# Universal Design and Mobile Devices

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**Abstract.** The use of mobile technologies for self services, and the inclusion of elderly and cognitively disabled users in the self-service society can be improved by the application of appropriate accessibility guidelines for mobile devices. We show how to operationalize the principles of universal design, and how to realize these principles on mobile devices. Ten categories of accessibility guidelines are presented, and accessible user interfaces for an electronic service on a mobile phone are demonstrated.

**Keywords:** Cognitive disabilities, Design guidelines, Elderly, Mobile phones, Self-service society, Universal design, User interface.

## 1 Trends and Developments

### 1.1 Development of the Self-service Society

The emerging self-service society undoubtedly has a great impact on all citizens. A few years ago customers preferred to speak to the help-desk directly. Today we expect to find the information we need and be able to purchase goods or access services *on-line*. The introduction of the self-service society affects nearly every area of our lives. Daily we get cash dispensed by automatic teller machines, we buy train tickets at self-service kiosks, we keep our own banking accounts over the internet, we file our final tax statement electronically, and we report the electricity-meter reading over the phone, to name just some examples.

Self-service thinking is transforming the way many businesses and public organizations operate. Both the service provider and the customer benefit from this. For the user the opportunity to control the timing and method of transactions is appealing. The driving force for the service provider is the opportunity to reduce administrative overhead and still give a better service. The emergence of secure electronic payment systems has accommodated the development of self-served electronic commerce and customer relationship management. Over the last decade this transformation has been vastly augmented by the internet.

Besides the technological advances made during the last decades, an equally important driving force behind the development is the commercialisation of *services*. Within many areas, the welfare state is clearly moving towards a regulatory state in which market mechanisms are widely accepted. The government's role is to ensure a legislative and regulatory environment where self-served solutions and electronic

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commerce can flourish. Consequently, cost-effectiveness must be gained and maintained. Since electronic solutions and self-services offer significant potential benefits for businesses and public organizations, these are and will be important drivers of this development (Figure 1).

The self-service "movement" is reinforced by societal reforms and national development programmes. One example is the goal of "round-the-clock service" as displayed by many Nordic public administrations. Over the internet the citizen may for example apply for a building licence in the middle of the night if he/she so desires. Another typical programme in the Nordic countries is aid to disabled and elderly citizens to enable them to lead as autonomous lives as possible. Therefore, both these groups are becoming increasingly important users of digitised self-services accessed from the home or from public places, such as day-care centres. Finally, maintaining the population of rural areas is an important governmental policy goal in the Nordic countries. To ensure sustainable settlement, services need to be available and accessible. Self-services provided electronically on a diversity of technological platforms seem to be a sought-after solution.

## 1.2 The Mobile Phone Industry

The combination of mobility and the internet is creating a new and powerful industry that will deliver attractive, content-rich services to users on the move. All over the world companies are preparing for the mobile internet. Mobile data networks with increasing bandwidth, together with advanced phones and handheld computers, are bringing a new generation of services into use. As the mobile industry keeps rolling out new services, the concept of self-service is entering yet a new stage. It will move from finding information on the web towards the concept of mobile portals and web-based services (Figure 1). In other words, the industrial development is moving towards a new class of services situated at the cross-section between telecom and ICT.

In many European countries, the penetration of mobile devices is rapidly approaching the penetration level of TV. Recent market research suggests that in Western Europe, the mobile phone penetration – which excludes phones that have not

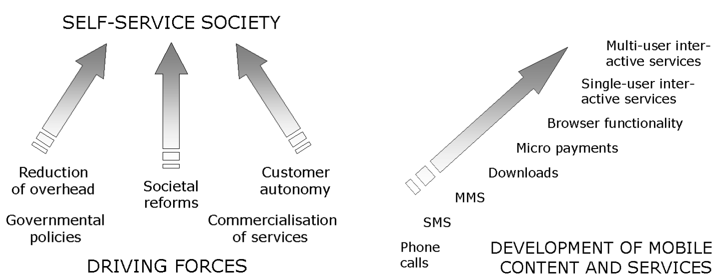


**Fig. 1.** Examples of the driving forces behind the development of the self-service society (left). Milestones in the development of services on the mobile phone (right).

been used for about three months – would rise to 98% in 2006 and hit 100% by 2007 [1]. The number of mobile phone connections is increasing in a similar manner all over the world [2].

In other words, the mobile phone is rapidly becoming common property. This development introduces new challenges to the usability and accessibility of the mobile content and mobile services. These challenges are reinforced by the self-service "movement" as described in the previous section, and they become even more demanding when new user groups enter the scene.

### 1.3 Elderly and Disabled People as Important User Populations

Our research focuses on the usability and accessibility of services on mobile phones. Accessibility problems are of particular concern to older people and people with disabilities. In parallel with the technological development, many developed countries undergo remarkable changes in their demography. The percentage of elderly citizens in the population is increasing rapidly. In Norway, for instance, it is estimated that in 2050, 15-28% of the population will be over 67 years old (13% in 2006) [3]. Another estimate says that in developed countries 20% of today's population is 60 years or older, and by 2050 that proportion is projected to be 32% [4]. Population aging is becoming a pervasive reality in developed countries. This must be taken into account when designing future technologies and services. As an OECD-report concludes, age exerts a strong influence on computer use, showing a significant decline after age 45. The findings show a negative association between age and cognitive skills [5].

Cognitively disabled people have difficulties interpreting what is seen or heard and/or difficulties making mental connections between different pieces of information, or have trouble with abstract reasoning. The type and degree of cognitive impairment can vary widely. Well-known cognitive impairments are dyslexia, dyscalculia, learning and language disabilities, and dementia. [6].

Cognitive skills or abilities, or the lack of these, thus define an important area of concern. Here the statistics clearly show the extent of the challenge. In Norway it is estimated that approximately 15% of the population aged 16-66 years suffer from a more or less permanent physical or psychological health problem that may cause difficulties in daily life [7]. International estimates show that 15-20% of the population have a language-based learning disability [8]. As shown above, the spectrum of cognitive disabilities is broad, and the affected population is large.

We acknowledge the great efforts that have been made for disabled users, e.g. those with visual or hearing impairments. However, it is obvious that the user requirements of *cognitively* disabled users have been poorly acknowledged in the context of self-service solutions or digital media generally. Therefore, practical guidelines for the interaction design of mobile devices for elderly and cognitively disabled users are called for. We limit our research to elderly persons and users with moderate cognitive disabilities who are potential users of self-services as outlined in Section 1.1. This limitation is made because it is reasonable to assume that not all information and services can be made accessible to a user population with severe cognitive disabilities, such as dementia or severe intelligence deficit, no matter what design principles are applied.

## 2 Towards Universally Designed HCI on Mobile Phones

### 2.1 State of the Art

The development of the mobile phone is more or less unproblematic for many, *but not for all*. Even "average" users are becoming increasingly confused by mobile services as these become more and more complicated to understand and configure. For cognitively disabled or elderly users, the situation is potentially much worse.

In order to compensate for the challenges, simple physical designs as well as design guidelines for content and interactivity are being developed in usability laboratories all over the world. Examples of physical mobile phone designs that aim at increased usability for the elderly are illustrated in Figure 2. The "elderly-design" is mainly achieved by stripping features from the established mobile phone concept and providing large buttons.

**Fig. 2.** Mobile phones for elderly and people with vision impairments, by Emporia [9], Kyocera [10] and Owasys [11]

A large number of different design guidelines are available for content carried by modern information and communication technologies. For the mobile phone, examples are the basic guidelines recommended by the W3C [12], or the guidelines suggested by Nikkanen [13] or Hays [14].

Many issues that are important to accessibility can be achieved by following accessibility *guidelines*. By using accessibility *tools* it is also possible to detect missing table headers, missing Alt-texts and so on. Moreover, it is becoming more and more common to provide options that make web-content accessible for users suffering from sensory disabilities. Large fonts and high contrast increase accessibility for users with vision impairments. Voice on the web makes content (more) accessible for people with dyslexia or other learning disabilities and people with impaired vision (e.g. elderly). In fact, many of the existing accessibility guidelines and accessibility tools based on established guidelines focus primarily on vision impairments. Other types of common disabilities, such as the cognitive ones, have not received an equal amount of attention. Even though this category of disability may appear conceptually and analytically difficult to handle, our work with mobile accessibility and usability has focused precisely on these users.

### 2.2 Mobile Usability Based on Principles for Universal Design

In order to approach accessible HCI-designs for mobile devices we have analysed the principles of universal design [15]. The principles are: 1. Equitable use. 2. Flexibility in use. 3. Simple and intuitive use. 4. Perceptible information. 5. Tolerance for error. 6. Low physical effort. 7. Size and space for approach and use.

Based on these principles and the underlying guidelines we have developed design guidelines for the management of service content on mobile devices. Our design guidelines are organized into ten categories of advice/guidelines, each contributing to the accessibility of the service through the user interface (UI). Below we present an overview of these.

**1. Navigation and work flow**

As we see it, navigation makes the service and its work flow work. The main navigation should be placed identically on all pages or cards of the UI, and critical functions should never disappear. The service should clearly express where the user is in the dialogue, and which tasks are active. The system should make it possible to go back to earlier phases of the dialogue, and it should be possible to end or terminate the dialogue at all times. In order to allow multiple navigation modalities the system should allow navigation by the device's physical keys and by screen buttons.

The small size of the screen implies splitting the task between a number of pages or 'cards'. However, one page or card should only contain related elements, and actions which are implemented as a series of pages or cards should be organized as a path of pages or cards, not a network. Scrolling should be reduced to a minimum. During complex tasks the system should inform the user about his/her progression. If the user can initiate several simultaneous tasks, the method of initiation should differ from ordinary navigation and input. In electronic forms it should be possible to proceed between (uniquely named) fields by using the Tab-key.

**2. Errors**

Error messages disturb any user, and even after decades of usability studies they are still often presented as cryptic alarms. However, error messages that are connected to the use of the service should be explanatory, easily read and presented in the user's mother tongue or the language he/she prefers. If the information is intended for the technical support personnel, this should be explicitly stated. It is also important that the error message is shown immediately after the occurrence of the error. In case of repeated errors, the system should offer additional information or propose an alternative way to proceed.

Not troubling the user needlessly implies that if any input is out of range or illegally formatted, the system should accept the valid input, and only invalid input and /or uncompleted input fields should be shown to the user. In case of web-applications the service should return automatically if the target page does not exist. Finally, it should be possible to present all error messages in an alternative modality, such as voice (cf. also points 7 and 9).

**3. Search and queries**

One of the most basic and frequently used functionalities is search. That is why it should be placed visibly. In order to manage the information (over)load, the presentation of the search results should be well-structured and easy to read. In connection with search it is often possible to choose advanced alternatives. In our case, the service should offer the use of simple search as default and advanced search options as optional. To support users who suffer from impairments connected to reading or writing, the search function should automatically correct misspelling based on lists of usual typing errors or alternative spellings (hyphens, capital letters, singular/plural forms etc.). The user should also be able to build personal lists of words.

**4. Input/output-techniques**
Multi-modality applies to input and output, too. It should be possible to give input and to confirm or end input both by using the physical keys of the device and by screen buttons (if appropriate). Multiple choices should be presented in a simple and consistent manner: alternatives in a menu or a list should be displayed together, and if necessary due to the number of alternatives, as layers or a hierarchical structure. The system should support self-population of input fields when the information is practically available. Word lists or dictionaries should be enabled in connection with input fields. The focal area or the working area should be accentuated.

**5. Time**
Sometimes the user needs time to accomplish a task. The more complicated the task flow becomes, the more flexibility should be offered with respect to elapsed time. The service should allow the user to work in his/her own pace, and it should show progression. Instead of time-out, the service should automatically save status and data input. Finally, when valid data input has occurred, or when the task is accomplished, the service should respond with appropriate feed-back.

**6. Text and language**
For this point we simply present a set of common rules. Information to the user should be available in her/his mother tongue or the language he/she prefers. Foreign or professional words, or extraordinarily long words or abbreviations should be avoided whenever it is possible to use ordinary words and everyday language. Sentences should be short and grammatically correct, and long texts should be divided into sections or summarized as a list.

The most important content should be presented first in all textual text units. All titles and labels should describe the content that follows, and all textual content should be relevant in the current use context. Text lines should not continue horizontally beyond the edge of the screen or the window. The text should not move unless the user explicitly allows this. Links should differ from ordinary text. Links in a text should not consist of one very short word or a string of many words. The name of a link and the title of the target page should correspond. Finally, links should indicate if they have been followed.

**7. Voice and sound**
In case of cognitive challenges, multi-modality *may* support the user. The user should be able to choose text and other information elements to be read aloud, and it should be possible for the user to choose precisely what should be read aloud (in a logical and meaningful order). The implementation of the UI should make it possible to read any user input aloud, and it should be possible to start and stop the reading at any time. An even more advanced feature, based on voice, is the management of the use session by speech input, with respect to both input and navigation.

**8. Graphics**
The use of graphic elements may support or confuse the user. For cognitively disabled users the requirements in this category are strict. We argue that graphic elements

should only be used to support focus, orientation or work flow. Moving elements should only be used when this feature adds information or supports the user. In that case, blinking and movement should be slow and non-persistent.

As far as colour is concerned, it is obvious that the contrast should be high and consistent, and opposite colours should not be used, in particular not combinations of red and green. Screen fonts should be used, and it should be possible to enlarge the text. Further we argue that it should be possible for the user to choose between different colour schemes, and that information should – naturally – be accessible even if multi-colour scheme is not available. It should at least be possible for the user to choose a simple high-contrast presentation. (Colour schemes in connection with *links* should follow established conventions.)

Icons or symbols should be consistent, and follow established conventions or standards. Otherwise the symbol or icon should clearly illustrate the functionality. Pictures, animations, illustrations or icons should not be used as links except those that are standardized symbols. If icons are used as links, an Alt-text should be provided.

**9. Figures and numbers**
Figures and numbers easily represent a barrier for many users and in particular for those suffering from dyslexia or dyscalculia. Therefore the service should minimize the need for, and support alternatives to PIN-codes and other figure-based codes deployed as user identification. The service should also support alternative presentation forms for quantity and volume, such as diagrams or verbal descriptions of quantity.

**10. Help and information**
Help and information functionalities are of crucial importance for all users. These should be placed and visualized identically all over the UI by using accepted principles or symbols. For instance, a question mark or an 'i' for information probably communicates better than a picture of a life buoy. Moreover, help or information functionality should be connected to all input fields, and when it is used it should be shown so that the use context remains unchanged. Finally, it should be possible to turn off any automatic help or information functionality.

## 4 Case: The Mobile Tax Demonstrator

Below we will illustrate how the guidelines affect the HCI-design of our case application: the mobile phone demonstrator for the Norwegian Tax Authorities [16]. The '*mobile tax demonstrator*' shall provide functionality for updating information required for tax calculations and consequently for ordering a new tax deduction card. This is a suitable service for demonstrating the principles, as it is meant to be used by all citizens, including the elderly and disabled. The screen shots show the demonstrator's user interface with dummy data. In order to demonstrate the realization of the guidelines, we have selected seven areas of detail, which we visualize below.

The demonstrator has been developed with the use of ServiceFrame. ServiceFrame is an application execution and creation framework based on Java. It provides functionality for communication with users connected through different types of terminals such as mobile phones, PCs or PDAs. ServiceFrame has been developed by Tellu AS [17] together with Ericsson NorARC as part of the ARTS research project [18]. It was created to support rapid development of internet and telecom services.

In our view, one of the most important areas of universal design in the context of services is that of managing the work flow. In Figure 3 the use of 'cards' is illustrated. The phases of the current task are organized as task cards, and the user maintains an understanding of position and progression. The number of the active card is clearly marked. Within one task the information may often be more comprehensive than the size of the screen. We take it for granted that two-dimensional scrolling should be avoided. We allow vertical scrolling, but we make an effort to manifest the position by a clearly visible scroll bar. The scroll bar also illustrates the relative vertical position on the card. In Figure 3 the scroll bar is illustrated.

The input-output techniques deserve a good deal of attention. In connection with input or output users often arrive in error situations. In order to avoid some of these we have implemented a colour scheme that indicates invalid or incomplete input. The colour scheme changes when the task is completed. Before completion a field or a card is identified in a colour that differs from the ordinary colour scheme of the design. This mechanism also ensures the quality of input data (Figure 4).

**Fig. 3.** Task cards and marking of the active card, i.e. the active task, in the task flow (left). Scroll bar showing the relative position (right).

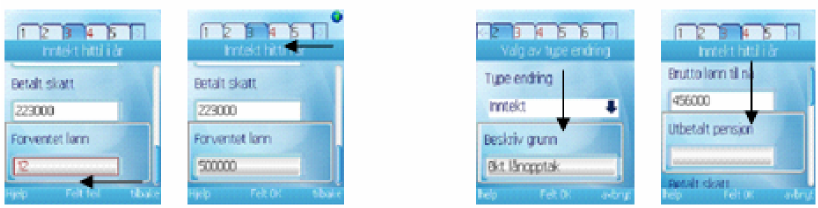

**Fig. 4.** Changes in the colour scheme indicate invalid input; input field containing '12' and card number '4' have changed colour (left). Working area is accentuated by a frame (right).

In a flow of tasks and in a sequence of dialogue activities the user needs a focal point. This may be connected to input or output, or to any information that the user manipulates. In our demonstrator, this challenge is solved by implementing a focal frame. This frame follows the active area of input or output as illustrated in Figure 4.

Another design feature connected to the visualization of the content is the size of the font. Obviously, both visual and cognitive impairments dictate the need to let the user choose both the density of information on the screen and the resolution of the presentation. In Figure 5 the possibility to adjust the size of the text is visualized in two different situations: a) the user chooses to enlarge all textual information, or b) the user only wishes to see one field of textual information in large font.

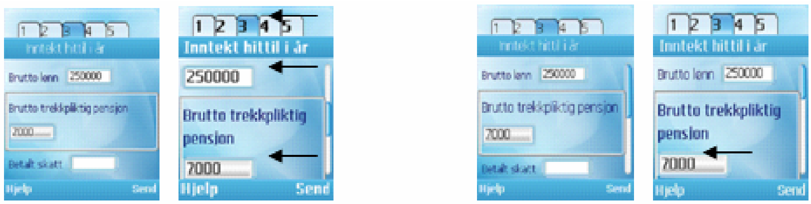


**Fig. 5.** Changes in font size all over the user interface (left), or only in selected fields (right)

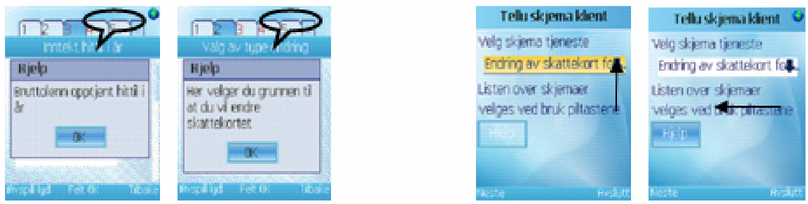


**Fig. 6.** Help texts can be read aloud (left). Menu and help functionality can be connected both to a physical key on the device, and to an easily operable screen button, as here (right).

Services on a mobile phone may often appear quite complex. Walking through a dialogue which is composed of several phases requiring navigation, selection, input, output, confirmation and so on, may easily lead the user into a trap. Hence, the help functionality can hardly be good enough. In order to prevent errors and to help the user out of trouble we have implemented two help functionalities in the tax demonstrator. One is voice-based help. Any help text that appears on the screen can also be read aloud, e.g. the help texts in Figure 6. Moreover, the help button on the screen is connected to the functionality of a physical key on the mobile phone (Figure 6). This feature also covers the requirement that the user should be able to navigate in alternative manners, i.e. function keys or screen buttons.

As a conclusion to this chapter, we wish to emphasise that generally not all services necessarily benefit from all guidelines as presented in Section 2.2. Also, conventions evolve together with technological changes. So, practically all guidelines are inherently unstable. Moreover, it is not possible to demonstrate all applicable guidelines in the context of one service. The screen-shots above should, nevertheless, illustrate our approach to universal design on mobile devices.

## 5 Concluding Remarks

Universal design evolved two decades ago. New accessibility challenges have arisen in parallel with the advances in information and communication technologies (ICT). Today ICT is addressed by design teams all over the world. In this paper we have approached accessibility for one specific technology. The next steps include profound usability testing of the demonstrator, and the development of industrial guidelines for a variety of mobile devices with different functionality, capacity, operating system, screen technology and so on. In other words, the work has just begun.

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## References

1. Digital-Lifestyles http://digital-lifestyles.info/display_page.asp?section=platforms&id=2177
2. Statistics Finland, http://www.tilastokeskus.fi/tup/maanum/index_en.html
3. The dessert-generation lives longer and works less (Statistics Norway. In: Norwegian), http://www.ssb.no/samfunnsspeilet
4. World Population Prospects – The 2004 Revision. United Nations (2005), http://www.un.org/esa/population/publications/WPP2004/2004Highlights_finalrevised.pdf
5. Learning a Living – First Results of the Adult Literacy and Life Skills Survey. OECD (2005), http://www.nald.ca/fulltext/learnliv/learnliv.pdf
6. http://webaim.org/articles/cognitive/#functional
7. Nearly half of all disabled persons are employed (Statistics Norway. In: Norwegian), http://www.ssb.no/emner/06/01/akutu
8. The International Dyslexia Association (IDA), http://www.interdys.org
9. http://www.emporia.at/shop/gb/index.php
10. http://www.engadget.com/2004/11/26/kyoceras-cellphone-for-the-elderly/
11. http://www.capitalaccessibility.com/products.html
12. W3C: Mobile Web Best Practices 1.0 – Basic Guidelines; W3C Proposed Recommendation (November 2, 2006), http://www.w3.org/TR/mobile-bp
13. Nikkanen, M.: One-handed use as a design driver: enabling efficient multi-channel delivery of mobile applications http://www.helsinki.fi/~mnikkane/publications/Nikkanen_One-handed_use.pdf
14. Hays, G.: Guidelines for User Interfaces for Mobile Devices http://www.developer.com/ws/article.php/10927_1143541
15. The Center for Universal Design (CUD), http://www.design.ncsu.edu/cud/about_ud/udprinciples.htm
16. http://www.skatteetaten.no/Templates/Artikkel.aspx?id=8681&epslanguage=NO
17. http://www.wildmedia.no/tellu-web/flash.htm
18. ARTS – Arena for Research on Advanced Telecom Services, http://www.item.ntnu.no/avantel/projects/ARTS/arts.html