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BROWSING AND NAVIGATING WEB APPLICATIONS WITH MOBILE DEVICES

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Pro gradu -tutkielma

Tämä pro gradu -tutkielma käsittelee mobiililaitteilla tapahtuvaa WWW-sovellusten selailua ja niissä navigointia. Sen tilaaja ja sponsoroija on Nordea Pankki Suomi. Tutkielma on teoriaa testaava tutkimus. Sen ensimmäinen osa muodostaa teoreettisen viitekehyksen toisen osan empiiriselle tutkimukselle. Käsitteellis-teoreettinen taustatutkimus luo kokonaiskuvan tämänhetkisistä mobiiliselaimista sekä viimeaikaisesta tieteellisestä tutkimuksesta, joka käsittelee mobiiliselaimia ja navigointirakenteita mobiililaitteille suunnitelluissa WWW-sovelluksissa.

Tutkielman toinen osa käsittelee kontrolloitua laboratoriokoetta, jossa vertailtiin kahden erityyppisen mobiilipankkipalvelun käytettävyyttä. Kokeen tarkoituksena oli selvittää, onko linkkien sijoittelulla vaikutuksia mobiililaitteille suunnattujen WWW-sovellusten käytettävyyteen. Myös ristikkäisnavigoinnin tarpeellisuutta tutkittiin. Kun tuloksia analysoitiin, huomattiin, että linkkien sijoittelussa on pyrittävä sovelluksen ulkoasun selkeyteen. Testisovelluksessa, jossa linkkivalikko oli näkyvillä jokaisen sivun yläreunassa, oli huomattavia käytettävyysongelmia. Kokeen toinen sovellus, jossa navigointi tapahtui erillisille valikkosivuille allekkain sijoitettujen linkkien kautta, todettiin paremmaksi kaikkien arvioitujen ominaisuuksien suhteen: Sen käyttö oli tehokkaampaa ja helpommin opittavaa, käyttäjät tekivät siinä vähemmän virheitä, he olivat sovellukseen tyytyväisempiä ja tiesivät paremmin sijaintinsa sovelluksessa. Kokeen tulokset ovat yleisesti hyödynnettävissä mobiililaitteille tarkoitettujen WWW-sovellusten suunnittelussa. Erityistä hyötyä niistä on Nordea Pankille mobiilipankkipalveluiden jatkokehityksessä sekä Nokialle, kun suunnitellaan uusia suosituksia mobiilisovellusten rakenteeseen liittyen.

AVAINSANAT: Navigointi, käytettävyys, mobiililaite, mobiiliselain, mobiililaitteelle suunniteltu WWW-sovellus

ABSTRACT

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This master's thesis considers browsing and navigating web applications with mobile devices. The thesis has been commissioned and sponsored by Nordea Bank Finland. It is a theory-testing research consisting of two parts. The first part forms the frame of reference for the empirical theory-testing experiment. By reading the conceptual-theoretical background research one can form a general picture of the current mobile browsers and the recent research considering browsers and navigation structures in mobile environment.

The second part of this thesis describes the controlled laboratory experiment, which is comparative usability testing of two different mobile banking applications. The purpose was to find out, whether the placing of the links has an impact on the usability of mobile web applications. Also, the effects of the possibility to cross-navigate were tested. When analysing the results it was noticed that the placing of the links must aim to clearness of the layout. The application, where a navigation bar was placed on the upper edge of every page, suffered from severe usability problems. The other application, where navigation happened through separate menu-pages where links were placed beneath each other, was preferable in all evaluated aspects: learnability, errors, efficiency of use, subjective satisfaction and the user's awareness of her/his current position in the application. The results are exploitable in mobile web application development in general, and especially when considering the further development of Nordea Bank's mobile banking applications. Nokia, as well, benefits from the results, when generating their guidelines for mobile application developers.

KEY TERMS: navigation, usability, mobile device, mobile browser, mobile web application

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I would also like to thank Anne Kaikkonen, who works as a researcher at the Nokia research centre, for helping me in the arrangements and in the implementation of the usability testing. The case would have not succeeded without her contribution in the laboratory arrangements and, of course, her mental support during the tests.

Jyväskylä, December 2004

Tuuli Hyvärinen

CONTENTS

1 INTRODUCTION

This thesis considers browsing and navigating web applications with mobile devices. The first chapter introduces the topic, and provides information about the contents of this report.

Mobile devices with internet connections, e.g. WAP and GPRS, are becoming widespread (Åkerman 2003, 5). Although mobile web applications did not make their expected breakthrough when first WAP services were released, WAP 2.0 and XHTML-Mobile Profile have given the mobile internet a new opportunity to succeed (Kaikkonen & Roto 2003a, 329; Roto 2003). Particularly the current HTML-enabled browsers extend the possibilities to use mobile devices for internet browsing. At the same time as the popularity of HTML-enabled browsers increases, also the amount of mobile commerce applications is expected to rise considerably (Shih & Shim 2002, 199). To some extent this has already happened.

The adoption of mobile web applications is related to their usability, as it is with all web applications (Nielsen 1999, 389). Navigation on the other hand is a very significant part of usability design (Buchanan, Farrant, Jones, Thimbleby, Marsden & Pazzani 2001). To make the success of mobile web applications possible, browsers' preferable features as well as applications' preferable navigational structure should be widely studied.

FIGURE 1 illustrates the components that have an influence on mobile web usability: the user, the device, the browser and the used site. This thesis focuses on the two latter one, the browser and the site, from the point of view of navigation and its' usability.

FIGURE 1. Components, which affect the user experience in mobile web applications (Nokia 2004a).

1.1 Goals and outcomes of this thesis

The purpose of this thesis is to study browsing and navigating mobile web applications. It should be noted that technical development of hardware components is excluded from the focus of the study, although technical aspects do have an impact on the usability of mobile web applications, too.

The contribution of the conceptual-theoretical background research is that it is the first research to create a general and extensive view of the topic. So far the field of study has been quite dispersed, and therefore a demand for this type of an overview exists.

The empirical part, a controlled laboratory experiment, which tested the effects of navigation placing and cross-navigation in mobile web applications by comparing two applications, creates contribution to the research field, too. It is significant already when thinking of its scale. The experiment involved 31 test users, when normally there are 8–15 test users. The subject of the experiment has not yet been covered in the scientific research and, thus, it offers new information for other researchers. Nordea Bank Finland can adapt the results of the experiment in the development of their next generation mobile banking applications, and Nokia Corporation can utilize the results when they generate their style guides for the service providers, as well as when they develop their future devices and browsers.

1.2 Key concepts

Important concepts in this thesis are: navigation, usability, mobile device, mobile browser and mobile web application. These terms are defined in this thesis as follows:

Navigation is "the path and actions needed to find a piece of information on a site and get back when needed (Kaikkonen & Roto 2003a)". It is "a basic part of using any software, just as wayfinding is integral to graphic and environmental design. It covers not only explicit sequential steps, but the ability of users to go from starting a program to getting useful work done (Schubin & Perkins, 1998)". In web applications browsing is "navigating to information and then using it (Schilit et al. 2001, 122; Trevor et al. 2001, 123)". Nielsen (1999, 188) defines three fundamental questions of navigation, to which the users have to be able to answer with the help of the navigation interface. They are: Where am I? Where have I been? and Where can I go? These questions are later in this thesis called "the fundamental questions of navigation".

Usability is a multidimensional concept that is traditionally associated with five attributes: learnability, efficiency, memorability, errors, and subjective satisfaction (Nielsen 1993, 26). However, it is hard to define usability exhaustively. It is a field of methods and concepts, through which the cooperation of the user and the device is tried to be made more efficient and pleasant from the user's point of view (Sinkkonen, Kuoppala, Parkkinen & Vastamäki 2002, 19). There are also ISO standard which aim to define usability: ISO 9241 sets ergonomics requirements for office work, and ISO 9126 defines usability requirements from the product's perspective (Abran, Khelifi, Witold & Seffah 2003). In this thesis the first mentioned definition made by Nielsen is used, since it appears to define usability fairly extensively from the user's point of view.

In addition to term *mobile device*, literature often uses terms "handheld device" and "small screen device". They all have the same meaning, although, with a slightly different emphasis. In this thesis, we have chosen to use the term "mobile device", because it is the most commonly used one. Our definition of mobile devices is the same as Weiss' (2002, 2) definition of handheld devices: They operate without cables, are easily used with one's hands and support addition of applications or have internet connection capability. They are small, light and they have small screens (Weiss 2002, 8-12). Weiss (2002, 21) divides the devices into three categories: phones, pagers and PDAs. This research is concerned with devices categorised as mobile phones or PDAs.

Mobile browser, in this thesis, refers to internet browser application that runs on a mobile device.

Mobile web application, in this thesis, refers to WWW-application, which has been especially designed for mobile browsers running on mobile devices.

1.3 Research questions and hypotheses

There are two main research questions in this thesis:

1) How can web browsing be supported by browser functionalities in mobile devices?
2) How should navigation in web applications be designed for mobile devices?

Chapter two gives an answer to the first main research question. There are three sub research questions related to the subject:

1 a) What is the background for mobile browsing development?

1 b) What is the situation of the current mobile browsers?

1 c) What types of approaches there are to mobile browsing in the scientific literature?

Chapter three, as well as the controlled laboratory experiment, is related to the second main research question. For being a part of the conceptual-theoretical background research, chapter three sheds light on the following sub research questions:

2 a) What has been found out in studies considering navigation in mobile web applications?

2 b) What has been stated about navigation in desktop web applications?

The controlled laboratory experiment and its results are presented and discussed in chapters four, five and six. As mentioned above, the experiment is related to the second main research question. The hypotheses, which were tested in the experiment, were:

> H_0: There are no differences between the usability of two mobile banking applications, when one of them follows menu page based navigation approach and the other web navigation bar approach.
>
> H_1: There are differences between the usability of two mobile banking applications, when one of them follows menu page based navigation approach and the other web navigation bar approach.

By answering to these main and sub research questions, and by testing the hypotheses, the aim of this thesis is to construct a concise picture of navigating and browsing mobile web applications.

1.4 Methods

Methods and approaches used in this thesis are: conceptual-theoretical research method, theory-testing method, experimental research approach, controlled laboratory experiment, and comparative method.

The first part of this thesis is a background disquisition, which forms the frame of reference to the second, empirical part. The background disquisition follows *conceptual-theoretical research method* (see Järvinen & Järvinen 2000, 15). The results of the conceptual-theoretical research are presented in chapters two and three.

The second part of this thesis uses *theory-testing method* (see Järvinen & Järvinen 2000, 36-67). On the basis of the conceptual-theoretical part, hypotheses have been formed, and they have been tested empirically. Theory-testing has been carried out by making *a controlled laboratory experiment* (see Järvinen & Järvinen 2000, 43-55).

Controlled laboratory experiment belongs to *experimental research approach*. Experimental research approach is often used in information systems research (see Benbasat 1989). When experimentally evaluating information systems and their usability, it is quite common to compare two or more systems, which are made for the same purpose but are diverse in some aspects (see e.g. Mason 1989, 22; Järvinen & Järvinen 2000, 46-49). In information systems research, *comparative method* is usually included in other research methods – for example, in controlled laboratory experiment. This is the case in our laboratory experiment, as well. Therefore, it could be called as a comparative laboratory experiment, too.

Comparative method, alone, is commonly used in social sciences (see Ragin 1987), where the comparison of variables is made, for example, between data gathered during different periods of time or among different social classes. The comparison of data sets enables researchers to make conclusions of the reasons behind the differences between the variables (Ragin 1989, 1-18). This applies, not only to social sciences, but also to information systems research.

The purpose of the comparative, controlled laboratory experiment made in this thesis, has been to find out, whether there are differences between the two applications, which have been tested, or not. The dependent and independent variables related to the empirical experiment are mentioned in chapter 4.

1.5 Structure of this report

This first chapter has described the issue at hand. The goals and outcomes of the thesis, as well as the methods that are used, have been introduced. In addition, the structure of this report is explained beneath.

The following chapter answers to the first main research question: How can web browsing be supported by browser functionalities in mobile devices? The theme is approached by looking at the current browsers and the suggestions that researchers have made in the literature considering mobile browser development.

From there on, this report aims to build up a respond to the second main research question: How should navigation in web applications be designed for mobile devices?

First step towards the answer is made by forming a review of the researches presented in the literature. That has been made in chapter three.

Because navigating web applications with mobile devices has not yet been extensively studied, the answer to the second main research question is expanded by conducting our own empirical study: a controlled laboratory experiment, where we compare the usability of two, slightly different, mobile internet applications. The background of the experiment is explained in chapter four. Chapter five introduces the results of the experiment. The conclusions of the experiment are gathered to chapter six.

Finally, in chapter seven the findings of this thesis are discussed. Chapter eight is a summary of this report.

2 WEB BROWSING WITH MOBILE DEVICES

This chapter presents the background of mobile web browsing. The purpose is to describe how mobile web browsing differs from the desktop web browsing that we have been used to. The main features of the current web browsers designed for mobile devices are introduced, and the research approaches considering the future possibilities of mobile web browsing are reported.

2.1 Background of mobile web browsing

There are a lot of differences between desktop and mobile web browsing. Knowing them helps to understand why web applications should not be the same for both platforms. However, there are some basic rules concerning web applications in general, and they apply to navigation design for mobile web applications, as well.

2.1.1 Differences between mobile and wired browsing

Mobile devices and desktop computers have fundamentally different characteristics. These are e.g. mobility, display size, memory and data storage abilities, data transfer rate etc. (Weiss 2002, 3-4). The most significant is the small screen size (Weiss 2002, 12; MacKay 2003, 684; Kaikkonen & Roto 2002, 329). These are the differences, which inflict that a structure which works for traditional internet web site has to be redesigned to be compatible with mobile devices (Weiss 2002, 67).

Because of the restricted characteristics of mobile devices, their users do not surf in the internet like wired users may do. On the contrary, mobile devices' users often have in advance planned assignments which they want to accomplish even if they were on the move (Weiss 2002, 66). Being on the move means that the context of use is varying a lot (see Badre 2001, 197). Mobile users may not be able to concentrate on the use of the device with such an extent as desktop users do – and they should not have to. Application design should take into account the changing context of use. The structure of mobile applications should not be too complicated.

In mobile web applications the detectable contexts of use are time, identity of the user, location of the user, and the device type (de Groot & van Welie, 2002). The biggest difference there, in comparison to desktop web applications, is the possibility to track down the location and the identity of the user. Location aware applications have therefore been a subject of study for many researchers (e.g. Jin & Miyazawa 2002; Kaasinen 2003; Aalto, Göthlin, Korhonen, Ojala 2004), as well as personalisation (e.g. Ozen, Kilic, Altinel & Dogac, 2001; Ho & Kwok, 2002). These subjects are especially interesting from the mobile commerce point of view, since they give totally new possibilities for targeting advertisements.

There are many interface design challenges considering mobile platforms, and the examples of the differences between mobile and wired web usage mentioned above give only some ideas, from where the design challenges come. In this thesis the main focus is navigation. Navigation is said to be 80% of the usability (Straub 2004) and a lot of things relate to it.

2.1.2 Principles for navigation design

Sinkkonen, Kuoppala, Parkkinen and Vastamäki (2002, 49) say that navigation is often the bottleneck of usability. “Navigation is hardly ever a part of the product’s content, but an instrument to find a way to the content, and thus navigating should be as easy and natural as possible.” They emphasise that navigation should be designed from usability’s point of view only.

Usability is hard to define and measure. Nielsen (1993, 26) mentions five attributes that usability is traditionally associated with. They are learnability, efficiency, memorability, errors and (subjective) satisfaction. The problem is that these attributes do not always correlate with each other. This can be seen in some of the studies discussed in this report. However, these attributes can give some sort of an impression of the usability of a system. Other usability principles that Nielsen mentions are, for example, using concepts that are familiar to the user, being consistent within the application’s features (words, situations, actions), giving enough feedback for the user, providing clearly marked exits, and allowing experienced users to use shortcuts (Nielsen 1993, 20). Also the user’s ability to answer to the fundamental navigational questions is important, because “if you don’t know where you are, then you also don’t have the ability to interpret the meaning of the link you just followed (Nielsen 1999, 188)”.

When designing mobile commerce applications, it must be noticed, that continuance is one significant factor of their trustworthiness. It means not only consistency within one application, as Nielsen (1993, 20) mentions, but also consistency between different electronic channels (Hiltunen, Laukka & Luomala 2002, 183). Bo Harald, who has been named to be one of the most influential technologists in the e-banking area (see Financial Times 2004), stresses the transference of user interaction models: Similarity between different channels lows down the threshold of testing new services (Hiltunen et al. 2002, 186). Same terminology and interaction schema should be used consistently (Weiss 2002, 67). Information volatility (changes in the services’ contents and structures) should be minimised when a user switches between large and small screen, because s/he creates a mental model of the service when s/he visits it via one service channel (MacKay 2003, 684). The user should be able to use the same mental model within the same service on other channels, as well (MacKay 2003, 684). The challenge is to design usable interfaces for all different service channels so that they can be recognised as parts of a harmonious entirety.

2.2 Current browsers

The current browsers for mobile devices enable the user to browse normal HTML-pages on the internet. The logic of the browsers is already somewhat satisfactory for the users, as it has been stated in the study made by Kaikkonen and Roto (2003b), but still there are a lot of weaknesses in the browsers. This chapter presents the main features of the current mobile browsers.

2.2.1 Current browser models and their characteristics

Most mobile phone models currently on the market have GPRS connection and an internet browser. In addition to the browsers of the devices’ producers (e.g. Nokia browsers), there are products from other manufacturers, too. These browsers can be downloaded from the internet either for free or for charge. At the moment there are mobile browsers available from Opera, Microsoft, Access, Fusion, NexGen Software and Openwave Systems (Digitoday 2004).

Because of the fast developing nature of the technology, it is hard to find objective information about the current mobile browsers. Product information is market oriented and the evaluation of the browsers on the basis of marketing material is difficult. Therefore we interviewed Teppo Jansson, who is a master of science in technology and works as a mobile application specialist at Nordea Bank Finland. Jansson (2004) describes the development rate of mobile browsers as extremely fast. According to him, the current trend is that the mobile browsers' characteristics are approaching the ones of a usual desktop browser. The time, when mobile browsers were still in their infancy – when they supported only WML and had black-and-white contents – is far back in the past. Jansson emphasizes that the current browsers understand standard HTML language, as long as the content stays relatively simple. For example, nested tables are not yet supported widely, because mobile browsers run on small screens and that makes rendering quite difficult. Nonetheless, users have already access to almost all WWW-pages with their mobile browsers.

Jansson (2004) says that all major phone produces, such as Nokia and SonyEricsson, have decent browsers in their devices. He notes that some produces even offer more than one browser model to their products. For example, Nokia offers some phones equipped, in addition to Nokia's own browser, also with Opera 6.10 browser, which is possible to install to SonyEricsson's models, as well. Jansson (2004) also refers to rumours in public (see Digitoday 2004) that in the future Nokia will offer also Mozilla browser in its devices. (Jansson 2004)

Jansson (2004) estimates that browser manufacturers are turning their backs to the "new languages" like XHTML and XHTML MP (Mobile Profile), and are building such good browsers that it is possible to browse all the existing services, which are mostly written with HTML. For example, the latest Nokia products have browsers which support HTML 4.01 (Nokia 2004c), and thus, they can be compared to desktop browsers.

At the moment many mobile browsers, which cannot yet read HTML, support XHTML Mobile Profile standard, WML 1.0 and WAP CSS at the same time. It means that with them users are able to browse both WAP and XHTML pages. For example, Nokia Series 60 mobile browsers support them both and the user does not have to know, how the pages, which s/he is browsing, are implemented (Nokia 2004b, 7). In addition, the latest version supports also HTML 4.01 (Nokia 2004c, 7). Already the support for XHTML has brought “normal web pages”, which can be browsed with desktop computers, to the mobile devices (Roto 2003).

2.2.2 Original and narrow layout options

If a user wants to browse normal HTML sites, in most current browsers it is possible to choose between the original layout and the narrow layout (see FIGURE 2). In original layout, the layout is not changed from what it is on desktop computer’s screen. The difference is that on a mobile device the user can see only one piece of the page at a time, and s/he has to scroll, both in vertical and horizontal directions, to see the contents of the whole page. Narrow layout means that the page has been decreased in horizontal direction so much that it needs to be scrolled only downwards. (Roto 2003) Most new browsers support this technique, although it might be called differently depending on the producer. For example, Opera Inc. calls the technique Small-Screen Rendering (Opera 2004).

Narrow layout has not yet been researched widely, but there is one usability research available from Kaikkonen and Roto (2003b). They have made a usability study with 11 participants to explore the user experience on narrow layout on mobile browsers.

Kaikkonen and Roto (2003b) used a WebViewer browser on Nokia 7650 phone. They asked users to browse one or two pages, which they were familiar with in desktop environment, with the WebViewer, and asked them to comment their experiences and emotions while they were browsing the sites (think-aloud technique). Kaikkonen and Roto (2003b) found out that the reorganisation of the page sometimes confused the users. Because the pages are shown in long and narrow format, some elements on the pages inevitable change their order. When users in desktop web are used to looking for some particular piece of information on a certain location, it was hard for them to locate it on the narrow layout page. Getting a picture of the whole site was considered to be more difficult than in PC world. If a site had same contents on the upper corner of every page, the users did not always notice to scroll down. However, the difficulties, which the users had, were not insuperable. Overall impression was that the idea of a normal web page that was shrunk in horizontal direction was easy to understand for the users. (Kaikkonen & Roto 2003b)

FIGURE 2. Original lay out (left), where the page has to be scrolled, both in vertical and horizontal directions, and narrow layout (right), where the page has to be scrolled only in vertical direction. (Nokia 2004a) The area, which can be seen on a mobile browser's screen, is marked with a red square.

To some extent, the narrow layout has one of the problems mentioned in chapter 2.1.2 (see Hiltunen et al. 2002, 183, 186). If the same service is available in several channels – in this case in desktop and mobile environments, users get confused if the structures are not convergent. If this and the difficulty of scrolling the pages could be overcome, the narrow layout would be a very good technique for it is so simple.

In the following chapter we refer to approaches made in the literature considering mobile browsing. They are more complex approaches than the narrow layout, and there the original content of a web page is sometimes heavily transformed.

2.3 Visions – transforming web pages with algorithms

One approach to solve the problem of mobile web browsing is to develop algorithms, which transform the content of web pages into smaller units, which are suitable for small screens. Algorithms reorganise the navigational structure of web sites in a way that is believed to be suitable for mobile users. These approaches have not yet reached commercial use, but there has been a considerable group of researchers suggesting this type of solutions.

First ones of the algorithmic approaches for mobile devices were developed in 1990's. An example of these early approaches is a small terminal browser called WEST (see Björk, Holmquist, Redström et al. 1999). The designers of WEST browser believed that all content in the internet would never become redesigned (or otherwise fit) for small screens, and so the demand for an approach similar to WEST browser would exist in the future, too.

WEST is based on cooperation between a client application (browser) and internet service provider's proxy server. The server first splits the content of a web page into small pieces, and then it extracts links to bind the pieces together. It uses text reduction algorithms to create different kind of views to the content. Client application shows the user a thumbnail view (which is a sort of a graphical summary), a keyword view and a link view of the browsed page. (Björk et al. 1999) In FIGURE 3 there is a picture of a thumbnail view presented on WEST browser.

Navigation inside the browsed page is arranged by dividing the content into several hierarchical levels. The user moves between them, for example, with device's softkeys – one level up or down at a time. Within the current level the user can zoom in and out the pieces, of which the level is constructed. The levels, as well as the pieces of the levels, are called similarly as in WAP 1.x technique: one level is called “a deck” and a piece of information on a level is called “a card”. (Björk et al. 1999, 193)

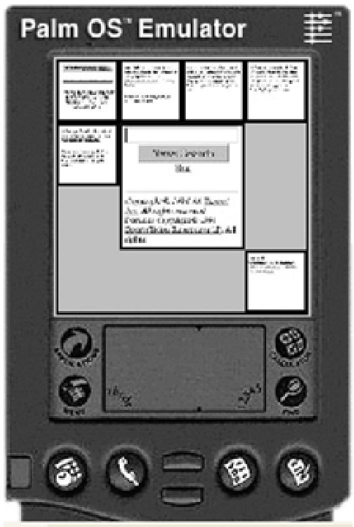

FIGURE 3. WEST browser’s thumbnail view (Björk et al. 1999, 187).

Although the basis for navigation in this model is fairly simple, it does not seem obvious how the algorithm would divide the content into pieces logically. Different levels in the content are necessary in showing the original page on a small screen, but the user’s ability to answer to the fundamental navigational question “Where can I go?” might not be easily answered on this type of a navigational structure. The user has to navigate to the top level of the page, when s/he wants to move to another part of the content structure. The different content levels, decks, are shown on the top level similarly as cards are shown on the lower levels – as thumbnails. If it is not clear at the beginning, which deck the user wants to look at, s/he has to go through them all. The user has to separately pick out every deck on the top level to take a closer look at the deck’s contents. To make that, s/he has to go through the cards in that deck. After seeing the contents of one deck, s/he has to return back to the top level to pick out the next deck (if the information was not in that deck, which s/he just went through).

Schilit, Trevor, Hilbert and Koh (2001) (also in: Trevor, Hilbert, Schilit and Koh, 2001) have presented a theory according to which web user interaction can roughly be divided into two separate functions: navigating and reading. Reading may also be replaced with other actions, such as writing an email, downloading a PDF, etc. In general this means that web browsing is “navigating to information and then using it” (Schilit et al. 2001, 122; Trevor et al. 2001, 123). Schilit et al. (2001) (also in: Trevor et al., 2001) suggest that when using a mobile device, these functions should be separated. This can be made through a middle-ware proxy server, which divides the content of a traditional web page into two parts: to a link collection, and to the contents connected to the links. Schilit et al. (2001) (also: Trevor et al., 2001) call the middle-ware proxy architecture, which they have developed, as Mobile Links (M-Links).

M-Links proxy server operates in the middle, when a mobile user requests a web site. M-Links uses HTML parser to separate the different content areas of a web site, and a special link engine that has algorithms to separate the HTML links from the other contents. The link engine names the existing links more sensible if needed (for example, “click here” -links are renamed so that they tell something precise about the contents; see: Trevor et al. 2001, 123 and Schilit et al. 2001, 125, 127), it categorises the long link lists (Trevor et al. 2001, 123; Schilit et al. 2001; 127) and extracts new links into the content (Trevor et al. 2001, 125; Schilit et al. 127). In the described version of M-Links it separates, for example, phone numbers and addresses from other HTML text areas (Schilit et al. 2001, 122). M-links also identifies the client device’s type and formats the content suitably for it (Schilit et al. 2001, 126). An example of a link list provided by M-links is shown in FIGURE 4.

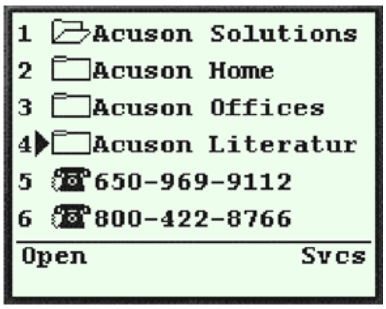

FIGURE 4. M-Links’ link list (Schilit et al.2001, 123).

The separation of the content and the links creates a new problem: how does the user recognise the context of the link. Schilit et al. solve this problem by making it easy to flip back and forward between the content and the links. User gets the context information by reading the text which is connected to the link. (Schilit et al. 2001, 125)

Schilit et al. (2001, 124) see M-Links as a clear advantage for mobile web users. Even in the future, when mobile devices develop, Schilit et al. (2001, 124) foresee, that portability inevitably induces the small size of the mobile device's screens, and thus links and contents are best to be separated.

Yet, the technique has been developed for very small screens; at the time of the study a medium sized screen in a mobile device was black-and-white and had the capability to show 10 lines of text and very constricted graphics (Trevor et al. 2001, 121). It might be argued that M-Links would only work for these kinds of devices. Extensive link lists, when they are separated from the contents, mean a lot of extra work for the user, who has to open every link to see its context. Users' memory load grows relatively heavy in this model.

Also Banerjee, Gupta and Basu (2003) have presented their model of proxy based mobile browsing. In their suggestion a proxy server fetches the web pages, which the user has requested by typing the URL into the browser. The proxy starts a session with the client, downloads the requested page and processes it according to a specific algorithm. This algorithm operates mainly on the grounds of HTML syntax, and it categorizes the information on a web page into predefined domain specific categories and sub categories. The categories are recognized by analysing the HTML tags. For example <table>, </td> and <hr> tags indicate, that there might be a new category beginning. Because a categorization based only on these tags would create too small and overlapping categories, some of these units are united and some irrelevant information is pruned. For example, pictures, which are smaller than 10 x 10 pixels, are deleted. Also duplicate links and navigation bars, which appear on multiple pages, are pruned from others than the highest navigation level. For identifying the semantic units of a web page Banerjee, Gupta and Basu (2003) have created a syntax-driven approach, that can identify the units of a well structured web page, but so far it does not work for more complex web pages. (Banerjee, Gupta & Basu 2003)

In the paper that describes the study of Banerjee, Gupta and Basu (2003), there is no reference to the user experiences on the system. Neither the usability was compared to original layout, nor were the downloading times reported.

Later the approaches, which use algorithms to transform web pages, have been developed further. Yin and Lee (2004) have presented a model, in which they first construct a graph of the web page by dividing the content into separate items on the basis of the layout and the visual shape of the items. For example, separate text paragraphs, links and pictures are all treated as single elements. The algorithm creates a tree model of the items. The tree model is based on the original layout structure. The purpose is to attach the interdependent elements with each other so that when they are presented in the final output, the interdependent elements are shown close to one another.

Xinyi’s and Lee's algorithm is based on the assumptions of the attractiveness of the different elements on a web page. Yin and Lee (2004) propose that not all contents on a web page should be shown to a mobile user. This would save not only loading time, but also the time that the user needs to browse through the page. Also the processing capacity of the mobile device would not have to be that big. (Yin & Lee, 2004)

Yin and Lee (2004) say that according to their experiments, they had to deliver only 39 % of the objects on a web page to gain 85% of the content that the users wanted to see. This is done by calculating the probability of the user to become interested in the contents of the page. The algorithm which Yin and Lee have created takes into account the size of the elements (the bigger, the more important), text length (longer text attract more users), matching with the link name (the elements that match with the name of the link leading to the current page are more relevant) and the placement of the elements (elements in the middle of the page are more important). After the elements have been evaluated with the algorithm, the system uses similar kind of ranking system as Google PageRank algorithm. The most probably interesting elements are shown first, and those parts, which are calculated to be irrelevant, are excluded. Elements are finally shown similarly as in narrow layout. Those elements, that are considered not to be important, are dropped out from the narrow layout web page (about narrow layout, see chapter 2.2.2). (Yin & Lee, 2004)

In our opinion a web page that has been transformed with the Yin’s and Lee’s system is clearly better than the original one, when considering how easy it is to browse the page and to navigate the site that is formed from such pages. The user does not need to scroll that much, and the content elements are sorted so that the most interesting one comes first. But the problem with this solution is, that when the users see only the “shortened” version of the contents, they cannot know, whether the original version would have contained something extra which would have interested them. For example, if a user browses a news site, and the system shows only the most likely visited links, but the user has some other interests than most of the readers, how will s/he know whether this information has been dropped out from her/his mobile version of the news site. Another point that might hinder the use of the system is its implementation. Yin and Lee (2004) suggest that the system would work through a personal gateway, and the algorithms would be running on the user’s own PC, which would be connected to the internet. However, it might be forbidden to install additional programs on one’s working place’s PC, and many potential mobile users might not have a PC with internet connection at home. How mobile is mobile internet connection, which needs a running table PC with an open internet connection to work properly? Besides, if the system is not extremely simple and easy to install and use, there probably are many users who do not bother to install it on their computers.

2.4 Visions – browsers as navigation cultivators

Approaches, which use algorithms for transforming the web pages, have been criticised in the literature. For example, Wobbrock, Forlizzi, Hudson and Myers (2002, 205) claim that web pages are too complicated to be shrunk with assistance of algorithms. Wobbrock et al. (2002) present another kind of solution to browsing the web with mobile devices. They have developed a browser interaction model which they see as the best solution to presenting web pages on small screens. This chapter introduces few of the browser centric approaches. These browser centric models are not yet commercially exploited, which is the case with the algorithmic solutions as well.

Wobbrock et al. (2002) have designed their browser for a pocket PC sized screen which has a touch screen and a stylus as interaction tools. Their browser is called WebThumb. It shrinks web pages so much that they fit PDA’s screen. A user can pick up elements from the shrunken web page to have a closer look at them. These chosen elements are shown as thumbnails on the screen, and the user can select with the stylus those thumbnail elements which s/he wants to look at more carefully: The thumbnails can be zoomed in and out. Text is presented with a Rapid Serial Visual Presentation (RSVP) technique, which means, that the words are “played” one by one as a stream to the user. (Wobbrock et al. 2002) FIGURE 5 beneath shows an example of WebThumb browser’s screen. In FIGURE 5 three elements have been chosen to have a closer look at.

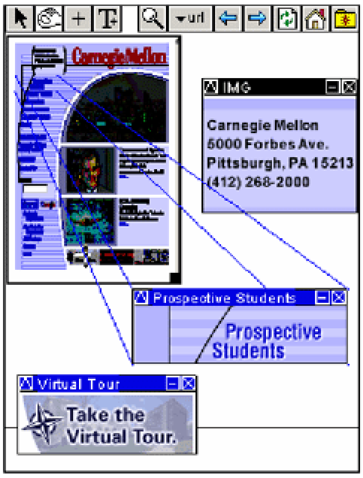

FIGURE 5. WebThumb browser, where three elements from the browsed web page have been selected to look closer at (Wobbrock et al. 2002, 206).

Wobbrock’s et al. (2002) do not report on user experiences considering WebThumb browser. There is not any information available on how easy or hard it is to navigate the shrunken web pages. Users are able to zoom in to the content, but zooming, reading with RSVP technique, and picking up elements all need to be made with different tools. The user has to do a lot of clicking and pointing out assignments. On the other hand, the approach enables maintaining the original structure of the web page, and thus the context of the information can be easily understood.

Similar types of browser approaches have been suggested by other researchers, too. De Bruijn, Spence and Tong (2001) have discussed the RSVP presentation technique, as well, but they use it in another context as Wobbrock et al. (2002). The RSVP technique itself is old; it was first presented in the literature already in the 1970’s (Öquist 2001, 12). De Bruijn, Spence & Tong (2001, 209) compare RSVP technique to riffling pages in a book to get an overall picture of it. De Bruijn and Spence together with Chong have presented a browser model that is based on this technique (de Bruijn, Spence & Chong 2002). The invention in this browser model is to unite RSVP with the navigation interface.

By using RSVP technique de Bruijn, Spence, and Chong (2002, 245) try to avoid unnecessary scrolling, which harms the user's ability to understand the structure of the browsed page. The main principle of RSVP browser is to show new links, which are available, as well as previously visited pages, with RSVP technique (as a graphical stream of links) to the user. The rate of one presented graphic may vary between 0.1 to 1.0 seconds. (de Bruijn, Spence & Chong 2002, 246).

In De Bruijin's, Spence's, and Chong's test the prototype of RSVP browser had sidebars, one of which expressed the current position of the user in the navigational structure of the current page. This one also had an action button, which started RSVP browsing action that showed the user the available links in the current page. The other sidebar indicated with small orbs the former sites, which the user had visited during the current browsing session. The title bar was on the top of the screen and in the middle of the screen there was a viewing area. (de Bruijn, Spence & Chong 2002, 246-247) The prototype model of the browser was developed to be used on a relatively big and coloured screen, sized of 8 x 8 cm and 32 pixels / cm (de Bruijn, Spence & Chong 2002, 248). The prototype version of the browser is shown in FIGURE 6. The sites that were tested with RSVP browser were especially modified for the purpose. Their structure was of the same kind as in typical WAP sites (de Bruijn, Spence & Chong 2002, 248).

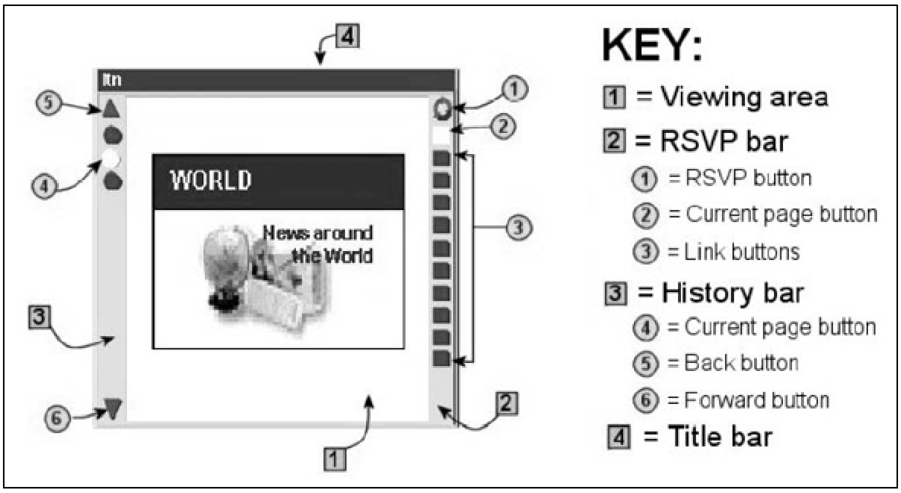

FIGURE 6. Prototype RSVP browser's structure (de Bruijn, Spence & Chong 2002, 247)

RSVP browser was designed to answer to the fundamental navigation questions which Nielsen has presented (de Bruijn, Spence & Chong 2002, 246). The history list in RSVP browser does not differ much from the history list in most current desktop browsers, but presenting available links with RSVP technique, and the user's current position in the page with orbs in the sidebar, are new ideas. The sidebar clearly helps the user to understand her/his current position in the application. As de Bruijn, Spence, and Chong (2002, 251) state, there is still a lot to explore in RSVP based navigation. In our opinion, it might be worth investigating, whether some of the functions of the tested browser could be implemented in dynamic (X)HTML-pages browsed with a mobile device. RSVP navigation is, however, not a substitute for a site's own navigational structure, it might only support it.

Jern, Ricknäs, Stam and Treloar (2003) have studied a browsing technique that is based on visual user interface (VUI) and zooming user interface (ZUI). It is designed for a PDA device, but when the screen sizes in mobile phones grow, ZUI presumably is an option for them, too. The technique is an advanced version of WEST browser (Wobbrock et al. 2001), which was introduced in chapter 2.3. In Jern et al. (2003) solution, there is no proxy server involved, like there was in WEST browser solution. Instead, the technology is running on the mobile device.

Jern et al. (2003) made a usability study in which they compared a traditional text-link based system to a visual and zoomable user interface, where images served as links and the users could zoom in and out within the images (see FIGURE 7). The application was an on-line shop for daily products. Jern et al. (2003) found out that for beginners the visual user interface seemed to be faster to use than the text-link system. The users liked the visual user interface, because they could see the product brands. Jern et al. (2003) emphasise this point, because being able to make choices by clicking on the brand images instead of text links would be an advantage especially for strong brand owners. In the visual user interface version the users could zoom in to the actual product images. (Jern et al. 2003)

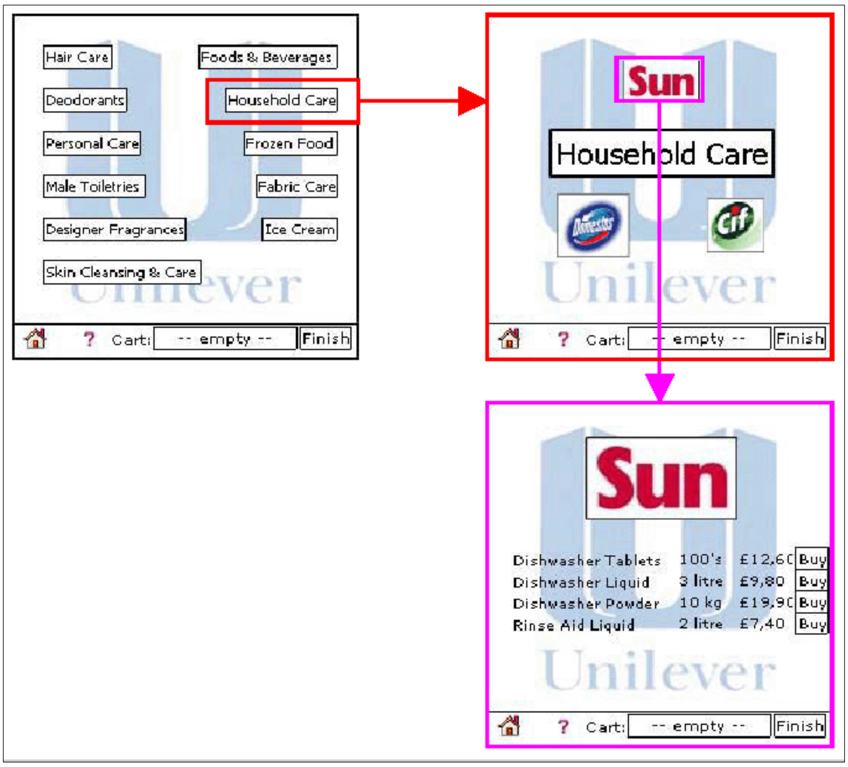

FIGURE 7. An example of the Zooming User Interface, which Jern et al. (2003) used in their study considering mobile on-line shopping system.

Jern et al. (2003) do not report of any negative opinions about the VUI or ZUI. They asked from all users about the fastness of the system, but they only report one answer: “The interface was fast enough.” We might think that because of the slow internet connections in mobile environment, the graphics will slow down the use of the system. Then again, we can see VUI and ZUI as future approaches, which can be useful, when the data transfer rates grow large enough.

Gutwin and Fedak (2004) have evaluated zoomable interfaces on PDA sized screens, too. They compared three different browsing techniques: A two-level zooming interface, a panning interface, and a fisheye view. Panning means that the screen shows only one piece of the original layout at a time, and the user can get an overview of the whole page by moving the area that the screen is showing. Moving can be done by mouse movements. Two-level zooming was in the study implemented so that the user could either choose a reduced overview of the whole page (where the details cannot be seen) or the same kind of panning view as in the panning interface. In the fisheye view the users saw an overview of the whole page, but simultaneously there was also a zoomed-in region inserted on the same screen.

Gutwin and Fedak (2004) found out that users liked the two-level zooming interface the best. There was no significant difference between the fisheye view and the two-level zooming view, but they both were considerably faster to use than the panning interface. The study can be criticised, because Gutwin and Fedak (2004) used a simulator instead of a real PDA device. The use of a simulator has been criticised in an article by Amant, Horton & Ritter (2004). The interaction is very much different with a simulator running on a PC than with a real PDA (Amant, Horton & Ritter). In this case, for example, it makes a difference, whether the user has a mouse or a stylus or a navigation button to control the movements of the panned area.

2.5 Summary

There are fundamental differences between desktop and mobile platforms when considering web browsing. The result of the differences is that the existing web applications have to be processed in some way to make them fit the mobile device’s screen and capacity.

The current browsers are already fairly competent with doing this. The evolvement started with WAP applications and has led us to HTML enabled browsers. The change has been significant and fast. The current browsers show the web pages first of all in the original layout. In the original layout the user has to scroll the pages in vertical and horizontal directions, which is challenging. Secondly, in most browsers there is the narrow layout option, which shows the page as such a long and narrow form that it fits the screen's vertical limits. There the scrolling has to be done only downwards. Pictures are shrunk and elements are rearranged one below another.

There are some usability problems relating to the narrow layout solution, but it seems that it is quite liked among the users. Yet, there is very little research information available on the user experiences considering the current browsers and their features. The current browsers should be studied more.

Comparing the results of the different studies considering browsing with mobile devices is difficult, because the researches have very different starting points: both the used devices and the analysed techniques differ from each other. However, we have identified in the literature two main approaches to browsing the internet with mobile devices. One of them is an approach based on algorithms. There the web pages are downloaded though a proxy server to the client device. On the proxy server the web pages are analysed with varying algorithms to make them fit the mobile browser's and mobile device's capacity. The supporters of the second approach criticise these algorithm based solutions, since they think that algorithms cannot be so sophisticated that they can process the content of web pages logically. The participants of the other approach try to create such a browser that can show the original web page in such a form that the content is easily understandable and easy to browse through. Among the both approaches there are sophisticated proposals of what mobile browsing could be and how the mobile devices' features could be supported. On the other hand, some of the earliest studies seem already to be out of date when thinking of the devices and browsers that are currently on the markets.

3 REDESIGNING NAVIGATION FOR MOBILE USE

Whereas the previous chapter described the background and different browsing possibilities for mobile devices, this chapter deals with studies that can be useful when redesigning and manually authoring navigation for mobile devices. Redesigned web applications for mobile devices would be the best choice from usability's point of view, but it presumes that multiple versions of the sites are designed and implemented (Gutwin & Fedak 2004), and in many cases that is not an option.

Chapter 3.1 discusses studies which consider the navigation structure on mobile applications. Due to novelty of the technology, the subject has been rarely studied, so far. Thus, to deepen the view, this chapter also presents studies considering the navigation structure in desktop environments. The earliest ones go back over twenty years, e.g. the studies of Card (1982), Landauer and Nachbar (1985), and Somberg (1987). These early studies considering menu selection in graphical interfaces can be seen as the basis for navigation research in mobile environment. The earliest desktop applications have been developed for quite small screens and, thus, have a somewhat convergent background with mobile applications. Navigating in hyperspace has fundamentally the same characteristics as menu selection in the earliest graphical computer applications, or even further back, in index searches from dictionaries or library catalogues (see Chan, Luk, Mak, Leong, Ho and Lu 2002). Some of the studies considering desktop applications are cited in chapter 3.2, as it is essential from the mobile point of view. Sub chapter 3.3 introduces literature that deals with the placing and the naming of the links.

3.1 Navigation structure – studies in mobile environment

"Navigation is a basic part of using any software, just as wayfinding is integral to graphic and environmental design. It covers not only explicit sequential steps, but the ability of users to go from starting a program to getting useful work done." (Schubin & Perkins, 1998)

How then to make this basic part of an application work? One of the most important questions of navigation is the structure of the navigation tree (Giller, Melcher, Schrammel, Sefelin & Tscheligi 2003). In an application made for mobile devices the page lengths and the broadness versus deepness of the navigation tree make a big difference in the usability of the application. Because of the small size of the screen, users have to either scroll down the pages to see all the links and the contents or find their way through a long path of links to their final goal on the site, and on the way to wait for all the different pages to be downloaded. Is one of these choices better? Is there a consensus about the optimal structure?

3.1.1 Tree structure, page lengths and scrolling the pages

Buchanan, Farrant, Jones, Thimbleby, Marsden & Pazzani (2001) carried out usability studies in which they first evaluated WAP usability in general and then compared three different types of WAP user interfaces. They evaluated WAP services which were implemented using WAP 1.x technology, where the content is made up of “decks” (that are downloaded one at a time) and “cards” which belong to a certain deck. After a deck has been downloaded, its’ cards can be browsed through without waiting. Links can exist between the cards within and between the decks. (Buchanan et al. 2001)

In their first study Buchanan et al. (2001) had 110 test subjects, which is a considerable amount in the usability testing field. The purpose was to get an overall idea of the users’ experiences on WAP scheme. In the evaluation Buchanan et al. (2001) used a simulator, which may have induced some distortion in the results. As we have mentioned earlier, using a simulator instead of a real device is not recommended because the simulator does not create an authentic user experience (see Amant, Horton & Ritter (2004) comments about simulators).

All test subjects (n=110) in the first study were university students with no former experience on WAP applications. They were asked to browse three different WAP sites and to find some information that interested them. After using the sites, users were asked to give subjective ratings about the simplicity, effectiveness and the usability of the sites. The average value that users gave was +0.8 on scale -2 to +2. Users considered the basic WAP scheme as easy to learn (70 % of the users agreed) and simple, but they said that the system was ineffective to use. The complex and error-prone navigation was interpreted to be the reason for this. On the basis of some earlier studies Buchanan et al. have made, they recommend avoiding complex, deep hierarchies. The more the users have to click in the application, the less they will like it. (Buchanan et al. 2001)

Buchanan et al. (2001) refer to another study, too, in which there were fifteen test subjects who also did not have experience on WAP applications. The study was, likewise, performed with a simulator. The simulator pictured a black-and-white screen that could show 6 lines of text, 20 characters on one line. The test subjects used three different kinds of implementation of a news service. The news service showed all together 9 headlines, but they all could not fit the screen at once. (Buchanan et al. 2001)

The first design method was to show each headline written on one line. It meant that the users had to scroll horizontally to see the whole text lines. The users had to also scroll downwards to see the tree last lines. The second design choice was to write the headlines on so short lines (max. 20 characters) that the users did not have to scroll horizontally at all. This way, one headline took 2-3 lines, and thus the users saw only two first headlines on the first screen. They could see the other headlines if they scrolled down. To see the last line of the last headline, one had to scroll down altogether 19 lines of text. The third design choice was to divide the headlines onto three cards. This time the lines were also made so short that the users only had to scroll vertically. The first two headlines were shown on the first screen, but to see the third one, the users had to scroll down 2-3 lines. To see all the headlines, the users had to move to the next card twice. The users had to complete certain tasks in all three versions of the news service, and the time used, as well as the errors made, was measured. (Buchanan et al. 2001)

The application, where the headlines were presented on a long and narrow page and the users had to scroll only downwards to see all the headlines (but did not have scroll horizontally), was the fastest one to use and induced the smallest amount of errors. The last interface, where the contents had been divided onto three cards, was the slowest one to use and there the users made the largest amount of mistakes. (Buchanan et al. 2001)

On the basis of their study, Buchanan et al. (2001) recommend, that WAP services should contain as little navigation as possible. Using simple hierarchies is the best choice. The amount of the information in a WAP service should be cut down when compared to normal web sites, and the amount of vertical scrolling should be kept minimum, as well as the number of keystrokes that the user have to do. Buchanan et al. (2001) do not state the reasons, why they recommend avoiding vertical scrolling – the interface with most vertical scrolling was after all the fastest one to use and induced the smallest amount of errors in their test. Buchanan et al. (2001) do not mention anything about horizontal scrolling in their recommendations.

Overall the WAP 1.x technology has been created with short cards in mind. The technology is based on an idea of a deck of cards – one downloads a whole deck of cards at once, and then one can riffle the cards within that deck without waiting for downloading. This technique itself drops a hint that one card should only contain little information. It is like a card play, where one gets the whole picture by browsing through all the cards s/he has in her/his hand. But as it was shown in the study of Buchanan et al. (2001), dividing the content onto many cards might not be the best solution, because the navigation structure then becomes more complex.

Also Kaikkonen and Roto (2002) have studied WAP applications. They did their study with WAP 2.0, which is based on XHTML Mobile Profile instead of WML, which is the mark up language in WAP 1.x technology. In WAP 2.0 the data is downloaded as single pages, not as decks of cards as in WAP 1.x. Kaikkonen and Roto (2002) found out that since in WAP 2.0 every page has to be downloaded separately, users dislike very short pages. Also in another study (Kaikkonen and Roto 2003a) the users felt that they had to wait for the short pages a longer period of time than for the long pages, and, therefore, they did not like a deep site hierarchy combined to short pages. Sites with flat hierarchy and long pages were considered to be more pleasant to use at least with WAP 2.0. When considering WAP 2.0 applications the pages should not be very short**.** When thinking of the results of Buchanan et al. (2001) study, one cannot recommend very short pages for WAP 1.x either.

In Nokia's guidelines for mobile applications there are no precise instructions for the page lengths or the navigation tree, but it is said that close related links are better to be kept on one page than to purposelessly deepen the structure just to divide the links onto more pages (Nokia 2004b, 8). Roto (2003), too, states on the grounds of the usability studies she has been involved with that if the links are closely related to each other, even 30 links can be presented on one page. The splitting of the content onto several pages is not recommended for the devices using GPRS connection because of the long downloading times. (Roto, 2003) This is an impact of the mobility, and it will apply as long as the data transfer rates stay at a relatively low level.

The maximum length of the pages depends on their content. According to the study of Kaikkonen and Roto (2003a, 334), plain text pages are considered to be fine when they have 20 screens full of information, but interactive pages are considered to be too long when they fill 6 screens. Also Giller et al. (2003) have found out that text pages are more pleasant to use when they are long, than when are divided onto several pages. In their study the users commented that when they can scroll down instead of choosing a link to the next page, they can self regulate their speed of reading. If they have to select a link and wait for the next page to be downloaded, they feel that the system is controlling their speed of reading the text.

However, there are problems with long pages as well. Kaikkonen and Roto (2002, 346; 2003b) have found out that (novice) users do not always scroll down the page to see all the information. If the users do not scroll down the pages, they do not see all contents or links on a long page. This can cause severe problems when using the application. The problem with scrolling the pages is contrary to the requirement mentioned above – that users liked long pages more, since downloading takes time.

Giller et al. (2003) compared in their study different type of navigation trees with different kind of mobile devices. They used an older mobile WAP phone with a relatively small black-and-white screen, a newer mobile phone with a large colour screen and two different PDA devices. There were three applications, each with a different kind of navigation tree, for all four devices. Giller et al. (2003) had designed the navigation trees especially for every device: different devices actually need different application structures since their characteristics are so dissimilar. Badre (2001, 195-196), among others (Kaikkonen & Roto 2003a, Buchanan et al. 2001, 673), has proved that the device has an impact on the user experience. Badre made a study where he tried to find out differences between different tasks conducted with different mobile devices. Devices that were used were all PDA devices (Palm Pilot, NeoPoint Phone, HP Jornada and IBM Thinkpad). The results of the study showed, that there were no significant differences between the different tasks (information gathering, searching, shopping and browsing), but there were differences between the PDA devices.

In Giller et al. (2003) study, the navigation structures were designed taking into consideration the device's screen capabilities. For every device, there was an application where all the links could be seen at a glance. This was the "best" navigation tree design according to Giller et al. hypothesis. The second navigation tree had less depth and more breadth. The third navigation tree was the opposite of the second one: more depth and less breadth.

The first structure, which was the "average structure", was preferred in all device classes according to the users' opinions. This structure was nor very deep neither very broad, and the users could see all of the link items at a glace. Still, the structure in the second application (the broadest structure) was the fastest one to use in all device classes. But when thinking of the users' preferences, the deepest structure was rated higher than the broad one, even though it was the slowest one to use. The qualitative data explains this finding: The items in the link lists are arranged more concise if the structure is deeper. There are less links to choose, which creates an impression of a simpler structure. On the basis of their study, Giller et al. (2003) recommend that all links should be able to see at a glance. (Giller et al. 2003)

Giller et al. (2003) do not mention how their applications were implemented: were they real WAP services or not. For example, users' comments about the downloading times were not mentioned. Slow downloading has been one of the main reasons for recommending broad navigation trees (Roto 2003, Nokia 2004b). Also the fact that all test subjects in Giller et al. (2003) study were novice WAP users might have induced the preference for deeper navigation trees: if a user is experienced with the technology and the application, s/he might prefer a broader navigation tree and a faster access to the target information. This is, however, only a hypothesis that would require further studies. And after all, the “average” structure satisfied the users the most – not the deepest structure.

To sum up, the navigation tree should not be very deep. Users do not like to make clicks (Buchanan et al. 2001). In addition, opening new pages takes needlessly time (Kaikkonen & Roto 2003a). The maximum breadth of the navigation tree depends on the content. If there are links that are closely connected with each other, they can be presented together (Nokia 2004b, 8). According to Roto (2003), up to 30 links can be presented on one page, but the rule of thumb is that all links should be able to see at a glance, without scrolling (Giller et al. 2003).

The problem of the mobile applications is that the devices and their screens are evolving rapidly. The characteristics of the client device have an impact on the user experience (Kaikkonen & Roto 2003a; Buchanan et al. 2001, 673; Badre 2001, 195-196). This means that exact and universally applicable guidelines are impossible to create.

3.1.2 List of links, keyword search or WAP type selection

Kaikkonen and Roto (2003a) have tested navigation both with a list of links and with a keyword search. These tests have been conducted with two different devices, Nokia 6510 and Nokia 7650 phones. Nokia 6510 has a relatively small black-and-white screen and Nokia 7650 has a relatively large, coloured screen. In the tests, there were 20 test users using Nokia 6510, and ten test users using 7650. The users had varying experience on WAP applications.

In both tests all the users could easily understand and select a link from a list of links. Surprisingly, also the keyword search was popular. Beforehand Kaikkonen and Roto (2003a) had thought that the keyword search might not be useful, since inserting text is so laborious with the devices. The keyword search was implemented so that when a user started inserting a word, the system offered two possibly matching words for her/him. Thus, the user did not have to type in the whole word (Kaikkonen and Roto

2003a). Kaikkonen and Roto (2003a) do not mention, which are the exact figures of the use of the keyword search, when compared to the use of the list of links. It is also not estimated, how small sites benefit from the keyword search. In desktop web, keyword based search engines inside the site are recommended for those sites that have more than 20 pages (Badre 2001, 143).

When using the smaller screened phone there were differences between the experienced and the novice WAP users. The experienced users liked to use the keyword search and the direct links to the main page of the service. On the other hand, the novice users liked the tree hierarchy instead of the keyword search. Seeing the main sections helped the novice users to understand the structure of the application. (Kaikkonen & Roto 2002, 346)

Chittaro and Dal Cin (2002) evaluated WAP-navigation choices in their study made among 40 subjects. They used Nokia 7110 WAP phone and a WAP service called CineWap in their study. The task given to the subjects was to search a particular movie and to reserve seats to see it. The position for the seats was assigned beforehand, as well as the name of the movie theatre.

The goal of the study was to compare how the subjects completed their task with two different kinds of navigation techniques. The researchers found out that for subjects, who were novice users with WAP, the easiest way to navigate was a list of links and a single choice selection. Other possibilities for navigation were action and selection screens. Action and selection screen means a solution, where the user selects an option, and then sees in a separate window the possible actions for that option. The user then selects an action, or can go back to the option window. (Chittaro & Dal Cin 2002) Action and selection screens are a common way to navigate in WAP applications.

The navigation choices that were compared in the study described above, were different than in the study made by Kaikkonen and Roto (2002; 2003a). However, the rallying point in both studies is that navigation through a list of links was found out to be easy.

3.2 Navigation structure – studies in desktop environment

As mentioned in the beginning of this chapter, desktop applications have somewhat convergent background with the mobile applications. The earliest desktop devices had small screens and their graphical abilities were not very sophisticated. Also later on the basic characteristics of navigation have been the same in both platforms, and what is most important, users are always about the same. This is why we ought to take a look at the studies considering desktop environment, too.

Navigation, in general, could be defined almost the same as menu selection, which was the early form of navigating in graphical interfaces. Norman (1990, 3) defined menu selection as follows: “Users are presented with a list of options from which they can choose and some mechanism by which they can indicate their choice.” What has been said about wideness and broadness of the lists in desktop environment? Are there rules for creating a navigation structure? When should navigation be graphical, and when should it be text based and happen through a menu-page?

3.2.1 Depth versus breadth

Ever since there were graphical user interfaces, menu selection has been studied. The basic characteristics of the studies have remained the same, and therefore we should take a look at the older studies, as well. For example, Landauer and Nachbar (1985) made one of the earliest usability studies about breadth versus depth in menu structures. They had alphabetically and numerically ordered menus with differing structures. In all of the structures the users had to find one word or a number out of 4096 potential ones. In Landauer’s and Nachbar’s menu tree, the number of the menu branches varied between 2 to 16. They found out that broad and shallow menus were the fastest ones to use, but they were not certain how widely the results might be generalised. Landauer and Nachbar (1985) state, that there will always be variations in the results, depending e.g. on the information organisation, the screen layout and the response mode (Landauer and Nachbar used a touch screen). This is very much true. For example, finding a certain word from an alphabetically ordered list is simple, and the list can be wide, because the user does not have to read through all of the words but only to take a glance on them, like was the case in the Landaur and Nachbar’s study.

But if the user is not certain, which word has been used to describe the phenomenon that s/he wants to find, semantically grouped menus and a deeper navigation tree might be more efficient, which is the case in the next presented study. In a mobile environment the screen size and the users' custom to scroll or not to scroll down the screen is one factor to add on this complex problem.

A more recent study about menu structures has been made, for example, by Larson and Czerwinski (1998). They conducted a study, in which they compared three different demo web sites, where the menu structures differed by their deepness and broadness. The data that they used was names of plant and animal species and names of plants and animals. The broadest structure had 32 top level categories, and each one of these 32 top level categories had 16 sub level categories. The second structure had the same amount of levels in the navigation, but it had 16 top level categories and 32 sub level categories under every one of these top level categories. The third structure was deeper but also narrower: it had 8 top level categories, and beneath every one of them 8 sub level categories, and under every one of these 64 sub level categories there was again 8 content level categories. All of the structures had 512 bottom level nodes. (Larson & Czerwinsky, 1998)

In the study there were 29 test subjects, who all used every one of these three web sites in order to find the asked piece of information. The users had different tasks in every application so that they could not learn from the previous searches which they had already made. The metrics that were measured were the lostness rates, the reaction times and the subjective ratings. (Larson & Czerwinsky, 1998)

Larson and Czerwinski (1998) found out that the reaction times were shortest in the second application, where there were 16 top level categories and beneath every one of them 32 sub level categories. The slowest application to use was the 8x8x8 application. The difference between the 16x32 and 32x16 applications was not statistically significant, but the 8x8x8 structure was remarkably slower than both of them. It was clear that a deep structure harmed the performance. The lostness rate (how much did the route, which the users took, differ from the optimal path) gave the same kind of results: the 16x32 structure was the best for the users, in the 32x16 structure the users got a little bit lost, and in the 8x8x8 structure the users were already very much lost.

Again, the differences between the two first applications were not that significant as when compared to the 8x8x8 application. But when Larson and Czerwinski (1998) asked the subjective opinions of the users, there were no significant differences between the ratings.

In Larson and Czerwinski (1998) study, all links were organised on the screen in (several) vertical lines (if needed), so that there was no need to scroll. The fact that the 32 x 16 structure was slower to use and induced more errors than the 16 x 32 structure, proves that it is better to show less links for the users at once. Users got more lost in the 32 x 16 structure, even though the links in the both structures could fit one screen. (Larson & Czerwinski 1998)

On the basis of the study of Larson and Czerwinski (1998) one cannot say what would be the optimal navigation tree structure in mobile environment. Obviously there the amount of the links that can fit one screen is much smaller. In any case it is clear that in Larson and Cherwinski's (1998) study, the deepest structure was the flabbiest. This consolidates the findings, which we reported in context with the studies in mobile environment. Also in those studies the deepest structures were slower and induced more errors than the flatter structures.

It is worth to notice, that the user preferences did not match with the results gathered from the quantitative metrics in the study described above (Larson & Czerwinki, 1998). The users preferred the broadest structure, although they had needed more time and had made more false selections than while using the more narrow structure. Users' preferences of the three tested navigation structures can be seen in TABLE 1.

TABLE 1. Users' preferences of the different navigation structures in Larson's and Czerwinski's study (1998).

	8 x 8 x 8	32 x 16	16 x 32
Best preferred application	6	11	2
Second best preferred application	2	3	14
Last preferred application	11	5	3

3.2.2 Scrolling

When it comes to scrolling of the pages, we should think of the immaturity of the mobile applications. For example, in 1996 Jakob Nielsen wrote that only 10% of the desktop web users bothered to scroll down the page, and thus the pages, especially the index page, should not be made longer than what fits on one screen (Jakob Nielsen's Alertbox 1996). If this recommendation is strictly followed in mobile environment, it sets a requirement for short pages and a deep navigation tree. Mobile screens are so small that only a limited amount of links can fit on them. Yet, we must bear in mind that in 1999 Nielsen wrote that during the past three years the desktop users had learned to scroll – if the needed information was not visible on the first screen, the users already knew to look for it by scrolling the page down (Jakob Nielsen's Alertbox 1999). We might presume that this trend will be similar with mobile devices. Mobile internet applications are at the moment still new for most of the users, and when using a mobile internet application the pages are often not yet scrolled down to see the whole contents of the page (Kaikkonen & Roto 2002, 346; 2003b). Perhaps the same development that happened with desktop web applications will apply to mobile internet applications, too. Maybe already in the near future we can give up the recommendation of trying to make the pages as short as possible.

3.2.3 Cross-navigation and site maps

There are also navigation related studies, which consider other points than the navigation tree structure or the page lengths. For example, Zimmerman and Walls (2000) report a study, in which they compared the user satisfaction in two different web sites. They did not compare the deepness and the broadness of the navigation three, but the effects of the possibility to cross-navigate within the pages. Zimmerman and Walls (2000) had two applications, one of which had a structure that was similar to the basic hierarchical organisational pattern and the other one a structure that followed the web organisational structure (see FIGURE 8 beneath).

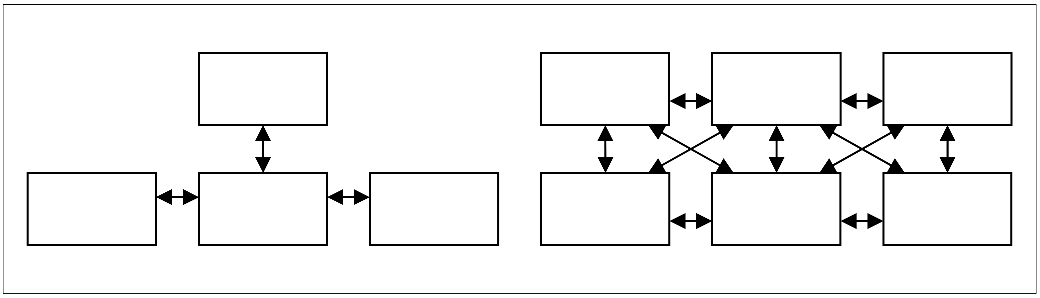

FIGURE 8. Basic hierarchical organisational pattern (left) and web organisational structure (right) (Zimmerman & Walls 2000). These were the navigational structures that Zimmerman and Walls (2000) compared in their study. They did not find any significant differences in the users' performances or preferences between these two structures.

Zimmerman and Walls had 33 users, who all used both of the applications. 25 qualitative questions about the applications were asked from the users. The questions covered the feelings of lost and frustration, troubles of finding information and how organized the users felt that the applications were, etc. Also the numbers of total movements during the given tasks were gathered. Zimmerman and Walls did not find any significant differences between the two structures, which is somewhat surprising. The reasons for not finding any differences were not analyzed in the research paper. We think that the amount of the links has slowed down the user performance in the web organisational structure. There the users had to scan through a wider amount of links, whereas in the hierarchical organisational structure the navigational paths are longer than in the web organisational structure, and thus none of them is more efficient or more pleasant to use. We are not aware of this type of a study in mobile environment.

In desktop web environment, there should be a site map if there are more than 20 pages within the site (Badre 2001, 141). Although the site map is good in desktop web applications, there are not yet research results available about the site maps in mobile environment. The problem is how the site maps can be presented on mobile screens. If the site structure is so complex that the site map would benefit the users, it will be quite hard to present it clearly and in a simple manner on a mobile screen.

3.2.4 Book index navigation or enriched navigation metaphor

Badre (2001, 61-66) has compared how two different navigational metaphors work in a desktop web application. Both of the applications were museum web sites and they had the similar content, but their navigation was strongly in contrast with each other. First one of the applications had a book index system as its navigational metaphor. There the users could see the key words in an index format, and could use them as the main navigation links. The other application had a 3-D spatial navigation, where the users could picture themselves actually visiting a museum.

Badre (2001, 61-66) found out that, if users have to accomplish a distinct task of finding a certain piece of information the index based method is more efficient. In the index based method the users make fewer clicks and need less time to find the information they need. On the other hand, the user satisfaction is higher when using the enriched navigation. The users are able to remember more things about the contents of the web site, if it is based on a 3-D spatial navigation method with enriched graphics. (Badre 2001, 62-66) We must, though, bear in mind, that in mobile environment the users are mostly searching a certain piece of information or making assignments planned in advance (Weiss 2002, 66), and they are not especially pleased to see entertaining pictures, if those slow down the actual assignment (Nokia 2004b, 8). Therefore, at the moment the index based navigation would be the best choice for mobile applications. But later, when the characteristics of the mobile devices' usage perhaps change into more entertaining direction, graphical interfaces might be better in some of the mobile applications.

3.3 Naming and grouping the links

"The user has certain tasks to accomplish and, consequently, wants to direct the computer to perform a subset of those tasks. The problem from the user's perspective is knowing what the computer can do and knowing how to direct it to do those tasks" (Norman 1990, 4-5). Here, when considering the navigation, one needs to think of the naming and the grouping of the links.

Card reported already in 1982 about a study, in which he compared different kind of groupings of the menu items. He compared three possible ways to structure the contents of graphical menus: alphabetical order, grouping to similar functions or grouping randomly. Menu items in the Card's experiment were word processor functions. In the test the users were first shown the whole menu, then they were shown the name of the menu item which they should look for, and during the performance the time to select the item was measured. Card especially studied the eye movements and the visual recognition of the searched menu item. He found out that alphabetically ordered menus were the fastest to use. (Card 1982) The problem in this study is that in a normal situation the user does not always exactly know the name of the link or the menu item which s/he is looking for. In that kind of a situation we presume that grouping the similar functions or links would be faster to use than alphabetically ordered items.

Later, word processor (and some other applications' menus as well) have grown significantly, and more efficient ways to present the menu items have to be considered, as Findlater (2004) points out. She has studied static, adaptive and adaptable split menus in desktop environments. Findlater (2004) compared the speed and the error rates from 27 users, who all used three applications with different split menu designs: static, adaptive and adaptable split menus. Split menu means that on the upper corner of the menu there are few items, which are separated with a line from the other items. These items are the most frequently or recently used items of that menu. Under the line there are all the rest of the menu items, for instance, in alphabetical order. (For example, Microsoft Office applications use a somewhat similar kind of a menu system.) The items in the upper corner can be either static, or they can dynamically change, or they can be personalized by the users themselves.

In Findlater's experiment there were four items in the upper split area. In the first application they were static, in the second one they changed to respond to the most frequently and recently used items (adaptive), and in the third application the users could select, which items were shown as the first four items (adaptable). The adaptive menu was in the test the slowest one. Between the static and the adaptable menus there was only a small difference, for the adaptable menu's favour. The adaptable menu was preferred by most of the users. (Findlater 2004) It might be useful to consider, if the results could be utilized in mobile environments, too. For example, on mobile internet sites' index pages there are often a lot of stabile links. Maybe they could be either adaptable or adaptive.

In the earliest studies, static split menus have been discovered to be much faster than traditional menus (Sears and Shneiderman 1994). Findlater (2004) found out that users strongly prefer the adaptable split menus. The problem that relates to the customizable menus is that the users are not very keen to customize them, if they are not forced to do that (Mackay 1991). But then again, automatically adaptive menus are problematic, as well. They do not take into account that the users tend to memorize the use of the systems. If the items in the menu move "randomly", those users, who are familiar with a certain menu structure, have troubles finding the menu items (Straub 2004). So, there are a lot of questions that are connected to the personalized and adaptive menus. There is also very little research information available considering mobile applications.

Naming the link properly is important, too. Badre (2001, 138) has stated, that the effectiveness of a link is related to its name and its location in relation to the other links. A link's name should tempt the user to select it, and to give a matching description of the result for selecting it. (Badre 2001, 138)

Users take advantage of their existing mental models when they use a new application or a web site. Users have, in other words, assumptions on the appearance and the functionality of the system. Into these assumptions the users can adapt new knowledge. Learning to use an application will be quicker, if it reminds the user of some known system, and s/he can make use of her/his former knowledge. (Badre 2001, 47-50) For example, in a banking application the users might take advantage of their former experiences on visiting a bank's branch office. They might expect that the same phrases and terms apply in an internet banking application, as well. In any case, it requires a thorough study to find out, what actually are the users' expectations. For example, young bank customers may not have the experience of visiting a bank's branch office, and the branch offices' terms (e.g. daily services) might confuse them. As Badre (2001, 50) says, designers should understand how the users organise their knowledge of the real word, and design the applications respectively.

3.4 Summary

When it comes to the structure of the navigation tree and the page lengths in mobile internet applications, there are no specific answers. They both are dependent on the contents of the page – whether it is a text page, a link page or an interactive page – and on the type of the device that the user has.

The difference between the broadness and the deepness of the navigation tree, from the users' point of view, is that when there are many links on the same level (a broad structure) the application is relatively fast to use (Giller et al. 2003). However, there are users, especially novice users, who do not always scroll down the pages to see all the contents (Kaikkonen & Roto 2002). This is a severe problem. Application designers should bear in mind, that the structure seems clearer, when there are less links available (Giller et al. 2003). That makes the application more pleasant to look at – and to use, at least when one is not experienced with the application.

Users' preferences do not always match with the quantitative results (e.g. Larson & Czerwinski 1998), and, thus, the designers should not only consider, which structure is the most efficient to use, but to find out, what are the user preferences. It has to be remembered, too, that the more links the users have to follow in order to get to their goal, the more time it takes. Larson and Czerwinski (1998) and Giller et al. (2003) claim that deeper navigation structures are slower to use. We assume, that experienced users become annoyed, if they constantly have to use a system where new pages are slow to download (with the slow mobile connections) and there are a lot of unnecessary levels to go through.

When it comes to the navigational structure of (desktop) web applications, it has been found out that neither is a traditional organisational navigation structure nor a complex web organisational structure better (Zimmerman & Walls 2000). There is no research information available about this matter in mobile environment, and we do not know, either, if the strict implementation of the navigation structures mentioned above has inflicted the equal results. In reality, a navigation structure often has some features of a web organisational navigation, even though it mainly was designed to follow the traditional organisational navigation structure.

In mobile applications the page's content guides the length of the page. Text pages can be relatively long, up to 20 screens, but interactive pages cannot. Six screens for an interactive page are too much. (Kaikkonen & Roto 2003a) Link lists can be long, if the links are closely connected to each other (Roto 2003; Nokia 2004b). In the early studies considering desktop applications it has likewise been stated, that alphabetically ordered link lists can be long (Landauer & Nachbar 1985). However, it would be preferable if all the links in a mobile application could be seen at once (Giller et al. 2003).

How much one screen can contain text or other elements depends on the device, which is used to browsing the application. It is important to remember that the characteristics of the client device make a difference in the user experience (Kaikkonen & Roto 2003a; Badre 2001, 195-196). And though the need to scroll does partly determine the page lengths, this might change in the future as it did with desktop web pages (cf. the comments about scrolling in desktop applications in Jakob Nielsen's Alertbox 1996 and 1999).

If the users are likely to search for a certain piece of information, index based navigation method is better than graphical navigation (Badre 2001). This applies at least to desktop applications, but most likely to mobile environments, too. If the purpose is to create a strong and entertaining application, graphical user interface is better (Badre 2001). This will be possible in the future mobile applications, when the data transfer rates evolve.

4 EXPERIMENT – COMPARISON OF NAVIGATION DESIGNS

This chapter describes the background of the theory-testing empirical experiment, which compared the usability of two mobile internet applications. The experiment was done in controlled laboratory environment. The goal was to test the following hypotheses:

> H_0: There are no differences between the usability of two mobile banking applications, when one of them follows menu page based navigation approach and the other web navigation bar approach.
> H_1: There are differences between the usability of two mobile banking applications, when one of them follows menu page based navigation approach and the other web navigation bar approach.

The hypotheses have been formed on the basis of the conceptual-theoretical background study, presented in the previous chapters.

4.1 Overview

The experiment was made for Nordea Bank Finland, who also sponsored it, and it was conducted in collaboration with Nokia Research Center. Information about the companies can be found on their home pages (Nordea 2004; Nokia 2004e).

In the experiment, two demo versions of an internet banking service were tested. The applications had the same characteristics, except the navigation placing and the possibility to cross-navigation. There were 31 test subjects, who all performed the same test tasks in both of the applications. During the experiment we gathered data, through which the usability of the applications could be estimated.

4.2 Background for the hypotheses

In desktop web applications navigation is often arranged through a menu bar, which is usually available on every page of the site, often placed on the upper edge of the page. It allows the user to cross-navigate within the different sections of the site without going back to index page or separate menu pages. We wanted to find out, whether the web navigation bar would work in mobile internet applications, too. In the literature there are not any studies covering the effects of either the navigation placing or the cross-navigation possibility in mobile environments, and we found the topic important to investigate.

The hypotheses considering the experiment are mentioned in the beginning of this chapter. H_0 was formed on the bases of the study of Zimmerman and Walls (2000), which we have discussed on pages 43-44 of this report. There the researchers did not find any differences between two applications, which supported different navigational patterns. The navigation approaches in the study were similar as in our experiment. However, in our experiment, the implementation of the navigation approaches was different than in Zimmerman's and Wall's study, and our experiment was conducted in mobile environment.

H_1 presumes that there are differences between the applications. This hypothesis can be justified on the basis of the results of some other studies. For example, Buchanan et al. (2001) recommend using simple hierarchies when designing navigation (more detail, see page 35 of this report). In our experiment, one of the tested applications contained menu pages, where the links were organised hierarchically beneath each other. On the other hand, the other application supported cross-navigation within the sub categories of the application, and thus offered shortcuts, which has been claimed to be important for experienced users (Nielsen 1993, 20).

4.3 Methods

As mentioned in chapter 1.4, the experiment presented in this chapter is based on theory-testing method (see Järvinen & Järvinen 2000, 36-67). The hypotheses, mentioned in the beginning of this chapter, were formed on the basis of the conceptual-theoretical research, and in the experiment they were tested empirically. Theory-testing was carried out by making a controlled laboratory experiment (see Järvinen & Järvinen 2000, 43-55). Also comparative method was used: two applications were compared in the experiment.

Usability assessment methods, which were used in the experiment, are observation, thinking aloud (see Nielsen 1993, 195-198), questionnaires (see Nielsen 1993, 209-214) and performance measurement. The performance measurement was done by calculating the time it took from the users to complete the tasks, and the clicks they made during the tasks.

4.4 Metrics and variables

Since the experiment was also a usability testing, the definition of usability needs to be considered. From the definition one can derive the metrics for the experiment. As mentioned earlier, the five attributes, which are traditionally associated with usability are learnability, efficiency, memorability, errors and (subjective) satisfaction (Nielsen 1993, 26). Other usability principles which Nielsen mentions are e.g. using concepts that are familiar to the user, being consistent within the application’s features (words, situations, actions), giving enough feedback for the user, as well as providing clearly marked exists and allowing the experienced users to use shortcuts (Nielsen 1993, 20). Also the user’s ability to answer to the fundamental navigational questions: ‘Where am I?’, ‘Where have I been?’ and ‘Where can I go?’ (Nielsen 1999, 188) is important from the point of view of the experiment.

From the attributes mentioned above, our experiment covered the following ones: learnability, efficiency, errors and subjective satisfaction. After the test sessions we asked the users to evaluate how well they were able to answer to the basic navigational questions (Where am I? Where have I been? Where can I go?). In this way we aimed to create an extensive estimation of which one of the applications was more usable from the user’s point of view. In chapter 5.5 we mention some usability problems which were noticed during the test sessions. They are divided into four groups: problems which relate to the device, problems which relate to the browser, problems which relate to the application and problems which relate to asking the opinions of the users.

Because of the experimental research method, the dependent, independent and controlled variables need to be defined. In this experiment the independent variables were: users' former experience with mobile applications, applications' navigation design (lay-out and structure), and the optimal paths considering the test tasks. The dependent variables were: amount of clicks, time spent, number of accomplished tasks, user preferences, and user feedback.

4.5 Testing conditions

The experiment's tests were carried out with a Nokia 3650 phone that has a Symbian 60 platform and a Series 60 operating system (Nokia 2004d). The phone has a 176 x 208 resolution colour screen and a 5-way scroll key, which allows the user to move in vertical and horizontal directions on the screen and to select an object or a link by pressing the scroll key down. The test browser was a Nokia browser.

The test cases were recorded with a microphone and two digital cameras, one of which was shooting the expressions of the test subjects while the other, extra small camera, was shooting the screen of the test phone. The mini-camera and the view, which it videotapes, can be seen in FIGURE 9. The two pictures were mixed together into one screen. The videotape that was hereby created was used to confirm the observations, which were made during the testing. In all test sessions there were 1-3 observers monitoring and taking notes of the events. The time between the clicks, which the users made, was traced with a PHP-script that was running on the same server as the test applications. The amount of the clicks made could be traced down from the PHP log page and the recorded tapes.

FIGURE 9. Mini-camera, which was attached to the phone (left) and the view that it videotapes (Nyyssönen, Kaikkonen & Roto, 2002). It should be noted, that the phone and the view are not related to our experiment.

4.6 Test subjects

There were 31 test subjects, 17 men and 13 women. One of the test sessions is excluded from results other than the subjective feedback, because during that test session the GPRS connection dropped down several times and the data gathered during the session is defective. In this defected session the test subject was a 22-year-old female.

In the rest of the test sessions the age of the subjects varied between 23 and 58 years (mean 36 years; standard deviation 9,6 years). The distribution of test users, sorted by the year of their birth, can be seen in FIGURE 10. All of the subjects had used mobile phones and desktop internet applications before, but their level of experience varied a lot. Some had an expertise experience with mobile internet applications and some had not used any mobile internet application before.

Although there were all kinds of test users when considering their skills with mobile phones and mobile internet applications, there was a considerable group of experienced users, possibly more than there would be in a pure random sample. 14 (47 %) test users used text message services or mobile internet services weekly or daily. On the other hand, 12 (40 %) test users had not used text message services or mobile internet services at all. By text message services are hereby meant services that can by ordered with SMS, for example, weather forecasts or contact information.

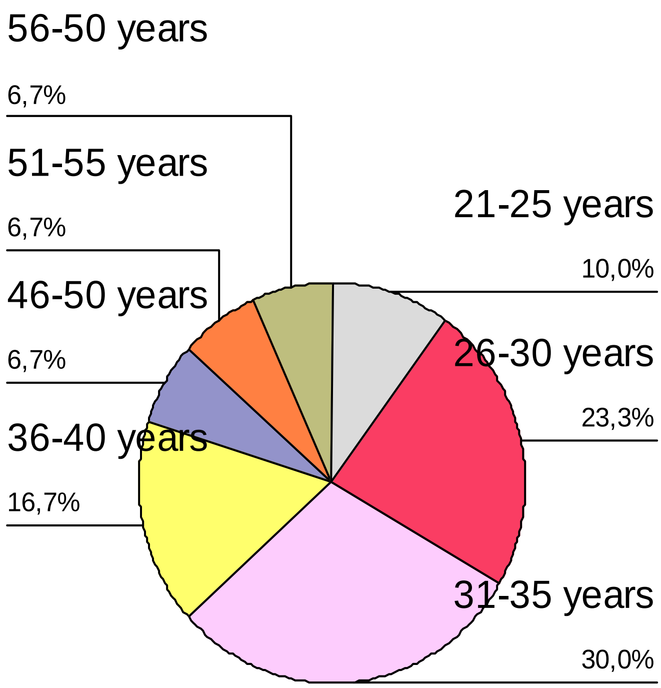

FIGURE 10. This graph illustrates the range of test users' age. Slices in the picture describe the percentages of the whole group. As it can be seen, there were no users between 41 and 45 years.

Only three test subjects out of 31 did not normally use any internet banking service. 71% (22 subjects) used Nordea Bank's internet banking service regularly, which might have eased their orientation in the tested applications. Yet, we assume that this has not inflicted any significant distortion in the experiment's results, since all Finnish banks have somewhat similar internet services at the moment and the words describing the services are about the same in all banks.

4.7 Tested applications

The tested applications were written in XHTML, and they were running on a normal WWW-server. They were mobile banking applications, which seemed to have about the same banking services as Nordea bank's internet service has.

The navigation structures in the test applications were not designed to be extremely conflicting, but to represent two possible ways to arrange the navigation. One of the applications (application A) had the main navigation only on its menu pages, while the other enabled cross-navigation within the application's sub-categories. However, both applications had links to the index page, to the former page and to the sign out page on the bottom of every page. Both test applications showed, at the most, three levels of the navigation structure at once. In application A the links were on the menu pages, and they were hierarchically organised in index form. In application B the links within the current sub categories were presented on every content page. The layout structure of the applications can be seen in FIGURE 11 and FIGURE 12.

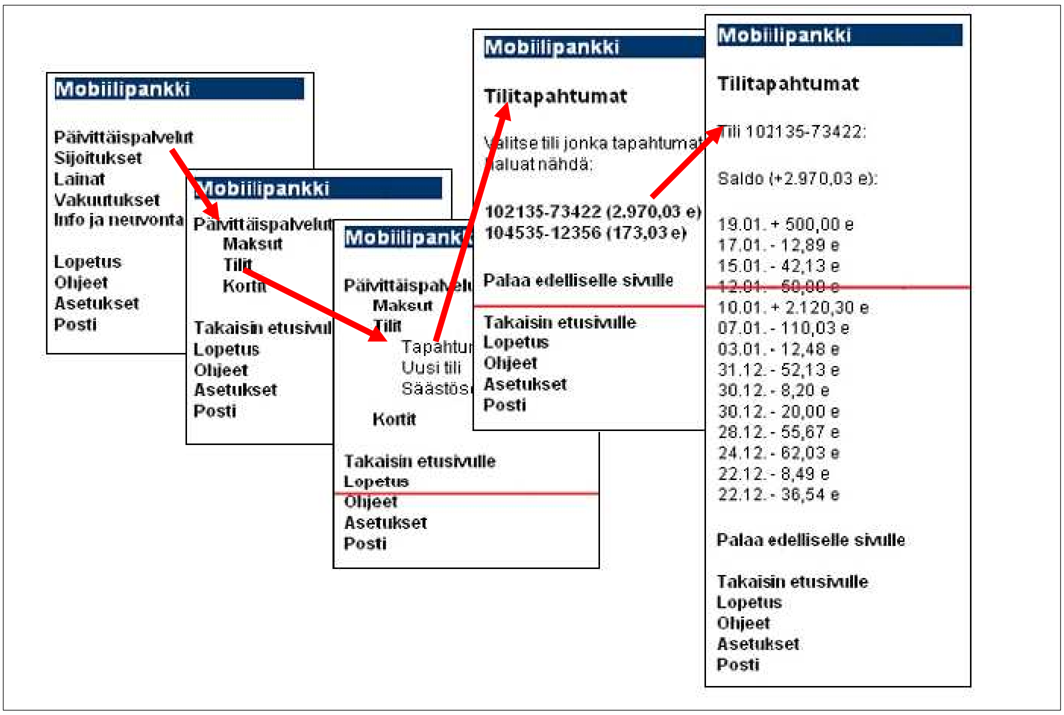

FIGURE 11. Lay-out in application A. Links in the application A were arranged hierarchically beneath each other. This arrows show the path from the index page to the account information page. The red lines approximately indicate the amount of the information that fits on one screen.

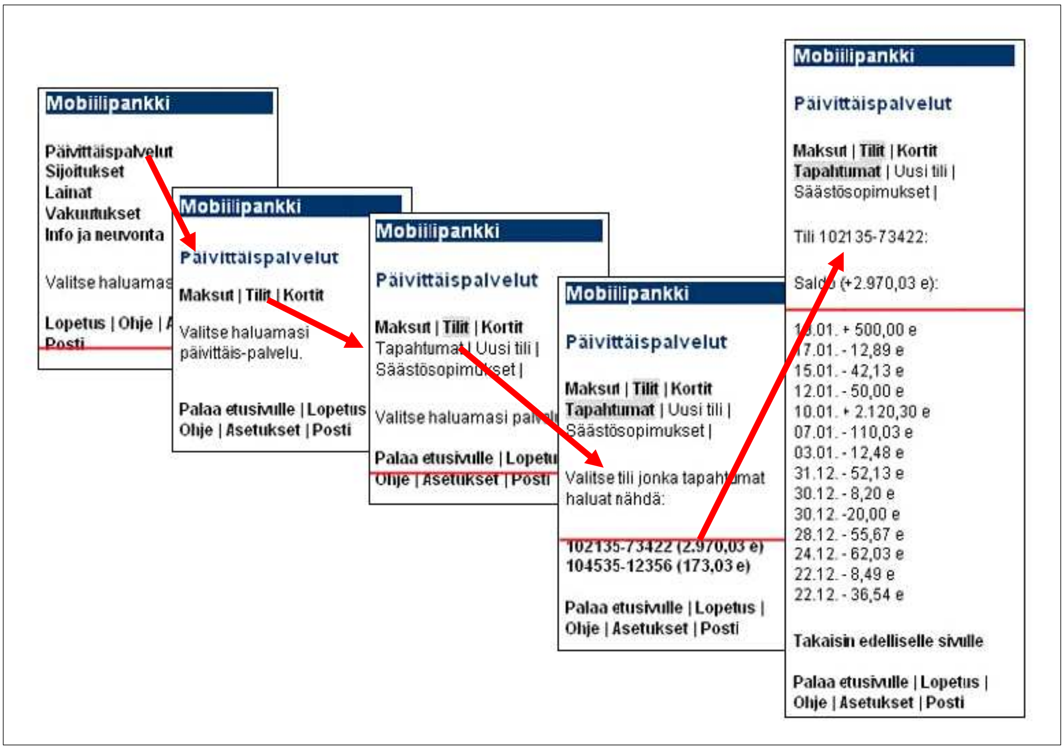

FIGURE 12. Lay-out in application B. Links in the application B were placed on the upper corner of the pages and they enabled cross-navigation within the current subsection. The arrows show the path from the index page to the account information page. The red lines approximately indicate the amount of the information that fits on one screen.

4.8 Testing process

At first, the test subjects were asked to fill in the background information form (see ATTACHMENT 1). After filling in the information, the form was scanned through by the test observers and the test subject was interviewed briefly. Then the test observers explained how the recording system worked and the reasons for recording. If the test user was not familiar with the testing device, s/he was shortly informed about the functions of the phone and the browser.

The test users were asked to do the tasks in their own speed, without hurry, as if the observers were not present. The test subjects were also asked to think aloud, while they were doing the tasks so that the observers would know if some particular point was easy, difficult, confusing or pleasing. The think aloud technique is one of the most popular techniques in usability studies, especially when it is combined with other techniques (Nielsen, Clemmensen & Yssing, 2002). It is, though, criticised because thinking is faster than talking, and furthermore, thoughts are spontaneous and sometimes hard to express with words (Nielsen, Clemmensen & Yssing, 2002). Thinking aloud may needlessly slow down the user's performance (Nielsen 1993, 195-198). However, to ask test users to think aloud enables the researchers to get some kind of picture of the users' mental processes (Nielsen, Clemmensen & Yssing, 2002) and their conceptions of the system (Nielsen 1993, 195). In this experiment the benefits of the think aloud –technique were considered greater than the risk of its influence on the time spent.

During the test session the observers wrote down what the test subject did and said (clicks and comments) and these notes were afterwards revised from the tapes and the PHP-logs. After completing both tests, the subjects were asked to give verbal comments, which were written down, and to fill in a questionnaire (see ATTACHMENT 2). When a test user had used both of the applications and had filled in a form about them both, s/he was asked to fill in a third evaluation form (see ATTACHMENT 3), which made her/him to compare the applications with each other. During the filling of the last form s/he could also take a look at print-outs of both of the applications.

4.9 Test tasks

Before the test session started, the context and the tasks were orally explained to the test subject. The test subjects were told that they were in the following situation: S/he has sold a lap-top computer to a student, who has promised to make an account transfer of 500 euros to pay for it. At the present moment, the student has made the account transfer on an ATM a moment ago. The test subject currently is on her/his way home, and s/he wants to check with her/his mobile phone if the payment really has arrived on her/his account. While doing this, s/he remembers that s/he has to pay 15 euros for her/his colleague for a lunch. S/he has the account information with her/him.

During the test session, the tasks were given to the test user on separate pieces of paper (see ATTACHMENT 4), so that the user did not have to recall any information on her/his own. The test situation started from the index page of the banking service, and it seemed about the same in both applications. In both applications the user had two own accounts, which s/he could see on the account information page. When making the payment, the test user had to choose the right account from the two possible ones. Test tasks are listed below:

1. Find out if a 500 euro payment has arrived on your account number 102135-73422.
2. Move to a page, where you can make a payment to your friend Kaisa Koski.
3. Make a payment.
    Payment information:
    Recipient’s account number: 102135-123123
    Recipient’s name: Kaisa Koski
    Message: Lunch
    From your account: 104535-12356
    Amount: 15 euros
    Confirmation code A: 1234
4. Go to the index page.
5. Check if the payment really left from your account number 104535-12356
6. Check the stock rates of the day.

The last task was given orally, after the subject had noticed, that the 15 euros had left from her/his account.

The test subjects performed the same tasks with both test applications so that every other test subject started with application A and every other with application B. This was done to outline the possible learning effects, which might have effected the amount of the clicks made and the time spent while doing the test tasks.

5 EXPERIMENT’S RESULTS

This chapter presents the results of the experiment. Some of the results are discussed here, too, although the final conclusions of the experiment are presented in chapter six.

> ”Human performance is an observable factor that is most often used in assessing the ergonomics of a system. Performance is a function of three basic variables: Speed, accuracy and quality. Well designed systems reduce the time that it takes for the user to perform a task. At the same time, error rate should be kept at a minimum. The severity of errors depends on their type. Some are easily correctable, others are devastating. (Norman 1990, 8)”

Above Norman lists three factors, which should be observed: speed, accuracy and quality. These are the basis also in our experiment. Yet, the results are organised according to the usability metrics that are mentioned in subchapter 4.2 Goals and metrics. The following ones of the usability metrics are estimated: learnability, efficiency, errors and subjective satisfaction. These metrics include speed, accuracy and quality, as well: speed is one of the factors of efficiency, accuracy can be associated with the amount of errors, and quality can be estimated with the subjective satisfaction. The users’ ability to answer to the fundamental navigational questions: Where am I? Where have I been? Where can I go? is covered, too. In addition to this, few other points considering the usability of the applications are mentioned in the last subchapter 5.5 Notes during the test sessions.

5.1 Learnability

According to Nielsen (1993, 27-30), learnability is the most fundamental usability attribute, because most systems need to be easy to learn. Nielsen suggests that the ease of learning is estimated by measuring the time it takes to reach a certain level of proficiency in using the system. The learning curve, which depicts the ease of use, can be formed by comparing the time used and the expertise level that has been reached.

In this case the learning can be estimated in those tasks, which were exactly the same in both applications. They are related to filling in the information on the New payment page. Of course, one cannot say what would be the final shape of the learning curve, but it can be estimated, if there appeared learning between the first and the second time of completing a certain task, and how significant this change was. One cannot unambiguously say, if the learning appeared in using the application or using the device, but we presume it was the both.

The learning effect, while filling in the payment information, was significant. The page was the same in both applications. When the users inserted the payment information in their first application, they needed an average of 4 minutes and 51 seconds. When they inserted the payment information for the second time, they used only 3 minutes and 3 seconds, on average. This means, that they improved their performance with 35 % only by practising the task once. In ANOVA analysis this variance of means gets a highly significant value (p=0). Yet, it has to be considered, that a part of the effect can be a consequence of using the think aloud technique. The users probably have had same type of thoughts when they used their second application, as what they had when they used their first application, and thus some of the users might have not mentioned them aloud during the second time anymore. Nevertheless, in our opinion, the difference is also a consequence of the learning. During the first time of usage, the users probably have talked aloud more, but they certainly have also thought more, and even the wondering of the effects of making a movement, takes more time at the first time.

What can be concluded from this is that even though a task would be hard for the users when they complete it for the first time, they learn a lot already with one practice. In our case we do not know, if the time would have diminished further on during a third usage of the application, and how many times of practice do users need in order to attain their optimal speed. We cannot distinguish the learning related to the application and to the device, either, but we can say, that the time that the users need for completing a task for the first time is not very significant, because it might amend quickly. The paramount thing is that the users are able to perform a task once; on the second time the difficulties of usage can be already significantly reduced.

When using the applications for the first time, many users had problems with selecting the account number from the pull down menu. It is interesting that when they used their second application, only one user could not select the account number, and only two users hesitated before the selection. The statistics about the use of the pull down menu can be seen in TABLE 2 below. The learning effect was strong in this detail, too. As mentioned, in our opinion, the biggest challenge for the application designers seems to be, how to make such applications that users can use them once – when they use it for the second time, the usage is already much easier.

TABLE 2. Differences in using the pull down menu.

Result / 1st or 2nd time	Did not notice	Could not select the account	Hesitated but succeeded	Succeeded with no difficulties
First time	7	4	10	10
Second time	2	1	2	26

An interesting point considering the learning is discussed also in subchapter 5.2 Time spent. It is noted there, that the time spent was reduced more when the users used the application A for the second time than when they used the application B for the second time.

5.2 Efficiency

This subchapter presents the results that are related to efficiency. They are the time spent and the clicks made.

5.2.1 Time spent

Efficiency of use can be measured by the average time it takes to complete certain specified tasks (Nielsen 1993, 193). In this experiment, the users were not told that the time they used was tracked. They were only asked to do the tasks in their normal speed. We thought that the awareness of timing would have made some users nervous or tempted them to needlessly hurry, and thus the results would have differed from the normal situation. But then again, now the users might have spent more time completing the tasks than in a normal situation, since they were asked to think aloud. As mentioned in subchapter 4.5, the think aloud technique is arguable, because thinking is faster than talking. Verbalising ones thoughts might be complicated and take unnecessarily much time (Nielsen, Clemmensen & Yssing, 2002; Nielsen 1993, 195-

198). This is why we did not remind the users of thinking aloud, if they seemed not to do it easily. Despite of the possible distortion which think aloud –technique might have caused to the time spent, we assume, that the figures are in the right ballpark. The possible distortions should be the approximately same with both applications.

When considering the time spent, application B got inferior results to application A. The test users spent more time doing test assignments in application B than in application A: In application B the average time spent was 10,78 minutes (647 seconds) and in application A it was 9,77 minutes (586 seconds). From these results we have ignored those test sessions, where the GPRS connection was notably slower than normally. The timing results are calculated on the basis of 26 tests sessions.

When comparing the times with ANOVA analysis, in spite of the one minute difference, there is no statistically significant difference between the means of time spent in application A and B ($p=0,359$).

Yet, there is a very significant statistical difference between the applications that the users used either first or second. In their first application the users spent time approximately 11,83 minutes (710 seconds) and in their second application only 8,72 minutes (523 seconds). There the margin is notably bigger and also statistically significant ($p=0,003$). It means that there was a significant transfer effect between the applications. It was related either to applications' contents and structure or to the using of the device.

We can confirm that some of the transfer effect is related to the application and not only to getting used to the device. This we can conclude on the basis of the statistically significant difference ($p=0,021$) between the groups, which are formed by taking into account both: the application that was used, and the order in which the test was conducted (e.g. if it was application A or B, and if it was used first or second). In TABLE 3 the means are listed and in FIGURE 13 there is a bar graph that depicts the difference between these groups. From the graph we see that the time which the users needed to complete the tasks in application A was considerably smaller when they used it after using application B first. This means that, in application A, the users could more easily make use of their former knowledge of the service's contents and structure. It seems that it was easier to understand the structure of the application A, and thus to adapt the former knowledge of the tasks there, than in application B. Some of the users noticed the transfer effect between the two applications, too: “This [application B] would be much harder, if I hadn’t used the application A first.”

Since the groups in this case were relatively small (13 users) we cannot make very far-reaching conclusions, but we can say that the application A seems to be easier to use when considering the time spent, although there is no statistically significant difference between the means of the time spent in applications A and B.

TABLE 3. Means of times spent in application A and B, when considering were they used first or second.

Application and order	Time spent (seconds)
Application A first	697
Application A second	476
Application B first	724
Application B second	570
Total	617

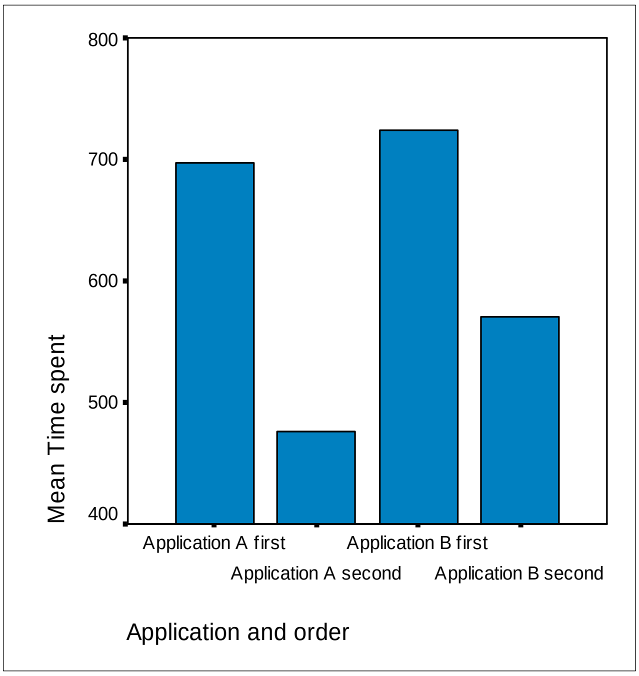

FIGURE 13. Means of the times spent, when taking into account the application and the order in which the applications were used.

5.2.2 Differences in the amount of clicks

The ease of use can be measured, for example, by comparing the amount of (mouse) clicks in two applications (Badre 2001,6). The amount of the clicks is the meter of the ease of use also in this experiment. The amount of clicks describes the efficiency of the applications, too. We should also bear in mind, that the less the users have to click in the applications, the more they will like it (Buchanan et al. 2001).

Differences in the total amount of clicks

The optimal amount of clicks was somewhat smaller in application B. There one could, theoretically, go through the tasks by making 18 clicks, whereas in application A one needed the minimum of 20 clicks. We counted also usage of the browser's Back button as a click. The total amounts of clicks made during the tests are listed in TABLE 4. As it can be seen, in both applications there were users that could complete the tasks with the smallest possible amount of clicks, but in application B the users did more unnecessary clicks and, thus, the mean in application B is higher than in application A. When considering the efficiency of the applications (actual number of clicks divided by the optimal number of clicks), application A gets a result closer to 1 (efficiency = 1,2315). This means that in application A the users went through the tasks, on the average, closer to the optimal route. In application B (efficiency = 1,3888) they did more unnecessary clicks.

As it can be seen in TABLE 4 below, the range of the amount of clicks is wide. The distribution of the total amount of clicks is illustrated in FIGURES 16 and 17. In ANOVA variance analysis, it can be seen that there is no statistically significant difference between the complete amount of clicks made in applications A and B ($p=0,840$).

TABLE 4. Statistics about the clicks made during the test.

Statistics about the clicks made	App. A	Std. error app. A	App. B	Std. error app. B
Mean				
95% confidence interval for mean	24,63	1,299	25,00	1,468
– Lower bound	21,98		22	
Higher bound	27,89		28	
5% trimmed median	23,48		23,89	
Median	23		23	
Variance	50,654		64,621	
Standard deviation	7,117		8,039	
Minimum amount of clicks	20		18	
Maximum amount of clicks	58		59	
Range	38		41	
Skewness	3,858	0,427	2,935	0,427
Kurtosis	17,388	0,833	10,803	0,833

Differences in the amount of clicks within the separate tasks

The amount of clicks within the separate tasks can be compared, as well. In the amounts one can find some statistically significant differences.

In tasks number two and six, there was, according to ANOVA variance analysis, a statistically significant difference when comparing the means of the amount of clicks between the two tested applications. In task number two, in which the users had to move from the account information to a page where they could make a payment, the difference is obvious (p=0): The route to take was two steps shorter in application B. In application B the optimal amount of clicks was 2, and in application A the smallest possible amount of clicks was 4. The average amount of clicks in application A was 4,33 clicks and in application B 2,57 clicks. When comparing the effectiveness figures, it can be seen that in application B the users did more unnecessary clicks. Even though application B was quicker to use according to the amount of clicks, using it was harder than using application A, when thinking of the amount of mistaken clicks.

The other statistically significant difference between the numbers of clicks can be found in task number six, which was the last task. The layouts of the pages related to this task can be seen in FIGURE 14 and FIGURE 15. In task number six the users were on the account information page, and they were asked to find the stock rates. The optimal amount of clicks was the same in both applications: Users needed at the minimum four clicks to find the stock rates. In application A the average value was 6,37 clicks. In application B the average value was 8,07 clicks. This difference was, according to ANOVA analysis, statistically somewhat significant (p=0,058). The difficulties in application B were inflicted by the amount of links that had to be scanned through to find the link to the stock rates.

The amount of sub links was same in both applications, but the difference was, as all around the applications, that in application A the links were arranged vertically beneath each other, and the level of the links was indicated by indention. In application B the sub links were shown one after another on rows, separated by a vertical line. The level of the links was shown by a bold typeface. When the user had opened the stock rates page, in application B the links stayed in the upper corner of the page, and the content appeared beneath.

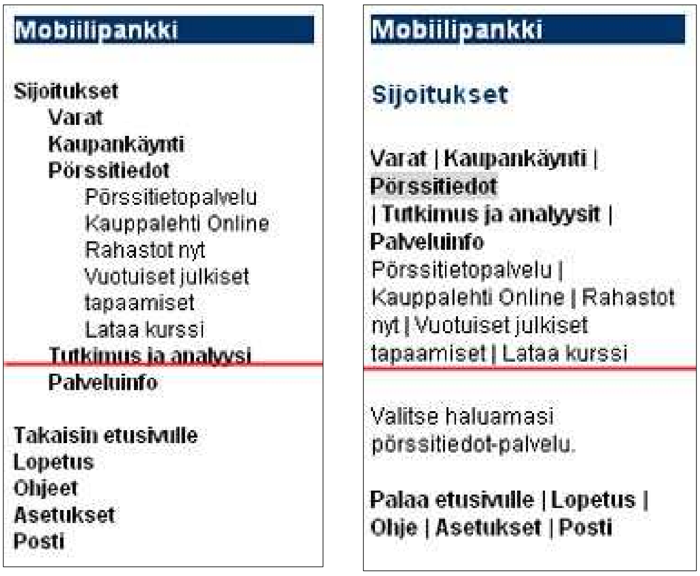

FIGURE 14. View of the pages in application A (left) and B (righ), when the user has opened the link Market information (Pörssitiedot). The red line approximately indicates the size of the phone’s screen.

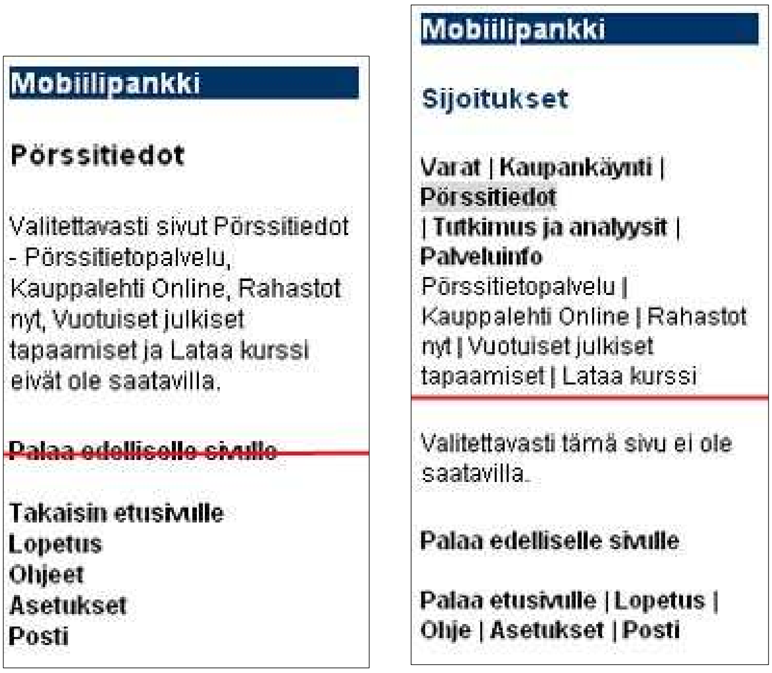

FIGURE 15. View of the pages in application A (left) and B (right), when the user has opened the link Stock rate information (Pörssitietopalvelu). The red line approximately indicates the size of the phone's screen.

As it can be seen in FIGURE 15, in application B the user had to scroll down the page to see the text "This page is not available" (Valitettavasti tämä sivu ei ole saatavilla). Many users did not scroll down, and so they did not find any contents on the page.

Differences in the amount of clicks due to gender and expertise level

There can be found a difference between the amounts of clicks, if the users are divided into two groups by their gender. In FIGURE 16, it can be seen that male users completed the tasks with fewer amount of clicks than the female users. This can be a consequence of the female users' smaller amount of experience on mobile internet applications. It can be seen, as well, that the marks in FIGURE 16 are approximately as far from axis Y as from axis X. It means that the users did about the same amount of clicks in both applications, though many female users seem to have made more clicks in application B than in application A (the round dots in FIGURE 16 are more often below the dash line than above it). Because there were more inexperienced users in the women than there were in the men, we can conclude that the application B was harder to use for the inexperienced users than the application B, and vice versa, the application A was easier to use for the inexperienced users than the application B.

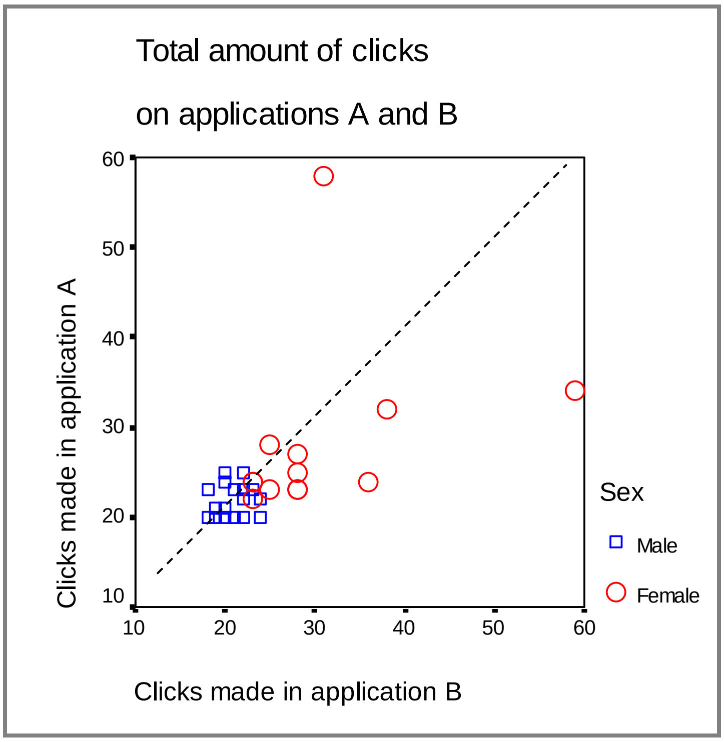

FIGURE 16. Total amount of clicks in applications A and B divided by the test users' gender. On the axis Y we see the amount of clicks a user has made in application A, on the axis X we see the amount of clicks made in application B. On the dots (23, 24) and (28, 23) there are two female users. It can be seen, that the male users completed the tasks with lesser amount of clicks than female users.

FIGURE 17 describes the means of the total amount of clicks as functions of the former experience. It can be seen that for application B the curve has a constant downward movement – the amount of clicks is inversely proportional to the amount of former experience with mobile internet and SMS services. This means that those users, who were experienced with mobile applications in general, could benefit from their know-how in application B. Actually, one could say that the user needed to be experienced to cope with the application B. The trend in the curve, which describes the amount of clicks made in application A, is not that strong. The former experience with mobile internet and SMS services did not correlate with the amount of clicks so strongly there, as it did in application B. Also those users, who did not have very much experience with mobile internet and SMS services, did approximately very well in application A, when thinking of the amount of clicks.

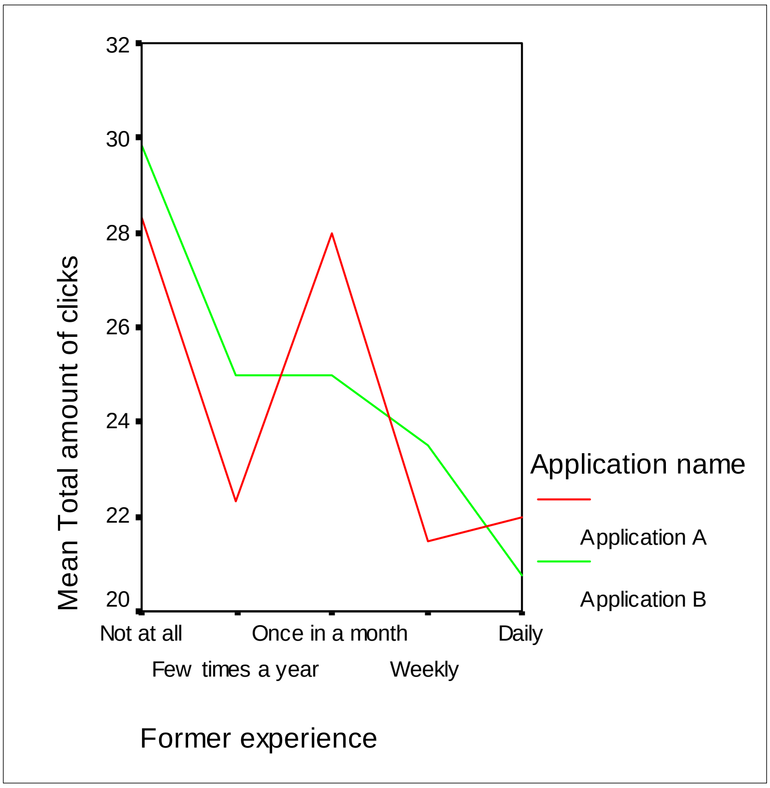

FIGURE 17. The amount of clicks in applications A and B illustrated as functions of former experience with mobile applications or SMS services. We can see that experienced users completed test tasks with small amount of clicks. Some test subjects with an average amount of experience with mobile applications or SMS services (used them once in a month) made a quite a lot of clicks in application A. On the other hand users with very little experience with mobile applications could complete the tasks in application A with a very small amount of clicks.

5.3 Errors - differences in task completion

Every test subject tried to perform the test tasks with both applications. Within these 60 performances there were all together 360 separate tasks, and 12 times we confronted a situation, where a user could not complete the given task. They are presented in TABLE 5 below. Ten of these situations happened while trying to find the stock rates from application B: Ten subjects stated that they cannot find the stock rates from application B. Some of the test subjects were convinced that there were no stock rates in application B. All subjects, though, could find the stock rates from application A. In both applications the links and the paths to the stock rate information were the same, only the positioning of the links was different. The arrangement of the links in application B, however, caused the need for scrolling – in appplication B the users had to scroll down to see any of the contents. Since many users did not scroll at all, they did not see the contents of the page, and thus believed that there were no stock rates at all. FIGURE 14 and 15 in subchapter 5.2.2 illustrate the path to the stock rates in task no. 6.

One subject would have stopped the test in the task number three, while he was inserting the payment information, if he had not received any help. This happened in the first application that he was using (application A). During the second time, while he was using application B, he could do the task by himself. The page for inserting the information was the same in both applications. One test subject could not perform the task number five in application B; she could not find the information of the paid amount of money from her account information. This problem occurred, because she did not realize that she would have had to scroll down the page to see the information. In application A she did complete the task, because she could see already on the first screen some of the text considering the account information. This hint guided her to scroll down the page in order to see the whole text.

TABLE 5. Failed tasks in applications A and B.

Task number	Failed performances in application A	Failed performances in application B
3 – Inserting payment information	1	0
5 – Checking, if the payment really has left	0	1
6 – Checking the stock rates	0	10

5.3 Subjective satisfaction

When comparing the opinions of the test subjects, application A was, in general, considered to be easier to use than application B. The feedback was given right after the test assignments. The users were asked to fill in a questionnaire, which evaluated the application on Likert scale (see ATTACHMENT 3). These questionnaires were filled in after both test applications. Users were asked to circulate a number that described if they completely agreed with the statement or completely disagreed, or something in between. The numbers were from 1-7, number 1 meant a complete disagreement and number 7 complete agreements. For all subjective measures we have counted the feedback from all 31 test subjects, whereas for the other results we have counted only 30 test sessions. This is a consequence of the failed GPRS connection, which caused problems in one test, and, thus, in that particular test session no other than subjective measures could be included.

On Likert scale, application A got the average of 5,61 points, when the average value for application B was 5,22 points. Those test subjects, who used application A first, gave it the average of 5,41 points, and those who used application A after using application B first, gave application A the average of 5,81 points. This means that application A was ranked even higher when the users had had the chance to compare it with application B. Although the differences between these average values are not statistically significant (in ANOVA variance analysis their significance value is > 5 %), they are in line with the results of the comparison questionnaire, where the users could compare the applications. There the users ranked application A higher in the average of 50 % of the questions, when application B was ranked higher only in 24 % of the questions. In 27 % of the questions, the users could not tell, which one of the applications they preferred.

When comparing the answers of the single questions, statistically significant differences between the two applications can be found. In those questionnaires, where the users separately evaluated the application which they just had used there was a considerable difference in statements “Links were placed on the screen well” and “There was the right amount of links visible on all pages”.

To a statement “Links were placed on the screen well” the users gave application B the average of 4,55 points, and application the average of A 5,71 points. The difference between these answers is, according to ANOVA variance analysis, statistically significant (p=0,005). To the other statement “There was the right amount of links visible on all pages” application B received the average of 4,55 points, and application A 5,52 points (p=0,014). These statistical differences clearly prove that, in application

B, the links were placed poorly on the screen – the menu bar type of navigation placing did not work in our experiment.

There were considerable differences in the answers to the single questions, which were partially formed on the basis of the fundamental navigational questions (Nielsen 1999, 188). The answers can be seen as bar charts in FIGURE 18 and as pure numbers in TABLE 6.

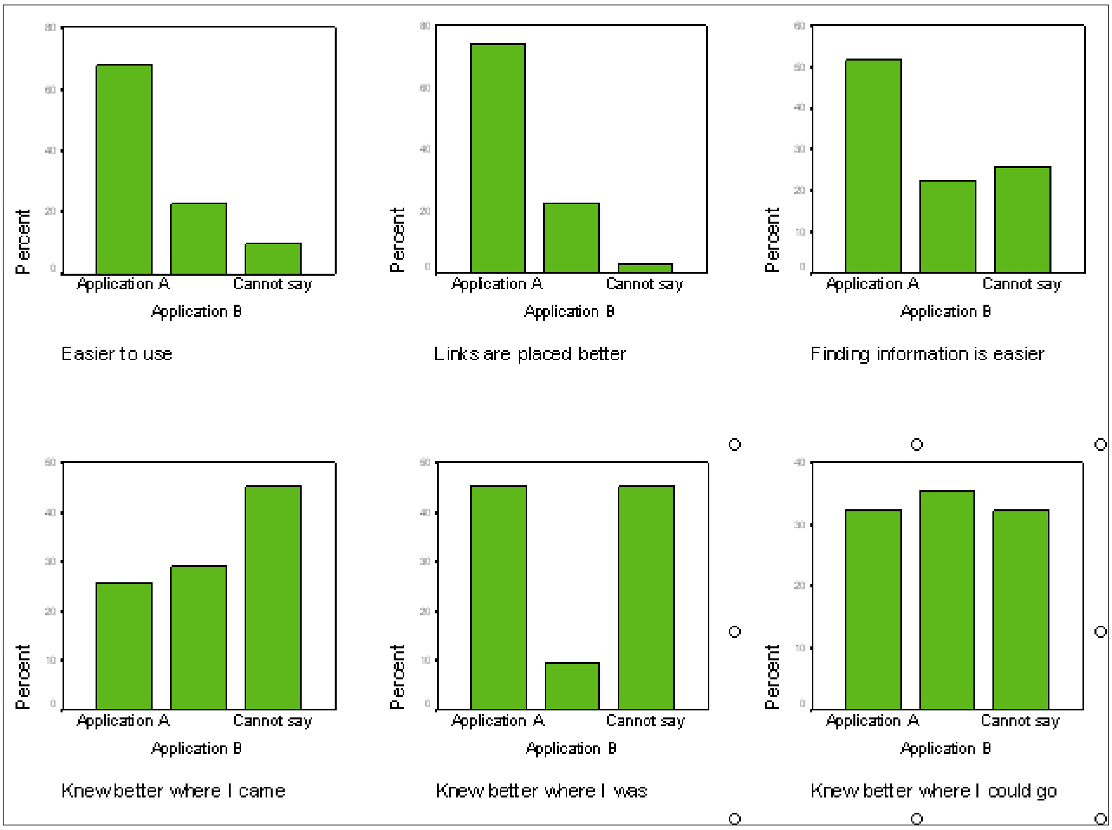

FIGURE 18. User preferences, when the users were asked to compare the applications with each other. It should be noted that here, as well as in all of the user preference results, we have counted the answers from 31 test subjects, although in the non-subjective measures there are results only from 30 subjects.

Although, in general, application A was preferred in the answers, there were few questions, where application B was ranked higher. These were "In which application you knew better from where you had come to the current page" and "In which application you knew better, where you could go". As it was expected, the users found application B better in these questions, probably because the links were visible on every page. But we would have expected that this would have benefited the application more. At first sight, it is also surprising that to a question “In which application you knew better, where you currently were?” the users chose application A to be better. This can be explained by the users’ experiences in the last task, where many users were complete lost in application B. This happened, because in application B there were so many links on the upper corner of the page that the users did not notice the change on the page. These results are also discussed in chapter 5.4 Knowing where you are, where you can go and how you can go back.

TABLE 6. The information of FIGURE 18 is presented here in table format: User preferences, when the users were asked to compare the applications with each other. It should be noted that here, as well as in all of the user preference results, we have counted the answers from 31 test subjects, although in the non-subjective measures there are results only from 30 subjects.

	Application A (amount / %)	**Application B (amount / %)**	**Cannot say (amount / %)**
Which application was easier to use?	21 (67,7%)	7 (22,6%)	3 (9,7%)
In which application the links were placed on the screen better?	23 (74,2%)	7 (22,6%)	1 (3,2%)
In which application it was easier to find the information you were looking for?	16 (51,6%)	7 (22,6%)	8 (25,8%)
In which application you knew better from where you had com to the current page?	8 (25,8%)	9 (29%)	14 (45,2%)
In which application you knew better, where you currently were?	14 (45,2%)	3 (9,7%)	14 (45,2%)
In which application you knew better, where you could go?	10 (32,3%)	11 (35,5%)	10 (32,3%)
Total	92 (49,5%)	44 (23,6%)	50 (26,9%)

The users often commented that application A was easier to use and it seemed somehow clearer. Other words, which were used to describe application A right after the test sessions, were: simple, easy to piece together, logical, hierarchical, guiding, calm, handy, fast, usable, clinical, pure, too slow, walks me over.

Some users, who preferred application B, stated that application B guided the user better by showing the path that the user had taken. Some of the users also mentioned that application B allowed them to move within the subsections without going back to the first page. 25 out of 30 test users used immediately the possibility to cross-navigate in application B, but only eight users mentioned, that the ability to cross-navigate was so significant that they would prefer application B, and even these users said that there were too many links on the page when trying to find the stock rate information in application B. The words, which were used to describe application B, were: fast, clever, confusing, absolutely better, full, too many links, quite intuitive, too much information, inconvenient, simple enough.

5.4 Knowing where you are, where you can go and how you can go back

It is extremely important for the user to know where s/he is, where s/he can go and how s/he can get back from there. These aspects relate to the fundamental navigational questions stated by Nielsen (1999, 188). The first one of these questions is said to be the most important (Norman 1990, 25; Nielsen 2000, 188).

Having used both applications, the users were asked about their preferences on the applications. The results can be seen in TABLE 7 below. While answering, the users had a chance to look at printouts of both applications. To a question “On which of the applications you knew better on which page you currently were?” the users clearly preferred application A. 14 of the test users said that they knew better where they were while using application A. Only 3 users chose application B to be better in this sense. 14 users could not choose their favourite.

Ten of the users said that they knew better in application A to which places they could go at the moment. Eleven users said that application B was better in this sense. The remaining ten users could not choose their favourite.

The users were also asked, on which one of the applications they knew better, from where they had come to the page they were using. 8 users said that application A supported better their knowledge of where they came from. 9 users chose application B to be better from this aspect, but 14 users could not choose their favourite.

As we can see from the TABLE 7, application A was, in general, better when considering the basic navigational questions. Altogether 32 subjects favoured application A, when only 23 subjects preferred application B.

TABLE 7. The preferred applications when considering the fundamental navigational questions.

	Application A	Application B	Cannot say
Knowing where you are	14	3	14
Knowing where you can go	10	11	10
Knowing where you came	8	9	14
Total	32	23	38

Before the experiment we assumed that application B might support the aspects of the fundamental navigational questions better. For example, the users were asked to check the movements on their accounts, and right after that they were asked to make a new payment. In application B the users could see the link to the payments already on the upper corner of the account information page. On application A the users were forced either to scroll down the page and choose a link to the previous page or to the index page, or to press the Back button at least twice in order to be able to see the link to the new payments. If the user did not remember the applications' structure, in application A s/he had to "go blind" backwards to find out the path to the payments. Yet, because the navigation bar in application B grew later so large that it was, for most users, hard to understand its structure anymore, it eliminated the good features of the navigation structure.

5.5 Notes during the test sessions

During the test sessions we noticed some situations, where problems often occurred to the users. Some of them are related to the usability principles that Nielsen (1993, 20) has mentioned: naming of the links is related to using concepts that are familiar to the user, the placing of the links relates to both; providing clearly marked exists and allowing experienced users to use shortcuts. The users awareness of her/his current position in the application relates to the placing of the links as well (see Nielsen 1999, 188). The causes are here divided according to the three components that affect the user experience in mobile applications (see FIGURE 1 on page 5). For making the future applications easier to use, we give some suggestions, how to improve these problematic features. The data has been gathered by observing the users in the test situation.

5.5.1 Device dependent problems

Using the scroll key is difficult for many users. Moving the cursor into four directions is hard for many users. This gives a good reason to think, whether the applications should only contain links one below another so that the need for horizontal movements would be minimized. Users' comments: "The menu is difficult to use, it's hard to move." "I have to say again that this button is not for a woman with long fingernails." "It's a little bit hard to choose that link…" "This [cursor] doesn't obey me. This is much too hard." "If I was younger… I have this erosion in my fingers." "Moving downwards with the scroll key was easier than moving sidewards."

Scroll key should not contain too many functions. In our test phone, the scroll key could indicate movements to five directions, plus it had different functions depending on how long the user pressed the button. A short press downwards selected an object (e.g. a link or a text field) but a little longer press opened the Bookmarks page, which was very confusing for some of the users. Two users, who opened the Bookmarks page, managed to get over it with a little help. Three other users had to interrupt the task at that point, when the Bookmarks page opened, because they, for some reason, kept opening it again and again. We presume it was some sort of stress reaction, since using the scroll key was so hard for them. Users' ability to estimate time-out lengths (time-out is an automatic change in the user interface from one mode to another) has been studied by Marila and Ronkainen (2004), who state that learning the time-out lengths is very hard for some users, when there is no visual or auditory feedback of the time-out length. In our case, the time-out of using the scroll-key to select a link was quite short. Selecting an object was hard, too, because the scroll key had a round shape. Pressing the right edge of the round scroll key was considered hard.

5.5.2 Browser dependent problems

Scroll bar could help users to understand that they need to scroll down. There should be some sort of an indicator that would help users to understand, whether they have already seen all contents of the page, or whether there is something left to see on the page.

Pull down menus are hard to use. As we already mentioned, there were troubles using the pull down menu. Pull down menus should indicate on their appearance by which button they can be opened with. If there is an arrow to right, the pull down menu should be opened by pressing the scroll key to right. Our test browser indicated the pull down menu by showing an arrow to the right, but it was opened by pressing the scroll key down. For eight users, it was very hard to find out, how to open the pull down menu. Some users did not notice the menu at all, even though they should have used it according to the task description. Users' comments during the test: "An arrow to right? No. Options-button? No. Cancel-button??" "An arrow to right…? How can I open this?" "This arrow to the right is bad. I first tried to press the scroll key to right." However, if the user succeeded, he might have liked the pull down menu: "Wow, balls! That was great!" "Ha! When I've done it once I know how it works!" "Why isn't this working? Well, I will bravely try – oh, it worked! I will remember that for the next time!"

5.5.3 Application dependent problems

Links on the upper corner of the pages should not fill out the whole screen. This conclusion came up already in the earlier subchapters considering the test results, but we still want to emphasize its importance. If the links are the only thing visible on the screen, many users do not realize that they have to scroll down the page to see the other contents. In our test, it was insuperable for 10 users to understand that they should scroll down to see the text contents, and thus they failed the last task in application B. There were also others, who had some problems in finding the information from the stock rate page. Altogether, more than two-thirds of the users suffered from the links filling the whole screen. Users' comments during the task: "This somehow doesn't go there." "This is a wrong place." "Did I go anywhere?" "This didn't move at all. Hey, this navi-button doesn't work!" "Isn't this the right path?" "It [the information] isn't here." "Oh, it didn't go there… Now I am a little lost. I am trying to go to Kauppalehti-online and I can't find it."

Extra space between the lines should be minimized, so that there would not have to be unnecessary scrolling. Three users mentioned this during the test. They all were experienced mobile internet users. User's comment: "Shorter line spaces would help here…"

Showing the current position of the user has to be designed carefully. Showing the user's current position is defined to be one of the most important qualities of a navigation structure (Norman 1990, 25; Nielsen 2000, 188; etc). Also, when a user selects an item, it should be highlighted (Badre 2001, 169). Our structure did not seem to point this out clearly enough. The location of the user was indicated by a background colour in the menu bar: the name of the latest chosen link had a light blue background. Also the name of the main section was stated in the upper corner of the screen. Our background colour was, however, not eye-catching enough and was mixed up with the indicator colour of the cursor. Only few users mentioned aloud that they had noticed the background colour of the latest chosen link, and even they seemed to mention it only to point out that the background colour was much too similar with the cursor colour. We can presume that a clearer indicator of the user's current positions would have boosted the application B's success, because there were a lot of links shown to the user at a same time, and some users did not seem to be fully aware, which link they just had chosen. If this type of solution is chosen to indicate the user's position, at least the colours should be chosen carefully.

Links on the bottom of the page are mainly used, when they happen to be visible on the screen. In our test applications, we offered links like "Back to the first page", "Quit", "Post" etc. on the bottom of every page. When the users had to move back to the index page, eight users consciously looked for the link. Eighteen users used the link only if it was shown on the screen without scrolling. Five users used it in the beginning only if it was shown on the screen, but during the "second round" (when using their second application) they looked for the link purposely. For one inexperienced user, the fact that the link to the first page was on the bottom of the pages, was very inconvenient. For her, it was very hard to move downwards on the pages. If the page was long, she did not go down enough to see the main links. When she wanted to go back to the first page of the application, she was totally lost. She was also not quite sure, what would happen if she would press the Back -button of the browser. This is a situation that should not happen to any user. Here are some comments from the users when they were trying to navigate back to the index page: “Now I wonder from where I can go… [looks for the index page link] Using Back-button is so inconvenient. I don’t want to use the Back-button, I want to have a link.” “I had to use the Back-button twice before I found the link to the index page.” “I have to scroll awfully long way before I get to the index page link.” However, as we mentioned, not all users even think about using the main navigational links: “Using Back-button is easier than using the links.”

Numbers are hard to insert in a text field. Numeric fields should be in number format as default. During the 62 performances, there were seven cases, where inserting numbers in a text field seemed clearly problematic. In addition to this, there were 10 performances during which a user mentioned that inserting numbers to a text field irritated him/her. Users’ comments during and after the test: “How do I get numbers here?” “This is too slow.” “Uups, this does something else… How do I get text insert off?” “Oh damn… I wonder if I somehow get the numbers on.” “It irritates me when taping the numbers is this hard. It should work.” “Most irritating was inserting the numbers.”

**-signs are not good in a password field.* Many users thought that they inserted a wrong mark when it changed into a *-sign. Some cleared the whole field, because they thought they made something wrong. For eleven users out of 31 the *-signs in the password field caused confusion. For one user, it was insuperable to fill in the password. Users’ comments: “The fact, that the marks are turning into *-signs confuses me, it’s not easy to notice a mistake.” “This password field should show me what I inserted – I would not make mistakes so easily.”

Link names are often not self-explanatory. Norman (1990, 19) mentions that menus can give a lot of information to the user, and their usage may require only little or no training. In our case some of the link names had ambiguous meanings for the users. For example “Daily services” and “Payments” as well as “Market information” -links seemed to lead the users to different associations. Especially those users, who had long experience in the banking field, were irritated that the naming of the links did not correlate with their expectations. After all, almost all users chose the right link after wondering what that link name might mean. Users’ comments: “I wonder which one it is. Perhaps Daily services.” “This [Daily services] could be more precisely named.” “I presume it is that [Daily services].” “This confuses me a little: is it a New payment or Own transfer? Maybe the Own transfer means my own accounts.” “I suppose Payments means that I would pay something, not a payment that has arrived.” “Do I have to choose Market information or Research and analysis?” “Why does this say Market information instead of Stock rates?” Finding the best matching names for the links is extremely important to make the application work. The following citation is from Norman (1990, 4-5):

> “The user has certain tasks to accomplish and, consequently, wants to direct the computer to perform a subset of those tasks. The problem from the user’s perspective is knowing what the computer can do and knowing how to direct it to do those tasks”.

In a web application, this means that the links have to be named correctly. Otherwise the user does not find the information or transaction page s/he is looking for.

5.5.4 Problems in asking the users’ opinions

Identifying the characteristics of the tested application and separating them from the browser and device dependent features is hard for some users. For example, the browser windows (e.g. Bookmarks page) could be opened with almost the same way as navigating the application was done (pressing the scroll key), and this confused some users when they gave feedback. Users also understood clicking the links and punching the scroll key (while scanning through the page, and moving between the links on a page) convergent. Taping in the numbers and letters in the text fields (while inserting the payment information) was considered “clicking” by some users. This might have caused some distortion while filling in the questionnaires. This should be taken into account, when formulating the questionnaires in the future. In our case, this, however, does not make a big difference, because in both applications the browser and device dependent features were exactly the same.

5.3 Summary

In this chapter, we have presented the results of a controlled laboratory experiment, which was a usability testing of two different mobile internet applications. The usability aspects were covered from the following viewpoints: learnability, efficiency, errors and subjective satisfaction. We also considered the users' ability to answer to the fundamental navigational questions: Where am I? Where have I been? and Where can I go?

The differences between the tested applications were related to their navigation design. The links were placed on the screen differently. In the first application (application A), the links were placed one beneath another on the menu pages, and the user had to go back to the menu pages in order to move between the sub sections of the site. In the second application (application B), the links were shown on every page, and they allowed the user to cross-navigate within the current sub section's pages. In application B, the links were organised to the screen the way menu bars often are in desktop applications – to the upper edge of the pages. The layouts of the applications are presented in FIGURE 11 and FIGURE 12 on pages 55-56 of this report. In all of the observed aspects, application A got better results when thinking of the usability aspects.

The learnability of the applications was quite hard to estimate, but we did conclude that it was easier to learn to use the application A. Those users, who did not have a lot of experience with mobile internet or SMS services before, did not have particularly much problems in application A, though, in application B, the inexperienced users seemed to have made a lot of unnecessary clicks. From FIGURE 17 one can see that the users needed to be experienced with mobile internet or SMS services to cope with the application B. In application A, also those users, who did not have very much experience with mobile internet and SMS services, did approximately well, when thinking of the amount of clicks. On the basis of FIGURE 13, one could also conclude that it was easier for the users to transfer their former knowledge about the mobile banking service to application A, than to application B. The structure of the application A was easier to understand for the users.

Application A was also more efficient to use. The users needed less time to perform the tasks in application A. When thinking of the amount of clicks made, the results were consistent with the time used. The total amount of clicks was smaller in application A, although the optimal amount of clicks was higher. It means that the users were able to use application A more efficiently than application B.

The error rate, meaning the failed task performances, also tells a harsh fact about the problems in application B. There were 11 failed tasks in application B, whereas the number in application A was only one. 10 of the failed tasks in application B were related to the last task. The users were supposed to find the stock rates information from the application. In application B, the links, which were related to the investments and were placed on the upper corner of the page, filled out the whole screen. To see the actual stock rates information, the users had to scroll down the page to see the text contents below the links. Only 21 users out of 31 succeeded in doing this. In application A, where the stock rates information was visible already on the first screen, there naturally was no problem in finding it.

The last nail to the coffin was the results of the user preference questionnaire. It is not a surprise that even there the application A was on the average the better one. When thinking of the other results, the surprise actually is that it was not ahead of application B more. In some single questions, application B was considered better. Two of those were related to the fundamental navigational questions. Application B gave better support for the users when thinking of their awareness of the route they had took. In other words, in application B, the users knew better from where they had come to the current page. Also, when thinking of the questions: Where can I go? application B supported the users more. This was natural, because the users could see the links on the pages. But to the question: Where am I? which is the most important one, application B did not give good enough support for the users. This relates to the last task, in which many users got totally lost. They were not sure whether they had already pressed the link, which should lead them to a page that contains the stock rate information, or not.

Some of the users were sure that the link was not working. Some told us that the application did not contain the stock rates at all. Some users clearly admitted that they were lost.

In subchapter 5.5.3, we stated that the links should never fill out the whole screen when there is some text contents on the page, too. In subchapter 5.5.2, we suggested that adding a scroll bar to the browsers might help the users to understand, whether the page contains some more information than is already on the screen. Some other usability flaws were also discussed in subchapter 5.5.

6 CONCLUSIONS OF THE EXPERIMENT

When analysing the results of the experiment, it was found out that index based navigation approach, where the links were hierarchically beneath each other on the menu pages, was considered to be easier to use than web navigation bar approach, where a menu bar was available on every page. The index based navigation approach was more efficient both in the time used and in the amount of clicks made, and it induced a smaller amount of errors for the users. Because some of the differences were also statistically significant, the conclusion about the hypotheses is the following: H_0 is invalid, and H_1 is valid. Differences between the applications exist.

Although the experiment was the first one to investigate the effects of the navigation placing and the ability to cross-navigate within the mobile applications sub sections, one notices that the results are congruent with the result of the former studies in mobile environment.

The most striking usability flaw of the menu bar navigation was that it contained a page, where the links filled out the whole screen, and there was still something left to see on the page beneath the links. When the users clicked a link on this page, a new page where the content was beneath the links opened, and the first screenful of the page did not change. This inflicted strongly on the user’s awareness of his/her current position. The users were not sure, whether they had clicked the link or not, whether the link worked at all, whether they had chosen a wrong link, or whether there were any information available about the subject at all, etc. One third – 10 users out of 31 – did not find the content on this type of a page. 21 users did find the contents, but it was hard also for some of them to understand to scroll. As we have mentioned on page 19 of this thesis, Kaikkonen and Roto (2003b) have found out, that if a site has the same contents on the upper corner of every page, users do not always notice to scroll down. That was the case in our experiment as well.

The scrolling of the page in mobile applications is clearly not yet internalized. The difficulties of scrolling have been stated already in the earlier studies. In our experiment, we saw that only on those pages, where it was obvious that the content shown on the first screen is continuing somewhere out of sight, the users understood to look for it and to scroll down. The earlier studies have proved that plain text pages are all right when they contain 20 screens full of information (Kaikkonen & Roto 2003a, 334). Also on link pages it is fine to present up to 30 links, if the links are closely connected with each other (Roto 2003). In these claims the essential thing is that the content has to provoke the users to keep on reading and scrolling down.

On the basis of our experiment, the rule of thumb that the user should be able to see all the links at a glance without scrolling (Giller et al. 2003), can be expanded. Our contribution to this rule of thumb is that, if the page includes some other contents than the links, also a part of this other contents has to be visible on the first screen. The users have to be allured to scroll down the page; they have to be forced to understand that there is still something hidden, out of sight, on the page. Because the scrolling is not yet internalized as a basic function, the contents of the page have to strongly support the need for scrolling. If the site structure requires so many links that they fill out one whole screen, navigation should not be arranged with a navigation bar.

In his 1990 published book, Norman says that the early menu systems have been criticised because of their menu structure. According to Norman (1990, 25), the menu structures were earlier often designed so that, if the user wanted to go backwards in the navigation structure, s/he could not return to the same point in the menu where s/he originally was. This is also somewhat the case in the application A in our experiment. The user is not able to directly change between the different states in the application; on the contrary, s/he has to always move through the menu pages. Before the experiment, we presumed that when the users could compare this somehow old fashioned way of navigating with more flexible menu bar navigation (in application B), they might prefer the ability to move between the different sections of the application without always returning to the menu pages. However, we found out that the menu bar navigation was hard to use, on the one hand, because of hardware features (selecting the links with a scroll key is harder when one has to move in four directions than if one has to move only up and down) and, on the other hand, because of the unclear positioning of the links. The users preferred the links to be linearly one beneath another on the menu pages, where the level of the links within the structure could be shown clearly by indenting the links differently.

When comparing these results with the former studies, they are, again, similar. Kaikkonen and Roto (2002, 346), for example, have stated that in their test the novice users liked to use links, which were organised according to the navigation hierarchy tree of the application, and seeing the main sections of the service helped the users. The navigation hierarchy tree equates with the link layout of the application A in our experiment. The layout of the links in application A, clearly made it easier to perceive the structure of the application. As we mentioned on page 15 of this report, "navigation is hardly ever a part of the product's content, but an instrument to find a way to the content, and thus navigating should be as easy and natural as possible (Sinkkonen, et al. 2002, 49)". In application B, the navigation bar took too much space on the screen and therefore became a part of the content of the pages. The placing of the links in application A was better – the links were an instrument to find a way to the content, but they were not visible on the actual content pages.

In chapter 3.2.3, we referred to a study made by Zimmerman and Walls (2000), which was done in desktop environment, but otherwise is somewhat similar to our experiment. Zimmerman and Walls compared the user satisfaction in two different kinds of web sites. As in our experiment, they did not compare the deepness or the broadness of the navigation three, but the effects of the possibility to cross-navigate within the pages. One of their applications had a structure that was similar to the basic hierarchical organisational pattern and the other had a structure that was based on the web organisational structure. Zimmerman and Walls did not find any significant differences in the usability of these two sites. We based our H_0 hypothesis on their study, but it was proven invalid. In mobile environment the links have to be organised on the screen so that the structure is easy to understand. The possibility to cross-navigate does not compensate the unclear view, which results from the links that are arranged as a menu bar. The menu bar, on the other hand, is essential to enable the cross-navigation.

We found out, too, that if the Back to the first page links etc. are meant to be used, and are essential for the fluent use of the application, it should be considered whether they could be placed already on the upper corner of the page. On the grounds of our experiment, the users do not often bother to search for the main navigation links from the bottom of the page, but use a Back button instead – even when the path to go backwards would be relatively long.

In our experiment, we discovered two important details related to showing the current position of the user, which is, as mentioned, defined to be one of the most important qualities of a navigation structure (Norman 1990, 25; Nielsen 2000, 188-189). It is clear that, when a user selects an item, it should be highlighted (Badre 2001, 169). In application B, the user’s current location in the navigation structure was shown by a background colour of the last chosen link in the menu bar, and by stating the name of the main section of the application in the upper corner of the screen. The background colour of the last chosen link was, however, not eye-catching enough and it was often mixed up with the cursor. This is a type of a usability flaw which one should not fall down to. Also a scroll bar type of an indicator that can be found in all desktop browsers should be added to the mobile browsers. The lack of a scroll bar or some other indicator that would show to the user how much of the page s/he has already seen should quickly be added to all mobile browsers. The fact that the users are not yet used to scroll down the pages in mobile applications is not surprising, when the browser does not in any way indicate, whether there is something left to see on the current page.

In our experiment, we noticed some other important factors influencing the user experience and the usability of the applications, too. Some of them are related to the browsers and some to the device. For example, the shape of the scroll key and its functions should be designed carefully – the users should not find the use of the application hard just because the use of the scroll key is so difficult. Also the browsers should make the graphical appearance of the pull down menus more intuitive. This type of difficulties should be considered by the browser and the device manufacturers, because they affect to the usability of the mobile applications in a negative way.

The index based navigation’s supremacy over the menu bar navigation in mobile applications applies at least to those cases, where there are a lot of sub category links. On the basis of our experiment, a structure where the links have been organised to the screen one beneath another, and the hierarchies are presented by drawing in those lines, which present the sub categories links, is not out of date. The users liked this kind of presentation format, and they used very positive words, when they were asked to describe it.

It must be remembered, too, that our experiment's results are related to mobile banking applications. They might be generalized to other transaction applications, which do not have an entertaining purpose. If the purpose of the applications would have been to entertain the user, the results might have been different. Also, when the devices and the browser types develop, and the users in general have more experience on mobile applications, the results of this experiment might not be valid anymore. For example, the scroll bars in the browsers will probably help the users to understand how much of the contents they have already seen. Then the scrolling might not be that big of a problem anymore, and the links can be placed on the screen differently.

7 DISCUSSION

When it comes to mobile browsing, the research field has been very scattered. It is a consequence of the novel technology – mobile devices with an ability to use internet applications have not been on the markets but only a few years. The researchers have had very different visions about the future development of the mobile browsers and their functionalities. These visions have been presented in chapter 2 of this report. Some of these approaches are already “out of date”, because at the time of the studies the devices were much more immature than what they are now. It is clear, though, that some of the features discussed in chapter 2 considering the future visions of the mobile browsers are worth to think of.

In the future, when the mobile applications and services develop further and become common, and the rate of the changes in the mobile devices has slowed down a little bit, the researchers will probably gain more unified visions about the best interaction techniques for the mobile browsers. The current browsers are already quite capable in browsing normal HTML pages, but it is clear that the future brings development to their features. An obvious example is the lack of the scroll bars in many current browsers at the moment.

In our opinion, the wisest thing to do in the browser development would be that the research would concentrate on developing the narrow layout technique further. The narrow layout is already supported by most of the mobile browsers, and it seems that it has come to stay. Making the narrow layout to work better than what it does now, maybe by combining it with some techniques that were presented in chapter 2 of this report, would really benefit the mobile internet users.

When thinking of navigating in mobile applications, the rapid rate of the development of the screen capabilities induces difficulties for long term research. Comparing the studies with each other is challenging, because it makes a big difference if the study was made with a tiny black-and-white screen device, which can only show 6 lines of text, than if it was conducted on a device that has a big coloured screen. When the data transfer capabilities have an impact to the recommended size of the pages, too, it is easy to understand that making use of the earlier research is challenging. However, we have noticed some common regulations for the navigation structure: The navigation tree structure can be neither too deep, nor too broad. The pages cannot contain as much information as in desktop environment, but the users do not like to wait for the downloading, either, if they do not get anything in response (Kaikkonen and Roto 2003a). The pages can be relatively long if they contain e.g. text (Kaikkonen and Roto 2003a, 334) or links which are closely related to each other (Roto 2003; Nokia 2004b). If the navigation tree is deep and the pages are short, the application naturally seems easier to use (Giller et al. 2003) – the need for scrolling, which is hard for many users, decreases – but on the other hand it takes more time to go through a deep structure (Larson & Czerwinski 1998; Giller et al. 2003), because it means that the user has to select much more links and wait for the pages to be downloaded.

In Nokia's guideline for mobile application developers it has been stated that the developers should carefully consider whether they need to provide all the contents of a traditional web site in the mobile service, or would just the information that the users are likely to need on the move be enough. With mobile browsers the users are not likely to surf, but to search some current information, like flight information or weather forecasts. (Nokia 2004b, 8) This is very much true. The mobile devices and browsers have their limitations, and it would be extremely hard to design a mobile internet system that contains a huge amount of information and is easily usable at the same time.

Our experiment, a usability testing of two slightly differing mobile banking applications, covered two points, which had not yet been studied. Our applications differed from their navigation placing and from the possibility to cross-navigate within the application. We found out that it is more important to offer a clear navigation structure than to offer the possibility to cross-navigate. The problems in the visual appearance of the application’s layout in a menu bar based navigation are so prominent that one should stick to the traditional index based navigation when designing mobile applications – at least for a while.

Our experiment was not perfectly designed. First of all, it was a controlled laboratory experiment, and therefore the mobile context, which appears in the real world, was not involved. The environment was not natural to mobile usage. Though, laboratory experiment was the only realistic possibility to collect the data as extensively during the experiment, as we did.

In addition, we noticed that our user interfaces included some obvious flaws which we might have been able to predict by doing a more concise heuristic evaluation (see Nielsen 1993, 225). The background colour, which was supposed to indicate the current position of the user, was chosen poorly. It was very hard to distinguish this background colour of the last chosen link from the cursor indicator. Some other minor user interface flaws were recognised during the actual test sessions, too. Some of these problems, as the text fields in the payment information page, might have gained needlessly much attention from the users, and we might have gotten more feedback about the other features of the application, if these obvious usability problems had not existed. The problems in the test applications, as well as other usability problems that we noticed during the test sessions, are presented in subchapter 5.5.

However, we can say that these design problems were not significant from the point of view of the final results, and that our experiment was generally speaking successful. The general knowledge of the usability of mobile applications has been expanded through our experiment. The results can be exploited, for example, in the further development of the mobile banking applications at Nordea Bank. Also Nokia Corporations can utilize the results, when they generate their style guides for the service providers, as well as when they develop their future devices and browsers.

8 SUMMARY

In this thesis we have studied browsing and navigating web applications with mobile devices. Our research has been composed of two parts: a conceptual-theoretical research part, which has formed the frame of reference to the second part, which was an empirical study, a controlled laboratory experiment, which compared two mobile applications. In this thesis we had two main research questions, which were: How can web browsing be supported by browser functionalities in mobile devices? and How should navigation in web applications be designed for mobile devices? The conceptual-theoretical background research covered the first main research question and gave some answers to the second main research question, as well. In the conceptual-theoretical background research the recent research and the state of the art in mobile browsing were introduced, and the studies considering navigating in mobile applications were discussed. The empirical part of this thesis was an experiment, where we tested the usability of two differing mobile internet applications. With the empirical part we expanded the answer to the second main research question.

In the conceptual-theoretical research we first referred to the background of mobile browsing development, and then to the current mobile browsers, which are quite mature already. They are capable of browsing most HTML pages and use mostly the narrow layout technique to present the web pages. It has been stated that the users are quite satisfied with this technique (see Roto 2003). As mentioned, our opinion is that from now on the research should concentrate on developing the narrow layout technique further.

After presenting the current browsers, we introduced the scientific research considering mobile browsing. This we divided into two categories. First, we presented a research approach, which concentrates on transforming the original web page with algorithms. The algorithms are often running on a proxy server and their purpose is to transform the original web page so that it fits the mobile device’s screen. The other approach, which we identified, was to develop the actual browsers and their features. We found out, that these browsers presented in the literature are often very complicated to use.

The contribution of the conceptual-theoretical part of this thesis is that it deals with a subject that has not yet been covered as generally as we do here – at least we are not aware of that kind of a study. The research field has been very scattered and by constructing this overview of the topic we have made it easier to evaluate, which would be the relevant further research topics in this field.

The research considering navigating in mobile internet applications has been very challenging to go through. As stated, the rapid evolvement of the mobile devices and technologies has had a great impact on the research results. There are hardly two studies made from the exact same starting point, and that makes the comparison of the studies hard. However, we found out some general rules which one should think of when designing the navigation structure for mobile devices. For example, a broad navigation tree structure is relatively fast to use (Giller et al. 2003), but on long pages especially novice users do not always scroll down the pages to see all the contents (Kaikkonen & Roto 2002). Then again, deeper navigation structures are slow to use (Larson & Czerwinski1998; Giller et al. 2003). In mobile applications the page's content guides the length of the page. Text pages can be relatively long, up to 20 screens, but for an interactive page six screens are too much (Kaikkonen & Roto 2003a). Link lists can be long, if the links are closely connected to each other (Roto 2003; Nokia 2004b).

What we noticed on the basis of the former studies was that the efficiency, at least when it comes to the speed of using an application, is not very relevant when thinking of usability. In many studies it has been found out that the time spent and the user preferences do not necessarily correlate. When thinking of mobile applications, the ease of use is more important than the ability to go through the application as fast as possible.

In our experiment we found out, that the menu bar based navigation does not work with the current mobile devices and browsers. The users in our experiment thought that the links which were arranged as a menu bar, seemed muzzy on the small screen. The majority of the users preferred the application, where the links were organised one beneath another on the menu pages of the application. Although the menu bar navigation enabled the users to cross-navigate within the application, the problems with the menu bar navigation were so significant, that the benefits of the cross-navigation were not worth it.

The most striking usability flaw of the menu bar navigation was related to a page, where the links in the upper corner filled out the screen entirely. For one third of the subjects it was overwhelmingly hard to find out the contents from the page, because the links (the navigation bar) filled out the whole first screen. 10 out of 31 subjects could not find the contents of the stock rates page in application B. The investments section included so many sub category links, that the actual contents of the page could not be seen on the first screen of the page. This confused the users, and they either thought that the page had not changed at all (that they had not succeeded to select the link) or that they had chosen a wrong link and they would have to choose the right one again. As a consequence, the users got totally lost and irritated. Scrolling down was better understood when the test subjects could see some part of the actual content already on the first screen of the page. This means, that when the site structure requires so many links that they fill out one screen, the navigation should not be arranged with a navigation bar.

Giller et al. (2003) have stated in their study that on one page there should not be more links than what the user can with one glance see. We state, that it is not enough, that the user can see the links at one glance. The users should not only see the links, but also other contents of the page, if the page contains something else than the links.

When interpreting the results of our experiment one must remember that so far they are validated only in our test applications. They most likely apply to other applications, which have a similar structure and which are non-entertaining applications, as well. But when it comes to entertaining the users or the structure of the service is very much different, our results are not directly exploitable. When the browsers and devices develop further, our results may not count anymore.

In any case, we have proven the impact of the placement of the links on the usability of the applications. As far as we know, the subject was not studied before. Our results show that in the described circumstances the placing of the links must aim to clearness of the layout. In our experiment the links seemed to be easy to use, when they were placed one beneath another.

During the experiment we have confronted a lot of interesting subjects for further research. The impacts of the placing of the links on the screen have to be studied further. Our experiment has scratched the surface of the subject. We showed that when comparing two different placing of the links, one was better than the other. Certainly there is some way, how the links can be placed even more efficiently and pleasantly, than in our experiment.

It is also clear that there are applications, where the possibility to cross-navigate is essential. How can the cross-navigation be implemented so that the usability does not suffer, as it did in our experiment?

A very important research field at the moment are the features of the browsers. What would be the best way to illustrate to the user, how much of the contents s/he has already seen on the current page? At the moment many browsers do not offer scroll bars in their interfaces. How should the scroll bars be implemented to the mobile browsers? How much do they help the user, when it comes to realizing whether one should scroll down the page or not?

There are future research questions considering the devices, too. For example, the features of the scroll key should be developed further. How could the moving into four directions be made easier for the users?

The research considering mobile internet applications is interesting. We are convinced, that the future research will reveal how the mobile applications can be made even more usable. There are a lot of problems with their usability at the moment. Studying the navigation further is one step forward in this development.

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Taustatiedot

ATTACHMENT 1

Tiedot käsitellään luottamuksellisesti ja nimettöminä.

1 Perustiedot

1.1 Sukupuoli: ◻ Mies ◻ Nainen

1.2 Syntymävuosi: 19_____

1.3 Koulutus

◻ Peruskoulu, keskikoulu tai kansakoulu
◻ Keskiaste (ammattikoulu)
◻ Ylioppilas
◻ Alin korkea-aste (esim. merkonomi, sairaanhoitaja, teknikko)
◻ Alempi korkeakoulututkinto (esim. insinööri, kandidaatti)
◻ Ylempi korkeakoulututkinto (esim. maisteri, lääkäri)
◻ Tutkijakoulutus

1.4 Olen tällä hetkellä

◻ Palkkatyössä, tehtävä / ammatti: ___________________________________
◻ Yrittäjä
◻ Opiskelija
◻ Työtön
◻ Eläkeläinen

1.5 Ala:

◻ Maatalous, kala- ja riistatalous
◻ Metsätalous
◻ Kaivos- ja kaivannaistoiminta
◻ Teollisuus
◻ Energia- ja vesihuolto
◻ Rakentaminen
◻ Kauppa
◻ Majoitustoiminta
◻ Ravitsemustoiminta
◻ Kuljetus
◻ Tietoliikenneala
◻ Rahoitus- ja vakuutustoiminta
◻ Kiinteistö- ja vuokraustoiminta
◻ Tekninen palvelu ja palv. liike-eläm.
◻ Julkinen hallinto
◻ Maanpuolustus
◻ Suojeluala, poliisi, palolaitos
◻ Koulutusala
◻ Tutkimus
◻ Terveyspalvelut
◻ Sosiaalipalvelut
◻ Virkistys- ja kulttuuripalvelut
◻ Uskonnollinen toiminta
◻ Muut palvelut
◻ Siivous- ja pesulatoiminta
◻ Järjestötoiminta
◻ Muu, mikä ___________________________

2 Aiempi internetin ja matkapuhelinpalveluiden käyttökokemus

2.1 Olen käyttänyt matkapuhelinta

- ☐ en koskaan
- ☐ alle puoli vuotta
- ☐ 0,5 – 1 vuotta
- ☐ 2 – 4 vuotta
- ☐ yli 5 vuotta

2.2 Matkapuhelimeni on

- ☐ ensimmäinen matkapuhelimeni
- ☐ toinen matkapuhelimeni
- ☐ 3 – 6:s matkapuhelimeni
- ☐ yli kuudes matkapuhelimeni
- ☐ Minulla ei ole matkapuhelinta.

2.3 Tämänhetkisen matkapuhelimeni merkki ja malli:

____

2.4 Käytän matkapuhelintani

- ☐ satunnaisesti, ehkä kerran viikossa
- ☐ useita kertoja viikossa
- ☐ koko ajan

2.5 Käytän matkapuhelintani yleensä seuraaviin tehtäviin:

____

____

____

2.6 Käytän tekstiviestipalveluita tai niin kutsuttuja mobiileja internet-palveluita (esim. WAP tai www-selain) matkapuhelimellani

☐ En käytä tekstiviestipalveluita tai mobiileja internetpalveluita koskaan

- ☐ Käytän tekstiviestejä vain henkilökohtaiseen viestintään
- ☐ muutaman kerran vuodessa
- ☐ kerran kuukaudessa
- ☐ muutamia kertoja kuukaudessa
- ☐ viikoittain
- ☐ päivittäin

2.7 Yleisimmin käyttämäni tekstiviestipalvelut tai matkapuhelimella käytettävät internet-palvelut ovat:

____

____

____

2.8 Maksan puhelimen käyttömaksut itse

- ☐ Kyllä ☐ Ei

2.9 Olen käyttänyt internetiä

- ☐ En käytä internetiä lainkaan
- ☐ alle puoli vuotta
- ☐ 0,5 – 1 vuoden ajan
- ☐ 2 – 4 vuoden ajan
- ☐ yli 5 vuoden ajan

2.10a Käytän internet-pankkipalveluita

- ☐ Kyllä ☐ En käytä

2.10b Käytän Nordean internet-pankkipalveluita (Solo)

- ☐ Kyllä ☐ En käytä

2.11 Käytän matkapuhelimella pankkipalveluita

- ☐ Kyllä ☐ En käytä

3 Aiempi pankki- ja finanssialan tuntemus

3.1 Pankkien käyttämä terminologia on minulle tuttua

1	2	3	4	5	6	7
TÄYSIN ERI MIELTÄ						TÄYSIN SAMAA MIELTÄ

3.2 Olen mielestäni asiantuntija rahaan ja talouteen liittyvissä asioissa

1	2	3	4	5	6	7
TÄYSIN ERI MIELTÄ						TÄYSIN SAMAA MIELTÄ

3.3 Tunnen sijoittamiseen liittyviä asioita hyvin

1	2	3	4	5	6	7
TÄYSIN ERI MIELTÄ						TÄYSIN SAMAA MIELTÄ

3.4 Tunnen vakuutuksiin liittyviä asioita hyvin

1	2	3	4	5	6	7
TÄYSIN ERI MIELTÄ						TÄYSIN SAMAA MIELTÄ

3.5 Olen mielestäni keskimääräistä kiinnostuneempi talouteen liittyvistä asioista

1	2	3	4	5	6	7
TÄYSIN ERI MIELTÄ						TÄYSIN SAMAA MIELTÄ

3.6 Maksan laskuja ainakin kerran kuukaudessa

☐ Kyllä ☐ Ei

3.7 Minulla on useampi kuin yksi tili

☐ Kyllä ☐ Ei

3.8 Minulla on sijoituksia, esim. osakkeita, rahastoja tms.

☐ Kyllä ☐ Ei

3.9 Tunnen lainanhaku- ja hoitokäytännöt

☐ Kyllä ☐ Ei

3.10 Hoidan sijoituksiani säännöllisesti, esimerkiksi seuraan salkkuni kehitystä ja teen toimeksiantoja

☐ Kyllä ☐ Ei

3.11 Seuraan rahamarkkinoita, esimerkiksi korkotasojen vaihteluja, valuuttakursseja jne.

☐ Kyllä ☐ Ei

3.12 Koulutukseni pitää sisällään talouspainotteisia asioita

☐ Kyllä ☐ Ei

3.13 Tiedän minkälainen on eläkevakuutuksen verokohtelu

☐ Kyllä ☐ Ei

Kysely - Testisovellus A

ATTACHMENT 2

Tämän lomakkeen avulla voit antaa palautetta äsken käyttämästäsi pankkipalvelu-sovelluksesta. Vastauksiesi avulla saadaan tärkeää tietoa testisovelluksen hyvistä ja huonoista puolista.

Ota huomioon kaikki tehtävät, joita suoritit testisovelluksessa. Lue väitteet huolella ja ympyröi asteikolta se numero, joka kuvastaa parhaiten, oletko samaa vai eri mieltä väitteen kanssa vai et.

Toivomme sanallisia kommenttejasi kaikkiin kohtiin, joihin pystyt niitä antamaan!

Ympyröi mielipidettäsi vastaava vaihtoehto (vain yksi)

1) Olen yleisesti ottaen tyytyväinen siihen, kuinka helppoa palvelun käyttö oli.

1 2 3 4 5 6 7

TÄYSIN ERI MIELTÄ — TÄYSIN SAMAA MIELTÄ

Kommentit:____

2) Palvelun käytön oppi nopeasti.

1 2 3 4 5 6 7

TÄYSIN ERI MIELTÄ — TÄYSIN SAMAA MIELTÄ

Kommentit:____

3) Pystyin suorittamaan kaikki minulle annetut tehtävät.

1 2 3 4 5 6 7

TÄYSIN ERI MIELTÄ — TÄYSIN SAMAA MIELTÄ

Kommentit:____

4) Tehtyäni virheen minun oli helppo korjata se.

1	2	3	4	5	6	7
TÄYSIN ERI MIELTÄ						TÄYSIN SAMAA MIELTÄ

Kommentit:____

5) Testisovelluksessa en kohdannut tilanteita, joissa normaalitilanteessa olisin lopettanut sovelluksen käytön.

1	2	3	4	5	6	7
TÄYSIN ERI MIELTÄ						TÄYSIN SAMAA MIELTÄ

Kommentit:____

6) Linkit olivat sijoitettu näytölle hyvin.

1	2	3	4	5	6	7
TÄYSIN ERI MIELTÄ						TÄYSIN SAMAA MIELTÄ

Kommentit:____

7) Testissä minun oli helppo löytää tarvitsemani tieto tai palvelun oikea sivu.

1	2	3	4	5	6	7
TÄYSIN ERI MIELTÄ						TÄYSIN SAMAA MIELTÄ

Kommentit:____

8) Tiesin koko ajan sijaintini sovelluksessa.

1 2 3 4 5 6 7
TÄYSIN ERI MIELTÄ — TÄYSIN SAMAA MIELTÄ

Kommentit:____

9) Tiesin koko ajan, mistä pääsisin siirtymään seuraavalle haluamalleni sivulle.

1 2 3 4 5 6 7
TÄYSIN ERI MIELTÄ — TÄYSIN SAMAA MIELTÄ

Kommentit:____

10) Tiesin koko ajan, mihin kaikkialle voisin siirtyä.

1 2 3 4 5 6 7
TÄYSIN ERI MIELTÄ — TÄYSIN SAMAA MIELTÄ

Kommentit:____

11) Tiesin aina, mistä olin käyttämilleni sivuille tullut.

1 2 3 4 5 6 7
TÄYSIN ERI MIELTÄ — TÄYSIN SAMAA MIELTÄ

Kommentit:____

12) Sovelluksessa ei tarvinnut tehdä turhia klikkauksia

1	2	3	4	5	6	7
TÄYSIN ERI MIELTÄ						TÄYSIN SAMAA MIELTÄ

Kommentit:____

13) Linkkejä näkyi sopivasti kaikilla sivuilla.

1	2	3	4	5	6	7
TÄYSIN ERI MIELTÄ						TÄYSIN SAMAA MIELTÄ

Kommentit:____

14) Yleisesti ottaen olen tyytyväinen sovellukseen.

1	2	3	4	5	6	7
TÄYSIN ERI MIELTÄ						TÄYSIN SAMAA MIELTÄ

Kommentit:____

Testisovellusten vertailu

ATTACHMENT 3

Käytettyäsi molempia sovelluksia, voit antaa niistä vielä vertailevaa palautetta. Vastatessa on hyvä miettiä kaikkia testissä suorittamiasi tehtäviä.

---

1. Kumpaa testisovelluksista oli mielestäsi helpompi käyttää (katso kuva liitteenä)?
   - ☐ Sovelluksessa A
   - ☐ Sovelluksessa B
   - ☐ En osaa sanoa

Mistä ero johtui?

___
___
___

2. Kummassa sovelluksessa linkit oli sijoitettu näytölle paremmin?
   - ☐ Sovelluksessa A
   - ☐ Sovelluksessa B
   - ☐ En osaa sanoa

Mistä ero johtui?

___
___
___

3. Kummassa testisovelluksessa oli mielestäsi helpompi löytää oikea tieto/tarvitsemasi sivu?
   - ☐ Sovelluksessa A
   - ☐ Sovelluksessa B
   - ☐ En osaa sanoa

Miksi?

___
___
___

4. Kummassa sovelluksessa tiesit paremmin, mistä olit tullut käyttämällesi sivulle?
   - ☐ Sovelluksessa A
   - ☐ Sovelluksessa B
   - ☐ En osaa sanoa

Miksi?

___
___
___

5. Kummassa sovelluksessa tiesit paremmin, millä sivulla parhaillaan olit?

- ☐ Sovelluksessa A
- ☐ Sovelluksessa B
- ☐ En osaa sanoa

Miksi?

____
____
____

6. Kummassa sovelluksessa tiesit paremmin, mihin kaikkialle voisit siirtyä?

- ☐ Sovelluksessa A
- ☐ Sovelluksessa B
- ☐ En osaa sanoa

Miksi?

____
____
____

7. Kun ajattelet molempia testisovelluksia, mitkä ominaisuudet niissä olivat hyviä? Miksi?

____
____
____

8. Mistä ominaisuuksista pidit testisovelluksissa vähiten? Miksi?

____
____
____

9. Jos voisit vielä parantaa parempana pitämääsi sovellusta, mitä muutoksia siihen tekisit?

____
____
____

10. Käyttäisitkö testisovelluksia vastaavaa pankkisovellusta matkapuhelimellasi, jos sinulla olisi selaimella varustettu matkapuhelin?

- ☐ Kyllä
- ☐ En

Miksi et käyttäisi / Missä tilanteessa käyttäisit, kuinka usein ja mitä palveluita käyttäisit?

11. Paljonko olisit valmis maksamaan palvelun käytöstä?

12. Kuinka stressaavana koit testitilanteen asteikolla 1-7 (1=ei lainkaan stressaava, 7= hyvin stressaava)?

1 2 3 4 5 6 7

EI LAINKAAN STRESSAAVA

HYVIN STRESSAAVA

Mistä stressaavuus / ei-stressaavuus johtui?

Kiitos vastauksistasi!

ATTACHMENT 4

Tilanne.

On 19. tammikuuta 2004. Olet juuri myynyt vantaalaiselle opiskelijalle vanhan kannettavan tietokoneesi. Veit koneen opiskelijan asunnolle, ja kävitte opiskelijan kanssa automaatilla, missä hän siirsi tilillesi 500 euroa korvaukseksi koneestasi.

Olet nyt matkalla kotiin, ja haluat saman tien tarkistaa, tuliko maksu varmasti tilillesi.

Samalla muistat, että olet unohtanut maksaa ystävällesi Kaisa Koskelle 15 euroa, jonka olet velkaa yhteisestä lounaastanne. Päätät maksaa heti velkasi takaisin.

Tehtävä.

Tarkista, onko tilillesi **102135-73422** tullut +500,00 euron suuruinen siirto.

Tehtävä.

Etsi palvelusta kohta, jossa voit maksaa maksun.

Tehtävä.

Maksa maksu seuraavilla tiedoilla:

Saajan tilinumero: 102135-123123 Saajan nimi: Kaisa Koski Viesti: Lounas Maksaja (automaattisesti Testi Henkilö) Tililtä: 104535-12356 Summa: 15 euroa Maksupäivä: 190104 Vahvistustunnus: 1234

Tehtävä.

Palaa takaisin etusivulle.

Tehtävä.

Katso, lähtikö tililtäsi **104535-12356** juuri tekemäsi maksu Kaisalle.

Suullisesti annettu tehtävä.

Etsi palvelusta päivän pörssikurssit.