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# **Designing Inclusive Mobile Services**

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## Abstract

Mobile phones are increasingly becoming common property, which we carry with us practically all of the time. Services we are used to access on computers are gradually becoming accessible by mobile phones. Disabled and elderly people are at risk of being excluded from using these services, as mobile phones have several constraints which make them hard to use for people with certain impairments – Mobile devices and services are usually not accommodating impairments.

The main objective of the project for which this report is written, is to propose principles for achieving increased inclusiveness of mobile services. A literature study was first executed to form a background for the proposition. An assertion about the proposed principle was stated, which was supported by implementing the principle on a mobile service, for illustrative effect.

The literature study consisted of an investigation of existing principles for Human-Computer Interaction design, some of which are specific for mobile devices, categories of disabilities, state-of-the-art on mobile phones accommodating disabilities, and the field of Universal Design.

Because of the boundaries of the project, a group to focus on when proposing principles, ‘people with a mild degree of reduced eyesight’, was chosen. The Universal Design principles “Equitable Use” and “Flexibility in Use”, similar principles to the latter were also among the Human-Computer Interaction principles, were chosen and modified before they were combined into the final principle, “Equitable and Flexible Use”. The principle states that users of mobile services should be provided the possibility of configuring presentation of output, without any focus on specific user groups. The reasoning for the choice of principle is that everyone wants to be treated as equals, but also wants to configure presentations of user interfaces according to personal needs and preferences.

The assertion states that the principle can be applied in a way which increases usability for the group in focus. The principle is applied by offering configuration of the screen content’s size in two ways: choosing size in an application’s settings and enlarging the area in focus by pressing a predefined key for this purpose. These are partly implemented on a service.

The result of the implementation indicates that the assertion is fulfilled, and that enlargement of screen content may serve as a guideline for the application of the principle. Since the chosen principle can be applied to increase usability, and a more usable service is a more inclusive service, the principle is concluded to increase the inclusiveness of mobile services. The principle calls for more precise guidelines on how to apply it – guidelines which accommodate other needs. It is also necessary to undergo a series of testing, in order to fully claim that the principle increases inclusiveness. More research is needed in order to fully exploit the potential of designing mobile services to support the needs of disabled people



## Preface

This report is the result of a project in the depth study TDT4730 Information Systems at the Norwegian University of Science and Technology (NTNU), Department of Computer and Information Science. The depth study takes place during the 9<sup>th</sup> semester of the Master of Computer Science study. The project assignment is given by Tellu, a company that develops and executes services for mobile phones.

The report documents the investigation of principles on user interface design, disabilities and the field of Universal Design, and the proposition of a principle for increasing the usability and inclusiveness of mobile services. It contains several Computer Science terms, as it is intended to be read by people from this field.

I would like to thank Riitta Hellman at Karde AS for her guidance and good advice during the accomplishment of this project, and also Geir Melby and Knut Eilif Husa at Tellu AS for providing assistance and feedback.

Trondheim, December, 2006

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# 1 Introduction

This chapter presents the project assignment, the research method that was used in the project, and the structure of this report.

## 1.1 Background and Assignment

Mobile phones have become common in the society. 92 percent of the Norwegian population owned a mobile phone in 2005 [SSB2006]. Mobile phones can now, as the technology increasingly permits it, be employed for several other purposes than telephony. The phones more and more tend to offer the same functionality and services as computers. Also public services known from the Internet are starting to become accessible by mobile phones.

A mobile phone has several constraints which affect its use and functionality, such as a small display and keypad, the shaping of the keypad, limited storage space, memory and battery capacity. The shaping of the keypad is usually keys for the numbers 1-9, the signs \*, # plus some extra keys. Characters require repeated key strokes. Some people have disabilities which make them experience problems with, or be unable to, use mobile phones. These people belong to a group which is often categorised as the “disabled and elderly”. The problems will in most cases be related to, or somehow be affected by, the constraints concerning the devices’ interface, the small size of display and keypad, and the keypad’s shape.

Research on interaction with mobile phones that are used as “mini computers” is scarce, and so are guidelines for how to design highly accessible mobile services or applications to be usable also by disabled and elderly people. Applications for mobile phones are yet such a new technology, that even guidelines on how to achieve usability for people without disabilities are scarce. As the mobile phone becomes an important channel and interaction device for services, the disabled and elderly are for these reasons in great risk of being excluded from the digital service society.

The company Tellu is a spin-off from Ericsson’s Norwegian research centre. They develop and execute mobile services. Users interact with these services through client applications on their mobile phones. Tellu wants their services to be as inclusive as possible, enabling also the disabled and elderly to use them.

This project’s assignment is to investigate existing principles and guidelines on user interface design and propose principles that Tellu can apply to make their mobile services more inclusive. The principles shall be adapted to Tellu’s Human-Computer Interaction (HCI)-package and implemented on a service to illustrate the effect of the application of the principles.

## 1.2 Research Method

The research method that was followed during this project comprised a literature study on areas that concerns the project. These studies formed a background which helped in setting

boundaries for choosing the principles, such as a focus group. First when the boundaries were set, principles could be proposed. The principles could be chosen from the ones in the literature study, self-created or a combination.

The principles were specified and combined into one principle, and an assertion concerning the group in focus could be presented. To support the assertion, the principle was implemented on a service. Since the principle is so general that it can be applied in many ways, a specific way of applying the principle had to be decided on. This application was implemented, first on Tellu's HCI-package, as all their services are based on this, then on a specific service.

The implementation was done using J2ME. J2ME (Java 2 Platform, Micro Edition) is one of the technologies that Tellu uses to create their mobile services, and is the only of these technologies which influenced this project. J2ME is also known as Java ME (Java™ Platform, Micro Edition). The technology makes developers able to use the Java programming language to make programs for mobile devices like mobile phones, personal digital assistants, TV set-top boxes and printers [SunMicrosystems2006].

Finally, whether or not the assertion was fulfilled and the principle does make mobile services more inclusive, is discussed.

### ***1.3 Structure of the Report***

The reminder of the report is organised as follows: Chapter 2 gives a brief introduction to Human-Computer Interaction and Usability, and presents several principles, requirements and guidelines. Chapter 3 briefly presents types of disabilities, which problems people with disabilities have with mobile phones and solutions that have been created to help them. The fourth chapter introduces the field of Universal Design, Universal Design principles, accessibility politics in Norway, Europe and the United States of America. The last section presents some mobile phones and solutions which their producers claim have a Universal Design.

In chapter 5, the principles are chosen and combined, and an assertion regarding the combined principle is presented. Chapter 6 presents a way to support the assertion by paper prototyping and implementation of it on a mobile service. The fulfilment of the assertion and the inclusiveness of the chosen principle is discussed in chapter 7, along with other topics. Chapter 8 presents ideas for future research.

## 2 Human-Computer Interaction

Many of the principles for design of user interfaces can be categorised as Human-Computer Interaction (HCI)-principles. Human-Computer Interaction became a research field early in the 1980s. It has increased in importance every year since, as the users no longer were only those familiar with computer technology. It is not the intention to thoroughly describe the field of Human-Computer Interaction in this report. Since there is a large amount of literature on the field, and the field is presumed known to the readers, this section will only give a short introduction to it and the main contributions within usability and accessibility.

[Myers et al.1996] provide this definition of HCI:

*“Human-Computer interaction (HCI) is the study of how people design, implement, and use interactive computer systems and how computers affect individuals, organizations, and society.”<sup>1</sup>*

Human-Computer Interaction arose from many fields of study, as the need for competence on how to improve interaction between humans and computers emerged. These fields are computer science, cognitive psychology, social psychology, perceptual psychology, linguistics, artificial intelligence, and anthropology [Myers et al.1996]. The motivation for HCI-studies is a goal of achieving high usability for the users of computer systems [Hartson1998]. This knowledge is now being used in the context of mobile devices, and new research challenges seem to arise. One of the goals of this report is to show how to apply principles for accessible HCI-design to mobile devices.

### 2.1 Usability

In order to make mobile services more inclusive, usability of mobile applications must be increased. The International Organisation for Standardization has developed ISO 9241, which states the ergonomic requirements for what they call “Human-System” interaction. In [ISO9241, 1998] part 11 – “Guidance on Usability”, usability is defined as the

*“Extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.”*

**Effectiveness** is defined as the “Accuracy and completeness with which users achieve specified goals”, **efficiency** as the “Resources expended in relation to the accuracy and completeness with which users achieve goals” and **satisfaction** as “Freedom from discomfort, and positive attitudes towards the use of the product”. ISO’s definition of usability from 9241-11 is widely quoted and acknowledged.

Several HCI-principles, also called guidelines, rules, etc., have been developed in order to achieve usability. These mostly concern the user interfaces of products and services, as that is what establishes the Human-Computer Interaction. A selection of such sets of principles will be presented in the following sections, some of the principles overlap. Guidelines for design-

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<sup>1</sup> The term “computer” is very limiting taken literally, and should rather be interpreted as devices within Information and Communications Technology (ICT).

ing interfaces of mobile devices and services are yet scarce, although some attempts have been made in this area. Along with the growth of the mobile market, it is likely that this field of research will expand during the next years. The three last sections of this chapter will present some of these works.

## **2.2 Nielsen's Usability Heuristics**

Jakob Nielsen is a pioneer in *heuristic evaluation* [Preece et al.2002], a usability engineering method for finding usability problems in user interface designs. Nielsen, in collaboration with Rolf Molich, developed heuristics for heuristic evaluation in 1990. He later revised them, resulting in ten usability heuristics. [Nielsen1994]

### **Ten Usability Heuristics [Nielsen1994]:**

*Supplementary comments are Nielsen's.*

#### **1 Visibility of system status**

The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.

#### **2 Match between system and the real world**

The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.

#### **3 User control and freedom**

Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.

#### **4 Consistency and standards**

Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.

#### **5 Error prevention**

Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.

#### **6 Recognition rather than recall**

Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.

#### **7 Flexibility and efficiency of use**

Accelerators – unseen by the novice user – may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.

## **8 Aesthetic and minimalist design**

Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.

## **9 Help users recognize, diagnose, and recover from errors**

Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.

## **10 Help and documentation**

Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.

## **2.3 Shneiderman's Eight Golden Rules of Interface Design**

Shneiderman proposes in his highly acclaimed book "Designing the User Interface" techniques and guidelines for interface design, which he has developed based on his own experiences with interactive systems [Shneiderman1998].

### **Eight Golden Rules [Shneiderman1998]:**

*Supplementary comments are Shneiderman's.*

#### **1 Strive for consistency.**

Consistent sequences of actions should be required in similar situations; identical terminology should be used in prompts, menus, and help screens; and consistent commands should be employed throughout.

#### **2 Enable frequent users to use shortcuts.**

As the frequency of use increases, so do the user's desires to reduce the number of interactions and to increase the pace of interaction. Abbreviations, function keys, hidden commands, and macro facilities are very helpful to an expert user.

#### **3 Offer informative feedback.**

For every operator action, there should be some system feedback. For frequent and minor actions, the response can be modest, while for infrequent and major actions, the response should be more substantial.

#### **4 Design dialog to yield closure.**

Sequences of actions should be organized into groups with a beginning, middle, and end. The informative feedback at the completion of a group of actions gives the operators the satisfaction of accomplishment.

#### **5 Offer simple error handling.**

As much as possible, design the system so the user cannot make a serious error. If an error is made, the system should be able to detect the error and offer simple, comprehensible mechanisms for handling the error.

### **6 Permit easy reversal of actions.**

This feature relieves anxiety, since the user knows that errors can be undone; it thus encourages exploration of unfamiliar options. The units of reversibility may be a single action, a data entry, or a complete group of actions.

### **7 Support internal locus of control.**

Experienced operators strongly desire the sense that they are in charge of the system and that the system responds to their actions. Design the system to make users the initiators of actions rather than the responders.

### **8 Reduce short-term memory load.**

The limitation of human information processing in short-term memory requires that displays be kept simple, multiple page displays be consolidated, window-motion frequency be reduced, and sufficient training time be allotted for codes, mnemonics, and sequences of actions.

## ***2.4 ISO's Ergonomic Requirements in ISO 9241***

As mentioned earlier in this chapter, ISO 9241 contains ergonomic requirements for Human-System interaction. The standard concerns hardware, environment and software. This section will provide an overview of some of the requirements regarding software;

### **ISO 9241-10: Dialogue Principles**

This part of the standard refers to the interaction between humans and systems as a “dialogue” and contains seven dialogue principles [ISO9241, 1998]:

#### **10-1 Suitability for the task**

The dialogue should support the user to efficient and effectively complete a task.

#### **10-2 Self-descriptiveness**

The dialogue should give a clear apprehension of what the user should do, either through feedback or on request.

#### **10-3 Controllability**

The user should be able to control the interaction; its pace and sequences.

#### **10-4 Conformity with user expectations**

The dialogue should be consistent throughout and not break with accepted conventions.

#### **10-5 Error tolerance**

The user should be able to continue the dialogue, although making mistakes.

#### **10-6 Suitable for individualisation**

It should be possible to customise the interface software to the needs of the task and the user's skills and preferences.

#### **10-7 Suitability for learning**

The dialogue should support learning on how to use the system.

These are general principles, more specific techniques are stated in parts 13-17 of ISO 9241.

## **ISO 9241-12: Presentation of Information Attributes**

Part 12 of ISO 9241 contains specific recommendations on how to present information on visual displays. The recommendations are based on seven presentation attributes [ISO9241, 1998]:

### **12-1 Clarity**

Information is presented quickly and accurately.

### **12-2 Discriminability**

Information can be distinguished accurately.

### **12-3 Conciseness**

More information than necessary for fulfilling the task is not presented.

### **12-4 Consistency**

Repeated information is not presented differently.

### **12-5 Detectability**

The attention of the user is directed towards the required information.

### **12-6 Legibility**

Information is easy to read.

### **12-7 Comprehensibility**

The meaning of the information is understandable to the user.

## ***2.5 Guidelines for Handheld Mobile Device Interface Design***

Jun Gong and Peter Tarasewich at the College of Computer and Information Science in Boston, have documented some guidelines for design of mobile device interfaces in their paper “Guidelines for Handheld Mobile Device Interface Design”. These guidelines are based on Shneiderman’s eight golden rules, with some additional guidelines [Gong et al.2004]. They claim that half of Shneiderman’s rules apply directly to mobile devices, these are:

### **1 Enable Frequent Users to Use Shortcuts**

### **2 Offer Informative Feedback**

### **3 Design Dialogs to Yield Closure**

### **4 Support Internal Locus of Control**

The four remaining rules have been changed to fit mobile devices:

*Supplementary comments by Gong/Tarasewich.*

### **5 Consistency**

Consistency takes on an additional dimension with mobile applications: the consistency across multiple platforms and devices for the same application. Users of mobile devices may need to switch between their desktop machines and different mobile devices frequently.

- The “look and feel” should be the same across multiple platforms and devices.
- Elements of mobile interfaces such as names, color schemes, and dialog appearances should be the same as their desktop counterpart.
- Create input/output methodologies that are device independent - avoid using methods specific to mobile platforms where possible.

## **6 Reversal of actions**

Allowing easy reversal of actions may be more difficult for mobile devices because of a lack of available resources and computing power.

- Mobile applications should rely on network connectivity as little as possible.

## **7 Error prevention and simple error handling**

Preventing and handling errors on mobile interfaces are similar to those for desktop interfaces, although the need becomes more critical due to the more rapid pace of events in the mobile environment. Error prevention also needs to take the physical design of mobile devices into account.

- Nothing potentially harmful should be triggered by too simple an operation (e.g., power on/off).

## **8 Reduce short-term memory load**

Given the limitations of a user’s short-term memory, interfaces should be designed such that very little memorization is required during the performance of tasks

- Rely on recognition of function choices instead of memorization of commands.
- Use modalities such as sound to convey information where appropriate.

In addition, they have proposed seven principles focusing on the interface design:  
*Supplementary comments by Gong/Tarasewich.*

## **9 Design for multiple and dynamic contexts**

The contexts of computer applications used in the office, home, or similar settings are relatively stable. On the other hand, with mobile applications, there can be a significant number of additional people, objects, and activities vying for a user’s attention aside from the application or computer itself. Environmental conditions (e.g., brightness, noise levels, weather) can change depending on location, time of day, and season. The usability or appropriateness of an application can change based on these different context factors.

- Allow users to configure output to their needs and preferences (e.g., text size, brightness).
- Allow for single- or no-handed operation.
- Have the application adapt itself automatically to the user’s current environment.

## **10 Design for small devices**

As technology continues to advance, mobile platforms will continue to shrink in size and include items such as bracelets, rings, earrings, buttons, and key chains. New or modified interaction techniques may be necessary to overcome the physical limitations. Speech input is a viable alternative for devices too small for buttons. Sound can also be used for output, taking the place of text or graphics.

- Provide word selection instead of requiring text input.

## **11 Design for limited and split attention**

Users of mobile devices often need to focus on more than one task. A mobile application may not be the focal point of the user’s current activities. Mobile devices that demand too much attention

may distract users from more important tasks. Interfaces for mobile devices need to be designed to require as little attention as possible.

- Provide sound and tactile output options.

### **12 Design for speed and recovery**

For mobile devices and applications, time constraints need to be taken into account in initial application availability and recovery speed. When time is critical, waiting a few minutes for an application to start may not be in the user's best interest. Given the different contexts under which mobile devices are used, users may need to quickly change or access functions or applications. When such situations arise, a user would need to quickly and securely save any work already performed and resume it later without any loss.

- Allow applications to be stopped, started, and resumed with little or no effort.
- Application should be up and running quickly.

### **13 Design for “top-down” interaction**

Mobile devices with small screens have limitations on the amount of information that they can present at one time. Reading large amounts of information from such devices can require large amounts of scrolling and focused concentration.

- Present high levels of information and let users decide whether or not to retrieve details.

### **14 Allow for personalization**

Different users have different usage patterns, preferences, and skill levels.

- Provide users the ability to change settings to their needs or liking.

### **15 Design for enjoyment**

While functionality and usability are keys to mobile application success, other factors are also influential. Aesthetics is also part of designing an overall enjoyable user experience with mobile devices. ... If functionality and usability are equal, an application or device will stand out if it is attractive in some way.

- Applications should be visually pleasing and fun as well as usable.

## **2.6 Guidelines for Mobile Application and Service Design**

Mikko Nikkanen at Nokia Enterprise Solutions has in his article “One-handed use as a design driver: enabling efficient multi-channel delivery of mobile applications” presented a collection of guidelines which he has acquired from multiple sources. Some of these guidelines were originally intended for a specific technology, such as search engines, but may also be suited for applications and services. He has divided the guidelines into three types; general, content and navigation.

### **General Design Guidelines for Mobile Devices [Nikkanen2003]:**

*The supplementary comments are Nikkanen's.*

#### **G-1 Design for users on the go**

The design for mobile devices must include context and forgiveness, and provide time-critical information.

#### **G-2 Enable fast use**

Two major considerations for the users of a mobile service are the cost of access and the speed of downloading content. Many users are paying for mobile services by the minute, so if

they cannot get the information they are looking for within a short period of time they will stop using the service.

### **G-3 Keep it simple**

The old adages about keeping a system simple stupid and about “less being more” certainly apply for mobile devices and services. For instance, the most successful PDA devices do not attempt to replace the PC, but to complement the PC use, and the use of some other traditional tools.

### **G-4 Provide feedback and navigation cues**

It should be obvious what the application is, and how one can navigate from the page.

### **G-5 Include self-recovering capabilities**

Even if the network goes down, the service or application need not. There should be means to restore the values or written text, or to have them restored automatically.

## **Content Design Guidelines for Mobile Devices [Nikkanen2003]:**

*The supplementary comments are Nikkanen's.*

### **C-1 Present the most important content first**

The most important content should appear at the top of the page.

### **C-2 Keep content compact**

It is recommended to keep the pages short.

### **C-3 Don't make the page layout complicated**

It is recommended to keep pages simple and task-oriented, possibly text only, and to avoid elements that don't add direct value to the content.

### **C-4 Use simple text elements and styles**

The elements used in text layout should be clear and simple.

### **C-5 Pay attention to page titles**

It is important that the page title elements are descriptive, since they enable bookmarking and knowing where one is. The titles should however be short, preferably less than 15 characters.

### **C-6 Keep documents small**

Because there are various memory restrictions in mobile devices, the documents should be kept as small as possible.

### **C-7 Use compact link names**

Long linked text can make a page difficult to read and time consuming to scroll. It is recommended to use only one or two words as the title of the link.

### **C-8 Design clear forms**

Forms should not be too long. A clear way to cancel the form filling and for going back should be provided, but attention should be paid to form resets, since on small devices, forms are laborious to refill if all values are reset by accident.

### **C-9 Use smart graphics**

If graphics are used at all on small devices, they should be made informative, small and simple.

## **Navigation Design Guidelines for Mobile Devices [Nikkanen2003]:**

*The supplementary comments are Nikkanen's.*

### **N-1 Minimize steps in navigation**

With small screen devices, it is very important to design for economy of navigation. Users will be frustrated by scrolling through long lists of options, filling out complex search forms, and seeing needless pages along the navigation path.

### **N-2 Selecting instead of typing**

It is recommended to consider whether it is possible to ask the user to choose from a default list using select lists, checkboxes or radio buttons rather than typing in a selection. Alternatively one can offer a default list together with an input box.

### **N-3 Keep the navigation consistent throughout the service**

The way in which a user makes his or her way through the pages that constitute a service, interacting via links, menus and data input should be kept consistent throughout the service.

### **N-4 Design flat menus**

It is recommended to keep menus flat, because it is often difficult to form an overview of a service containing too many layers, and because a deep hierarchy makes the use more difficult.

### **N-5 Cross link**

The Back functionality is the most important way to go back. However, when users need to go back several levels, links to the starting page and subsection main pages are useful. A simple tree design is efficient, but the deeper the navigational hierarchy gets, the more necessary it becomes to get back to the starting point, and also to other pages.

### **N-6 Provide confirmations for important actions**

Confirmations must be there for actions like changing important values or deleting items. Even though the user needs to click OK on the confirmation page, that requires much less effort than e.g. returning to a list to check if an item was really removed.

### **N-7 Searching should be intuitive**

Searching should be a step-by-step, logical process. Once the search is performed, the results must be easy to scan, and the information should enable making good, informed choices within the results.

## ***2.7 Guidelines for User Interfaces for Mobile Devices***

Grace Hays at Hewlett-Packard, proposes several development guidelines in her article "Successful User Interfaces for Mobile Devices". She divides them into application, deck, card and navigation guidelines. She uses the notion "card" about a specific screen on the mobile device, whereas a deck is a sequence of such cards, intended to be viewed sequentially. [Hays2006]

### **Application Guidelines [Hays2006]:**

*The guidelines have been transformed into points, and the supplementary comments by Hays have been shortened.*

#### **A-1 Organize decks as wizards that guide a user through specific functions**

Present only the information the user really requires.

Minimize user interactions.

#### **A-2 The presentation layout should be consistent across the application**

Use the same types of elements for the same types of information

Keep the application simple (avoid unnecessary images and sounds).

### **Deck Guideline [Hays2006]:**

*The guideline have been transformed into a point, and the supplementary comments by Hays have been shortened.*

#### **D-1 Utilize decks to effectively display and guide users through multiple “cards” or screens**

Split large content bodies into multiple cards within a deck.

Label cards using a “1 of 3” or “1/3” to show the total number of cards in the deck, and the current card location.

When allowing the user to delete information, provide a confirmation card or “delete screen” so the user doesn’t inadvertently delete input data.

### **Card Guidelines [Hays2006]:**

*The guidelines have been transformed into points, and the supplementary comments by Hays have been shortened.*

#### **C-1 Scrolling should be minimized**

It is easier to move from card to card, than to handle lots of scrolling.

#### **C-2 Do not leave a row empty**

Some devices do not have scrollbars. Instead, use something to indicate that there is content following an originally blank line.

#### **C-3 Put titles on cards**

Try to keep these labels at five characters or less.

#### **C-4 Limit cards to nine items per card**

Use a “More” link as the 10th item. Too many elements causes unnecessary scrolling and it is easy for the user to get lost.

#### **C-5 Avoid wrapping the text of lists, menu items and links**

It clutters the screen and is less understandable to most users. Avoiding it allows the user to see more list items at a time. Wrapped links become difficult to read.

#### **C-6 Do not define more than two softkeys**

Many mobile devices do not support more than two.

### **C-7 Use softkeys to accept or present options**

...on cards that display information or confirm a user action. Users are most familiar with the softkeys, and proper setup of your wizards will effectively guide users with these softkeys.

### **C-8 Provide multiple paths to the same information**

For instance, to find a specific phone number, allow the entry of a zip code or city/state information.

### **C-9 Do not let the user proceed after entering improper information**

Mobile applications do not have display room to indicate many erroneous fields at once. If you ask for a date, validate the date before accepting more information.

### **C-10 Construct and use informative titles on input fields**

Communicate field type as well as format. Restrict length on input fields when possible, and distinguish between alpha and numeric fields. Avoid relying on font type and color.

### **C-11 Only use images or icons when they are necessary**

They take up precious screen space and bandwidth and can make the card too busy and unclear.

### **Navigation Guidelines [Hays2006]:**

*The guidelines have been transformed into points, and the supplementary comments have been shortened.*

### **N-1 Avoid cards with input fields when navigating backwards**

Otherwise, as users press back/clear, they will erase the inputted values.

### **N-2 Use intuitive links or softkeys**

Use “previous” and “next” to guide the user linearly in the deck. Use “more” to indicate jumping to additional pages of the same data.

### **N-3 Put navigation links at the beginning or end of a card**

Avoid embedding links in text unless they are very context sensitive.

### **N-4 Map the safest or most common action to the “accept” or “OK” softkey**

### **N-5 List link choices in the interface, not in the softkey options**

### **N-6 Incorporate a “done” softkey when possible**

To pop the user up to the next highest level.

## **2.8 HCI and Mobile Phones**

Although there is a lot of literature on the field of Human-Computer Interaction, it seems that very little of it specifically treats interacting with applications on mobile phones and how to achieve usability of mobile applications. A few efforts have been made, of whom some were presented in the previous sections, to introduce design principles for the user interfaces of mobile phone applications.

Most HCI-principles are so general that they can be applied on mobile applications. In some cases the principles should be used with precaution. As Grace Hays pointed out in the principle C-9, “Do not let the user proceed after entering improper information”, what is a good way of increasing usability of applications on large devices may be a bad solution on small devices. General principles may also be too general to be of much help for developers. For instance, “Make the interface content easy to apprehend” does not tell developers anything about how to fulfil the principle.

To sum up, principles intended for design of mobile phone user interfaces are scarce. General principles can be applied, but may not be very useful. Principles need to be specific, in order for developers to apply them in a way they can feel certain will increase usability. The field of Human-Computer Interaction needs more research, development and testing with users on mobile phone user interfaces to evolve more of such principles.

### 3 The Disabled and Elderly

In order to take into consideration the needs of the disabled and elderly when designing user interfaces, one has to know who these users really are, and which limitations they actually have.

The disabled are traditionally thought of as someone with a permanent, severe impairment, but the disabled group includes other types as well. Practically every human being gets disabled in some degree during his or her life, and the seriousness and duration of these disabilities can vary greatly. Anyone can be born with a disability, have predisposition to develop one or have an accident which causes one. A crick in one's back can make it impossible to even get out of bed. A sprained wrist can affect the ability to hold and handle things. Someone who has lost their glasses can be unable to read text and/or recognize objects, seeing the world in a blur. As people become older, they tend to get poorer vision, hearing, memory, ability to move, etc. These impairments in the aging population are disabilities<sup>2</sup>, as they affect, sometimes strongly, the way the elderly interact with and navigate in the society.

This section will provide a rough categorisation of impairments, made by Katherine and Gregg Vanderheiden, the latter is the Director of the Trace Research & Development Center at the University of Wisconsin-Madison. The categorisation was published as part of their report "Accessible Design of Consumer Products: Guidelines for the Design of Consumer Products to Increase Their Accessibility to People with Disabilities or Who are Aging" [Vanderheidens1991]. This categorisation will be used in the remainder of the report. The impaired users' problems with mobile phones, as well as some of the technologies that can be used to decrease such problems, will also be presented.

#### 3.1 Visual Impairments

This category is very important in connection with ICT equipment, as one usually need sight to interact with ICT user interfaces. It becomes even more important regarding mobile phones, as one will need very *good* sight to interact with such small devices. Visual impairments comprise everything from very poor vision, to people who can see light but no shapes, to people who have no perception of light at all [Vanderheidens1991]. 3 percent of the Norwegian population were registered as having "Reduced eyesight" in 2002 [SSB2006, StatBank], while the European percentage was 2,8 with "Difficulties in seeing" in 2002 [Eurostat2003]. Two types of visual impairments will further be presented.

##### Colour Blindness

The cones in our eyes receive wavelengths in three parts of the visible spectrum, classified as red, green and blue. The colour blind have reduced ability to distinguish between certain colours or wavelengths of light. Colour blindness is divided into three main groups; anomalous trichromacy (the green or red pigment is tuned towards the red or green spectrum), dichromacy (one of the pigments is missing) and monochromacy (two or all three of the pigments are missing). These first two types are further divided, as illustrated in table 1. [Rigden1999] [Tiresias2006]

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<sup>2</sup> It is therefore unnatural to constantly talk about the "disabled and elderly", as the elderly referred to in this context are disabled. From now on, the expressions "disabled" or "impaired" will be used.

Main type	Sub-category	Characteristics
Anomalous trichromats	Protanomolous	Red-insensitive
	Deuteranomolous	Green-insensitive
	Tritanomalous	Blue-insensitive
Dichromats	Protanope	Red-blind
	Deuteranope	Green-blind
	Tritanope	Blue-blind

**Table 1** Types of colour blindness [Rigden1999]

A fruit stall can be seen as in figure 1. Picture A is how people with normal vision would see it, picture B is how people lacking the red pigment would see it, picture C people without the green pigment and D people without the blue pigment.

A: Normal vision



C: Deuteranopic vision



B: Protanopic vision



D: Tritanopic vision

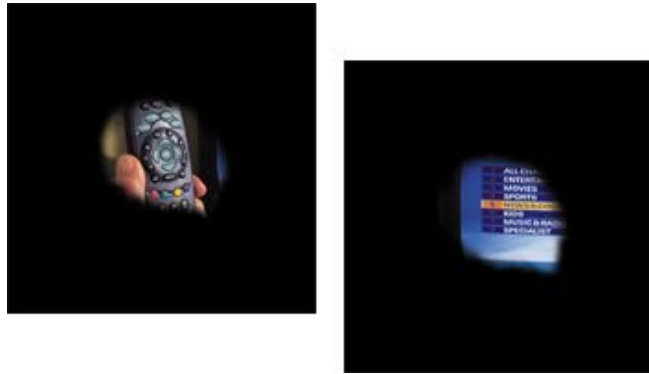


**Figure 1** A fruit stall as seen with some types of colour blindness [Tiresias2006]

### **Retinitis Pigmentosa**

Retinitis pigmentosa is a slow bilateral degenerative disorder of the retina, and leads, among other things, to progressive loss of peripheral vision. The first detectable symptom is night blindness, followed by constriction of the visual field. This gives a decreasing tube of vision, known as tunnel vision (tunnel vision can also be caused by glaucoma [RNIB2006]). The disease often results in total blindness. [Williamson et al.1986]

Figure 2 illustrates what it is like to suffer from tunnel vision.



**Figure 2 The effect of tunnel vision [RNIB2006]**

People with visual impairments have problems in situations where information is displayed visually. Those with severe visual impairments can obtain information by reading Braille or by auditory information. Others may obtain information by wearing glasses, using magnifiers, bright light, etc. Large size of text, easy-to-read fonts and high contrast between the colour of the text and the background is also important. [Vanderheidens1991]

The vision-impaired can have great difficulties in handling mobile devices, since one of their most important characteristics is their limited size. A limited size of the device gives a limited display and keypad size, which, combined with a need to display much information, often results in small characters and images. Several solutions exist for some types of visual impairments.

Software that enlarges parts of the screen has been developed. One of these solutions is Mobile Magnifier by Code Factory. Mobile Magnifier automatically detects and magnifies the area of interest. The user can zoom in and out to see as much as necessary of the screen, see figure 3. [CodeFactory2006, Mobile Magnifier]



**Figure 3 Using Mobile Magnifier [CodeFactory2006, Mobile Magnifier]**

Code Factory is also one of the companies that offer software for translating information on the screen into audio. Their software, Mobile Speak, provides speech feedback as the user navigates through the phone's interface by speaking all of the information displayed. It also gives the vision-impaired access to all of the phone's applications – including third-party applications which are not part of the phone's standard software. [CodeFactory2006, Mobile Speak]

Some people with visual impairments depend on Braille for input and output on mobile phones. Several companies deliver Braille devices. Handy Tech Elektronik GmbH's Brailino can be connected to mobile phones by using Bluetooth technology.



The Braille display offers 20 characters and an ergonomic keyboard, shown in figure 4. Their software package Talks&Braille adds speech output and Braille support for mobile phones. [HandyTech2006]



Figure 4 Brailino [HandyTech2006]

Braille devices enable the severely vision-impaired to write and read text messages, add contacts to the phone's address book and use many other of the functions a mobile phone can have.

Many phones have raised nibs on the keys, usually on the number 5 key. This helps people identify keys by touch. Some mobile phones are specifically designed for the vision-impaired. The Owasys 22C developed by Owasys has no screen; all feedback is given as audio, see figure 5. As with most phones of today, a headset can be connected to obtain privacy [Owasys2006]. Samsung's Touch Messenger has a Braille keyboard and display integrated [Samsung2006]. As seen in figure 6, the keyboard is on the top area of the phone and the display is underneath it.



Figure 5 Owasys 22C [Owasys2006]



Figure 6 Touch Messenger [Samsung2006]

### 3.2 Hearing Impairments

The Vanderheidens separate between having a hearing impairment and being deaf. People with hearing impairments can use their hearing when communicating, whereas the deaf can not [Vanderheidens1991]. For the sake of simplicity, the deaf will be included in the hearing-impaired group in this report. In Norway, 3 percent of the population was registered with "Reduced hearing" in 2002 [SSB2006, StatBank], while 2 percent of the European was registered with "Difficulties in hearing" [Eurostat2003].

Someone with a hearing impairment will have problems with obtaining auditory information. Solutions include use of hearing aids, sign language, lip-reading and TDD's (telecommunication devices for the deaf, makes it possible to communicate by phone). Information represented both auditory and visually is in many cases of great help, and can be useful for everyone, as we all get into situations where for instance background noises are very loud, making auditory information difficult to apprehend [Vanderheidens1991].

Regarding mobile phones, the hearing-impaired will have problems with perceiving sounds they make, such as a phone call coming in, low battery and other alerting sounds, feedback sounds – which can be particularly important to hear in some situations and/or applications, and of course they will have difficulties with communicating by phone. Most mobile phones have the possibility of notifying their user by vibrating, it is also possible to buy gadgets which vibrate when the phone rings.

Users of hearing aids have had trouble with interference when using mobile phones, as many digital mobile phones generate electromagnetic fields [HREOC2000]. Some attempts have been made to solve this problem. Nokia is one of those firms who offer loopsets, see figures 7 and 8, that can be used to increase the distance between the hearing aid and the mobile phone sufficiently to avoid interference. The loopset uses induction technology to transmit the sound from the mobile phone to the hearing aid [NokiaDis2001].



**Figure 7 Nokia Accessibility Loopset LPS-4**  
[NokiaLoopset2006]



**Figure 8 Nokia senior engineer Mikko Haho with Nokia loopset and mobile phone**  
[NokiaDis2001]

A TDD, also called textphone, is used by typing a conversation instead of talking. RNID Typetalk in Great Britain is a company that provides operators who reads the text for the receivers, or writes it when the receiver is hearing-impaired. When both parties of a conversation have textphones, they can communicate directly, without a third party involved. [RNIDtt2006]

Vodafone has developed software which enables the use of Nokia Communicator 9210i as a textphone [Vodafone2005], see figure 9. Another solution is to connect a textphone to the mobile phone. The one shown in figure 10, developed by Sensory Communications, can store messages/conversations received for later viewings, and also has several other features [SensoryCom2006].



**Figure 9 Nokia Communicator 9210i**  
[Vodafone2005]



**Figure 10 TextLink 9100M** [SensoryCom2006]

The arrival of the 3G network has provided video telephony as an alternative communication method. Video telephony can make face-to-face conversations by phone possible, thereby might also lip-reading by phone be possible. If the video-equipment of the phone can record a sufficient area of the upper body, sign language communication by phone might also be accomplished. This will be highly dependent on the network's capacity, the phone screen's resolution, etc. Nokia is one of the companies who deliver video-call equipment; the Nokia 6630 mobile phone can be connected to their Video Call Stand [NokiaVideoCall2006], see figure 11. They also have several phones with video-call equipment integrated, which will suit those who are able to hold their mobile phone during a conversation.



Figure 11 Nokia Video Call Stand PT-8 and 6630 [NokiaVideoCall2006]

As we have seen, there are several solutions for people with hearing impairments. These mostly concern how to communicate by mobile phones. Mobile applications that use audio may require other types of solutions for the hearing impaired, in order for them to perceive all of the information.

### **3.3 Physical Impairments**

People with physical impairments have limited or no ability to manipulate their body, or part of it. Statistics do not focus simply on the category “physical impairments”, but on types of physical impairments, making it difficult to get a correct number or percentage – as many have several physical impairments and thereby can be counted in multiple categories.

According to [Vanderheidens1991], problems include “...poor muscle control, weakness and fatigue, difficulty walking, talking, seeing, speaking, sensing or grasping (due to pain or weakness), difficulty reaching things, and difficulty doing complex or compound manipulations (push and turn)”. Assistive devices such as mobility-, manipulation-, communication- and computer/device interface aids will often be necessary for people in this group.

Physically-impaired may experience great difficulties in using mobile phones, according to which impairment(s) they have. Pressing the correct keys, or any, may be a hopeless task, even holding a phone is impossible or very difficult for some. People who have trouble speaking will not be able to use an ordinary mobile phone for communicating – in that case, textphones can be of help (This also applies to those who cannot speak, mentioned here as they do not fit into any of the Vanderheidens' categories).

Several handsfree kits have been developed for mobile phones, although most of these are not designed specifically for people with impairments. Sony Ericsson's Advanced Car Handsfree

HCA-200, figure 12, supports voice recognition; it is possible to make or accept calls just by talking [SonyEricsson2006]. Connecting such a kit to a wheel chair will enable some physically disabled to use mobile phones, at least for making phone calls.



Figure 12 Advanced Car Handsfree HCA-200 [SonyEricsson2006]

### 3.4 Cognitive/Language Impairments

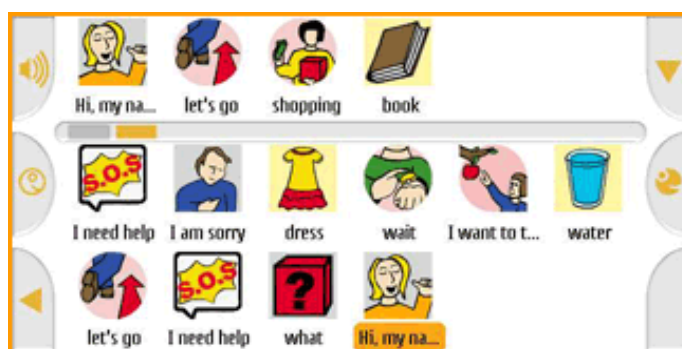
Cognitive impairments comprise many disabilities, such as severe retardation, inability to remember, and absence or impairment of specific cognitive functions (usually language) [Vanderheidens1991]. As for physical disabilities, the categories here are so many and so complex, making it hard to acquire a somewhat correct percentage of the population by adding them.

Those who have a cognitive impairment may have difficulties in recognizing and retrieving information, solving problems, etc. People with language impairments may have problems with comprehending written and/or spoken language, and/or expressing themselves. This does not only concern those who suffer from dyslexia, but also those who have to relate to a second – or more – language. There are no specific devices for people with these impairments, but using techniques like displaying information well arranged in a simple language, using obvious sequences, etc. can help some (and will also generally benefit people without such impairments). [Vanderheidens1991]

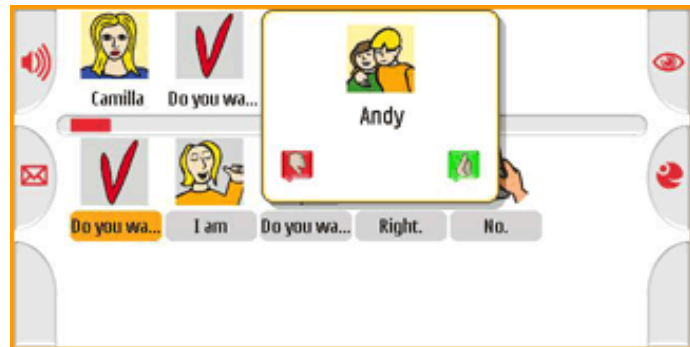
People with cognitive and/or language impairments will generally have the same problems with mobile phones as those mentioned above, although the user interface constraints of mobile phones may increase these problems. They may have trouble expressing themselves orally and/or by writing text messages, using the phone's features, such as adding people to the address book, using its applications, etc. Surveyable presentation of information, simple language and obvious sequences will be of help.

Lingsoft, Inc. has developed Imagetalk Symbol Writer, communication software based on symbols, for people with speech and language disorders. The software has features for face-to-face communication, writing messages and calendaring [Lingsoft2006], see figure 13.

Imagetalk® Composer and Imagetalk® Archive for face-to-face communication:



Imagetalk® Messaging for mobile communication:



Imagetalk® Calendaring for managing daily tasks and appointments:

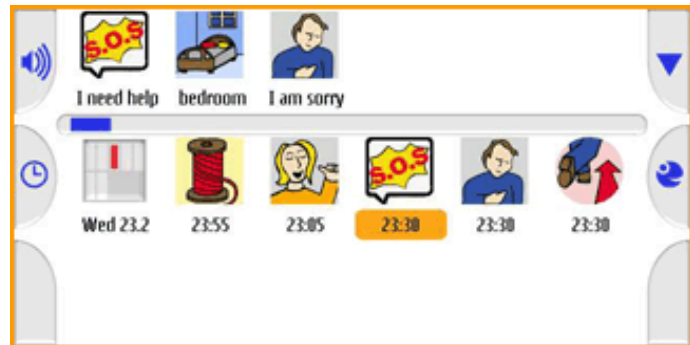


Figure 13 Imagetalk Symbol Writer features [Lingsoft2006]

### 3.5 Disabilities and Statistics

As mentioned briefly, some people may have several disabilities within a category, which causes complications for keeping track of the number of people within each category. In addition, the four categories can in some cases be connected. The description of physical impairments mentioned difficulty of seeing – which may be counted also as a visual impairment. People may have multiple disabilities which belong to separate categories, for instance can someone be both deaf and blind.

There is also people who are not aware of, or do not want to admit to themselves and others that they have a disability, which leaves them unregistered. This illustrates that it is hard to know the total number of disabled people, and also the number within each category.

## 4 Universal Design

There is still too little done within the field of Human-Computer Interaction regarding disabled people. Application of Human-Computer Interaction principles is supposed to increase usability, although usability for people with *disabilities* is usually not increased, as HCI-principles have rarely been made with the intention to accommodate disabilities. It is therefore necessary to investigate other fields and principles that do so.

In the 1950s, designing for people with disabilities became an autonomous area of attention. A social policy of moving people with disabilities into the community instead of institutionalising them, evolved. Special solutions tailored to individuals were the practice until the 1970s, when ideas of normalization and integration came. It was at that time, design first was recognized as a condition for achieving civil rights. [AdaptEnv2006]

The continual focus on including disabled people in the community has led to the evolution of the field mostly known as “Universal Design” in the United States of America and “Design for All” in Europe. This report will use the term Universal Design, as it is increasingly used by the Norwegian government [Brynn et al.2006].

Universal Design/Design for All is also called “Universal Usability”, “Inclusive Design” and several other terms. Many definitions of the notions are used, although the content basically is the same. Accessible Design is also a term often used about the field of Universal Design. Until Universal Design evolved, the notion usually meant designing products and services to be accessible to the disabled (tailoring). Universal Design has a broader focus; to design for *all* people.

Ron Mace, the inventor of the term “Universal Design” developed this definition:

*“Universal design is the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design.”* Ron Mace [CFUD2006]

The Center for Universal Design further adds:

*“The intent of universal design is to simplify life for everyone by making products, communications, and the built environment more usable by as many people as possible at little or no extra cost. Universal design benefits people of all ages and abilities.”* [CFUD2006]

Jim Tobias, the President of Inclusive Technologies, a firm that develops, markets and purchases accessible and usable products, and Gregg Vanderheiden have in [Tobias et al.2000] presented this definition:

*“Universal design is the process of creating products (devices, environments, systems, and processes) which are usable by people with the widest possible range of abilities, operating within the widest possible range of situations (environments, conditions, and circumstances), as is commercially practical.*

*Universal design has two major components:*

- 1. Designing products so that they are flexible enough that they can be directly used (without requiring any assistive technologies or modifications) by people with the widest range of abilities and circumstances as is commercially practical given current materials, technologies, and knowledge; and*
- 2. Designing products so that they are compatible with the assistive technologies that might be used by those who cannot efficiently access and use the products directly.”*  
[Tobias2000]

The European Institute for Design and Disability adopted “The EIDD Stockholm Declaration” in 2004 [EIDD2004]:

*“Design for All is design for human diversity, social inclusion and equality. ... Design for All aims to enable all people to have equal opportunities to participate in every aspect of society. To achieve this, the built environment, everyday objects, services, culture and information – in short, everything that is designed and made by people to be used by people – must be accessible, convenient for everyone in society to use and responsive to evolving human diversity...”* [EIDD2004]

Note that words like “disabled” and “disability” is not mentioned in the definitions. That is the core of the field of Universal Design; it is not about making special solutions for the disabled. One should rather think of what makes the product or service unusable to people with (or without) all kinds of abilities, and then try to design it considering as many as possible of these. The first two definitions state that in as great extent as possible (“commercially practical”), anyone should be able to use a product or service. In other words, it is not possible to create a product which absolutely everybody can use. Someone will always have a combination of disabilities that makes them unable to use a specific product, as it either is not (yet) possible to make a product for people with such combinations, or the industry does not find it rewarding. A product which accommodates people with all or many types of disabilities can be too expensive to produce, or it may be slow and even annoying to use for many people. Imagine for example a product with lots of loud warning sounds and light signals; this could lead to a severe decrease in the number of customers.

The aim of Universal Design is, like in Human-Computer Interaction, to achieve usability. The difference between the two is that Universal Design consciously considers how to achieve usability for *all* people.

## **4.1 Why Design Universally?**

As mentioned earlier, the existence of this field is connected to laws of civil rights. Below, a selection of the articles in “The Charter of Fundamental Rights of the European Union” [EURights2000] is presented. All of these somehow concern dignity and/or inclusion for human beings.

### Article 1: Human dignity

Human dignity is inviolable. It must be respected and protected.

### Article 3: Right to the integrity of the person

Everyone has the right to respect for his or her physical and mental integrity.

#### Article 21: Non-discrimination

Any discrimination based on any ground such as sex, race, colour, ethnic or social origin, genetic features, language, religion or belief, political or any other opinion, membership of a national minority, property, birth, disability, age or sexual orientation shall be prohibited.

#### Article 25: The rights of the elderly

The Union recognises and respects the rights of the elderly to lead a life of dignity and independence and to participate in social and cultural life.

#### Article 26: Integration of persons with disabilities

The Union recognises and respects the right of persons with disabilities to benefit from measures designed to ensure their independence, social and occupational integration and participation in the life of the community.

The articles 21, 25 and 26 belong to the part concerning equality. Equality generally means having the same possibilities and opportunities as anyone else. The disabled may not want to be treated like “outsiders”, being referred to special solutions or even not at all having access to the same products and services as everyone else – it might harm their dignity. This is an important reason for designing universally.

Universal Design also has several other benefits, as stated in a study made for the European Commission by the Telematics Applications Programme. The benefits are seen from three perspectives; the end users’, the national governments’ (“policy”) and the businesses’.  
[TAP1998]

#### End User Perspective [TAP1998]

- The disabled and elderly are naturally mentioned. They benefit when products accommodates them as well as others.
- Universal Design can benefit all users. People in very loud environments may benefit from a design that also accommodates people with hearing impairments, someone who are in darkness or have to focus on a particular task or point (driving) may benefit from design considering people with visual impairments, etc.
- Simple and error-friendly products can benefit people with “Techno-stress”, described as loss of dignity due to incapacity of handling new technologies, and thereby avoiding contact with them. An estimate is given, of concerning 30-40 percent of the adult population.
- ICT equipment designed with flexibility can benefit users with different preferences and tastes, different styles of interaction and different degrees of technical skill.

#### Policy Perspective [TAP1998]

- Equality will be considered and contributed to, trying to avoid discrimination in the society through design.
- The governments can spend less money on welfare when designs make the disabled more independent and integrated.
- The governments want to ensure that their nations’ industries are competitive and successful – which they can be by good designs on products and services.

#### Business Perspective [TAP1998]

- Businesses gain more customers when their products/services accommodate people with disabilities

- Since Universal Design improves products and services for all users, they will be better, more usable and more competitive.
- More usable products and services can remove or decrease other costs, such as resources spent on help-desks etc.
- When people see that a company is making efforts to make products/services more usable, the public opinion of a business can be raised and its brand name can be more acknowledged.

These benefits should be strong motivations for making universally designed products and services. However, there is not any overflow of principles or guidelines connected to Universal Design. Two such sets will be presented in the next sections.

## **4.2 The Principles of Universal Design**

What seem to be the most quoted and acknowledged principles of Universal Design are those developed by The Center for Universal Design at North Carolina State University. The principles can be used to “evaluate existing designs, guide design processes and educate designers and customers about the characteristics of more usable products and environments”, they consider how to achieve universal usability [CFUD1997]. In addition to the principles, the authors have provided definitions and guidelines for each of them<sup>3</sup>:

### **1: Principle One: Equitable Use**

The design is useful and marketable to people with diverse abilities

#### **GUIDELINES**

- Provide the same means of use for all users: identical whenever possible; equivalent when not.
- Avoid segregating or stigmatizing any users.
- Provisions for privacy, security, and safety should be equally available to all users.
- Make the design appealing to all users.

### **2: Principle Two: Flexibility in Use**

The design accommodates a wide range of individual preferences and abilities.

#### **GUIDELINES**

- Provide choice in methods of use.
- Accommodate right- or left-handed access and use.
- Facilitate the user's accuracy and precision.
- Provide adaptability to the user's pace.

### **3: Principle Three: Simple and Intuitive**

Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.

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<sup>3</sup> Copyright © 1997 NC State University, The Center for Universal Design

## GUIDELINES

- Eliminate unnecessary complexity.
- Be consistent with user expectations and intuition.
- Accommodate a wide range of literacy and language skills.
- Arrange information consistent with its importance.
- Provide effective prompting and feedback during and after task completion.

### **4: Principle Four: Perceptible Information**

The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.

## GUIDELINES

- Use different modes (pictorial, verbal, tactile) for redundant presentation of essential information.
- Provide adequate contrast between essential information and its surroundings.
- Maximize “legibility” of essential information.
- Differentiate elements in ways that can be described (i.e., make it easy to give instructions or directions).
- Provide compatibility with a variety of techniques or devices used by people with sensory limitations.

### **5: Principle Five: Tolerance for Error**

The design minimizes hazards and the adverse consequences of accidental or unintended actions.

## GUIDELINES

- Arrange elements to minimize hazards and errors: most used elements, most accessible; hazardous elements eliminated, isolated, or shielded.
- Provide warnings of hazards and errors.
- Provide fail safe features.
- Discourage unconscious action in tasks that require vigilance.

### **6: Principle Six: Low Physical Effort**

The design can be used efficiently and comfortably and with a minimum of fatigue.

## GUIDELINES

- Allow user to maintain a neutral body position.
- Use reasonable operating forces.
- Minimize repetitive actions.
- Minimize sustained physical effort.

### **7: Principle Seven: Size and Space for Approach and Use**

Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.

## GUIDELINES

- Provide a clear line of sight to important elements for any seated or standing user.
- Make reach to all components comfortable for any seated or standing user.

- Accommodate variations in hand and grip size.
- Provide adequate space for the use of assistive devices or personal assistance.

“The Principles of Universal Design were conceived and developed by The Center for Universal Design at North Carolina State University. Use or application of the Principles in any form by an individual or organization is separate and distinct from the Principles and does not constitute or imply acceptance or endorsement by The Center for Universal Design of the use or application.”

### 4.3 Fundamental Principles for Universal Usability

Gregg Vanderheiden, who is one of the authors of “The Principles of Universal Design”, has in his article “Fundamental Principles and Priority Setting for Universal Usability” presented “basic access” principles and their reasoning [Vanderheiden2000]. Universal Usability is defined similarly to Universal Design in [Tobias2000], which he co-wrote in. These principles are more directed towards disabilities, as one can see by them and their reasoning, presented in the table below:

<b>Basic Access Principle</b>	<b>Reasoning</b>
Make all information perceivable (including key & control-status & labels) <ul style="list-style-type: none"> <li>- Without vision</li> <li>- Without hearing</li> <li>- Without reading (low vision or cognition)</li> <li>- Without color perception</li> <li>- Without causing seizure</li> </ul>	Information which is presented in a form that is only perceivable with a single sense (e.g., only vision or only hearing) is not accessible to people without that sense. (Also not accessible by anyone using a mobile technology that does not present all modalities such as a phone – or automobile audio-only browser.)
Provide as least one mode for all product features that is operable: <ul style="list-style-type: none"> <li>- Without pointing</li> <li>- Without vision</li> <li>- Without requirement to respond quickly</li> <li>- Without fine motor movement</li> <li>- Without simultaneous action</li> <li>- Without speech</li> <li>- Without requiring presence or use of biological parts (touch, fingerprint, iris, etc.)</li> </ul>	Interfaces which are technology or technique specific cannot be operated by individuals who cannot use that technique (e.g., a person who is blind cannot point to a point in an image map; some people cannot use pointers accurately). (Also not accessible to mobile users who are using voice to navigate for example.)
Facilitate navigation <ul style="list-style-type: none"> <li>- Without sight</li> <li>- Without pointing ability</li> <li>- Without fine motor control</li> <li>- Without prior understanding of the content</li> </ul>	<p>Many individuals will not be able to use alternate access techniques if their layout is too difficult to understand.</p> <p>Many individuals will not be able to operate products, such as workstations, with</p>

<ul style="list-style-type: none"> <li>- Without the ability to hear</li> </ul>	<p>sufficient efficiency to be competitive if navigation is not easy.</p>
<p>Facilitate understanding of content</p> <ul style="list-style-type: none"> <li>- Without skill in language used on product</li> <li>- Without good memory</li> <li>- Without background</li> </ul>	<p>People with cognitive difficulties may not be able to access and use complex devices or products with language.</p> <p>Many others may find that they are unable to master alternate access techniques if layered on top of complex interfaces or content.</p>
<p>Compatible with assistive technologies commonly used by people</p> <ul style="list-style-type: none"> <li>- With low vision</li> <li>- Without vision</li> <li>- Who are hard of hearing</li> <li>- Who are deaf</li> <li>- Without physical reach and manipulation</li> <li>- Who have cognitive or language disabilities</li> </ul>	<p>In many cases, a person coming to a task includes the assistive technologies they have with them. If they cannot use products directly, it is important that the products be designed to allow them to use the tools they carry with them to access and use the products. This also applies to mobile users, people with glasses, gloves or other extensions to themselves.</p>

**Table 2 Fundamental Principles for Universal Usability [Tobias2000]**

The Principles of Universal Design were more specific than Vanderheiden’s. Their guidelines give developers an idea of how to apply them. Vanderheiden’s principles seem to be more appropriate to use as reminders of *who* to accommodate, since they do not tell how.

## **4.4 Politics and Legislation**

Authorities can make resolutions of laws, and reward or subsidise the industry for efforts towards accessibility and usability for the disabled and within Universal Design. This section will give an overview of the disability and Universal Design politics of Norway, EU and USA. Particularly for a relatively new field like Universal Design, a governmental policy is important in order to make businesses adopt the concept, and thereby provide for its further development.

### **4.4.1 Norway**

In 1976, parts on accessibility and usability for the disabled were added to the Act of planes and buildings (“Plan- og bygningsloven”). The first time a public policy that focused on participation and equality was launched, was in 1981. Parts that realise equal participation in the Universal Design sense were later added to several laws [Brynn et al.2006]:

- Act of kindergartens (“Lov om barnehager”).
- Act of work environment (“Lov om arbeidernvern og arbeidsmiljø”).

- Act of primary, secondary and comprehensive school (“Lov om grunnskolen og den videregående opplæringen”).
- Act of universities and colleges (“Lov om universiteter og høyskoler”).
- Regulation on elucidation of consequences, Act of planes and buildings.

The Norwegian parliament has come with several announcements and public elucidations concerning Universal Design the recent years, listed in [Brynn et al.2006]. “The government’s plan of action for increased accessibility, for people with reduced ability of functions” from 2004, comprises important areas of the society. The plan states several actions, also in the area of Information and Communications Technology, which shall be executed in the years 2004 – 2009. [NorwegianGov2004] The actions are very specific, and will not be interesting in this context.

None of the publications regarding ICT provide specific guidelines on how to achieve Universal Design. In “Universal Design everywhere!” (“Universell utforming over alt!”), an introduction on Universal Design made for the Social- and Health directorate [NorwegianSHDir2003], the principles of Universal Design from the North Carolina State University [CFUD1997] are presented. This may imply that the public sector in Norway in the future shall relate to these.

#### 4.4.2 The European Union

The European Union’s fundamental rights [EURights2000] mention non-discrimination, the elderly and the disabled, as seen earlier in this chapter. In the EU, the responsibility of providing equal possibilities and accessibility lies with the different units of the European Commission [Brynn et al.2006]. The legislation and regulations of the European Union mostly use the term accessibility, and in connection with disabled people only, thereby not using the Universal Design approach.

Several regulations and directives concerning people with disabilities exist within the areas of transportation and buildings. There are two resolutions within information and communications technology [Brynn et al.2006]:

- Council Resolution 5165/03 on “eAccessibility” – improving the access of people with disabilities to the Knowledge Based Society.
- Council Resolution 2002/C 86/02 on the eEurope Action Plan 2002: accessibility of public websites and their content.

An exception regarding to the lack of a Universal Design approach, is the work with “Participation for all in the Knowledge-based Society”, **eInclusion** (‘e’ for electronic), which eAccessibility is a part of. eInclusion is a project working to prevent that people, who from some reason are disadvantaged, are “digitally excluded”. Accessibility is here stated to concern also the elderly and people with specific environmental or social situations, in addition to the disabled. One of the suggested solutions is to use “Design for All” [EUeA2006], although guidelines for designing for all is not given. The European Union’s policy does not seem to focus highly on Universal Design, or to provide guidelines for achieving it.

#### 4.4.3 The United States of America

In the USA, non-discrimination of people with disabilities became an area of focus in the early seventies. In Section 504 of the Rehabilitation Act of 1973, discrimination on the basis

of disability is prohibited. The section apply to federal grants and programs; “...*any program or activity receiving Federal financial assistance or ... any program or activity conducted by any Executive agency or by the United States Postal Service*“ [USS508 2006].

The Americans with Disabilities Act (ADA) was established in 1990. The responsible parties are now expanded to include both public and private entities. Whether they receive federal funds is no longer of any consequence. ADA prohibits discrimination on the basis of disability in the areas of employment, public accommodations, commercial facilities, transportation and telecommunications. [USADA 2006]

Section 508 of the Rehabilitation Act, added by the U.S. Congress in 1998, requires Federal agencies to make electronic and information technology accessible to disabled people. Section 508 covers specific types of technologies, among those are *software applications and operating systems* and *web-based intranet and internet information and applications* [USS508 2006]. A selection of the requirements, according to relevance for this report’s focus, is shown in the table below:

<b>§ 1194.21 Software applications and operating systems</b>	
(c)	A well-defined on-screen indication of the current focus shall be provided that moves among interactive interface elements as the input focus changes. The focus shall be programmatically exposed so that assistive technology can track focus and focus changes.
(d)	Sufficient information about a user interface element including the identity, operation and state of the element shall be available to assistive technology. When an image represents a program element, the information conveyed by the image must also be available in text.
(e)	When bitmap images are used to identify controls, status indicators, or other programmatic elements, the meaning assigned to those images shall be consistent throughout an application's performance.
(h)	When animation is displayed, the information shall be displayable in at least one non-animated presentation mode at the option of the user.
(i)	Color coding shall not be used as the only means of conveying information, indicating an action, prompting a response, or distinguishing a visual element.
(j)	When a product permits a user to adjust color and contrast settings, a variety of color selections capable of producing a range of contrast levels shall be provided.
(k)	Software shall not use flashing or blinking text, objects, or other elements having a flash or blink frequency greater than 2 Hz and lower than 55 Hz.
(l)	When electronic forms are used, the form shall allow people using assistive technology to access the information, field elements, and functionality required for completion and submission of the form, including all directions and cues.
<b>§ 1194.22 Web-based intranet and internet information and applications</b>	
(a)	A text equivalent for every non-text element shall be provided (e.g., via “alt”, “longdesc”, or in

	element content).
(b)	Equivalent alternatives for any multimedia presentation shall be synchronized with the presentation.
(j)	Pages shall be designed to avoid causing the screen to flicker with a frequency greater than 2 Hz and lower than 55 Hz.
(n)	When electronic forms are designed to be completed on-line, the form shall allow people using assistive technology to access the information, field elements, and functionality required for completion and submission of the form, including all directions and cues.
(p)	When a timed response is required, the user shall be alerted and given sufficient time to indicate more time is required.

**Table 3 Technical Standards, Section 508 [USS508 2006]**

The American policy does not seem to be very Universal Design-oriented either, as it separates between people with and without disabilities. Although, the requirements of Section 508 can be applied on products and services as a step towards universal design.

## **4.5 Mobile Phones: What Has Been Done**

Some efforts have been made to introduce the concept of Universal Design in connection with mobile phones. Several producers have attempted to design their devices, and in some cases also their software, universal. However, universally designed third-party mobile applications and research on Universal Design and mobile phones seem to be scarce or non-existing.

### **4.5.1 NTT DoCoMo**

NTT DoCoMo is a Japanese producer of mobile phones and mobile phone accessories. The company has stated that it wants to focus on Universal Design. They have in cooperation with Mitsubishi Electric Corporation developed a phone with two screens, where the lower screen replaces the keypad, see figure 14. On the lower screen, the number and types of buttons can be pre-programmed. For first-time users or, for example, people with cognitive impairments, the lower screen can be set up to show buttons with the names of the people the user will call regularly. More experienced users can display the regular arrow keys and keypad, buttons for most used functions, etc. Touching the screen activates the current button's function. The phone is currently in the planning and testing stage.

[NTTDoCoMo2006]



**Figure 14 NTT DoCoMo's Universally Designed Mobile Phone [NTTDoCoMo2006]**

## 4.5.2 Fujitsu

Another company which wants to make products with a Universal Design is Fujitsu, who developed the Raku Raku phone in response to the growing demand for mobile phones that can easily be used by everyone. The paper “Universal Design Activities for Mobile Phone: Raku Raku PHONE” describes how a Universal Design is obtained [Irie et al.2005]. Below, the most essential features are repeated (Irie et. al’s descriptions of the features have been shortened).

### Buttons [Irie et al.2005]:

- Sufficiently large buttons located at sufficient intervals and protruding at least 0.5 mm from the body surface. Button positions can be sensed and input can be made without errors.
- Sufficiently large characters on buttons in a highly visible typeface printed in high contrast to the background, thereby avoiding incorrect reading.
- Start and End buttons are shaped differently from other buttons, figure 15 (a). The user can easily distinguish them visually or by touch.
- Lighting of buttons to be operated when a videophone call is received, figure 15 (b).
- Three one-touch dialling buttons for making calls to pre-programmed numbers, figure 15 (c). The buttons must be held down for at least one second to avoid incorrect button operation.

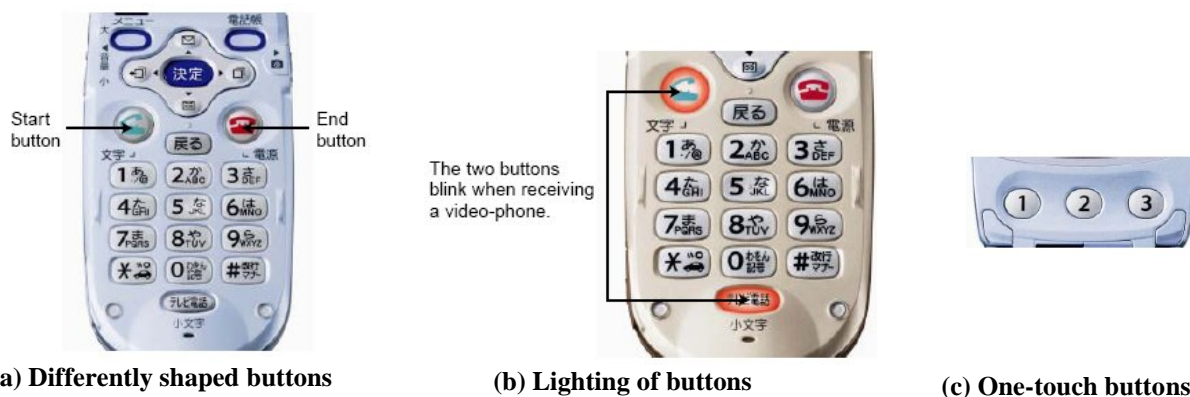


Figure 15 Button Design [Irie et al.2005]

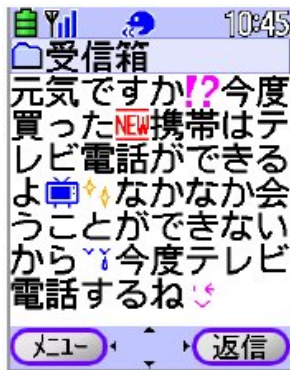
### Display [Irie et al.2005]:

- Sub-display on the back of the phone can show large characters, and is easy to read also when the display’s light is off.
- High contrast set between displayed characters and background enhances visibility.

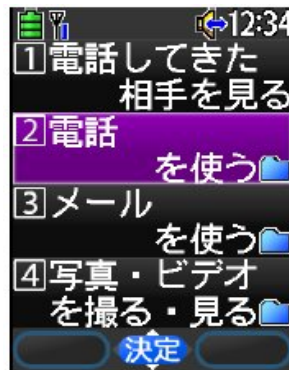
### User Interface [Irie et al.2005]:

- Large easy-to-read characters, figure 16 (a).
- Inverted screen display, figure 16 (b), optional inverting the colour scheme of the screen, thereby enhancing visibility.
- User-friendly camera and videophone functions, easy-to-understand operation procedures and simple screen display.
- Enhanced guidance function on-screen, figure 16 (c).

- Simple e-mail functions; Users unfamiliar with e-mailing will also be capable of sending e-mails.



(a) Large characters



(b) Inverted colours



(c) Guidance function

Figure 16 User Interface [Irie et al.2005]

#### Audio Functions [Irie et al.2005]:

- Text reading function, covers a wide range of content, including i-mode sites, guidance for operation, e-mail and phone book.
- Pictograph reading.
- Support of voice-activated call feature.

#### 4.5.3 Toshiba

Toshiba has established a Universal Design philosophy and standards for all of their product groups. They claim to have a Universal Design on mobile phones by an ergonomic design on operational key pitches and shapes, raised nib on the #5 key, large, easy to read text, selection of mode according to user skill, and a graphical user interface design which takes into consideration the problems with separating between specific colours [Toshiba2006].

#### 4.5.4 The Fastap Keypad

The Fastap keypad has two keyboards imposed on top of each other, see figure 17. This makes it possible to have more than 50 keys on the front of a handheld device with the size of a phone. Users can access applications more quickly and with less keystrokes. The inventors claim that "...the Fastap technology complies with the ideas of Universal Design and that therefore it has the potential to replace the 12 key keyboard in use of mobile phones..." and "Fastap technology can help make use of data devices easier for all people, if it can provide reduced cost or hindrance to all phone subscribers then we believe we have achieved the essence of Universal Design" [Hare2002]. This was written back in 2002, when the Fastap technology was at the starting stage. Mobile phones with Fastap keyboards are now being sold in the US, Europe and Asia [DigitWireless2006].



Figure 17 Phone with Fastap keypad [DigitWireless2006]

## **4.6 *The Future of Universal Design***

The practitioners of HCI have never been united in a desire to make products and services usable also by people with disabilities. Universal Design is clearly a more inclusive field than Human-Computer Interaction, as it focuses on designing usable products and services for everybody. Universal Design can even serve as a step towards treating everybody equally, by making products and services usable for more people without tailoring solutions.

The principles on how to achieve usability for all are not many. Norway is one of the countries which requires a Universal Design on some products and services in its legislation, but does not provide specific directions on how to design universally. Regarding mobile phones, very few efforts on research and application of Universal Design have been made. Even efforts within older parts of ICT are scarce. More research on how Universal Design can be applied on mobile phones is needed to better be able to encourage use of Universal Design, and, for the designers and developers, to be able to easily apply Universal Design in ways they can feel confident will have a positive effect.

## **5 Choice of Design Principles**

This chapter will provide the selection of approach, focus area, a group to focus on and design principles for achieving increased inclusiveness of mobile services.

### **5.1 Method of Approach**

When designing services that accommodate the elderly and disabled, a method of approach should be chosen. One is the “old-fashioned” Accessible Design approach: tailoring of services for types of disabilities. For a mobile services developer it would mean finding principles for all or several disabilities, and then customise a service (in this project’s case, J2ME applications) to be usable for the disabilities, and possible combinations of them, resulting in a large number of versions of the same application. Several versions of a J2ME application will have to exist anyway, as some mobile phones treat the same application in different ways. An application’s graphical user interface might appear completely different from phone to phone – and not always how the designer intended. Using this approach will demand making a number of disability versions for each of these versions. This is hardly feasible considering the amount of resources and work needed. There is also the matter of dignity and equality; people with disabilities may not want “special treatment”, particularly if it can be avoided.

Another approach is Universal Design, presented in the previous chapter. The philosophy of Universal Design is in line with the goal of making mobile services as “inclusive as possible”, stated in the introduction of this report. The negative aspects regarding resources and work will then be non-existent, as designers consider how many a product or service can accommodate with no or little extra costs. Another negative aspect then occurs; that this may result in less inclusive services than by tailoring. The dignity issue will also disappear, since Universal Design is to make a product which can be usable without modifications. Universal Design thereby seemed to be an appropriate approach, despite the risk of not accommodating as many as possible.

Finding and implementing guidelines for design of services that considers the constraints of as many as “commercially practical” [Tobias2000] is a huge task. It might also be necessary to do more research, like a more thorough study of types of disabilities. Particularly regarding the time perspective, the boundaries of this project would have had to be exceeded; a “clean” Universal Design approach was unfortunately not possible to have. Because of this, a disability or groups of disabilities to focus on was chosen, and a working definition of a Universal Design approach, that is more appropriate concerning this project’s boundaries, was made.

### **5.2 Group of Disabled in Focus**

As a part of the reasoning for the selection of a group to focus on, a brief description of the problems people with different impairment types can have with use of mobile services represented as applications, is provided:

### **Visual Impairments**

For Human-Computer (or human-mobile) Interaction to arise, the graphical user interface of mobile applications is extremely important for most users. A graphical user interface can be hard or impossible to interact with for people with visual impairments. A higher probability of incorrect input, since they in some cases cannot or barely see which key they press and/or the content of the display, also makes low tolerance for error a problem.

### **Hearing Impairments**

Audio-notifications and -feedback can be hard to perceive for people with hearing impairments who are using mobile services. This can, as they miss important messages, also lead to problems with low tolerance for error.

### **Physical Impairments**

People with physical impairments can have trouble with interaction that demands certain or any movements. Time-limitations and low tolerance for error will be problematic for those who struggle with navigating and writing or input by voice.

### **Cognitive/Language Impairments**

Like the vision-impaired, people with cognitive and/or language impairments will have problems with relating to a graphical user interface. They struggle with understanding the content of it, which leads to problems with understanding how and when to interact. This makes time-limitations and low tolerance for error problematic also for these people.

As seen, all of the categories may have problems with low error tolerance. The problems two of the categories can have with graphical user interfaces is although more critical, as it prevents many from being able to use the services at all, or very poorly. Better usability and accessibility of graphical user interfaces might reduce the probability of making errors in the first place. Accordingly, the possible focus groups were narrowed down to two; visual and cognitive/language impairments.

These two groups have separate problems with a graphical user interface; the vision-impaired struggle with *seeing* the content of it, which causes several types of interaction problems, whereas the other group struggle with *understanding* the content and how to interact with the user interface, because of disabilities like low intelligence, short-term memory or language-skills. Deciding on design principles for anyone in the latter group will most likely require a thorough study on the types of disabilities, their problems and techniques for reducing these problems, and was consequently not an option in this project.

To further narrow down the remaining category, severe visual impairments were excluded. The focus was on people with a “mild” degree of reduced eyesight, like long-/nearsightedness which can be corrected or almost corrected by using glasses.

## **5.3 Design Principles**

The definitions of Universal Design presented in chapter 4, stated that Universal Design was to design for *all* people, “to the greatest extent possible” [CFUD2006], “with the widest possible range of abilities, operating within the widest possible range of situations as is commercially practical” [Tobias2000]. Since a focus has been selected, it will replace the

designing-for-all philosophy. The working definition of the modified Universal Design approach for this project is:

*Design of mobile services to be usable also by most people with a mild degree of reduced eyesight, without requiring any assistive technologies or modifications.*

“Modifications” here means tailoring a service to be usable by people with these impairments, which section 5.1 states is not desirable.

### **5.3.1 Existing Principles**

When the area which is to be found design principles for, its focus group and other design boundaries had been set, a next step was to see how any existing principles and guidelines could be of use according to this. Universal Design principles may be of most interest, as the approach is based on Universal Design.

Three of the principles from The Center for Universal Design [CFUD1997] provide elements to consider. Users will in this project be the focus group and people without disabilities. The first principle, “Equitable Use”, reminds us that a design should be usable by all of these, without making any distinctions between them. The second principle, “Flexibility in Use”, is about considering individual preferences and abilities when designing. Principle four, “Perceptible Information”, says that necessary information should be communicated effectively to the user, regardless of the user’s abilities. Information is not communicated effectively when the user cannot see it. These principles can be very relevant when designing a graphical user interface that accommodates the focus group.

Section 4.3 presented the “Fundamental Principles for Universal Usability” [Tobias2000]. Only one of these principles, to make all information perceivable, is of relevance according to the chosen focus group. This principle is basically the same as “Perceptible Information”, mentioned above.

Some parts of the technical standards of the US’ Section 508 were presented in section 4.4.3. Of these do the ones regarding colours, (i) and (j) in § 1194.21 Software applications and operating systems, concern the focus group. Colour blindness or poor use of colour contrasts can cause problems for them, (i) and (j) are some steps that should be taken to reduce these problems.

Human-Computer Interaction principles have been developed, as mentioned earlier, with the intention of increasing usability. Few such principles are concerned with how to actually *see* an interface, since that is not an issue for people without disabilities. Although, some of these principles might be appropriate for this context.

Among Nielsen’s “Ten Usability Heuristics” [Nielsen1994] is “Consistency and standards”. People who have problems interacting with graphical user interfaces because of their sight may struggle even more with recognition, when the same object/function is represented in several ways. Number eight, “Aesthetic and minimalist design”, says not to present more information than needed in a dialogue, as important information can get decreased visibility in competition with any extra information. Vision-impaired people would benefit from not having to concentrate on perceiving something that turns out to be irrelevant information.

Shneiderman [Shneiderman1998] also mentions consistency in his first principle. The other of Shneiderman's golden rules do not apply to visual impairments.

In ISO's "Dialogue Principles", part 10 of ISO's ergonomic requirements [ISO9241, 1998], presented in 2.4, is consistency again mentioned in 10-4, "Conformity with user expectations". 10-6, "Suitable for individualisation" states that interface software should be possible to customise according to skills and preferences of the user, which surely can benefit people in the focus group.

The presentation attributes of part 12 of ISO's ergonomic requirements [ISO9241, 1998], "Presentation of Information Attributes", presented in 2.4, can all be of relevance. Some of these have already been mentioned:

- Information should be presented quickly and accurately
- Information should be possible to distinguish accurately
- Information should not be presented unless it is necessary
- Repeated information should always be presented in the same way
- Direct the user's attention to the important information
- Easy-to-read information
- Easily comprehensible information

Using these attributes as design principles should benefit people with mild visual impairments.

The first eight of Gong and Tarasewich's "Guidelines for Handheld Mobile Device Interface Design" [Gong et al.2004], presented in section 2.5, are not of interest in this context. Number nine, "Design for multiple and dynamic contexts", is of relevance as we have several user groups. Particularly the supplementary comment of allowing users to configure output according to needs and preferences, similarly to 10-6 of the ISO Dialogue Principles, can be useful, as a user without impaired vision may feel uncomfortable with voice output, large text, etc. Number 10, "Design for small devices" by providing word selection over text input can be beneficial. People who have trouble reading small letters will experience problems with using a phone's keypad. Guideline number 11, "Design for limited and split attention" can by effects like sound and tactile output make the user aware of when certain events occur, to make sure the users do not miss important events. Number 13, "Design for "top-down" interaction", by presenting high information levels and letting the user choose to see details, helps to keep the user interface well organised and free from unnecessary information. Guideline number 14, "Allow for personalization", basically deals with the same as number nine in this context.

Among Nikkanen's collection of guidelines, "Design Guidelines for Mobile Devices" [Nikkanen2003], presented in 2.6, are also some of relevance. Guideline C-1, "Present the most important content first", C-2, "Keep content compact", C-3, "Don't make the page layout complicated", C-4 "Use simple text elements and styles" and C-9, "Use smart graphics", are simple, easily applied guidelines which can all improve the usability for people with visual impairments. Word selection over input is also mentioned by Nikkanen, in guideline N-2.

Hays' guidelines for "Successful User Interfaces for Mobile Devices" [Hays2006], presented in 2.7, also includes the consistency issue in guideline A-2, "The presentation layout should be consistent across the application". The rest of her guidelines are not very relevant in this context.

### 5.3.2 Selection of Principles for Mobile Application Interfaces

Principles for this project could either be chosen directly from the existing ones mentioned above, or they could be chosen and modified, or entirely new ones could be created. Careful consideration resulted in choosing adjusted versions of two of the principles from The Center for Universal Design.

Because of the importance of dignity, “Equitable use” was chosen, and some of its guidelines were customised and/or adopted:

#### **Equitable Use**

The design should provide the same means of use for all users whenever possible, and avoid segregating or stigmatising any users.

Users may not want the exact same means of use, or it may not be possible to provide it. Flexibility should therefore be available, although without segregating or stigmatizing user groups. In connection to this, an adjusted version of “Flexibility in Use”, similar to “Suitable for individualisation”, “Design for multiple and dynamic contexts” and “Allow for personalization”, was an important follow-up principle:

#### **Flexibility in Use**

The design accommodates a wide range of individual preferences and abilities by allowing users to configure output to their needs and preferences.

Since the goal of this project is to find principles which make mobile services more inclusive, the descriptions of the principles should be more directed towards this field. That, and the decision to combine the two, leads to the following principle, which is so general that it can consider anyone, regardless of type of impairment or skills:

#### **Equitable and Flexible Use**

*A mobile service should provide the users with the possibility of configuring presentation of output according to their needs and preferences, without segregating or stigmatising anyone.*

Principles are used to increase the usability of products and services. It is the author’s opinion, that:

**The principle “Equitable and Flexible Use” can be applied in a way which makes a mobile service’s graphical content more perceivable to people with mild visual impairments, thereby increasing usability.**

The principle was implemented on a service in order to see if this assertion can be correct, presented in the next chapter of this report.

## 6 Implementing the Principle

There are many ways to apply the principle “Equitable and Flexible Use”, but the available time and the composition of Tellu’s HCI-package permitted partly implementation of only two. This chapter describes how the principle was applied, the changes in Tellu’s framework and the implementation on a service.

### 6.1 *The Idea*

People in the focus group have impairments which make it difficult for them to see clearly. It is likely that the smaller the presentation of a mobile phone application’s user interface is, the harder it will be to perceive the content of the user interface. The idea is to give the user, with no focus on skills and abilities, the possibility of configuring the size of the user interface elements in an application. It consists of two parts, where one is to let the user access the application’s settings and choose text size, such as small, medium or large. Small is default text size. All text, frames and other elements on the screen should then be scaled up according to the size given by the user. The other part considers that the user may not want to enlarge everything on the screen, for example because he/she only experience problems with seeing the content in some cases. This is solved by enlargement of the area in focus, by pressing a key predefined for this purpose.

Figure 18 presents a paper mock-up that illustrates how this can be realised in a general application. The paper mock-up does not attend any other design and usability considerations, such as which type of font is the best to read, whether or not a scroll bar is a usable feature, etc.

Figure 18 (a) shows the screen’s appearance with a small font, and presents the Menu and Settings choices. When pressing the right soft-button (soft-buttons are the keys usually located directly below the display), the settings screen will appear.

Figure 18 (b) presents an example of how the settings screen can look, the user changes the text size by choosing the area with “MEDIUM” or “LARGE” written on it, which in this figure is meant to represent what we think of as buttons from PC interfaces. When the user selects medium text size, everything on the screens will be scaled up accordingly, as shown in figure 18 (c).

Figure 18 (d) shows that the area which was in focus in (c) has been further enlarged by pressing a specific key, for example #. The main/focus area (in yellow) is the only part of the screen where items can be enlarged in this manner, as it is not possible to get the heading, scroll bar and menu-line in focus.

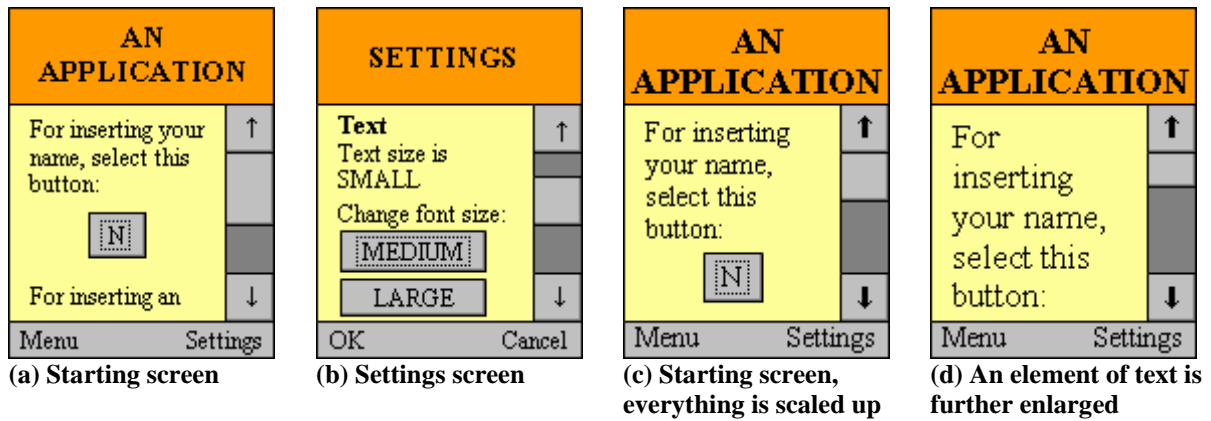


Figure 18 Paper mock-up: how the idea can be realised

## 6.2 Contribution to Tellu's Framework

Tellu and Ericsson NorARC have as part of the ARTS research project [ARTS2006] developed the Java framework ServiceFrame. The framework enables model driven development by using UML 2.0. It was created to make development of internet and telecom services more rapid, by separating the services from the underlying dependencies of the system: ServiceFrame is layered on top of two other frameworks, ActorFrame and JavaFrame, where ActorFrame is on top of JavaFrame. This separation makes the developers able to focus on the service they are developing, rather than technicalities [Bræk et al.2002].

Tellu is in the process of developing their own HCI-package for J2ME applications which is integrated with ActorFrame, but it can also be used to make applications without the extensive framework, as illustrated in figure 19. The HCI-package contains elements needed to build a user interface, such as drawing of text, input fields and lists.

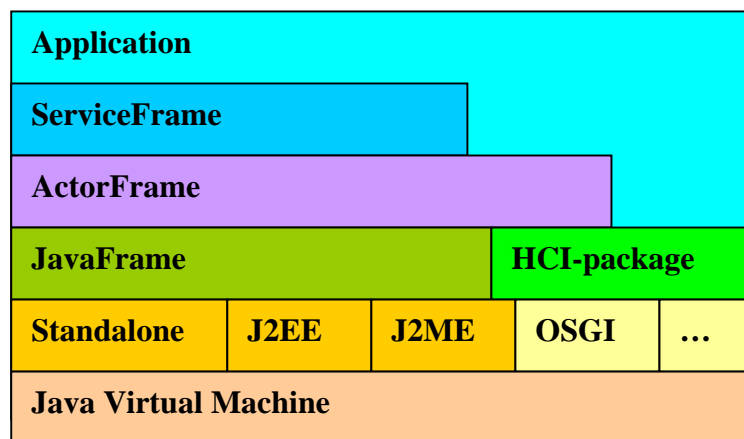


Figure 19 Architecture of frameworks with HCI-package

For implementation of the idea described previously, only the HCI-package was necessary to alter. Since the HCI-package is not fully developed, it has several flaws which made full implementation of the idea not possible to carry through at this time. The implementation was therefore restricted to enlargement of text and input fields only. These are the most important alterations/contributions that were made:

- The possibility of changing text size, which can be implemented on an application in two ways: change of text size affects all the text and input field elements in a screen, or only the one (or ones; a text element is often grouped together with an input element, as a label) in focus.
- A text element, for instance, is not only the text in it, but also the space and/or frames surrounding it, such as line-space if the text is divided on several lines. The elements have to define their height according to their font's height, in order to be able to dynamically calculate their layout (when the text size changes, everything must change accordingly). This way of defining their height was implemented some places, but now had to be used consistently.
- When the size of the text changes, the elements must update and communicate their new layout, such as calculating their new height and width. Updated height and width is necessary for calculating the following element's position coordinates.

### **6.3 The Idea Demonstrated on a Service**

Tellu is as a part of the research project OSIRIS [OSIRIS2006] cooperating with the Norwegian Tax Administration (“Skattedirektoratet”) to make a demonstrator of a mobile service. The mobile service shall provide functionality for changing of information regarding to tax calculations. This is a highly suitable service for demonstrating the idea, as it is meant to be used by practically all parts of the Norwegian population. The screen shots show a prototype with “dummy” data, as the development of the demonstrator is not completed.

#### **About the implementation on the service:**

- The functionality was implemented in the HCI-package. The service's J2ME application only needed to call on this functionality when certain keys were pressed and execute necessary checks, such as which is the current font size.
- Support for a “Settings” screen is not yet implemented by Tellu, the enlargement request was therefore for testing purposes communicated in the same way as for when only the area in focus should be enlarged; by pressing predefined keys on the keypad.
- Since the contribution to support for enlargement in the HCI-package only comprised text and input field elements, the size of the heading and menu-line were configured directly in the code when the screen shots were taken, to illustrate the idea as well as possible. The scroll bar was not enlarged in any way for the screen shots, as it turned out to be difficult to do.
- Tellu uses J2ME's built-in fonts. These fonts have only three sizes; small, medium and large. In order to make the heading “stand out” when the text size was large, it had to be made bold, as the heading already was large and could not get any bigger.

Like the paper mock-up, the implementation of the idea on the service does not attend other design and usability considerations.

The following figures present screen shots from a phone emulator. Different emulated phones may give different presentations of the screens, as the display sizes vary and the hardware producers implement the J2ME application program interface differently. Seeing the service on the physical phones might also give another impression than on the corresponding emulated ones. As the intention of showing the screen shots is to illustrate the idea, in order to

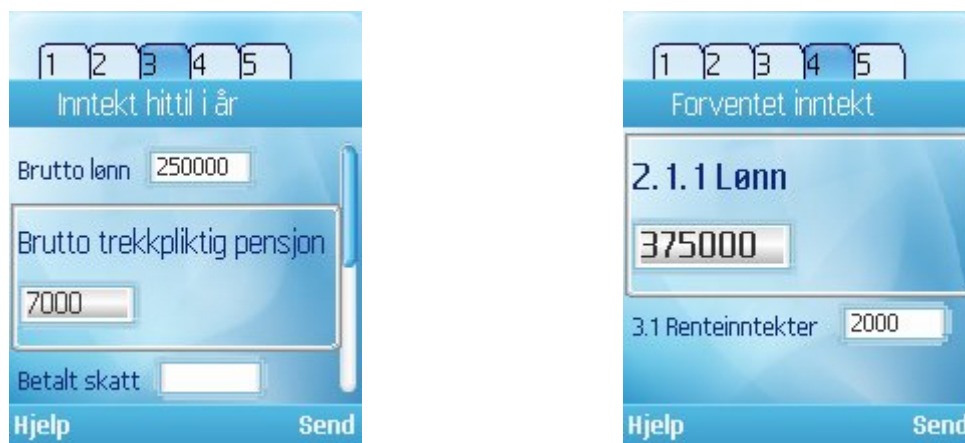
see if it may increase usability for people with a mild degree of reduced eyesight, only one emulated phone was used when taking them; the Sony Ericsson K700.

Figure 20 shows two screens from the mobile service with default text size. The user navigates between screens by pressing the left and right keys. Navigating between elements on a screen is done by pressing the up and down keys. Elements in focus have frames around them.



**Figure 20 Screens with default text size (small)**

The next figure shows the same screens, but now the elements in focus have been scaled up by pressing a predefined key. In screen number 3, “Inntekt hittil i år”, the focus area has been enlarged once. In screen 4, “Forventet inntekt”, it has been enlarged twice, which is as big as it can get.



**Figure 21 Default text size, but elements in focus are enlarged**

Figure 22 shows how the screens will appear when the user has configured the application to use medium text size. The size of the heading was medium when default (small) was set, and is now large.



**Figure 22 Screens set to show elements with medium text size**

The following figure shows the screens configured to show the same text size as in figure 22. Selected elements have been enlarged once, which is as large as they can get.



Figure 23 Screens with medium text size and elements in focus enlarged

The final figure from the service shows what the screens look like when the user has chosen large text size. Since the heading was large and there is no bigger font size in J2ME, it was made bold. Whether or not this was more readable is another discussion, which will not be taken here.



Figure 24 Screens with large text size

## 6.4 About the Application of the Principle

The two parts of the principle “Equitable and Flexible Use” were attended by the idea presented in section 6.1. The first part, configuring of presentation of output according to needs and preferences, is attended by letting the users change the application’s settings for size on presentation of output and enlarge certain elements as they please. The second part, not to segregate or stigmatise any users, is attended by presenting these options as functionality directed towards everyone, not only the focus group. It could have been unwise to direct them only towards vision-impaired, as others can benefit from them as well. Also users who are tired, who are driving, etc. may benefit from enlargement of output.

The implementation of the idea on a service has illustrated the effect enlargement of elements can have, thereby providing a fundament for deciding if the assertion was correct; whether or not usability for people with mild vision-impairments was increased.

## 7 Discussion and Conclusions

The assertion stated in section 5.3.2 claimed that the principle “Equitable and Flexible Use” could be applied in a way which increases the usability for the chosen group, people with a “mild” degree of reduced eyesight. In order to decide if changing the size of user interface elements really does increase usability, tests should have been performed on people from the group in focus. Since testing will be too comprehensive for this project, only the screen shots can indicate whether or not usability has increased.

It is evident that people with mild visual impairments can benefit from the possibility of choosing the size of the presentation of user interface elements. Even by studying the screen shots with a “normal” eyesight, it seems that the attention and effort needed to perceive the content decreases as the size of the elements gets larger. Usability must therefore be increased and the assertion fulfilled, as people from the group in focus will be more able to perceive the content when characters are bigger and easier to distinguish from each other, than when they are small. To increase usability further, the services should provide larger fonts than what is built-in in J2ME today. Although, very large font sizes can have a negative affect, as users are in greater risk of losing context the less they see of a screen’s original content. A different set of colour contrasts might also have been beneficial regarding perceiving content, but configuring colours was not a part of the solution.

Many design principles and guidelines are very general, as one can see by studying some of those presented in the previous chapters. This can be a negative aspect, particularly when they have not been further defined, since a lack of directions on how to apply a principle may be more likely to lead to a poor and unusable product or service. The principle “Equitable and Flexible Use” is also general. We have now seen it applied as enlargement of screen content, and this is concluded to increase usability for the focus group. Thus, enlargement may serve as a guideline to the application of this principle:

### **Equitable and Flexible Use**

A mobile service should provide the users with the possibility of configuring presentation of output according to their needs and preferences, without segregating or stigmatising anyone.

**GUIDELINE:** Offer enlargement of screen content

This principle can be categorised as a Human-Computer Interaction principle, as it concerns interaction with ICT equipment. As mentioned earlier, not just the group in focus can benefit from the chosen application of this principle. If possibility of enlargement is applied, also people who have their focus elsewhere may be more able to apprehend the service’s content. This should make the principle with the enlargement guideline qualified to also be a Universal Design principle for mobile services.

This project was supposed to result in a proposition of one or several principles for making more inclusive services. Since the chosen way to apply the principle “Equitable and Flexible Use” was concluded to increase usability, we can state that the principle can be applied to increase usability, although not all applications of it may do so. A more usable service ought to be a more inclusive service. As more people can use a service they can configure to fit their needs, than if they do not have this option, the resulting principle must make mobile services more inclusive.

The principle does not as such contribute with a totally new way of doing inclusive design, but the two parts of it are very important. The possibility of configuring presentation of output may be extremely important in mobile services, as people use their mobile phones in many contexts and environments and have very different needs. Some might not want, for instance, every word in a mobile service to be read up for them, while others are dependant of this functionality. Besides, a mobile service can end up to be more confusing than usable if many, different disabilities are accommodated at the same time. The other part of the principle, not to segregate or stigmatise anyone, is also very important. Everyone should be treated equally regardless of their abilities.

Many have contributed to the field of Human-Computer Interaction with design principles, also called rules, guidelines, etc. This report has presented a selection of these. Most of the HCI-principles concern interaction with computers, not mobile phones.

Regarding Universal Design, the knowledge base is underdeveloped. A thorough search resulted in only two sets of principles, where the author of one set is a co-author of the other. These sets are meant to be applicable on all kinds of products and services. No one seem to have made principles with a Universal Design focus specifically for Information and Communications Technology, thereby also not for mobile phones and services. In order to make principles less general, which makes them easier for developers to apply in a way that increases usability, principles should be made for specific areas, such as mobile services. It is evident that much remains to be done regarding Universal Design and mobile phones.

At a first glance, Universal Design may seem like a very appealing approach. However, the main “ideological” contribution, i.e. usability for all people “to the greatest extent possible”, may also be not so great at all. What about all of those who will not be accommodated? As mentioned earlier, some have disabilities or combinations of disabilities which prevent them from using certain products and services with today’s technology. This is not possible to do anything about. Then, there are others, who will be excluded because companies will loose their return on investment by accommodating them, or because of any other reason which enables them to claim that they have designed for all to the greatest extent possible. Moreover, if a service is only available with a universal design, several users will not be able to use this service since *their* needs have not been accommodated, and they will depend on someone helping them. This is incompatible with having equality as a motivation for Universal Design.

The focus on Universal Design increases. The authorities of Norway and the European Union have started to use the Universal Design concepts. Eventually, more businesses will want to or have to plead a Universal Design philosophy. Some of these may be less serious than others, and since the Universal Design concept is very open to misuse by letting those applying it decide who should be accommodated, usability for all can easily end up as usability for people with no disabilities. To prevent this, either the concept should be altered or some kind of control system, such as certificates, should be introduced.

Usability of mobile services is opposed by the trend we have had for the last years; mobile phones have continually been getting smaller. Display resolutions have increased, making screen content smaller and hard to see for many. The keys on keypads are smaller and often placed close to each other, making it harder to press the correct key. This evolution have been driven by the market; many buyers want their mobile phone to be small. The trend will hopefully change when today’s largest user groups get age-related impairments and discover that a small device size can be impractical.

Because mobile phones usually have a very small device size, enlargement of screen content may not help the mildly vision-impaired sufficiently – the size of the keys on the keypad will remain the same. In order to achieve full usability, these people can use phones developed for people with visual impairments. Most producers make some phones with larger keys and larger printing on the keys, than on their “normal” phones. Combining solutions for increasing the usability of the device and of the interaction may be the best strategy for people with any type of disability.

## 8 Future Work

Much remains to be done in order to increase the inclusiveness of mobile services. Maybe most importantly, more research on interaction with mobile phones is needed in order to see which solutions and principles are good or not. Acknowledged user interface design principles for applications on computers may not be applicable to applications on mobile phones, as the device interfaces are completely different.

The proposed principle, “Equitable and Flexible Use”, should have more guidelines on how to apply it. The guideline suggested accommodates mainly people with “mild” visual impairments, although others may benefit from this application. Guidelines which accommodate people with other types of disabilities need to be found. This will in turn require a more thorough investigation of types of disabilities and their consequences for use of mobile phones.

Naturally, more principles on design of mobile services ought to be proposed.

The proposed principles need to undergo series of usability tests on people with different types of disabilities, in order to claim that the principles increase usability and inclusiveness of mobile services.

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