoy learning. They have always supported my studies without pressuring. I thank my mother for taking loving care of the grandchildren during my many conference trips.

Finally, I want to stress the important role of my family in this project. Tommi has been an exceptional husband in supporting my post-graduate studies throughout. He has carried the responsibility of our two daughters and home when I was traveling or late at work. If he had lower self-esteem, he would not have encouraged me for the studies. I thank Sonetta (8) and Jannika (6) who have borne with me during this process, and for the Mothers' Day card 2006 where Sonetta had drawn a picture of her mother as she best remembered me: at a laptop computer writing this dissertation.

Mothers' Day card 2006 (Sonetta, 7)

List of Original Publications

This thesis consists of an overview and of the following publications which are referred to in the text by their Roman numerals.

I Kaikkonen, A., Roto, V. 2003, Navigating in a Mobile XHTML Application. *Proceedings of Human Factors in Computing Systems conference (CHI'03)*, Fort Lauderdale, USA, pp. 329-336.

Anne Kaikkonen and I contributed to the study in question and the paper 50% each. Anne Kaikkonen acted as a domain specialist, while I designed the study. We analysed the results and authored the paper together.

II Roto, V., Kaikkonen, A. 2003, Acceptable Download Times in the Mobile Internet. In Stephanidis, C. (ed.): *Universal Access in HCI. Volume 4 of the Proceedings of HCI International 2003*, Crete, Greece, pp. 1467-1471.

This paper describes a set of results from the same study as paper I. We authored the paper again closely together with Anne Kaikkonen.

III Roto, V., Kaikkonen, A. 2003, Perception of Narrow Web Pages on a Mobile Phone. *Proceedings of International Symposium on Human Factors in Telecommunications 2003*, Berlin, Germany, pp. 205-212.

I designed and executed the study while Anne Kaikkonen ran some of the usability tests as well as the data analysis. Anne Kaikkonen helped especially with chapter 3 of the paper.

IV Roto, V., Oulasvirta, A. 2005, Need for Non-Visual Feedback with Long Response Times in Mobile HCI. *Proceedings of the 14th International World Wide Web Conference 2005*, Chiba, Japan, pp. 775-781.

The study in question was initiated by me, and designed together with Antti Oulasvirta. Antti Oulasvirta acted as a psychological experiment expert by designing the study details and running the statistical analyses, while I was planning the technical parts of the study and ensuring that the analyses will provide the needed results for this paper. Antti Oulasvirta contributed mainly in chapters 3 and 4 of this paper.

V Roto, V., Laakso, K. 2005, Mobile Guides for Locating Network Hotspots. *Workshop on HCI in Mobile Guides*, in conjunction with MobileHCI 2005 conference. Salzburg, Austria. (5 pages)
http://www.comp.lancs.ac.uk/computing/users/kc/mguides05/pdfs/Roto_LocatingHotspots.pdf

The paper is based on user studies run together in a project team, the closest colleague being Salla Myllylä. Katri Laakso contributed mostly to chapter 4 as a mobile guides specialist.

VI Roto, V. 2006, Search on Mobile Phones. In Vaughan, M., Resnick, M. (eds): Perspectives issue of the Journal of the American Society for Information Science and Technology (JASIST): Best Practices and Future Visions of Search User Interfaces. Vol 57, number 6 (2006), pp. 834-837.

The article describes some of the results from the same study as paper I. I authored the article itself alone.

VII Roto, V., Popescu, A., Koivisto, A., Vartiainen, E. 2006, Minimap – a Web Page Visualization Method for Mobile Phones. *Proceedings of Human Factors in Computing Systems conference (CHI) 2006*, Montreal, Canada, pp. 35-44.

I planned and executed the user study in question together with a team of Mika Rautava, Andrei Popescu, and Elina Vartiainen. I was the main responsible both of the study and the article. Andrei Popescu considerably helped with the Visualization Method and Results chapters. Antti Koivisto and Elina Vartiainen helped for example with the Prior art chapter and with the figures.

VIII Roto, V., Geisler, R., Kaikkonen, A., Popescu, A., Vartiainen, E. 2006, Data Traffic Costs and Mobile Browsing User Experience. *MobEA IV workshop on Empowering the Mobile Web*, in conjunction with WWW2006 conference. (6 pages)
http://www.research.att.com/~rjana/MobEA-IV/PAPERS/MobEA_IV-Paper_7.pdf

The user studies described in the paper were run together with Salla Myllylä, Mika Rautava, Elina Vartiainen, and Andrei Popescu. I was the responsible person of all the studies. For the article, Roland Geisler helped with the statistics and billing models, and the paper benefited from contributions also by Anne Kaikkonen, Andrei Popescu, and Elina Vartiainen.

Summary of Publications

I started my expedition towards improved mobile web browsing user experience by examining how to develop usable WAP sites for mobile use. As a natural start, **paper I** focuses on site usability by providing tips on how to avoid usability problems when designing mobile optimized web sites. It describes differences and similarities between PC and mobile phones and how these differences affect navigation on the site.

In paper I, we did not answer the question of how quickly the pages should load to provide acceptable user experience, and we were asked to analyse this topic. In **paper II**, we discuss how users coped with the longish download delays due to the slow wireless connection. Again, we provided guidelines for site design so that users do not have to wait for too long.

Year 2003 we saw that the existing WAP services cannot always provide the best user experience, but there were many users who truly appreciated access to the full web even on mobile phones. In **paper III**, we report the findings of a usability study of viewing web pages on a mobile phone. Although the user experience was surprisingly good, we found many fundamental usability problems with the state-of-the-art method to view web pages on a small screen, Narrow Layout. This was the first time we investigated browser usability, not site usability. We understood that when viewing full web pages on a mobile phone, we need to take the site as is, and it is the browser that has to provide a view to the pages in a usable way.

From now on, I concentrated in investigating the possibilities that a mobile browser can offer to improve mobile browsing user experience. A perfect mobile browser would take the mobile use context into account and let the user concentrate to the environment whenever needed. In **paper IV**, we present a study to provide tactile feedback to inform the user that a page that was being loaded has now arrived. This is one step towards a Minimal Attention User Interface (Pascoe et al 2000) in a mobile browser.

We started a series of user needs interviews as the basis for a mobile browser design early 2003. Already after the first user study, it was clear that connection speed and cost were among the main obstacles making mobile browsing commonplace. To find out how the user experience would change if the connection was fast and the data costs flat, we went to interview people who used Wireless Local Area Network (WLAN) connection for mobile web browsing. In **paper V**, we report the finding that now the problem was to locate a suitable WLAN hotspot. The system should allow the user easily locate a network hotspot that fulfills user's criteria. We realized this is not a task for the browser, since many other applications share the same requirement as well, so we proposed a mobile guide system to provide means for locating network hotspots.

Web search engines are elementary tools for web usage on PCs, but we were not sure whether entering keywords on the limited keypad of a mobile phone is what the users want. In **paper VI**, we discuss the finding that users are surprisingly willing to type in search keywords also on the limited keypad of a mobile phone. This is a good example of strong usage patterns adopted from PC browsing to mobile browsing, even though the context is not optimized for these patterns.

In paper III, we analysed the pros and cons of viewing full web pages on a small screen. Since we noticed several usability problems with Narrow Layout method, we designed a novel web page visualization method called Minimap. **Paper VII** discusses the reasons behind the design decisions we made for Minimap. The recently published Web Browser for S60 is based on this visualization method, and the feedback so far has been highly positive.

Mobile browsing cost is a very interesting topic to investigate, since although cost is seldomly mentioned as an influencing factor to user experience, we constantly see its high influence on mobile browsing user experience. In **paper VIII**, we discuss how users perceive mobile data traffic costs and how they affect the user experience. The list of user experience characteristics in the case of mobile browsing were published in this paper for the first time.

The publications of this dissertation discuss some of the relevant attributes that affect mobile browsing user experience. There are, however, a set of other attributes that have come up in our various user studies but not made it to publications. See chapter 5 for our findings of these characteristics.

1. INTRODUCTION

User experience (UX) is considered as an important factor in product success today (Pine & Gilmore 1998, Jordan 2003, McCarthy & Wright 2004). As technology matures and becomes commonplace, a high level of usability is taken for granted and something more is needed to make people engaged with a product. To an increasing extent, also immature technology needs to fulfil not only utilitarian but also hedonic user needs. User experience research has come to fill the gap between a usable and an engaging product. There has been, however, too little empirical research on user experience so far. Hassenzahl & Tractinsky (2006) note that "the absence of empirical research – whether qualitative or quantitative – impedes theoretical advancement and restricts our understanding of UX as concept and its further development". This dissertation provides some empirical research results to advance the research on user experience.

In mobile web browsing, we have seen the path from mobile dedicated, separate web to a world where the full web, normally accessed on a personal computer (PC), and the mobile specific web cannot always be distinguished. A mobile phone is now technically capable to provide access to the very same sites as a PC and vice versa. The early mobile browsers for full web content just made the technology work on a mobile device but did not pay too much attention to the overall user experience of accessing the sites. Although the current browsers have addressed the most obvious limitation, the screen size, we are still far away from the goal of a truly enjoyable mobile browsing experience. To reach this goal, the different parties (site developers, connection providers, and device manufacturers) need to understand the building blocks of good user experience and co-operate to make mobile browsing a seamless experience.

This research has been done with the Software and Applications Laboratory in Nokia Research Center. The research team that I have been part of has investigated and addressed the user needs for full web on mobile phone, the visualization and interaction, as well as a number of other topics specific for mobile access to the full web. The intermediate result, a full web browser for mobile phones, has received very good early feedback both from our studies and from the market. It seems that addressing the factors affecting user experience helps to create positive user experiences.

1.1 Relevance of mobile internet access

In our user studies, typical use cases for mobile browsing are checking webmail, latest news, weather information, public transportation timetables, discussion channels, hobby club news, online education, and using internet search tools to find various pieces of information. As with web browsing on a PC, also in mobile browsing there are a few popular sites and a vast number of sites that people visit but are not highly popular. This is why it is very hard to provide mobile optimized sites for all use cases.

When speaking about full web on mobile phones, people start to smile and wonder who would need the web so badly that would use a tiny mobile phone to get online. One can certainly wait to get to a PC, or, if not, check the Wireless Access Protocol (WAP) sites that are much more usable on a phone. Let me explain why I believe billions will use a full web on mobile phone one day.

First, internet contains increasingly important information for our daily lives, which should not require a PC to be accessed. In the end of 2005, the information and services in the web had attracted more than a billion internet users worldwide (eTForecasts 2006a). The number

is big compared to the amount of installed PCs (0.8 billion, Gartner 2005), but small compared to the number of mobile phones in use (2.2 billion, Gartner 2006). In developing countries, cellular phone networks are widely available, whereas there are few fixed line internet connections in use. eTForecasts (2006b) estimates that "PC-based Internet usage will remain important in the future, but internet access via cell phones and Smartphones will become increasingly important. Cellular Internet usage will be particularly important in developing countries where the price of PCs is too high for most households". Also Ipsos Insight (2006) notes that "Mobile Phones Could Soon Rival the PC as World's Dominant Internet Platform".

Second, user studies have shown that WAP is more usable on mobile phones, but full web is what people want (Kaasinen 2005, p.82). When people access their favorite full web site on a mobile phone for the first time, they are clearly excited, which is often not the case when accessing WAP sites for the first time. The vast amount of information available in the web can never be copied to a mobile specific web, so people's hobby club pages will not have different versions for mobile devices and a PC. Also the World Wide Web Consortium (W3C) drives a One Web initiative where the same content would be accessible from any device.

Third, mobile phones have already become so powerful that many tasks that required a PC can now be done on a mobile phone. The displays of the latest smartphones are very high quality with 352x416 or more pixels and good contrast. The smartphones are able to connect to the Internet not only via cellular telecommunications networks but also via Wireless Local Area Networks (WLAN). With ever improving displays and connection speeds, we can well imagine people accessing the same web pages on PCs and mobile phones.

According to a Nokia slogan, life goes mobile. Web content is many times as relevant on the move as at the desk, so it is just a matter of user experience when masses will start to access the web through their mobile phones.

1.2 Evolution of mobile internet

The internet has developed from ARPANET of 1968 and from a university collaboration network of 1983 to a worldwide system of interconnected computer networks. The first World Wide Web (www, web) pages were published 1991 at CERN, providing information over the internet using HyperText Markup Language (HTML).

In 1998, Nokia released the world's first mobile phone that was able to access information in the internet. At the time, mobile phones were not capable of downloading and showing large web pages, but specific mobile-optimized web pages were needed. The user needs for internet content on the move are different from a stationary context, so it was logical to provide different services for mobile phones and for PCs.

Since the technical and user requirements were different, also the markup language of pages had to be different. Handheld Device Markup Language (HDML) was the first hypertext language specifically designed for handsets. Since that, many light markup languages have been defined for mobile use: Compact HTML (C-HTML), Wireless Markup Language (WML), Extensible HTML (XHTML) Basic, and XHTML Mobile Profile. The first version of Wireless Application Protocol (WAP) standard defined by WAP Forum used WML and the current WAP 2.0 version uses XHTML Mobile Profile.

In Japan, telecom operator NTT DoCoMo used Compact HTML (chtml) for its i-mode services targeted for its mobile phone subscribers. Mastering the whole chain of designing compatible handsets, providing connection, ruling service user interface (UI) style, and taking care of billing, DoCoMo has made i-mode services a success.

WAP services in other parts of the world were not very successful. The users were promised internet to be available on the handsets, so the expectations were relatively high. The user experience of mobile browsing did not meet the expecations, however. The settings required to get connected were very hard to configure, web addresses known from PC did not work, the sites available did not look like web sites, the selection of sites was very limited compared to the full web, connection was slow, and expenses were high. Users did not start using the mobile sites. Most mobile service developers did not get return on their investments, and had to shut down the mobile sites. Only lately, after fixing many of the above problems, usage of mobile services is slowly increasing.

On handset side, a browser that supports the specific markup language(s) is required. The mobile browser (also called microbrowser) may be provided by the handset manufacturer, the telecom operator, or the end-user can install an add-on browser to the handset her/himself. Since the markup languages used by mobile sites are different, a single mobile browser may not be able to show all different mobile sites. It is possible, however, to build a browser that understands all the different markup languages. WML used by WAP 1.x services was so different language from HTML that ordinary HTML browsers on PC could not render WML pages. WAP 2.0 uses XHTML Mobile Profile, which is understood also by PC browsers so that the WAP sites can be viewed both on mobile devices and PCs.

In the early days of the current millennium, when still struggling with the difficulties of getting WAP services fly, mobile browsers supporting HTML became available also for mobile phones. Some mobile services such as Mobile Google started to convert HTML pages to WML. This meant that users could access the same web pages on their mobile phones as on their PCs, although the format of the web pages still had to be changed to better fit the limited devices.

In this dissertation, I concentrate in the end-user experience of mobile internet browsing, so the technical aspects and operator's business models are of interest only when they affect end-user experience.

1.3 User experience

In order to make the web access on mobile phones a success, we need to take care of the overall user experience, not just usability of a web site (Jordan 2000). Unfortunately, user experience is a vague term and "taking care of the overall user experience" means very different things to different people. User experience research is in its infancy, but the industry needs both a good definition for user experience, as well as the methods for designing for and evaluating user experience.

Most of the practical research has addressed the process of designing for good user experiences, but few researchers have tried to come up with a formal definition for user experience. In order to design for good experience, it would be important to state what a good user experience stands for and how we can reliably say whether a certain product provides good user experience or not. Even the fact that user experience is a mental state of the user is not verbalized, but the definitions start by "user experience is a consequence / a result / every aspect of user's interaction / all the aspects of how people use" or similar.

Hassenzahl and Tractinsky (2006) provide a very good recent summary of the user experience research status and guide researchers to new interesting paths. There does not exist, however, publications that would give practitioners concrete user experience building blocks for designing and evaluating user experience.

The earlier we can assess user experiences the better for the product. User experience cannot be evaluated in a vacuum (Isomursu et al 2004), and we cannot control users' internal state or use contexts. Yet we need to understand why the user liked or disliked a product. Was it because of expectations, mood, aesthetics, or sunlight? End users cannot always analyse the actual reasons. Is it a good overall experience if I enjoy an excellent hotel breakfast but only afterwards find out it was not included in the room fee? At which point should we evaluate user experience?

Understanding the user experience building blocks helps us both in defining, designing, and evaluating user experience. In mobile browsing, the number of factors affecting user experience is relatively big, because there are so many players on the technology side, and the users and use contexts are diverse. One of the aims of this dissertation is to provide a case for more general user experience research for testing the new theories about what user experience is composed of.

2. RELATED RESEARCH

To understand the scope of this dissertation, I will first clarify the meanings of essential terms, and then introduce the previous research done close to my topic. I examine the related research first on high level, user experience in general, and then on relevant domain areas: user experience in desktop web browsing, mobile context, and finally in mobile browsing. I also discuss the related research done in the area of user experience design and evaluation, because those are very important in industrial product development.

2.1 Terminology

Web browsing refers to the action of accessing the web pages available on the internet, linked to each others by a hypertext system. *Web site* is a collection of web pages behind a specific internet domain or sub-domain. I prefer to use the term web site to web service, since the services I refer to are provided on web sites. Currently, there is not just one web but several separate webs: the full web accessible from HTML browsers, WAP accessible from WAP browsers, i-Mode accessible from i-Mode browsers, voice web accessible from voice browsers, etc. The World Wide Web Consortium works towards *One web*, which means "making, as far as is reasonable, the same information and services available to users irrespective of the device they are using" (W3C 2006). Also in this dissertation, I use the term "*web*" to refer to all the separate webs, because hopefully they will unite one day. To refer to a specific separate web, I use the specific terms "*full web*" for the web typically accessed from a PC, "*mobile web*" for all mobile optimized sites such as WAP or i-Mode, and "*voice web*" for the voice-enabled web targeted for eyes-free use.

By *mobile phone*, I mean a wireless handheld device capable of receiving and making phone calls. My research has aimed at designing positive mobile browsing experience for Nokia S60 mobile phones. S60 is a platform and user interface (UI) style that provides 5-way interaction (vertical and horizontal movement + selection) and two softkeys. The key difference between S60 device and some Personal Digital Assistant (PDA) devices is that PDAs typically provide a stylus for pointing items on the screen, while a mobile phone provides focusing UI with arrow keys or a joystick.

Many times, a mobile phone is seen as a single, compact product including all its features. When investigating mobile browsing, we need to see the mobile phone as a device that includes many software products; applications such as the browser. Although a mobile phone typically provides a browser by default, one may purchase another browser from 3rd party developers and use that instead of the browser that was in the device. Opera and NetFront are typical 3rd party browsers for Nokia S60 phones. So, the browser application inside the phone is a different product from the mobile phone, just as the PC browsers are different products from the PC itself. Both the phone and the browser have an effect on user experience, but we need to see the difference between these two system components.

I use terms characteristic, factor, component, and attribute to refer to matters that affect user experience. *Characteristic* is an overall term to describe factors, components, and attributes in general. I use term *factor* to refer to a high level concept that affects user experience. *Component* refers to one part of a system factor. *Attributes* are the bits or aspects of a component or factor, the lowest level in this concept hierarchy.

I will describe the meaning(s) of user experience in section 2.3, but let us first compare the difference between user experience and some similar terms.

Usability is defined in ISO 9241-11 standard as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use". Usability is an essential part of user experience. User's satisfaction with a product is important also in user experience, but the satisfaction in user experience may come from other factors than system usability.

User satisfaction is seen as one of the three key components of usability, others being effectiveness and efficiency. Also user experience is about user satisfaction, but the source of satisfaction is different. Usability leads to satisfaction by eliminating the usability problems, but user experience is about designing for pleasure in the first place (Hassenzahl & Tractinsky 2006).

The lack of a good, well-known definition for user experience has made "user experience" a buzzword that has various interpretations (Forlizzi & Battarbee 2004). The term user experience is discussed throughout this dissertation, especially in chapters 2.3 and 7.1. Below, I list some definitions for user experience that state some of the characteristics that have an effect on user experience.

User experience:

> "All the aspects of how people use an interactive product: the way it feels in their hands, how well they understand how it works, how they feel about it while they're using it, how well it serves their purposes, and how well it fits into the entire context in which they are using it" (Alben 1996)
>
> "Every aspect of the user's interaction with a product, service, or company that make up the user's perceptions of the whole". (UPA 2006)
>
> "The overall experience, in general or specifics, a user, customer, or audience member has with a product, service, or event" (Shedroff, online). Shedroff defines experience separately as "the sensation of interaction with a product, service, or event, through all of our senses, over time, and on both physical and cognitive levels".
>
> "A result of motivated action in a certain context." (Mäkelä & Fulton Suri 2001)
>
> "A consequence of a user's internal state (predispositions, expectations, needs, motivation, mood, etc.), the characteristics of the designed system (e.g. complexity, purpose, usability, functionality, etc.) and the context (or the environment) within which the interaction occurs (e.g. organisational/social setting, meaningfulness of the activity, voluntariness of use, etc.)." (Hassenzahl & Tractinsky 2006)

In addition to these definitions, there are also definitions that explain what user experience means in terms of user's emotional state or product lifecycle, but the above are the most relevant ones for this dissertation.

Acceptability, or *acceptance*, is close to user experience in the sense that it addresses more aspects than usability. According to Nielsen (1993), it covers also usefulness, practical acceptability, and social acceptability. There is also a narrower perspective to acceptability, listing acceptance as one of the attributes of usability (ISO 9241-11).

There is a research field similar to user experience, which aims to understand what makes products successful on the market. These technology acceptance models have striking

similarities with HCI field (Jones & Marsden 2005), and can be used as an information source for understanding user experiences.

Kaasinen (2005) presents a technology acceptance model for mobile services (Figure 1). This model is interesting because it states that user's perceptions of value, trust, ease of use, and ease of adoption are key influencers in system acceptance, even before taking the system into use. This model is in line with the user experience definitions in that a user has expectations for the system and if the system fails to meet these expectations, user experience is poor. It also takes trust and value as attributes affecting system acceptance, unlike Nielsen.

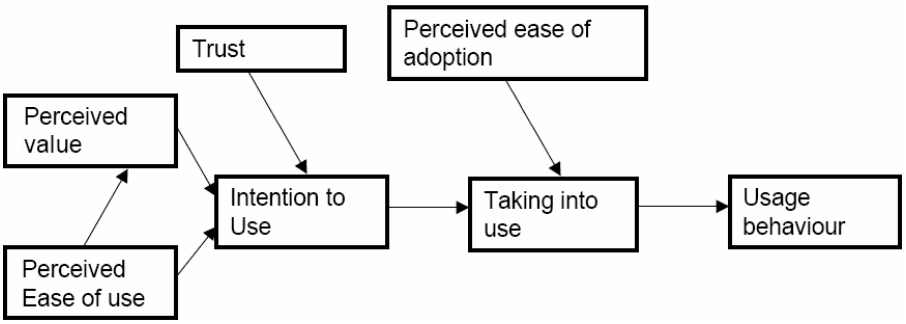


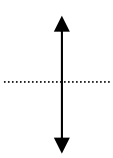
Figure 1. Technology Acceptance Model for Mobile Services (Kaasinen 2005)

I see the following differences between the terms acceptance and positive user experience:

1. Acceptance is often associated in the phase prior taking a system into use, whereas user experience has more weight on the later phases.

2. Acceptance may sometimes mean negative user experience: if the situation is impossible to change or the change would be possible only at great cost or risk, the user *accepts* even an uncomfortable situation.

I claim acceptance means neutral user experience: an acceptable system meets user's expectations, but does not delight the user by exceeding the expectations (Figure 2). This is close to the point made by Battarbee (2004, p. 24) that "an experience" is "multisensory delightful, unusual, and stands out from the rest". Also Forlizzi & Ford (2000) further denote that "experience" is different from "an experience", and means experience in the sense of "the experience of the moment, and accumulated experience". This is similar to a neutral user experience, which does not involve strong emotions or even focused attention to the product experienced. Note, however, that Battarbee does not map experience and an experience on an axis of good or bad experience, but talks about experience in a positive sense. According to Ortony & Clore (1988, p. 118), also the term Satisfaction means meeting the expectations, but exceeding expectations generates pleasure or joy (p. 86).



\+ Expectations exceeded: delightful, positive user experience

0 Expectations met: acceptable, neutral user experience

\- Expectations not met: disappointing, negative user experience

Figure 2. User experience in relation to user's expectations.

2.2 User needs for internet on a mobile device

Researchers have been investigating the user needs for internet sites and services on handheld devices from the mid-1990. Kaasinen found that while on the move, people use services that provide utility, communication, or fun. The services need to be personal, comprehensive, topical, and familiar (Kaasinen et al 1999, Kaasinen 2005).

Sellen & Murphy (2002) aim to identify those use cases from desktop browsing that are likely to transfer to mobile browsing. Finding specific information and browsing to kill time were seen to fit well mobile browsing, but information gathering, which requires scanning and comparing large amounts of data from different sites, and is typically taking more than 20 minutes, was seen less suitable for mobile browsing.

We have not found much evidence in the literature on the need for the full web on mobile devices, although we have come up with this need in several user studies of ours. Kaasinen (2005 p. 82) noted that despite technical problems, users appreciated access to the full web because it provides a good selection of services and each service contained a good amount of information. Market analysts do expect mobile access to internet to increase, especially in emerging markets, as explained in chapter 1.1, Relevance of mobile internet access.

2.3 User experience

There are many perspectives to user experience. Norman and Jordan list the *goals* of a successful product: to engage users on behavioral, visceral, and reflective level (Norman 2003), or to provide users functionality, usability, pleasure, and pride (Jordan 2003). Nokia follows these lines by stressing wow, flow, and show factors (Nokia 2005). All three definitions agree that in addition to behavioral level, which includes the right functionality and usability (flow), there is also visceral level (pleasure, wow) and reflective level that includes the self esteem of owning the product (pride, show). The reflective level by Norman (2003) includes also other properties specific to human thinking or emotions such as moral and empathy.

In order to reach the above goals, we need to identify the *building blocks* of user experience. There are a number of researchers who have investigated user experience from that perspective, and this dissertation takes this perspective as well. In this section, I will analyse the user experience definitions by Mäkelä & Fulton Suri (2001), Hiltunen et al (2002), Arhippainen & Tähti (2003), and Hassenzahl & Tractinsky (2006) to get an understanding of the building blocks of user experience on a general level.

Mäkelä & Fulton Suri (2001) (further explained in Kankainen (2003)) define user experience as "a result of a motivated action in a certain context. The user's previous experiences and expectations influence the present experience, and the present experience leads to more experiences and modified expectations" (Figure 3).

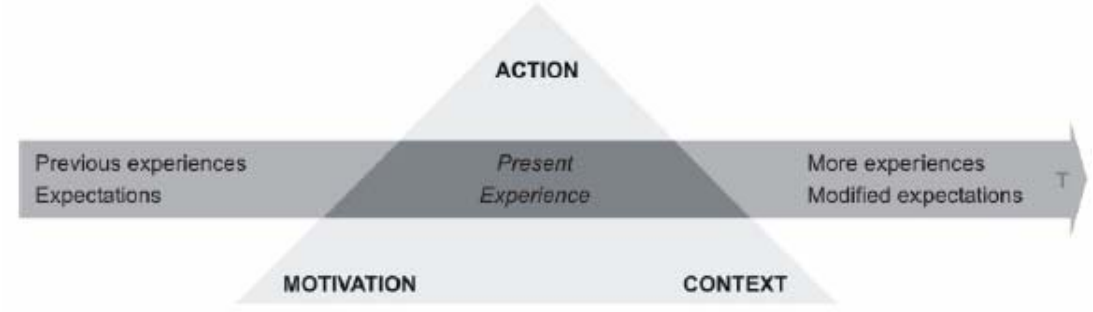


Figure 3. User experience definition by Mäkelä & Fulton Suri (2001).

This research has the merit of showing how important user's changing expectations are in user experience. Also Hiltunen et al (2002) list expectations as an important building block of user experience (Figure 4).

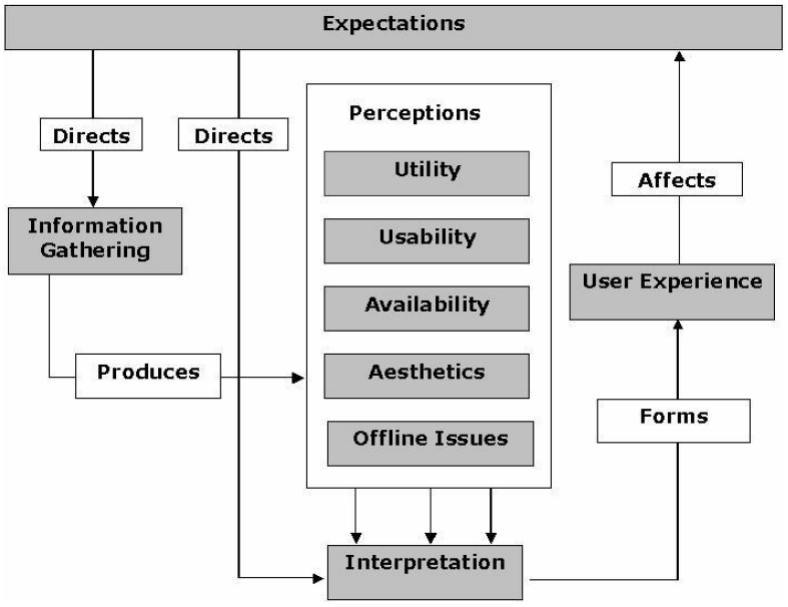


Figure 4. The user experience cycle by Hiltunen et al (2002).

Hiltunen et al (2002) base their model on Neisser (1976), where user's mental model, schema, directs exploration of information and thereby the selection of objects for use, and the objects used modify the schema. Table 1 shows the components perceived by the user when using an object, which are interpreted before a user experience is formed.

Component of Perception	Definition
Utility	The user perceives the service as providing the kind of services that he or she finds valuable
Usability	The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. (ISO 9241-11)
Availability	The service is available when expected
Aesthetics	The user finds the look and feel of the service appealing
Offline issues	This is an umbrella category containing such things as brand (i.e. which company is providing the service) and the supporting backend business processes (e.g. how quickly net store can deliver).

Table 1. Components affecting interpretation of system use by Hiltunen et al (2002).

Forlizzi and Ford (2000) investigate what influences user experience by investigating the characteristics of a user-product interaction, and what surrounds it (Figure 5). The prior experience appears as one of the attributes in this model as well.

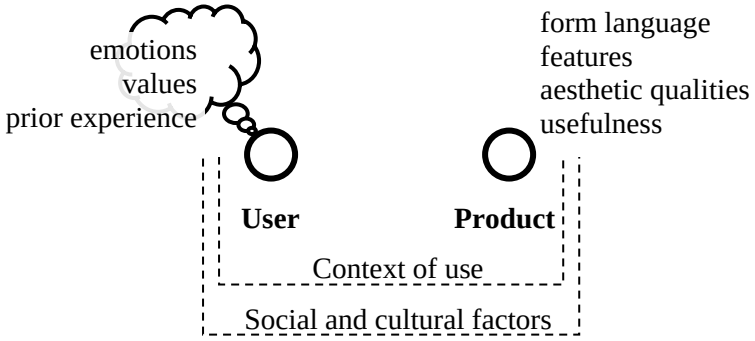


Figure 5. Influences on experience by Forlizzi & Ford (2000).

Arhippainen and Tähti (2003) list five components affecting user experience and a good amount of attributes for each component (Figure 6). They list specific attributes such as age of the user, symbols as cultural factors, or weight of a product. Listing all the user experience building blocks in this level of detail is very challenging, so I try to combine these items to higher level attributes. Age does not influence user experience as such, unlike the mental and physical resources as well as the previous expectations that are somewhat related to age. On product side, functions, size, weight, language, and symbols influence the usability, usefulness, and appeal of the product, so I think they do not have to be listed separately. I also see that the cultural factors influence the user and social context, and are not a separate topic. Social factors fall inside the Context of use.

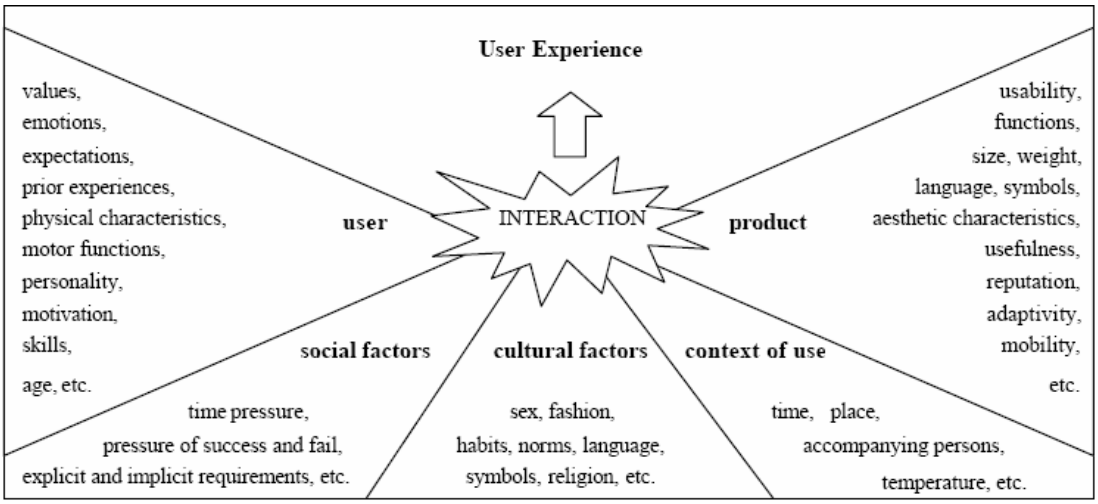


Figure 6. User experience components by Arhippainen & Tähti (2003).

Hassenzal & Tractinsky (2006) discuss the different approaches to user experience definition, and define it as "a consequence of a user's internal state (predispositions, expectations, needs, motivation, mood, etc.), the characteristics of the designed system (e.g. complexity, purpose, usability, functionality, etc.) and the context (or the environment) within which the interaction occurs (e.g. organisational/social setting, meaningfulness of the activity, voluntariness of use, etc.)." Hassenzahl & Tractinsky did not present a graph of this definition, but I took the liberty of presenting the definition in a graphical form (Figure 7).

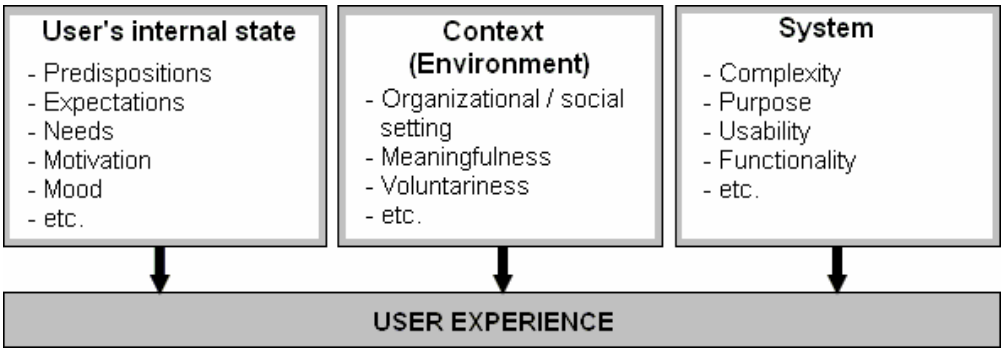


Figure 7. User experience definition by Hassenzahl & Tractinsky (2006).

All the aforementioned definitions agree that user's internal state affects user experience, so user experience is personal. All definitions agree also that previous experiences and expectations affect user experience. When the user has a need and motivation, s/he will act and execute the task, which then provides a user experience. The current mood of the user affects, for example, her/his patience.

The difference between usability and user experience is said to be about emotions: while good usability means the lack of discomfort, good user experience means delighting the user (Blythe & Wright 2003, Hassenzahl & Tractinsky 2006). Good usability is required for a great user experience, but it is just one part of it.

User experience is unique, depending on the current user's internal state and the context. This is why one cannot design an experience, but rather design *for* an experience (Wright et al 2003). Many product designs aim to produce some specific emotions, such as pleasure or excitement. It is even harder to design for a specific emotion than for positive user experience in general, because the users and use contexts change (Mäkelä & Fulton Suri 2001, McCarthy & Wright 2004 p. 11).

Hassenzahl (2003) provides a good example of the effect of user's internal states by distinguishing between two different use situations: goal mode and action mode. In goal mode, the user mainly wants to achieve a goal, such as finding out a bus timetable. In action mode, the user mainly wants to find stimulation, like when killing time by browsing some web sites. The demands for positive user experience in these two cases are very different. Hassenzahl (2003) concludes that each product can be used in both modes, so both stimulation and effectiveness should be available for a user.

2.4 User experience in web browsing

Surprisingly, user experience literature is often solely about web site user experience. Garrett (2002) defines web site user experience by investigating site strategy, scope, structure, skeleton, and surface. Garrett's book is aimed to help web site developers in designing web sites that provide a positive user experience.

The Observing User Experience book by Kuniavsky (2003) is also largely about web user experience. It does briefly point out that user experience is affected by the site, browser, and the use environment, but the focus is clearly in evaluating the user experience of a site being designed. Although the PC hardware or connection speed do not affect user experience when using a PC for web browsing, in mobile case these attributes have a significant effect on user experience.

Jennifer Fleming investigates the navigation aspects of a web site in her book Web Navigation: Designing User Experience (1998). The book has been written in the early days of the web, so she notes the establishment of the connection, browser, URL entry, connection speed, and site usability do affect user experience (p.4-5). Since the book is about navigation, she does not analyse these aspects further.

2.5 User experience in mobile context

Dey and Abowd (1999) define context as "any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves." In the field of context-aware computing, the system tries to detect contextual information based on which the system adapts its functionality (e.g. Korkea-aho 2000). When we investigate how context affects user experience, we look at the context from a bit different perspective, because the user him/herself perceives context. For example, the user knows her/himself, so unlike a context-aware system, the user does not have to think about identity, or physiological state. Instead, the user senses or knows many such details about the environment that a technological system is unaware of, e.g. beautiful or surprising views, social rules, and temporal tensions.

Mobile context is very different from stationary desktop environment, so a set of researchers have started to investigate the effect of mobile context to user experience. Jones and Marsden (2005, p.52) note that people make use of interdependent resources and activities

as they work to achieve their goals. They quote Nardi and O'Day (1999, p.49) to get the role of mobiles into perspective: "We define an information ecology to be a system of people, practices, values, and technologies in a particular local environment. In information technologies, the spotlight is not on technology, but on human activities that are served by technologies."

So, researchers should go to the real mobile context to understand the information ecology. Or should they? Kjeldskov (2004) and Kaikkonen et al (2005) have studied the possible differences in usability test results when testing in a laboratory versus in real mobile context, and concluded that for basic software interaction related usability, mobile context does not provide any better results than a laboratory context. However, when investigating overall user experience, not basic software interaction related usability, the mobile context is a central influencer that cannot be neglected.

How is mobile context different from laboratory environment? What are the user experience building blocks that a researcher should pay attention to when out in the wild? The physical context includes everything we can see or feel, the tangible physical surroundings, temperature, and lighting. Also the current location and noises around are part of the physical context (Schilit 1994).

Kim et al (2005) have two main level components in their research on the use contexts for mobile Internet: product and context. They divide the mobile context into personal and environmental context, where personal context includes internal context (goal, emotion) and external contexts (hand, leg), and environmental context includes physical context (visual and auditory distraction) and social context (co-location, interaction). I think in user experience research, user has to be separated from context, because user is the main focus of interest, the one to have the user experience.

Tamminen et al (2004) investigated multitasking, personal and group spaces, and temporal tensions in mobile context. These can be derived to Task context, Social context, and Temporal context that all describe the different dimensions of mobile context. Oulasvirta (2006) investigates the interruptions in mobile context and their effect on interaction with technology. Interruptions are part of the Temporal context and closely related to the Task, Social, and Physical context.

2.6 User experience in mobile browsing

The specific case of mobile web browsing user experience has not been investigated thoroughly. There is not a single publication that would list all characteristics of mobile browsing user experience, but the findings are scattered in this research domain.

Palen and Salzman (2000) investigated mobile phone use in general with novice users, and found that the customer experience reached beyond usability of the phone, from hardware and software to "netware" and "bizware". Netware included the availability of cellular network as well as the services the operator provided, e.g. call waiting and call forwarding. Bizware included calling plans, phone bills, sales, marketing, customer service, and manuals.

Also Jones & Marsden (2005) see that interaction design should address not only software and hardware but also product identity and the whole package presented to the user, including the marketing, customer care, charging plans, etc. The goal is to provide a "solid, distinct, understandable, trustworthy, and satisfying user experience".

Hjelmeroos et al (2000) investigate usability of the mobile web browser in Communicator 9000, and list findings that are related to the user interface style of Communicator, page visualization method, connection, and the sites. Their finding was that both consistency and inconsistency between the PC browser and a mobile browser is desired, and it is very hard to predict which is preferred in a particular case.

Hiltunen et al (2002) give many examples of mobile browsing in their book, and mention the following aspects influencing mobile user experience:

- User: Needs, goals, tasks, interpretations of the world, cultural context, personal characteristics, skills, interaction techniques
- Task space: multitasking, interruptions
- Physical context
- Social context
- Technological context
- Privacy, security
- Device: Processing power, memory and power consumption, user interface styles
- Connection: network unreliability, varying bandwidths

The items above provide the most comprehensive set of characteristics affecting user experience in mobile browsing; they just need to be mapped under the three high-level user experience factors: User, Context, and System. For example, the technological context is more about the earlier experiences and knowledge of the specific *user* than about the surrounding *context*. No matter what kind of technology there exists, users' understanding of the technology defines the specific user experience.

Some of the above items can be grouped to a higher level term. E.g. privacy of a service is important, but if the user trusts the service provider, s/he has the confidence that the service provider does not violate her/his privacy. So privacy is included in Trust attribute.

2.7 Designing and evaluating user experiences

It is interesting that many definitions of user experience define in fact the process of designing systems that could then produce intended user experiences. They often lack the definition of what is the target of the process, what is the user experience and how it can be measured to check if the target was achieved. Because the user experience is understood in so different ways, also user experience evaluation is done in many different ways.

For web sites, the simplest user experience measure used is to check how many visitors come to the web site. The same applies also for WAP sites. We have seen, however, that the plain hit count does not necessarily mean that the site provides a positive user experience, because just by defining the right keywords the site is ranked high in a search tool and lots of people come to check the site. Nobody knows whether they are pleased or not with the site, although the site gets lots of hits.

Ellis & Ellis (2001) address web site user experience measurement from the site owner's perspective, but propose user centered methods for measuring. The site owner defines what kind of experience the site should provide, and measuring the site is done against this criteria. They list usability testing, focus groups, contextual research, site evaluations, online evaluations, and measurement tools as possible evaluation methods. I believe this

comprehensive set of methods will reveal not only whether the site owner's goal is reached, but also what the users expect from the site.

In scientific publications, the most popular way to evaluate user experience is to investigate the emotional state of the users. In Experience Sampling Method (Csikszentmihalyi & Larson 1987), the users are living their normal life during the study, but are asked to fill in short questionnaires about their activities and feelings several times a day. This method is used in psychology, and it helps understanding the use contexts and users' emotional states. Isomursu et al (2004) utilized a camera phone and asked the users take short video clips during a field trial showing their experiences with the system. They found that this Experience Clip method fits to mobile context better than pen and paper methods. The method motivated the participants to shoot funny, exaggerated clips and even invent new uses for the system.

According to Mäkelä & Fulton Suri (2001), "the user's previous experiences and expectations influence the present experience, and the present experience leads to more experiences and modified expectations". This indicates that we should understand users' expectations to be able to analyse the reasons for the current experience. Tähti et al (2004) have used Emocards by Desmet et al (2001) for gathering emotional feedback on system use. This study has the novelty of measuring user's mood before the system use, not only during and after the use. I see this as the first step towards evaluating user experience by weighing *expected* experience against *realized* user experience. User experience evaluation is discussed further in chapter 9.3, Evaluating user experience.

2.8 My view to user experience

In this dissertation, I aim to identify characteristics, or building blocks, of user experience. To be able to do this, I need to narrow down the broad scope of user experience. First, I will start by investigating user experience of a use case, not the overall user experience. Here I utilize the idea of Forlizzi & Battarbee (2004) that the overall user experience consists of smaller experiences. Second, I will talk about user experiences, not all experiences.

2.8.1 User experience in a use case

I see the attitude towards the examined piece of the system being very close to the concept of "overall user experience", so the attitude formation theories may be applicable also for user experience research. I am not capable to analyse how attitudes are different from user experiences, but to my understanding, emotional attachments do not fall inside attitudes, although the emotional relationship between a system and the user is an important part of user experience.

Use cases are a relevant part of my user experience theory, since they provide concrete material both for designing and evaluating user experience. I realize the traditional meaning of use case implies a goal for the interaction, but user experiences are not always goal-oriented, at least not conciously. I want to broaden the concept of a use case to cover all interaction with the examined piece of a system, whether it is one-way or two-way, purposeful or not, changing system state or not. The use case has a definitive beginning and end, but the reference period may vary as needed: one use case may mean a click of a key, fiddling with a device while talking to a friend, the day carrying wearable computing equipment, or an email discussion extending over several days.

The user experience in a use case is formed based on perception and emotional judgement of a specific part of a system after interacting with it. The perception of the system is affected by the user's state, context, and system's interface. The resulted user experience typically affects user's state, which in turn influences the forthcoming user experiences.

The user experiences from use cases do not form the overall user experience alone, but together with attitudes and emotional relations not tied to the use cases. To be able to talk about user experience, we demand at least one use case with the system. The existing attitudes and emotional relations before the first interaction case only form *expectations* for the forthcoming user experience.

According to Wright et al (2004), user experience may change after the actual use case; this phenomenon is called reflecting. If the user has obtained new perceptions or information concerning the system after the use case, these may change the overall user experience. For example, if a friend praises her system, it may change user's attitudes towards this system, which in turns changes the overall user experience.

In summary, I claim that the overall user experience is formed out of use case experiences and perceptions and information received outside the use cases. The overall user experience affects the user experience of the next use case. This model of user experience formation is illustrated in Figure 8.

While the top part in Figure 8 illustrates the role of use cases in overall user experience formation, the bottom part of the model lists the building blocks of user experience in a specific use case. Following Hassenzahl & Tractinsky (2006), the use case model consists of three main factors affecting user experience: User, Context, and System. The interaction takes place within a context, and the context is likely to affect both the user and interaction, sometimes also the system (e.g. context-sensitive systems).

User's state includes the motivation and the mental and physical resources available for interacting with the system. User's current emotional state, knowledge, attitudes and expectations affect the perceived user experience as well. Context refers not only to the physical surroundings but also to the social and temporal context, as well as the task context that is related to the current motivation for interaction. The different contexts are explained in chapter 5.6, Mobile context. The system includes all parts of it that are needed or otherwise involved in the interaction. I see it very useful to examine a product as a part of a bigger system, not as an isolated object. This is why I have listed several different types of system components under system, but not all of them are relevant for each use case.

This is a high level model hiding even important details. For example, company image and brand are not visible, although I very much agree they do affect user experience. I think company brand and image affect a use case through the attitude that is listed as one attribute in user's state. Information and images about several companies form attitudes, and attitudes are the high-level attribute affecting user experience.

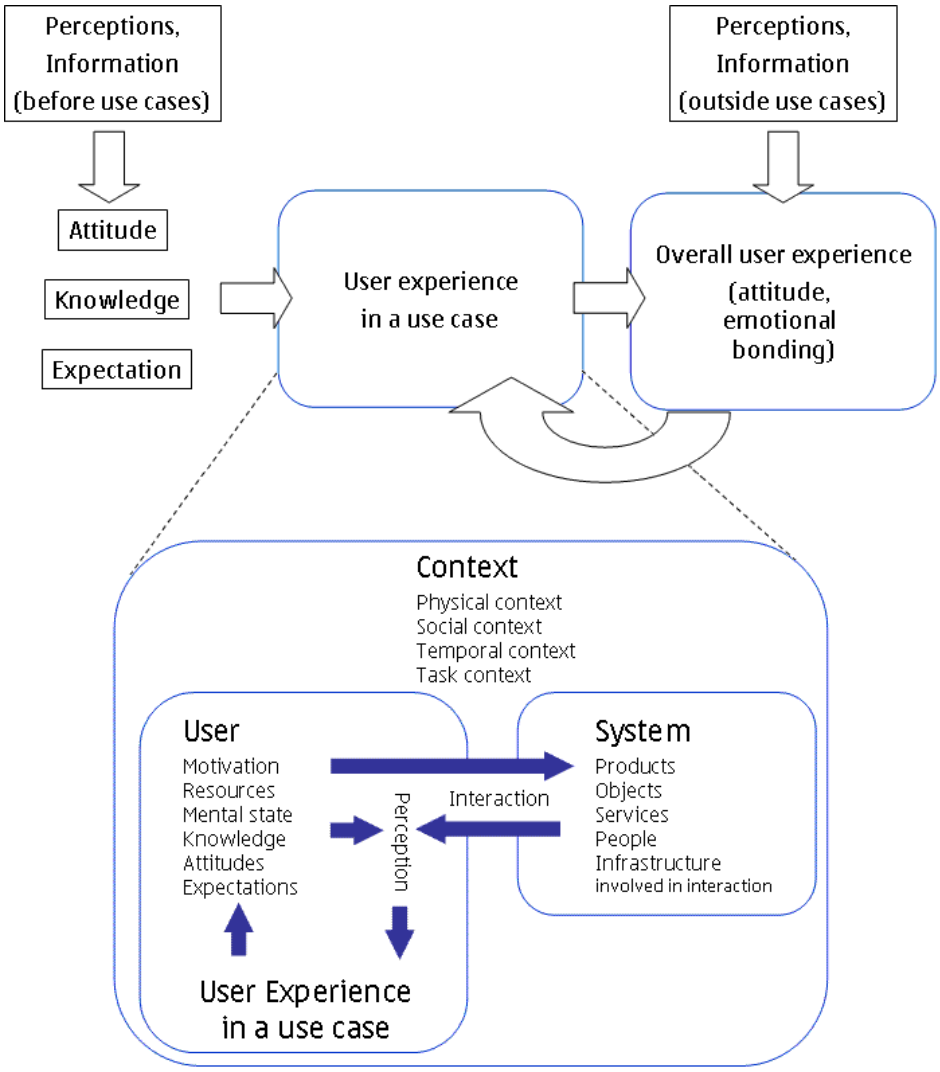


Figure 8. User experience building blocks

2.8.2 Experience or user experience?

Forlizzi & Battarbee (2004) use the term experience, not user experience, when referring both to the case where a person uses a system and the case where the user experiences just the context, e.g. walks in a park. In my model in Figure 8, user experience requires interaction with a system. I think we need to make a difference between "experience" and "user experience", otherwise the variety of different types of experiencing cases is too big to get hold on. Making this difference would help us to understand what is meant by experience or user experience, to identify the factors affecting user experience, and also to evaluate (user) experience in a systematic way.

Experience itself is mostly studied in the field of art and psychology, pioneered by John Dewey (e.g. Dewey 1925,1934), and the key is to understand how the current experience is related to sensations, perceptions, emotions, and earlier experiences. User experience builds on top of experience research by adding knowledge about two-way interaction with a system.

I claim that user experience is a special case of experience, where the person can *use* a system, with or without a purpose. Using means that the user not only senses the system, but also has the *opportunity to manipulate or control* the system. The system is a product, object, or a set of them; service systems often involve a human being such as a librarian. If there is no system at all, or if the person cannot control the system, we should use the term experience instead of user experience. A roller coaster and a billboard are examples of systems that a person cannot control. In these cases, the "system" is just part of the context and we cannot talk about user experience, but plain experience.

The above distinction between experience and user experience is inconsistent with many user experience definitions which state that visiting a museum or an event creates a user experience. I disagree. A concert is an experience, not a user experience, even if the person interacts with the artists by cheering or applauding. The concert is not meant to be controlled by a single member of the audience. Visiting a museum is an experience, not a user experience. However, if the person uses some kind of museum guide or interacts with a piece of interactive art, the museum provides the *context* for the user experience where the system in question includes the guide or the piece of interactive art. Similarly, traffic lights beside the road act only as context for car driving user experience. All tools typically create a user experience, because they are used to manipulate some parts of the system. A web site creates user experience, because the user manipulates it by controlling which pages are shown and when. The same applies to monitoring systems used in control rooms: a user can typically control which views are shown to him, even if he could not manipulate the actual object being monitored through the system.

3. RESEARCH QUESTION

Although user experience as a term is widely used especially in the industry, there is no specific, comprehensive definition for it in the literature (Hassenzahl & Tractinsky 2006). The user experience research has identified three high-level factors affecting user experience: user, context, and system. These are not always articulated clearly, but appear there in a form or another. User's earlier experiences, the current mental state, the mental and physical resources, and expectations affect the current user experience. Each user experience is unique. The system refers to the product or service infrastructure that the user is interacting with.

It seems very demanding, if not impossible, to list the measurable attributes of user experience for all types of systems (products and services) and contexts out there. However, the comprehensive set of components is required in order to design and evaluate user experience of a specific system. Even if one wants to evaluate user experience of a single system component, e.g. a web site, one needs to be aware of the other components and how they might affect user experience. Otherwise, it is impossible to control the variables in user studies and identify the real sources of disappointments or delights. For example, a very attractive design of a handset is likely to affect the overall user experience when testing a site with the handset.

I saw the user experience definitions even for the specific case of web browsing on desktop computers insufficient for the case of web browsing on mobile phones. The model about web browsing user experience in the current research covers mostly site design, but rarely the other system components required to get the page presented to the user, such as the mobile device and connection.

In Figure 9, I have collected the mobile browsing user experience characteristics found from the related research. Items in italics are rarely mentioned in user experience literature.

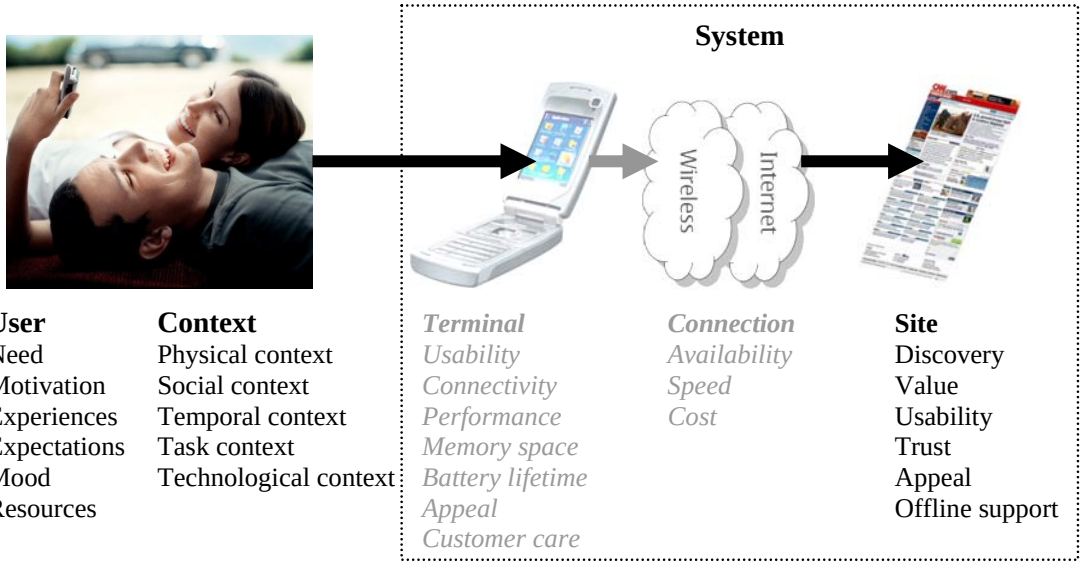


Figure 9. The components affecting mobile browsing user experience according to previous research

My hypothesis is that the existing knowledge about the factors influencing user experience in the specific case of web browsing on mobile phones is not comprehensive. The goal of my research is to fulfil the list of the components and attributes that may affect mobile browsing user experience, and verify that the rarely mentioned items do have an effect on user experience.

Thus, my main research question is:

What are the attributes affecting user experience when browsing web pages on mobile phones?

It seems a mobile browsing system is an interesting domain area for user experience research, because many user experience researchers find the web, mobile phones, or mobile contexts interesting areas for user experience research. This dissertation investigates these three combined. Mobile browsing includes many non-trivial aspects indeed:

- Mobile browsing requires a mobile device, connection, and web sites. Each of these is provided by a different party, and each party may aim to deliver conflicting experiences.
- Mobile context provides a different use context from office environment for web browsing.
- Mobile phone is a very personal device that users have an emotional relation to.
- Mobile browsing should fulfil both utilitarian (find a specific piece of information) and hedonic (entertainment while waiting) needs, the right balance depends on the case.
- Mobile web browsing may have complex billing models.
- Because mobile browsing technology is immature, each component is clearly visible when evaluating user experience.

Because of the above reasons, this domain area provides interesting information about the building blocks of user experience. This research results to new knowledge also about user experience in general.

4. RESEARCH FRAMEWORK

The research in this dissertation falls inside the human-computer interaction (HCI) science. My research reaches to several disciplines within or closely related to the human-computer interaction science: experience design, cognitive science, information visualization, and computer science. Also, some aspects of the research are close to psychology and social psychology and some other aspects to the science of commerce.

There are at least two different classifications for user experience research. First, Forlizzi and Battarbee (2004) present the following classification: Product-centered approach studies how to create compelling products; User-centered approach aims to better understand users' needs, goals, behavior, and emotions; Interaction-centered approach studies the role of products in bridging the gap between designer and user. This dissertation is closest to the Product-centered approach. Second, Hassenzahl and Tractinsky (2006) divide the research to 3 categories in a different way: Beyond the instrumental, which studies the non-instrumental, hedonic needs of users; Emotion and affect, which studies the emotion and affect mainly before and after product use; Experiential, which studies the components that have an effect on experiences. This dissertation falls inside the last category.

4.1 HCI Perspective

We have followed the human centred design process for interactive systems defined in the ISO 13407:1999 standard (Figure 10). My research has followed the typical route of a researcher: I started with constructive research, trying to find solutions for existing problems such as which kind of user interface works for WAP 2.0 sites, or which kind of visualization method is the most usable when showing large web pages on small screens. We used empirical methods to evaluate our designs. Through the contextual user interviews, I noticed tackling these issues is not enough, but the overall user experience was influenced by many other factors than just the site and the browser. My reseach shifted towards exploratory research, trying to identify the components that affect mobile browsing user experience.

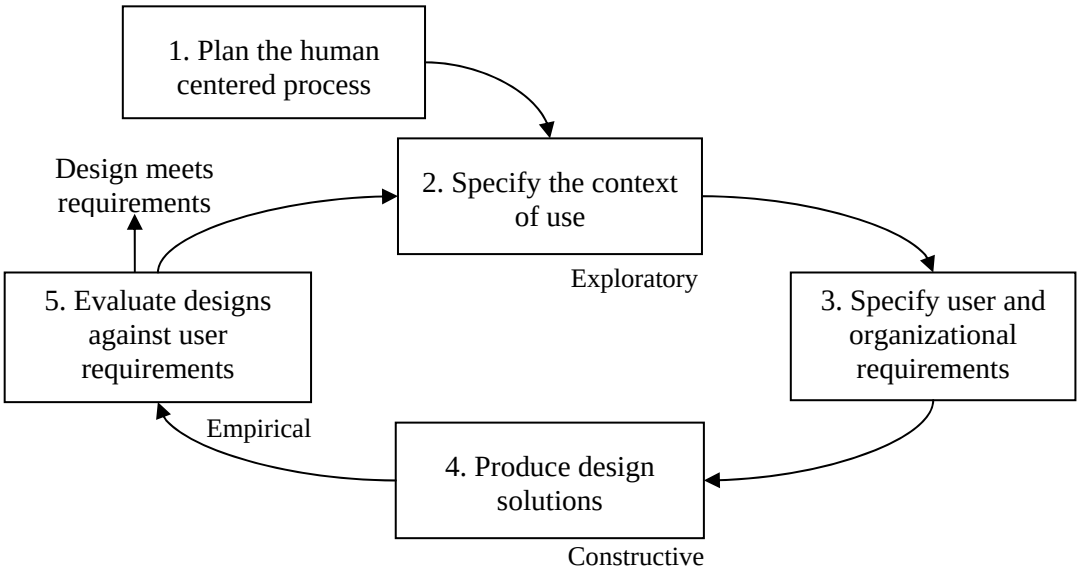


Figure 10. Human centred design process (ISO 13407) with research methods.

As my background is in computer science and in human-computer interaction, the perspective of my research is limited to this framework. When running the user studies and analyzing the data, this perspective inevitably affects the results.

Psychologists and industrial designers are experts in investigating why people feel the way they do, and how the experiences are born. This is important to better understand different types of experiences. People with HCI background typically investigate what the users' mental models of the system are like and then try to understand why users think the way they do. In the two hypothetical interviews of a mobile browser user below, I illustrate the different interests of these two points of view. I call them Psychological and HCI approach, although the line in between these approaches is thin.

Psychological approach

User: <Looks frustrated> This is slow.

Psychologist: How do you feel about it?

User: I hate waiting.

Psychologist: So for you, it is important that it is fast?

User: The faster the better. This is just much slower than what I'm used to on a PC.

Psychologist: Did you expect it to be faster?

User: Yes, but I do understand a mobile phone cannot be as fast as a PC.

HCI approach

User: <Looks frustrated> This is slow.

HCI specialist: What makes you think so?

User: It takes so long after a click to see the page coming.

HCI specialist: What do you think makes it slow?

User: Well, the connection here is much slower than on my PC. This is a heavy page as well.

The psychological approach successfully discovered that the user looked frustrated because he hates waiting and because the system response times did not fully match his expectations. The HCI approach discovered that the user wants at least some parts of a page to be visible on the screen as soon as possible, and that the user understands the response time being dependent on connection speed and page heaviness. The psychological approach revealed us more about user's emotions, whereas the HCI approach did not verify what exactly the user felt, except that he looked frustrated about the slowness. The psychological approach did not result to design requirements, whereas the results of HCI approach might help the designers to provide useful information for the user.

My goal was to gather user needs for the browser, so I applied the HCI approach in the user studies. I am aware that I lack the ability for executing detailed experience analysis on emotional level. My analysis is limited to the level of positive, neutral, or negative user experience, not investigating more specific emotional states of user experience.

4.2 Methodology and Implementation

I started to investigate mobile browsing in usability tests in laboratory environment. First, we conducted a comparison test for evaluating usability of different UI styles for WAP sites **(Paper I)**. In this study, we analysed the usability problems that we witnessed the users to face with each of the UI styles. In the analysis phase, we noticed that the results were two-fold: site-related usability problems and browser-related usability problems. In this

comparison test, the usability problems were identified by observing how users find functions, by listening to their verbal comments while executing given tasks, and by examining the ratings they gave for each UI style after testing it.

The next study about a Narrow layout web browser **(Paper III)** was a traditional usability test, where the users browsed their favorite web sites with the mobile browser. As in traditional usability tests, we gathered data by observing users' actions, listening to their comments while executing tasks, and by asking them to rate ease of locating hyperlinks on the pages and the utility of web browsing on a mobile phone.

We also conducted a study where usability was not in focus, but rather user behavior in mobile context while browsing the web on a mobile phone. This was an extensive, quantitative study where we examine users' attentional resources with long response times in different types of mobile contexts. The test setup was very interesting, since recording device interaction, user's eyes, and the environment was a challenging task with portable and unobtrusive equipment. In the data analysis, we recorded the status of page loading, type of mobile context, movement method, and focus of attention (device / environment) with time stamps from a video quad. We then calculated the length of continuous attention span to the device after starting to load a page. We also calculated the number of times the user switched attention between the phone and the environment during the longish response times of web pages. The test setup and data analysis is described in Roto et al (2004).

When we started to design a usable web page visualization method for small screens, we did not have any prototypes for usability tests, just the existing mobile browsers out there. We understood that to fulfil user needs, we have to learn more about the motivations and usage patterns of people who use mobile web browsers. We started a series of semi-structured in-depth end-user interviews following the guidelines of Contextual Inquiry and Contextual Design (Beyer & Holzblatt 1998), which are recommended methods to ensure good user experience (Kuniavsky 2003 p. 160-182, Vredenburg 2002, Fleming 1998 p. 82). By using these methods, we get reliable information about individuals' mobile browsing habits and motivations, to the level of interaction with the device. We soon noticed that it is hard to get to the real contexts of mobile browsing, because interviewing in a crowded bus is quite impossible and moving between the locations where people do mobile browsing would be time consuming and laborious. In the first study, only one interview was executed in mobile context: while sitting in a long-haul train. The other interviews of the first study took place in a comfortable laboratory environment, but to get an idea of the context, we asked the users to describe the environment of the browsing cases that we were replaying.

As soon as we had the first prototype of our web page visualization method, we tested it in a lab using a traditional usability testing method. This gave us valuable information for further development of the method, and after some small lab evaluation rounds, we were ready to give the prototype out for 20 participants to be used for 8 days on the field. In this long-term field study, users executed web browsing tasks sent for them daily, and they were encouraged to use the browser as much as possible for their own needs. Again, we compared our method to the state-of-the-art method used in commercial mobile browsers by letting the participants use each browser for 8 days. We collected data from task-specific easiness ratings, diaries, post-test ratings, and focus group discussions. The studies are reported in **paper VII**.

We have continued the contextual inquiry studies in different parts of the world: Helsinki, Boston, Tokyo, and London. We have run 35 interviews altogether, 6-9 interviews per study (Table 2). We interviewed users who browse the web on their mobile device, but we have

broadened the focus step by step to cover all online traffic on handheld devices. A broader scope helps us to understand users' motivations and reasons for their usage patterns more thoroughly. WLAN users are interesting interviewees, because they have a fast and free connection even on their handhelds. They provide us a preview of the future of mobile browsing. This is why we have run some studies concentrating solely on WLAN usage.

	Location	Interviewees	Time	Scope
1.	Helsinki, Finland	6	2/2004	Web pages on small screen browser
2.	Boston, U.S.A.	9	10/2004	WLAN browsing on laptops and PDAs
3.	Helsinki, Finland	6	3/2005	WLAN browsing on Nokia Communicator
4.	Tokyo, Japan	7	5/2005	Internet access on handhelds
5.	London, UK	7	11/2005	Internet access on handhelds (WLAN/3G)

Table 2. Our Contextual Interview studies on mobile browsing

In the interviews, we have the best chances to understand all the system components that affect user experience in mobile browsing. The data comes both from participants' stories and from observing how they use the mobile browser. Typically, we first discuss with the interviewee to find out their background and daily online routines, and then ask participants to replay their recent use cases. We listen to their comments about the device capabilities, browser user interface, connection speed and cost, and utility of the web sites that they access via a handheld device. If they do not comment on these spontaneously, we ask them specifically at the end of the interview.

After the interviews, we follow the phases of Contextual Design: an interpretation session of the interviews, affinity wall building, and affinity wall walking. In the interpretation session, we write observations, use cases, user comments, and wishes down into a form of notes. Below, I present an example of each type of a note. The code in front of each note is a unique id for the note: the letter identifies the study (e.g. J for Japan), the first number the interviewee ID in that study, and the last number the note ID in that interview.

J2-9 When she got to the target page, she saved the page and exited the browser to cut the connection. Right after this, she accessed the browser again to read the saved page. She thinks she can save money by minimizing the time the connection is on.

F1-53 He said he uses the 9500 Communicator instead of the laptop for browsing on the home terrace, because the 9500 display is brighter in sunlight.

L6-34 He said £5 for an hour of WLAN time in Starbucks is quite expensive.

U7-58 His number one wish was to have no fee for connection (from his PDA to web).

We typically collect 50-100 notes per interview, and 400-700 notes per study. The notes are categorized onto an affinity wall in a bottom-up manner during a group excercise, and the categories get titles to describe the basic idea of the category. There are three levels of category titles. Below an example of the titles for one category, built bottom-up starting by grouping individual notes (listed here only as note ids). Note that "I" is here a generic user's voice, it does not refer to any one interviewee.

3. To gain a browsing experience similar to a PC, I need a billing model similar to a PC

3.1 I want to control costs and know how to save in data expenses

3.1.1 I want controllable browsing costs
L2-26, L4-39, L2-46, L1-41, L6-19, L5-14

3.1.2 I don't have a clear picture about how my browsing costs cumulate
L1-40, L2-24, L4-11, L2-25, L5-57

3.1.3 I know how to save money when I check my email with my mobile device
L5-34, L7-43

3.1.4 I'm not cost sensitive about pennies
L5-59, L2-23

3.2 I want a reasonable flat rate

3.2.1 I'm ok with flat rates as long as they are reasonable priced and include enough of data
L5-58, L6-34, L5-19, L5-43, L4-54, L5-13

3.2.2 My online access habits depend on the available connection and its price
L5-56, L7-42, L4-44, L7-38

3.3 I don't want to pay for something that is available for free

3.3.1 I don't want to pay for mobile services / internet content
L3-27, L6-52, L7-52, L7-29

3.3.2 I would use games on the phone/PDA as long as I don't have to pay for them or they are reasonably priced
L1-33, L2-30, L2-28, L2-27, L6-51, L1-30

In the example above, collecting such a big number of notes about the importancy of price in mobile browsing shows that people constantly keep the price issue in their mind, consciously or not, and adjust their usage patterns to find a cost-efficient way of browsing. We have found the similar collection of price-related notes from each study, which shows that the phenomenon is not just a local peculiarity.

Mobile web browsing is a new technology and it was typically hard to find interviewees who have accessed full web sites via their handheld device. The ones we found were early adopters of the technology, except in Japan where mobile browsing was part of everyday life even for non-technical people. To the interviews, we did not accept professionals in telecommunications, so we hope the early adopters presented the use cases of the late adopters of tomorrow.

The target user group for mobile browsing in our studies has been S60 smart phone users. Smart phone users are typically relatively willing to use new technology and familiar with PC browsers. However, they do not necessarily have previous experience on mobile browsers. We have put effort on finding heterogeneous participants for our usability studies, and run the studies with participants of different backgrounds, genders, ages, and previous mobile browsing experience. Our aim has been that various different user groups could benefit from the findings, and that the user groups for mobile browsing could be as heterogeneous as the user groups for PC browsing today.

5. RESULTS: ATTRIBUTES AFFECTING USER EXPERIENCE IN MOBILE BROWSING

The focus of this dissertation is to examine which components and attributes in the system affect mobile browsing user experience. Figure 9 described the characteristics that previous research has identified to affect web browsing user experience. In this chapter, I describe our findings not only about the known characteristics but also about the new ones that are missing from Figure 9. The results are based on the user studies explained in chapter 4.2, Methodology and Implementation. Many, but not all of the findings are described in the publications included in this dissertation.

In addition to the findings that identified user experience characteristics, explained in this chapter, we have also run user studies on the mobile browser prototype that we have developed. The results from the browser studies are discussed in chapter 6.

5.1 Sites

Many publications about user experience concentrate a lot in web site design, and the web site is obviously an important component also in mobile browsing user experience. As the trend is to link other sites closely together (payments on another site) and even to combine information from many sources onto one site, we should increasingly think not only about one site but a combination of related sites. Below, I present our findings about site discovery, perceived value, usability, familiarity, and appeal.

5.1.1 Discovery

Finding a site or page on the web is not an easy task, since there are more than 50 billion public web pages out there (Gil 2006), and the number is quickly increasing. Web search tools such as Google and Yahoo are elementary when discovering a piece of content from the web. Although the browsers provide page bookmarking mechanism and auto-complete for URL entry, users seem to increasingly count on web search engines when locating even familiar pages.

In our XHTML site study, we were surprised how eager the participants were in using keyword search within the site even with the numeric ITU-T keypad of a mobile phone **(Paper VI)**. Search is one of the use patterns of web browsing that are so strong on a PC that people use them on a phone as well, even if the keyboard is much more limited. Search provides often the shortest way to the target page, so entering a keyword may be less time consuming than navigating through several pages over a slow connection. Cost-concious users also know that they can save data traffic costs by using search and thereby minimizing the amount of pages loaded.

In the contextual user interviews, we have seen search engines being used to avoid the heavy main page of a site. A user entered a set of keywords he knew would bring up a specific page on an online banking site. Unfortunately, this time the search tool provided him a different set of results, and he had to find the correct set of keywords to find the wanted page. He seemed motivated to learn the right keywords to be able to locate the page easily on a search tool in the future.

5.1.2 Value

A frequent question for web browsing on a mobile phone is utility: does anyone really need to access web sites on a mobile phone? We have discussed about mobile browsing use cases with more than 50 mobile browser users, and they all are convinced that Internet access on mobile devices will increase in the future. Many of the interviewees could be seen addicted to mobile browsing, since they used the browser even when their closest people (e.g. family) did not like it. Some kept the mobile phone on the bedside table so that they could browse right before going to bed, first thing in the morning, and even when waking up in the middle of the night. Being addicted is not a good thing, but it shows that the utility of mobile browsing is very high at least for these early adopters.

I saw the most advanced mobile browsing culture in Japan, where even non-technical house wives use mobile services. Mobile browsing was nothing special for them, but an everyday tool to get information about train routes, for example. The interviewees discussed about the available new mobile services with their friends, and were interested to try out these new services.

When we moved from usability tests to user needs studies, we realized that email is the number one reason to get online on handheld devices. Not all email systems are on the web, but an increasing number of people are using Webmail in addition to, or instead of corporate email. If one has Webmail, the motivation to access the web on a mobile device is high. Webmail is one of the most important use cases for a mobile browser.

Utility and usefulness are terms used in traditional human-computer interaction. User experience and technology acceptance researchers rather talk about *value* (Kaasinen 2005, p. 73), which covers also useless but pleasurable use cases. When one has some time to kill, one may start mobile browse entertainment sites, or sites that do not provide any “useful” content. This type of mobile browsing is not highly useful, but it has the value in entertaining the user. This is why I prefer term *value* to *utility*.

The penetration of Internet access on PCs is very high, and we believe that as life goes mobile, mobile access to Internet will be an integral part of the lives of our children. This requires, of course, that we are able to improve the mobile browsing user experience. The value of having web access available also in mobile contexts will be as high as the value of the web on PC today.

5.1.3 Usability

A web site designed specifically for a particular type of a device often leads to best usability. The amount of content on one mobile optimized page is much smaller than on a page designed for a large desktop screen. This makes it much quicker and less expensive to load over a slow connection and easier to view on a small screen.

WAP 1.x sites consisted of cards instead of pages, because the page size was typically comparable to the size of a playing card instead of an A4 page. To make moving from card to the next one quick, a deck of cards was sent to the mobile device at once, and the first arrived card was visible and interactive as soon as it arrived.

The amount of different types of devices was vast already back then, so making the WAP site look nice on all of them required laborious implementation of different versions of the site. Also, developers of HTML sites found it hard to understand how to write deck sites

with WML. End users found WAP sites boring because there were limited possibilities to play with graphics on cards. WAP 2.0 introduced Cascading Style Sheets (CSS) that make authoring for different types of devices much easier, and XHTML Mobile Profile that is very similar markup language to HTML. In fact, it is so similar that one can view the XHTML MP sites on a desktop browser. This was the first big step towards the One Web goal of W3C (2006).

Getting rid of decks and cards meant a change in site structure. We have investigated how WAP 2.0 site structure affects its usability and what are the best working user interface styles for a site **(Paper I)**. At the time, there were no WAP 2.0 sites alive, so we developed dummy sites (with no dynamic content). We compared 3 different user interface styles for providing the same content in different ways:

	**Banana** "long content"	Long pages, flat hierarchy; Selection lists; Layout tables; Images
	**Orange** "slices"	Short pages, deep hierarchy; Multi-page forms; Choice for text input or value selection; Data tables; Small images
	**Apple** "for experts"	Keyword search prioritized; Accesskey shortcuts; Textual input; No images

We found that interactive pages need to be relatively short, but informational pages can be much longer. Participants were pleased to have enough of content on the target page after all the effort they made to get there. The navigational pages in between have to be short and without big images, since one wants to proceed from these pages as quickly as possible. We also found that it is laborious to return multiple pages back, so direct links to the site main page or subsection main page are recommended.

5.1.4 Familiarity

When viewing a large web page on a small screen, we noticed a significant difference in the frustration level of users depending on whether they were familiar with the page layout or not **(Paper VII)**. It is easy to understand that if the user knows the location of the needed link or the number of main colums on the page, they can navigate with the keyhole view much more easily than when you have no clue where to go next.

Another interesting finding was that the usage patterns that people have on a PC for dealing with sites should be possible also on the phone. Even if the patterns might not be highly usable on the phone, they have a positive effect to user experience. One of these patterns is opening several browser windows for viewing search results, which is a common habit of expert users on a PC (Aula et al 2005). Of course, the concept of several windows on a screen of 176x208 pixels sounds useless (Hjelmeroos et al 2000), but users feel frustrated if they cannot use the same strategy on the mobile phone as they use on the PC. In our browser, the user can have several "windows" open at the same time in the browser, even though only one window can be visible at a time.

5.1.5 Appeal

One of the reasons for usability research evolving to user experience research has been the fact that it is not only usability but also other kind of appeal, or seduction (Khaslavsky & Shedroff, 1999), of the site that makes site users happy. Appeal means very different things to different users; appeal of a web site may come e.g. from aesthetics, vibe, or brand of the site.

We found that some users were unhappy WAP site users because their favorite web sites were either not available on WAP format, or the WAP format was too stripped down version of the PC site. As an example, one Finnish user wants to read news from Guardian web site, because he has noticed that Guardian handles interesting topics and speaks at the tone he likes. It did not matter that the page was big and did not provide optimal usability on a mobile phone. The appeal of the PC site draws these users to use full web sites on mobile phones.

5.2 Connection

The connection is an essential component in mobile browsing system, and from all our studies, we have a number of findings about the effect of connection availability, speed, cost, trust, and customer care for mobile browsing user experience. I have been unable to find previous research that would have listed connection trust and customer care as relevant factors in user experience, and the other attributes are rarely mentioned as well.

5.2.1 Availability

In Finland, we are used to a very good coverage of GSM network, all the way from the metro tunnel to summer cottages. Mobile phone users in the other parts of the world are not as fortunate, and are suffering from loss of network coverage much more often. Also in Finland, 3G users have realized what it means not to have network coverage everywhere.

According to our user studies, people learn to know where the poor coverage areas are in their daily environments. Someone stops to fetch the train connections to the phone before reaching the underground tunnel, someone else has walked with the WLAN handheld around his house to find out the range of his home WLAN.

Unfortunately, finding the fastest, cheapest, and/or most trusted network is not easy today. Handhelds do show the availability of 3G or WLAN networks, but if one is not within the reach of one already, it is very hard to know where to go to find one. The industry has developed solutions to this problem in the form of signal detectors and hotspot locators. It seems that these devices are not very popular, since the market research companies have not investigated their popularity yet and none of our interviewees knew that such devices exist. We have discussed a solution in the form of a mobile guide system in **paper V**.

WLAN range is very small by definition, and today, people cannot move much while being connected over WLAN. Fortunately, the handover between different WLANs and between WLAN and cellular networks is being tackled (3GPP 2003). In the future people will seamlessly get the best connection available at a location and are able to move from one network to another without losing the connection. Still, a mobile guide will be needed for a long time because not all networks will share the same speed, cost for traffic, and trust level, so users will want to locate a network that they prefer.

5.2.2 Speed

The cellular connections used for mobile data traffic today are considerably slower than wired connections. The Circuit Switched Data (CSD) connection was used in the second generation telecommunications network (2G), and it provided 9.6kbps data transmission speed for one radio time slot. CSD was followed with other GSM-based data transmission systems like High Speed CSD (56.6 kbps), GPRS (up to 80kbps), EDGE (up to 236.8 kbps), and UMTS (up to 2Mbps). There are also other 2G, 2.5G, 2.75G, and 3G networks available for mobile data traffic, and more are being developed all the time.

Some handheld devices and even mobile phones are WLAN compliant, which means they are able to utilize Wireless LAN connections, not only the cellular connections. The latest versions of WLAN, 802.11g, provide data transmission speeds up to 54Mbps (IEEE 2003).

I am often asked about the limit for acceptable download delay in mobile browsing. In the XHTML site study over GPRS connection, we saw that it is very hard to introduce any limits for acceptable download time **(Paper II)**. Users cleverly estimate how heavy the next page will be or how much processing the system is doing, and based on that estimation, the download delay is acceptable or not. When the users knew the next page is a plain static list of links, they were more irritated with the delay than with the same delay when waiting for search results. It is interesting that the experience is tied to the user's expectations; we have seen the same pattern in other cases as well.

Typically, the textual content on a page is visible relatively quickly, but the images take much longer time to load. On navigational pages, it is important for users to be able to proceed as quickly as possible, without waiting for graphics to download. Site developers should take care that the content is readable and the layout of the page is clear even before the graphics has arrived. Graphics was appreciated when viewing the main page of the service (for the first time), but not on the subsequent navigational pages. In the auction service, images of the items being sold were useful, and users were willing to wait for them. The early studies on web sites Spool et al (1999) and Hjelmeroos et al (2000) have shown that the users over a slow connection are willing to wait for relevant images only, not for decorative ones, and our studies support this finding.

In mobile context, a too slow connection speed may mean that the user is not able to find a specific piece of information before it is too late, or that other methods to find out the information are quicker than mobile browsing. We have not encountered many use cases where the users would have used mobile browsing to find out urgent information in a hurry. We believe this is partly because of the slow connection speed of 2G networks. The speed of a 3G network makes at least mobile optimized sites fast enough for quick information fetching.

5.2.3 Cost

In **paper VIII**, we discuss the findings from the contextual interviews, and note that it is very hard for users to understand, follow, and control mobile data traffic costs. Users try to figure out how the costs cumulate, but it is a hard task for them. Typically, mobile data is paid by the volumes of data, but many users think it is the connection time or the number of page loads that counts.

Although billing by time is easy to understand and control, it leads to unwanted usage patterns. Users try to plan the browsing session carefully, proceed to the target page as

quickly as possible, and cut the connection as soon as the target content has been loaded. They can relax and concentrate in the content only after the connection is cut. Before starting to type in a textual value, they cut the connection. Long page loading times truly irritates them. This kind of usage patterns fit poorly mobile context where one should be able to concentrate in the environment at any point. We have heard stories where users were driving a car, browsing, and trying to react as quickly as possible after a page loaded. They were horrified even themselves that this kind of situations do take place.

Home WLAN connection enables users to browse for free, because the fixed broadband connection at home is typically charged a flat fee, no matter how much you browse. There are many WLAN hotspots that provide a free connection for their customers, and cities have started to provide free WLANs for everyone. It is unbelievable that the fastest connection is suddenly also the least expensive one. Users of mobile browsers hope the free WLAN will continue to spread.

Unfortunately, many WLAN hotspots today charge as much as 7€ for an hour, which is the smallest period of time one can buy. Thinking about the typical mobile browsing use case where one just needs a small piece of information quickly, this kind of billing is not suitable. In the U.S., our interviewees knew about several free WLAN hotspots, so they refused to pay for WLAN at any case. In other countries, people simply find another way to get the piece of information they need.

5.2.4 Trust

When a user trusts the connection, s/he expects that nobody is following one's data traffic, and that the connection stays up for the entire browsing session. Not all mobile browsing needs to be secured, but when disclosing personal information, especially credit card number, one wants to be sure that the confidential information will not be stolen and all needed information will reach the recipient. Typical examples of confidential browsing cases relevant also on mobile devices are online shopping, banking, Webmail, and sending comments to chat groups.

In the U.S., WLAN culture is most mature, but surprisingly, our U.S. users seemed to be least worried about connection security (late 2004). Users' comments included "I'm not worried about the open connection, because a lot of people are doing it." and "Security is something to think about, but I guess I haven't really thought about it." It seems that WLAN became popular before anyone informed people about its security problems.

In other countries, the media has spread the word that WLAN connections are not secure because many WLAN networks are open and let anyone follow the data traffic. Our interviewees have also realized they should not use open WLAN networks. However, the complexity of the public hotspot security makes it hard to understand when the WLAN is "open", when secured. Many public hotspots charging for use ask the user to log in to the network with a password, so it makes users think they are secure after the login: "The Starbucks WLAN is password protected, that's the security. All packets are going through Starbucks, and I trust Starbucks." It requires a WLAN specialist to understand that this password does not yet mean that the connection will be secure.

Several interviewees reported that they do not trust wireless connection for confidential browsing, but go to a fixed-line PC to do the confidential browsing tasks. The reasons include both data traffic security and the threat of losing the connection. Especially in the U.S., cellular connections are unreliable due to the coverage problems, so people have not

learned to trust the persistence of wireless connections. They do not do transactions where connection cut might result even to loss of money.

5.2.5 Customer care

Users do not necessarily see the difference between a device problem and a connection problem. If a connection does not work, many times the users contact the device customer care. In Japan, we encountered a case where the connection provider (telecom operator) sent a huge bill for a customer, and in this case it was obvious that the customer wanted to contact the operator, not the device support.

The Japanese user called to the operator's customer care to find out how the data traffic costs had cumulated, but did not get any help. The operator could not tell which sites had generated the huge sum for the bill, so the user was left ignorant about how to save data costs next time. The customer care made the bad user experience even worse in this case.

5.3 Gateway

A gateway, or an access point, is typically in between the wireless and the fixed internet, provided by the network carrier or sometimes by the browser manufacturer. All mobile browsing traffic goes through this gateway. It is possible for the gateway component to transform the content to better suit a limited mobile device, or block access to certain Internet sites. The same can be done on a separate proxy server in between the origin site and the gateway (Kaasinen 2001), but for simplicity reasons, we assume the optimizations are done on the gateway.

Because most users are not aware of the gateway existence, we have not heard many interviewees to mention it. In this chapter, we list the findings from our studies that were affected by the gateway existence.

5.3.1 Page optimizations

In the Narrow layout study, reported in **paper III**, users were surprised how nice experience it was to browse full web pages on a mobile phone. They accessed the pages on WebViewer browser by Reqwireless Inc. that routes all traffic through a gateway that is closely integrated to the browser. This gateway executes smart transformations to the page content, and the dialogue between the browser and the gateway is optimized to provide amazingly short download delays even for heavy web pages. Although the users are not aware of these transformations happening, the optimizations have a great effect on user experience, mainly in terms of performance.

The gateway is not in use in many mobile browsing systems, because it has its drawbacks. As we explain in **paper VIII**, page transformations for millions of users may make the gateway a bottleneck and in fact decrease performance. The gateway cannot optimize encrypted content, although many relevant mobile browsing cases use encryption: Webmail, chat sites, banking, and shopping. If the gateway alters the content, e.g. filters some heavy content out or scales down images, the gateway provider runs into copyright problems. The end user must give the permission for these changes, which means the gateway must identify each user. This, in turn, creates a privacy problem that the gateway provider can follow ones traffic.

5.3.2 Access restrictions

Especially in the early days of mobile internet, operator gateways limited the WAP access to the operator site and the services available through the operator. This Walled Garden approach resulted to poor user experience, and most operators have now opened up the access to all sites.

In our interviews, we have seen the operator blocking access to the full web in Japan and in the UK. In Japan, the selection of mobile services was very good, so this limitation did not affect user experience dramatically. Still, users wanted to have access to the full web either because the needed services were not available via the operator, or the services that are free in the full web are charged in the mobile web. In the UK, the Walled Garden operator was marketing their 3G connection by quick internet access, and subscribers were very disappointed not to have access to anything else but the few sites that the operator allows them to go to. “What do you use 3G for if not for web browsing”, they commented.

5.4 Browser

Typically, a mobile browser is not in the focus of user experience studies. The previous research does not even mention the browser separately, but it is seen as an integral part of the mobile device itself. It is possible, however, for users to install different browsers on their S60 phones, and using a different browser creates a different user experience. I will show that especially in the case of web browsing, the browser is in a key role in influencing mobile browsing user experience.

Browser usability, functionality, and content support affect user experience. Browser usability includes various aspects, for example web page visualization method, interaction with the content, and the methods to get to the pages in the first place. Content support refers to the abilities of the browser to show WAP pages, simple HTML pages, or even the full web content out there (malformed HTML and embedded content). These topics are discussed in more detail in the following sections.

5.4.1 Usability

I have investigated usability of mobile browsers since 2002, when I noticed the importancy of it to the overall experience of mobile browsing. The look and feel of content on a small screen affects page usability, especially in the case of large full web pages. According to our early usability studies, if the look of content, background, and interactive components (links, text boxes, drop-down lists, check boxes) is different from a desktop browser, users do not recognize them being the same as on PC **(Paper III)**.

The web page visualization method is perhaps the most important feature affecting web browser usability. In our user interviews, users complained if the page was shown on a PDA or phone exactly the same way as on a large display. It was laborious to scroll around a large page to find out what the page contained, and the user felt lost especially if the page contained lots of white space. The worst problem was the horizontal scrolling that was required for reading text columns that were wider than the screen. As long as the pixels on the displays are relatively large on a small screen, one-to-one rendering is not feasible.

The state-of-the-art mobile browsers today use a visualization method that I call Narrow Layout **(Paper III)**. It formats the page content to tall and narrow tubes. Some users were happy with this formatting, but some complained that too many pages got broken. Even

though the browser provided an Original layout mode as a backup for Narrow layout, not all users had realized how and why the Original layout could be used. We have investigated the Narrow layout in **Paper III** and **Paper VII**, and found several usability problems that the relayout introduces.

The mobile browser must be designed for the input controls that the device has. The interaction with a 5-way key and numeric keypad is very different from a pointing device (e.g. a mouse or pen). While a mouse often provides a scrolling wheel and a way to move the pointer directly onto a link, a 5-way key allows the user to scroll and move the focus from one link to another. On a focusing interface, the focus is always on one interactive component, if one exists within the current view.

Interaction on a text field is an interesting case where browser can decide how the keys function. Some mobile browsers require the user first to move the focus to the text field, then click it to enter text editing mode, and finally let the user type in text. The click is required because the keypad keys are used for two purposes: function shortcuts and text entry. After executing a shortcut that changes the view, the focus might automatically move to a text field. If the text editing mode would now be started automatically, the user could not use the key shortcuts before moving the focus out of the text field. When the user wants to type in the focused text field, we have noticed that even some expert-level users do not remember to click before starting to type. Because we have also noticed that only few users utilize the keypad shortcuts, users should not be forced to click the field to type in text.

5.4.2 Content support

The mobile internet has not been highly popular outside Japan and Korea. The early difficulties of WAP killed many mobile sites, and only the most popular sites are still alive. This created a chicken – egg problem: now that users would be able to access mobile sites, there is not enough content available for them. Most users are used to the vast amount of information available on the full web and the offer on WAP is often a disappointment. Based on our user needs studies, I strongly believe that mobile browsers need to support the content in the full web, not only the WAP content.

There are various types of content on the full web, and few pages are well-formatted HTML. In order to show the pages in the way that page designers meant, the browser needs to support many kinds of content. Non-technical users do not understand why some parts of the page are empty, unlike on the PC.

Unfortunately, some full web content is very hard to view on mobile phones. Large data tables and Macromedia Flash components that include small text can be viewed at once on a large screen, but are impossible to comprehend on a small screen. If we zoom out the page to better fit the small screen, the texts become too small to read. If the texts are kept readable, you can see only a small part of the animation at a time. In these cases, the browser cannot do much but the content developer should provide more mobile friendly content.

5.4.3 Functionality

Our studies showed that users would like to follow the same usage patterns as on the desktop computer, such as keyword search **(Paper VI)** and opening up multiple windows (discussed in section 5.1.4, Familiarity). They would also like to have additional functionality useful specifically on a mobile phone. For example, we found that users often

looked for a zooming function when viewing large pages on a small screen, although not all PC browsers provide such a function. Minimizing data expenses and preparing for out-of-network-coverage cases would require specific browser functionality as well.

When designing a full web browser for a mobile device, selecting relevant functions for a mobile browser is a painful task. All PC browsers provide more than 50 functions in their menu structure, plus the bookmark lists created by the user. An S60 phone has only one main level menu ("Options" mapped to the left softkey) plus one level of submenus. The most important functions should be available right on the main menu level, not in the submenus, so the maximum number of functions in a usable Options menu is no more than 25. When developing mobile optimized features for an ordinary mobile phone browser, we have to think about the Options menu burden, and avoid adding new functions there.

5.5 Mobile Device

A mobile phone is very different browsing device from a PC. The lists of published differences are included in Hjelmeroos et al (2000), Hiltunen et al (2002), and **Paper I**, but the most important differences specific to the mobile device and mobile browsing include the display, keys, memory space, processing power, and battery life.

5.5.1 Usability

Display

The most obvious difference between PC browsing and mobile browsing is the screen size. The users we interviewed seemed to appreciate the PDA/Communicator screen size, but thought that browsing on any smaller screen would be unusable. When we interviewed smartphone users, the comments were very similar: surprisingly, phone users had few complaints about the small screen size but they thought that browsing on any smaller screen would be unusable. Rather than complaining about the screen size, many users complained about some web pages that did not take small screen browsing into account.

Even on PDA and Communicator, users suffered from a keyhole view problem: they did not know how large the page is, and where the target content is located. On PDA, this was mainly because the pages were intact, shown exactly in the same format as on the PC. On relatively low resolution screens of the PDAs, 1:1 text size was even too big for close viewing.

The display resolution and contrast improve text readability a lot. We have recently run a few user studies with the latest Nokia phone prototypes, introducing a display of 352x416 pixels, physical size being no more than 35 x 41.5 mm. The browser users are amazed about the display quality and their ability to read even tiny texts on it. In these cases, the display quality, not only its size, was a clear factor affecting mobile browsing usability.

In addition to a high quality display, the browser software can provide a visualization method that alleviates the small screen problems. Visualization was discussed in chapter 5.4.1.

Keys

In addition to the display, the limited keypad on mobile phones is an obvious difference between mobile browsing and desktop browsing. It was interesting to notice in Japan that a

17-year old male who did not use a PC at all, saw the phone keypad so simple and handy for him that he would prefer to use it over the “complicated” PC keyboard. This might be a Japanese peculiarity, but maybe there will be more opinions like this in the emerging markets where the phone is many times the only device used for accessing the Internet.

For users of limited keypad devices, we have seen that entering a URL is the most painful text entry task, and the browser should provide all possible aids to help typing in the URL. When the browser provided auto-complete for URLs, our interviewees entered the beginning of the URL and picked the familiar address from a proposed list. Here again, we were surprised that the URL entry pattern was copied from the PC browser. This usage pattern seems to function better than bookmarking pages and finding the bookmark, even when the keypad is limited.

Also search engines are used a lot even on limited keypads **(Paper VI)**. Search is used a lot on a PC, and the lack of a proper keypad does not preclude users’ search habits on a mobile phone.

No pointing device

Web pages are designed for mouse interaction, and an increasing number of pages include image maps or show more content when the mouse pointer is on top of an item by recognizing a ‘mouse over’ event. Mobile phones typically do not provide a pointing device, but the focus moves from link to link or from form item to item when the user scrolls the page with a joystick or scrolling keys.

The users in our contextual interviews who used a Nokia Communicator that provides an arrow pointer controlled by a rocker key did not always like this control, since it was harder to move the pointer than focus on top of a link. This may be a matter of the input control, because a joystick-type mouse control is widely used on laptops (e.g. IBM TrackPoint).

Browser access

The time and number of clicks required to get to the first relevant web page on a mobile browser has an effect on mobile browsing user experience, because a mobile browser is many times used for finding a specific piece of information quickly. Outside Finland, many operators bundle the phone and the operator subscription, and have specific adjustments done to the phone user interface. Typically, these operators want to provide a dead easy access to their WAP portal, even by providing a dedicated key for that.

The participants recruited to our studies use the mobile browser relatively often, and most of them seemed to have a quick enough access to the browser. Either the device provided a hard key for the browser, or a softkey function available in the basic, idle state of the phone. The rest accessed the list of applications to start up the browser.

If the shortcut is available in one of the softkeys in the idle state of the mobile phone, it is very likely that a majority of users will test the function. If the first time use provides a positive user experience, a majority of users may continue using the Internet on phone. The threat is that if the user is not keen on mobile browsing, s/he has to find a way to map the softkey to a more useful function.

UI style

Each Nokia phone follows a UI style, which ensures a series of phones to have a consistent UI, e.g. Nokia S40 or S60. The UI style defines the screen resolution, the keys available, and the software UI look and feel to a certain extent. All native applications in the phone follow the agreed look and feel, so that users do not have to learn new rules for each application. Consistency increases usability also in the case of the browser. Some third party browsers available for S60 do not follow the UI style of the phone, and this may lead to usability problems and puzzled users.

Unfortunately, I do not have user study results on mobile browsers not conforming to the S60 UI style. My own experience with some third party demos that have not been designed the 5-way key in mind require using either modes or numeric keys for essential functions like scrolling, link selection, and zooming. It is often very clumsy to adjust the logic of pointer based interaction to S60, especially if the interface heavily counts on zooming. It is no wonder that these browsers have not made it to market.

5.5.2 Connectivity

New types of wireless networks are being developed all the time, and different combinations of wireless networks are available in different locations. It is increasingly important that the phone supports different types of networks. In our studies, users were pleased to have WLAN enabled phones, because they provide a fast and inexpensive way for mobile browsing.

Mobile Internet access is especially useful while traveling: you are able to check local information from the web and read the news from homeland. However, your phone might not be able to connect the local cellular network, if it is different standard from the homeland network. Our interviewees have reported helplessness if their phone does not work while traveling.

Support for a network standard in a device does not automatically mean that it can be used right away. The device needs to have the settings for that network as well. In operator variant phones, the network settings are readily there, but if the user buys the phone from a common phone shop, s/he has to get her/his operator settings to the phone before the data connection works. Configuring the settings was a laborious task in the early days of WAP, and this is one of the major reasons why WAP did not fly. In modern cellular networks, the data connection settings come to the phone automatically when the network notices a new SIM+IMEI code pair in the network, meaning that the SIM card is used in a phone for the first time. The user just needs to accept taking those settings into use.

The remaining problem of today seems to be roaming in a foreign network when traveling abroad. There might be various operators available, but your operator might have roaming agreement for data traffic with one of them only. If you roam in one of the other operators' network, your mobile browsing does not work.

In summary, good connectivity of the phone means that the phone utilizes the fastest/cheapest connection available as automatically as the user wants. Also, data connections must work without configuring the network settings, even while roaming in a foreign network.

5.5.3 Performance

Mobile browsing speed is determined not only by the connection speed, but also by device performance. The delay from clicking a link to the point when the next page is scrollable is the key performance meter for mobile browsing, and the delay consists both of the data transfer over the connection, and the time the device renders the page. The device performance is most visible in the WLAN enabled phones, but otherwise, it is the connection speed that determines the page loading delay.

Most users do not see the device performance affecting mobile browsing experience, but we have heard some WLAN handheld users making the note that WLAN connection on the handheld is slower than the same connection on a laptop. The difference was not a big one, but the users seemed to have felt it. They had even compared the speed by loading the same page at the same time on laptop and the device and concluded that it must be the device performance that slows down the device. They accepted the situation but expected the future devices to be capable of the same speed as the WLAN laptop.

5.5.4 Memory space

Memory space has an effect on how large cache the browser can use, which in turn determines how many pages the user can step back without reloading the pages from the network. In the most limited phones, the memory space is not enough to fit even one whole web page to the memory at once, so the system needs to decide how to show the page in this case.

The memory space affects user experience most clearly when the system needs to radically decrease the page content shown on the device. Especially when the pages are split into many pieces, we have seen users complaining about the laborious way to navigate the pages backwards.

5.5.5 Battery lifetime

As mobile phones become more powerful, provide high resolution displays and WLAN connections, battery power may not keep up to the development. Many of our interviewees in Japan had a new phone with a bright high resolution display, but they were wondering why the battery lifetime was worse than in their old phone.

An extreme case about the battery lifetime to user behavior was a house wife who was afraid of running out of battery if she would browse while shopping or meeting friends. She said she browses the web on her phone only in places where can recharge the battery easily, e.g. at home. It is very unfortunate if the battery prohibits mobile browsing, so I hope the new battery technologies become mature quickly.

5.5.6 Appeal

Mobile phone is a personal device that expresses its owner’s personality in a similar way to a car. The design of the phone has always been an important factor in purchasing a mobile phone, and it will be increasingly important in the future.

Device appeal covers user’s attitude towards both the design and brand of the device. Browsing on a device you love might be more enjoyable than on a device you hate, even if the site itself provides the very same experience. The design and brand appeal affect

especially when study participants are handed a phone which they normally would not choose to use. When we compare two browsers, we always use the same phone model for both. The results would be very hard to analyse in a fair way otherwise.

5.6 Mobile context

When developing products for mobile use, one should understand the nature of the mobile contexts that the products are used in. Our study participants have reported using mobile browsers in public transportation, at bus and train stops, while walking on a street, in coffee shops, restaurants, pubs, shopping centers, parks, university campuses, hotel rooms, during meetings or lectures, and, surprisingly often, at home or even while driving a car. This chapter discusses the factors that affect mobile browsing user experience in these contexts.

When the user needs a specific piece of information, it is often easier to check it from the mobile phone than to go to a PC. In this case, one may even be near to a PC, but if moving to the PC and/or getting the PC browser up and running require more effort than the mobile browser, one prefers to use the mobile browser. We have heard many stories where the person is lying on a sofa or bed at home or in a hotel room and browsing on a mobile device. These are typical examples of what we call relaxed browsing.

A specific piece of information may be needed also in a hurry, even on the street. In Tokyo, all our interviewees used a train route service that works nicely on mobiles and informs the quickest set of trains needed to get from place A to B. Depending on the time, different routes might provide the quickest connection. If one misses a train connection, s/he wants to check which set of trains is best at the moment. The mobile service was so handy that some interviewees used it even while walking. Checking public transportation timetables is one of the few examples of browsing literally on the move; normally one sits or stands still while browsing.

When one has some time to kill, s/he checks her/his favorite sites that might have some new content for him. According to our studies, reading news while commuting is one of the most popular use cases for mobile browsing. Also when waiting for someone in a coffee shop, in front of ladies fitting room, or at bus/train stop, one starts to use the mobile browser mainly for hedonic needs: to entertain oneself, to avoid embarrassment, or to look cool.

There are many different ways to classify different context factors (e.g. Schilit 1994, Hiltunen et al 2002, Kim et al 2005, Tamminen et al 2004). In this dissertation, I have the focus in the user experience and I follow the main level categorization consisting of user, context, and system. The contextual factors found in the existing research and our studies can be divided to physical context, social context, temporal context, and task context.

5.6.1 Physical context

Human body senses various circumstances in the physical context, such as temperature, light, rain or humidity, objects the user is in contact with (e.g. slippery road), movement of those objects (e.g. moving bus), and all other visible objects. Heavy crowdedness and noisiness are part of the physical context, if they physically affect using the mobile browser. Otherwise, they can be considered as part of the social context.

The current location matters when using location-aware online services. A Japanese male was happy to get the local weather forecast by just entering the weather page. Online games

that count on location seemed to attract two Japanese mobile users, even if the idea in the game was very simple (e.g. collecting points by moving long distances).

5.6.2 Social context

Social context refers to the expectations other people have for the user in the current context, or the willingness of the user to participate in a social situation. Examples of social context affecting mobile browsing are undetected browsing in a meeting and sharing browsing results with a friend. As Forlizzi & Battarbee (2004) note, social context has a great influence on user experience.

Many male interviewees of ours had to cut down mobile browsing because their family members, especially wives, did not accept browsing e.g. in a restaurant. On the other hand, the wife was sometimes the reason to use the browser; when checking the estimated landing time of her plane, or when waiting her nearby ladies' fitting room in a department store (which helps the husband in the embarrassing situation). The latter case is similar to many Japanese use cases where the mobile browser saves users from unpolitely staring others while commuting; instead, they can focus their attention to the phone. We found many cases where mobile browser was used with other people, e.g. to find out an answer to a question that a group of people argued about, or to check the selection of cars for sale using everyone's own mobile phone and then showing the best candidates to others.

In our user study comparing laboratory context to mobile context, we found that people do behave differently in different types of social contexts (Oulasvirta et al 2005). In a laboratory with no social interaction, users concentrated in using the mobile browser, but in mobile context, they shifted their attention quickly to the environment. Walking on a busy street required the most attention.

5.6.3 Temporal context

Unlike one would think, temporal context does not refer to the current time of the day or time of the year in this case. Time alone does not directly affect the user experience. If it is a winter night, it is likely to affect temperature, lighting, social context, user's mental resources and needs, but not directly user experience. The relevant contextual information is not in the time itself, but in the attributes the time affects.

Temporal context as a user experience component refers to the time period that the user is able to dedicate for the system given the context restrictions, e.g. finding out which bus to take before missing it. In case of multitasking, the period dedicated to the system is split to many pieces, e.g. browsing while waiting for a bus, continuing the session in the bus, and later at home.

We have run a study on users' attentional resources in mobile context. We found that with longish response times of full web browsing on mobile phones, users' attention stays on the mobile device less than 4 seconds **(Paper IV)**. In the laboratory, the number is around 10 seconds (Miller 1968, Card et al 1991, Nielsen 1993). We also found that users keep shifting the attention between the device and the environment if the browser provides only visual feedback for page loading. We concluded that in mobile context, non-visual feedback is recommended for delays longer than 4 seconds.

The non-visual feedback means typically audio or tactile feedback such as vibration. Unlike audio feedback, tactile feedback is personal and does not disturb people nearby (Brewster et

al 2004), so we implemented vibration feedback for web page downloads to communicate that the textual content of a page has arrived. Our hypothesis was that this step towards a Minimal Attention User Interface (Pascoe et al 2000) would improve user experience, because the user could then fully concentrate in the environment while waiting for the system response. Ten users tested a prototype browser with vibration feedback for 8 days, and a majority of the feedback was positive. According to users' diaries, the users did concentrate on other tasks while pages were loading, and they benefited from the vibration feedback. Only situations in which absolute silence would have been urged, the vibration motor sound was annoying.

Our hypothesis was that if users are provided vibration feedback for page downloads, they do not glance at the display as often as without vibration. To test that hypothesis, we ran a field test with 6 users who were familiar with the vibration feedback. Unfortunately, our small scale study did not reveal a significant difference to prove the hypothesis. We considered running a larger study to find significance, but it is laborious and expensive to plan and run a study where we could compare browsing with and without the vibration feedback. For example, half of the participants should be used to the vibration feedback.

The study reported in **paper IV** showed also that there was a significant difference in gaze patterns between young adults, aged 20-27 years, and middle-aged participants of 40-47 years. In mobile context, the young adults looked at the display for 2.3 seconds shorter in average than the middle-aged participants. This implies that young adults do multitasking more actively than middle-aged people.

5.6.4 Task context

Task context refers to the role of mobile browsing case in the higher-level goal the user has. Mobile browsing does not fulfil the goal alone, but is one task along the way there. For example, one of our interviewees was driving a car when he got a call from his remote customer asking whether he could visit them next day. He promised to check the possibilities. When he stopped at a gas station, he checked the flight options from his mobile browser and then called back the customer.

We have often seen that a browsing task is started on one device and continued on another device. In Finland, an active blogger used the commuting time to read news and blogs on his mobile device and posted the most interesting ones to his own blog. When he got to a PC, he continued by writing comments to the added links. This was an example of a case where browsing task was started on a mobile device and completed on a PC. In Japan, a family man retrieved information from the web on PC at work, and when he had to leave home, he sometimes continued the information retrieval on the phone while commuting. In this case, the task started on a PC and was completed on a mobile device.

In all these cases, mobile browsing task is just one part of the use case. The user may also have several ongoing tasks at the same time, such as the car trip in the first use case above.

5.7 User

As I mentioned in chapter 4, investigating user's internal state is not my expertise area. With my background, I am not capable of deep analysis of user's emotions, needs, and motivations. Here, I list only the findings that we have made in our studies, and do not even try to provide a comprehensive analysis of the personal factors influencing user experience.

When users try out accessing full web pages on a mobile phone for the first time, the response is typically a positive surprise. During our usability tests, it was obvious that there were many problems using the large pages on such a limited device, yet the overall user experience was positive **(Paper III)**. What explains this conflicting result? Below, I analyse the possible reasons that come from the user needs and expectations.

First, many people have some favorite web sites that they would like to access also while being mobile, e.g. Webmail, journey planner, maps, hobby club, or chat site. The *need* for accessing these sites is at least as big as on a desktop browser, so they found the utility high. After the lab test, some of them even asked if it was possible to get the tested browser into their own mobile phone, so they were *motivated* now to take the action and start using a mobile web browser.

Second, it sounds ridiculous to view the large pages on a mobile phone, so, although we did not specifically ask them, users' *expectations* were probably low. Also the possible earlier failure *experiences* with WAP sites have made them expect failures with the full web as well. As they were able to accomplish something on the full web browser, even if with some difficulties, the overall user experience was positive. This tells about the importance of internal expectations for the system as an influencer to user experience.

The mental and physical *resources* available for mobile browsing are typically more limited than in the case of desktop browsing. The amount of stimuli in the environment affects the attentional resources available for system usage. We found that if the user is walking, the environment often requires more attentional resources than when s/he is standing still or sitting (Oulasvirta et al 2005).

The mental and physical resources refer also to the personal characteristics of a user, e.g. age, possible disabilities, and the size of the fingers. Accessibility features typically address users with limited mental or physical resources, no matter if the resources are limited by the user or by context. Accessibility features designed for mobile context might help also disabled users, such as a voice browser for both blind users and for users who are driving a car while browsing.

6. CASE: DESIGNING A MOBILE BROWSER FOR GOOD USER EXPERIENCE

The different characteristics affecting user experience are important to know when designing for positive user experiences. A single designer cannot normally affect all the components in the entire system, but the effect of each component should still be realized in order to make the system successful. For example, if a site designer does not take into account the content support limitations in the browser or connection cost, the resulting user experience may be poor and not many people visit the site.

In the case of mobile browser, the experience should primarily come from the web sites, and minimally from the browser. If a web site wants to create a relaxing experience, the browser user interface should not conflict with this goal by providing a flashy, stimulating user interface. At best, the user can interact with the site in a flow mode (Csikszentmihalyi 1975) where the browser does not require the user to think about the browser, but lets him totally concentrate in the site and enjoy the experience provided by the site. This is in line with the slogan "Don't make me think" by Krug (2000), which applies especially to all tools, including a web browser. Web content, in turn, is allowed to make me think, if I want that kind of stimulation.

In this chapter, I will describe a case where most of the user experience characteristics listed in chapter 5 were taken into account in product design. The case is about the development of Web Browser for S60, which Nokia Research Center has been investigating and prototyping. Our work started with the goal of finding a usable solution for viewing large pages on the small screen of S60 devices (Figure 11), but the user studies have guided us to prototype many other features related to the user experience characteristics. We have filed four patent applications for the features on the way, but note that not all of the prototyped features listed here may be incorporated in the commercial browsers. The main findings related to the characteristics are listed below.

Figure 11. S60 devices share the same UI style

6.1 User

In our contextual interviews, we have asked users in what kinds of situations they access Internet on their handheld devices. We found that mobile browsing takes place either when one needs a specific piece of information, or when one has some time to kill. This is in line with Dhar and Wertenbroch (2000) who discovered that user's goals are utilitarian, hedonic, or, typically, a mixture of these.

Many people have no *experience* on mobile sites, but on PC web sites only. Their favorite sites might not provide a mobile version of the site, or they do not know the address for the mobile site. They *need* to have access to the full web, even if large pages are not highly usable on small screens. We believe that when we let users access the full web sites on mobile devices (and they may complain about the poor usability), site developers have a good reason to work on a more mobile friendly site. We believe that full web access on mobiles drives mobile friendly content, not kill it.

User's *mental and physical resources* available in mobile context are more limited than in front of a stationary PC, so our browser prototype works on one-hand devices and provides vibration feedback for long response times **(Paper IV)**. Solutions like Rapid Serial Visualization Protocol (RSVP) for mobile browsing (Bruijn et al 2002) are not optimal for mobile context, because they require the user to fully concentrate in the animations on the screen. Typically, it is easier for users to scroll to the wanted position on a large page than to constantly look at the animation and be ready to stop it quickly when there's interesting content or when something requires attention in the environment.

We also examine multimodal browsing, aiming at a Minimal Attention UI (MAUI) (Pascoe et al 2000). We are investigating the ways to control the browser with voice commands and to listen to the texts on page rather than reading them. We want to support multimodal content that allows the page author to define how the page works by voice. Listening to the news from my favorite news site while commuting, even while driving, is a promising use case.

6.2 Context

Physical, social, temporal, and task context are addressed mainly by providing the browser in an ordinary mobile phone. Mobile phones are specifically designed for mobile context, that is, allow one handed use, viewing the content both in dark and in sunlight, in freezing temperatures, etc. The browser has a minimal set of audio tones to avoid embarrassment in social environments, and when the user has set the silent mode on in the phone, the browser is silent as well. Our testers have commented that full web content looks great on the bright high resolution displays, and they are proudly showing their own web page and other pages to others.

Our browser lets users interact with the page at a pace of their own. They do not have to wait for the whole page to load before scrolling and clicking, and the browser does not animate the content if the content author does not provide animations. This helps users to cope with interruptions in browsing. Because the browsing task is often one part of a bigger task, the browser co-operates with the other phone applications. When a message includes a hyperlink, the user can click it and the browser application is started and the page showed automatically. The user can also save a page for later use.

6.3 Device

It is clear that an ordinary mobile phone is not an optimal device for full web browsing, since it is designed mainly for communication. If we designed a handheld device targeted speicifically for web browsing, we would come up something like the Nokia 770 Internet Tablet. Because the existing device base for ordinary mobile phones is huge and we cannot expect all people to replace their mobile phone with an Internet Tablet, we wanted to take the challenge to design a browser software that would provide as good user experience as possible on an ordinary mobile phone.

The mobile browser user interface has to go hand in hand with the device. We have designed our browser specifically for Nokia S60 phones, which are designed to be used with one hand (thumb), and so do not provide a pointing device such as a mouse or a stylus.

6.3.1 Display

A small display is very handy to carry with you, because it fits into your pocket. Mobile phone displays are also bright enough to be used even in sunlight. But how to fit web content onto a small screen in a usable way? There are four approaches to tackle this task:

1. Create web content that fits the small screen nicely

   WAP and other mobile content systems provide the information in a mobile friendly way, and usability is best with this mobile optimized content. Unfortunately, there is not enough content on the WAP sites to fulfill user needs today.

2. Develop displays that are big but still fit the pocket

   The technology is not there yet, but several different methods are being investigated.

3. Filter out irrelevant content and show relevant content only

   It would be great if I could get only the relevant content on each web page to my mobile device. Several researchers have tried to generate content filtering systems either based on the HTML structure (Björk et al 1999, Buyukkokten et al 2000 and 2001, Chen et al 2003, Mukherjee & Ramakrishnan 2005, Bandelloni et al 2005), or user's preferences (Bickmore & Schilit 1997, Anderson et al 2001). The reason why these have not made it into products is that the full web content does not follow the recommended structures. Instead of using header tags, sites show titles as images, and instead of HTML, sites use Macromedia Flash. It seems impossible to automatically identify and separate irrelevant content from relevant.

4. Develop web page visualization methods for small screens

   There exist several visualization methods for the specific case of web pages on small screens, some counting on the existence of a pointing device (Fulk 2001, Milic-Frayling & Sommerer 2002, Baudisch et al 2004, Lam & Baudisch 2005), some designed for mobile phones without a pointing device (Trevor et al 2001). Despite these delicate methods, the industry has adopted the simple Small Screen Rendering method by Opera Software, which reformats the web pages to a narrow and tall page that fits the screen width of the small display. I have identified several usability problems with this layout (**Papers III and VII**), and wanted to develop something different. We saw that developing a visualization method is the most convenient way to tackle the small screen problem, because alternatives 1-3 did not seem to provide help.

One of the key drivers in developing a web page visualization method was to maintain the page layout as much the same as possible, but provide more content on the screen and avoid horizontal scrolling while reading a text column. The users should also be able to see an overview of the page very easily. Antti J. Koivisto from the Software and Applications Laboratory of Nokia Research Center came up with an idea about squeezing the layout horizontally, and providing a transparent page overview called Mini Map (Figure 12). While Antti was the mother giving birth to these features, my role was to be the father who gave the seeds in the form of usability requirements. Of course, the contribution from the whole browsing team was vital for the development of these browser features.

Figure 12. Mini Map appears on the content while scrolling continuously.

As described in **Paper VII**, we first ran a usability test with a browser prototype where the Mini Map appeared right away after starting to scroll. The users found this very disturbing, since they could not read the text and scroll at the same time. We could have given up at this point, but luckily I had discovered in earlier user tests that there are two ways of scrolling: incremental (click by click) and continuous (press and hold). When users are reading, they typically do incremental scrolling, and when they try to navigate to a position on the page or to get an overview of what is on the page, they scroll continuously. We adjusted the Mini Map to appear only after one second of continuous scrolling. This very small change made a huge difference in usability; now users did not have problems reading the text and scrolling at the same time. They got the overview when they were likely to need it: while scrolling longer distances quickly.

6.3.2 UI Style

We follow the UI style of S60 by providing Options menu of 2 layers, even though a browser requires a lot of functions and providing them all through one menu is challenging. The menu structure is the main reason why not all functions that we propose are incorporated in the commercial browser: the menu simply cannot provide too many functions, otherwise the main level menu would become overwhelmingly long. Many users are not interested to learn and use all browser functions, and the user experience is often better with a simple rather than complicated browser menu.

On the devices optimized for browsing, e.g. on the Nokia 770 Internet Tablet, there is a stylus that makes it possible to activate functions visible outside the page area, on header and footer. On S60, the 5-way key is used mainly for scrolling and link selection, so it is not possible to provide e.g. icons at the header that the user could easily access. Instead, we provide shortcuts to the main functions in the numeric keys.

6.3.3 Memory space

Web pages might require several megabytes of memory space, and if the cache is too small to fit them all, user encounters lots of delays when stepping back several pages. To tackle this problem, we introduce a Visual History in the Web Browser for S60. Visual History shows thumbnails of the previously visited pages, and the user may move back to any number of pages very quickly. Only after selecting the wanted page, the user may have to

wait for the page to reload from the server. Visual History does not require, however, the user to wait for pages that s/he is not interested in.

Figure 13. Visual History

6.4 Connection

6.4.1 Availability

As the cellular connection is not available everywhere and WLAN connection is spotty, we have addressed the out of coverage case by providing an Auto-update feature in our browser prototype. The idea is to load the favorite pages on a periodical basis and store them in the phone, so that the user can access these pages even while offline **(Paper VIII)**. This is not done by default, but the user needs to activate Auto-update. On WLAN enabled phones, updates are done over WLAN connection only, which is not typically charged by data.

6.4.2 Speed

The browser implementation does have an effect on how quickly the content appears on the phone. Nokia has naturally been testing where the loading bottlenecks are and optimizing speed where possible. Our user studies have helped to understand that the total page download time does not really matter, but the time when the user is able to read and scroll the content at the top of the page does. The rest of the images may not even be there when the user already proceeds to the next page. The Web Browser for S60 allows now the user to interact with the page as soon as possible.

6.4.3 Cost

I have to admit I did not realize the effect of data traffic cost to mobile browsing user experience until we started the contextual interviews. My own phone bill is paid by the company, so are my friends' bills. However, 74% of the mobile phone users globally pay their phone bill themselves (Strategy Analytics 2006), and the cost of mobile data traffic kills their interest in browsing. When testing mobile browsing for the first times, one might find some useful services, and become eager to learn to use the system. Only after receiving the first huge phone bill they realize how expensive hobby this is. Only the most motivated users will dare to use the browser after this.

We have tackled the cost control issue by thinking how the user could better understand and control browsing costs (**Paper VIII**). The mobile device cannot get the exact cost information or even the billing method from the connection provider, so we cannot help the user to follow the actual cost cumulation. Instead, we provide loading progress indication by showing the kilobytes loaded, because most smart phone subscriptions are billed by data volume. In the state of the art browsers, non-technical users do not know how to control browsing costs, because they do not realize that setting image loading off is actually the way to reduce browsing cost. We provide the end user an intuitive cost control user interface by having a setting "Cost of browsing" with user selectable values Normal, Intermediate, and Budget.

In the current prototype version, the Budget mode downloads HTML file only, not the images or other embedded content on the current page. The Intermediate mode takes the small screen into account and does not load the images that the user does not go to see, but after the user stops scrolling, the images on the current viewport are downloaded. The Normal mode acts like the desktop browsers, and download all content for the page. In our user studies, it was surprising that when using 3G network, the users did not see the difference between the Intermediate and Normal mode. The images arrived fast enough to the current screen in the Intermediate mode so it did not disturb the user experience.

6.4.4 Trust

The browser itself cannot do much for informing the user about the current connection, since there is a separate piece of software in phones to handle connections. The browser has a little space on the screen for showing what type of connection is used (GPRS, 3G, WLAN), and the current signal strength. These pieces of information are the most important ones for user to evaluate connection trustworthiness: which connection is used and how robust the connection is. As WLAN connections become more common, I hope we are able to provide more information about WLAN networks to allow users better decide whether they can trust the WLAN provider or not **(Paper V)**.

6.5 Gateway

It is possible to have a gateway somewhere in the Internet to optimize data traffic by transforming web page format to better fit the mobile device, and by reducing costs of data traffic over the expensive wireless connection. We analyse the gateway solution in **paper VIII**.

We are not counting on gateway optimizations, but developed our browser solution so that it does not require a gateway. This client solution allows users to gain the same experience on unsecure (http) and secure (https) pages and with different operators. For the mobile browser users, it is often hard to understand where the optimizations happen: is it the site, carrier, or the browser that formats the pages. The user should be able just to access the site, not care too much about where the optimizations take place. But when the optimizations are visible and disliked, the user should find the way to get rid of the optimizations.

6.6 Site

The old thinking model of WAP expected site developers to take care of all the work by making their sites mobile friendly. We took another point of view by trying to support the existing full web content out there. We minimize altering the content on pages, because we found that familiar looking pages improve usability, appeal, and trust, and thereby user

experience. We know usability cannot be optimal when viewing large pages on small screens, but if the large page fulfils user's need, we provide her/him a way to access the page even on a mobile phone.

Nokia saw that the browser is a key enabler application, but it is hard to make it support the ever increasing variety of web pages and content formats out there. In June 2005, Nokia announced co-operation with Apple to provide an open source browser on S60 devices, and the browser itself was published late 2005. Using an open source browser in mobile devices will improve mobile browsing experience, and not only in Nokia devices. When more and more mobile users access full web sites, it also drives the site developers to provide mobile friendly content for the existing mobile customers.

6.7 User experience evaluations

We executed many usability evaluations for the browser prototype, as we explain in **paper VII**. The paper describes mostly the results from a field study where 20 users compared two different mobile browsers in their daily environment for 8 days each. We collected feedback as feedback questionnaires, logs, and diaries. We concentrated in usability of our web page visualization method, but we used the methods recommended for user experience evaluation (Jordan 2000, Kuniavsky 2003), see chapter 4.2, Methodology and Implementation.

Because not all users had used a mobile browser before this study, we wanted to compare whether our browser provides better or worse user experience than the state-of-the-art browser. Comparing two products tells us much more about user preferences than testing a single product, because users can articulate easier what they liked or disliked in each product.

We measured the overall user experience by a preference rating between the two tested browsers: which browser the users would prefer to use, if they have the need for browsing web pages on a mobile phone. This result shows clear preference to our browser (Figure 14). 18 out of 20 users preferred Minimap and as many as 12 users *strongly* preferred it.

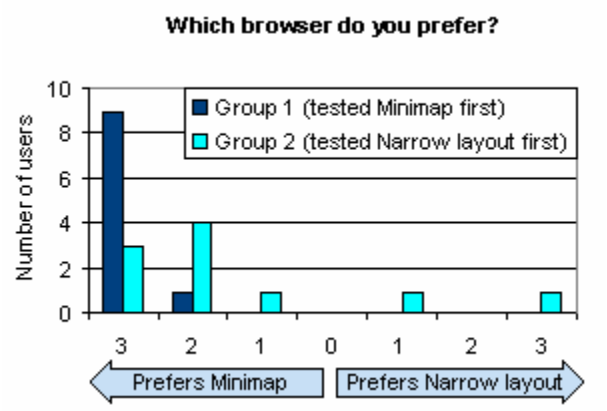


Figure 14. Browser preference results

It is interesting that the group who tested Narrow Layout first did not have as strong preference to our browser as the group that tested Minimap first. We did not find out the exact reason for the different preference ratings of the two different groups, but if we would have been able to evaluate the relation between expectations and the resulted user

experience, we might have been able to analyse this difference better. I discuss the challenges in user experience evaluation more in chapter 9.3, Evaluating user experience.

6.8 Outcome

As shortly documented above and in **paper VII**, we came up with a Web Browser for S60 that has a unique web page visualization method called Minimap. 18 out of 20 long-term field study participants preferred our browser to the state of the art browser. The new browser has got very positive feedback also in the press after being published November 2005:

"2005 will be remembered as the year the Web made its way to our cell phones, but nobody will think back on those first, awkward attempts at browsing with fondness. [...] Until we saw a demo of Nokia's new browser, we did not think the mobile Web had really come of age."
-- *Rachel Rosmarin (Forbes 2006)*

"…this browser is the most promising and important software regarding mobile browsing in a while. It innovates and it's using a truly powerful engine (if only carriers would make GPRS cheaper). While Opera and Netfront will quickly follow in terms of feature-set, Nokia has paved the way to become the first browser manufacturer where mobile browsing is practical and a joy to use."
-- *Eugenia Loli-Queru (OS News 2005)*

The first S60 phones with the Mini Map feature arrived to shops spring 2006. Note that the product version was developed in another part of Nokia, and is not exactly the same as the prototype developed in Nokia Research Center that we have described in **paper VII**. The main differences between the research prototype and the actual browser product are the increased display resolution and replacement of the focusing system with a pointer. We are eagerly waiting for end user comments after the phones are widely in use.

The Minimap web page visualization method is the most visible outcome of our mobile browsing team in Nokia Research Center. All the main ideas of this method, except the pointer solution, are invented in our team. Four patent applications have been filed related to the method, one about the Mini Map that appears while the user keeps scrolling the page continuously for more than a specific time, and disappears soon after scrolling stops (Figure 12).

7. CONCLUSIONS

Based on the results described in the two previous chapters, I present a set of characteristics affecting mobile browsing user experience. First, however, I need to shortly clarify my understanding of the general characteristics of user experience and how our findings relate to the general user experience research. Many of these topics are further discussed in chapter 9, Future work.

7.1 User experience

I proposed the term "user experience" to be used only when the person is *using*, not only experiencing a system or object. A *user* manipulates or controls the system or object, not only witnesses a phenomenon. If there is no system component involved, i.e. when the experience comes from the context itself, we should talk about plain "experience". Viewing a beautiful landscape does not provide *user experience*, since the viewer is not using the landscape, but it provides an *experience*. User experience is evaluated in terms of system's influence on the experience for the current internal state of the user in the current context.

User experience consists of smaller experiences (Forlizzi & Battarbee 2004), so the possible reference period for examination can vary from a single key click experience to multi-year experience of a product. The overall product user experience involves all the phases from pre-purchase to dispensing with the product and even beyond that. When designing new products, we can evaluate the designs by sampling only shorter periods of product lifecycle, and by examining particular use cases with product prototypes. The user experience in each such use case is unique, because the user's internal state, the use context, and the system are dynamic. In this research, I chose the reference period to include loosely one use case, which typically refers to one user's goal and one browsing session, together with the related activities before and after it. It should be kept in mind, however, that the previous use cases clearly affect user's expectations for the examined use case, and, together with information and perceptions received from other sources, build up an attitude towards mobile browsing in general. This model of user experience was presented in section 2.8.1, Figure 8.

When examining user experience in a particular use case, the building blocks on high level consist of user's state, context, and the system that the examined product is part of (Hassenzahl & Tractinsky 2006). Sometimes the 'system' is simply replaced with term 'product' (Forlizzi & Ford 2000, Arhippainen & Tähti 2003), but then we lose some aspects relevant in user experience. Products are increasingly dependent on other products or systems, and if those fail to deliver a good user experience, the examined product will not be able to do it either. This is clearly visible in the case of a mobile browser: it is impossible to use a mobile browser without the mobile device, the connection, and the web sites, and the user experience is an outcome from all these components working together. An alarm radio is much less dependent on other products, but a good user experience of the alarm radio requires a very reliable power source and a suitable radio channel. Even a simple object, such as a knife, cannot be used without the meet or bread to be cut with the knife, and the products that are used for cleaning and storing it. Investigating the role of the product in the system often leads to better user experience than investigating the product as an isolated object. This is why it is beneficial to have a "system", not a "product" as one of the three main user experience factors. Unfortunately, "system" is often associated with high technology, but I want to stress that a system may consist of simple objects solely.

Kankainen (2003) stresses the strong relation between user's expectations and user experience, and expectations are listed also by Forlizzi & Ford (2000), Arhippainen & Tähti

(2003), Hiltunen et al (2002), and Hassenzahl & Tractinsky (2006) as an influencing factor for user experience. According to our studies, even if system use case includes struggling with problems, the overall user experience might be positive **(Paper III)**. This phenomenon takes place if the usage was, after all, easier than the user expected, or the resulted value higher than expected. Expectations should be understood better when evaluating user experiences (see chapter 9.3, Evaluating user experience).

I presented the finding, seldomly discussed in the user experience literature, that product pricing has an interesting effect on user experience. If a person pays a product before starting to use it, the price is influencing the expectations for the product: an expensive product is expected to provide better user experience than a cheap similar product. This might be one reason why cost is not listed in previous research: cost is seen as an influencer to expectations, not directly to user experience. Typically, cost is not affecting a specific use case as directly as in the case of mobile browsing, so its influence is easy to forget. The case of mobile browsing is interesting because many users pay for the usage only *afterwards* by the amount of data transferred and it is hard to know the cost in advance. For example, a great browsing user experience abroad will result to a huge bill two weeks later. Can we still say the user experience remains great, although the user is furious about the system, complaints about it to friends, and will never again browse the web abroad? The bill was, after all, just a delayed response from the system, but still part of the use case. This is a good example where the user experience changes afterwards, a phenomenon called reflecting by Wright et al (2004). Similar examples of delayed system responses are receiving a parcel from a web shop or getting spam emails after giving out email address. The true user experience cannot be evaluated until the bill has arrived, that is, until the user understands the total cost of use.

7.2 Characteristics of mobile browsing user experience

After our first XHTML MP study, we noticed it was not only the site that affected mobile browsing usability. We identified two other components that affected users' opinions on whether the system was usable or not. Figure 15 shows the finding we made: there are 3 layers affecting mobile browsing usability (Roto 2005).

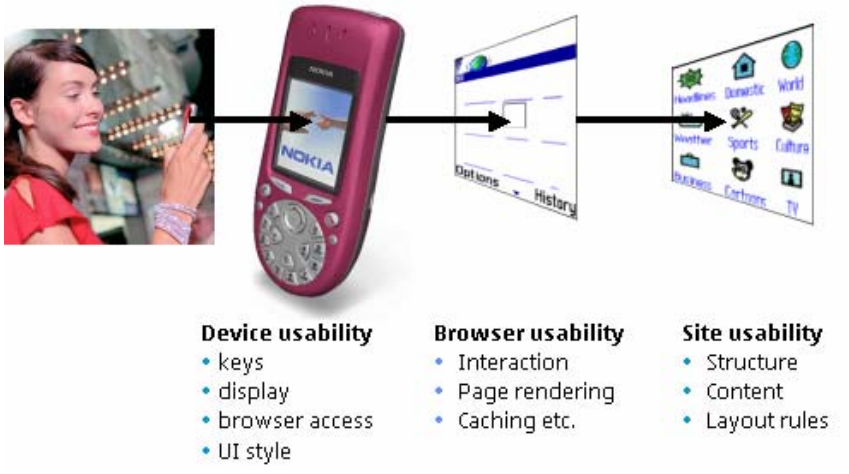


Figure 15. Components affecting usability of mobile browsing use case.

This model addressed the fact that the users of a mobile site, and even usability professionals, have difficulties distinguishing the different layers, or components, in the chain. The situation gets even more obscure if there is a gateway that formats page content or layout. This model was adopted by the World Wide Web Consortium (W3C 2006). When I refer to device usability, browser usability, or site usability later in this dissertation, I mean the attributes listed in Figure 15.

Usability is just one part of user experience. Also in our user studies, we soon realized that there are several other factors in addition to usability that users are experiencing when accessing internet sites on a mobile phone. It seems that the same rule applies to user experience components as for usability components: you pay attention to user experience only when it is worse or substantially better than you expect. In desktop browsing, the PC, browser, connection, and context of use are so standard that even researchers do not realize or remember to mention them affecting web browsing user experience. In mobile browsing, however, the wide variety of devices, browsers, connections, and use contexts make these components clearly visible. When using different combinations of these components, user experience of the same web site may change dramatically.

My research question was

What are the attributes affecting user experience when browsing web pages on mobile phones?

Figure 16 answers the question by listing the components and attributes that have an effect on mobile browsing user experience. Compared to Figure 9, which summarized the scattered references from previous research, I have added the Browser and Gateway components to the System, and added attributes Trust and Customer care to Connection component. These additions are marked in *italics*. Our studies also supported the findings from previous research that the components and attributes of Figure 9 do influence mobile browsing user experience.

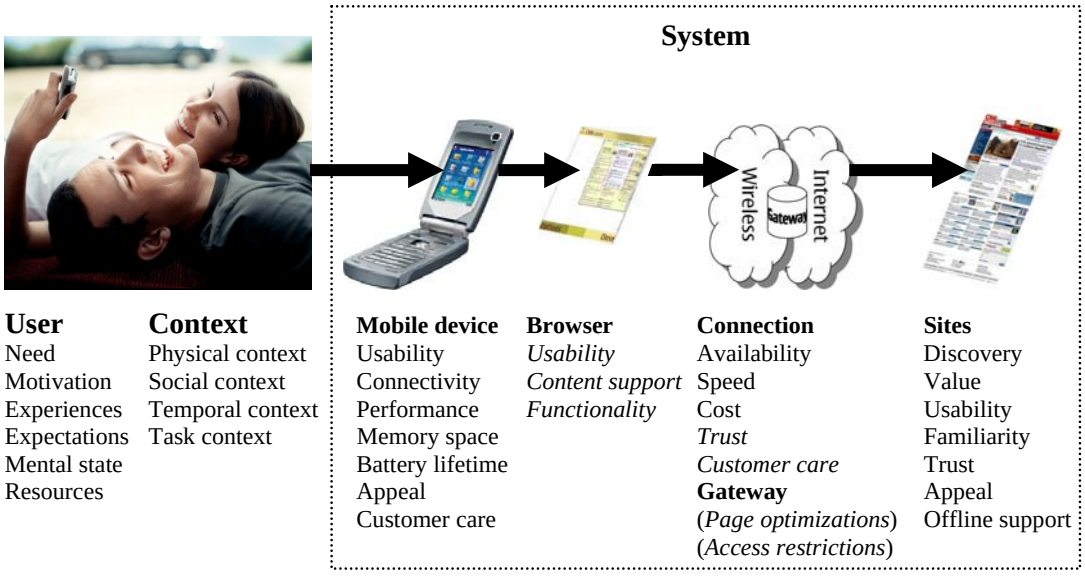


Figure 16. Characteristics of mobile browsing user experience.

Characteristic:	Short explanation:
USER	The person controlling or manipulating the system
Need	The underlying need that the system helps to fulfil
Motivation	The reason why the system is used
Experiences	The knowledge gained by using or hearing about similar systems
Expectations	The idea of how the system will work, the outcome, and investment
Mental state	The current emotional state of the user, e.g. mood, vigilance level
Resources	The current physical and mental abilities available for the task
CONTEXT	The circumstances in which mobile browsing takes place
Physical context	Physically sensed circumstances, geographical location
Social context	Other people's influence on user, user's social contribution goals
Temporal context	Time available for task execution
Task context	Role of mobile browsing task in relation to other tasks
SYSTEM	The system required for the examined product to work / be useful
Mobile device	The device used for mobile browsing
Usability	Input and output mechanisms, UI style, browser access
Connectivity	The ability to connect to Internet via different types of networks
Performance	The ability of the device to execute commands efficiently
Memory space	The data storage size available for mobile browsing data
Battery lifetime	The period the battery lasts without recharging
Appeal	Attractiveness, e.g. look, functionality, reputation
Customer care	Assistance available in print, online, over the phone, face to face
Browser	The software application used for interacting with web pages
Usability	Learnability, memorability, efficiency, getting by errors, satisfaction
Content support	The ability to render different types of content available in the web
Functionality	The set of functions that fulfil the user needs for mobile browsing
Connection	The wireless and wired networks required to access the web sites
Availability	The existence of a network that can be used to access the sites
Speed	The actual throughput of the network
Cost	The amount of money spent on data transfer over the connection
Trust	User's confidence on security & robustness of the connection
Customer care	Assistance available in print, online, over the phone, face to face
Gateway	(or proxy) A network node through which user's data traffic is routed
Page optimizations	Transforming web content to more suitable format for a device
Access restrictions	Blocking access to some web sites from a user

Site	Set of web pages behind the same web domain name
Discovery	Finding a site/page from the web
Value	The characteristics of the site that the user appreciates
Usability	Structure, content, information visualization
Familiarity	Identifiability of the pages
Trust	User's confidence on content correctness and respect for privacy
Appeal	Attractiveness, e.g. look, content, reputation
Offline support	Serving the user outside the web site

The definitions above are incomplete; the terms were explained in more detail in chapter 5.

The number of found characteristics is extensive, and we could continue opening the attributes and listing more details for each of them. It would be more interesting, however, to identify the most important characteristics from this list. It is clearly the site that provides the value to the user in the mobile browsing system. The site should also deliver most of the user experience, while the other parts of the System are just enablers for this experience. The concept of an invisible enabler tool is familiar from usability practice, but many user experience researchers think also tools should provide experiences in order to differentiate from other tools. When designing the mobile browser, we did not want to steal the show from the site when it comes to experience, but with most important browser functions, such as backstepping, we do provide Visual History functionality that has created positive reactions among users.

The presented user experience characteristics can be used by user experience researchers, designers, developers, managers, and even by marketing people. Mobile browsing is an interesting case for user experience researchers because of the following reasons:

- Mobile browsing system requires a mobile device, browser, connection, and a web site. Each of these is typically provided by a different party, and each party may aim to deliver conflicting experiences.
- Mobile browsing context provides an interesting context of use to be examined.
- Mobile phone is a very personal device that users have an emotional relation to.
- Mobile browsing should fulfill both utilitarian (find a specific piece of information) and hedonic (entertainment while waiting) needs.
- Mobile web browsing may have complex billing models.
- Because mobile browsing technology is immature, each component is clearly visible when evaluating UX.

Researchers and practitioners who develop methods for user experience evaluation may test their ideas against the model of user experience in mobile browsing case. In an optimal case, the evaluation method should be able to identify the origins of good and bad user experience to the attributes in the model, or bring up new attributes into the picture. For example, a questionnaire investigating mobile browsing user experience could investigate the topics listed in Figure 16.

The model presented hopefully helps designers to take the full picture into account when designing one piece of a mobile browsing system. Although the model is for mobile browsing, it highlights the fact that investigating the product in question as an integral part of a bigger system is highly recommended when targeting at good user experiences. Usefulness and value of the product is closely related to the User and Context attributes, so these should be addressed already in the product concepting phase.

This holistic viewpoint has proven to be a powerful framework for innovations in our mobile browser development case. If we had investigated just the mobile browser, not the mobile browsing system, I might have listed the browser on the System side and kept the Technological context item (Hiltunen et al 2002, Figure 9) on Context side to include the device, the connection, and the site. Listing these components on the System side, however, highlights the fact that a browser needs to be designed as part of the browsing system chain, not as an isolated product.

Product or user experience managers benefit from the model by assigning work force into investigating the attributes already when defining product concepts. Understanding the other players in the system may initiate fruitful collaboration between the different parties, which makes the whole system more seamless and thus improves user experience.

User experience is increasingly important part in product marketing, as long feature lists do not impress most customers anymore. Marketing people should understand the user experience characteristics that the product is designed for. In an optimal case, marketing could use the same materials as product concepting people and create appealing marketing campaigns based e.g. on relevant use cases rather than features as such. The different contexts are often easy to communicate in visual marketing, and using them together with the attributes listed for User may well motivate people to buy the product.

8. DISCUSSION

In this dissertation, I have shown that there are many different components on the system side in the case of mobile browsing. The complexity makes this domain an interesting research area, as it is not trivial to make all these components work well together to provide a positive user experience. Investigating a complex system often provides new knowledge to the research field, and mobile browsing did help us to see the potential building blocks of user experience. I found that it is beneficial to see a product as an integral part of a system, and take pricing information and user expectations into account when evaluating user experience.

According to Blythe & Wright (2003), user experience means taking user enjoyment as the strarting point for the design rather than implementing solutions for the existing problems. The list of characteristics I presented can be seen as a list of potential problems that restrict the design. Should not the designer ignore this list and just design a perfect mobile browsing experience? Visioning the perfect world is a very valuable exercise, and this vision hopefully will drive the design. Ignoring the facts, however, would lead to a disastrous user experience. Pointing out the set of attributes helps designers to avoid problems that are inevitable if they ignore their existence. Because a product is a part of a system, it is an interesting exercise to think what will happen if the other parts of the system do not work optimally. Taking the imperfect world into account already in the design phase and creating innovative solutions to cope with the challenges is likely to lead to an enjoyable user experience.

If one company would take care of all the components in the system, they could design the components to work well together. In Japan, there is one company, DoCoMo NTT, that manages all components on the system side: It sets requirements for mobile devices, browsers, and i-mode sites, and provides the connection and gateways. The user gets both the device and the connection from DoCoMo, and DoCoMo decides the pricing. Mobile browsing is a daily routine for ordinary Japanese people.By managing all parts in the chain DoCoMo has obviously succeeded in providing positive user experiences for mobile browsing. However, the access to the full web will create a new uncontrollable component for them.

In order to provide a seamless flow through the components in mobile browsing system, the system needs to enable several players to work seamlessly together, like the players were from the same team. This would require standard interfaces between the components, and not too many totally different types of each component. It is not possible, however, to force all devices to follow the same screen size and interaction rules, neither it is possible to force web sites not to provide any new types of components. What can be done is to make the browser the intertwiner of the various types of sites and devices.

For practitioners, it would be useful to provide a set of “user experience heuristics for mobile browsing”. Unfortunately, I do not have an extensive list of guidelines at hand, so I cannot run a similar analysis as Molich & Nielsen (1990) to derive mobile browsing user experience heuristics. I feel obligated, however, to provide an initial answer to the guestion: What are the principles to be followed when targeting at a good user experience in mobile web browsing? Below, I have collected some principles that address the key user experience factors User, Context, and System, plus a methodological advice for developers.

User:

1. Provide access both to the mobile optimized web and to the full web
2. Support the usage patterns familiar from a PC

Context:

3. Provide the web in one hand (do not require two hands)
4. Provide minimal attention user interface

System:

5. Provide a good web page visualization method for a small screen
6. Overcome the possible lack of full keyboard by smart software to support text input
7. Provide cost information and simple ways to cut the costs down
8. Minimize the response times for page downloads
9. Save battery power when it is getting empty

Method:

10. Follow user-centered design process

Investing in user experience seems to be fruitful even with immature technology. When we understand the characteristics of user experience, we can design products that delight users. We do not know about the mass market feedback yet, because the phones with the Web Browser for S60 arrived to shops only in spring 2006, but the initial feedback from operators, press, and some bloggers has been very positive. The spontaneous comment by Eugenia Loli-Queru of OS News (2006) states exactly what our Minimap user experience activities aimed for: “mobile browsing is practical and a joy to use”.

9. FUTURE WORK

The very meaning of user experience continues to raise discussions. Researchers are trying to identify the different perspectives to user experience research (Forlizzi & Battarbee 2004, Hassenzahl & Tractinsky 2006), but it seems still hard to find common understanding between the researchers from different backgrounds. In this chapter, I discuss the topics that should help us to understand the different perspectives to user experience, but that still require further research to be settled.

9.1 Pricing and user experience

It is surprising that none of the user experience definitions mention financial cost of the system as an influencer to user experience. In the case of mobile browsing, price has an interesting role, because the costs may cumulate all the time while browsing. If one does not realize how much the browsing costs, the user experience might be good until one receives the bill. Only after receiving the bill the user is able to evaluate if the value or pleasure gained from mobile browsing was worth the money, and the attitude towards mobile browsing might change dramatically. In this interesting case, user experience may be determined weeks after finishing the act itself.

Typically, one pays for a product before using it, and has certain expectations for value and/or pleasure that the product will bring. If the product was expensive, the user typically has higher expectations for it than for an inexpensive product, and s/he might not be pleased with the product even if it would work relatively nicely. So I argue that pricing does have an effect on user experience and should be listed as an important influencer on user experience.

9.2 Designing user experience

Designers design products a specific type of user experience in mind. When they evaluate user experience, they want to know whether users get the intended experience. If not, they are disappointed. For example, Ellis and Ellis (2001) state that user experience on a web site "consists of ensuring that the actual experiences of users on your site match the experiences you expect them to have". HCI people might think that this attitude is similar to the attitude of engineers who implement systems: they expect users to think in the same way as they think themselves, and are disappointed if the users do not understand how their system was intended to be used.

Designers and engineers are similar also in the way that a few of them want just create products for themselves and people very similar to them. Designers might even want to design for unpleasant experiences. The pieces of modern art aimed at generating anger or disgust are typically appreciated only by the other artists who understand that the negative emotions were actually the goal of the design. Only experienced art lovers are able to enjoy and appreciate this kind of art, because they respect the fact that the artist was able to evoke the particular emotion that he originally wanted. This is similar to technology that requires specific knowledge and logic to be used, but if you happen to understand the uncommon logic behind the system, you respect the developers who created this unique system. The phenomenon of negative emotions creating eventually positive experiences has been analysed e.g. by Desmet (2003).

In HCI field, I hope we understand that some products are aimed just for a very specific audience and we should try to identify the target users before evaluating the products. We are in a key position to deliver a message to designers and technologists that their designs

will not be applicable to all users. HCI people have seen how hard it is for product designers to articulate what their target user group is, because they easily think everyone will use their product. Unfortunately, HCI people are often the party to identify the characteristics that the target users need to have to be able to use the product or enjoy the design.

The target users are the ones that are likely to appreciate the design. I claim that only expert users, whether they are art, technology, or other domain experts, are willing to take the painful path via negative emotions to achieve the positive experience. It is not acceptable to expect other people to appreciate designs that require specific knowledge or way of thinking, or force them to struggle through the long path. A boxer whose opponent beat him with a skillful knock-down may appreciate this learning experience afterwards, but beating a man on the street and expecting him to appreciate the experience is not acceptable. Pushing difficult designs to mass markets and expecting people to learn to understand them is not acceptable.

If users experience the design or system in a positive way, even if it was not the way intended by the designers or developers, will user experience evaluations show failure? Should the designers or developers be disappointed? If they are open-minded, they are not. Developers did not design the Short Messaging System (SMS) for end user communication, but they are not disappointed that users now widely use their system for text messaging. They might feel sorry that they did not design the system specifically for this type of use, but it was a success story anyway. As long as users' experiences are positive, the user experience evaluation results should be positive. In design phase, it is good to aim for a specific kind of experience, but many times, it is more important to evaluate whether users get a positive or negative experience in general, instead of a specific, intended experience. This is why I will talk about positive user experience, not an intended user experience in the following section.

9.3 Evaluating user experience

In industry, user experience is interesting from the point of view of a product: does a product provide a positive user experience or not. After designing for a positive user experience, we should be able to evaluate user experience. If the resulted user experience is negative, i.e. the users are disappointed or angry, we should analyse the origin for the poor result to be able to improve the product. The evaluation method should provide enough of data for this problem analysis. The earlier the evaluations can be done, the easier it is to change the product to the right direction.

As I stated in Figure 16, there are a number of attributes affecting mobile browsing user experience. The attributes play a different role in different cases, and the users are often not able to identify the exact origins for a positive or negative experience. The effect of one attribute to the total user experience can be seen by altering the attribute, e.g. using different connection speeds. It is very hard, however, to keep the other attributes unchanged. User experience is personal and changes over time (Forlizzi & Battarbee 2004), meaning that we will not get consistent results from different users even in an identical context. The participant her/himself is the only one that can estimate how the system should work in order to gain a positive user experience in the current unique situation.

User experience is typically evaluated by user's subjective satisfaction towards the product only after executing some tasks with it. In these cases, user's initial internal state is not often addressed. The research by Tähti et al (2004) is an exception here, since they evaluated user's feelings towards the system both before and after using it.

Kankainen (2003) and Hassenzahl & Tractinsky (2006) describe user experience as a consequence or result of a use case, whereas I think user experience is a continuous, varying mental state, or "sensation" as Shedroff (online) states. For example, in the beginning of an information retrieval task, the user may find it harder than expected to locate the needed information, and the user experience is negative. Later during the same task, however, s/he may find the located information of higher quality than expected, and the user experience is positive. So, the length of the reference period affects the evaluated user experience, and the shorter the period is, the more specific sources for disappointment or delights we can find.

As discussed already in section 7.1, User experience, I think the key to user experience evaluation is to analyse whether the product met the *expectations* that the user had before starting to use it. After a cursory literature search, it seems there is not much research done on evaluating user experience through user's expectations. Carr (2001) has investigated quality of life and found that expected level of health must be taken into account when evaluating quality of life. Buttle (1995) discusses the role of expectations in service quality evaluation and the challenges of taking expectations as a criterion in service quality evaluation. These papers are very relevant also in user experience evaluation and indicate that many different sciences deal with very similar questions as we in user experience evaluation.

An expectancy-value theory states that people's attitudes towards an object form out of beliefs that the object has a specific attribute, and the value attached to the attribute (Fishbein 1963). Shah and Higgings (1997) use the expectancy-value theory in goal commitment: the commitment to take an action is dependent on the expectancy and value of the outcome of certain behavior. If the expected value and the likelihood of achieving the goal are high, a person is motivated to take the action. The publications about expectancy-value model seem to rarely discuss the role of effort or cost that reaching the goal will require. According to our studies, user experience was poor even if a valuable goal was achieved, if it took more effort than originally expected. We found that users did not even start mobile browsing if they expected it to be too laborious or too expensive. Good user experience rose easily in cases where the effort was lower than expected.

To stimulate discussion, I propose the diagram in Figure 17 about the relation between user's expectations about the investment (effort or cost) of reaching a goal, the value or pleasure attached to this goal, and the realized user experience. This diagram is inspired by the facts that expectations are important influencing factors for user experience (Mäkelä & Fulton Suri 2001, Hiltunen et al 2002, Arhippainen & Tähti 2003, Hassenzahl & Tractinsky 2006), and that the user is not motivated to take an action if he expects it to be too much effort or too costly (Kankainen 2003).

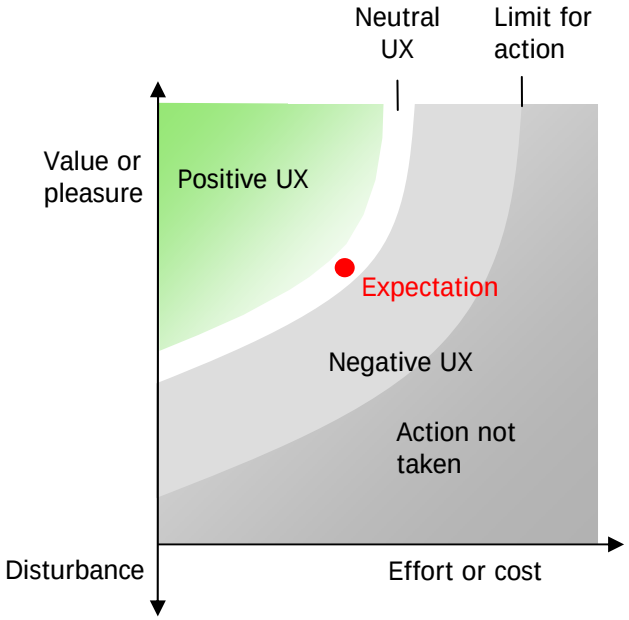


Figure 17. User experience is relative to user's expectations about investment vs. value

This diagram shows the fact that if the effort or cost (investment) is seen high compared to the value or pleasure, the user does not have the needed motivation to act, i.e. to start mobile browsing or to buy a device (dark gray area). If the value or pleasure is expected to be high compared to the investment, action is taken. When action is taken, the expectation of benefit versus effort is always somewhere above the Limit for action line. As we noted in chapter 2.1, Terminology, user experience is acceptable if the expectations are met, negative if not met, and positive if exceeded.

The Neutral UX curve shows the norm against which the user judges the resulted experience. The shape of the Neutral UX curve varies by person and context. In Figure 17, the curve might reflect a business user with a mobile browsing task: s/he is not willing to put much extra effort (time) to gain more value, neither s/he is happy with a lot less value even with decreased effort. Also the Limit for action line may be steeper or flatter, depending on person's preferences.

The Expectation dot is located differently in each use case. In Figures Figure 17 and Figure 18, it is drawn onto the Neutral UX curve, but the expectation be placed at any area of the graph. It is open, however, if the expectation can reside above the Neutral UX curve, since it would mean the user experience be positive even if the expectation was not met.

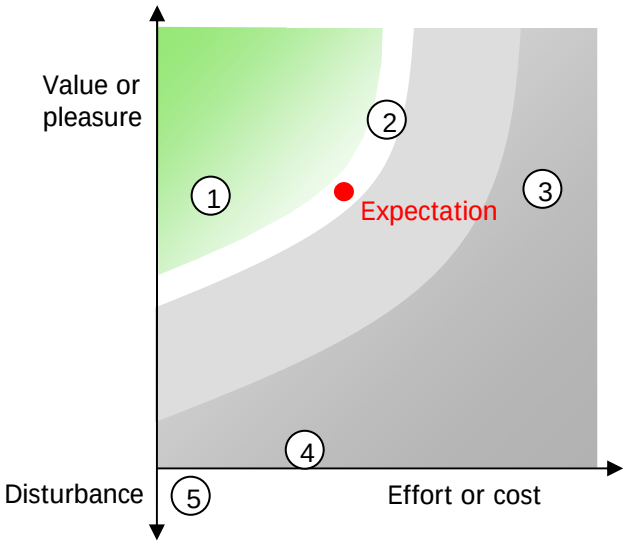


Figure 18. Examples of realized user experience.

Figure 18 shows some examples of user perception about the realized value or pleasure and the needed investment as effort or cost. In the case of mobile browsing, the examples could be as follows:

1. The user found useful or amusing information with a lot less effort and cost than expected, and is very pleased.
2. The user found the information she was looking for, and noticed another interesting piece of information. S/he invested some more time and effort for mobile browsing and gained more value than expected. This is often what happens when browsing the Internet, so the user experience is still neutral.
3. It was very hard to find the needed information. If s/he would have known how hard it would be, s/he would not have even tried.
4. The information was not available where the user expected, and s/he gave up.
5. The user receives notification of a new spam email.

One may argue that in many cases, the user has no expectations for system usage. These are cases where the user does not pay too much attention to the system when using it, e.g. when taking milk from a fridge or answering a phone call. In all cases, however, the user does have expectations for system usage but s/he cannot articulate these expectations. Only if the system does not work as expected, e.g. the fridge door is stuck or the phone call would not be activated in the usual way, the user pays attention to the system. Especially in the cases where the user has precise expectations for the system, even positive changes in the system easily lead to negative user experience.

The problem in evaluating user experience through expectations is the difficulty to analyse user's expectations in an artificial laboratory setting. In real life, the user always has a

certain motivation for purchasing a product, and different users value different product aspects differently. For example, Keinonen (1997) notes that most people compare devices mainly by price and outlook, and only technical people are able to compare devices based on the functionality.

Together with VTT Tampere, we are in the process of testing how user experience could be weighed against user's expectations. We show advertisements and product package to the user in the beginning of a field study and evaluate user expectations based on this early information of the product. After this, the users use the device for two weeks, and evaluate how pleasurable s/he sees the device as a whole each day. At the end, we will ask how pleasurable the user estimates the device as a whole, and whether the original expectations were met. If the expectations were exceeded, the product delighted the user and the user experience was positive. We will also run another round with the same user with another, similar device. On the second round, the user can compare the experiences learned with the first device to this other device. We are facing some difficulties here, because it is hard for users to express their expectations after a short glimpse to product advertising materials, and the pleasure scale during the field trial reflects the success of daily tasks, not the overall relation to the product.

According to my current knowledge, a widely accepted way to evaluate user experience is still missing. This comes from the fact that user experience is a new and still obscure topic and requires a definition itself. Future research is needed to understand user experiences, to develop methods that allow product developers evaluate user experience in various phases of product development, and to develop methods for clarifying users' expectations and their relation to realized user experience.

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