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Commercial Graphical User Interface for Digital TV

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Master's Thesis in Human Computer Interaction



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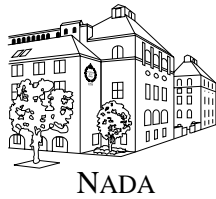


**KTH Numerical Analysis
and Computer Science**

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Master's Thesis in Human Computer Interaction (20 credits)
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Abstract

Commercial Graphical User Interface for Digital TV

This report describes the development of a prototype for a new type of graphical user interface (GUI) for digital TV set-top-boxes. There were three main goals: to produce a prototype of a GUI with a different graphical layout than the one currently used in Ecton AB's set-top-box, to establish a working menu hierarchy for the GUI and to include commercial ads in the GUI. Designing with the inclusion of commercial ads from day one was done to establish whether a commercial GUI with a high level of usability is plausible and, more importantly, if it is accepted by users.

The prototype was refined through an iteration process of prototype building, usability tests and qualitative interviews with potential users. General GUI design theories as well as TV specific GUI design issues were taken into consideration during the entire design process.

The results show that a commercial GUI is indeed plausible, but there is a deep distrust towards everything that has to do with commercial ads on computers and TVs. This might make the introduction of such a GUI difficult. Both the goals of creating an interface different than the current one and to establish a menu hierarchy were accomplished even though the menu hierarchy is not yet finished due to uncertainties about exactly what functions and services will be included in the end product.

Sammanfattning

Kommersiellt grafiskt användargränssnitt för digital-TV

Denna rapport beskriver hur en prototyp för en ny typ av grafiskt användargränssnitt (GUI) för digital-TV-boxar togs fram. Tre mål sattes upp för exjobbet: att skapa en prototyp av ett GUI som skiljer sig från Ecton AB:s nuvarande gränssnitt rent layoutmässigt, att fastställa en menyhierarki för gränssnittet samt att ha med reklam i gränssnittet. Att bygga gränssnittet med reklam redan från början gjordes för att utröna huruvida ett kommersiellt GUI med hög användbarhet verkligen är möjligt samt för att se om det är något användarna finner acceptabelt.

Prototypen förbättrades stegvis genom en iterativ process av prototypbyggande, användbarhetstester och kvalitativa intervjuer med potentiella användare. Generella teorier för gränssnittsdesign såväl som TV-specifika problem vid gränssnittsdesign togs i beaktande genom hela processen.

Resultaten visar att ett kommersiellt gränssnitt mycket väl är möjligt att skapa men också att användarna hyser en stor misstro till allt som har med reklam att göra i både dator- och TV-världen. Detta kan göra att introduktionen av ett kommersiellt gränssnitt kan bli svår. De båda andra målen, att ta fram en prototyp för ett layoutmässigt annorlunda gränssnitt samt fastställa en menyhierarki uppnåddes inom ramarna för vad som var möjligt. Menyhierarkin är inte helt komplett då alla funktioner som skall finnas i digital-tv-boxen ännu inte är fastställda.

Foreword

I would like to thank Ecton AB for the opportunity to do my master thesis at the company and for answering all industry specific questions. I would also like to thank my tutor Sinna Lindquist for answering all my questions every time I showed up at her office unannounced.

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1 GENERAL

1.1 Background

The future of television is digital. In Sweden the terrestrial analogue TV broadcasts will be shut down in 2008 [Radio- och TV-verket, 2003] and in many other European countries the transition to digital broadcasting will take place within the next 10 or 15 years. Digital broadcasts have already begun though and a market has opened up for set-top-boxes (STB) to enable digital TV in our old analogue TV sets. With this new broadcasting standard comes many new technical possibilities and most STB:s today are more than just digital-to-analogue converters. Everything from electronic program guides to video functions and internet access is being built into the modern STB. With all these functions comes the need to control it all. The solution generally adopted is a graphical user interface (GUI) shown on the TV screen.

Ecton AB, one of the competitors on the STB market, wanted a new GUI for their set-top-box. They wanted the graphical layout of this GUI to differ from their current one which they were not quite satisfied with. They also wished to examine the possibility of including commercial ads in the GUI. Could this be done without interfering with the usability of the GUI? Commercial ads can generate substantial extra revenue for the company but there is also the risk of losing customers if the GUI is rendered useless by the ads.

The goal of my master thesis was to produce a prototype for this new commercial GUI. It should differ in layout, include commercial ads and still maintain a high level of usability.

1.2 Problem definition

There are two major problems when it comes to designing this new commercial graphical user interface (GUI). The GUI:s in many of today's set-top-boxes for digital TV vary greatly in design and usability. Most of them leave a lot to be wished for in both areas. The reason for that basically depends on one factor: experience. The concept of showing a GUI on a TV screen is a new area of expertise and it presents a whole new set of problems to take into consideration: maintaining the TV concept, what fonts and sizes to use due to limitations in picture resolution and distance to the screen, what colours are usable due to certain colours' tendencies to flicker and bleed on TV screens and so on.

Further more, in the academic world of human computer interaction commercial ads of any kind is a big no-no. It distracts the user from the task at hand. For a company on a competitive market the possibility to include commercial ads in their product could be a very promising economic asset in the form of extra revenue. To mindlessly attach commercial ads in a GUI just because the technology allows it, as often seen on various web pages, is generally not a good idea. It will most likely hamper the user's interaction with the GUI. The problem is to find a way to let the users concentrate on the task at hand and still show the commercial ads. Unfortunately, for reasons unknown, this is an area where precious little research can be found.

1.3 Scope of master's project

The scope of this master's project was to develop a prototype of a new type of graphical user interface (GUI) including commercial ads. There were three main goals:

- The GUI should differ in graphical layout from Ecton AB's current GUI and possess a high level of usability.
- A menu hierarchy was to be established. This will make the implementation of the final product easier by giving a clear structure to work with. A clear menu hierarchy will also improve the usability of the GUI.
- Commercial ads were to be included to study how people react to them in order to determine if, where and how commercial ads can be included in an interface without drastically affecting the usability of the GUI.

1.4 Delimitations

Some distinct delimitations were needed to make this project manageable by one person within the given time frame.

Interaction tools

Even though navigation in the graphical user interface is an important part of the project the actual tools for navigating (i.e. remote control, keyboard etc.) were not evaluated. A mock up of a very simple remote control was shown to the users to give them an idea of how the interaction could be done but nothing more was done.

Services and functions

No study of what services or functions to include were done. Instead a set of services and functions included in Ecton AB's current set-top-box were included as well as a few future functions that will be included in their next generation of boxes. Some of these functions require complex graphical interfaces meriting a project of their own and in such cases they were either not included in the prototype or only represented by a very simple interface to give the users an idea of what to expect.

Interviewees

Potential users with handicaps that would affect the usage of a graphical user interface were not interviewed in this project.

1.5 Theory

All GUI:s (graphical user interface) are meant to allow people to use a program or a service but only a user adapted GUI will let them do that with minimum effort in an easy and intuitive way. It should be obvious to the user what options are available and how to use them [Eronen, 2000]. What constitutes as easy and intuitive may of course vary from case to case and from person to person and when it comes to an appliance such as the TV the users are such a wide and diversified group that it is considered impossible to please every user [Ergo Gero (1), 2004]. However, this should not discourage the GUI designer from producing a GUI that will be easy and intuitive to most TV viewers. By including the commercial ads in the user adaptation process rather than just adding them after the GUI has been developed a commercial GUI with a high level of usability should be quite plausible.

Designing a GUI for a TV screen includes issues specific for that type of display (see chapter 3) but the fundamental principles to support usability still remain the same and can be divided into three main categories: learnability, flexibility and robustness [Dix et al., 1997]. All three categories can be further divided into sub categories but only a brief summary will be given below. Further more, language and layout are two important parts of interface design and are also described below.

1.5.1 Learnability

Learnability has to do with how easy it is for a novice user to initially learn how to use the GUI and later on to attain a maximal level of performance. This is achieved by making the interface predictable to the users by making possible operations visible as well as maintaining a high level of consistency throughout the GUI when it comes to input-output in similar situations. By using publicly accepted standards and/or conventions in selected parts of the GUI the users will also be able to generalize from this and their familiarity with similar situations and thus improve the learnability of the GUI [Dix et al., 1997].

1.5.2 Flexibility

A flexible system should let the users initiate most dialogs with the system and minimize any artificial constraints on the input dialog. It should also allow the users to pertain to more than one task at a time, to pass on the control of a certain tasks to the system (or to gain control from the system). The user interface should also be customizable by allowing either the user or the system to modify the interface for specific needs. The user's customization should be restricted to more cosmetic changes while the system should be able to change function or content based upon the current state of the system. This also ties in with the robustness of the system [Dix et al., 1997].

1.5.3 Robustness

A user should be able to determine the internal state of the system through the GUI and also, as far as possible, to recover from any possible errors that have been recognized by the user. Ideally it should not be possible for the user to commit any errors at all but some decisions that are perfectly valid in the system might at a later time be perceived as an error by the user who must then be able to correct or recover from this. Responsiveness and task conformance are also important factors when considering a system's robustness. A system with long response times will feel unreliable to users and if it does not support the tasks that the users expect to be available to them this will also reduce the robustness of the system in the sense that it is not complete [Dix et al., 1997].

1.5.4 Language

From the programmer's and company's point of view a GUI supporting only one language (e.g. English) would be preferred as it requires less work and therefore is cheaper to produce. From the user's point of view the possibility to use menus in their own language is a huge benefit, especially since not all users will be familiar with any other languages than their native one. In all prototypes the language used was Swedish. That does not mean that every written word in the GUI is necessarily a Swedish word but rather words used in Sweden when referring to the concept of TV, video, menus etc. This way the users can immediately access their conceptual knowledge [Anderson, 2000] about these functions without first going through possible translations of words.

1.5.5 Layout

The layout of a GUI is tightly tied to principles of learnability, flexibility and robustness. Even though there are several ways to vary the layout of the GUI some important rules still need to be followed.

"The user should easily be able to recognize the interactive elements (buttons and such) and those should roughly be arranged along vertical and horizontal dimensions, so that the user can anticipate the movement of the focus according to the arrow keys used (or other input devices). They should also be able to clearly identify information-based content and navigation links to central nodes and lead-in points. The information chunks which belong together should have the same consistent layout and once chosen, a screen layout should be reused continuously. A consistent approach to the screen layout allows the user to confidently predict the location of information and navigation controls across the information chunks" [MUSIST, 2004]. What this amounts to is to build a clear pattern in the GUI as shown in figure 1. This does not necessarily limit the possible layouts available to the designer as a good working pattern can be accomplished in many ways as shown in figure 2.

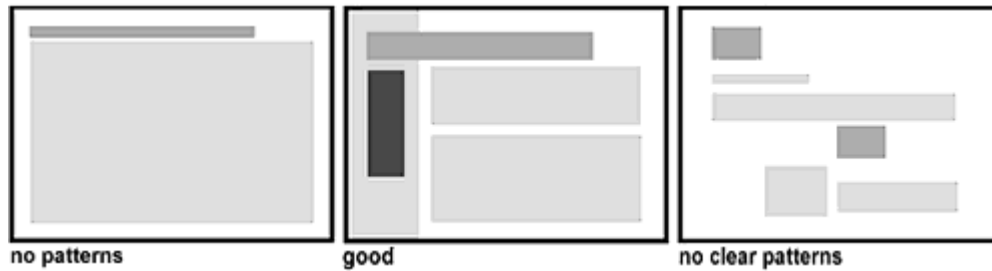


Figure 1: Building up clear patterns [MUSIST, 2004]

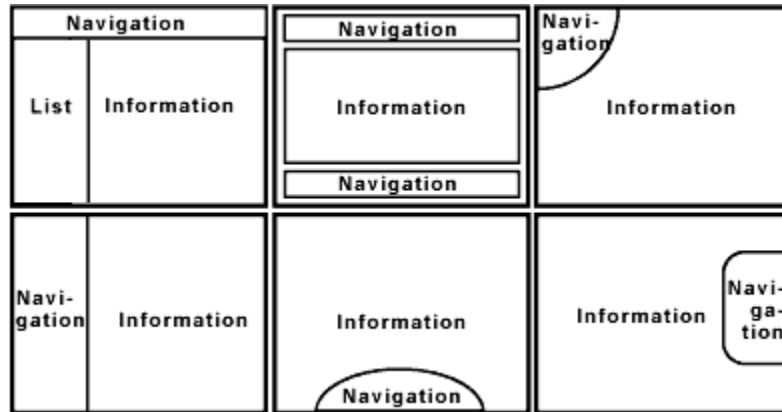


Figure 2: Examples of possible screen layouts [MUSIST, 2004]

1.6 Methods/approaches

The prototype of the commercial graphical user interface (GUI) was developed through an iteration process where prototype design was followed by usability tests and qualitative interviews with potential users. A prototype design session and a set of interviews required approximately one week each and this was repeated a total of four times. For each turn in the iteration process the GUI was refined through the findings in the interviews. This choice of approach to solve the problem is a bit time consuming but often results in a very user friendly GUI with a minimum of confusing options from the user's point of view.

1.6.1 Iterative design and prototyping

It is never possible to fully anticipate how a GUI will be used or what features the users will expect. The best way to solve this problem is to actually implement a prototype of the GUI in some form and test it on real users and then modify it. That is the essence of iterative design. With each pass of prototyping and testing the GUI will be further improved and can also be made more complex as confidence in the design grows. Iterative design is considered necessary for a good interactive system design but there is one big problem: time. It takes time to build prototypes and with each extra pass in the iteration process it takes even more time. By employing rapid prototyping techniques this time sink can be countered to some degree. The rapid prototyping techniques used in this project were throw-away prototypes in the form of storyboards and limited functionality simulations [Dix et al. 1997, Preece et al. 2002]. The time spent on iterative design should at least to some extent be compensated by the fact that the resulting product is often less prone to fail once it is released since it has been tested and refined prior to release.

Throw-away prototypes

The idea of throw-away prototypes is that the design knowledge gained from the prototype is used to build the final product (or the next prototype) but the actual prototype is discarded. To build each prototype from scratch is time consuming but it also allows the designer to change prototyping techniques between iterations. This also allows for more and more advanced prototypes, going from storyboards to limited functionality simulations as the confidence in the design grows. This also gives the designer the possibility to try out different approaches to solve a problem and thus avoiding that flawed solutions are inherited from one prototype to the next due to recycling. It also has the added benefit that any adequate tool can be used for the prototype building process since the end product should only draw upon the findings of the prototypes. This makes the entire prototype design process a lot easier [Dix et al. 1997]. There are other types of prototypes available to developers, such as incremental and evolutionary prototypes. Incremental prototyping is when small parts of the product are fully developed and put together in larger blocks until the product is complete. Evolutionary prototypes are the opposite of throw-away prototypes. For each pass in the iteration process the prototype is recycled and improved upon [Dix et al. 1997]. Neither of these two prototypes were considered useful in this project though as they would require that all hardware is available and that was not the case.

Storyboards

Storyboards are snapshots of how the GUI will look in different situations. The snapshots can be hand made sketches or paper printouts. There are two major benefits to using this prototyping technique, it is easy to make changes and the users are more prone to suggest changes in a simple prototype where they feel they are not ruining someone else's work. The drawbacks of this technique are that it is slow and static. Changes on the "screen" take time as the designer has to replace one piece of paper with another and dynamic content like clocks and animations is almost impossible to simulate for the exact same reason [Preece et al. 2002]. The storyboards in this project were drawn by using the program Paint Shop Pro. With the tools available in the program mock ups of the interface were drawn and printed to A4-size papers. By cutting out the different parts of the menus and placing them on another paper with a picture printed on it the interaction with menus on the TV screen was simulated. The possibility to make the paper cut outs stick to a TV screen with the help of static charges on the screen's surface was also used to give the users a better impression of how it is all supposed to work. This was a slight modification of the storyboard concept.

Limited functionality simulations

A limited functionality simulation is a computer program simulating some of the functions in the GUI. This kind of prototype is much better when it comes to demonstrating the work that the GUI will accomplish since the interaction will be quicker and smoother than with the storyboards and more complex functions can be simulated [Dix et al. 1997]. The limited functionality simulations used in this project were created using the programming language C#, Microsoft's integrated development environment Visual Studio .NET and DirectX. This made it possible to build GUI prototypes with functioning menus and simulated TV broadcasts. It is important to remember that it is still a throw-away prototype that is produced and no code should be recycled. Because of this the choice of programming package is of little importance as long as it can be used to simulate everything that should be evaluated in the prototype.

1.6.2 Qualitative interviews and usability tests

In the iterative design process it is important to know which aspects of the prototype that work and which do not. To know that something is not working as intended is not enough though. It is imperative to know why certain concepts or features do not work or are not being used. Without that information it will be very difficult to improve the GUI.

Qualitative interviews are in-depth interviews done with a limited number of users in order to gain a deeper understanding of how they perceive the GUI and its functionality. This kind of interview is perfect for establishing the reasoning behind a user's actions and expectations. This takes time and requires strict attention from the interviewer during the entire interview. It is also often difficult to get a statistic match between interviewees and the actual user group. This is sometimes seen as a weakness but advocates of the

method say that individual reasoning has little or no connection with demographic statistics. As long as the interviewee matches some part of the target group that is enough [Trost, 1997].

The time aspect and the limited number of people involved are the two main drawbacks when comparing this method to quantitative interviews where a large number of people answer the exact same questions through given alternatives (typically yes, no or some sort of grading). Quantitative interviews are good for establishing people's feelings toward something and are typically performed by sending out questionnaires to a large number of people. It is desirable to statistically match these people with the target group. The strength of this method is that it is very useful to pinpoint flaws and errors in a product and what type of user is having troubles with it, but the results from qualitative interviews say nothing about the reasoning behind the answers. Because of this it gives no real suggestions as to what can be done to improve the design.

Combining these two techniques would of course be a good way to find most problems and then reveal the reasons for these problems. Due to limitations in both time and resources qualitative interviews were deemed to be the only viable choice for this project. Because of this some errors or flaws in the design might slip through the prototype process undetected but the major ones are still likely to be caught with only a few interviewees [Trost, 1997].

Usability tests are performed with users to observe how they operate a system or perform certain tasks. Do users handle tasks the way the designer imagined? Are they able to do what they want? The tests can also show if the system works as intended and if there are any specific problems with the system. Through observations like these the design can be improved. Interviews can be used to further establish more subjective user-experience goals like satisfaction [Preece 2002].

In this project qualitative interviews and usability test were performed simultaneously. This allowed for quick questions about choices the user made while using the interface. The questions were asked immediately after an action had been performed and hopefully before the users forgot why they did it or that they did it at all. Not all decisions are made on a conscious level and even if they are the reasoning behind it can quickly be forgotten. It was also desirable to establish the user's immediate feelings when first confronted with the commercial ads and the qualitative interview could therefore not be postponed to after the usability test.

Before the tests/interviews started all users were asked to either explore the prototype GUI or to perform certain tasks in it. In order to get as much insight as possible to how the users reason while using the GUI they were encouraged to think aloud. This is a method often used to further the understanding of users' decision processes or attitudes by letting the users describe what they believe is happening, why they take an action and what they are trying to do [Dix et al. 1997]. During the part of the qualitative interview that took place after the actual testing users were encouraged to speak freely about their likes and dislikes about the GUI. This often resulted in more of a discussion than an interview but almost always raised interesting questions that could be pursued further.

All observations, questions, answers and spontaneous user comments that were of interest to this project were written down for immediate analysis after the test/interview session. For the last set of interviews and usability tests a video camera was used to record the users' interactions with the GUI and the interviews. There were two reasons for this: The prototype was quicker and easier to use, making it hard to keep up with only pen and paper. The users were allowed to interact with the GUI on their own and could be expected to forget to think aloud. In previous tests all interaction with the GUI had to go through the interviewer but this would not be the case this time. Since it was the last set of tests and interviews it was also desirable to get as much out of it as possible.

1.6.3 Selection of users

The persons participating in all tests and interviews were chosen among people I know. They were typically chosen to differ as much as possible from each other in order to roughly match the extremely diverse group that TV viewers form. As described above the concept of qualitative interviews is not to get a perfect statistic match of the target group and pinpoint their views of things, that is what quantitative interviews are for, but rather to get a few representatives of that group and to find out more about the reasoning behind their views of things. It is still desirable to cover as much as possible of the target group though. By choosing

as diverse users as possible their expectations of and experiences with the GUI will hopefully help to catch as many flaws and errors in the prototype as possible. In this project a total of 9 different persons were involved as users in the tests and interviews, four women and five men with ages ranging from 14 to 57. Their interest in computers, TV and technology in general varied from none to experts. Preferably one user above the age of 60 should have been included in the tests but unfortunately there was none available on short notice that didn't also match the delimitations for interviewees (see 1.5). All versions of the prototype were designed with the sensory, cognitive and motor changes that accompany aging in mind though.

All in all 11 different users participated in the usability tests and qualitative interviews. Six of the users participated in all four sets of tests and interviews. One user tested only the first version, one user tested only the third and another three users tested only the last version.

1.7 How to read this report

This report is primarily a detailed account of my master thesis but can also be read in a more general sense as a guide to designing a commercial graphical user interface (GUI) for digital TV set-top-boxes.

This first chapter should have given the reader a basic understanding of what is needed to design a GUI as well as an overview of why and how this project was executed. Chapter two explains why the inclusion of commercial ads in the graphical user interface should be examined and possible benefits and drawbacks are discussed. After that specific TV design issues are discussed in chapter 3. These are of a more practical nature than the general GUI design theory described in 1.6 and mostly deal with limitations due to the technology used. If these issues and guidelines are not taken into consideration there is a substantial risk that the GUI will not work properly on a TV screen. Chapter 4 gives a brief overview of hardware, software and standards used in the digital TV industry 2004. In chapter 5 basic design decisions for the prototype are followed by a walk-through of each of the four versions of the prototype including results from usability tests and interviews as well as a short description of the tests. The compiled results are then presented in chapter 6 and discussed in chapter 7.

2 COMMERCIAL ADS IN THE GRAPHICAL USER INTERFACE

Any graphical user interface (GUI), no matter how perfect, can be ruined and shunned by users if commercial ads are included without any thought behind it. An example of this is the far too common occurrences of web pages losing visitors due to pop-up ads and banners rather than lack of content or usability (without the pop-ups and banners of course). It should therefore be of interest to research how a GUI can be designed with the possibility of adding commercial ads without affecting the usability of it. In the academic world of human computer interaction it is common practice to strive for optimum usability in all kinds of applications. This usually means removing everything that is not related to the task at hand and minimizing any sources of interruption [Dix et al. 2000]. This is not always a valid option outside the academic world though. In a competitive market where exposure in the form of commercial ads can make or break a company's success there will always be a demand on possibilities to maximise this kind of exposure. Unfortunately this tend to reduce usability to a second rate priority. It should not have to be this way and that is what makes the concept of a user adapted commercial GUI interesting.

2.1 Benefits

Including commercial ads in the user interface could be beneficial for both the users, the companies and anyone who wants to market products or services. There are basically two ways a user could benefit from this. First of all, the revenue the manufacturer of the set-top-box (STB) can collect from letting up space for commercial ads might lower the cost of the STB for the end consumer. Secondly, commercial ads is a way to make people aware of a new (or to the user unknown) product or service on the market and they might just find some of them useful. From the companies' point of view the advertising business is a huge money machine and the possible extra revenue from commercial ads can be quite substantial. Being able to lower the price of the STB for the end user through this could also give a company an edge on a competitive market where the end consumer is always looking for lower prices. Finally, TV is a mass market and the advent of digital TV and the new market for STBs that goes with it offers yet another way for the marketers to expose products and services to the masses.

2.2 Drawbacks

As well as possible benefits from including commercial ads in the graphical user interface (GUI) there are naturally a couple of possible drawbacks. If handled wrong the commercial ads can substantially lower the usability of a GUI by distracting the user in various ways or even hinder them in performing a task in the GUI. The content of these ads might also be of concern to the user, e.g. politics, alcohol and adult content. Depending on the users' views on some of the content and how strongly they feel about it the GUI might even be rendered unusable and cause the users considerable aggravation. Further more, if the users do not like how the commercial ads are included in the GUI or the general messages conveyed through the ads they will most likely not buy the set-top-box and this is naturally not what the company inteded. In addition, dwindling sales figures might cause marketers to back off and further reduce the revenues for the company. Depending on how frequently the users actually use the GUI and the exact placement of ads within the GUI might make the marketers feel that their money can be better spent elsewhere.

3 INTERFACE DESIGN FOR TV

Much of the knowledge needed to design a graphical user interface (GUI) for the TV screen with a high factor of usability can be referred to as general design issues that are common for all type of user interfaces (see 1.6) but there are also some new concepts and restrictions to take into consideration. The points raised below are of a more practical nature than the general design issues since they are mostly derived from restrictions imposed by the TV technology of today and how we use this technology. They are nonetheless very important in order to design a usable GUI for TV.

3.1 The users

Generally when designing a graphical user interface (GUI) the developer has a “typical user” in mind. When it comes to television and the millions of users involved the notion of a “typical user” is no longer useful but there are some common traits and trends that can be taken into consideration [Ergo Gero (1), 2004]. First of all, TV viewing is a passive task in the sense that the amount of interaction with the actual TV set is minimal. The user turns on the TV set, leans back and is entertained. The use of the remote control to change channel or volume can of course be seen as an active task, but in contrast to an active task like using a PC, where the user usually leans forward and constantly interact with the system through mouse and keyboard, watching TV is indeed a passive task. Watching a TV program can be emotionally a very active task [Mountford et al., 1992] but has more to do with the content of a specific program rather than watching TV in general. This passiveness is in no way a drawback but rather the strength of the TV concept, maximum output for minimum input, and should therefore be maintained even though new functions will indeed require some more input from the user. New technology is also often developed with young healthy people in mind but with the aging demography TV interfaces should rather be designed with a 60-year-old viewer in mind. This means understanding the sensory, cognitive and motor changes that accompany aging [Eronen, 2000].

3.2 Maintaining the TV context

Even though the development of digital TV and the possibilities to integrate TV and computer offers some new and exciting areas to explore the most important new functions relate directly to TV viewing. The majority of TV users only care about new opportunities to enhance TV viewing. It is generally undesirable to leave the TV context when bringing up the graphical user interface (GUI) on the screen, mainly because the users still want to know what is going on in the programs they are watching but also because they don't like to switch from one context to another. That is a typical computer phenomenon that most TV viewers are not used to. The sound should always be there unless the user mutes it and the video should always be at least partly visible. There are basically two types of layouts to choose from in order to keep the video visible. One is the picture in picture layout where the GUI cover the entire screen and the TV picture is shown in a window approximately $\frac{1}{4}$ the size of the screen. This way the user can see the entire picture while using the GUI, but because of the small size of the picture it will be difficult to interpret subtitles and to notice details in the picture. This is the layout of Ecton AB's current GUI (there is no screenshot available of this GUI due to a agreement with Ecton AB). The other way is to let the GUI float in front of the picture. This will not change the size of the picture but will block out parts of it. If the floating approach is chosen it is important to not cover the entire picture, even if it just a border around the GUI it will still give valuable information to the users as to what is going on. For this approach it is also advisable to make the GUI using 3D-graphics and making it semi transparent to further enhance the apparent depth separation between the interface and 2-D video [Ergo Gero (1), 2004].

3.3 Picture resolution

It is important to realize that digital TV has nothing to do with the picture resolution on our TV screens but rather with the transmission of the TV signal between antennas. What is important for the designer to know is that TV screens are inferior to computer screens in terms of resolution. There is currently a number of standards for TV screen displays around the world and a few more are being developed and most of them use different resolutions depending on both picture encoding (PAL, NTSC) and aspect ratio (4:3, widescreen) [Ergo Gero (1), 2004]. With the development of flat TV screens using the same technology as for computer screens this might change over the next 10 or 20 years as people buy new TV sets but until then we must adapt to low resolution TV screens. For PAL systems with a 4:3 aspect ratio the resolution is approximately 625*500 (lines * pixels/line). Most modern computers graphic cards with a TV-out port show a resolution of 800x600 pixels (or more) and therefore information/details will be lost due to the conversion to a lower resolution. This low resolution severely limits the available space for information and the level of details to be displayed in the graphical user interface (GUI) and in combination with a required minimum size of text (see Font size below) getting all necessary information into the GUI can be challenging. If one adds the goal of maintaining the TV context (see 3.2) it gets even harder.

3.4 Colours

Using colours is an effective way of adding extra meaning to a graphical user interface (GUI) but there are certain things that need to be taken into consideration. First of all conceptual design and layout have priority to the employment of colours. Before colours can be used the data must be structured appropriately in a black/grey/white mode. This also avoids operating problems for users with colour-blindness or black and white TV sets. Secondly, some colours or combination of colours work better than others, especially on a TV screen. For instance, white should be avoided as background colour since large white areas on TV screens tend to flicker. Pastel colours should be chosen over intense glowing colours since long sessions of intense glowing colours on the screen leads to signs of fatigue sooner than pastel colours [MUSIST, 2004]. The number of colours used should also be limited since it gives a more aesthetically pleasing look but also because when using more than about 6 colours the ability to pick out individual elements declines [Ergo Gero (2), 2004].

The colours in themselves can convey feelings, as shown in figure 3, and they are often used to emphasise something, like red for alarms or warnings and green for “ok” alternatives.



Figure 3: Typical everyday meaning of colours [MUSIST, 2004]

This is good to know when the main colour for the GUI is chosen since it will send a message of what to expect to the user. However, the designer must be aware that the meaning of colours can differ between different parts of the world. The examples given here hold true for Europe and America. In all prototypes where colours were used blue was used as background colour since it can convey a feeling that the interface is intuitive and trustworthy (as shown in fig. 3) but also because it is sometimes referred to as the colour most people choose as their favourite one.

3.5 Fonts

When selecting the fonts for the graphical user interface (GUI) there are several to choose from and most of them might look appealing on the computer screen or printed on paper. Due to the picture resolution, viewing distance and colour display limitations relating to TV screens only a handful of fonts are left for the developer to use. The three main points to take into consideration when selecting one or more (preferably no more than three) fonts to use in the GUI are face, size and style [MUSIST, 2004].

Font face

With the use of computers several new font faces have been developed that are better suited for screen display than the old fonts for paper printing. This has not reduced the number of fonts designed specifically for paper printing though since the printing business in general has been computerized. The result is a wide variety of font faces to choose from and when designing a GUI for TV the following guidelines should be taken into consideration:

For better legibility the standard font for the text body should have the following characteristics:

- proportional
- on-screen optimisation
- clear shaping of letters
- strong lines
- wider letters
- larger height of the lower cases (comparing to the total height of the font)
- wider letter spacing (comparing to the equivalent printer font)

Avoid fonts with the following characteristics

- monospaced
- containing letters with fine lines
- smaller height of the lower cases (comparing to the total height of the font)
- delicate serifs and ornamental details
- narrow letters
- less letter spacing

Serif less standard font faces are less critical than serif fonts, but they also give the text a more technical and unwelcome look. For larger text bodies a very clear and legible font should be used. Examples of font faces that have the right features for display on a TV screen are Arial, Avalon, Gill Sans and Univers. For this project Arial was the font used.

Font size

The user of a normal TV set should be sitting at a distance of at least 5 times the height of the screen. All texts must therefore be presented in a font and size that are easily legible. The minimum font height (h) in mm can be derived from the viewing distance (d) in mm by using the formula $h = 0,0052 \cdot d$.

With a viewing distance of between 2 and 4 meters this gives a minimum font height of 10.4 – 20.8mm. Generally a font size of at least 20 pixels or more should be used to attain this and it was the size used in the limited functionality simulations (see 5.1.3). The actual height of a 20 pixels font size will vary depending on the size of the TV screen but so will the viewing distance and the end result is usually acceptable. There are of course screens that deviate significantly in size but are used for TV viewing, like wall screens and the displays on mobile phones. Those kinds of screens require special solutions.

Font style

As a general rule italic font styles should never be used since they severely reduce the legibility of the font and bold styles should be used with care especially when using smaller fonts. Table 1 gives an example of different fonts and styles for different information types.

Font	Pagetype	Headlines	Text Body	Navigation	Footer
<i>Proportional sans serif</i>					
arial standart	+	+	+	+	+
arial bold	+	+	+	+	+
arial italic	(*)	(*)	–	(*)	–
arial bold italic	(*)	(*)	–	(*)	–
<i>Antiproportional serif</i>					
courier standart	+	+	–	+	–
courier bold	+	+	–	+	–
courier italic	(*)	(*)	–	(*)	–
courier bold italic	(*)	(*)	–	(*)	–
<i>Proportional serif</i>					
times standart	+	+	0	+	0
times bold	+	+	0	+	0
times italic	(*)	(*)	–	(*)	–
times bold italic	(*)	(*)	–	(*)	–

(*) only usable for larger font sizes

Table 1: Example of different fonts and styles for different information types. [MUSIST, 2004]

4 STANDARDS, TECHNOLOGY AND EQUIPMENT

4.1 Broadcasting standards

4.1.1 Analogue broadcasting

There are 3 main standards for terrestrial analogue television broadcasting in the world, PAL, NTSC and SECAM. All analogue TV receivers comply with at least one of them. They all have their pros and cons but most of all these standards are the reason why a TV set bought in one country might not work in another country. These standards are also not compatible with the digital broadcasting standards and that is the reason why a set-top-box (STB) is needed to convert the digital signal to analogue in order to watch digital TV on our current analogue TV sets.

4.1.2 Digital broadcasting

There are basically two standards for terrestrial digital television broadcasting, DVB and ATSC [Whitaker, 2001], where DVB, without a doubt, is the dominating standard world wide while ATSC is used in USA and Canada. These standards will gradually replace the analogue standards as the analogue broadcasting networks are shut down.

4.2 Hardware

4.2.1 TV screen

In order to watch a TV program you need a TV screen. There are however a number of different types of TV screens available on the market. The most common type is the cathode ray tube (CRT) which dates back to the very first TV. Several new technologies have emerged though that typically take up less space or allow for substantially larger display sizes than CRT. Among these are LCD/TFT (which is now quite common as flat screens for computers), plasma screens and projectors of varying designs. CRT was the only type of screen used in this project.

4.2.2 Set-top-box

The set-top-box (STB) is connected to the TV much like a VCR or DVD player. The main purpose of a digital TV STB is to act as a D/A-converter to allow the users to watch digital TV broadcasts on their analogue TV sets. Most, if not all, STB manufacturers have added extra features to their boxes though ranging from electronic program guides to recording possibilities. With all these extra features comes the need for a graphical user interface (GUI) and interaction tools to fully take advantage of them. As stated earlier the development of a prototype for such a GUI was the main purpose of this project. There was no STB used in this project, instead a laptop computer running the prototype was connected to the test user's TV screen.

4.2.3 Interaction tools

The standard interaction tool for TV sets is the remote control and this will most likely be the case with digital TV STB:s as well most of the time. With the more complex features available in digital TV broadcasts and STB:s a more advanced remote control in conjunction with some other form of interaction tool such as a keyboard or possibly voice commands is a plausible solution to allow quick and easy access to all features. In this project no research of possible interaction tools was done. Users were given a picture of a very simple remote control with four directional buttons and three buttons labelled "Menu", "Ok" and "Back". This was

considered the minimum number of buttons needed to navigate through the menus in the graphical user interface (see figure 5.5.1, fig. 21).

4.3 Software

4.3.1 Platforms and operating systems

All set-top-boxes (STB) need a platform [Chorianopoulos, 2003] to run on in order for electronic program guides and other features to function. The more advanced STB:s are typically run like computers with an operating system such as Windows XP, UNIX or Linux as their platform but there are specialized platforms like Open TV, Liberate and Canal+ Media highway. All technology providers, except Microsoft [Microsoft Television Platform, 2004], support the Multimedia Home Platform (MHP) which is a competing platform in itself developed by the DVB Project [Whitaker, 2001 & DVB Project, 2004]. MHP has seen limited success on its own but has nonetheless become the most widely accepted standard for interactive television applications, because it is an open standard, with other proprietary platforms giving the choice for MHP application development or developing their own MHP-compliant implementations. The biggest problem for MHP at this time is its reliance on Java. As long as MHP is tied to a programming language/environment that is controlled by a company (SUN), the MHP can not be pushed by the EU as a standard for the European continent. The DVB project is working to make MHP operating system and programming language agnostic though and MHP is already the most widely used platform in Europe today.

4.3.2 Programming languages

What programming language to choose for the development of a graphical user interface (GUI) for the STB depends on what platform is used. Not surprisingly Java is a popular choice due to its platform independency and an available TV API. Other languages such as C++ are also popular and if the Microsoft Television platform is used any programming language in the .NET framework can be used since it assumes a common language runtime for all builds [Chorianopoulos, 2003].

4.4 Requirements and limitations

The requirements and limitations on hardware and software vary depending on what platform and Set-top-box (STB) is being used and what services are offered through the digital broadcasts and return channels. It is therefore impossible to specify any exact requirements and those of an inquiring mind are recommended to look up various platform and STB manufacturer's web pages for more information [DVB Project, 2004, Microsoft Television Platform, 2004 & Open TV, 2004]

5 THE PROTOTYPE

All in all four versions of the prototype were created. Usability tests in combination with qualitative interviews with potential users were conducted for each version. The first two versions were simple storyboards while the last two were more advanced limited functionality simulations. Since the prototype was in Swedish the texts in all screenshots are in Swedish. The menu hierarchy graphs have been translated into English and in the text Swedish words are given as reference after the English words so the reader can identify options in the screenshots.

5.1 Basic Prototype design decisions

5.1.1 Layout

The layout chosen for the prototypes was to have floating menus and windows in front of the picture. The reason for this was that there are only two sorts of layouts to choose from for this kind of application (see 3.2). Ecton AB's existing graphical user interface (GUI) utilize the picture-in-picture layout and they had specifically asked for something new. For the mock-up program guide and channels/stations/programs lists findings in another master thesis were used as inspiration [Dogan, 2001].

5.1.2 Menu hierarchy

Having all available functions listed in the main menu is not desired. From an aesthetic point of view it makes the GUI look cluttered but the limited screen space also makes it increasingly hard to fit all choices on the screen at once if their numbers grow. In order to make the main menu perspicuous and the addition of more functions easier, related or similar functions were grouped together in submenus. The few functions that could not be group in any way were left in the main menu. Throughout the project this hierarchy was altered to accommodate changes in the functions available to the users as they occurred.

Because of the passive nature of TV viewing (see 3.1) it was decided to use the three-click rule as a guideline for structuring the menu hierarchy. In this case meaning that users should be able to find what they are looking for within 3 clicks of the Ok button on the remote control when starting in the main menu. This means that no part of the menu hierarchy should have a depth of more than three levels. This was only a guideline though as the validity of the three-click rule have been questioned: "The number of clicks isn't what is important to users, but whether or not they're successful at finding what they're seeking" [Porter 2003].

5.1.3 Font and colours

For all text in all prototypes Arial was the font used and the size was set to 20 pixels as minimum. The font is designed especially for screen use and its bold and italic font styles work well on screens (see 3.5). As for the colours used all prototypes except the first one had a blue background colour for the menus and the font colour was either black or white depending on what colour gave the best contrast to the background (this differed between paper printouts and TV screens). The first prototype was printed in grey scales.

5.1.4 Graphical design

When using the floating menus layout it is recommended to enhance the 3D look of the menus. For the first two prototypes (storyboards) this was not a problem using 3D button templates in Paint Shop Pro and resizing them as well as placing text on them to simulate the menus. For the last two prototypes (limited functionality simulations) this was somewhat harder to achieve using the standard button and window designs available in C# but the addition of a moving background image helped to strengthen the 3D effect. Making the menus semi-transparent can further enhance this effect (see 3.5) but this was not done here, based on personal experiences with semi-transparent graphical user interfaces where texts were difficult to read.

5.1.5 Icons

Throughout the prototype no icons were used to represent functions or menu choices. Icons have to be carefully chosen so that they convey the intended message to the user and can indeed be very useful when the available screen space is limited and also make the interface more attractive. When it comes to choosing between text based or pictographical interfaces it has been shown that it comes down to the user's personal taste and that most users would choose the type of interface they are most efficient in [Westerink et al., 1998]. Because of this and the time it would take to design acceptable icons it was decided to exclude icons from the prototype and stick with text based menus.

5.1.6 Interaction Tools

In this project no research of possible interaction tools was done. In the first three tests users were given a picture of a very simple remote control with navigational buttons consisting of four directional buttons and three buttons labelled "Menu", "Ok" and "Back". The standard numeric, volume and channel buttons found on any TV remote control were also included but were not intended to be used for navigation but rather to make it look more like a normal TV remote control. The seven navigational buttons were considered the minimum needed to navigate through the menus in the GUI. "Menu" would open and close the graphical user interface, "Ok" was used to select an option in the GUI and "Back" would undo the last push of either the "Menu" or "Ok" button. The users were told to say out loud what buttons they used on the remote while navigating the GUI.

In the fourth and final version of the prototype an on-screen remote control with only the navigational buttons was used and users could press the various buttons by clicking on them using an ordinary PC mouse.

5.1.7 Equipment and software used

Storyboards were created using a shareware version of Paint Shop Pro 7 and printed on A4 size paper using a grey scale laser printer and a colour ink jet printer. For the limited functionality simulations C# and Microsoft's Visual Studio .NET with DirectX 9 SDK installed were used. All prototypes were developed on a high end PC (see 9, item 1) connected via S-video cable to a TV set for quick verification of design decisions. All user tests of this kind of prototype were performed in people's homes using a laptop PC (see 9, item 2) connected to their TV sets.

5.2 Version 1

The main purposes of this version were to probe the users for acceptable locations for commercial ads and to try out the concept of letting submenus and windows replace previous menus to save screen space. Saving screen space is essential in order to block out as little as possible of the picture but should not have priority over usability.

5.2.1 Design

This first version was a grey scale storyboard where the “TV screen” was a picture of some people printed on an A4 size paper. The menus were cut out from other printouts and placed on the “TV screen” according to the users’ input. The main menu and all submenus were aligned to the top left corner of the screen and had their options laid out horizontally. All menus replaced each other as the users navigated through them. No commercial ads were present in this version (fig. 4-6).



Figure 4: The main menu.



Figure 5: TV submenu (replacing the main menu).



Figure 6: The program guide (replacing the TV submenu).

5.2.2 Hierarchy

The focus for the menu hierarchy in this version was on grouping the different functions together in submenus. All alternatives in the main menu except Favourites (Favoriter) and Player (Spelare) lead to submenus. The reason for this was that there were no other related functions to group Favourites and Player

with. Favourites is a list of TV channels and radio stations that the user has specified as his or her favourite choices. This function is useful when there are a large number of channels/stations available and of interest to the user. Recognizing a name in a list is easier than recalling exact numeric representations, e.g. is MTV stored as channel number 7 or 8? Player is a media player much like Microsoft's Multimedia Player but with added recording capabilities.

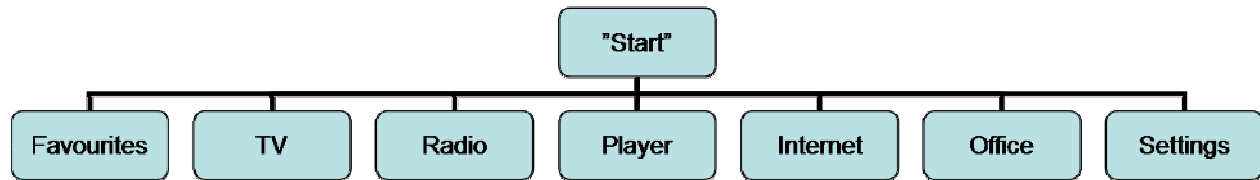


Figure 7: Hierarchy - the main menu. All alternatives lead to submenus except Favourites and Player. "Start" represents the state when the TV is turned on but the GUI is not visible.

The TV and Radio submenus (fig. 8) share an identical structure since basically the only difference is the moving picture. The Channels/Stations (Kanaler/Stationer) alternative brings up a list of all available TV channels or radio stations, the Programs choice brings up a list of all programs currently transmitted on the different channels/stations and the Guide choice brings up an electronic program guide where the user can see the tableaux for today.

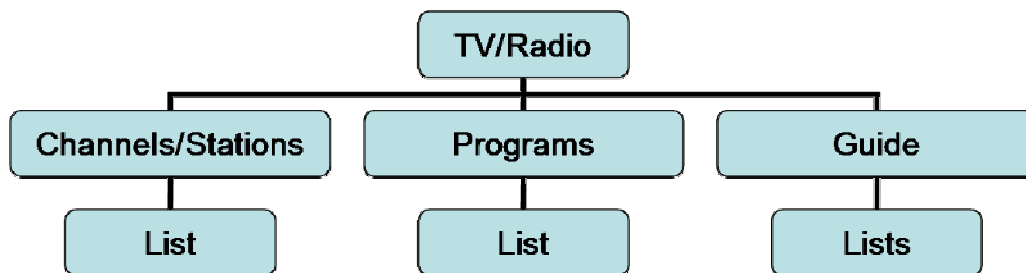


Figure 8: TV and Radio submenus have identical hierarchies.

Both the Internet and Office submenus (fig. 9) contain alternatives that were all included in the prototype as alternatives but in contrast to the previous functions described here they were left at that and no windows were designed to show the look and feel of the functions. This was done because each of these functions require a complex graphical user interface (GUI) on their own and to even design mock ups of those would have taken too much time from the rest of the project.

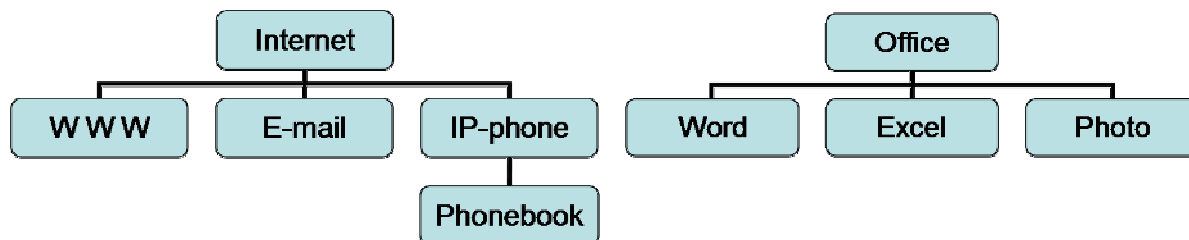


Figure 9: Internet and Office submenus.

The Settings submenu (fig. 10) was also implemented only as alternatives in a submenu without any windows showing the actual functions. This was pretty much done because of uncertainties of what settings were actually needed for each function and what functions actually needed to have settings available.

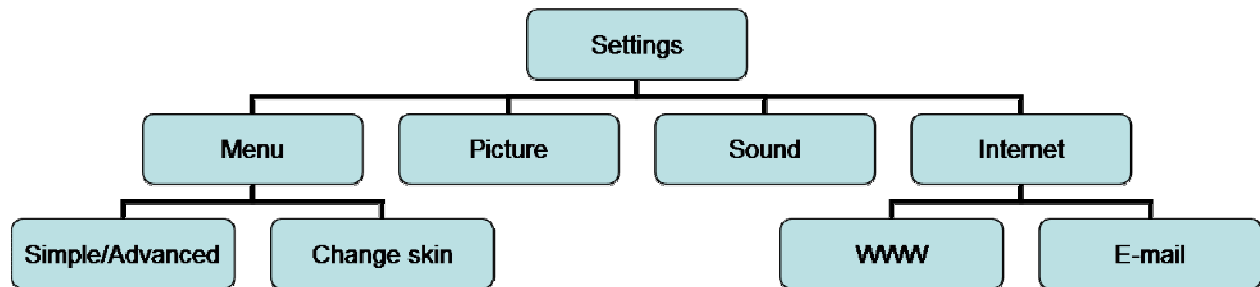


Figure 10: Settings submenu.

5.2.3 Usability test and qualitative interview

In this first set of tests and interviews a total of seven persons were interviewed, two women and five men. The users were given information about what functions they could expect in the STB. The usability test consisted of letting the users explore the interface, using the mock-up remote control, and to think aloud while doing it. If they had any questions they were free to ask them since there was no user's manual available and also because these questions were considered important leads to focus on in the interview. Whenever the user performed an unexpected action the usability test was halted. The user was then quickly interviewed to establish the reasoning behind his/her action. Unexpected actions could be to explore only certain parts of the GUI or try to do or find things that are not possible or available in the GUI.

The interviews were conducted partially while the users tested the prototype and were then continued afterwards. The main goal of the interviews was to establish where in the GUI users deemed commercial ads to be acceptable and/or unacceptable.

5.2.4 Observations and interview results

- Visible menu hierarchy needed. Submenus replacing other submenus or the main menu made the users lose their way in the menu hierarchy if they were distracted (which can be expected when people are watching TV)
- Change of content or option names. One of the options for either listing channels or the one listing programs in progress was seen as superfluous, depending on user preference. Combining the two into one option was suggested by one user.
- On screen guides needed. Users were sometimes uncertain how to navigate and tended to look at the screen for some time before asking for assistance. The instructions were easy though and no user had to be told more than once what to do. This suggests that a pop-up window with instructions could appear if there is an extended period of inactivity from the user. The fact that two users suggested this approach on their own further strengthens this assumption.
- The concept of commercial ads was met with distrust from all users except one. It turned out that they expected pop-up windows like on the internet or disrupting commercials like the ones you get while watching movies on commercial channels. It is clear users do not wish to wait for something because of commercial ads or to be disturbed by them.
- Four users said commercial ads while browsing the menus would be ugly, distracting or "too much" in conjunction with commercial ads in the TV broadcasts. Including commercial ads in other places was "ok" as long as they are not too intrusive.

5.2.5 Improvements for the next version or final product

- Replacing submenus and main menu as the user progress through the menu hierarchy was not a successful solution. Drop-down menus might improve the usability of the GUI.

- Combining the channels/station option with the program option in the TV/Radio submenus. Each entry on this new list would show a channel name, the program currently running, start and stop time and a progress bar.
- The order of the options should be looked into. When opening up the main menu or a submenu the most frequently used options should come first. This could be accomplished either by implementing an intelligent adaptable GUI or by doing quantitative interviews and update the GUI.
- Include a pop-up window with clear short instructions on how to navigate the GUI.

5.3 Version 2

The purposes of this version were to monitor the users' reaction to the commercial ad included in the program guide and to see if the drop down menus makes the menu hierarchy more visible and thereby making menu navigation easier.

5.3.1 Design

The second version of the prototype was a storyboard much like the first version but printed on a colour ink jet printer. The biggest “technological” difference was that this time a real TV screen was used and the cut out paper menus stuck to it by the static charges found on all TV screen surfaces. As for the layout, this version had a horizontal main menu with the same options as the first version but submenus appeared as vertical drop down menus with the main menu left in place (fig. 11). The selection of a function makes all menus disappear and the function window appears aligned to the top left corner of the screen. The options in the submenus were changed some (see 5.3.2) and a commercial ad was included in the program guide (fig. 12). A simple on screen guide was created for this version and was shown to the users if they had not done anything for five seconds or more after opening up the main menu.



Figure 11: Main menu and TV submenu.

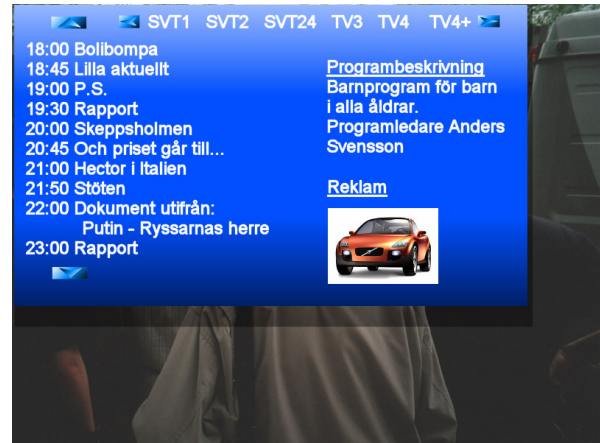


Figure 12: Program guide with commercial ad.

5.3.2 Hierarchy

The menu hierarchy for the second version of the prototype remained pretty much the same as for the first version but a few important changes were introduced. The TV and Radio submenus were still identical but the functions included had changed some (fig. 13). Right now (Just nu) will bring up a list of all available channels/stations and for each one the program currently broadcasted along with start and end times shown in text along with a progress bar.

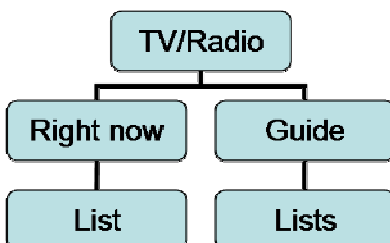


Figure 13: Revised TV and Radio submenus. Compare with fig. 8 to see the changes.

5.3.3 Usability test and qualitative interview

There were six persons in this set, two women and four men. These six persons had all participated in the first set of tests and interviews as well. This time each person was given 11 tasks to do with the graphical user interface (GUI) for the usability test. These were simple tasks, like changing channel, as well as more complicated tasks such as recording a program and play a CD. All these tasks could not be performed to their full extent due to limited simulations of functions. This was no problem as the intention was to observe how the users navigated through the menus to find the function they were told to use.

Observations of the navigation and the questions users asked while navigating were used to establish what to follow up in the interview. Several tasks included using the program guide. The intention of this was to observe the user's reaction to the commercial ad included in the guide. If the users did not say anything about the commercial ad during the usability test this was brought up in the interview to ascertain their views on this. This was also the main goal of the qualitative interview. As for the first version interviews were also used to investigate unexpected actions and questions.

5.3.4 Observations and interview results

- Only one user commented on the commercial add without being asked about it. When the subject was brought up with the other users they were all opposed to the idea (to a varying degree). Once again it turned out that they expected the real commercial ad to be noisy, animated and quite possibly hinder the usage of the program guide. Nothing had been said to that effect though.
- The on-screen help text was well received. One user expressed concerns that five seconds was too fast for it to appear and another user requested the possibility to turn the on screen guide off completely. Yet another user wanted a help button on the remote control in order to get help when he actually wanted it and not when the system triggers it.
- Those users not accustomed to the Windows Media Player (or similar programs) had a hard time accepting the "all in one player" in this prototype.
- One user requested a clock in the GUI and two other users were uncertain what program was currently running while using the program guide.

5.3.5 Improvements for the next version or final product

- Program guide for tomorrow or the next seven days was asked for. This service is available in digital broadcasts and there is no good reason not to include it in the GUI.
- Restructuring of the Player end choice is necessary. Make it look as if there are different players for the video, DVD, CD and jukebox. They should all use the same engine and basic GUI layout to maintain the consistency in GUI.
- Adding a clock to the GUI would let users keep track of time and help to clarify what programs are currently running while browsing the program guide.
- The horizontal layout used for the main menu does not allow for the possible addition of more options without making the navigation more complex. A vertical main menu would.
- The distinction between menu and functions need to be clear. With the current menu hierarchy it is hard to tell what should be in the menus and what should be included in the function windows which in turn affect the consistency of the GUI.
- The final product should include an on-screen help text as the one used in this version. It must be possible to turn it off or experienced users are likely to get annoyed.

5.4 Version 3

This version was the first limited functionality simulation. It was programmed in C# using Microsoft's Visual Studio .NET and was shown on TV screens using an 800x600 pixel resolution. The purposes of this version was to include the findings from the previous, more primitive, versions and see how it would work out on a real TV screen and to observe the users' reactions to a commercial ad where the picture is update regularly.

5.4.1 Design

The layout of this prototype was changed to allow for more options to be added to the main menu in the future. Options are now listed vertically and the main menu is aligned to the top left corner of the screen. Submenus appear to the right of the main menu or previous submenus. Clocks were included in various places of the graphical user interface (GUI) in order to let the users keep track of time no matter what part of the GUI they are using (fig. 14). The selection of an end choice alternative (see 5.4.2) makes all menus disappear and the end choice appears aligned to the top left corner of the screen. A picture box containing commercial ads (changing every five seconds) was included in the program guide (fig. 15).

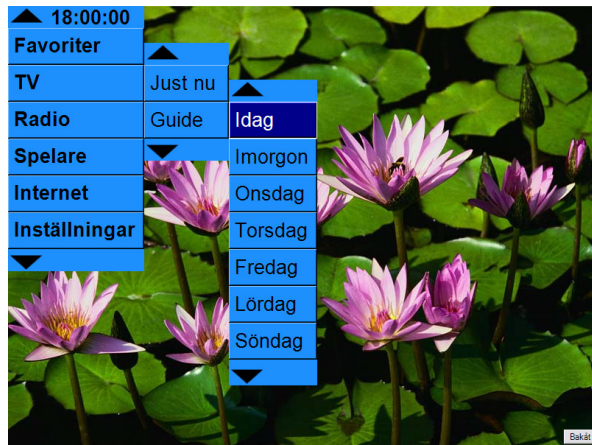


Figure 14: Main menu, TV and Guide submenus.



Figure 15: Program guide.

5.4.2 Hierarchy

In order to make the distinction between menus and functions more obvious the concept of end choices was introduced in the menu hierarchy. Each function is represented by one or more end choice. The alternatives in a menu should either be a submenu or an end choice. When an end choice is selected the main menu and possible submenus should be closed and the function associated with that end choice should be displayed in a separate window. In this version a few functions were removed or added after some discussion with Ecton AB. This in conjunction with the findings from previous versions meant that some major changes were introduced to the menu hierarchy. In all figures below end choices are represented by ovals while submenus are squares. Items with white background only serve to clarify details and are not really part of the menu hierarchy.

The Office alternative was removed from the main menu (fig. 16) and the Player alternative was renamed to Players.

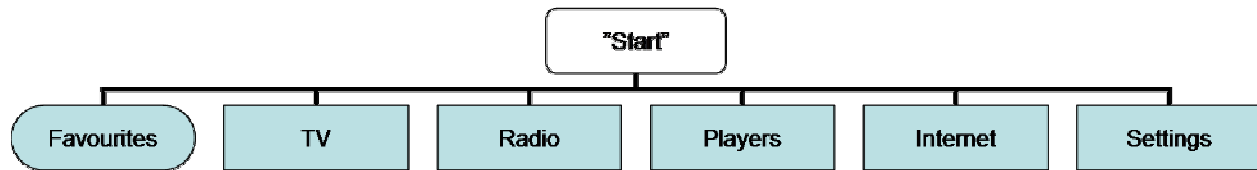


Figure 16: Main menu with one end choice and five submenu alternatives.

In the TV and Radio submenus the Guide alternative was transformed into a submenu with an end choice for each of the coming seven days. All end choices lead to the same function, the electronic program guide, but with different tableaux for different days (fig. 17).

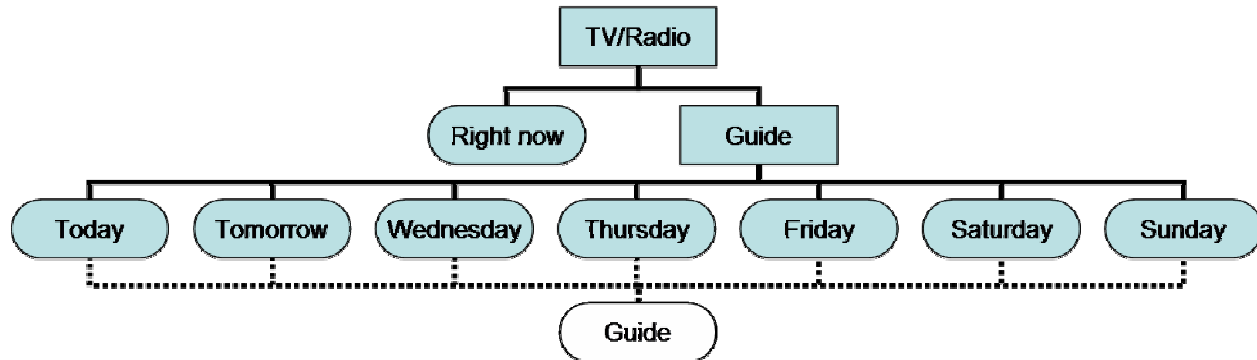


Figure 17: TV and Radio submenus with seven days as end choices in the Guide submenu.

The Player option in the main menu was renamed to Players and transformed into a submenu containing the Digital Video, DVD, CD, Jukebox and Photo end choices (fig 18). The CD, DVD, Digital Video and Jukebox end choices lead to the same player function. This was done to make the choice of media more obvious to the users in accordance with the findings in version two. The Photo end choice was placed in the Players submenu to see if users would accept it to be grouped with the other end choices that also handle locally stored media files.

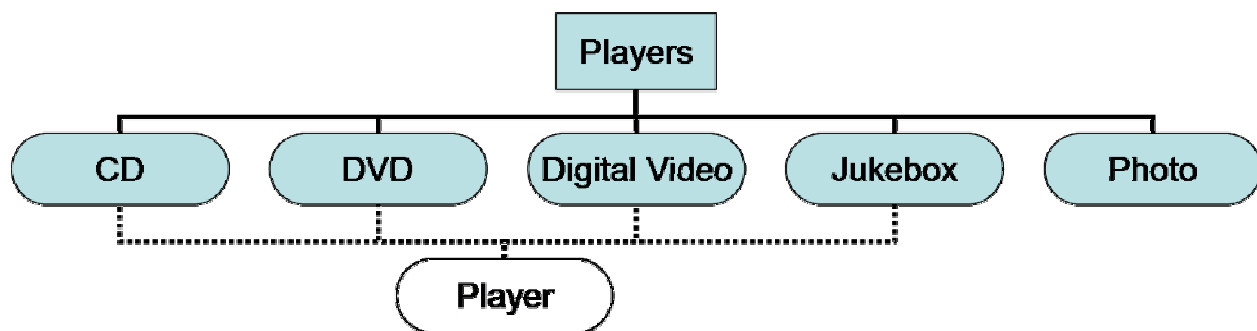


Figure 18: The new Players submenu. CD, DVD, Digital Video and Jukebox end choices lead to the same player function.

A Video on demand (VoD) end choice was added to the Internet submenu (fig. 19) after Ecton AB had confirmed that a VoD function would be available. As in earlier versions none of the functions corresponding to the end choices in this submenu was implemented in the prototype because of their complexity and the amount of time it would take.

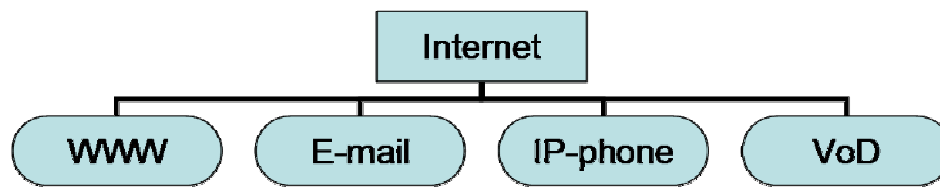


Figure 19: The new Internet submenu.

Even though the Settings submenu remained pretty much the same as in previous versions this was the first time the functions corresponding to the end choices were implemented. In this version the functions were represented by simple mock-ups but it gave the users a hint of what it would look like and what could be done.

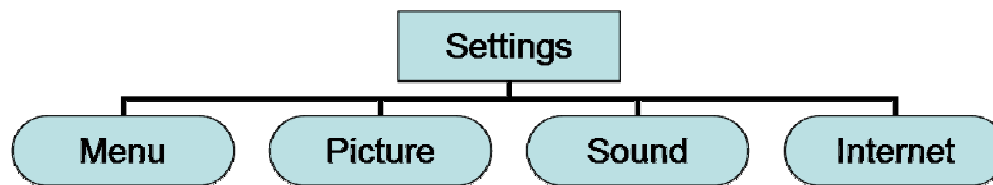


Figure 20: The Settings submenu remained the same.

5.4.3 Usability test and qualitative interview

Seven persons participated in this set of tests and interviews, four men and three women. One of the women had not been interviewed before while the others were the same group as in the previous two tests.

Just like in the first version the usability test consisted of letting the users explore the interface, using the mock-up remote control, and to think aloud while doing it. This was a more advanced prototype but the controls for this prototype were not user friendly. Letting the users say what they wanted to do with the remote control and showing the result to them was the most effective way of simulating the interaction between user and GUI. Whenever an interesting situation arose the test was halted and the topic at hand was discussed with the user before continuing.

In this version the commercial ad in the program guide was replaced with a new ad every five seconds. The main goals of the qualitative interview was to establish the users' feelings toward this and also to once again probe them for possible locations where commercial ads could be shown. This was done because this version of the prototype would give the users a better understanding of how intrusive the commercial ads would be. The possibility to show commercial ads during start up of the set-top-box had been discussed with Ecton AB before this set of interviews and was discussed with all users.

5.4.4 Observations and interview results

- The commercial ads changed too often according to all users in the test. Three users pointed out that the constantly changing ads were distracting them and they would look more at the ads than at the program guide.
- The possibility of showing a commercial ad while the STB is starting up was discussed with every user and four of them felt it was a good way to use the down time. One user stressed that a progress bar was essential and that a long start up time must not be a goal in itself to allow for long exposure of an ad.
- None of the users wanted commercial ads to show up while browsing the menus. Generally because it would "just be too much" but two of them also pointed out that the end choices, like the program guide, is where they will spend most of their time while using the GUI and that is where they would expect to find any commercial ads.

- Only two users commented the placement of the Photo option and they were of opposite opinion. One said a “photo player” was unheard of and that the Photo option should not be under the Players option. The other user felt the placement was good since “you play the photos on the TV screen”.
- Icons looking like the directional buttons on the remote control were used to give visual cues to users as to what buttons to use on the remote. Several users thought it was obvious what buttons to use and two of them incorrectly interpreted the icons as indicators suggestion they could scroll to other options not seen in the menu.

5.4.5 Improvements for the next version or final product

- Favourites were shown as a submenu but should really be displayed as an end choice to make the interface more consistent. This was a design error.
- Photo was placed under the Players option but should really be a choice of its own in the main menu. The main reason for moving the Photo option would be that the interface, although not included in this prototype, will differ significantly from the common interface used for the other players and it would improve the consistency of the interface to have Photo as an end choice option in the main menu.
- Directional arrows in the GUI should either be removed or the connection to pressing a button should be made stronger, perhaps by letting the corresponding icon flash every time the button is pressed.
- Increasing the time before the commercial ads change should make them less intrusive in the GUI.

5.5 Version 4

This last version of the prototype was similar to the previous version but with some changes to make it look and feel more like a finished product. The addition of video playback to simulate TV broadcasts was the most significant change. The purposes of this version were to let the users do all the interaction with the graphical user interface (GUI) themselves and observe how they handle the navigation in the menus and to establish their feelings toward a slow changing commercial ad and the GUI in general.

5.5.1 Design

By including Microsoft's DirectX 9.0 package .avi video files could be played to simulate the TV broadcast. A small on-screen remote control with only the buttons needed for menu navigation was added to the screen. All implemented functions could be controlled by the users simply by clicking on the buttons of this remote control using a mouse. In the layout some minor but still noticeable changes were made: icons corresponding to remote control buttons were removed and all scrollbars in the program guide and other end choices were hidden to give the GUI a more finished look (fig. 22). Some options were moved around in the menu hierarchy according to the findings in previous versions and the timer for changing commercial ads in the program guide was increased from five to ten seconds. A highlight trail is left in the main menu and submenus as the users traverse the menu hierarchy to make it easier to orient oneself, especially when returning to the menus from an end choice by using the "back" button (fig. 21). Finally, a simple version of changing the graphical skin of the GUI was implemented by letting the users change colour scheme for the GUI in the Settings (Inställningar) part of the menu.



Figure 21: Main menu, TV and Guide submenus. On screen remote control in bottom right corner.



Figure 22: Program guide.

5.5.2 Hierarchy

Only one thing changed in the menu hierarchy from the previous version. The Photo end choice was moved from the Players (Spelare) submenu to the main menu (fig 23 & 24). This was done to make the hierarchy more consistent. The GUI for the Photo function will differ significantly from the Player function and it would therefore reduce the consistency of the menu hierarchy to have them grouped together.

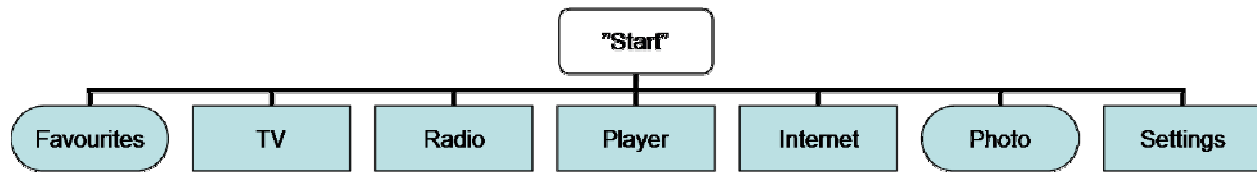


Figure 23: Main menu with Photo end choice.

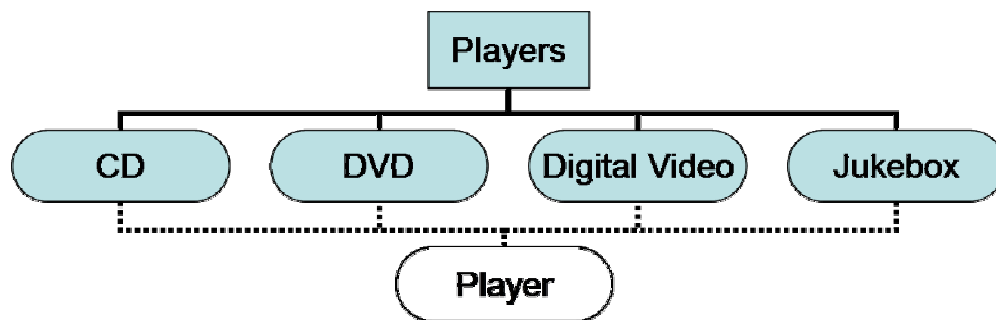


Figure 24: Players submenu without the Photo end choice.

The complete fourth version of the menu hierarchy can be found as an attachment at the end of this report.

5.5.3 Usability test and qualitative interview

In this final set of tests and interviews there were nine participants, six men and three women. Three of them, two men and one woman, were new additions while the remaining six were the same group as in all previous tests. These new users were brought in to establish how a person with no prior experience with the GUI would handle it and react to the commercial ad.

There was one major difference in the test and interview setup this time as a video camera was used to record the interviews and the users' actions on the TV screen. There were several reasons for this: The prototype was quicker and easier to use, making it hard to keep up with only pen and paper. The users were allowed to interact with the GUI on their own and could be expected to forget to think aloud. In previous versions all interaction with the GUI had to go through the interviewer but this would not be the case this time. Since it was the last set of tests and interviews it was also desirable to get as much out of it as possible.

The usability test in this version consisted of letting the user explore the interface at their own leisure using the on-screen remote control. Just as in the previous version whenever an interesting situation or question arose the usability test was halted and the topic at hand discussed.

The goals of the qualitative interview was to establish the users' feelings toward the slower changing commercial ad in particular and the final version of the GUI in general. The commercial ad was changing every 10 seconds which is double the time in the previous version. Would this make any difference to how the users perceive it? Since this was the last version of the prototype the users' general opinions of the commercial GUI were of interest. Any difference in opinion between the new and old users were of special interest. Would the new users accept the commercial GUI? The old users seemed less reluctant to use a commercial GUI when they tried out the third version than they were when they tried out first version. Was this because they got used to the concept or because of improvements in the design?

5.5.4 Observations and interview results

- While navigating the menu hierarchy four of the users tried to use the left directional button on the remote instead of the Back button to go back from a submenu to the main menu. This is logical since the menus expand to the right and therefore moving the highlight marker left would plausibly close the active submenu.
- Five users felt the commercial ads were discrete but still noticed them. One user wanted the ads to change faster to make it more obvious that it is indeed commercial ads and not something related to the program info showed in the program guide.
- Two of the new users said they preferred not to have commercial ads in the GUI. One of them was opposed to commercial ads in general while the other one felt it was a bit too much in conjunction with commercially financed TV channels.
- Even though all users changed the skin of the GUI all but one changed back to the default blue colour scheme before continuing to explore the interface. The one who did not change back did not like the colour blue and was relieved to find this option.
- No users had problems navigating and finding what they looked for.

5.5.5 Improvements for the final product

- Left and right directional buttons are not used while traversing the menu hierarchy. Using them as alternative buttons for Back and Ok would give users an alternative way to navigate through the menu hierarchy.
- Letting the users change colour theme or the entire graphical skin of the GUI will ensure that a maximum number of users will be satisfied with the look and feel of the GUI.

6 RESULTS

The three important parts in this project was to establish a menu hierarchy, maximize the usability of the graphical user interface (GUI) and to examine how and where commercial ads can be incorporated in the GUI and how this will be received by the users. Below is an assessment of how successful this project was in each of these areas.

6.1 Menu Hierarchy

A solid structure for the menu hierarchy has been established. Every function or service available corresponds to one or more end choices in the hierarchy. These end choices are reached as options in the main menu or submenus where related end choices are grouped together. This makes it a flexible hierarchy where new end choices can be added as options either in the main menu or by grouping them with existing options in submenus. This approach allows functions and services to be developed as stand alone applications instead of integrated with the menus. These applications can then be called upon by selecting an end choice in the menu hierarchy.

The functions used to build the menu hierarchy for the prototype were those available in Ecton AB's set-top-box, functions that other students were researching, such as Voice over IP, and a few desired functions suggested by Ecton AB. Some functions were removed or changed during the course of the project. Furthermore, some bad grouping choices had to be corrected. That posed no real problem, it rather proved that the menu hierarchy was flexible and easy to adapt to changes. The complete fourth and final version of the menu hierarchy is attached at the end of this report. The hierarchy is still not complete due to incomplete specifications but can easily be corrected.

6.2 Graphical layout and usability

The layout of the graphical user interface (GUI) differs significantly from the GUI currently used in Ecton AB's set-top-box. By using a vertical layout of the main menu more options can be added to the GUI without making navigation more complex.

It was only the menu and program guide that had their usability examined. Other parts of the GUI were not tested at all even if they were included as mock-ups. Relevant GUI design theories and TV specific issues have been taken into consideration when designing the GUI.

The usability tests and qualitative interviews strongly suggest that the final version of the prototype possess a high factor of usability. None of the users had any problems navigating through the menu hierarchy and finding the option they were looking for. Since the menu hierarchy do not change in an "intelligent" way the users can learn navigational patterns to reach different options in the menus which greatly enhance the usability of the GUI.

6.3 Commercial ads

Not entirely unexpected all users were initially opposed to the idea of commercial ads in the graphical user interface (GUI), or at least very sceptical. During the interviews it became apparent that they expected the ads to be intrusive both in graphics and sound and that it would even hinder the use of the GUI. The source for this distrust seem to stem from the internet and commercial TV channels where the users feel "commercially abused", for lack of a better word, by constant interruptions in programs, pop-up windows, spam mail etc. This is a strong indication that users must not be kept waiting because of commercial ads in the GUI since this is basically what the "commercial abuse" is all about. It also affect the robustness of the system. There are

of course individual preferences to take into consideration as well, some people do not like commercial ads in any form what so ever but it is far from everyone who feel that way. Many people even welcome commercial ads, especially if they can somehow benefit from them.

This suggests that to successfully include commercial ads in a GUI for the STB it must be done in a quick, non-intrusive way and the owner of the STB should benefit from it. The ads should typically be much like their printed counterparts: only graphics, no sound or animation. The location of the commercial ads must also be carefully thought through. The interviews and usability tests show that the Program Guide was a good place to put ads but the interviews also suggest that ads could be displayed while the STB is starting up since it can not be used during that time.

7 DISCUSSIONS

7.1 Commercial graphical user interface, yes or no?

The results basically suggest that a commercial graphical user interface (GUI) is a possibility as far as development goes. The fact that all users expect the commercial ads to be intrusive and disruptive should be taken into serious consideration since consumers do not always buy a product based on what it offers but rather what they expect it to offer. A commercial GUI such as the one prototyped in this project could lower the price of a STB and give an edge on a competitive market where the end consumer is always looking for lower prices. Exactly how big this price cut should be was not established in this project but suggestions from the users varied from 10 to 50 percent depending on the original price.

The biggest problem would probably be to convince potential buyers that the commercial ads are indeed discreet and that the STB is as good as or better than any other STB on the market. To overcome people's preconceived notions about commercial ads will be a difficult but hopefully not impossible task for a marketing department to accomplish.

Quantitative interviews should be performed to establish if there is really a market for a commercial GUI since it was not done in this project. Such an interview could also establish if people in general would think that a commercial GUI in combination with commercial TV channels would be "too much". It would also be of interest to know if a STB with a commercial GUI would be considered a low budget alternative to "serious" STB:s with an ordinary GUI. These are important questions that should be answered before any decision on marketing the commercial GUI is made.

This project was carried out from the users' point of view and when it comes to the placement of the commercial ads it is important to keep in mind that their preferences might not be the same as those of the marketers who pay to have their ads in the GUI. An advertising agency can be consulted to establish if the user preferred placements are profitable or not.

7.2 The new interface and menu hierarchy

As there already existed a graphical user interface (GUI) based on the picture in picture layout (see 3.2) and Ecton AB had requested a different looking GUI. This meant that there was really only one options left which made the selection of layout concept easier than expected. The exact location of the floating menus on the screen and creating the menu hierarchy was more troublesome though and changed quite a lot during the process of prototyping and testing. Whether this kind of interface is better than the existing one is difficult to tell since no comparative study has been made and especially since this commercial GUI is still just a prototype while the existing one has been develop for a couple of years and is a finished product. A careful comparison should be conducted before any decision on replacing the current GUI is made.

Deliberately no intelligent behaviour was implemented in the prototype. Intelligent behaviour could be to automatically reorganizing the menu hierarchy according to how frequently different functions are used or to "predict" what the users want to do, based on former actions, and do it for them. This can probably be successfully included in the implementation of various functions, but the menu hierarchy should not be changed except when updated to a new version. Changing the menu hierarchy while in use would severely reduce the consistency and usability of the GUI. Users are likely to get confused and aggravated as they have to learn new navigational patterns each time the hierarchy changes.

7.3 Realizing the commercial graphical user interface

If the decision should be made to go ahead and produce the commercial graphical user interface (GUI) these are few recommendations to keep in mind. All the versions of the prototype have one thing in common: they are throw-away prototypes. That means only the findings from the various tests and interviews should be used when the final product is produced, no code should be recycled in order to avoid inheriting programming flaws from the prototype.

It is recommended to implement the GUI using Java. There are several reasons for this: It is generally considered a good platform coding graphical user interfaces, accessing data from files and networks and coding remote control events [Peng et al., 2000]. It is also tightly knit to the DVB Project's Multimedia Home Platform which is more or less the defacto standard in Europe (see 4.2.1). Even though the limited functionality simulations in this project were programmed using C# equivalent coding can be done in Java using the Java TV API which has been developed for the digital TV industry.

By adhering to the Model-View-Control paradigm and using the menu hierarchy established here the possibility to enable optional skins for the GUI should be no problem. Exactly how to implement the optional skins (XML, Java or other) need to be further investigated though.

Last, but not least, the commercial ads in the GUI must be programmed to appear without delaying or hindering any actions the user may want to perform. All interviews in this project suggest that the tolerance level among users for delays of any sort due to commercial ads is very low.

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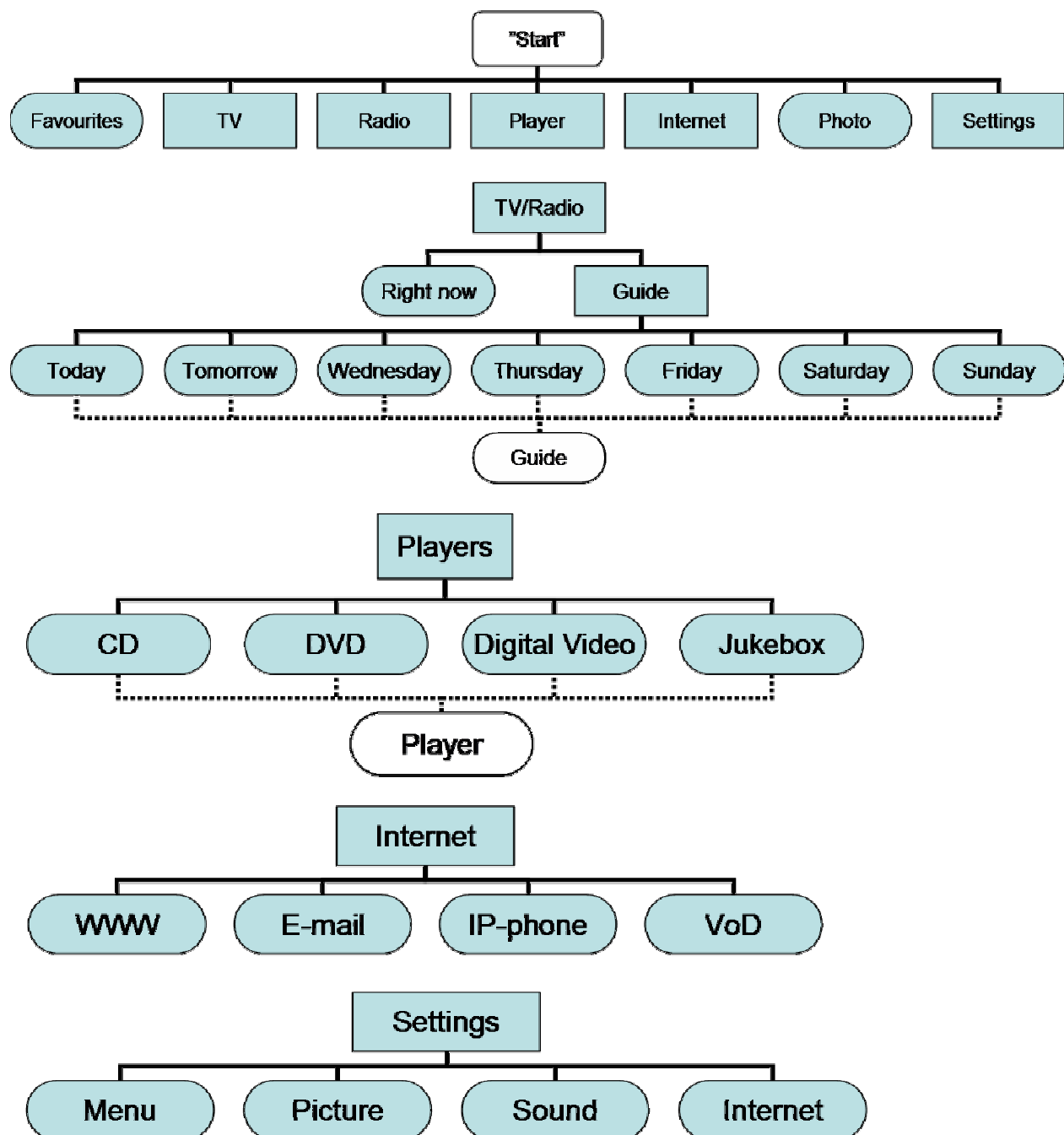
9 EQUIPMENT REFERENCE LIST

1. Stationary PC: AMD Athlon 2500+ XP, 1GB RAM, GeForce FX 5900 Ultra (256MB RAM).
2. Laptop: Intel P3 1GHz, 256MB RAM, integrated graphics chip set (8MB RAM)

10 ATTACHMENT 1

This is the fourth and final version of the menu hierarchy.

End choices are marked with ovals while submenus are squares. Items with white backgrounds are clarifications. “Start” represents the state of the GUI when no menus or functions are visible. End choices with white background are not really part of the hierarchy but serve to clarify that all end choices above correspond to the same function.



11 ATTACHMENT 2

These were the goals, questions and tasks for the usability tests and qualitative interviews:

Version 1

Usability test

User task:

Explore the interface using the mock-up remote control and think aloud while doing it.

What to look for:

Can submenus and function windows replace previous menus without the user getting lost while navigating the menu hierarchy?

Anything else of interest...

Qualitative interview

What is the user's feelings towards commercial ads in the GUI?

Where in the GUI would the user prefer to have commercial ads?

Version 2

Usability test

User tasks:

1. Bring up the menu and wait 5 seconds.
2. Use Favourites to change channel.
3. Check what is on channel X without switching to that channel.
4. What is on SVT1 tonight?
5. The show you are watching is interesting but you don't have time to watch the rest of it. Record it.
6. Stop the recording.
7. There is recorded music available in the STB. Check what is available and play one of the songs.
8. When is "Dokument Utifrån" on SVT1?
9. Check what films are recorded on the STB and play one of them.
10. Turn off the film.
11. There is a CD in the CD player. Play it.

What to look for:

What navigational buttons are used to go from one function to another?

Do the users immediately find what they are looking for?

Anything else of interest...

Qualitative interview

What is the user's reaction to the commercial ad included in the guide?

Version 3

Usability test

User task:

Explore the interface using the mock-up remote control and think aloud while doing it.

What to look for

How does the new layout of the main menu work?

Do the users immediately find what they are looking for?

Are they distracted by the changing commercial ad?

Anything else of interest...

Qualitative interview

Establish the users' feelings toward the commercial ad in the program guide changing every five seconds.

Check again for possible places to put the commercial ad now that the user has a better understanding of how intrusive it will be.

Especially check users feelings toward showing commercial up during start up of STB.

Version 4

Usability test

User task:

Explore the interface using the mock-up remote control and think aloud while doing it.

What to look for

Can the users handle the GUI on their own?

Do they need any instructions?

Do the users (especially the new ones) immediately find what they are looking for?

Are they distracted by the changing commercial ad?

Anything else of interest...

Qualitative interview

Does the change of time for changing commercial ads have any difference?

Establish general feelings towards a commercial GUI.