Högskolan i Halmstad
Sektionen för Informationsvetenskap, Data- och Elektroteknik

To make a mole hill out of a mountain

challenges in designing a recognizable GUI for an e-newspaper service on small screen devices

Högskolan i Halmstad
Sektionen för Informationsvetenskap, Data- och Elektroteknik

To make a mole hill out of a mountain

challenges in designing a recognizable GUI for an e-newspaper service on small screen devices

Author:
Giel de Steur

Date:
20th May 2006

Supervisor:
Carina Ihlström

Abstract

The purpose of this study was to: obtain and review guidelines for designing on a small screen from several theoretic sources and to purpose own guidelines for this context. There was chosen for the development of 3 different prototypes meant for the use on 3 different mobile devices. Those mobile devices had a different screen size and were: an e-reader, PDA and mobile phone. The prototypes provided the user with a future e-newspaper service (a TV schedule).

First design principles for good usability on small screens were abstracted from literature. With this knowledge the three prototypes were developed. The development started with writing down the functional and user requirements for the prototypes. After that the developing process had two stages. The first stage was a low-fidelity prototype, this were sketches of the graphical user interface that was commented by users. The second stage was a high-fidelity prototype, this stage consisted of three fully functional prototypes. The three different prototypes were used in a user evaluation. After the evaluation interviews with the users took place to obtain additional information.

In this research the main question was: *"What are the challenges for designing the (graphical) user interface, as a part of an e-newspaper service which is aimed at use on multiple devices with heterogeneous screen sizes, to be recognized as the same service?"*.

The results from this research are three challenges in designing the (graphical) user interface for devices with small screens. These challenges are: how to make the user recognize the service in the software (recognition of service), how to develop one service on multiple devices (use on multiple devices) and how to develop software that it is useful and pleasant to use (usable software). In total fifteen guidelines derived from theory were found, this research shows that thirteen of them are applicable when designing for small screens. Three of those thirteen are reformulated in this study to make them fit better in the context. Next to this, seven additional guidelines were proposed in this study. Examples of the purposed guidelines are: reconstruct the layout from the non-digital service in the interface as much as possible, explore the targeted user group, built further on their mental model and pay attention to possible disabilities of the group, implement extra's that give users a good reason to use the service and make it easy for the user to select the sought information.

Table of contents

1. Introduction

In this chapter the problem from this research project will be introduced. This chapter gives the user additional information about the subject of this research. First the background of the problem will spoken of (§1.1), in this paragraph the context of this research will be shaped and the research question will be given. The purpose of study is the subject of §1.2, there in will be explained why this research is done and what the targets are. The last paragraph of this chapter is §1.3, there the borders of this research will be set.

1.1 Problem background

Fifty years ago most people never left their hometown. Today, all airline companies routinely accommodate even the youngest children. Our western society has become more and more mobile. Three important factors play a role in this change: modern companies become increasingly cooperative so once dislocated workers will meet each other now, manufacturing work is being more and more replaced by service work that takes place where the customer is, and the development of the mobile phone (Kristoffersen and Ljungberg, 2000).

We can be anywhere on the world and still communicate with everybody else and have access to information regardless of where we are (Kristoffersen and Ljunberg, 2000). Weinberger (2000) describes this as information at any time, any place, and in any form. Technological developments make us more mobile. Kleinrock (1995) stated that people thought of computers as associated with their desktop. Though nowadays many people use IT (also) while they are "on the move" (Kleinrock, 1995; Kristoffersen & Ljunberg, 2000). They switch between different settings, for example people use a desktop at the office or at home, a laptop while traveling by train and a mobile phone or PDA when walking on the street. There is a variety of mobile devices that serves our needs for information at any time, any place and in any form. These devices are among others PDA's, mobile phones and even wearable computers.

These mobile devices are becoming to be dominant players in information and communication application in the near future. The mobile devices know however more restrictions (if compared with stationary computers) because of their limited screen size, smaller storage capabilities, slower processors, etc.

Given this trend, the focus within mobile computing and interface design will be on how to design the Graphical User Interface (GUI) in such a way that services can migrate between the devices, i.e. from a stationary device at the office or home to the PDA or mobile phone while on the move. With this migration it is of important that the user recognize the service as one and the same on both devices. This research aims at the design and usability problems that are inherent to developing (web) applications for small screen devices. The following research question is formulated for this research:

"What are the challenges for designing the (graphical) user interface, as a part of an e-newspaper service which is aimed at use on multiple devices with heterogeneous screen sizes, to be recognized as the same service?".

This research is done in the context of the project Designing Ubiquitous Media Services through Action Research from the Media-IT research group, which is part of Högskolan i Halmstad. The project aims at finding solutions for multi-channel publishing of mobile services in a newspaper context.

1.2 Purpose of study

The purpose of this study is to:

- Investigate what a good way is to design a (graphical) user interface for mobile devices with a smaller screen.
- Obtain guidelines for designing on a small screen from several theoretic sources. With this knowledge a theoretical framework of design guidelines can be conducted.
- Develop three different prototypes for all different screen sizes, named under §1.4.

- Evaluate the prototypes made. Users will give their opinion about the program, about the usability, about the efficiency, effectiveness and about the recognition (does the service look alike).
- Purpose own guidelines for this context. The already obtained guidelines will be reviewed and new guidelines derived from the user test will be added.

1.3 Demarcation

The research will only be done on three dissimilar screen sizes within this research those are: an e-reader (8 inch), Personal Digital Assistant (2.5 inch) and Global System for Mobile Communications (1.8 inch). Furthermore there will be only a prototype made, not a complete program. This is because the purpose of the prototype is just to check the guidelines derived from the theoretical material. Also this project is aimed at one service from an e-newspaper. The service will be studied separately, so not in combination with the rest of the e-newspaper.

2. Technical Backgrounds

In this chapter different technical backgrounds about techniques will be presented. For this project the technical backgrounds are important. In the rest of the text there will be many references to the techniques presented in this chapter. This chapter start with the e-paper technique (§2.1). A view on the Personal Digital Assistant (PDA) will follow (§2.2) and this chapter will be ended with the explanation of Global System for Mobile Communication (GSM) in paragraph 2.3.

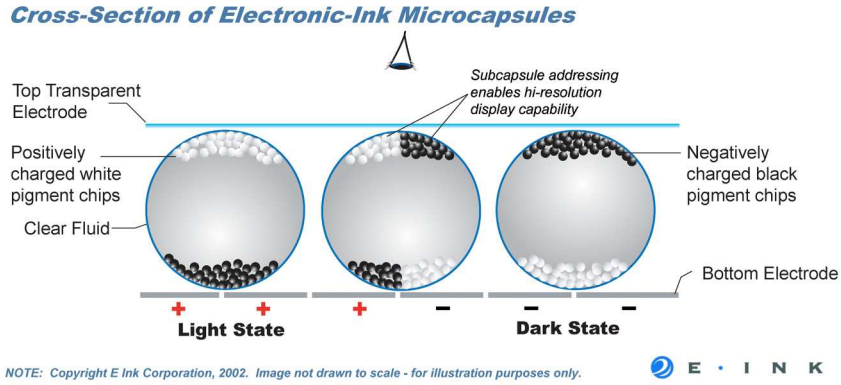
2.1 E-paper

Electronic paper (e-paper) is an umbrella term for a multitude of different technologies that can be used to produce screens. On this moment two technologies for e-paper are on the market, these are electrophoreses and dipolar rotation. A third technique is upcoming and is called electrowetting (Ihlström *et al.* 2005).

One commercial product that uses the electrophoreses technique is E Ink, from E ink corporation, USA. E Ink Corporation holds the patent to e-ink and license the production of e-ink to about 16 companies. Among those companies is Royal Philips Electronics (the Netherlands).

With e-ink there are millions of microcapsules, as small as the diameter of a human hair. These microcapsules are charged with a positive or a negative charge. If positive charged they color white, if negative they color black. When a negative electric field is applied, the white particles move to the top of the microcapsule where they become visible. This makes the surface appear white at that spot. At the same time, an opposite electric field pulls the black particles to the bottom of the microcapsules where they are hidden. This process is made visible in figure 1:

Figure 1: E-ink technology
Source: E-ink 2006



E-ink can be applied on different materials such as plastic, glass and paper. Since the technology is not limited to one particular carrier. Some other advantages of E-ink technology are that it is less power consuming because power is only needed when the microcapsules have to view another color (differently charged) and that the human eye can not perceive any flicker on the display because of the fast updating frequency.

E-paper technology is developing fast. More and more companies invest in "plastic electronics" and come up with new prototypes or launch their products on the consumer market.

Sony was the first company that launched an e-paper product on the (Japanese) market, the Sony LIBRIé. In spring 2006 they will launch a new product, on the U.S. market (Sony, 2006). The Sony Reader, as the device is called, is able to perform approximately 7500 page turns per battery change. It has a 6 inch-screen and weigh 250 grams. There is 64 MB space (about 80 eBooks) and the device has slots for removable media such as Memory Stikcs ®. The Sony Reader is not only applicable for eBooks but it allows the user to open more file types, such as PDF files, which can be read or MP3 music to listen to.

On the 13 of July 2005 Fujitsu announced "World's First Film Substrate-based Bendable Color Electronic Paper" (Fujitsu, 2005). The e-paper Fujitsu developed features vivid color images that are unaffected even when the display is bend. Further on it has an image memory function that enables continuous display of the same image without the need for electricity. It uses about one-hundredth to one-thousand the energy of conventional displays, while being far lighter and thinner, as slim as 0.8 mm. Fujitsu thinks this product will be on the market between April 2006 and March 2007.

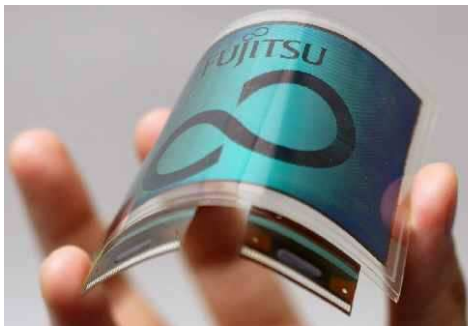


Figure 2: Bendable color display
Source: Fujitsu, 2006

iRex Technology BV is a spin-off from Royal Philips Electronics. In April 2006 they will make their e-reader device called the "iLiad" available on the Dutch market (iRex, 2006). The iLiad has an 8.1 inch screen and supports 16 levels of gray. It weighs 390 grams and has a memory of approximately 224MB internal FLASH memory for storing content (sufficient for 1 month of newspapers, 30 books and many other documents). The user can interact with the device using the stylus, a sort of pen. This device has, upon other ways the possibilities to connect via Wi-Fi (802.11g).

Another company that has developed an e-paper is Plastic Logic. Investors are e.g. Siemens, Dow venture capital, BASF venture capital and Intel capital. The technology that Plastic Logic developed allows printing electronics on thin flexible plastic. The process used by Plastic Logic is scalable for a large area, high volume and aimed at low cost. Their device is 10 inch (approximately A5) diagonal with 100ppi resolution and 4 levels of grey scale. (Plastic Logic, 2006). They further state that they work on a prototype which is 14 inch diagonal and 150ppi.

Figure 3: Rollable display
Source: Polymer Vision

As a division of Royal Philips Electronics in the Netherlands Polymer Vision has yet another dimension of e-paper devices. They developed a rollable display which they call "READIUS" (Polymer Vision, 2006). Currently the rollable display (see Figure 3) has a bending radius of 0.75 cm and a display of 4.8 inch with 240x 320 pixels. Polymer Vision sees a market in companies using the technique but it can also be used for entertainment or navigation (GPS).

There are some other devices on the market that can do basically the same as the devices described above. For example the Hanlin e-BOOK from Tianjin Jinke Electronics Co., LTD is a Chinese product but aims also at the western market (Tianjin Jinke, 2006). The Hanlin e-BOOK has almost the same specification than the Sony Reader. Hewlett Packard (HP) is working on a color e-reader that should be light, thin and flexible. The HP device should display e-books, magazines, etc. HP aims at as low production costs as possible.

Not only in the paper domain there are developments. Siemens has unveiled a paper-thin color TV screen. Siemens new color display screen can be printed on paper or cardboard directly. This makes it possible for mass-production in books, magazines, etc. Another application of e-paper technology is in watches and clocks. Both Citizen and Seiko have launched just that. E-paper is thin, light weight, fully flexible and consumes less power. This makes it suitable for many applications, even beyond the ones named in this paragraph.

2.2 Personal Digital Assistant

A Personal Digital Assistant (PDA) is a small mobile handheld device. It is often referred to as "handheld". Many people also refer to it as the name of the device like "IPAQ" (from Compaq/Hewlett Packard) or "Palm" (from 3com's Palm devices, like the Palm T|X Handheld). The PDA is a small device which you can use in the hand. It is used for business and personal purposes, often to make small notes, keep up an address book or an agenda. Generally one

can say that the PDA is computing, it stores information and it has retrieval capabilities. Many applications have already been written for PDA's but this number is still growing. More and more PDA's are combined with communication techniques such as telephone, paging systems and wireless network (Williams, 2004).

Most of the PDA's get user input via the screen, on which also handwriting can be received. The handwriting and other navigation are done with the "stylus", a sort of pen. This means that the users interact with this device not via a normal keyboard and mouse (however a small keyboard that you can attach to the PDA is sometimes an option). This is a remarkable difference that distinguishes the PDA from the desktop computer. So is of course the screen size. As said before the PDA is made to fit in the hand. Kamba (1996) expects that several things (like screen resolution) on the PDA will change, but states that the display size is unlikely to change very much in the future.

A PDA is like a desktop computer used via an operating system. This operating system is the core for the user to interact with the system. The operating system initiates the applications (like a notepad, the agenda, etc.) on the user's request. For the PDA there are six different operations systems on the market. This are:

- Symbian
  On this moment Symbian has the biggest marketshare. This operating system is developed by Ericsson, Nokia, Samsung and Panasonic. The core of this operating system is based on the EPOC platform from Psion. Symbian don't have high hardware demands. It can run on many systems and next to that it is highly compatible with other PDA operating systems.
- Microsoft Windows CE
  This operating system is Microsoft's response to the PDA market. The program was announced in autumn 1996, so almost 10 years ago. Microsoft wanted to develop an own operating system that was suitable for mobile devices. Windows CE has the same "look and feel" as the other windows operating systems.
- EPOC OS
  This system is old and not used very much anymore. From the start EPOC OS was owned by Psion. However there was not much interest in this product from the market. In 1998 this operating system is part of the joint venture that exploits Symbian.
- ECOS /M3
  This is an operating system which is based on Linux. Linux Red Hat more precisely. It is developed by Red Hat & 3G Lab Ltd and it is aiming on wireless PDA's and the next generation mobile phones.
- Palm OS
  An operating system that is developed by Palm and that is focused on the palm handheld devices. Palm OS is well known (mostly because of the Pilot in the 1990's). Since spring 2000 Palm OS supported color screens, that was rather late but palm didn't want to lose their name on being the most battery saving operating system. Palm OS standard have some functions like: agenda, to-do-list, address book, notepad, calculator and small games.
- Newton Intelligence
  This is the operating system of the Newton Message pads. Their initial release on the market (version 1.0) was a failure. After that there were some more releases. After the media had written about version 1.0 many people chose for Palm OS.

Figure 4: How does a PDA looks?
Source: Palm

The PDA looks like the one shown in figure 4. The different parts of this Palm T|X Handheld PDA are shown in this figure. As you can see the user can interact with the PDA via the stylus or the buttons. Communication from the PDA with other PDA devices or with the internet can take place via Bluetooth, infrared or wireless network (ISO 802.11b).

2.3 Mobile phone

A mobile phone is an electronic telecommunications device. The device is also called "cell phone". It is an entirely portable device which is not required to be connected with a wire to the telephone network. A decade ago the purpose of the device was straightforward. It was a device that allowed one to make and receive calls from wherever the person was. Nowadays that point of view has changed. Mobile phones are now far more. They are text-messaging systems, organizers, cameras and information providers, according to Bristow (2006).

All mobile phones (except satellite phones) connect to the network using wireless radio wave transmission technology. This technology is continually improved in the last years and has still not come to an end. In this paragraph I will give a short explanation of the different standards (1G to 4G).

The first generation of mobile cellular telecommunications systems (1G) appeared in the 1980s. Analog transmission techniques for traffic were used by this first generation and it was almost entirely voice. There were several competing standards. The most successful were: Nordic Mobile Telephone (NMT) used in Scandinavia and Eastern Europe, Total Access Communications System (TACS) a UK standard for the Middle East and south Europe and Advanced Mobile Phone Service (AMPS) for the USA. The world is focusing on 3G and even beyond 3G, but the 1G networks are still used and expanded in some countries. Countries with a more advanced

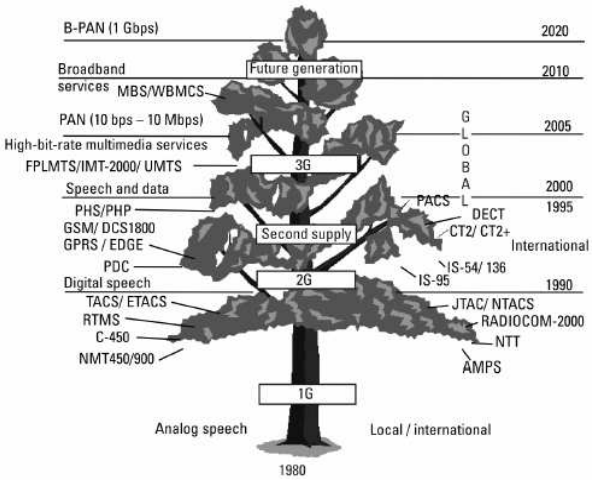


Figure 5: Family tree of mobile generations
Source: Prasad, 2003

telecommunications infrastructure however will close or have already closed the 1G networks, to make place for more effective digital networks (Korhonen, 2003).

Digital radio transmission for traffic is used by the second generation (2G) mobile cellular systems. This makes the difference between the first and the second generation clear; it is a digital/analog split. There are four main standards in the second generation: Global System for Mobile Communications (GSM), digital AMPS (D-AMPS), Code Division Multiple Access (CDMA) and Personal Digital Cellular (PDC). GSM is by far the most successful and widely used 2G system, the first network was opened in 1991 in Finland. The 2G networks still operate all over the world and are used for most of the mobile communications today.

The third generation mobile telephone technology (3G) is an improvement on 2G. The services associated with 3G provide the ability to transfer both voice data (a telephone call) and non-voice data (such as downloading information, exchanging email, and instant messaging. Already in 1991 the standardization of 3G was in progress. The ETSI (European Telecommunications Standards Institute) was working on a new system called UMTS (Universal Mobile Telecommunications System). The first country that deployed a commercial 3G network was Japan in 2001 (by NTT DoCoMo).

The newest generation is the fourth generation (4G). 4G is a wireless telecommunication technology. The IEEE (Institute of Electrical and Electronics Engineers) official name for 4G is "3G and beyond". As access technology increases, voice, video, multimedia, and broadband data services are becoming integrated into the same network. This network can be 4G. Shanti (2003) states that 4G is intended to provide high speed, high capacity, low cost per bit, IP based services. The fourth generation is expected to be commercially deployed between 2010 and 2015 (see also figure 5).

Each mobile phone, as being the device to use the services mentioned above is different. Today's mobile phone is small and fits into the pocket. Mobile phones often have features beyond sending text messages and make voice calls. Those features include Internet browsing, music (MP3) playback, personal organizers, e-mail, built-in cameras and camcorders, ringtones, games, radio, infrared and bluetooth connectivity, call registers, and ability to watch streaming video or download video for later viewing. The user interact with the mobile phone via the numerous keyboard and some additional buttons for navigation (some types have a built in QWERTY keyboard or it can be attached) and a small screen. The screen size is different for each phone, but about 1.8 inch diameter is a common. The newer mobile phones have a full color screen with over 64.000 different colors. Future prospects for the mobile phone include e-reading, translation, speech recognition, GPS positioning and image scanning (according to Wikipedia, 2006).

Figure 6: Some mobile phone models
Source: www.delda.com/ auctions/all.jpg

3. Theoretical frame

In the following chapter a theoretical frame will be provided. The current study has many links to studies already carried out earlier in this field. To indicate what the "field" exactly is, this chapter is written. This chapter start with a view on our changing society, in which people get more and more mobile (§3.1), it continues with a view on the ongoing changes in the media branch (§3.2). After that the chapter will be narrowed to the devices which are important in this research, the small screen devices and especially the design issues that are a factor when developing a new product for those devices (§3.3). A theoretical summary will close the chapter (§3.4).

3.1 Our "mobile" society

"*Mobility is part and parcel of future organizations…*", write Kristoffersen and Ljungberg (2000, p. 137). They state that we become more and more mobile, that we can be anywhere on the world and still communicate with everybody else and have access to information regardless of where we are. Some statistics in their work confirms this: 25% of the computer systems sold are for mobile use; 300.000 people are, at any time, airborne above the USA and 300.000 people travel by car and train into London every morning.

Mobility can be three things according to Kristoffersen and Ljunberg (2000), it can be wandering (for example walking to a colleague in the same building), it can be traveling (going from one place to another in a vehicle) or it can be visiting (spending time for a prolonged period before moving to another place). In all this mobility we use different devices. For visiting we can use all kind of IT devices like desktop computers, portables and mobile devices. For traveling it is not possible to use the desktop computer but still we can use a portable computer like a laptop. When it comes to wandering it is only possible to use mobile devices such as a mobile phone or a PDA. According to Kleinrock in 1995 people thought of computers as associated with their desktop, but he foresees that many of them will be what he calls "nomads"; people on the move using IT (Kleinrock, 1995).

There are three main reasons for the change in mobility according to Kristoffersen and Ljungberg (2000). The first reason lies in the context of organizations. Companies nowadays are becoming increasingly cooperative, they work project and team-based. This cooperation leads to increased used of IT, which bridge the distance. It also leads to mobility, workers get to know each other and they often try to meet physically. The second reason is that the western society has changed from manufacturing to service work. In the 1960s manufacturing work has been in decline and service work increased. Manufacturing takes place where the equipment is located; service however takes place where the customer is. The third and last reason can be found in the adoption of the mobile phone.

Today more then 91 per cent of the population in Sweden between the ages of 16 and 75 have a mobile telephone subscription (Williamson and Öst, 2005). In addition to this Ling writes that younger and younger teenagers adopt the mobile phone every day (Ling, 2000). The use of mobile telephones has grown enormously during the last decade, in for example Sweden the use has raised 5 times. The mobile phone out numbers the land-line telephones in many countries.

The mobile phone has changed from being a rare and expensive piece of equipment mostly used in business to a low-cost personal item. This conclusion is shared by Berg *et al.* (2005), who write that Mobile telephones have become individualized and that its use has been highly privatized.

With high levels of mobile telephone penetration such as indicated before, a mobile culture has evolved (Wikipedia, 2006). The mobile phone has had an impact on the way people speak to and relate to one another. People have highly become dependent on the technology for their social life. The mobile phone acts as a key social tool here. The mobile phone is seen as a part of every day life, the device and its services are integrated in our society. It is no

longer a device to only communicate with but also a device for work, it is something to explore and something to play with.

Especially younger people are at ease with the high tech technologies. Sometimes they use their mobile phone, even when there is a land-line available. This is simple because all the information is stored in the mobile phone; telephone numbers, messages, names, pictures and all other kinds of information (Berg *et al.* 2005). Older people are often helped by younger people. The older people are depending on the younger generations to understand and use the newest technologies.

The vision of future telecommunications is "information at any time, any place, and in any form" according to Weinberger (2000). According to him PCs and PDA's will soon become the gateway for high-speed access. Those devices will provide a control of the "intelligent" home environment. In this one can conclude that for the future mobile devices become more and more important in our society, and that the internet plays a very important role in this ongoing development.

3.2 Mediamorphosis

Everything around us changes, and so is the media. Already before Christ mankind was communicating. Communication and information carriers changed over the ages. First people communicated via signs, symbols, etc. After that people begin to develop spoken language and begin to draw images (e.g. cave paintings). Still before Christ people were also able to express written language on clay tables, on bones then on bamboo and later on parchment and vellum (Fang, 1995). Around the year 250 A.D. paper spreads to central Asia, not more then 200 years later ink is found and true printing can start. In 600 A.D. the first books are being printed in China. In 1309 paper is used in England and the Chinese technique reaches the rest of Europe. Newspaper rise all over the world and printing is enhanced.

Then electricity creates a wired world. In the 1840's words were transformed into electrical impulses (Crowley & Heyer, 1995) with the coming of the telegraph. The spoken word was delivered to the receiver by a wire. After the telegraph the telephone was developed. The development of media and communication continues with image technologies. The photographic slide appears in 1849. While photos and cameras become more enhanced another important technology begins to spread; the radio. With the radio the world is becoming wireless. Where the written word was already broadcasted via the newspapers the radio made it possible to broadcast the spoken word directly into many households. The missing part, moving images broadcasted towards many, is becoming reality in the late 1920's when the TV is being introduced. The development after that is the computer (and later on the internet) which introduce a period of digitalization and fast access to information everywhere on the world.

This short review of history points out that our ways of communication change. The audience that is reached has become bigger and more divergent. Every medium has it own ways of delivering the message to the receiver, new ways are being founded and old ways change because of technological progress. Fidler (1997) calls this change of media "mediamorphosis". In his book Fidler (1997, p. 22-23) defines mediamorphosis as: "*The transformation of communication media, usually brought about by the complex interplay of perceived needs, competitive and political pressures, and social and technological innovations*". With this definition Fidler not only state that the media are changing but also what variables play a role in this change. Persistently is spoken about *change* of media. If one takes in account the timeline from Fang (1995) we can see that older forms of media usually do not die, they continue to evolve and adapt. Fidler (1997) agrees and also adds that new media do not arise spontaneously and independently, they emerge gradually from the metamorphosis of old media.

When we take a look on the history of the newspaper we can see that it starts with the invention of writing, paper and ink. It develops itself by technological inventions such as the hydraulic and steam rotary press. It can then be delivered to many and production goes faster and faster. With the introduction of the computer the newspaper also start to use the

internet as broadcast media. On 19 January 1994 the first newspaper to regularly publish on the Web, the Palo Alto Weekly in California, begins twice-weekly postings of its full content (Carlson, 2003). The future of the newspaper is likely to be found in digital technologies. Negroponte (1995, p. 152) already envisioned such a newspaper: *"Imagine an electronic newspaper delivered to your home as bits. Assume it is sent to a magical, paper-thin, flexible, waterproof, wireless, lightweight, bright display. The interface solution is likely to call upon mankind's years of experience with headlining and layout, typographic landmarks, images and a host of techniques to assist browsing"*.

Where the future will go exactly is impossible for anyone to predict exactly and with certainty. It is despite that fact possible to say that the media will continue to change, depending on the variables given by Fidlers definition. And in the coming decade the media will be more and more digitally oriented.

3.3 Design for small screens

As already stated in paragraph 3.1 our society gets more and mobile and the use of mobile devices grows. The mobile devices use a small screen for user interaction. Those small screens are up to 12 times smaller then a computer screen. A normal screen measures between 13 and 23 inches diagonal, where a PDA screen is only 2.5 inch diagonal. On mobile phones this is even 1.8 inch. Also the screen resolution is different. That on a computer screen is about 1600 x 1200 pixels and on a PDA this is 240 x 320 pixels. This makes it harder to present the same amount and the same quality of data for the smaller devices.

Not only is the screen different, the use of the mobile devices differs from the regular desktop computer. Murugesan and Venkatakrishnan (2005) write that users of mobile devices want brief, important, timely information. The user of a mobile device pay for the information they receive (either for the amount of data received or for the time spend online), therefore they want information that fits their needs and that is important and short. The longer they have to search or the more they have to read the more expensive it gets. As Condos *et al.* (2002) notices in some cases reading one article on a poor designed WAP page is more expensive then buying a whole newspaper.
Users of mobile devices also want to perform tasks quickly and with less effort then on a desktop computer. The mobile phone is used in many different scenarios during our day. It is impossible to describe al those scenarios. On the average the user has less time to complete a task then on a desktop computer because he or her is moving. To illustrate that mobile users want to perform tasks quickly and with less effort Lindroth *et al.* (2001, p. 649) writes *"…when you are writing down a person's address in the Palm while he stands in front of you, seconds feels like minutes"*. This situation is possible. Mobile really means mobile, it means anywhere; in the supermarket, on a business meeting, in the train, on the beach, etc.

This also shows that it is much harder to design for those small screens. Lindroth *et al.* (2001, p. 642) says the following about designing for small screens: *"If designing for the web is hard with different browsers, screen sizes etc, try designing an interface on a screen with the size of half your credit card that might be used on the run in a dark alley with the rain pouring down".* As stated before, the situations where the application will be used are unpredictable. It is impossible to think of all possible scenarios while designing this application. There are factors that make the situation even more complicated. The developer of an application or a website that is supposed to be shown on a mobile device has to deal with diversity of devices. Murugesan and Venkatakrishnan (2005) name, to exemplify this, the differences between the devices self (for example a PDA or a mobile phone). Those devices have a different screen size, a different handset, a different keyboard layout, different features, different input capabilities, etc. There are many different producers who make mobile devices and even more different models.

When digitalizing an existing service or an existing document it is of the utmost importance that the users recognize the service or the document. Albers and Kim (2000) state that if a user builds up a wrong mental model it causes incorrect interpretations. Once the mental model is activated the new information will be interpreted with respect to the activated schema. This means that if a user does not or incorrectly recognize the digital service or the

digital document, the digital service or document missed its goal and it takes much more time and effort to use. Time and effort should be minimized when using a mobile device which points out the importance of making the document or service recognizable. Toms and Campbell (1999) agree in the importance of recognition and prove that a digital document has three layers. First the interface layer, this is the layer where the user get access to and use the document. The second layer is the format; this is the lay-out of the document. A user can recognize a specific document by seeing only the lay-out. A newspaper for example is build up by columns and headlines. The third layer is the function layer. In this third layer the semantic content is saved. When designing a service the developer can use visible cues from these layers to perform a better recognition.

In the field of interface design rules for designing have been formulated. Some are applicable for use when designing for small screen devices. The five usability attributes from Nielsen (1995) are useful. He states that an interface should be easy to learn (learnability), efficient to use when learned (efficiency), it should be easy to remember (memorability), it should have a low error rate (errors) and it should be pleasant to use (satisfaction). Condos *et al.* (2002) formulated 10 rules for WAP services. They state that a developer should make careful use of graphics (1), avoid long lists and indicate the length of the list (2). Important options should be visible to the user (3) and the program should provide clear, helpful and meaningful error messages (4). Dead ends should be avoided (5), content should be presented appropriately and well formatted (6). Navigation and names of menus should be done consistently (7). Provide the user with sufficient prompting (8) and minimize user input (9), tasks should be structured (10) to aid the user's interaction with the system. The eight golden rules of interface design from Shneiderman (1998) are considered, but are in my opinion not applicable for designing for small screens or they are already covered by and integrated in the rules given above by other authors.

3.4 Theoretical summary

Summarizing the theoretical framework I conclude that our society is changing. It is becoming more and more mobile. Mobility and mobile devices are intertwined with our lives and are a part of every day life. This trend will not decrease but will increase more. With the techniques that will be developed in the (close) future it will be possible to be even more mobile and to use information at any time, any place, and in any form.

The media will change in the same direction. With people becoming more and more mobile the media can not stay behind. The media has evolved and changed from the beginning of mankind and a new generation, the "digital" one have already began. The media will aim at digital forms of bringing the news and other information to their customers. One of the possibilities in that is the development of an electronic newspaper. A newspaper that use the best from the printed newspaper, such as the mobility, the ability to read in sunlight, the flexibility and the best from the web such as the mobility and the possibility to come with updates.

Mobile devices are made to fit in the pocket, they should be small, easy to carry and easy to operate. This demands shaped limits to the screen size of those devices. With a new, much smaller screen size emerging another approach to design is needed. Mobility means anywhere in any possible scenario, at any time. Users want the information to be brief, important and fast. The users want to perform their tasks in a faster way with less effort then a regular desktop computer. To obey to that new approach to design some scientist presented guidelines. The design rules adapted from Nielsen (1995) and Condos *et al.* (2002) are given on the next page. To make it possible to analyze them better the 15 guidelines were grouped in three themes, to know: learn & remember, user emotions and efficiency.

Theme	*Guidelines*
Learn & remember	• An interface should be easy to learn (learnability); • it should be easy to remember (memorability); • navigation and names of menus should be done consistently; • structure tasks to aid the user's interaction with the system.
User emotions	• it should have a low error rate (errors) ; • it should be pleasant to use (satisfaction); • avoid long lists and indicate the length of the list; • important options should be visible to the user; • the program should provide clear, helpful and meaningful error messages; • dead ends should be avoided;
Efficiency	• efficient to use when learned (efficiency); • make careful use of graphics; • content should be presented appropriately and well formatted; • provide the user with sufficient prompting; • minimize user input;

4. Method

In this chapter the method used to perform this research is being explained. In the first paragraph the chosen method is stated (§4.1). The way literature is founded will be the topic of §4.2. This is continued by the way the user test are conducted, how the prototype is designed and build (§4.3) and how it is tested on users (§4.4). The method of data analysis will be the subject of §4.5. In the two last paragraphs on this chapter I will present some critics on the method (§4.6) and possible alternatives that could have been used (§4.7).

4.1 Chosen method

The study of human computer interaction for mobile devices is a relatively young research field. Carrying out a research in this field is something quite different from a research on (applications for) desktop computers. The problem with mobile devices is that they are used in an endless number of situations, for which it is impossible to define all scenarios (Lindroth *et al.* 2001). Lindroth *et al.* (2001) further state that new methods should be explored to conduct research in the field of mobile devices.

With that in mind I tried to answer my research question: *"What are the challenges for designing the (graphical) user interface, as a part of an e-newspaper service which is aimed at use on multiple devices with heterogeneous screen sizes, to be recognized as the same service?"*. In order to do this I have chosen for qualitative methods for this research. Those methods are designed to help researchers understand people and the social and cultural contexts within which they live. Auerbach (2003, p.3) gives the following definition: "*Qualitative research is research that involves analyzing and interpreting texts and interviews in order to discover meaningful patterns descriptive of a particular phenomenon*". Qualitative methods give a deeper understanding then purely quantitative data, states Silverman (1999). He continues by saying that words and images are ought to be more valuable then numbers in those methods.

The main reason for choosing qualitative methods was that the point of view of the participants and its particular social context were an important foundation for this research and these had to be investigated. If using the opposite of qualitative research, quantitative research, both these points were largely lost (Kaplan and Maxwell, 1994).

To gather data I used different techniques. First of all the already existing and described design guidelines were found by conducting literature studies. With these principles three design prototypes were designed and build and finally tested by using usability testing.

4.2 Literature studies

The literature studies were initiated with the purpose to find a set of design guidelines to develop a good prototype that could be used in the usability test. Those guidelines were also about to be reviewed and completed by the outcome of the usability test. I began to search via libraries and databases on internet. The terms I used were "design" and "usability" in combination with mobile devices. This was done to find articles and books of which the accuracy can hardly be questioned. I attached much value to a stable and correct base in the beginning of my research. I also used references made by documents that I already found. Then I expanded my search by using two favorite search machines on the internet; Google and AltaVista. I did this to get a view of the research project in relation to other projects and other research done in the field of interface design and/or mobile devices. For this search I used the same terms as before.

I started the search for relevant literature in the end of January 2006 and it continued to the end of February 2006. In the same period I also searched for literature concerning research methods, prototyping and usability testing.

4.3 Design and build of the prototypes

In order to answer the research question properly it was necessary to design and build prototypes, to conduct the usability tests on. For this research three different prototypes were designed, one for each device. For this research these devices were respectively e-reader (8 inch), PDA (2.5 inch) and mobile phone (1.8 inch). In this paragraph the design and building phase which took place as part of this research is clarified. First the choice of the actual service from the e-newspaper will be given (§4.3.1), after that the procedure followed when actual designing and building the prototypes is given (§4.3.2).

4.3.1 Choice of e-newspaper service

The e-newspaper holds the potential of combining the advantages of the online newspaper and the printed newspaper. This combination makes it possible to enlarge advantages compared to the currently existing newspaper media. Ihlström *et al.* (2004) write about the e-newspaper that: *"new services embedded in the newspaper product […] are made possible by this new media"*. Considered the time I had for this project it was an impossible mission to try to make the whole e-newspaper available on small screen devices and this was also not the purpose of this study. Therefore I haven chosen to use one "new service" as meant by Ihlström *et al.* in the quote above.

For this research I have aimed at the TV time schedule as being the service. The TV schedule can be found in most of the newspapers around the world. It is a service that many people appreciate and use. In the current prototypes of the e-newspaper developed by the Media-IT research lab from Högskolan i Halmstad the TV time schedule is not included. With the use of the TV time schedule it was possible for me to combine the best from two worlds, the overview and the familiar design of the printed edition and the interactivity from the web. To avoid the minor differences in for example lay-out I have chosen to use the TV table from Aftonbladet, a national daily evening newspaper in Sweden, as being the basic for this research.

4.3.2 Prototyping process

A prototype is a model or mock-up of the product being designed (Skidmore & Eva, 2004). In the case of software development it is a model of the application. The prototype(s) can be used as a tool to communicate design with (potential) users. There are two types of prototypes: low-fidelity prototypes and high-fidelity prototypes (Preece *et al.* 2002). Low-fidelity prototypes are cheap and easy to make. This can be for example a scratch (Preece *et al.* 2002). The users than get an idea of the possibilities there are. They can comment the prototype or explain why they prefer one design above another. Their argumentation can be used in addition to already existing design guidelines. High-fidelity prototypes are prototypes that look very much like the final product. They are made to show the user what they get, to make small changes or for testing purposes (Sommerville, 2001).

The prototype design and build process in this research started with formulating specifications. Three different kinds of requirements were elicited, these were: (i) hardware requirements, in these requirements the hardware to build the prototypes on was identified, (ii) functional requirements, the functions of the system were determined and (iii) usability requirements, in where is for example stated how easy the user should learn the system. The main source for the requirements was the design guidelines founded earlier during this study in the literature. This analysis I did by examining the TV schedule in the newspaper on paper. My own intuition and experience was used to add new functionality to the service, made possible by the use of digital techniques.

After the specification phase three prototypes were made, based on the requirements. First these prototypes were "low-fidelity"; sketches on paper which only gives an impression to potential users. These low-fidelity prototypes and the requirements were being commented by one IT student, with 7 years of education in the field of IT and in the age of 22 and one teacher in his late forties. With this input the "high-fidelity" prototypes were built. High-fidelity prototypes are totally functional prototypes (Sommerville, 2001). These high-fidelity prototypes were tested by one IT students who had not seen the low-fidelity prototypes. The

test on the high-fidelity prototype was done on a desktop computer and not on the mobile devices. The test was generally to check if navigation, usability and functional requirements were met. After correcting the comments on the high-fidelity prototype there were three "final" prototypes that were used as a tool in the usability tests.

The prototypes were built with HTML, PHP, XML and XSL for the e-reader and for the PDA. For the mobile phone I had to choose to use WAP as language. This is an XML based language that is designed for use on the mobile phone.

For the prototypes data from Aftonbladet was used. The information received from Aftonbladet consisted of an extended TV schedule, with the programs, actors, movie rates, descriptions, times, the channels, etc. this information covered four days. This data came in a Microsoft Word document and had to be converted into XML. I also received a more extended description of 3 or 4 programs that were on TV those days. This was a text (about 200 words) and an image. This text came in a Microsoft Word document and had to be converted into HTML. The images were JPG files and could be used after shrinking them about 50%.

4.4 Usability test

Usability tests are designed to find flaws in user interfaces, according to Shneiderman (1998). This chapter describes the tests I did for this research in order to find design issues that are important when designing for heterogeneous screen sizes. In this chapter I first give the chosen test method for this research (§4.4.1), then the materials that will be used in the test, will be given (§4.4.2) examples of this are the hardware that will be used. In §4.4.3 I will explain how the subjects were selected and at the end of this chapter in §4.4.4 I explain the procedure followed when testing.

4.4.1 Choice of test

For the usability test I used three methods: laboratory experiment, the think-aloud method and interviewing. The reason for choosing these methods is that this combination made it possible to retrieve rich qualitative data.

The basic method was the laboratory experiment. A laboratory experiment takes place in a controlled environment, this can be a laboratory room but it can also be an office, a hallway, etc. (Kjeldskov and Graham, 2003). Kjeldskov and Graham (2003) also write that a laboratory experiment in relation to mobile Human computer interaction research can be useful to evaluate design ideas, specific products or theories about design. Laboratory experiments facilitate good data collection and they are also highly replicable. Usability testing in laboratory settings is also discussed by Shneiderman (1998).

During the laboratory test I chose to use the think-aloud method to gather rich and qualitative data. The think-aloud method is one of the most popular usability tests. It is a method in which the test subject verbalizes his or her thoughts (van den Haak and de Jong, 2005). By inviting users to use the think-aloud methods the research can gain information on *why* they are doing it, Shneiderman (1998) states that this is an effective technique. Kjeldskov and Graham (2003) say that thinking aloud makes laboratory experiments suitable for qualitative information gathering. Wright and Monk (1991) add that there are significant gains from designers carrying out their own evaluations.

Interviewing is done because the researcher is interested in other people's stories. Most simply put, stories are a way of knowing (Seidman, 1998). Interviewing can be used to find out what others feel and think about their worlds, it can be used to understand experiences. (Rubin and Rubin, 1995). I chose interviewing for this research because (i) I think it is important to really understand the user's world, opinion and experience about the devices presented in the tests and the difference of design. Next to that (ii) I want to understand the arguments that the user's use as a basis for their opinion. These two reasons legitimate the choice for either a semi-structured or an unstructured interview (Easterby-Smith, *et al.* 2002). Seidman (1998), Rubin and Rubin (1995) and Easterby-Smith *et al.* (2002) all agree that an interview should some how be structured. In general all of them give the advice to

make a checklist or to make some main questions that can be used as a guide in the interview. For this research I used semi-structured interviews.
In semi-structured interviews the interviewer sets up a general structure by deciding in advance the ground to be covered and the main questions to be asked. The detailed structure is left to be worked out during the interview, and the person being interviewed has a fair degree of freedom in what to talk about, how much to say, and how to express it (Drever, 1995). I think this gives the richest data and still provides unity by using a structure.

4.4.2 Materials

To conduct the test I used different materials. This subparagraph explains what material I used and for what purpose.

The tests were based on the three developed prototypes. The three prototypes were installed on the devices they were meant for. The devices were one mobile phone from Sony Ericsson type T630, one PDA from Dell type Axim X5 and one HP/Compaq tablet PC tc 1000 because the e-reader was not yet available. In the last case the prototype was being displayed in an 8 inch diagonal wide window on the device to simulate an e-reader.

To record the results from the test two webcams were used. One webcam was meant for recording the face impressions from the subjects, to see eye movement and other impressions that can indicate user thoughts about the prototypes. The second camera was used to record the actions the user performed on the prototypes, for example what buttons the user pressed. In order to record what the user said (while using the think-aloud method) about the prototypes it was necessary to use an audio recorder. I chose to use an MP3 recorder.

"Being at home" is the most plausible situation for real use of the chosen service. In order to make the user feel comfortable and at home the test were conducted in a quiet room, on a couch. The tests could not be conducted in a real life setting because it is difficult to record the use of the devices then. The target of this research is to compare the three devices. Since only one device of each type was available it would take to long to carry out the tests.

4.4.3 Subjects

The intended end-user of the prototypes is very wide. It is everyone up from the age of about 15 years, with or without education, male or female and with or without computer experience. I tried to select my subjects in a way that they reflected this intended user group.

The user group consisted of a total of 8 participants, 50% was male and 50% was female. This group was scattered in age. The dispersion of age is given in table 1. All of the test subjects were native Swedish speakers, the prototype was in English and they were also asked (when invited to participate) to speak English during the test. Three people in the test group had a Bachelor, or similar, degree. Two of them were students at the time. Three of them had a college degree and two had a master degree. The test group had different professions. Two of them were students, one of them was electrical technician, one was project assistant, two were teachers, one was purchase coordinator and one was secretary.
Subjects were asked to state their experience with a desktop computer on a scale from one to ten, where 1 was very low and 10 was very high. The majority of the subjects state that they have an above average computer skill (see table 2).

One subject worked with a tablet PC before, 4 worked on the PDA and 3 used WAP on their mobile phone before.
4 didn't work with any of the devices before.

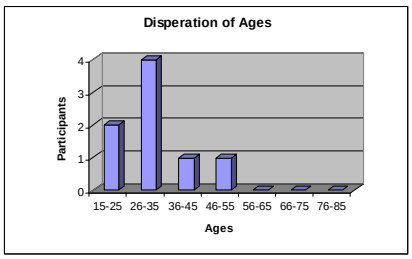


Table 1: Dispersion of ages

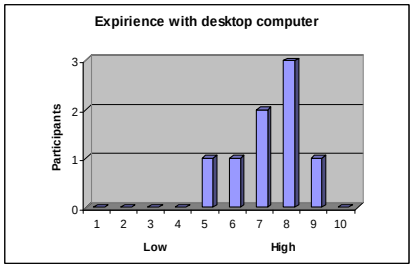


Table 2: Computer experience

4.4.4 Procedure

Participants were first told that it was not they that were tested but the products (Shneiderman, 1998). To make this message stronger it was accompanied by an announcement that the service they were about to see needed some serious testing because it was a prototype. This is, according to van den Haak and de Jong (2005) a possible way to perform a less competitive evaluation. This means that they not blame themselves but the prototypes for mistakes. Subjects were asked if they agreed to videotape them and that their voice was recorded. Furthermore the think-aloud method was being explained and the importance of their comments were pointed out. The time to complete all assignments was depending on the subjects experience with computers and the devices. However in general it took subjects between 30 and 60 minutes. No time limit was told to the subjects and they were free to use as much or less time as they wanted.

The first device that was tested was the tablet PC, where an 8 inch window was displayed. The user were given three different tasks that they should accomplish, without mentioning that time was being recorded. The completion time was kept to ask the subject a question concerning that in the interviews on the end of the test. The tasks differed in difficulty. The first task was the easiest one, task get more difficult towards the last task, which was the hardest. The subjects who had never worked with the devices before were given the possibility to play for about five minutes with every device. This was done in order to reduce their inexperience, that otherwise could have effected the results. The second device was the PDA. The researcher loaded the correct page and then handed the device over to the user. The user performed three tasks again. Starting again with the easiest and ending with the hardest task. The tasks were in the same context as the task performed on the tablet PC.

The last device was the mobile phone. The researcher again loaded the correct page and handed the device over to the user. The user performed the last three tasks on this device. Starting with the easiest and ending with the most difficult task. The tasks were in the same context as the tasks performed before (for a complete overview of the task see appendix A).

When the user finished with all the devices a semi-structured interview with open questions took place between the user and the researcher. This interview took between 15 and 20 minutes. It was aimed at the differences between the devices and which device they preferred and why. An overview of the open questions asked in this semi-structured interview is added in appendix B.

4.5 Data analysis

The themes from the design guidelines in §3.4 were used in the data analysis. I reviewed the evaluations for every device and marked user comments, problems, and also interaction with the software that went smooth. I reviewed my interview notes and where necessary I listened to the recorded interviews again.
The reviews from both the evaluations and the interviews were used to compare the users' acts and opinions with the already existing theory. By doing this I was able to see which guidelines are applicable for the prototypes as they were used in this research. It was also possible to see what design guidelines needed to be reformulated to fit better in the context of this research.
The users' acts and opinions derived from both the evaluations and the interviews were also used to come up with additional guidelines in the context of this research.

4.6 Critics on the method

There are also disadvantages about the methods I used for this research. First of all qualitative research is sometimes called "soft" research (Silverman, 1999). This is because it is based on the opinion of the subjects interviewed and the interpretation and opinion of the researcher. This type of research is politically influenced and don't bring "hard" prove in the terms of numbers or amounts.

There are disadvantages to prototyping. When it comes to low-fidelity prototypes it is said (Preece *et al*. 2002) that there is a limited error checking, that they output only a poor

detailed specification to code to, that they have navigational and flow limitations. For high-fidelity prototypes the disadvantages include that it is time consuming to create this kind of prototype. However in this research the prototypes will only be used to evaluate the design rules formulated by others and possibly append own rules generated from the tests.

For the laboratory experiment disadvantages include that it has limited relation to the real world and that the results have an unknown level of generalizability outside laboratory settings (Kjeldskov and Graham, 2003). Real mobility is not tested and in real users have time limits (when someone else is waiting for an answer, for example) and environment limitations. Lindroth *et al.* (2001) say that conventional usability test take less consideration to the context of its use.

There are also some comments to make on the think-aloud method, such as van den Haak and de Jong (2005) state. They say that the presence of the researcher influences the user. Sometimes the users blame their self instead of the test object. They feel that they have to perform well in the presence of the researcher. In addition to this van den Haak and de Jong (2005) also found that subject that use the think-aloud method hardly express their thoughts of the test object but mostly the action they undertook. In this study the subjects had to speak English to me, this was not the native language of the subject. This fact makes thinking aloud even more difficult.

I chose for a semi-structured interview with open questions. This type of interview expects much from the interviewer. The interviewer has to get the questions answered and at the same time give the interviewee the freedom to talk about their experience. The interview was also conducted in English which makes it more difficult for the interviewee.

4.7 Alternative methods

This research could have been carried out by using quantitative methods such as a survey research. This however doesn't explain the context and the personal point of view from the subject. By using qualitative methods it was possible to evaluate the product openly and compare the different devices in a conversation with the user.
I also could have used a field study to perform the user test. This however doesn't have many advantages over the laboratory experiment, in this research. The main target was to compare the service on the different devices, evaluate the design guidelines and possibly add new guidelines to the already existing ones. For this comparison it was hardly necessary to put the user and the hard- & software into different real life settings.

The think-aloud method could have been substituted by the constructive interaction method. In this method a team is working together. I didn't use this method because it is harder for one researcher to follow both subjects.

To develop the software a software development method (such as the waterfall-model) could have been used. These methods have less advantage over the prototyping approach, which is used now, moreover because the prototypes made now are made in close cooperation with IT professionals. The software development methods are mostly aimed at larger projects with known requirements and they take much time when following every step.

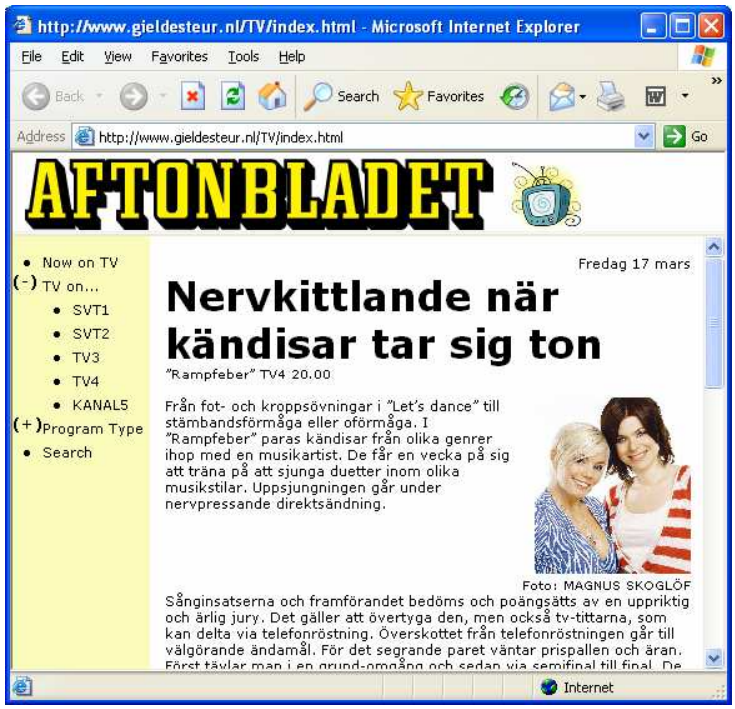
5. Developed prototypes

For this research prototypes were developed as a tool to perform the user tests on. This chapter describes the prototypes that were developed and used in this study. In total there were three prototypes, each prototype had a different screen size and was designed for one designated device. This chapter starts with the prototype developed for use on the e-reader device (§5.1). The chapter continues with the prototype for the PDA (§5.2) and the chapter ends with the prototype for the mobile phone (§5.3).

5.1 E-reader

The prototype developed for the e-reader was the largest prototype. The prototype had a diameter of 8 inch. Because the e-reader was not yet available it was presented on a tablet PC. The prototype was built as a webpage and was displayed with Internet Explorer. In figure 7 the e-reader prototype as it was used in the tests is given.

Figure 7:
The prototype for the e-reader



Aftonbladet is a well-known Swedish newspaper. To stay close to the users existing knowledge and mental model I chose to use Aftonbladet's logo left up on the screen. To underline that this prototype was a TV schedule I added a small logo of a TV behind Aftonbladet's logo. I also chose to use the same colors as Aftonbladet's website (yellow & white for the background and black text). The verdana letter type was also chosen because Aftonbladet's website uses this.

The screen is divided into three parts. The upper part contains the logo, the left part is used to present a menu and the right side is used to show data on. On the initial page (when you open the TV schedule, like in figure 7) the section where the data is shown presents information about TV programs today with an extended description and sometimes an image. Right up in that screen the user can also see today's date. The menu is located to the left. There are four main options. This is done in order to keep the interface as easy as possible and to make it easy to remember as in Nielsen's attributes learnability and memorability (Nielsen, 1995). Navigation and names of menus should be done consistently (Condos *et al.*, 2002), the TV channels are named the same everywhere in the program and menus are structured. One of the menus was opened when starting the page (TV on …), the other was not (Program Type). The user could open the menu by using the + before the menu. In the first prototype this menu structure wasn't available, but this was recommended by an IT expert who commented the prototype.

In the prototype the user can find the programs that are now on TV (menu option: now on TV). The user can also find the programs for a specific date by clicking on the menu option "TV on…". In that menu option there is also the possibility to see the schedule for a specific time span on a specific date for one or more channel(s). In the menu option "program type" the user has the possibility to choose the schedule on a specific date for different types of programs, in this prototype that are: movies, series, soaps or sport programs. With the search option the user can search for a program by name, by actors in it or by a specific time and channel. Within the search option the user have to specify a date as well.

In the overviews with time and channels the logos of the different channels are used (as shown in figure 8. The logos are shown to make it easier for the user to recognize the service as being a TV schedule. It is also close to the users' earlier experience with TV schedules. The times and programs are shown below those logos and are presented in rows. This is also done because the same structure is used in the paper version of the TV schedule (in Aftondbladet).

Figure 8: Program overview, incl. logos

5.2 Personal Digital Assistant

The prototype for the PDA is generally the same as the prototype that was build for the e-reader. The prototype for the PDA however measured 2.5 inch diameter, which is almost 3 times smaller. In figure 9 you can see the prototype as it looked on the PDA. The prototype was shown in pocket Internet Explorer. This is a version of Internet Explorer that is much smaller and developed for the PDA. It looks however a little different. The toolbar for example is not positioned up (as most users are familiar with) but below on the device.

The navigation menu changed place in the PDA prototype. According to the design guidelines earlier found during this study (see chapter 3) important options should always be visible to the user. The menu plays a very important role but it consumes much screen space if placed to the left. To save screen space the menu was placed just under the logo. There it only consumed one line of space. Only the main menu items were given and there was no possibility to expand menus. The names of the menus were not changed, this is in accordance with the rule that navigation and names of menus should be done consistently.

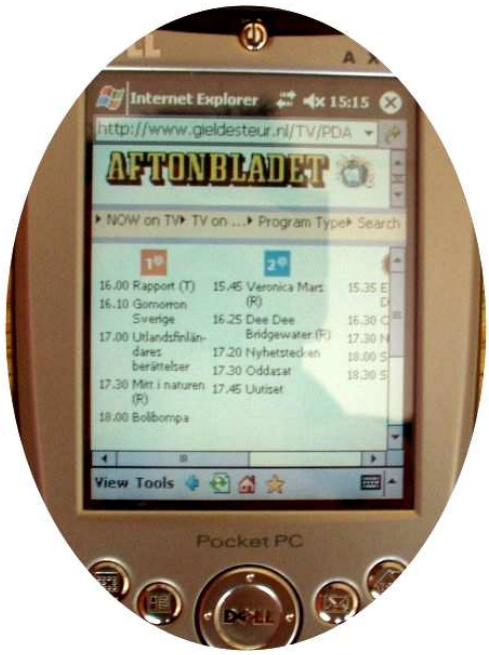


Figure 9: Prototype for the PDA.

The main page was also changed. With this small screen size it was not possible to give extended information about the programs. The PDA is also not meant for reading large amounts of text. In stead of the long descriptions the main page was changed to an overview from which programs there were now on TV (also available via the menu item "now on TV"). The now on TV list takes the current time and shows only the five next programs. This is done because one of the design rules indicates that long lists should be avoided.
It is also more efficient as Nielsen states in his attribute efficiency (Nielsen, 1995).

The images, colors and general layout were the same as they were in the e-reader prototype. By doing this content was presented appropriate and well formatted (Condos *et al.* 2002).

5.3 Mobile phone

The prototype for the mobile phone differed very much from the other prototypes. Again it was smaller, the prototype had a diameter of 1.8 inch. Next to that the prototype was viewed by the WAP browser that was built in on the mobile phone. In Figure 10 the prototype is showed on the device used in the test. This view can differ somewhat on every mobile phone, depending on the phone's screen size and the WAP browser software.

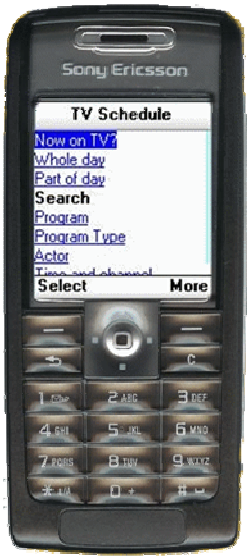


Figure 10: mobile phone prototype

The prototype that is made for the mobile phone is totally text based, this is the most noticable change. It is text based because it takes long to load images on a mobile phone and images consume more screen space then text does. The design guidelines I found also state that a designer should make careful use of graphics. Another very important and noticable change is the main page. When opening the TV schedule on the mobile phone the user only get a menu. This menu is devided into two parts. The upper part contains three links that lead to a (quick) overview of programs on one or more channels. With the links in the lower part the user can search in the TV schedule.

The menu items in the upper part are "Now on TV?", "Whole day" and "Part of Day". Now on TV takes the current time and selects two programs for every channel that are next on TV. It present them as text under each other. The channel name is also text (see Figure 11). In the menu option whole day the user first select the channel(s) he/she want to show and then a date. An overview from all programs on the selected channel(s) is generated. Part of the day is almost equal to the menu option whole day but here the user select a begin and end time. An overview from the programs on the selected channel(s) between the given times will be generated. The difference between a part of the day and a whole day is made to avoid long lists (design guidelines).

Figure 11: text based overview

Figure 12: try again possibility

The menu items in the lower part are "Program", "Program Type", "Actor" and "Time and channel". With all these options the user can search the TV schedule. The way the search methods work is equal to the other prototypes. If the software can't find the program that corresponds with the users input the user gets an error message and is able to try again, according to the desing guidelines (see figure 12). If a program is found then the user has the possibility to return to the main menu (see figure 13). These two things are done to avoid dead ends (design guidelines).

In the whole prototype special attention is paid to the links where users have to click on when submitting information. This links are always visible on the same screen where information is inputted. No scrolling is necessary to submit information. This is a result of the design guidelines, which state that important options should be visible to the user.

Figure 13: main menu option.

6. User evaluation

In this chapter the results from the user evaluation and interviews will be described. Every user tested the prototypes (see chapter 5) and cooperated in an interview. The results are divided among the different themes with guidelines. The different themes, including the rules that are part of this theme, can be found in paragraph 3.4. In the first paragraph (§6.1) the theme learning & remembering is spoken of, after that the themes user emotions (§6.2) and efficiency (§6.3) are presented.

6.1 Theme "learning & remembering"

In this paragraph the results from the user test and the interviews will be described in the light of the theme "learning and remembering". In this theme there will be spoken of the ease of learning and remembering the interface. Learning and remembering are important processes that take place when people use software. A designer should build an interface in such a way that it is easy to learn and easy to remember (Nielsen, 1995). The paragraph is divided into the three prototypes used in this research, to know: e-reader, PDA and mobile phone. In the end of the paragraph suggested improvements for the prototypes are given.

Prototype for the e-reader
When the users were evaluating the prototype designed for the e-reader some interesting facts came up in the light of the theme learning and remembering. Other facts in this theme came up when having the interview with the user about the e-reader. When one talks about learning it is important to take the existing knowledge from a user into account and build new knowledge on it. As noted Albers and Kim (2000) said that if a user builds up a wrong mental model it causes incorrect interpretations. The evaluation showed that the prototype for the e-reader should be based on the users' existing knowledge of Internet applications. Four out of eight users had problems with the links in this application. The links were not underlined and black (which makes them look like normal text). When the user moved the pen over the link the cursor changed, most users however expect a link to be blue colored and underlined. Another observation that strengthens the statement that the user uses knowledge about internet was that one of the subjects tried to click on the Aftonbladet logo to go back to the main page. One user stated in the interview that this prototype "*feels close to the Internet*". Albers' and Kim's (2000) statement about mental models is also important for recognition of the service. Toms and Campbell (1999) agree in the importance of recognition if a service should look the same and add that a user can recognize a document by seeing only the layout. Five out of eight people explicitly state that the prototype for the e-reader in this research is recognizable as the TV schedule in the newspaper. They expect a TV schedule to have times, program name and a channel and being built up in columns. One user also name that she need to know what kind of program it is, she said "*If you see the headline you don't know what type of program it is … I need to know what kind of program it is"*.

That a service can be recognized and that it fits the users' mental model are important factors for Nielsen's usability attribute learnability (Nielsen, 1995). The user is positive on the points about the mental model and the recognition of service. On learnability however the opinions differ. In the interview all subjects reflected that they think that it is necessary to learn the device and the software, but the expected time to learn is different. One user expected that he needed much learning time, and even suggested a help function. Another user expected that she needed "*some days*" to learn. Two others said that they would be able to learn the application fast. One of them said "*maybe I'm more convenient with it…when I've used it a couple of times more*".

Condos *et al.* (2002) putted up the design guideline "navigation and names of menus should be done consistently". In the prototypes the navigation was not consistent. The menu itself and the place of the menu were different. Three of the users said that they didn't have a problem with the different places of the menu in the different prototypes. One user commented though that the menu should be visible the whole time in the prototype for the e-reader. This is easier to navigate, according to her. Three users said that the menu names were unclear; the user did not understand the meaning of the menu until they clicked on it.

Those three subjects also said that the menu names were not equal with the mobile phone. For an easier understanding it is necessary to name the menus the same.

The last comments the user had for this prototype in this theme were about the structuring of user tasks. Condos *et al.* (2002) say in one of their guidelines "*structure tasks to aid the user's interaction with the system"*. In the assignments the user had to fulfill, they had to search for specific information (the best movie). This took about 3 or 4 actions. The user thought this was too long and wanted an option to search for that directly in the menu. Two subjects also looked for this information on the front page (where 3 programs were described). The actions the user undertook and the comments they made, points at a discrepancy in task analyses and structuring for this prototype and these users. Two other subjects however completed the test on this device exactly as planned. This makes structuring and analyzing user tasks a complex but very necessary design task.

In this user test it was not possible to extensively test the memorability of the user interface. Nielsen (1995) state an interface should be easy to remember and calls his attribute "memorability". The e-reader was also the first prototype tested, and that meant the first contact with the software. Two users commented in the interview we had that they would however probably remember the working of the interface next week. If one takes this in combination with a statement as "*I have to learn it first, then I would be much faster"* one can draw the conclusion that memorability (Nielsen, 1995) is depending on learnability (Nielsen, 1995) and that if the memorability improves the efficiency improves too.

Prototype or the PDA
The second prototype the users evaluated was the one meant for the PDA. Interesting information was gathered from the tests and from the interview that took place after the evaluation. The prototype was generally the same as the prototype meant for the e-reader (which the user used before this test). The menu didn't have subitems this time. To save screen space only the main items were used in the menu. Three users made clear that the naming of the menus should be better. This was important for the user, especially on mobile devices because the user can't try every option. Murugesan and Venkatakrishnan (2005) agree in this. They state that the user want brief, important, timely information. Three users however state that the prototype was easy to navigate and one state that it was consistent. One user thought that it was important to always see the menu when using the prototype. See calls the menu the list and say about it: "*that you have the content in front of you and the list on the side and that it doesn't change*". The rule "navigation and names of menus should be done consistently" from Condos *et al.* (2002), does apply for the prototype for the PDA. The statement from Murugesan and Venkatakrishnan (2005) about brief, important and timely information emphasizes this even more because when navigation is poor it takes more time to complete a task.

The evaluation and interviews show that when it comes to Nielsen's usability attribute "learnability" (Nielsen, 1995) the ability to learn can be improved by good and consisting naming of menus (Condos *et al.*, 2002). The description of the menus has to be easy for the user to understand and should reflect their thoughts. Before the user clicks on the menu name he expect something to happen, or he expect something to see. These expectations should be fulfilled to make it easier for the user to use and to learn. Albers and Kim (2000) wrote that it is important that the user recognize the service, and if the user builds up the wrong mental model (so, expectations) that this can cause incorrect interpretations. Their statement is thus in accordance with the user comments on this point. When it comes to the learning time the user didn't agree on what fast and not was, as in the prototype for the e-reader. One user expected much learning time, where he couldn't say how much. One user expected to need some days to use and two users expected to learn the interface "fast".

When the users were asked if the prototype looked like the actual TV schedule, two subjects answered positive. This was two subjects less than in the prototype for the e-reader. When those two users were asked to explain this difference they stated that the overview was missing on the prototype for the PDA, one commented about this prototype: "*that one was a bit hard, the overview was hard*". This overview was according to them necessary.

Toms and Campbell (1999) point out that a user can recognize a document by seeing only the layout. One of the specific characteristics (next to the ones already mentioned in the paragraph about the e-reader) of the TV schedule could be, according to this users, the overview.

It was difficult to test Nielsen's attribute memorability (Nielsen, 1995). The prototypes were used the first time and the test took about one hour (depending on the users' skills). Because the prototype for the PDA was the second prototype that was used and because it looked like the prototype for the e-reader, one could slightly notice that the users started to remember where several options were. One user said in the interview that the prototype was "easy to remember" and two subjects stated that they would probably still remember where the options were if I would ask them next week. The importance of Nielsen's attribute (Nielsen, 1995) was underlined by another user, who said: "*I want to do it fast, if you're used to it, this errors wouldn't occur"*.

Prototype for the mobile phone
In the context of the theme learning & remembering the last prototype to test was developed for use on the mobile phone. This prototype looked very different from the other prototypes and the interface is text based (only a menu). The menu had seven options, one with an equal name to the main menu in the previous used prototypes. In the interviews one user said that the mobile phone was hard to navigate, one said that it was easy to navigate and one subject stated that this was the easiest to navigate (from all prototypes). In the tests the users did not had problems with other menu names. Condos *et al.* (2002) state that "navigation and names of menus should be done consistently". This is true within the design of one product. The divergence of user opinions on the point of navigation however, points out that this rule is not (automatically) applicable when designing one service meant for the use on heterogeneous devices.

Task analyses are important when designing for the mobile phone. Condos *et al.* (2002) stated that in the design guideline: "structure tasks to aid the user's interaction with the system". One user commented that when he searched for "programs" he first want to enter the program name instead of the date, he said "*I want to search for a program, I don't want to insert a date*". In this way he would know that he was correct. In the interview another user also said that it was easier to get one question at a time (and not to fill in for example two times on one page). To make the program easier to understand, learn and use the task should be structured, according to the rule put up by Condos *et al.* (2002).

Two subjects stated that they did not recognize the TV schedule in the prototype for the mobile phone. Toms and Campbell (1999) stated that the user can either recognize a document by the lay-out or by the semantic context. In the case of the mobile phone the user obviously fails to recognize the lay-out. The lay-out in different columns, as used in the newspaper, the e-reader prototype and the PDA prototype, is impossible to fit into the small mobile phone screen. This non-recognition of the correct document can have serious implications according to Albers and Kim (2000). It can lead to incorrect interpretations which lead, according to them to the use of much more time and effort when using the application. This can not be seen in the completion time of the assignments. Users were slower than when using the prototypes e-reader or PDA but this significant time difference can be ascribed to the smaller screen and the loss of overview. The amount of wrong answers given was even lower as in the other programs. In this one can conclude that the users did not activate the wrong mental model, as this possibility is described by Albers and Kim (2000). Stretching that conclusion it could be possible that the user is still able to recognize the document by its semantic context. This is however not proven by this research.

For Nielsen's usability attribute "learnability" (Nielsen, 1995) the conclusion that users do not activate an incorrect mental model is important. The learnability is in this research influenced by the use of another type of device as the users were used to. In the evaluation of this prototype the user had most problems with the WAP interface on the phone it self. Four users commented that it would have been easier when they used their own mobile phone. One among them said "*this is another mobile than mine, so I've to get the hang of it*". Six subjects didn't have much trouble when completing the assignments. The other 2 subjects were older

in age and had far more problems with especially the device and less with the software. In total 4 subjects said in the interviews that they think it is easy to learn and remember the software. Remembering, as being one of Nielsen's usability attributes (Nielsen, 1995) could hardly be tested because it was the first time the software was used. It is as in the previous page about the prototype for the PDA possible to see improvement in the users use of the menu's, they know what the can expect behind a menu name.

6.2 Theme "user emotions"

In this theme there will spoken of the design guidelines that are closely related to the users feelings about the interface. This is one of the most important themes when designing software. If the software doesn't make a good impression or users get a negative experience they will not use it.

Prototype for the e-reader
In the context of user emotions the users gave much information. Sometimes verbally, sometimes by expressions (a sigh or a look) and sometimes by what they were doing on the interface.

The users had many problems with the search function. They couldn't find programs or channels. All users commented that the search function didn't work well. One of Nielsen's usability attributes is "errors" (Nielsen, 1995). Nielsen writes that an interface should have a low error rate. Users couldn't agree more with him on this point. One user said that the prototype had a low error rate, partly because of the better overview the prototype gives. Among other things the error rate has an influence on Nielsen's usability attribute "satisfaction" (Nielsen, 1995). An interface should, according to Nielsen, be pleasant to use. All users named the search function again as "not pleasant". Two users also state that the interface is visually pleasant, one user said that the interface was user friendly and simpler than the other prototypes and one user said that the he had enough overview in this prototype. Satisfaction is important to the users, because the software is made to be of assistance to the user. Therefore the users have to like working with it.

One user of the prototypes said that it took long to show information. She said "*It took long time to load and see something"*. This could be because there was a dead-end in the application (noticed by all users). When a user searched and the search didn't return any program an empty screen appeared. All users waited about 10 to 15 seconds before going back. There was no error message displayed and the user thought the computer was still receiving information, which was not the case. This is against two rules from Condos *et al.* (2002), the first was "dead ends should be avoided" and the second was "the program should provide clear, helpful and meaningful error messages". It was clear that this application did not obey to those rules. The user expected this however. Those two guidelines are therefore important.

According to Murugesan and Venkatakrishnan (2005) users of mobile devices want brief, important and timely information. If users have to wait for information that is not coming up that is wasted time. While the user want according to this rule timely information. As stated before one user commented that it took long to show information. It is therefore to say that the users do want timely information. To the other parts in the description of Murugesan and Venkatakrishnan (2005), brief and important information, the users are less convinced when it comes to this prototype. The descriptions in this prototype shown on the frontpage were long and so were the lists of programs. One user stated that information can be longer (in contrast to the other prototypes) and two subjects asked for more different program types. One subject said "…*I like the program type, it should have more options*". In this prototype that, according to the users, looked more like a real PC it is not very necessary to show brief and important information only. Nor is the rule "avoid long lists and indicate the length of the list" from Condos *et al.*(2002) applicable.

The links that were only black (as mentioned earlier in the §6.1, Learning & remembering) delivered problems. Not only did the user not understand that it was a link, the user also didn't see it. Blue and underlined links catch the eye. Just black text doesn't and therefore

users oversaw information. Condos *et al.* (2002) wrote that "important options should be visible to the user". A link to a description of a program is quite important in this application. It should therefore be visible to the user. One can argue that it was visible, but visibility in this case can be expanded to recognition and eye-catching. This test shows that where Condos *et al.* (2002) talks about "options" we can substitute this with "navigation elements", such as important links, buttons, places where user input is expected, etc.

Prototype for the PDA
The prototype for the PDA was the second to test. The prototype for the PDA was generally the same as the prototype meant for the e-reader. In the context of the theme user emotions interesting data was found, both from the tests and from the interviews.

Nielsen's usability attribute satisfaction (Nielsen, 1995) scored good on this prototype. Five users chose the PDA as being their favorite device, one of the reasons to do so was that the interaction with the device was more easy. One user stated that the software on it was visually pleasant; one other subject added that it had a better quality by saying "*I don't know why but I have the feeling that it is better quality…*". One subject said that the overview in this prototype was gone. It was according to this subject harder to get the total picture. As in the prototype for the e-reader the search function didn't work well. This had a negative influence on the satisfaction. The errors the users reported from the search function were not in accordance with the statement that an interface should have a low error rate (Nielsen, 1995). There was also not a clear, helpful and meaningful error message when there were no results to display, this made the users running into a dead-end. Both rules "the program should provide clear, helpful and meaningful error messages" and "dead end should be avoided" are rules from Condos *et al.* (2002). The users waited for the results to be displayed. If this didn't happen then they tried other functions to come to the right answer. If they would also search for other ways when using the program in a real-life setting, without assignments have to be questioned.

As in the prototype for the e-reader two users said that they thought that the option "program type" which gave several categories of programs to choose from was very easy, but they also said that it contained to less items. One of those subjects stated about the amount of items: "*I don't know how many but something you can recognize and look for. Like documentaries, soaps, series, movies, news, for adults, for children...*". This point is not in accordance with the rule from Condos *et al.* (2002) who state that long list should be avoided and that the length of the list should be indicated. An expansion of the list is also partly not in harmony with the statement from Murugesan and Venkatakrishnan (2005) who write that users of mobile devices want brief, important and timely information. Next to the list the users didn't want more or less information on the screen. This makes Murugesan and Venkatakrishnan (2005)'s statement not totally untrue. Timely information is important to the users. It is noticeable that the users get slightly more impatience than when using the prototype for the e-reader.

Prototype for the mobile phone
The mobile phone was the last device used in the user tests. In this part I reflect the results from the user evaluations and from the interviews, in the theme user emotions.

First of all the users seem not as patient as with the other prototypes. If for example the user acknowledged problems with inputting text they got back and tried other options. This is inline with the statement of Murugesan and Venkatakrishnan (2005), who say that users from mobile devices want brief, important and timely information. In the interviews two users said that the information is short enough and that they don't miss information.

If users are not as patient as with the other prototypes, as in this research, it becomes more important to reduce the errors in the software. Nielsen (1995) has the guideline that the user interface should have a low error rate. In this research the user had problems with inputting text however the input on the forms on this device was checked. The user couldn't input a number like 9.20 because the mobile expected two numbers, a dot and two numbers (so, 09.20). This was sometimes preventing errors and on the other hand for one user frustrating because he didn't understand why he couldn't enter 9.20. An error message if one was trying

to input incorrect data was not given by the mobile phone software. Another comment was that the date notation was unusual, this was the English notation without "-" (e.g. 19032006).

When it comes to Nielsen's usability attribute satisfaction (Nielsen, 1995) the subjects are divided in opinion. Two subjects said that it is not easy to use the mobile phone, one subject said that the small display is a problem, one subject said "*I don't get this one, it is much harder*", one said that "*I don't trust the mobile phone*" and on the other hand one subject said that it was much faster to use the mobile phone and two subjects said that the mobile phone was easy to use and that the text based interface is no problem what so ever. As one can read in the comments they are more focused on the devices than on the software. The software was judged as easy to use by three subjects.

Again all users had problems with the search function. The user was unable to easily find programs, actors or channels. All users commented that the search function didn't do what they expected. This time special attention was given to dead-ends, according to the rule "dead ends should be avoided" from Candos *et al.* (2002). The search function gave the possibility to try again. Despite of the extra attention users run into some "dead-ends" in the software. The user used a link in the menus phone to go back to the main page. The software itself didn't give enough opportunities to go back to the front page. For some users it was a problem to find the "back" button on the mobile phone. This cost time for the user, and that is something users don't have. Murugesan and Venkatakrihsnan (2005) agree in that by their timely information and the addition that users of a mobile device pay for the information they receive. This test showed moreover that dead ends should be avoided.

Condos *et al.* (2002) also wrote that the program should provide clear, helpful and meaningful error messages. In the light of Murugesan and Venkatakrishnan (2005) messages should be brief and important. Therefore the user saw a small error messages when search went wrong. All of the users understood the message and appreciated it. As said before; the mobile phone didn't give an error message when the user was trying to input data in an incorrect format. This was noticed by two users who would have been better of with a small notice of the mistake they made. One user also warned for an overflow on error messages. He said "*I like an error message that tells me that I did something wrong, but I don't want error message all the time or for everything*". One can conclude that the error messages give the user important information and that they are necessary. This confirms the rule from Condos *et al.* (2002) and because the error messages are important for the user it is also in accordance with Murugesan and Venkatakrishnan (2005).

Again none of the users complained about long lists. There were several long lists with programs but users didn't seem to have many problems with scrolling on the mobile phone during the test. When asked upon that all the subjects also said that scrolling was no problem, one subject added that important information should be visible first. That confirms the rule from Condos *et al.* (2002) that important options should be visible to the user. The user want to this first. However it is against their other rule "avoid long lists and indicate the length of the list". In this prototype there was no evidence that users had problems with long lists or that the length should be indicated (this indication takes screen space again). One user even asked for a list with date and times to pick because he thought that this was easier when inputting data in the phone interface.

6.3 Theme "efficiency"

The last theme has to do with the time in which the user is able to complete a task on the software. The user wants to complete the tasks as good and as fast as possible. The software should be designed in a way that this is possible.

Prototype for the e-reader
The evaluation with and interviews about the prototype for the e-reader delivered some valuable information towards the theme efficiency. All the users stated that they want to input as less as possible in the search function. The search function should accept one letter, a half word, a part of sentence, etc. and not only the exact term. The user also doesn't want the search function to be case sensitive. It should accept both capital and normal letters. One

user said "*I got stuck at the capital P… does it have to be like* this?". With the option search channel the user want to input only a 5 for channel 5. Some users opted for the use of wildcards, such as *. Condos *et al.* (2002) made the rule "minimize user input". All users agree that this rule is true and should be obeyed. Lindroth *et al.* (2001) said that the users want to perform tasks quickly and with less effort. The test results indeed show that the users want to have quick results after inputting very less data. One user said that the prototype for the e-reader was the most efficient because it looked like a windows application. In this one can see again (like in the theme learning and remembering) that users activate the mental model from using internet in a windows environment. This underlines what Albers and Kim (2000) said; that recognizing a service is important and that users activate a mental model when using a new service.

Another point to efficiency was that one user opened now on TV and saw many programs that were next on TV. He missed a date notation and said "*where is the date, how do I know that it is today?*". He expected the date to be right up in the interface so a user would know for what date the schedule was shown. With the descriptions of the programs the same user missed the channel they were on. This user explicitly wanted to see information. Towards the menu the users stated that when one clicked on KANAL5 the date was missing. Users had no idea for what day the schedule was shown. When looking at the different movies that were on TV on a specific date two users expect a head above the plusses and an explanation of which rate is good and bad. One user said "*They have some plusses for that movie but they don't say what they think is the best*". Condos *et al.* (2002) state in one of the design guidelines "provide the user with sufficient prompting". In the cases as shown above the user clearly wanted to have more information about what he was actually seeing. Providing user with sufficient prompting is in that case important. The users' need to explicit information is also important in another rule from Condos *et al.* (2002), "content should be presented appropriately and well formatted". As said before the user sometimes missed clues to know what he was actually looking at. Towards the last named rule, one user said that he appreciated "*the overview of all shows*" and one other said that the information was well structured per channel and program. The design guideline that content should be presented appropriately and well formatted is important and special attention should be paid to explicit information, to help the user recognizing what he or she is actually looking at.

Condos *et al.* (2002) also made the rule "make careful use of graphics". In the prototype for the e-reader there were several images. In the tests none of the users had problems with those graphics. In the interviews users were asked if they appreciated the icons for the channels. Six subjects stated that the icons were appreciated. The icons are useful for the connection to the paper. One of the subjects said about this "*I thought it was the real Aftonbladet*". The icons and also the logo in the header (in this case from Aftonbladet) make the service better recognizable. It activates the correct mental model which is according to Albers & Kim (2000) very important. This shows once again that the use of graphics make the document recognizable only by lay-out and without semantic content, as stated by Toms and Campbell (1999). One user said that the use of colors make it more like a newspaper. In this prototype the rule that one should make careful use of graphics is not true.

Nielsen's usability attribute efficiency (Nielsen, 1995) was hard to test. Nielsen explains his attribute as efficient to use when learned. In this user evaluation the software was tested for the first time. One can therefore barely conclude anything in the context of his attribute because the phrase "when learned" is not obeyed to. One user however said that the information in the prototype was efficiently used and in the context of the previous theme learning and remembering users already said that they would "*probably remember it next week*".

Prototype for the PDA

Again the PDA prototype was a look a-like from the prototype for the e-reader. Here I will present the results from the user evaluation and interviews about the PDA in the light of the theme efficiency. Five users chose the PDA as their favorite device. They stated that the device is light weight (two users) and that inputting information goes fast (2 users). Condos *et al.* (2002) has as a design guideline that the user input should be minimized. Interesting to see is that the users agree to his rule. However the input goes fast on this device the user still

want to input as less data as possible. The search function was again criticized because much, and very precise input was required. This is not efficient for the user. Lindroth *et al.* (2001) agree in that, they write that the user want to perform a task quickly and with less effort.

Like in the prototype for the e-reader the users misses explicit information about the schedule such as the date in the overview of "now on TV", the heading for the movie rates and the channel when the description of a program is given. Condos *et al.* (2002) have two rules to support this: "content should be presented appropriately and well formatted" and "provide the user with sufficient prompting". One user said "*how do I know that this is channel 3?*". The user should be given clues to interpret data and to know what they are actually looking at. The users want the interface to explicit information, both for navigation purposes (where is the user in the program) as for indicators (do the plusses indicated a rate?). The subject in the evaluations and interviews agree both that content should be presented appropriately and well formatted and that sufficient prompting is necessary.

In the prototype for the PDA the same colors and images were used as in the prototype for the e-reader. Condos *et al.* (2002) write about images that they should be used carefully. There is not sufficient evidence from the user test nor the evaluation to support their statement. As in the prototype for the e-reader the subjects think that the colors and the icons used for the channels made it easier to recognize the service. Toms and Campbell (1999) also state that when a person sees a lay-out (without semantic content) they are able to recognize a document. According to Albers and Kim (2000) this recognition is important for the correct interpretation of new data. One user had however a problem to recognize the icons. He never used the service (the TV schedule) and was therefore not able to recognize the icon. As Albers and Kim (2000) already warned for, this would activate the wrong mental model and infact it takes much more time for the user to use the interface. The user suggested that there next to the logos could be a describing text. Coming back to the rule from Condos *et al.* (2002) to use images carefully this means that a designer should pay attention to people who are maybe not able to recognize the images. A describing text could be added to avoid this problem and 7 out of 8 users do not agree with Condos *et al.* (2002) therefore one can conclude that this rule is not applicable.

Again Nielsen's usability attribute "efficiency" (Nielsen, 1995) was very hard to get results from. Nielsen (1995) meant that an interface should be efficient to use when learned. In this case users were not able to learn the interface. It was the first use. In the test you could see that 7 subjects used this prototype with more convenience. This was because the prototype for the PDA looked like the prototype for the e-reader which the user saw before. The user remembered options from the last time.

Prototype for the mobile phone
In this part the theme efficiency will be paid attention to in the context of the prototype for the mobile phone. Both user evaluations and the interviews are described. That efficiency on the mobile phone is important and is described by one user who stated in the interviews "*efficient information is very important on the mobile phone*". Murugesan and Venkatakrishnan (2005) agree in this. They write that users of mobile devices want brief, important and timely information. One other user said that only text is perfect. "*Images aren't important, the focus is here on information*" is a quote from another user. This makes not only clear that he wants short and timely information but it also means that images aren't important. Condos *et al.* (2002) has the design guideline "make careful use of graphics". According to three users information should be fast on the mobile phone. The images make mobile applications much slower and so more expensive, and less efficient for the user. One user state, as quoted before, that the images aren't important. In saying so he agrees with Condos *et al.* (2002). One can say that four users agree that the focus shouldn't be on the images, for this type (unlike the two earlier used mobile devices) Condos *et al.* (2002) is right.

Condos *et al.* (2002) write that user input should be minimized. This was proven to be right in the user evaluations. Subjects asked questions like "*how do I fill in text?"*. This problem is mostly caused by using another phone then the users are daily using but it is valuable to note this problem. The T9 dictionary that is on the phone is not understood by all users and can

cause problems when inputting texts. Users want to use as less information as possible when inputting text into the mobile phone. The search function should accept this and show the results for even the slightest input. For the mobile phone the users give up very fast (fastest of all the prototypes tested with) when inputting text is not working as expected or wanted. This is very close to what Lindroth *et al.* (2001) writes, that users want to perform tasks quickly and with less effort. The user in this case wants to input the text as easy and as fast as possible. Minimizing the input as Condos *et al.* (2002) states is a very useful guideline.

As in the prototypes used before (for the PDA and e-reader) the users wanted information to be more explicit. The users missed the channel when they were viewing the program description and the day shown when getting an overview of a whole day. This information was according to one user very important. Condos *et al.* (2002) state in one of the guidelines "provide the user with sufficient prompting" and in another "content should be presented appropriately and well formatted". The users agree on both guidelines. Users want to have explicit information (prompting) about where they are and what they are actually seeing. One user said that information was well structured per channel and program. On the structure one other user commented that it was easy to see now on TV, you got a direct overview on which programs were next on TV.

Like in the other two prototypes it is hard to come up with conclusions about Nielsen's usability attribute efficiency (Nielsen, 1995). The users were not able to learn the interface well in the evaluation and that is a necessity in Nielsen's attribute efficiency (Nielsen, 1995). This prototype was text based and not like the other prototypes the user had seen. Some menu options were named the same. It is to difficult to observe if the user was using knowledge gained in the earlier prototypes.

6.4 Suggested improvements for the prototypes

In this paragraph some improvements will be suggested for the prototypes. In the evaluation it was noticed that the prototypes are not yet finished and that some improvements can be made to make the prototypes more usable for the end users. In this paragraph this suggestions will be named.

The search function in all the prototypes was criticized by all users. The user expects a search function not only to search a specific program but the user expects it to take the slightest input and come up with fitting results. The user want to use wild card (e.g. "*") and parts of words (e.g. "parl" in stead of parlamentet). There should furthermore be no difference in the capital letters and normal letters (e.g. "P…" and "p…" should give the same result). The search function should come up with a list of fitting results so the user can pick the correct result. If no result are found an error message should be showed, rather than an empty page.

The menu used in the prototype or the e-reader gave problems. The menu was hard to learn and was interpreted wrong. Some menu options could be opened, by clicking the "+" before it (see figure 14). Sub options became visible and could be used then. The sub menus as well as the main menu items (such as Program Type) had functionality.

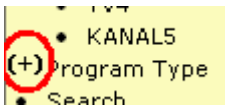


Figure 14: menu

The problems users encountered were mainly that they didn't expect that the menu could be opened at all and most of the users didn't expect functionality in the main menu items. This problems can be solved by taking out functionality from the main menu items or to make the menu in such a way that when the user click on the "+" the main menu item is opened (as a page on the right part).

In the prototype for the PDA in stead of the descriptions of TV programs, the programs that were now on TV were shown. This was not well understood by the user. The user didn't understand that that what was showed were the programs that were next on TV. To make this clear a header should be added. Another comment that was heard was that there are +'s by movies but the interface don't tell the user what it is. A header "rate" should be added.

Another problem with the search function in the prototypes for the e-reader and the PDA was that radio buttons and text fields were used in the user interface (see figure 15). The user should chose a bullet and then put in a word. Most of the users didn't understand this. The user only filled in a text. This should be avoided and three different sub items could be used under the main menu item "search". The information filled in, in a form should be checked. If the user didn't fill in all the information, or in an incorrect form an error message must be shown and the user must be given the option to try again.

Figure 15: bullets & text fields

Other problems discovered were:

- The date format used in the prototype for the mobile phone was uncommon for the users. They were not used to the English date notation and had no idea what "20032006" was.
- Links were not blue and underlined, the user overlooked them in this case;
- The logo from Aftonbladet was not clickable. This logo must refer to the home page.

7. Discussion

In this chapter the results will be discussed. To structure this chapter it is divided in sub-paragraphs. First the different challenges will be named that were found during the research (§7.1). After that the existing guidelines as mentioned in the theory will be reviewed (§7.2) and additional guidelines will be purposed (§7.3). In the end of this chapter there will be a reflection towards the method and a personal note (§7.4)

The research question in this research was: *"What are the challenges for designing the (graphical) user interface, as a part of an e-newspaper service which is aimed at use on multiple devices with heterogeneous screen sizes, to be recognized as the same service?"*.

7.1 Challenges

As the research question already states this research is trying to come up with challenges. In this research three challenges were recognized. In the building of the prototypes it is possible to distinguish the challenges for a designer and in the user tests one can recognize what the user considers important.

Recognition of service

The first challenge is the recognition of service. In the research question one can find the phrase "to be recognized as the same service". This is in my opinion a very important challenge when it comes to designing. The service in this research (the TV schedule) was already known by users from the newspaper on paper. To get the same performance when using the digitalized version the service should be recognizable. Recognition is important on every prototype compared to the non-digital service (e.g. prototype for the PDA vs. newspaper) and it is important when comparing the prototypes among themselves (e.g. prototype for the e-reader vs. prototype for the mobile phone).

As one can read in §3.4 there are already many guidelines which give guidance on designing a user interface. The guidelines used in this research have however a shortcoming. This is that they provide no guidance when it comes to the design of a recognizable service meant for the use on different devices. The guidelines focus on the use of software meant for the use on one device only.

Toms and Campbell (1999) hit a striking truth in their report. A document (and with that its recognition) contains according to them different layers. One of them is the layout and another is the semantic content. This is very important when one have to make a recognizable service. One have to distill the way the layout is built up and try to reconstruct that in the design of the GUI. If that is impossible (such as with the mobile phone) the designer have to pay much attention to the semantic context and present visible clues to make the user recognize the document.

An interface should also be built on the mental model the users already have, Albers and Kim (2000) said. Therefore it is important to know who one is designing for. The designer has to get an idea of the mental model a subject use. In this research it became clear (during the user tests and interviews) that the user use earlier experience on the internet to interpret the new interface and the previous experience from the TV schedule to interpret data. This information was not available when designing the prototypes and it was a real challenge there. The designer has to leave clues on the interface so the service will be recognized. In the prototypes this was done by using the logos from the channels and the column oriented layout. It is almost impossible for the designer to predict on forehand which mental model the user has. Only a research on the targeted group can deliver a correct view on the characteristics of the mental model the users within that group have in common.

Use on multiple devices

The second challenge was the use on multiple devices. It was a real challenge to design and built a service that was used on three different devices. In the research question one can read the following phrase: "*which is aimed at use on multiple devices with heterogeneous screen*

sizes". It does however not stop with the heterogeneous screen size. As Murugesan and Venkatakrishnan (2005) said, the devices have a different screen size, a different handset, a different keyboard layout, different features, different input capabilities, etc. The challenge for the designer is to develop one service that fits a very wide range of devices in such a way that the service is still recognizable.

When designing the prototypes the challenge was to make a recognizable service for three specific devices. In reality people use a much wider range of models and devices. There are differences in the way the different models present the GUI to the user. In this research this was noted because first I used a design tool from Nokia to develop the prototype on my desktop PC. The prototype was however used on a Siemens mobile phone. Some errors came up and information was presented slightly different. These differences are however important when one expects the user to be able to use the service on different devices (because the service should be recognizable).

When designing, the screen real estate was the most problematic. Lindroth *et al.* (2001) underline this in their research by saying that it is much harder to design an interface with the size half of your credit card. All the devices in this research had a different screen size. When designing for the smaller screens the designer still want to provide the user with enough information. In this the task for the designer is to recognize important information and to present that. In the prototype with more screen space the designer can present more information (such as a whole day on TV on all channels). In the prototypes with less screen space it is not possible to show much data on the screen, the user will lose the overview in that case. To present the information on devices with smaller screens, selections in the data should be made.

In the user evaluations something noticeable happened. When the user took another device at hand the user also seemed to switch expectations. The users seem to see them as different devices that don't have to look alike. There were no complaints about the amount of information showed on the screen (that was less when the screen size was reduced) or the way information was presented. The users seem to take for granted that a prototype look slightly different on a different device. Users do however want to use the hardware they are familiar with, such as their own mobile phone. The navigation and input are easier when the user can use own hardware.

When designing for the use on multiple devices the challenge consists of developing software that can be used on the different devices without endangering the recognition. It is also important to show only the important information on smaller screens and to give the user tools to carefully select what they want to see. Furthermore the user wants to use the hardware they are most familiar with. The software should be able to function on a wide range of devices.

Usable software

The third and last major challenge was to design usable software. In this research fifteen design rules towards usability were found in Nielsen (1995) en Condos *et al.* (2002). A designer should always try to make the software as usable as possible. In the design of the prototypes I tried to work in accordance with all the design guidelines found. This was a challenge on its own. On the prototype for the e-reader and the prototype for the PDA the recognition of service was prioritized. More effort was given towards learnability, memorability and visual presentation in those prototypes. In the prototype for the mobile phone the focus was on efficiency, fewer errors, no dead ends and well formatted and presented data.

In the user evaluation the users stated however that every design guideline was almost equally important. In the prototype for the PDA and the prototype for the e-reader the user missed the error messages and run into errors and dead-ends. In the prototype for the mobile phone the user had problems with navigation and sometimes they had no idea where they were in the software. On all the prototypes the user thought efficiency could be raised by implementing a good search function with the use of wildcards.

More attention should also be paid to disabilities people might have. About 5 subjects in this study commented in the interviews that the program was not usable for everyone. They had the feeling that older people were not able to use this prototype. One subject indeed had to get glasses to read on the PDA, subjects also expected that older people were not familiar with the use of mobile phones.

The challenge for the designer is to obey to the design guidelines and by doing that developing usable software. There is no priority in the design guidelines, they are equally important to the user. In this research there were no design guidelines that contradicted. A designer should keep the target user group of the software in mind. This can prevent disability problems such as to small text or navigational problems.

7.2 Revisiting existing guidelines

In this research I found that 13 out of 15 design guidelines were applicable for the prototypes made in this research. The design guidelines are in that case useful when designing a part of an e-newspaper service aimed on different devices. With two of the guidelines it was hard to get a solid conclusion. Below here all the different design guidelines used in this study will be discussed.

Learnability is one of Nielsen's usability attributes (Nielsen, 1995) he says about this attribute that an interface should be easy to learn. However the users' opinion on the time to learn the interface differs they agree that an interface should be easy to learn. Learnability can be improved by using the correct mental model and a good recognition of service.

In this study there were two guidelines that were to hard to get a valid conclusion for, these were two of Nielsen's usability attributes (Nielsen, 1995): efficiency and memorability. Nielsen describes efficient as: an interface should be efficient to use when learned, and memorability as: an interface should be easy to remember. On both these points it is expected from the user that he used the software more than once. In this evaluation the software was used for the first time and it was therefore very hard to draw conclusions. In the case of for example memorability one could only use a comment from a subject that he would "probably" remember the interface next week. This is however not very stabile. There was no sufficient evidence found to doubt or to approve Nielsen (1995) on either of his attributes efficiency and memorability.

Nielsen (1995) describes his usability attribute errors as; an interface should have a low error rate. For all the prototypes the user proved to agree in this rule. Users had problems with the input on the prototype for the e-reader and the prototype for the mobile phone, mostly because of the hardware. This however had a negative influence on Nielsen's attribute satisfaction (Nielsen, 1995). The users also said that more overview prevented errors. If users really want to find the answer they are very creative in finding other ways to the solution. For example if the search function did not give the correct output users looked in the overview of a whole day to find what they wanted. This should however be prevented because it takes more time and is discouraging the user to use the software.

Satisfaction is Nielsen's fifth usability attribute (Nielsen, 1995). He describes it as, an interface should be pleasant to use. When reviewing the users' comments they makes clear that this is a very important point. The user wants an interface to be pleasant. Nielsen (1995) did not define pleasant. This makes the rule so general that everything can be shared under this rule. In my opinion (after reviewing the user comments) this rule can be split up. I think Nielsen's satisfaction should at least contain:

- <u>The software is easy to use.</u>
  Software should be easy to interact with. Interaction is a key item in the usage of software. If this is done well the user will be more satisfied.
- <u>The user interface is pleasant to see.</u>
  Visually pleasant software is encouraging the user to make use of the software. The user will be much more satisfied with a user interface that is well designed and where the user can find what he/she wants.

- The software fulfills the user expectations.
  Users have certain expectations of what the software should be able to do. In the TV schedule context for example the user wants to find programs and times, as well as program descriptions. The software has to obey to that wish.
- The software is close to the users' existing knowledge.
  The software should build further on the users' existing knowledge and mental model. This is valuable both for the satisfaction and for the recognition of service.

The rule "make careful use of graphics" also from Condos *et al.* (2002) is not true for the prototype for the e-reader and the prototype for the PDA, but it is true for the prototype for the mobile phone. In the prototype for the PDA and the prototype for the e-reader the colors and images helped the users to recognize the service and to make it feel closer to the newspaper. On the prototype for the mobile phone the subjects say that the focus is on the information. This means that images and colors are less important in the mobile phone. They would only slow down the connection.

The user did not agree to the rule "avoid long lists and indicate the length of the list" from Condos *et al.* (2002) on any of the devices. The subjects clearly comment or show in the evaluation that they have no problem what so ever with long lists or scrolling. One user even asked for more lists (for example to select dates and times).

"Important options should be visible to the user" is a rule from Condos *et al.* (2002). This rule is true for all the prototypes. Users want to see important options at first sight. It is frustrating to not see a button or to forget to fill in information because one had to scroll. Condos *et al.* (2002) leaves in the middle what important options are. The phrase "important options" can be substituted with "navigational elements, links, buttons and input items". Furthermore I am convinced that the word "visible" should be expanded. The user don't only want options to be visible but they have to be more than that. They have to be eye-catching and recognizable. The rule from Condos *et al.* (2002) can be altered into this rule: "navigational elements, links, buttons and input items should be recognizable, visible and eye-catching for the user". This rule applies better in the context of this research.

Condos *et al.* (2002) also have the guideline "the program should provide clear, helpful and meaningful error messages". This guideline is true. The users indeed want to have an error message. In the prototype for the PDA and the prototype for the e-reader the users waited for information to display when in fact no results were found and just an empty screen was presented. Users would be helped with an error message that no results were found. An error message should also state why an error appeared. In the prototype for the mobile phone this was not done well. The message just said that the program was not found instead of saying that the user input was wrong. An error message has to help the user and make sense. Condos *et al.* (2002) noted this very well.

"Dead ends should be avoided" is one of the rules from Condos *et al.* (2002). This is true for all the prototypes. When the user runs into a dead end it takes time to recognize that it is a dead end and to come out of the dead end again. Therefore dead ends should be avoided. When the user comes into a dead end it is important to show an error message (according to the rule "the program should provide clear, helpful and meaningful error messages" also from Condos *et al.* (2002). This would help the user to recognize the dead end, which can save valuable time (and in the case of the mobile phone, even money).

According to Condos *et al.* (2002) "content should be presented appropriately and well formatted". This is agreed upon by all the users, for all prototypes. The presentation of information is important, especially on the smaller screens. As stated before, the presentation of information is especially important when the service should be recognized. The recognition is partly depending on the way information is presented.

The rule "navigation and names of menus should be done consistently" from Condos *et al.* (2002) reached a remarkable conclusion. This rule is true inside one prototype. Within one prototype the user expect the menu to be in the same place and always visible, names should not differ within one prototype. When taking another device at hand however the subject

seems to switch and don't experience much problems with different names or a different menu. The user seems to accept that when taking a new device the interface is different too. It does help the user when, especially the menu names are the same on all different devices. That makes it easier for the user to remember options and to use the interface more efficient. The rule would fit better if we rephrase it to "navigation and names of menus have to be done consistently within one application, but within one service designed for multiple devices it is just recommendable for the sake of memorability".

Condos *et* al (2002) write "provide the user with sufficient prompting". This is an important rule for the user. The user wants to have very explicit information to recognize data. Visual clues should be presented in the program to help the user understand what he/she is actually seeing. Examples in the developed prototypes were that the user wanted to have a date in the timetable so it was clear from what date the user was seeing the schedule.

"Minimize user input" is also a rule from Condos *et al.* (2002). A very important rule indeed that certainly is important for the design of a mobile service and for design in general on mobile devices. Users want to input as less as possible and often they even have problems to input data. Input should be easy and the users rather pick from a list then input text. It should also be possible to input half words or half sentences.

"Tasks should be structured to aid the user's interaction with the system" (Condos *et al.* 2002). The user evaluation shows that his rule is also true. A designer should analyze the user tasks in order to get a good view of the way the user will interact with the program. The users want to complete tasks as easy as possible and in as less steps as possible. A designer should consider menu options for frequently used or main tasks.

7.3 Proposed guidelines

The whole study concluded next to the check on existing guidelines in additional guidelines for designing a user interface for heterogeneous devices with dissimilar display sizes where the user must be able to recognize the service as one and the same. The additional guidelines found in this research are:

1. *Reconstruct the layout from the non-digital service in the interface as much as possible*. For the sake of recognition the user interface in the digital service must have the same look as the layout in the non-digital service. The more the digital service looks like its non-digital equivalent the better the recognition will be.
2. *Present clues for the recognition of the semantic meaning by explicating information.* This research showed that a user can easily get lost in information. Therefore the user interface should present simple visible clues to the meaning of the information that the user is seeing. This can be for example a date when an overview of programs is given.
3. *Explore the targeted user group, built further on their mental model and pay attention to possible disabilities of the group.*
   Acquiring a good image of the target user group is necessary to built good and suitable software. When designing the software the targeted user group should be kept in mind. It is important to know what mental model the user group uses, so the designer can build further on that. Whenever reviewing the user group their disabilities should also be paid attention to and the software should provide help with those disabilities.
4. *Implement extra's that give users a good reason to use the service.*
   When a service will be digitalized it have to prove it self towards (the majority) of people. People have to see the surplus value of a digitalized service before using it. Portability on it self is in the case of a newspaper service not enough. The service can have addition as a good search functions, links to the internet, etc. In this research the users appreciated the trailers for the films and the external links. One user also named the possibility of an alarm, so the user receives a message on his PC or mobile phone to remind him.
5. *Make selections of important data to present.*
   When the screen size gets smaller a selection of data should be made to present on the screen. The most important information has to be visible first. Therefore the designer should make selections of information whereby important information will be showed first.

6. *Make it easy for the user to select the sought information.*
   As said in the previous rule (important) information has to be selected to present on the small screen. The user however will expect that the same amount of information is available on the small screens. The users must therefore be able to select information themselves. The process of selecting the information must be as easy as possible and the user should have the possibility to find the wanted information in a few steps.
7. *Make software as device independent as possible.*
   As said before there is not a general mobile device. Mobile devices are there with different screen sizes, input methods, models, etc. If one develops software for mobile devices it is necessary to develop and test this on more then one device. This makes the software more device independent and thus reachable for a wider group of users.

7.4 Critics on method and own reflection

The methods used in this study were prototyping, laboratory study and think-aloud. Prototyping was used to develop the software and is a very easy and good technique in my opinion. It allows the designer to make a sketch of the GUI first (a low-fidelity prototype). This sketch can then receive comments from users and other designers in a preliminary state, where the designer is not caught in his own thoughts and where changes can be easily made. After that the real software is made and again checked by users. This makes it a stabile and good method. The laboratory study used in this research was also a very good method for this research. The laboratory setting gave options to look what the users were doing, to record carefully and to talk with the user in a quit room with enough time on us. The think-aloud method used in the user evaluation was not such a good choice. The think-aloud method is meant for comments during the tests. The users have to tell what they are doing on the interface and why. In my research the users had to speak English to me, which was not their native language. Even though there were no comments in Swedish either. It is hard for the user to use a device or an interface and explain at the same time what and why they are doing something. Some people start very well with talking aloud but after the first few minutes the amount of comments decreases. By asking the users what they did and how they came to an answer they gave it was possible to make the think-aloud method work.

In this study I was astonished by the amount of users that already use the internet for digital services as the TV schedule. I asked four people how they used the schedule and they all answered that were checking it on the internet, on a desktop PC. This shows moreover that the use of digital service is going to grow. Fidler (1997) already said that the media will be more digitally oriented. In this decade after he wrote about the changing media, signs that prove his theory are visible. In the coming period this will become more visible and mobility is also going to play a bigger role.

8. Conclusions

In this chapter the conclusions from this research will be given. The research question was: *"What are the challenges for designing the (graphical) user interface, as a part of an e-newspaper service which is aimed at use on multiple devices with heterogeneous screen sizes, to be recognized as the same service?"*. In this research there were three challenges:

- How to make the user recognize the service in the software (recognition of service)
- How to develop one service on multiple devices (use on multiple devices)
- How to develop software that it is useful and pleasant to use (usable software)

In this research and throughout those challenges different design guidelines were used. The guidelines were adapted from theory. In this research a review was given to the existing guidelines, some guidelines were reformulated to make them fit better and additional guidelines were proposed.

The guidelines that fitted as they were formulated by the original author were:
From Nielsen (1995):

- Learnability (an interface should be easy to learn)
- Efficiency (an interface should be efficient to use when learned)
- Memorability (an interface should be easy to remember)
- Errors (an interface should have a low error rate)

From Condos *et al.* (2002)

- The program should provide clear, helpful and meaningful error messages
- Dead ends should be avoided
- Content should be presented appropriately and well formatted
- Provide the user with sufficient prompting
- Minimize user input
- Tasks should be structured to aid the user's interaction with the system

The reformulated design guidelines that fitted better into the context of this research were:

- Nielsen's usability attribute satisfaction (Nielsen, 1995) should at least contain:
    - The software is easy to use.
    - The user interface is pleasant to see.
    - The software fulfills the user expectations.
    - The software is close to the users' existing knowledge.
- Navigational elements, links, buttons and input items should be recognizable, visible and eye-catching for the user.
- Navigation and names of menus have to be done consistently within one application, but within one service designed for multiple devices it is just recommendable for the sake of memorability.

The additional guidelines purposed in this study were:

- Reconstruct the layout from the non-digital service in the interface as much as possible.
- Present clues for the recognition of the semantic meaning by explicating information.
- Explore the targeted user group, built further on their mental model and pay attention to possible disabilities of the group.
- Implement extra's that give users a good reason to use the service.
- Make selections of important data to present.
- Make it easy for the user to select the sought information.
- Make software as device independent as possible.

Further research in this case is possible on Nielsen's usability requirements memorability and efficiency (Nielsen, 1995) in relation to the interface for services shown on different screen sizes. Those attributes require the user to work more then once with the software over a longer period in time.

References

Albers, M. and Kim, L. (2000). User Web Characteristics Using Palm Handhelds for Information Retreival in *Proceedings of IPCC/SIGDOC Technology and Teamwork*. Cambridge, MA, September 2000, IEEE: New York, pp. 125-135.

Auerbach, C. F., (2003). *Qualitative Data: An Introduction to Coding and Analysis*. New York, NY, USA: New York University Press.

Berg, E., Mörtberg, C. and Jansson, M. (2005). Emphasizing technology: socio-technical implications in *Information Technology & People*, vol. 18 No. 4, 2005, pp. 343-358

Condos, C., James, A., Every, P. and Simpson, T. (2002) Ten usability principles for the development of effective WAP and m-commerce services in *Aslib Proceedings*, vol. 54 No. 6, 2002, pp. 345-355.

Crowley, D. and Heyer, P. (1995). *Communication in History: Technology, Culture, Society*. 2nd ed. White Plains, NY, USA: Longman Publishers.

Drever, E. (1995) *Using semi-structured interviews in small-scale research: a teacher's guide*. Glasgow: Scottish Council for Research in Education

Easterby-Smith, M., Thorpe, R. and Lowe, A. (2002) *Management research*. 2nd ed. London: SAGE Publications Ltd.

Fang, I. (1995). Communication Timeline. Minnesota, Minneapolis, USA: School of Journalism and Mass Communication.

Fidler, R. (1997). *Mediamorphosis: understanding new media*. Thousand Oaks: Calafornia: USA: Pine Forge Press.

Haak, M.J. van den & Jong, M.D.T. de (2005) Analyzing the interaction between facilitator and participants in two variants of the think-aloud method in *Professional Communication Conference, 2005*. IPCC 2005 10-13 July 2005 pp.323 - 327

Ihlström, C., Åkesson, M. & Nordqvist, S. (2004). From Print to Web to e-paper - the challenge of designing the e-newspaper. In *Proceedings of ICCC 8th International Conference on Electronic Publishing*, ELPUB 2004, Brasilia, pp. 249-260.

Ihlström, C., Sabelström Möller, K. & Åkesson, M. (2005). The Challenge of Production in e-paper Publishing - from new consumption to new workflows. Presented at In proceedings of TAGA 2005, Toronto.

Kamba, T., Elson S.A., Harpold, T. Stamper, T. and Sukariya, P. (1996). Using small screen space more efficiently in *Proceedings of ACMCHI96*, pp. 383-390.

Kaplan, B. and Maxwell, J.A. (1994). "Qualitative Research Methods for Evaluating Computer Information Systems," in *Evaluating Health Care Information Systems: Methods and Applications,* J.G. Anderson, C.E. Aydin and S.J. Jay (eds.), Sage, Thousand Oaks, CA, USA. pp. 45-68.

Kjeldskov, J. and Graham, C. (2003). A Review of Mobile HCI Research Methods" in *Proceedings of the 5th International Mobile HCI Conference*, L. Chittaro (Ed.), Udine, Italy, September 8-11, 2003, pp. 317-335.

Kleinrock, L. (1995) *Nomadic Computing – an opportunity*. Computer Communication Review. ACM SIGCOMM.

Korhonen, J. (2003) *Introduction to 3G Mobile Communications*. 2nd ed. Norwood, MA, USA: Artech House, Incorporated.

Kristoffersen, S. and Ljunberg, F. (2000). Mobility: From stationary to mobile work in *Planet Internet*, Braa, K., Sørensen, B. and Dahlbom, B. (Eds.) Lund, Sweden: Studentlitteratur.

Lindroth, T., Nilsson, S. and Rasmussen, P. (2001). Mobility usability: Rigor meets relevance when usability goes mobile in *proceedings of the 24th conference on Information Systems Research in Scandinavia*, S. Bjørnestad, R.E., Moe, A.I., Mørch and A.L. opdahl (Eds.), Bergen, Norway, August 11-14, 2001, pp. 641-654

Ling, R. (2000). We will be reached: the use of mobile telephony among Norwegian youth in *Information Technology & People*, Vol. 13 No. 2, pp. 102-120.

Murugesan, S. and Venkatakrishnan B.A. (2005). Addressing the Challenges of Web Applications on Mobile Handheld Devices in *Proceedings of the international Conference on Mobile Business (ICMB'05)*.

Negroponte, N. (1995) *Being digital*. London: Hodder & Stoughton.

Nielsen, J. (1995) *Usability Engineering*. Mountain View, California, USA: AP Professional.

Prasad, R. (2003) *WLANs and WPANs towards 4G Wireless*. Norwood, MA, USA: Artech House, Incorporated.
Preece, J., Rogers, Y., Sharp, H. (2002). *Interaction design: beyond human – computer interaction*. New York, NY, USA: John Wiley & Sons, Inc.
Rubin, H.J. and Rubin, I.S. (1995) *Qualitative interviewing: the art of hearing data*. Thousand oaks, California, USA: SAGE Publications Inc.
Santhi, K.R., Srivastava, V.K., SenthilKumaran, G., Butare, A. (2003) Goals of true broad band's wireless next wave (4G-5G) in *Vehicular Technology Conference, 2003. VTC 2003-Fall. 2003 IEEE 58th,* Orlando: Florida: USA, 6-9 Oct., pp. 2317 – 2321
Seidman, I. E. (1998) *Interviewing as Qualitative research: a guide for researchers in education and social sciences.* 2nd ed. New york, NY, USA: Teachers College Press.
Shneiderman, B. (1998) *Designing the User Interface: strategies for effective human-computer interaction*. 3rd ed. Reading, MA, USA: Addison Wesley.
Silverman, D. (1999). *Doing qualitative research: a practical handbook.* Thousand Oaks, CA, USA: Sage Publications Ltd.
Skidmore, S. and Eva, M. (2004). *Introducing Systems Development*. Hampshire: Palgrave Macmillan.
Sommerville, I. (2001). *Software Engineering*. (6th edition). Harlow: Pearson Education Limited.
Toms, E.G. and Campbell, D.G. (1999). Genre as Interface Metaphor: Explouiting Form and Function in Digital Environments in *Proceedings of the 32nd Hawaii International Conference on System Sciences*.
Wahl, N.J. (2000) Student-run usability testing in *Software Engineering Education & Training, 2000.* 13th Conference on 6-8 March 2000 pp. 123 - 131
Weinberger, G. (2000) The new millennium: wireless technologies for a truly mobile society in *Solid-State Circuits Conference, 2000. Digest of Technical Papers. ISSCC. 2000 IEEE International,* San Francisco: California: USA*,* 7-9 Feb. 2000, pp. 20-24
Williams, D.H.(2003) *PDA Robotics*. Blacklick, OH, USA: McGraw-Hill Professional Publishing.
Williamson, S. and Öst, F. (2005). *Svensk Telemarknad 2004*. Stockholm: Post & Telestyrelsen, pp. 32
Wright, P.C. & Monk, A.F. (1991). The use of think-aloud evaluation methods in design. SIGCHI Bulletin, 23, 1, 55-57

Internet:
Carlson, D.E. (2005), *The online timeline*. Retreived 27 February 2006 from http://iml.jou.ufl.edu/carlson/1990s.shtml#1994
E Ink (2006) retrieved 20 February 2006 from http://www.eink.com
Fujitsu, (2005) retrieved 3 March 2006 from http://www.fujitsu.com/global/news/pr/archives/month/2005/20050713-01.html
iRex, (2006) retrieved 3 March 2006 from http://www.irextechnologies.com
Platic Logic (2006), retrieved 3 March 2006 from http://www.plasticlogic.com/downloads/usdc06-presented-9-web.pdf
Polymer Vision (2006), retrieved 3 March 2006 from http://www.polymervision.com
Sony, (2006) retrieved 3 March 2006 from http://www.sonystyle.com/is-bin/INTERSHOP.enfinity/eCS/Store/en/-/USD/SY_DisplayProductInformation-Start?CategoryName=&ProductSKU=PRS500&TabName=specs&var2=
Tianjin Jinke (2006) retrieved 3 March 2006 from http://www.jinke.com.cn/compagesql/English/embedpro/prodetail.asp?id=20
Wikipedia contributors (2006). Mobile phone in *Wikipedia, the Free Encyclopedia*. Retrieved February 6, 2006 from http://en.wikipedia.org/w/index.php?title=Mobile_phone&oldid=38313080.

Appendices

Appendix A – Assignments to test users

Again welcome. Thanks for participating in this user tests. Again I want to let you know that the products you're about to see are preliminary and need thorough testing, this can only be done with your help. Please give as much comments as possible so the products can be made better. The correctness of the answers is less important then the way you come to your answer.

The first device is the Tablet PC. Please perform the tests below.

1. Which program is there today (pretend that it is 2006-03-17) on Kanal 5, at 13.20?
2. What is (according to Aftondbladet) the best movie on 2006-03-19?
3. What is the last word shown in the trailer for the program Prison break on 2006-03-20?

The next tasks should be performed with the PDA:

4. What is the next program today (pretend that it is 2006-03-17) on TV3?
5. How many programs start on 2006-03-18 between 11.00 and 13.00 on SVT2?
6. Who is the male member of the Red team in the show "Parlementet" on 2006-03-19 at 20.30?

The next tasks should be performed with the Mobile Phone:

7. Which program is the next that start on KANAL 5?
8. How many programs will start on 2006-03-17 at SVT2 and TV3 (total amount) between 16.00 and 18.00?
9. Search for the following programs, can you find them on 20032006?
    a. Vädret
    b. Nyheterna
    c. Prison break

Appendix B – Interview guide

Target: To hear the user experience on the different prototypes for the different devices, in such a way that I can distil guidelines from that.

What were your expectations about the prototypes before you started?
What was true and what was not?
Why did you expect just that?
Which one is your favorite device? (+WHY)
Can you imagine yourself using this device in the future?
Do you think the devices are suitable for the TV schedule??
Can you name some differences in the design of the prototypes?
What is your opinion about those differences?
Why did you notice them?
What do you think about the time in which you completed the assignments, did it feel fast or slow to you?
If I give you the following list, can you say the words that are applicable to the prototypes and tell me why?

- Speak the users' language
- Consistent
- Recognizable
- Easy to remember
- Flexible
- Efficient
- Visually pleasant
- No irrelevant information
- No distracting information
- Low error rate
- Short information
- Efficient use of information
- Information is structured
- Easy to navigate
- Information is complete
- Error messages are god
- There are no "dead-ends"
- The links are very clear

Easy to use the program
It's suitable for everyone
Fast
Have many extras
Do the prototypes look a like on every device?
Do the prototypes look like the TV schedule?
Scientists (like Nielsen) say that scrolling is resulting in easily overlooking information and therefore not good. Do you agree to them?
Can you name three good and three bad things about the prototypes?