

CHALMERS



Universal Remote Control for Smartphones

Development of an iPhone App

Master of Science Thesis

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Göteborg, Sweden, 2011

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Cover:

The icon of the developed remote control app

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ABSTRACT

The report is the product of a master thesis work and describes the process of developing an iPhone application that controls home entertainment systems and other remote controlled devices found in homes. The project is mainly focused on the process and methods of product development and does not focus as much on the technology behind the app.

The project is done in collaboration with another group that develops the hardware that can send and receive infrared signals and radio frequency signals. The iPhone communicates with the hardware through Wi-Fi.

A market analysis was made to investigate the interest for the product and also to be able to make priorities among the possible features to implement. The analysis was made through a survey on the Internet and through personal interviews.

An important factor when developing an iPhone application is the usability and therefore the study of cognitive ergonomics is used.

To support the product development process state of the art methods within the field is used. The result of the project is a working prototype with a customisable interface ready for further testing.

Key words: *iPhone, App, Remote control, Product development, Software development, Market analysis, Cognitive ergonomics*

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1 INTRODUCTION

In the year of 1955 the first remote control was introduced, its only purpose was then to control TV:s. Today there is an apparent increase in the interest for home entertainment systems where a number of different electronic appliances are used, each with their own remote control. With an increasing number of remote controls there is also an increasing confusion of which remote control does what, the remote controls themselves can also be confusing with more buttons than one can possibly need.

There is also a rapidly increasing market for smartphones with large touch screens and competent processors. These phones have a great potential for replacing all confusing remote controls and making one intuitive tailored solution that can control home entertainment systems, lights, garage doors and much more.

This master thesis describes the product development process behind the software for a universal remote control on the iPhone.

The thesis is written for the master programme *Product Development* under the *Department of Product and Production Development* at *Chalmers University of Technology*. The project is supervised by Andreas Dagman, assistant professor at the Department of Product and Production Development.

The project is done in collaboration with a second group that is developing the hardware necessary to communicate with the devices the remote control is supposed to control.

1.1 PURPOSE

The purpose of the project is to gather the control for a large number of electrical appliances in the home, thus replacing traditional remote controls.

1.2 GOAL

The project aims to produce iPhone software able to communicate with the hardware that is responsible for sending the signal to the devices. The interface will be made to suit an everyday user and should thus be simple and intuitive.

1.3 DELIMITATIONS

The project is limited to developing a solution for the iPhone only, due to existing experience with this platform.

The work will be conducted in two group, group A and B. Group A constructs the hardware and group B designs the iPhone software and the communication between hardware and iPhone. This report concerns the software part.

The software part of the project initially focuses on producing a solution for a few selected appliances.

1.4 THE REPORT LAYOUT

The first part of the report is theory based and describes what tools and methods are available, there are three theory parts in total. The iPhone theory will introduce software development on the iPhone, what programming language to use and what development tools are available. The next chapter concerns the field of cognitive ergonomics where the basics of this science are described and useful methods are presented. The last theory chapter describes state of the art product development tools.

The project approach describes which of the available methods were chosen and how they were implemented in the project. Possible changes or variations of the methods are presented as well.

The execution of the project and results gained from it are presented in chapter 6. This chapter's layout is inspired by the six phases of product development presented in *Product Design and Development* (Ulrich & Eppinger, 2008).

The two following chapters discuss what has been learned from the project and what could have been made different. The chapters mainly discuss the project methods used and will be less centred on the actual product.

The last chapter lays out the possibilities of further developing the product and what would be the next step in the process.

2 STATE OF THE ART TECHNOLOGY WITHIN IPHONE APP DEVELOPMENT

The following chapter presents the theory needed to build apps, such as what programming language is used, what developer tools to use and what design guidelines to follow. The word app is frequently used in modern mobile technology and is short for application, which is a program on the device. An app can for example give the user instant information about the weather for today or the latest news from the stock market, but it can also give enjoyment in the form of a game. Developing an iPhone app includes a number of complex steps that includes programming the app, managing the network connections and designing the interface to follow guidelines put up by Apple (Apple, 2011).

2.1 IPHONE APPLICATION DEVELOPMENT GUIDELINES

“OS Human Interface Guidelines describes the guidelines and principles that help you design a superlative user interface and user experience for your iOS¹ app.” (Apple, 2011)

As stated in the quote above there are carefully developed guidelines for designing an interface in order to make the user feel confidence and recognition when he/she uses the app. These are written down in Apple’s developer documentation, which contains information and tutorials to get developers started on creating an app. The guidelines are the result from Apple’s testing and experience with software development and are not based on a specific scientific paper. Also it is not said to be the only right way, but it should be followed to create a similarity between apps.

Guidelines can consider such things as the shape and size of buttons, the colour of fields on the screen or the transition when switching between views. The guidelines are by no means strict rules of exactly how to design the app; they just point in the right direction (Apple, 2011).

2.1.1 STANDARD COMPONENTS IN AN APP

Standard components are for example buttons, navigation bars, menus and tables, these are all designed by Apple. In Figure 2.1 examples of some standard components can be seen. Below is an explanation of the most common components:

¹ The iPhone operating system

- *Views* are the basic building component of all apps. A view can cover the whole screen or a small part of the screen.
- *Table views* are built up of a number of different cells; one cell is often one row in the table. A table can consist of one or more sections, a section is a group of cells. A cell can be connected to an action, acting like a button, or it can display information.
- *Tab bar* is a field with buttons at the bottom of the screen. It is used to navigate between views. The tab bar tells the user what tab that is selected by highlighting it.
- *Navigation bar* is a bar in the upper part of the window that shows the user where in a hierarchy of view he/she is. It does this by displaying the title of the current page in the middle and the title of the previous page on the navigation button on the left.



Figure 2.1 - Standard interface components on the iPhone

All components have guidelines for size, colour, placement, function etc. Buttons has for example a minimum size of 44 by 44 pixels (Apple, 2011) so that a person with big fingers can press a button without pressing the button next to it as well. Buttons do very specific things depending on how they look, for example a button that forms an arrow at the end is only for navigation.

2.1.2 STANDARD NAVIGATION IN AN APP

The hierarchy of an app and how to navigate it is important for a streamlined and simple app. The user is never supposed to feel lost in an app; it should always be easy to find the way back to a certain view. The animation when transitioning between views is also important, this tells the user how to get back to the previous view again and what the view is supposed to do. For example if the view is pushed to the left, the user should be able to press a back button to get back (Figure 2.2). And if a so called *modal view* (Figure 2.3) appears from the bottom and covers the whole screen it calls the user's attention to a task that often involves choosing an option, the view can easily be dismissed by pressing cancel.



Figure 2.2 - Navigation between views



Figure 2.3 - Modal view

2.2 THE PROGRAMMING LANGUAGE OBJECTIVE-C

Apps are programmed in the language Objective-C, which is an objective based programming language that extends the classic language of C (Apple, 2010). To compile the objective-c code, the developer tool Xcode is needed. Xcode is the only official IDE (Integrated Development Environment) that supports the development of iPhone apps (Apple, 2011). Besides compiling the code, Xcode is also used for designing the graphical interface. Figure 2.4 shows an example of what Xcode looks like.

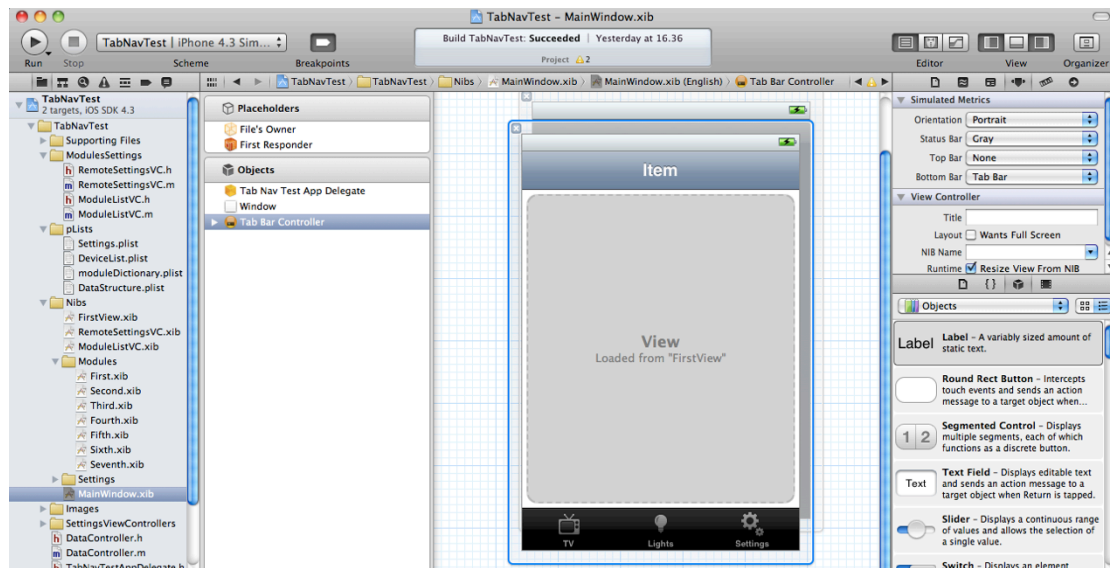


Figure 2.4 - Designing a graphical interface in Xcode

2.3 COMMUNICATION WITH WI-FI AND BONJOUR

To communicate with the hardware, used to send IR-signals and radio frequency signals, Wi-Fi is used. Wi-Fi, or WLAN (Wireless Local Area Network), is wireless communication through radio waves. It allows computers, phones, gaming devices etc. to communicate wirelessly with each other and connect to the Internet (the Wi-Fi Alliance, 2011). The Wi-Fi trademark is owned by the Wi-Fi Alliance, but the use of WLAN is licence free. The alliance offers to certify a product after testing the interoperability with other devices; this gives the customer an assurance that the product works as intended.

Bonjour, as described by Apple, is a zero-configuration networking protocol that is widely used on WLAN devices at the present (Apple, 2006). *Networking protocols* is a set of rules computers follows when communicating with each other. Zero-configuration means that no special configuration is needed by the user, the devices will automatically find each other and will immediately be able to communicate without any help from the user. Without Bonjour all devices in a WLAN would need to configure their IPs, ports and protocols to match each other.

3

THEORY AND METHODS WITHIN COGNITIVE ERGONOMICS

Cognitive ergonomics is the study of how to optimise the well-being and efficiency of people in their work place. It studies closely how the brain processes every day situations and how the process of decision making works. It involves the fields of HMI (Human Machine Interaction), HCI (Human Computer Interaction), Gestalt laws etc. In the following chapter the cognitive ergonomics methods used for designing the iPhone interface will be presented.

3.1 THE BASICS OF COGNITIVE ERGONOMICS

The purpose of cognitive ergonomics is to study the cause of bad work environments, high stress levels or causes of accidents and then to propose how to improve them. This do not only apply to professional operators of machinery, it can also apply to people using a computer for gaming or to someone surfing on an iPhone.

The cause of a bad environment can be for example high levels of noise, bad lighting, high stress levels or a high mental work load. Stress levels can be affected by information overflow from a GUI (Graphical User Interface) or too little or incomplete information from the GUI or confusion on how to act in certain situations. This may cause small or big accidents depending on the operator's tasks.

Cognitive ergonomics theory often mentions the study of stimuli and how these affect humans. A stimulus is information perceived by one of the five human senses. Stimuli are then interpreted by the brain, which then triggers an action from the person. The stimuli can be interpreted differently depending on how clear the information is. It is more effective to send stimuli trough several senses, like the iPhone making a sound and vibrating to give the user feedback on an action.

To optimise the cognitive ergonomics of an app HMI and HCI can be used. Both describe a more specific cognitive ergonomics aimed at the interaction between users and different forms of computers such as a PC or an iPhone. To achieve an interface that gives clear information to the user, methods like Gestalt laws and HTA need to be considered. These methods will be presented below.

3.2 USE CASE

Use cases (Bligård, System view and system engineering, 2010) are used to analyse the interaction between an actor and the machine. Each use case describes a specific situation, a story, and the steps the actor need to take to complete the case. The method has its purpose in answering these questions (Bligård, System view and system engineering, 2010):

- Who is the primary actor, the secondary actor(s)?
- What are the actor's goals?
- What preconditions should exist before the story begins?
- What main tasks or functions does the actor perform?
- What exceptions might be considered as the story is described?
- What variations in the actor's interaction are possible?
- What system information will the actor acquire, produce or change?
- Will the actor have to inform the system about changes in the external environment?
- What information does the actor desire from the system?
- Does the actor wish to be informed about unexpected changes?

The information gathered from the method can be used to minimise the steps of the specific situations and simplify the interaction between actor and machine. But the method is general and does not give a deep understanding about the interaction. Therefore it should be used only as a foundation of the system analysis. (Bligård, System view and system engineering, 2010)

3.3 HIERARCHICAL TASK ANALYSIS

Hierarchical task analysis or HTA is a method used to breakdown tasks in to smaller pieces. Each task is divided in to sub tasks, which in turn are divided in to new sub tasks and so forth. The task and all sub tasks are represented with a node in a tree diagram, giving an overview over the task, see Figure 3.1. The method is used to make designers and developers aware of how a task is done using their product. The awareness will make it possible to further improve the product and make it less mentally demanding to use. (Bligård, Operator task and requirements, 2010)

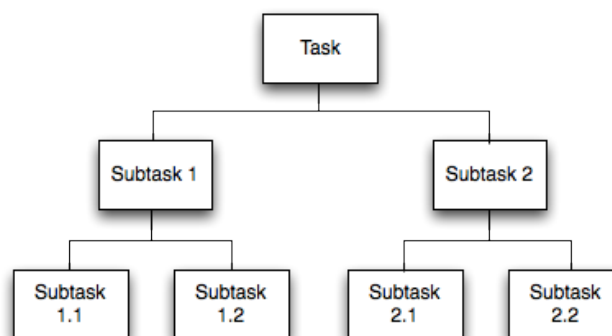


Figure 3.1 - Illustration of a HTA tree diagram

3.4 GESTALT LAWS

The gestalt laws describe how the brain interprets things and how you could design your product to make it intuitive. The laws are proximity, similarity, continuity and closure and are described as follow (Bligård, Basic cognitive theory, 2010):

- *Proximity* describes how we group things together if the distance is narrow. On a remote control you can find how this law is used, the volume buttons are often put close together on one side and the change channel buttons are put together on the other side.
- *Similarity* describes how things with the same shape and colour often are linked. This is also often used on remote controls, where the colour and shape might differ between the general buttons and the teletext buttons.
- *Continuity* describes how we link things; in Figure 3.2 the brain interpret two lines crossing instead of the possible V shapes.
- *Closure* describes how we fill in the blanks between parts to see a symbol we know. In Figure 3.2 the brain interpret the three V shapes as a triangle.

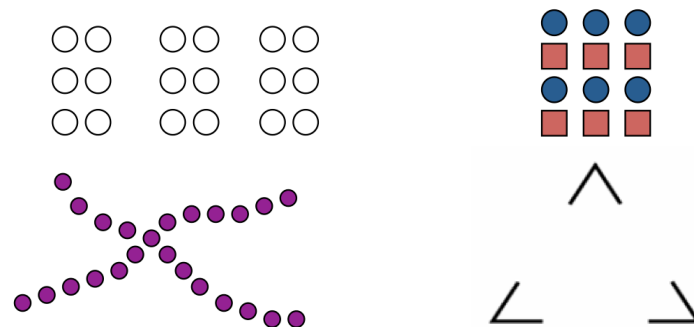


Figure 3.2 - The gestalt laws, from top left to bottom right, Proximity, Similarity, Continuity and Closure (Bligård, Basic cognitive theory, 2010)

4 PRODUCT DEVELOPMENT METHODOLOGY IN THEORY

The methods presented in this chapter are based on material taught in the Product Development Master Programme at Chalmers. Ideas from *Product Design and Development* (Ulrich & Eppinger, 2008), *Engineering Design* (Pahl & Beitz, 1995) and *Produktutveckling* (Johannesson, Persson, & Pettersson, 2004) are used extensively as well.

The methods together forms a generic product development process which helps to plan, perform and document the work behind a product. Because they are generic methods they often have to be modified to fit the project, therefore these methods should be seen more as guidelines than actual rules to follow.

4.1 GENERIC DEVELOPMENT PROCESS

A generic and well-defined development process is important for a project in order to ensure the quality of the resulting product, coordination, planning, management and seeing opportunities for improvement (Ulrich & Eppinger, 2008). This generic process consists of six phases that are listed below:

0. *Planning*

This stage is done before the launch of the actual development process. It includes strategies, market analysis, target market and other goals.

1. *Concept Development*

Product concepts are generated and evaluated based on customer needs. One or more concepts are selected for further development.

2. *System-Level Design*

The product's subsystems are defined and a general picture of the product is formed.

3. *Detail Design*

In this stage the complete description of all parts of the product is developed. All design elements are accounted for down to the exact design, measurements and colour. Also the production price is estimated if it is relevant.

4. *Testing and Refinement*

The testing involves preparing prototypes of the product to test function, usability, customer satisfaction etc. Possible problems are solved and a final product is completed.

5. *Production Ramp-Up*

The purpose of the ramp-up is to train the work force and to solve possible problems with the production process.

4.2 PLANNING METHODS

The planning is predominantly done before the launch of the project, but also during the project to account for delays or to update the schedule in case of changes made by the customer. The planning involves scheduling the work with deadlines etc. and also distributing the work in the project group.

4.2.1 AGILE SOFTWARE DEVELOPMENT

Agile development is a collection of methods developed by the Agile Manifesto (Agile Manifesto, 2001), which describes a work process tailored for software developers. Agile development is carried out in self-organising and cross-functional teams and the work revolves around twelve main principles that can be summarised in these statements:

- Individuals and interactions over processes and tools
- Working software over comprehensive documentation
- Customer collaboration over contract negotiation
- Responding to change over following a plan

These points doesn't mean that a project group should not use processes and tools or should not document their work. Instead it means that the main focus of a project is to satisfy the customer and focus more on achieving goals than to talk about them.

As seen in Figure 4.1, the work is carried out in iterations and each iteration will result in a working subsystem of the software. These iterations should not be too long but should be kept at around one to three weeks. (Cohn, 2006)

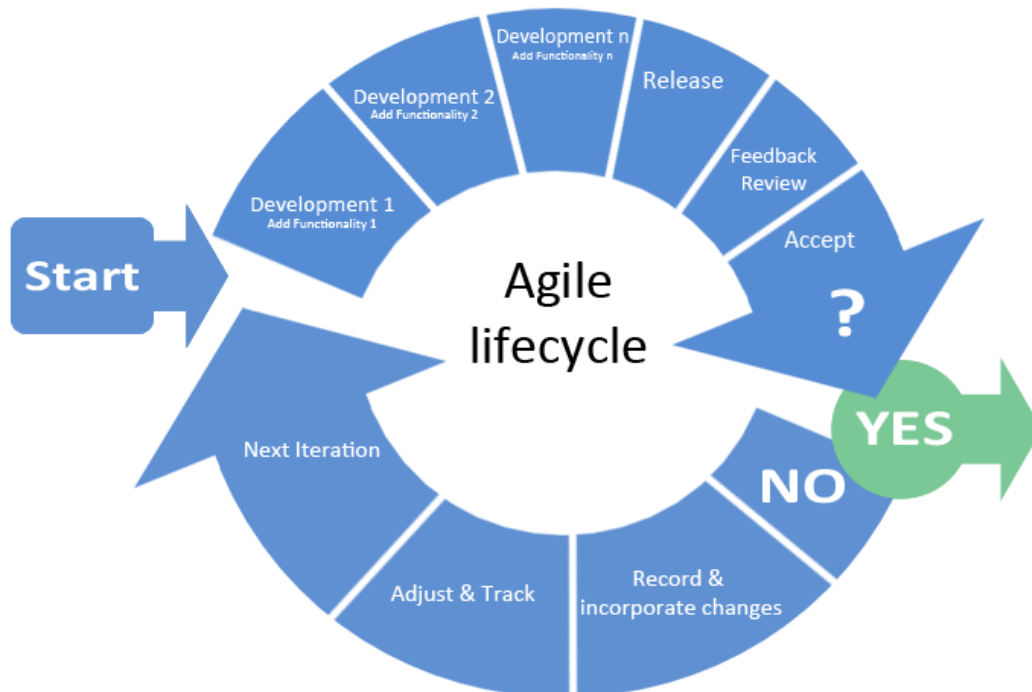


Figure 4.1 - A graphic representation of Agile Development (Vedo, 2010)

After each iteration, a completed subsystem of the software is presented to the stakeholder, who then has the possibility to give frequent feedback and to make changes that the team can respond to quickly without redoing too much work. (Cohn, 2006)

4.2.2 GANTT CHART

Gantt chart is a planning tool, where the user is given an overview over his/hers tasks. The chart displays all the planned tasks on the y-axis and the time line on the x-axis. All the tasks are represented by a bar, with a specific start and end date. The complete time line represents the time limitation of the project. (Ulrich & Eppinger, 2008)

4.3 METHODS FOR PERFORMING A MARKET ANALYSIS

Producing a successful product means giving the market what it wants, therefore a market analysis needs to be performed. In the analysis the user needs is the most important aspect to consider, the need is what controls whether the product is wanted or not. A need for the product might not yet exist on the market, or the market might already be saturated by the competitors' similar products. If the market is not ready for the product, or if the product is not adapted to what the market requires, it will not be successful. An extensive analysis on the current market must therefore be performed before the actual development work is started.

4.3.1 TREND ANALYSIS

A PEST-analysis (*Political, Economical, Social and Technological*-analysis) can be performed in order to get an overview of the present trends from a political, economic, social and technological aspect, which can be used to predict changes in the market and plan how to use them to your advantage by adapting the product for sustainability. (Karlsson, 2010)

4.3.2 SWOT ANALYSIS

To elicit *strengths* and *weaknesses* of the organisation or team as well as *opportunities* and *threats* within the market a SWOT-analysis is used. Academics at the American business schools developed the technique in the sixties and since then it has become a popular method for measuring the compatibility between internal qualities and external conditions (Hill & Westbrook, 1997).

- **Strengths** describe the advantages the project team or organisation has in relation to the competitors. It can also describe how the team stands out in the current market compared to the competitors.
- **Weaknesses** outline the disadvantages of the organisation or team in relation to the competitors.

- **Opportunities** describe favourable aspects of your product in the market. Examples of opportunities are new technology, change in regulations etcetera.
- **Threats** describe unfavourable circumstances in the market of your product.

The analysis results in an understanding of how to differentiate a product and increase the awareness of the competition and of possible threats on the market.

4.3.3 ELICITING USER REQUIREMENTS AND DESIRES

Good communication with prospective customers and users is important in order to get a good overview of their needs in the product. This can be attained in a several different organised ways, a couple of which is given in this section. However, it should be said that the suggested processes are generic in nature, they are highly adaptable, and most companies with experience have developed their own process for managing customer needs. However, it is beneficial to use a generic process as a ground to build your own specific model on (Kaulio, Karlsson, Rydebrink, & Klemets, 1996).

ELICITING USER NEEDS WITH ULRICH AND EPPINGER'S PROCESS

Ulrich and Eppinger describe a process for gathering and interpreting data as well as translating it into specific user requirements and desires (Ulrich & Eppinger, 2008). It contains the following steps.

- 1. Gather raw data from customers**
Questions and/or observations are used to collect raw data as previously described. This results in a list of customer statements concerning all aspects of the product.
- 2. Interpret the raw data in terms of customer needs**
The customer statements are analysed and interpreted in order to compose a list of user needs. The user needs should be expressed in terms of *what* the product has to do, not in terms of *how* it should do it.
- 3. Organise the needs into a hierarchy of primary, secondary and (if necessary) tertiary needs**
Similar user needs are grouped for an easier overview. Redundant statements are eliminated and a *primary* need is set for each group. The rest are considered *secondary* needs, which describes the primary needs further.
- 4. Establish the relative importance of the needs**
All needs cannot be considered to be of equal importance. Therefore, all needs have to be compared against the others in order to get a weight value assigned to them.
- 5. Reflect on the results and the process**

The results are verified against the information elicited from the customers. A reflection is done on whether there are any areas in need of follow-up interviews/surveys and other ways the process could be improved.

ELICITING USER NEEDS WITH THE PRODUCT REQUIREMENT ENGINEERING PROCESS

The *PRE* process (*Product Requirement Engineering*) (Kaulio, Karlsson, Rydebrink, & Klemets, 1996) is another way of eliciting user requirements. PRE is a full framework of descriptions on how to manage customer demands, this includes a six step process with suggestions on methods to use for each step. The suggested steps and methods of PRE are described below.

1. User selection

First a proper target group is selected for the intended product, through for example a *stakeholder analysis* or a *customer segment matrix*.

2. Data collection

Data is then collected from the target group through methods such as *interviews, surveys, focus groups* or *observations*.

3. Data analysis

The results of the data collection are then analysed and interpreted. In this step, analysis methods such as histograms for describing statistics from a questionnaire can be used. The analysis should result in a list of user requirements and desires.

4. Visualisation

The resulting list of user requirements and desires now need to be communicated internally in the development team. There are numerous methods for visualising the requirements and ease the communication, e.g. *sketches, scenarios* and *personas*.

5. Verification and value assessment

In this step, the user should be contacted once again, in order to verify that the gathered user needs have been correctly appreciated. In this step the needs can also be compared against each other in order to determine their value to the customer.

6. Concept generation

This step treats how to use the list of requirements and desires to create concepts. This will however not be covered here, since this section only deals with eliciting user requirements. For more information on methods for concept generation, see section 4.3.11.

4.3.4 USER INTERVIEWS

Conducting interviews with prospective customers is an excellent way of exploring user requirements and needs. There are certain guidelines that should be followed in order to elicit good data from the interviewees, e.g. “the

goal is to elicit an honest expression of needs, not to convince a customer of what he or she needs” (Ulrich & Eppinger, 2008). Ulrich and Eppinger propose a list of common questions that can be used and also some tips on how to conduct the interview. One example is to use visual aids, which could be a competitors product or some kind of mock-up. Another example is to look for nonverbal information in an interviewee, e.g. facial expressions.

One or more members from the development team usually conducts the interviews. The interview is best conducted in the interviewee’s environment and lasts about one to two hours (Ulrich & Eppinger, 2008).

4.3.5 USER QUESTIONNAIRE

A questionnaire, also called survey (Ulrich & Eppinger, 2008), is a way of reaching a larger group of people with a set of general questions. Ulrich and Eppinger notes that the enthusiasm of the survey population is very important, un-enthusiasm will greatly lessen the quality of the result. Therefore it is important to choose a survey population that has a need for or is interested in the final product. Another important factor to consider is the sample size needed for the survey. A larger group will need more generalised questions but will elicit more statistically correct data, a smaller group will give more qualitative data instead of quantitative.

4.3.6 OBSERVING THE PRODUCT IN USE

Data collection can also be done through observing the product in use. When a person performs a certain task often enough he develops a habit. Such a task might be difficult to describe in details since a habit can be performed without thinking. Additionally the user can be unsure about which details are relevant to the interviewer. Users might also be hesitant about describing problematic situations objectively because they blame themselves for the problems instead of flaws in the product design. In these cases it might be more fruitful to observe the user performing the task instead of, or in addition to, asking questions about it (Ulrich & Eppinger, 2008).

4.3.7 CREATING REQUIREMENT SPECIFICATIONS

The requirements specification is not a static document; changes during the product development process are common. The specification should be created early in the process, but with an open mind to changes. It is supposed to work as a foundation during concept generation and selection phase. It also makes it possible for the developers to verify the result of the development process. (Almefelt, 2009)

When formulating the requirements there are many guidelines to be followed. Hull et al. presents these statements that each requirement should meet (Hull, Jackson, & Dick, 2004):

- Atomic: each statement carries a single traceable element
- Unique: each statement can be uniquely identified
- Feasible: technically possible within cost and schedule
- Legal: legally possible
- Clear: each statement is clearly understandable
- Precise: each statement is precise and concise
- Verifiable: does not impose a solution of design specific to the layer below

The full set of requirements should also meet:

- Complete: all requirements are present
- Consistent: no two requirements are in conflict
- Non-redundant: each requirement is expressed once
- Modular: requirements statements that belong together are close to one another
- Structured: there is a clear structure to the requirements document
- Satisfied: the appropriate degree of traceability coverage has been achieved
- Qualified: there are acceptance criteria appropriate to demonstrate that the requirements are acceptably met.

The requirement specification should, except the formulated requirements, validate the requirements and present evaluation/verification methods, see Table 4.1. The validation should present why the requirements are stated, e.g. to meet standards or a technical demand. The verification method should present how to control if the product fulfils the requirement. (Almefelt, 2009)

Table 4.1 - Example of Requirement specification

Requirement	Validation	Evaluation/Verification
Requirement group 1		
R1: Requirement 1.1	Validation 1.1	Verification 1.1
R2: Requirement 1.2	Validation 1.2	Verification 1.2
D1: Desire 1.1	Validation 1.3	Verification 1.3
Requirement group 2		
R3: Requirement 2.1	Validation 2.1	Verification 2.1
D2: Desire 2.1	Validation 2.2	Verification 2.2

4.3.8 WEIGHING MATRIX

To compare the importance of the desires in an objective and rational way, a weighing matrix can be used. The Matrix is used to make a comparison in pairs, where every desire is individually compared to the others. The pair can in total get 1 point. If one desire is more important than the other it will get the point and the other will get 0 points. If the desires are equally important, they will share the point, in other words, each desire will get 0.5 points. To calculate the

weight, the sum of points for each desire is divided by the total sum, giving a weight between 0 and 1 or 0 and 100%. (Johannesson, Persson, & Pettersson, 2004)

Table 4.2 - Example of an weighing matrix

	Desire 1	Desire 2	Desire 3	Sum	Sum/Tot
Desire 1	-	0	1	1.0	0.33
Desire 2	1	-	0.5	1.5	0.50
Desire 3	0	0.5	-	0.5	0.17
Tot:				3.0	1.00

4.3.9 DESCRIBING USER SATISFACTION USING THE KANO MODEL

The Kano model describes how to achieve customer satisfaction by including product functions that fulfils different customer needs and requirements. The functions can be divided into three main dimensions: the basics, performance and excitors/delighters. These can be represented by three curves on a satisfaction scale as seen in Figure 4.2.



Figure 4.2 - The Kano model (Karlsson, 2010)

The basics curve describes how satisfaction is affected by whether the essential functions of a product are present; these functions are so called 'must haves'. The second dimension is performance, which describes how well it performs its functions. And the third dimension is excitors; these are unexpected functions that fulfil needs the customer did not know they had. The model shows that basic functions cannot satisfy a customer on its own. The performance increases the satisfaction linearly, and the excitors always add to the satisfaction, even if they don't work fully.

4.3.10 METHODS FOR CONCEPT DEVELOPMENT

The concepts of a product are the early suggestions of how to solve a problem. The concept contains information on technology, working principles, what design to use etc. A concept is generated from several combined functions and is selected based on how well they can handle the requirements and desires. The concepts are formed and chosen through several iterations where fulfilling the customer needs is top priority. (Ulrich & Eppinger, 2008)

4.3.11 CONCEPT GENERATION METHODS

The purpose of the concept generation process is to thoroughly explore the possible and impossible solutions for the product. The process involves using the creativeness and experience from the project group and also searching externally for the opinion and ideas of the future customers. A thorough search of existing products is also a very important step in the process. (Ulrich & Eppinger, 2008)

THE FIVE-STEP METHOD

The five-step method is a structured approach to generate concepts presented by Ulrich and Eppinger (Ulrich & Eppinger, 2008). The method is designed to reduce problems one might face during the process and are suitable for less experienced teams. The method is presented by Ulrich and Eppinger in a linear way, but it is also pointed out that this method is almost always iterative. The five steps are as follow (Ulrich & Eppinger, 2008):

1. Clarify the problem

Clarifying the problem consists of developing a general understanding for the problem and then, if necessary, breaking it down into sub problems.

2. Search externally

External search is according to Ulrich & Eppinger aimed at finding existing solutions to both the overall problem and to sub problems.

3. Search internally

Internal search is the use of personal and team knowledge and creativity to generate solution concepts. This may, according to Ulrich & Eppinger, be one of the most open-ended methods in new product development.

4. Explore systematically

Systematic exploration aims at navigating the space of possibilities by organising and synthesising the solution fragments.

5. Reflect on the solutions and the process

This step should be carried out throughout the whole concept generation process and generally aims at making sure that the work is done in a correct way.

BRAINSTORMING FOR IDEAS

The brainstorming method (Pahl & Beitz, 1995) is designed to generate a flood of ideas from a group of at least five people from different parts of society. The members of the group need to be open-minded, creative and able to present their ideas verbally. No ideas are too impossible or too absurd to mention, but they should be concrete enough to sketch down on paper. A session should take no longer than about 30 minutes; very little new information will be elicited after that.

USER FOCUS GROUP

Focus groups are conducted by a moderator, who can be either a member of the project group or a hired market research professional. The group consists of eight to twelve potential customers and the proceedings are often observed by the rest of the project members remotely, through video or a one-way mirror if such a room is available. Focus groups inherit the same positive aspects as those of interviews, in terms of depth, with the addition that discussions can arise within the group from points that an interviewer might not have considered in a one-to-one interview. Focus groups however usually demand more resources to conduct than interviews. (Ulrich & Eppinger, 2008)

MORPHOLOGICAL MATRIX

In the development process, it can be helpful to divide the problem in to sub problems in order to find good solutions. These sub solutions can then be combined to create full solution concepts. Morphological matrix is a method for combining sub solutions systematically. The matrix is constructed with sub functions on the y-axis and solutions x-axis as seen in Table 4.3.

Table 4.3 – Example of Morphological matrix

Sub functions \ Solutions		Solutions			
		1	2	...	m
1	Function 1	S11	S12	S1...	S1m
2	Function 2	S21	S22	S2...	S2m
⋮	Function...	S...1	S...2	S.....	S...m
n	Function n	Sn1	Sn2	Sn...	Snm

4.3.12 CONCEPT SELECTION METHODS

The selection process is intended to result in one or more concepts to move forward with. The selection process involves a number of analytic methods and concept testing. The process might result in further concept generation and may therefore involve several iterations to take the new concepts into consideration. (Ulrich & Eppinger, 2008)

ELIMINATION MATRIX

Elimination matrix or selection chart (Pahl & Beitz, 1995) is applied to the process if a large amount of concepts have been generated. The elimination process builds on seven criteria, where concepts not fulfilling the criteria are eliminated. The criteria are as follow

- A. Compatibility assured
- B. Fulfils demands of the requirement list
- C. Realisable in principle
- D. Within permissible cost
- E. Introduce favourable ergonomic conditions
- F. Preferred by designer's company
- G. Adequate information

Criteria A and B are go/no go decisions and should be considered first. Criteria C and D are not absolute and the decision should be made considering how well a concept fulfils the criteria. E, F and G are preferential criteria and should only be used if the amount of concepts are so many that a full evaluation is too time consuming. An example of an elimination matrix can be seen in Table 4.4. (Pahl & Beitz, 1995)

Remote Control Concepts	Compatibility assured				Decision
	Fulfils demands of requirements list			Comment	
	Realisable in principle				
	Within permissible costs				
Concept 1					
Concept 2					
Concept 3					
Concept 4					

Table 4.4 – Example of Elimination matrix

KESSELRING MATRIX

The Kesselring matrix, also called the evaluation matrix (Pahl & Beitz, 1995), uses the weights of the desires acquired in earlier steps. These weights are multiplied with a subjective value acquired using a value scale (Table 4.5), to form a total scoring of each concept. This scoring value gives a measure of how well the concepts fits the desires. An example of a Kesselring matrix can be seen in Table 4.6. (Pahl & Beitz, 1995)

Table 4.5 – Points awarded in Kesselring Matrix and Guideline VDI 2225 (Pahl & Beitz, 1995)

Value Scale			
Use-value Scale		Guideline VDI 2225	
Pts.	Meaning	Pts.	Meaning
0	Absolutely useless solution	0	Unsatisfactory
1	Very inadequate solution		
2	Weak solution	1	Just tolerable
3	Tolerable solution		
4	Adequate solution	2	Adequate
5	Satisfactory solution		
6	Good solution with few drawbacks	3	Good
7	Good solution		
8	Very good solution	4	Very good
9	Solution Exceeding the requirement		
10	Ideal solution		

Table 4.6 - Example of Kesselring matrix

No.	Evaluation Criteria	Wt.	Concept 1		Concept 2		Concept 3		Concept 4	
			Value	Weighted Value	Value	Weighted Value	Value	Weighted Value	Value	Weighted Value
1	Desire 1	5%								
2	Desire 2	9%								
3	Desire 3	32%								
4	Desire 4	14%								
5	Desire 5	18%								
6	Desire 6	23%								
		100%		0,0%		0,0%		0,0%		0,0%

PUGH MATRIX

The Pugh method, developed by Stuart Pugh in the 1980s, is a way of quickly narrowing the number of concepts in a project (Ulrich & Eppinger, 2008). The method uses a matrix with the selection criteria on the y-axis and the concepts on the x-axis.

Table 4.7 - Example of Pugh Matrix

Selection Criteria	Concepts			
	A (Reference)	B	C	D
Criterion 1	0	-	-	0
Criterion 2	0	-	0	+
Sum +				1
Sum 0	2		1	1
Sum -		2	1	
Net Score	0	-2	-1	1
Rank	2	4	3	1
Continue?	Yes	No	No	Yes

As seen in Table 4.7 all concepts are compared to a reference, this can be an earlier product, an industry standard or a straightforward concept that the group is very familiar with. This reference gets the score of 0 while the others are either better, worse or equal to it. When the concepts are rated they are ranked, the next step is then to decide whether to continue with them or not. Another decision can be to revise a concept or combining two that complement each other. The new or revised concepts are then added to the matrix and compared to the others in another iteration of the method. In *Produktutveckling* (Johannesson, Persson, & Pettersson, 2004) it is suggested to iterate a third time with weights to the criteria in order to get a more precise result.

4.4 METHODS FOR SYSTEM LEVEL DESIGN AND DETAIL DESIGN

The design phases of the product development process, system level design and detail design, follows the theory and methods described in chapter 3, Theory and Methods within Cognitive Ergonomics.

5 PROJECT APPROACH

The following chapter explains how this project uses the standard methods and also treats the physical arrangement and roles of the project.

5.1 ADOPTED PROCESSES AND METHODS

The structure of the development process is inspired by the six phases of the generic development process presented by Ulrich and Eppinger and described in chapter 4.1. To adapt the method to the specific project, the last phase, *production ramp-up*, is replaced with a verification phase. In Figure 5.1 the adapted generic development process is shown.

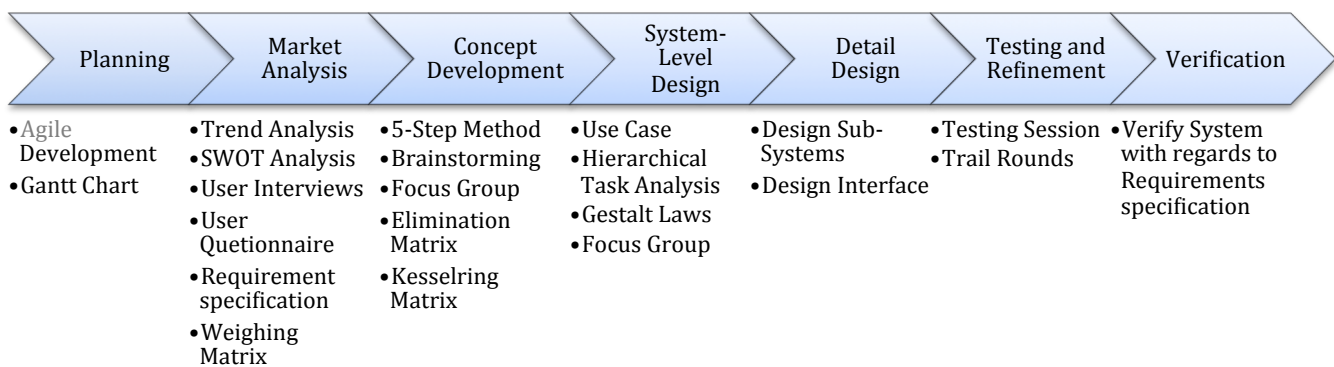


Figure 5.1 - The Generic Development Process of the project

5.2 PHYSICAL ARRANGEMENTS

To profit and support the development process an office was used. The office was shared with Team A, which made it possible to have close contact and support each other in the process. The office also provided good environment for development with three whiteboards and a corkboard. The location of the office was at the department of Product and Production Development at Chalmers University of Technology. Providing a locality of experts in the field of product development and software development.

The process was further supported by software development tools, necessary for iPhone software development. The software was developed on two macs running the software Xcode 4.0 and tested in a simulator and on two iPhones.

5.3 ROLES AND RESPONSIBILITIES

The project was conducted in two separate teams, Team A and Team B, with two members each. As the team only had two members no leader was decided. The work was divided and made separately by the members, where the other

member worked as a reviewer. Big decisions were taken in consultation with Team A, but with a final decision within the team.

5.4 PROJECT PLAN

To plan and execute the project, Agile software development was used. Gantt charts were used to plan how much time each step would take. A planning report was written early on to put down in words how to execute the project and to get a better overview of what to do.

5.4.1 AGILE SOFTWARE DEVELOPMENT

It was appropriate for the software part of this project to use agile development. This enables subsystems to be analysed and reviewed continuously, the progress will also be easier to grasp. The project was divided into base functionality and additional functionality, which will be added if there is time. Therefore it is important to complete every added function before adding a new one. Hence, each iteration of the agile development process will add one function to the system.

5.4.2 GANTT CHART

The project has a time limitation of 20 weeks; therefore planning of time resources is of great importance. The planning was made using Gantt charts, where the six major phases of product development were the tasks. The Gantt chart can be seen in Figure 5.2.



Figure 5.2 - Gantt chart for the project process

6 EXECUTION AND RESULTS OF THE PRODUCT DEVELOPMENT PROCESS

This chapter presents the execution and results of the development process. The chapter follows the generic development process presented in chapter 4.1 Adopted Processes and Methods. In the end the proposed solution will be presented, followed by testing and verification of the solution.

6.1 RESULT OF MARKET ANALYSIS

The project revolves around a product produced side-by-side with a hardware team, and for the groups to begin developing their respective parts, they both will need to perform a market analysis and search for requirements. The requirements are largely based on end-user needs, concerning the product as a whole, which are interesting for both groups. Both groups doing a full market analysis was therefore considered a waste of both time and resources, and instead a joint market analysis was performed. To start, a joint focus was put on the overall product and its intended market as well as overall end-user needs; to later digress into more individual work on setting specific requirements for hardware and software respectively.

The requirements for the product are primarily elicited using interviews and surveys, but they also need to be adapted to a specific product target group as well as the current market situation, which has been described through a trend analysis.

A SWOT analysis has been performed as well, to analyse the environment of the idea and compare it with other solutions available on the market.

6.1.1 PEST ANALYSIS

Recent trends have been analysed from a social, economic and technological perspective, in order to see what is happening on the market at the moment, and to verify that the proposed product is in fact a good fit on the market.

SOCIAL AND ECONOMIC TRENDS

Early adopters are always looking for new innovative products to be released. Since the current alternatives for universal remote applications requires additional hardware to be attached to the smartphone, this idea can be viewed as innovative since it requires nothing else than starting the application on your phone. If the user interface is constructed in such a way that it is intuitive and easy to use, yet still powerful and functional, the product will sit well with the

early adopters and through them the word will spread out that it is a cool and hip product, generating a craving for it on the market.

When flat screen TV:s first arrived they were considered expensive luxury equipment, but over time the technology has become more and more affordable and today the flat screen is practically standard appliance in the average home. Other appliances such as surround sound systems, DVD/Blu-ray players and external media boxes have also become cheaper. The use of a high definition projector and projector screen in the living room can still be considered a luxury item, but their price is steadily decreasing as well. These economic trends have led to an increased number of users, which means that more and more people are getting their coffee tables filled up with remote controls. A survey conducted by Logitech concludes that the average living room has four or more devices with remote controls (Logitech, 2010). Swedish people are now also watching more TV than ever, with about three hours a day per person (Oscarsson, 2010). The more time people spend in their couch watching TV and the more extra equipment they buy, the more use they will find for a simple universal remote control.

TECHNOLOGICAL TRENDS

A low price tag on the equipment is not the only thing that attracts people, but also that technology inside it is getting better. Every time a new technology is released, older hardware will seem more and more out-dated, and these last few years we have seen a lot of new releases on the technology market. Examples of these are improvements on the TV screen with the introduction of LED and 3D technology, but also functional advances such as interaction with Internet applications through a broadband connection as well as home theatre media boxes for viewing downloaded or recorded movies and TV shows. With an increased number of functions, the remote controls also needs to be able to control them, which often leads to more buttons, making the remotes controls increasingly complex. It should also be noted that even though the number of functions in the equipment increases, people do not necessarily use all of them, which leads to a large number of buttons on the remote controls that are rarely ever used.

Since 2007, when Apple released the iPhone, the market for smartphones has increased rapidly. In 2010 the sales of smartphones reached 1,75 millions in Sweden, which constitutes 45 per cent of the country's total mobile phone sales, to be compared with the sales for 2009 which only reached 0,78 million or 25 per cent of sales (MobilTeleBranschen, 2011).

Today's smartphones holds a large touch screen display, which can be fully utilised by third party applications. With this display, the user interface for a remote control application can be tailor made to fit any individual by only showing the functions that he/she wants to use. And because of the rapid growth of the smartphone market, the same growth is implied for the market of

applications for them, which is why now is a good time to combine the areas of smartphone applications and home cinema control equipment.

6.1.2 SWOT ANALYSIS

In order to analyse the environment of the idea and to compare it with the solutions on the market, a SWOT-analysis was made. The result of the method is the possible strength, weaknesses, opportunities and threats for the realisation of the idea. The result can be seen in Table 6.1.

Table 6.1 - SWOT analysis for the product

		Helpful	Harmful
Internal	Strengths	<ol style="list-style-type: none"> 1. Utilises the power of the iPhone 2. Big high definition display 3. Touch screen 4. Internet access 5. Modes of communication 6. The users have experience with the iPhone user interface 7. Less important size and shape restrictions 8. Experience with the iPhone 	<ul style="list-style-type: none"> • Limited experience of market • Limited resources • No name on the market
	External	Opportunities	<ol style="list-style-type: none"> 1. Expensive products on the market 2. Growing smartphone market 3. Growing amount of remote controls 4. Growing amount of functions 5. The market trends 6. Physical UI on products of today 7. Limited modes of Communication on the products of today 8. No direct competition found
			<ol style="list-style-type: none"> 1. Tough competition 2. iPhone solutions already on the market 3. Bounded by the limited iPhone market 4. Decreasing iPhone market share 5. Limitations of the iPhone

STRENGTHS

By using a smartphone to act as user interface, advanced technology can be utilised whilst the price is kept to a minimum. The smartphones can provide the product with computing power, a big high definition touch screen and Internet access. The smartphones also has the ability to communicate through different types of mediums, including Bluetooth and Wi-Fi. The user will in most cases have some level of experience with the smartphones' user interface, giving the product an advantage within human-machine interaction. As the products hardware is stationary and will not demand any direct interaction with the

user, the size and shape of it will be less important. The developers also have high level of experience with the iPhone and product development processes.

WEAKNESSES

The developers have limited experience of the market and therefore have less understanding about trends and pit falls. The resources are also limited, which can act as a constraint for the product. The limited resources are time (20 weeks), personnel (Two engineers on software resp. hardware) and money (10 000 SEK). A newly launched company will also have no name on the market, which sets higher demands on the product introduction to reach success.

OPPORTUNITIES

A variety of universal remote controls can be found on the market today, with a price range from 50 SEK up to 30000 SEK (Prisjakt, 2011). But to get a product with similar or better user interface as the one possible on a smartphone, the price would range higher than 1000 SEK (Prisjakt, 2011). The smartphone market grows every year (MobilTeleBranschen, 2011), which makes the potential market of the product grow as well. A growth can also be seen in the amount of electronic equipment used in the homes, leading to more remote controls in the living room. The growing amount of equipment also leads to more functions and settings, making the process more complex (Logitech, 2010). As the products of today often have a physical interface, and have no ability to adapt to different situations, it could make the complex task even harder. Investigating today products, within the same price range, shows a lack of communication modes. The remote controls can generally only communicate through IR signals. As the idea for the intended product is to have the ability to communicate through multiple mediums, with no need for attaching additional hardware to your phone, no direct competitor has been found.

THREATS

The market for universal remote controls is well established with tough competition. The competitors are global electronic companies as *Philips* and *Logitech*, specialised companies such as *RTI* or small newcomers like *L5 remote* and *RedEye*. The *L5 remote* (Figure 6.1) and *RedEye* (Figure 6.2) are solutions developed to take advantage of the iPhone (L5 Technology LLC, 2011) (Thinkflood, 2011). Another threat is the limitations of the iPhone and its market. The iPhone has restrictions on how apps can utilise the hardware (Apple, 2011), the performance of the iPhone hardware can also be seen as a limitation of the product. The smartphone market is still growing, which could be seen as an opportunity, but the iPhone is still only the third biggest product on that market and with a shrinking market share, therein lies a threat to make the product dependent on the iPhone (Gartner, 2010).



Figure 6.1 - The competitor L5 Remote (L5 Technology LLC, 2011)



Figure 6.2 - The competitor RedEye's attachable solution and docking solution (Thinkflood, 2011)

6.1.3 ELICITING REQUIREMENTS AND DESIRES

The process of eliciting requirements and desires is inspired by the *Eliciting user requirements process* (Ulrich & Eppinger, 2008) and the *Product requirement engineering process* (Karlsson, 2010). The two processes presents a given way to elicit requirements, but highlights that the process should be tailored to fit the specific project. The applied process has six steps; the first three steps are taken from the Product requirement process and the corresponding steps in the Eliciting user requirement process are disregarded. The fourth step of the Product requirement engineering process, *visualisation*, is disregarded as it is only used to communicate in larger projects. The fourth, fifth and sixth steps of the applied process are as following *Establish the relative importance of the needs*, *Verification and Value assessment* and *Reflect on the results and the process*. A visualisation of the process can be seen in Figure 6.4 and in Figure 6.3 the handpicked steps are displayed.

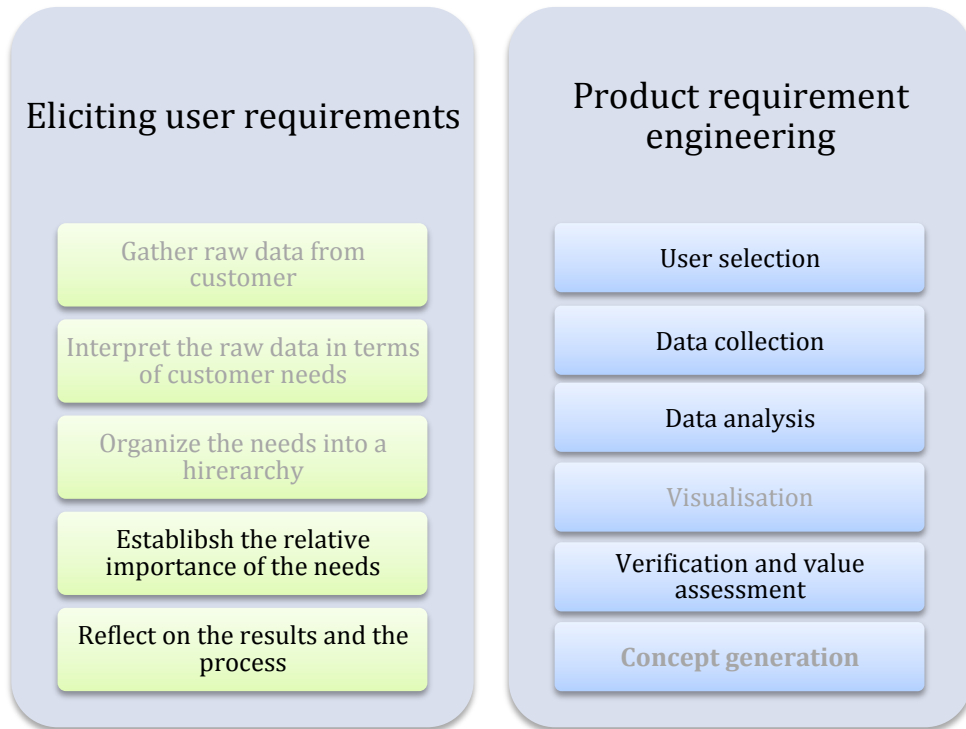


Figure 6.3 - Handpicked steps of the eliciting requirement and desires process

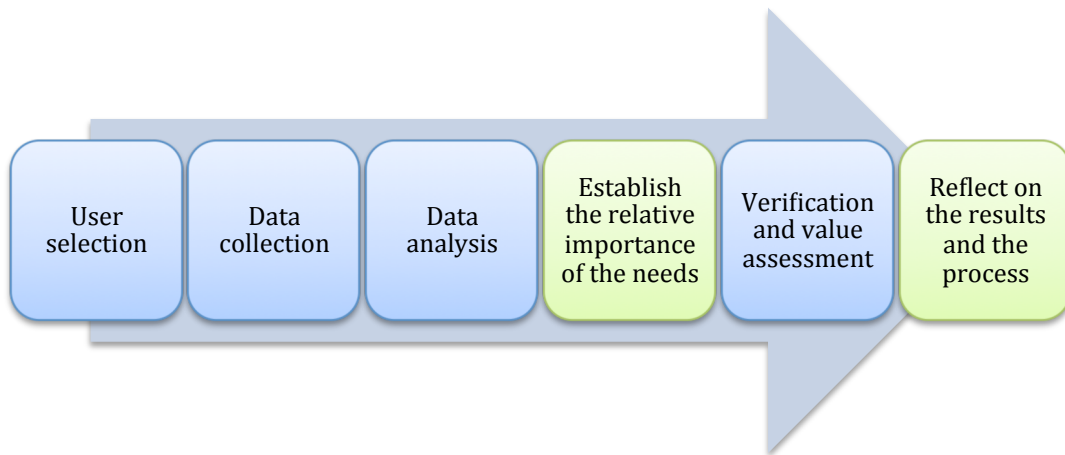


Figure 6.4 - The tailored eliciting requirement and desires process

USER SELECTION

The studies were carried out with possible future customers/users. This is basically every iPhone user or anyone with appliance that can be controlled using a remote control. It was of extra interest to ask users of other types of universal remote controls what they like about them, what they would like to see changed and also if they would prefer to use a smartphone instead of their current solution. iPhone is not the only interesting platform to work on, future expansion to other operating systems might be of interest and therefore the interest from Android users was investigated.

Because the user group of smartphones has grown and diversified so much, it is important to cover many different user demographics. The demographic groups of smartphones ranges from very young teenagers to retirees, as seen in Table 6.2. A gender demographic breakdown of iPhone subscribers also shows a majority of men in the group, as seen in Table 6.3.

Table 6.2 – Age demographic breakdown of smartphone subscribers (comScore Data Mine, 2010)

Age (year)	Per cent of mobile market (%)
13 – 17	7
18 – 24	17
25 – 34	28
35 – 44	23
45 – 54	15
55 – 64	7
65+	4

Table 6.3 - Gender demographic breakdown of iPhone subscribers (Kellogg, 2010)

Women (%)	Men (%)
45	55

DATA COLLECTION

In order to gather statistics about regular home equipment, a survey was performed using a web questionnaire. The questionnaire focused on determining how many and what types of remote controls are present in peoples' homes today, the full questionnaire can be found in Appendix B – The Questionnaire. The selection group was assembled using Facebook and consisted of approximately 550 people. The gender distribution was approximately 60 percent men and 40 percent women. The age distribution had the majority in the span of 18-24 and 25-34. To get more participants in the span of 35-44, the questionnaire was uploaded to the home cinema forum '*Min Hembio*'. The results were rendered from a total of 260 submitted answers, from users with an age distribution as shown in Figure 6.5.

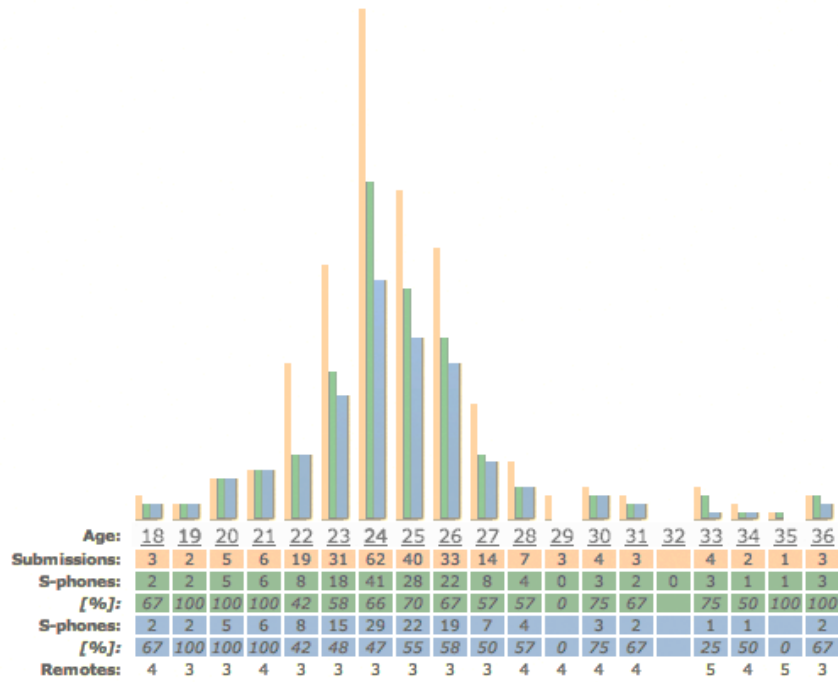


Figure 6.5. Age distribution and smartphone ownership. Orange represents all people who answered the questionnaire. Blue represents people that own a smartphone. Green is the same as blue but also includes people who plan on getting a smartphone.

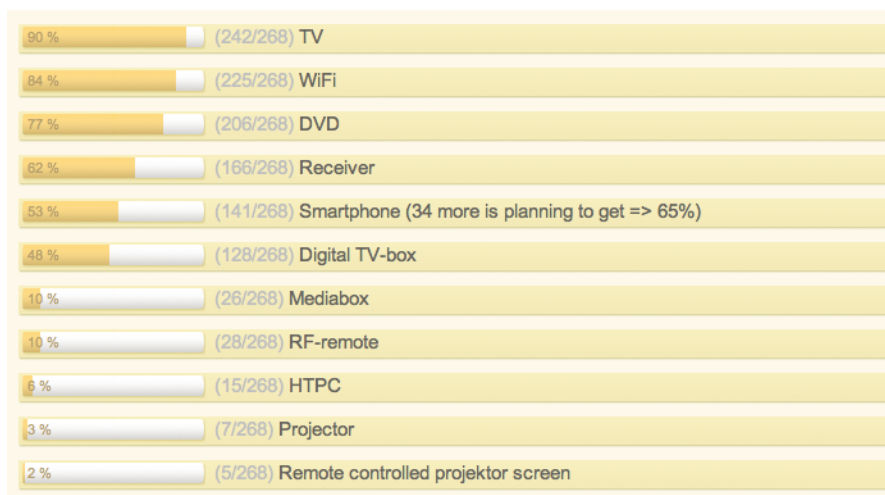


Figure 6.6 - A list showing what equipment are most common in homes today, according to the result of the questionnaire

The results showed that most people have a TV (90 %), DVD/Blu-Ray (77 %) and a receiver (62 %), and almost half of the people have a digital TV box (48 %). Most of them have a Wi-Fi connection at home (84 %). Smartphone owners represent 53 %, while an additional 12 % is planning to get a smartphone. The statistics can be seen in Figure 6.6.

The statistics gathered resulted in a good collection of quantitative market data, but the questionnaire also served as a mean to generate qualitative data in the form of customer needs statements. The people currently owning a universal remote control were asked to give their opinions of it in terms of what they like about it, what they dislike, which functionality they often and rarely use respectively, what their remote control lacks and how it could generally be

made better. The ones who did not own a universal remote control were asked about what could make them buy one.

Aside from the questionnaire, semi structured interviews were also carried out with people within the chosen product target group. These were used to get a more detailed description of user needs and desires, by having a more laid back conversation with the ability to ask follow-up questions when interesting opinions came up. The interview template can be found in Appendix C – The Interview Template.

DATA ANALYSIS

At this time, a large set of customer statements have been collected and categorised. These statements should now be analysed and interpreted, in order to compose a list of requirements. Each customer statement may be used to set up one or more requirement. However, one person's interpretation of a user statement may differ from another's, and for this reason it is wise to do this step in collaboration with at least one other team member (Ulrich & Eppinger, 2008). This step was therefore done through a discussion session together with the thesis writers of the collaborating hardware group.

In the data collection step the needs of the users were elicited. In this step the underlying requirements and desires are found and presented. The focus is now only on the iPhone software, to read more about how requirements were elicited for hardware, see Team A's report.

To sort the requirements and desires three different subsystems were created.

- Navigation system
- Remote control system
- Overall system and additional functionality

The complete requirement specification can be found in Appendix A – The Requirement Specification.

ESTABLISH THE RELATIVE IMPORTANCE OF THE NEEDS

In order to get a good comparison between desires and later be able to do a Kesselring matrix, a weighing matrix was performed. The weighing matrix was inspired by the weighing matrix presented by Johannesson et al (Johannesson, Persson, & Pettersson, 2004) and described in the theory chapter. But Johannesson et al describes how a desire can get 0, 0.5 or 1 point, which makes it possible to say that two desires are equally important. To prevent that from happening and to get a higher resolution, the point system used has four levels; see Table 6.4

Table 6.4 - Point-system of the weighing matrix

++	Much better
+	Better
-	Worse
--	Much worse

The weighing matrices were made four times, one for each subsystem and one total for all desires. The last one was made in order to get a total list over the desires with their relative importance. The weighing matrix for the additional functionality is not presented in this chapter, as it does not have any impact on the concept development and screening process. The desires describes additional functionality, hence, they should not affect any basic functionality.

NAVIGATION SYSTEM

The weighing matrix for the navigation system is used to compare the six desires of the system. The most important desire is to construct an intuitive system and the least important is to provide the user with an overview mode, see Table 6.5.

Table 6.5 - Weighing Matrix for the desires of the navigation system

		N1	N2	N3	N4	N5	N6
Overview mode	N1	0					
No limit in amount of remotes	N2	-	0				
The system should be intuitive	N3	-	--	0			
As Few user interactions as possible to change remote	N4	-	-	+	0		
Use without watching	N5	-	-	+	-	0	
Recognizable interface	N6	-	-	+	-	-	0
Sum +1:		1	2	7	3	4	5
Weight:		5%	9%	32%	14%	18%	23%

REMOTE CONTROL SYSTEM

The weighing matrix for the remote control system is used to compare the 13 desires of the system. The most important desires are to have an intuitive system with feedback to user interactions. It is also important to provide a user interface for digital TV box. The least important desires are to provide a user interface for other appliances, see Table 6.6.

Table 6.6 - Weighing Matrix of the desires of the remote control system

		R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13
Modifiable interface	R1	0												
The system should be intuitive	R2	-	0											
Interface for digital tv box	R3	--	-	0										
Interface for HTPC	R4	+	+	+	0									
Interface for projector	R5	+	+	+	+	0								
Interface for projector screen	R6	++	++	+	+	+	0							
Interface for X-box	R7	++	++	++	+	+	+	0						
Interface for PS3	R8	++	++	++	+	+	+	+	0					
Interface for Mac	R9	++	++	++	+	+	+	+	+	0				
Support as many buttons as possible	R10	-	+	+	-	-	-	-	-	-	0			
Use without watching	R11	-	+	+	-	-	-	-	-	-	-	0		
Give feedback to user interaction	R12	-	+	+	--	--	--	--	--	--	-	-	0	
Recognizable interface	R13	-	+	+	-	-	-	-	-	-	-	-	+	0
Sum +1:		11	16	17	6	5	4	3	2	1	8	9	17	10
Weight:		10%	15%	16%	6%	5%	4%	3%	2%	1%	7%	8%	16%	9%

VERIFICATION AND VALUE ASSESSMENT

The resulting requirement specification and the weighted desires were in this phase of the market analysis verified by discussions with the former interviewees. This was done to verify the data analysis and established relative importance of the needs. The interviewees were in this case given an example of the result and the verification was carried out as a discussion.

This type of verification has also been followed up along the product development process, partly by the hardware group, but also with focus group meetings.

REFLECT ON THE RESULTS AND THE PROCESS

The results from the weighing matrices and the customer interaction have given a foundation for the continuing work with concept development. The requirement specification constructed in this phase of the project is not a complete specification. The requirement specification is a living document and will change as the project goes on. The market research gives the team an understanding of the market, but in further development, new customer interactions need to be done. The process will be followed up by a deeper analysis of the existing market and a focus group will be created and used during the development and verification of the product.

A total weighing matrix was done during the market analysis. This data will be used as a checklist for possible expansions to the system. In Table 6.7 the desires are presented sorted by the relative importance.

Table 6.7 - Desires sorted by the relative importance

Desires	Weight
Installation - Record button	8,5%
Interface for Digital-box	8,1%
The system should be intuitive	7,6%
Give feedback to user interaction	7,2%
Overview mode	6,0%
Recognizable interface	6,0%
Use without watching	5,6%
As Few user interactions as possible to change remote	5,4%
Modifiable interface	5,2%
No limit in amount of remotes	5,2%
Play/Record Macros	5,0%
Support as mant buttons as possible	3,3%
EPG - TV-guide	3,3%
EPG - Click to watch	3,1%
Interface for HTPC	2,5%
Support as many protocols as possible	2,5%
Interface for projector	2,3%
Interface for projector screen	2,1%
Be able to connect to hardware through Internet	1,9%
Interface for X-box	1,7%
Interface for PS3	1,6%
Interface for Mac	1,4%
EPG - Click to plan	1,4%
EPG - Click to record	1,0%
Timer - Plan start	0,8%
Timer - Timer Start	0,6%
Timer - Plan stop	0,4%
Timer - Timer stop	0,2%
Sum	100%

6.2 RESULT OF CONCEPT DEVELOPMENT AND SELECTED CONCEPT

This chapter explains the steps taken to generate and select concepts and what methods that were used in achieving this. The result from the concept generation and the concept selection respectively are described as its own chapter.

6.2.1 CONCEPT GENERATION

The concept generation stage of the project was inspired by the five-step method developed by Ulrich and Eppinger and described in the theory chapter. The method fits a project where the team does not have a deep knowledge of the market in question and need to investigate it further. The process follows the flow chart presented in Figure 6.7.

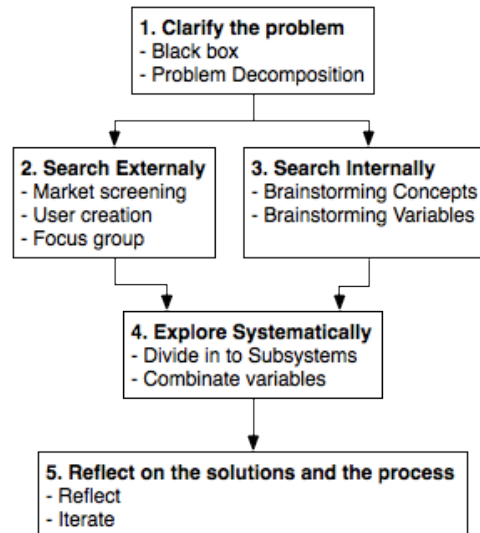


Figure 6.7 - The five-step concept generation method

CLARIFY THE PROBLEM

The aim is to produce an app that can communicate with the user and the communication station. The app should be able to receive commands from the user, using the touch display or the accelerometer. It should also be possible to give feedback on the touch display or with sound or vibrations. To communicate with the communication station, the app needs to transmit and receive Bluetooth or Wi-Fi signals. A black box representation of the system is displayed in Figure 6.8.

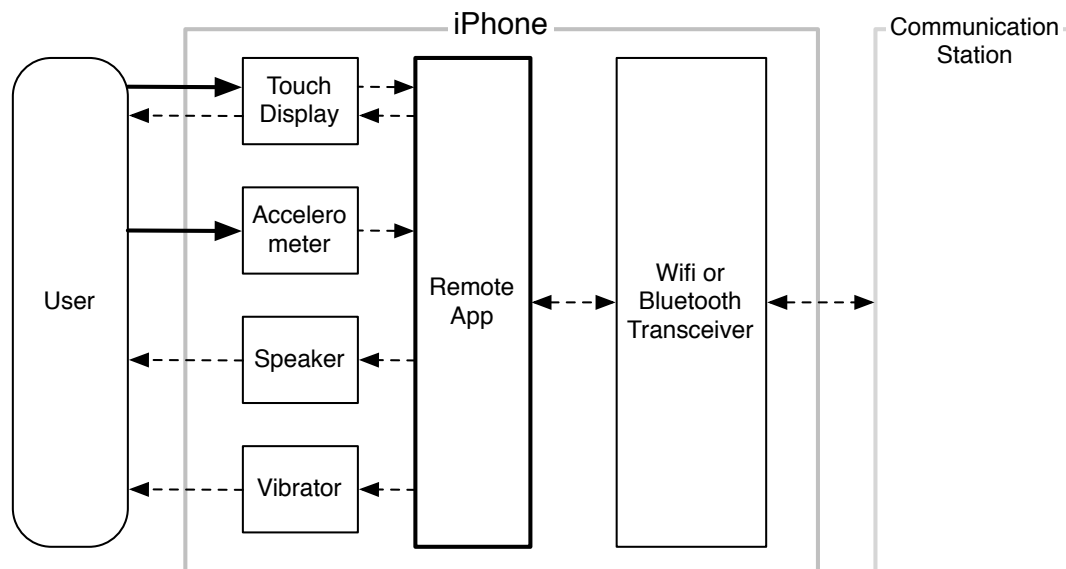


Figure 6.8 – Black box of the software system

SEARCH EXTERNALLY

The market analysis gave a view over how the market is composed and what the customer demands are. In this phase of the concept generation, the market and the customers are further explored.

MARKET SCREENING

In the market analysis the market of universal remote controls was screened. To gain more knowledge about the specific market, remote control apps to smartphones, the iPhone Appstore was screened and Google was used to search for competing solutions. To find relevant apps, these keywords were used: *Remote, control, TV and IR.*

USER CREATION

To gain knowledge of the market demands, interviews were held. During these interviews, the interviewees were told to imagine their own solution to the problem by describing what they look for in a product. As the interviewees came with different background and with their own view of the problem, a number of new solutions were found.

FOCUS GROUP

To evaluate the developed ideas and receive more ideas and later to combine these into concepts, a focus group was held. The group consisted of students at Chalmers who in one way or another had come in contact with the remote control problem and was interested in discussing a solution. The problem was further explained and the developed ideas presented for the group in the form of simulations made with the iPhone programming software, Xcode. These simulations were used as a mediating tool to better explain possible navigation principles and remote control interfaces and through these get a discussion going. The simulations were made in advance and were digital mock-ups with dummy navigation systems and sketches of some basic control interfaces. The discussion generated several new ideas that were earlier unexplored.

SEARCH INTERNALLY

To explore the existing knowledge in the project groups, an internal search was performed. Everyone in the groups contributed to putting together concepts built from earlier experiences and also what the market analysis with interviews gave.

BRAINSTORMING – CONCEPT

Based on what was learned in the market analysis, the groups used their own experience to form ideas about how to perform the given task. The brainstorming was conducted on a white board where every possible, and impossible, concept was drawn up. No judgements on the possibilities of realising the concept were allowed. The outcome of the brainstorming session was many concepts, these concepts worked as a foundation for following concept generation phases and especially the focus group session.

BRAINSTORMING – VARIABLES

The brainstorming on variables was performed to realise what could be changed in every aspect of the task. The task of building a user interface was divided in different subgroups where every subgroup contained a number of different aspects of the iPhone software that could be tweaked and utilised to build a competent app. The result can be seen in Figure 6.9.

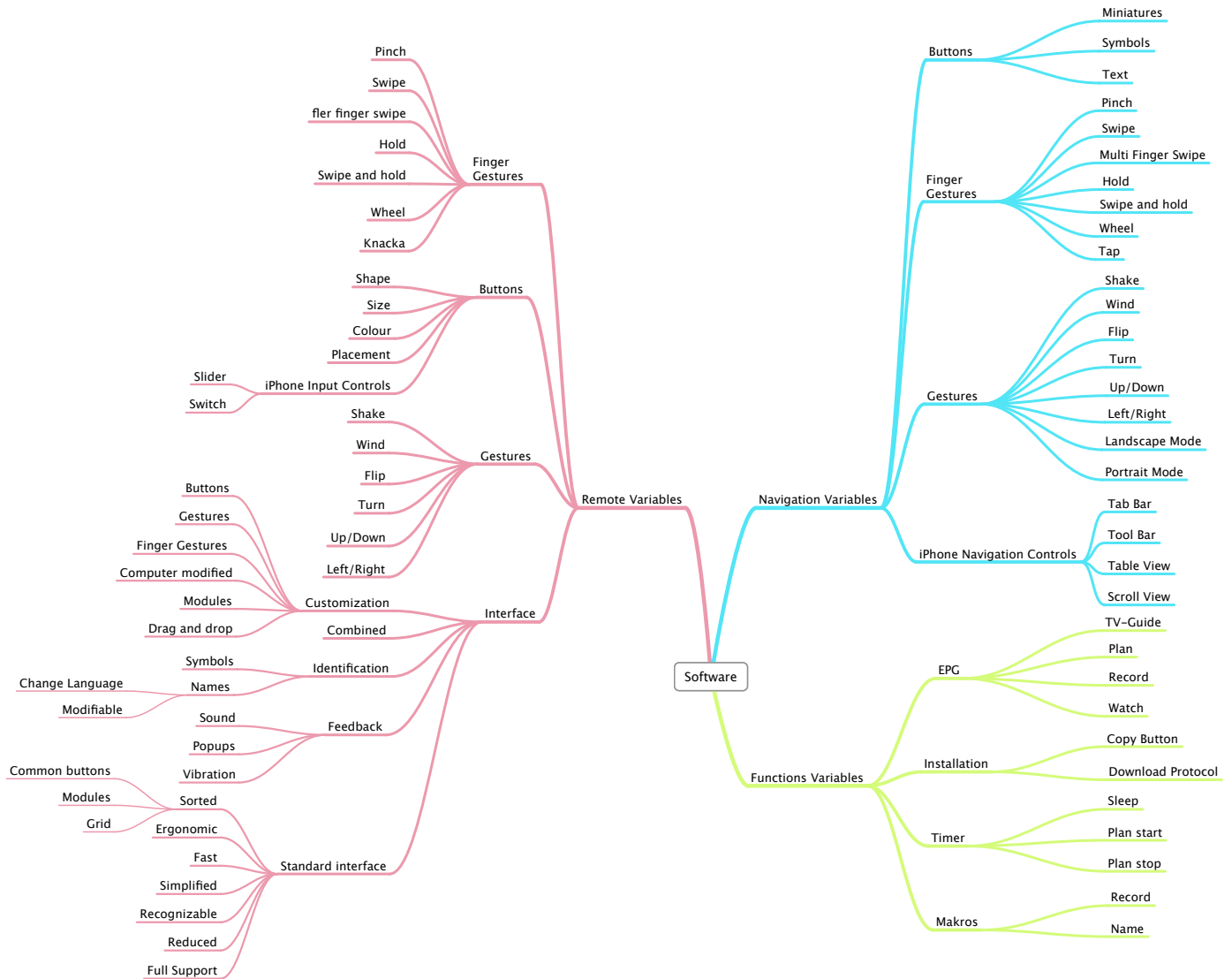


Figure 6.9 - Result from brainstorming variables

EXPLORE SYSTEMATICALLY

To be able to sort the concepts and variables and get an overview over the possibilities, subcategories were created. The categories were:

- Remote Control Concepts/Variables
- Navigation Concepts/Variables
- Additional Functionality

The variables of each category were mixed to create new remote control concepts and navigation concepts. This gave a comprehensive picture of the solutions and some new concepts were created.

REFLECT ON THE SOLUTIONS AND THE PROCESS

The concept generation phase gave a greater understanding about how flexible the solution can be. The created concepts do not exclude another; in many cases it does not even make another concept redundant. Therefore, the final concept should be a mix of matching concepts.

THE CONCEPTS

The result of the concept generation phase is divided into three categories; *Navigation Concepts*, *Remote Control Concepts* and *Additional Functionality*, see Figure 6.10.

Navigation Concepts describes how to switch between remote controls and how to navigate in the settings menus.

Remote Control Concepts describes how the remote controls should look, what buttons they should contain and if they should be customisable or not.

Additional Functionality are concepts that handles possible extra features in the app. Those will be features that are not essential to the functionality of the remote control and they will therefore have lower priority.

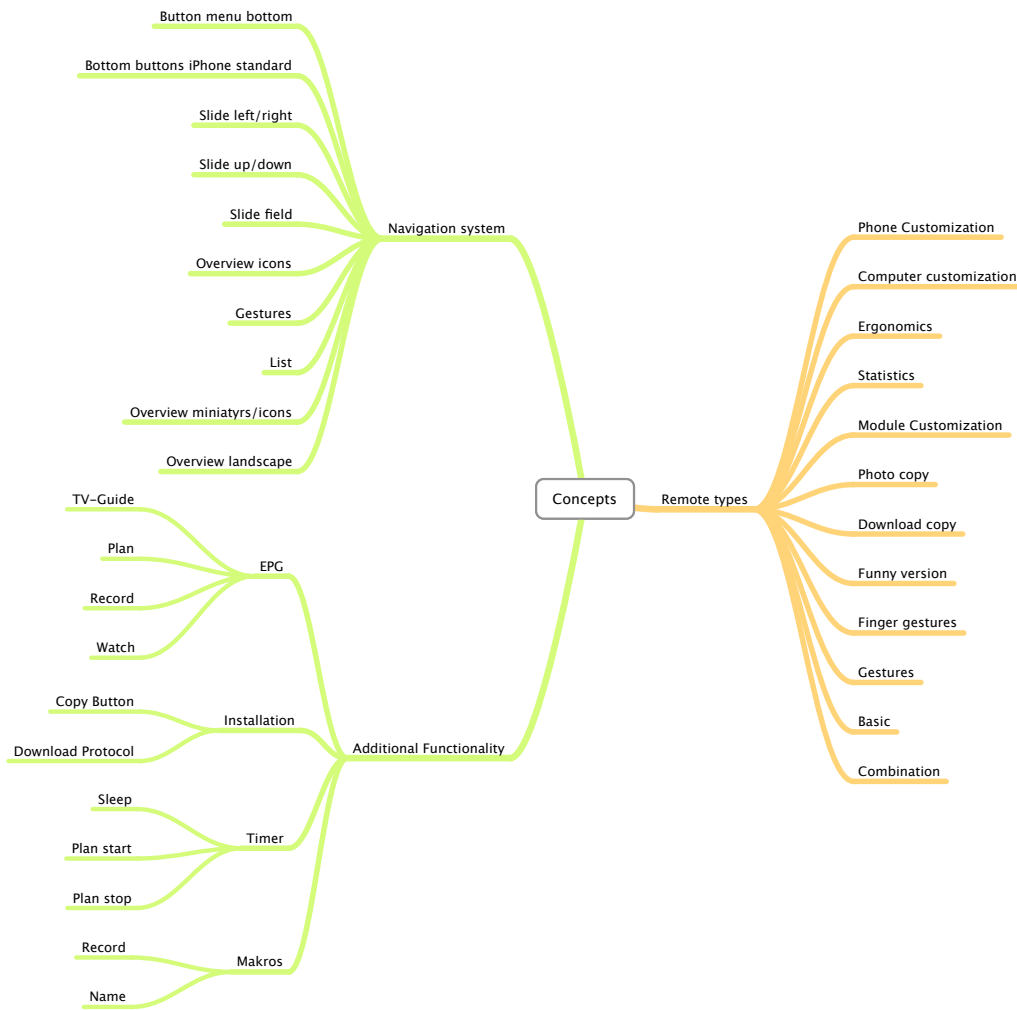


Figure 6.10 - The concepts

NAVIGATION CONCEPTS

Nine different navigation concepts were found and are presented below. One concept does not exclude another, meaning that they could be combined to improve the performance. But some concepts could make others redundant, meaning that the combination will not improve the performance.

Tab Bar

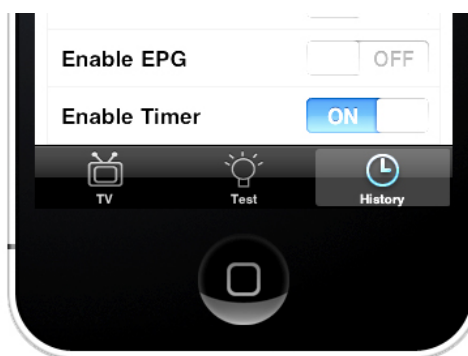


Figure 6.11 - Tab Bar Buttons

Buttons on the tab bar usually have a small icon and a text label. This bar is positioned at the bottom of the screen (Figure 6.11) and can contain a maximum of five tabs. This is a standardised way of navigating in an iPhone app and fits well with Apple's UI guidelines.

Scroll View Bottom



Figure 6.12 - Miniature Scroll View Button

The scroll view, a view that can be scrolled to reveal additional objects, at the bottom (Figure 6.12) is initially hidden and pops up when the user needs it, possibly through a finger gesture or a tap at a certain part of the screen. In the scroll view, clickable miniatures or symbols are shown, which will give easy access to all controls. When clicked, the control will appear in full screen and the scroll view disappears.

Slide Left/Right



Figure 6.13 - Slide Left/Right

A big scroll view (Figure 6.13) that is presented in full screen displays one remote control at a time, a new control is displayed by sliding a finger left or right across the screen. This navigation model will give an easy and intuitive way of selecting remote control but will limit the overview of the available remote controls.

Slide Up/Down

This concept has the same principle as the last but the slide motion is done up and down across the screen.

Top Scroll Field



Figure 6.14 - Top Scroll Field

A small view at the top of the screen (Figure 6.14), containing the name of the current remote control, slides to the sides and lets the user slide from remote control to remote control. This concept has the advantage that not the whole screen is scrollable which can cause problems when using a remote control as it can start scrolling when the user tries to press a button. It also makes it possible to use finger gestures on the screen, which would otherwise be interpreted by the phone as scrolling through controls.

Gestures

The navigation can be performed through hand gestures such as a flick with the wrist or by shaking the phone (Figure 6.24).

Table View



Figure 6.15 – Table View

A table view (Figure 6.15) presents the remote controls in a list where you press the name of the remote control, which is then displayed in full screen. This solution enables the user to save many remote controls and still be able to overview them.

Overview Portrait

The remote controls are displayed in a grid (Figure 6.16) with either an icon or a miniature representing the remote control. The user defines the placement and size of the icons. The icon is clicked and the remote control zooms to full screen.



Figure 6.16 - Overview Portrait

Overview Landscape

This concept is built on the same idea as the last (Figure 6.16) but with the difference that the icons are shown only in landscape mode. The user highlights the remote control he/she wants to use and rotates the screen to see the full remote control.

REMOTE CONTROL CONCEPTS

Ten different remote control concepts were found and are presented below. One concept does not exclude another, meaning that they could be combined to improve the performance. But some concepts could make others redundant, meaning that the combination will not improve the performance.

Phone Customisation

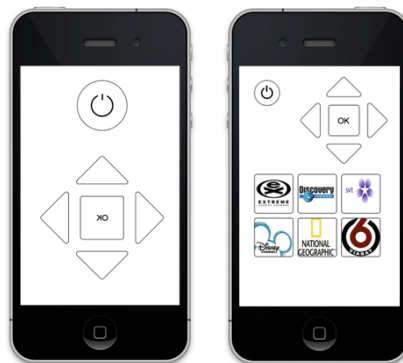


Figure 6.17 - Phone customisation example

In this concept the user has been given the ability to change the remote controls appearance to fit his/hers needs. The user can change everything from the buttons size, form, symbol or colour, to the layout of the complete remote control. The amount of buttons can also be changed to fit the needs of the user, see Figure 6.17.

Computer Customisation



Figure 6.18 - Computer customisation example

This concept has the same basic principle as the above, therefore the same advantages. But in this concept, the user has been given the ability to change the remote control's appearance on a computer, see Figure 6.18. This will make it easier for the user to make big changes and maybe share his/hers remote control with other users. The disadvantage is the need of a computer and that the process will be more time consuming.

Module customisation

The module customisation concept is a limited version of the above customisation concepts. The limitation lies in how buttons can be rearranged. In this concept, buttons are arranged in different modules, the content of the modules are fixed and cannot be customised. But the modules themselves can be arranged to fit the users need.

Ergonomics



Figure 6.19 - Ergonomic example

This concept is based on the research of cognitive ergonomics, with the goal to create a remote control demanding low mental processing. The remote control will have a logical and easy to use layout, with buttons that are clear and easy to understand, see Figure 6.19.

Statistics

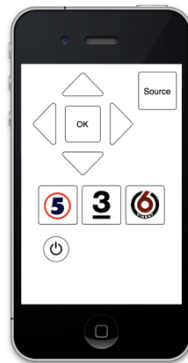


Figure 6.20 - Statistics example

The concept Statistics changes the layout using statistics about the user profile. The most utilised button will have an easy to reach placement and will be large and clear, see Figure 6.20. The buttons less used will be placed less reachable and will be smaller. The changes will be done every time the app starts, but if the user follows his/her own pattern, the layout will soon be static.

Photo/Download Copy



Figure 6.21 - Photo/Download Copy

The Copy concepts use a real photo of the remote control as user interface; see Figure 6.21. The photo can either be downloaded from Internet or be shot with the camera of the phone. This will give the user the advantage of recognising the remote control layout, but with a disadvantage in ergonomics.

Funny Version



Figure 6.22 - Funny Version

The Funny version is a concept developed to adapt the remote control to children by providing a funny and easy to use interface, see Figure 6.22. The concept cannot replace the original remote control fully, but could simplify the usage of the advanced appliances of today.

Finger Gestures



Figure 6.23 - Finger Gestures

The iPhone user interface allows and utilises many finger gestures. This concept takes advantage of the most basic finger gestures, making the remote control easy and fast to work with, see Figure 6.23. The disadvantage of this concept lies in the limit of gestures and the learning curve of the user.

Gestures



Figure 6.24 - Gestures

One of the built in features of the iPhone is an accelerometer, which can detect motion in three dimensions. This can be used to detect specific gestures, linked to actions as e.g. changing channel or volume up/down, see Figure 6.24. But the concept suffers from the same disadvantages as the finger gesture concept and it is a complex task to deliver a nice user experience.

Basic



Figure 6.25 - Basic

The Basic concept is based on the very basics of a remote control interface. All buttons have a fixed placement, with a fixed size, shape and colour, see Figure 6.25. Giving the user an easy to understand interface, but with disadvantages in user experience and cognitive ergonomics.

Combined

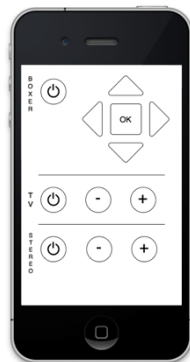


Figure 6.26 - Combined

The Combined concept delivers a remote control interface where the most common buttons, from all your remote controls are represented; see Figure 6.26. The concept will make it easy and fast to control all your appliances, but with the disadvantage of not being able to do more advanced operations.

ADDITIONAL FUNCTIONALITY

These concepts represent additional functionality that can be built in to the system. One concept does not exclude another, meaning that they could be combined to improve the performance. It also does not make another redundant, meaning that the combination will improve the performance.

Installation

The installation process is essential for the app to work with different appliances. But it is important that the process is easy to follow even for a non-technical user. The installation process can be done in two ways, copy button or download protocol. Copy buttons means that the app can interpret the signal from your ordinary remote control and the user can assign that signal to any button in the app. This means that the user have to do every button, one by one. If the user wants a faster way to install the app and knows the model-ID of the appliances, he/she can use the download protocol installation process. This means that the user simply types in the model-ID into the app and if the model can be found in the database, the remote control will be installed.

A combination of these two processes could be that the user uses the copy button installation process, until the app recognises the appliances' protocol and auto installs the app.

Timer

The timer function will allow the user to plan the usage of his/hers appliances. If the plan is to watch TV at 21:00, one can set the time in the iPhone app and the app will send the signal to the TV at the right time.

The function could also be used the other way around, e.g. as a sleep function. If the user wants the TV to turn off in 20 minutes, he/she can set the timer in the app and the app will send the signal to the TV at the right time.

A third way to use the timer function could be as a parental control. If the TV should be off at 22:00, the user can set the timer in the app and it will work as described above.

Electronic Program Guide

The Electronic Program Guide (EPG) function presents the TV guide and enables the user to see what is on the TV. The user can also use the guide to click on the program he/she wants to see and a signal to the TV will be sent. The EPG function could also include other appliances such as media recorders. This could make it possible to find an upcoming program in the guide, click it to plan to watch it or record it.

The app could also search the EPG to find some specific programs that the user wants to watch. The found programs could in the same way as mentioned above, either be planned or recorded.

Macros

The macro function allows the user to make a series of actions, with only one click. Meaning that the user could have a button named '*Watch Movie*', by pressing it, all appliances will adjust to a pre set movie state. Macros can be recorded and named to fit the users specific needs. This function will make it

easy to handle more advanced appliances and reduce the time and effort needed to set the appliances to the right state.

6.2.2 CONCEPT SELECTION

The following chapter describes how the selection of the generated concepts was done. While generating the concepts it was decided that the concepts were to be developed into three different categories that were completely independent from each other and could be combined after the selection. No screening was done for the category additional functionalities since they cannot be compared to our requirements and desires.

The screening process was done using elimination matrices and Kesselring matrices. The Pugh matrix was not used because the combination of Kesselring and elimination matrix would give a more detailed comparison. The Kesselring matrices were done in two individual iterations for both navigation and remote controls. This was done due to the realisation that concepts could be combined to complement each other.

ELIMINATION MATRIX

As a first step in the concept selection process elimination matrices were used. This was done to reduce the large amount of concepts, making it possible to gain deeper knowledge about the remaining concepts. The elimination matrix was inspired by the selection chart presented by Pahl and Beitz (Pahl & Beitz, 1995) and described in chapter 4.3.9. Criteria E, F and G were not used as the amount of concepts were manageable using the more extensive method Kesselring. In Table 6.8 it can be seen that the concept Gestures was ruled out due to not being realisable.

Table 6.8 - Elimination Matrix for Navigation Concepts

Navigation Concepts	Compatibility assured				Decision	
	Fulfils demands of requirements list					
	Realisable in principle					
	Within permissible costs					
	Comment					
Tab Bar	+	+	+	+	+	
Scroll View Bottom	+	+	+	+	+	
Slide Left/Right	+	+	+	+	+	
Slide Up/Down	+	+	+	+	+	
Top Scroll Field	+	+	+	+	+	
Gestures	+	+	-	+	No Know-how, Time Consuming	-
Table View	+	+	+	+	+	
Overview Portrait	+	+	+	+	+	
Overview Landscape	+	+	+	+	+	

In Table 6.9 it can be seen that three different concepts were ruled out due to not fulfilling all requirements or not being realisable.

Table 6.9 - Elimination Matrix for Remote Control Concepts

Remote Control Concepts	Compatibility assured				Decision
	Fulfils demands of requirements list				
	Realisable in principle				
	Within permissible costs				
	Comment				
Customizable	+	+	+	+	+
Customizable Computer	+	-	-	-	-
Ergonomics	+	+	+	+	+
Statistics	+	+	+	+	+
Photo/Download Copy	+	-	-	-	-
Funny Version	+	+	+	+	+
Finger Gestures	+	+	+	+	+
Gestures	+	+	-	-	-
Basic	+	+	+	+	+
Combined	+	+	+	+	+

CONCEPT SCORING

The final selection of concepts was done using Kesselring matrices. This phase was done in two iterations, where the top scoring concepts from the first iteration were combined, to create new improved concepts, evaluated in the second iteration. The concepts are rated in a scale from one to ten, together with the weighing this result in a score with a maximum of 100%.

FIRST ITERATION

In the first iteration of the concept scoring, the concepts developed in the concept generation phase were examined. The first iteration resulted in several concepts with a high score, marked in green in Table 6.10 and Table 6.11. These concepts were further developed to create the final concepts. The remote control concept funny version was in this stage deleted as it would not replace the original remote control fully, but it could still be seen as a nice compliment to give the app a higher customer value.

Table 6.10 - First iteration Kesselring matrix for the navigation concepts

No.	Evaluation Criteria	Wt.	Tab Bar		Scroll View Bottom		Slide Left/Right		Slide Up/Down		Top Scroll Field		Table View		Overview Portrait		Overview Landscape	
			Value	Weighted Value	Value	Weighted Value	Value	Weighted Value	Value	Weighted Value	Value	Weighted Value	Value	Weighted Value	Value	Weighted Value	Value	Weighted Value
1	Overview mode	5%	8	4%	7	3%	4	2%	4	2%	4	2%	9	4%	9	4%	9	4%
2	No limit in amount of remotes	9%	4	4%	6	5%	6	5%	4	4%	6	5%	9	8%	8	7%	8	7%
3	The system should be intuitive	32%	8	25%	6	19%	8	25%	5	16%	7	22%	8	25%	8	25%	7	22%
4	As Few user interactions as possible to change remote	14%	9	12%	7	10%	8	11%	7	10%	8	11%	6	8%	6	8%	5	7%
5	Use without watching	18%	7	13%	6	11%	7	13%	6	11%	7	13%	7	13%	7	13%	7	13%
6	Recognizable interface	23%	9	20%	7	16%	8	18%	6	14%	7	16%	9	20%	8	18%	7	16%
		100%	78,2%		64,1%		74,6%		55,5%		69,1%		79,1%		75,9%		69,1%	

Table 6.11 - First iteration Kesselring matrix for the remote control concepts

No.	Evaluation Criteria	Wt.	Customizable		Ergonomics		Statistics		Funny Version		Finger Gestures		Basic		Combined	
			Value	Weighted Value	Value	Weighted Value	Value	Weighted Value	Value	Weighted Value	Value	Weighted Value	Value	Weighted Value	Value	Weighted Value
1	Modifiable interface	15%	9	14%	3	5%	7	11%	6	9%	3	5%	3	5%	7	11%
2	The system should be intuitive	23%	6	14%	9	20%	6	14%	9	20%	9	20%	5	11%	7	16%
3	Support as many buttons as possible	11%	6	7%	7	8%	9	10%	3	3%	3	3%	9	10%	6	7%
4	Use without watching	13%	8	10%	8	10%	5	6%	7	9%	9	11%	3	4%	6	8%
5	Give feedback to user interaction	24%	7	17%	9	22%	7	17%	8	19%	7	17%	7	17%	7	17%
6	Recognizable interface	14%	7	10%	9	13%	5	7%	9	13%	9	13%	4	6%	7	10%
		100%	71,0%		77,2%		64,6%		73,7%		69,2%		52,3%		67,6%	

CONCEPT COMBINATION

The first iteration of concept scoring resulted in four navigation concepts and four remote control concepts. To further develop these concepts, they were combined, minimising the weaknesses of each concept. To find new combinations, matrices inspired by the morphological matrix were used. The morphological matrix is supposed to be used to combine sub solutions and to create complete solutions. But in this case the morphological matrix is used to combine solutions to the same problem and create new improved concepts, see Figure 6.27 and Figure 6.28.

The navigation concepts were combined two and two, creating four new and improved concepts. Figure 6.27 illustrates the different combinations of navigation concepts. The new concepts are:

Tab Bar with More List – A combination of Tab Bar and Table view. The Tab Bar has been completed with a more button, which will take the user to a Table view.

Table View with Tab Bar – Another combination of the Tab Bar and Table View. The main screen is a Table View, but in remote control mode a Tab Bar can be seen in the bottom of the screen.

Tab Bar with More Rows – A combination of Tab Bar and Overview Portrait. The Tab Bar has been completed with a more button, which will take the user to an overview portrait screen.

Table View with Slide – A combination of Table view and Slide left/right. The main screen a Table View, but in remote control mode the user can slide left or right to access other remote controls.

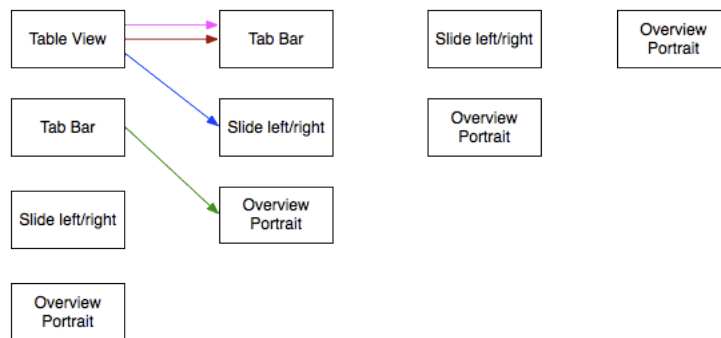


Figure 6.27 - Combination matrix for the navigation concepts

The remote control concepts were combined in up to four stages, creating eight new and improved concepts. Figure 6.28 illustrates the different combinations of the remote control concepts.

Custom Ergonomic Modules – The remote control consist of ergonomically composed modules. The modules can be added/deleted and moved.

Combined Custom Ergonomic Modules - The remote control consist of ergonomically composed modules. The modules can be added/deleted and

moved. The remote control also combines the buttons from different appliances.

Ergonomic Gestures – The remote control is ergonomically composed and has the ability to detect finger gestures.

Custom Gestures – The remote control can be fully customised with both buttons and finger gestures.

Custom Ergonomics Modules Gestures – The remote control consist of ergonomically composed modules with the ability to detect finger gestures. The modules can be added/deleted and moved.

Combined Custom Ergonomic Modules Gestures - The remote control consist of ergonomically composed modules with the ability to detect finger gestures. The modules can be added/deleted, moved and combined with different appliances.

Ergonomic Combination Gestures – The remote control is ergonomically composed and has the ability to detect finger gestures. It also combines the buttons from different appliances.

Combined Custom Gestures – The remote control can be fully customised with both buttons and finger gestures. It also combines the buttons from different appliances.

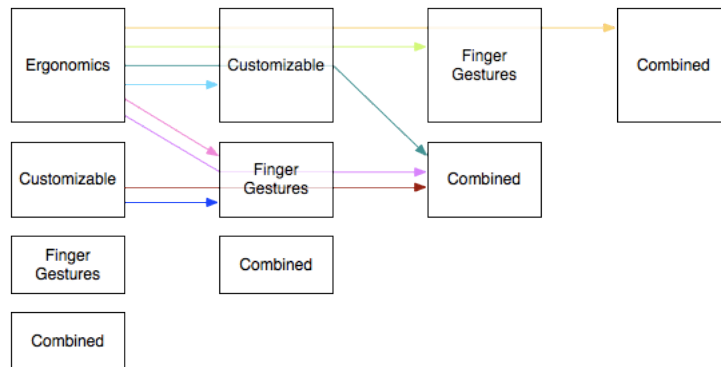


Figure 6.28 - Combination matrix for the remote control concepts

SECOND ITERATION

In the second iteration of the concept scoring the new and improved concepts were examined. The same Kesselring matrices were used and the score can therefore be compared between the iterations. The second iteration concept shows a higher score in general and a higher top score; see Table 6.12 and Table 6.13.

Table 6.12 - Second iteration Kesselring matrix for the navigation concepts

No.	Evaluation Criteria	Wt.	Tab Bar with More List		Table View with Tab Bar		Tab Bar with More Rows		Table View with Slide	
			Value	Weighted Value	Value	Weighted Value	Value	Weighted Value	Value	Weighted Value
1	Overview mode	5%	9	4%	8	4%	9	4%	8	4%
2	No limit in amount of remotes	9%	9	8%	9	8%	9	8%	9	8%
3	The system should be intuitive	32%	7	22%	7	22%	8	25%	7	22%
4	As Few user interactions as possible to change remote	14%	8	11%	8	11%	8	11%	9	12%
5	Use without watching	18%	7	13%	7	13%	7	13%	8	15%
6	Recognizable interface	23%	9	20%	8	18%	7	16%	7	16%
		100%		78,6%		75,9%		77,3%		76,8%

Table 6.13 - Second iteration Kesseling matrix for the remote control concepts

No.	Evaluation Criteria	Wt.	Custom Erg Modules		Comb Custom Erg Modules		Erg Gestures		Custom Gestures		Custom Erg Modules Gestures		Comb Custom Erg Modules Gestures		Erg Comb Gestures		Comb Custom Gestures	
			Value	Weighted Value	Value	Weighted Value	Value	Weighted Value	Value	Weighted Value	Value	Weighted Value	Value	Weighted Value	Value	Weighted Value	Value	Weighted Value
1	Modifiable interface	15%	8	12%	8	12%	3	5%	9	14%	8	12%	8	12%	3	5%	9	14%
2	The system should be intuitive	23%	8	18%	8	18%	9	21%	7	16%	9	21%	9	21%	9	21%	6	14%
3	Support as many buttons as possible	11%	7	8%	8	9%	7	8%	6	7%	7	8%	8	9%	7	8%	7	8%
4	Use without watching	13%	8	10%	8	10%	9	12%	9	12%	9	12%	9	12%	9	12%	9	12%
5	Give feedback to user interaction	24%	9	22%	9	22%	9	22%	7	17%	9	22%	9	22%	9	22%	7	17%
6	Recognizable interface	14%	9	13%	9	13%	9	13%	8	11%	9	13%	9	13%	9	13%	8	11%
		100%	82,7%		83,8%		78,8%		75,9%		86,3%		87,4%		78,8%		74,7%	

6.2.3 THE FINAL CONCEPT

From the concept selection methods one concept was chosen for the navigation and remote control respectively, below are the chosen concepts presented and motivated.

NAVIGATION INTERFACE

The navigation system uses the standard interface of a tab bar with the built in more-function that makes the system able to handle more than five remote controls. This is the maximum number of tabs Apple recommends that an application have due to the minimum touch area that is comfortable to use.

The largest influencing factor for choosing this concept was the similarity to other applications found on the iPhone. It is very important that the user can recognise the navigation system in order to instantly know where to press and what will happen when he/she does. Another important factor was the comfortable overview the user gets immediately when looking at the screen, it is also very easy and quick to navigate between the users most common remote controls. Navigating without looking is also easy, as the user knows where the buttons are located.

REMOTE CONTROL INTERFACE

The remote control interface has its foundation in the ergonomically composed modules. The modules contain buttons from the same area of use, e.g. standard buttons, number pad or teletext. The layout of the modules is ergonomically composed, demanding low mental processing.

The user can customise the remote control to fit his/hers needs by simply add/remove or move the modules. Modules can be added controlling different appliances, creating a remote control that combines two or more remote controls.

The remote control also has the ability to detect finger gestures, making it easier to use it without watching. Standard finger gestures can be added or removed by the user.

To access the settings of the specific remote control, a standard settings button is placed on the remote control. By pressing it, one will go to the settings menu, displaying the different types of appliances supported by the app. Here the user can add or remove complete remote controls or modules for all appliances. Finger gestures can also be enabled or disabled.

6.3 RESULT OF SYSTEM LEVEL DESIGN

The system level design outline the basic architecture of subsystems of the product as well as an analysis of how the product will be used. The use analysis was made with use cases, the gestalt laws and hierarchical task analysis (HTA).

6.3.1 USE CASE

To get an overview over how future user will use the system use cases were done. Three different use cases were created:

- Create a new remote control
- Configure the remote control
- Start your TV

All the cases are common tasks and something the user can be expected to do at least once. The use cases give an insight about how well the system works and how well the defined actor can complete the task.

CREATE A NEW REMOTE CONTROL

The first use case describes the process of creating a new remote control. The actor is an iPhone owner, who has experience with the phone's user interface.

Use case name	Create a new remote control
Summary	The iPhone owner has downloaded the app and wants to create a remote control for his/hers TV
Actor	iPhone owner (experienced with the interface)
Precondition	The user knows the brand and model number of his/hers TV. The iPhone is ready to use with the app downloaded to the phone.
Description	<ol style="list-style-type: none"> 1. The user starts the app 2. Enter the settings menu from the Tab bar 3. Press <i>'Edit'</i> to enter editing mode 4. Add new remote control 5. Press <i>'Done'</i> to exit editing mode 6. Set title and subtitle of your new remote control 7. Choose a icon 8. Go to menu <i>'Devices'</i> 9. Choose <i>'TV'</i> 10. Choose your TV model from the list
Alternatives	The user can choose to create a remote control to fit a device already installed. In that case, step 7 to 9 can be skipped.
Post condition	The remote control is created but needs to be configured to fit its purpose

CONFIGURE THE REMOTE CONTROL

The second use case describes the process of configuring the remote control. The actor is an iPhone owner, who has experience with the phones user interface.

Use case name	Configure the remote control
Summary	The user has created a new remote control and wants to configure it to be able to control his/hers TV
Actor	iPhone owner (experienced with the interface)
Precondition	The user has remote control he/she wants to configure. The iPhone is ready to use with the app downloaded to the phone.
Description	<ol style="list-style-type: none"> 1. The user starts the app 2. Enter the remote control from the Tab bar 3. Press <i>'Settings'</i> to enter the remote settings menu 4. Press <i>'Edit'</i> to start the editing mode 5. Add new modules, total of 4 active modules 6. Press <i>'Done'</i> to exit editing mode 7. Press each module and choose the matching TV module (Module 1 -> TV Module 1 and so forth) 8. Press <i>'Back'</i> to go to the configured remote
Alternatives	If the user starts with a newly created remote control, the control will have two active TV modules from the start. But the user can also choose to configure an already existing remote control. In that case the user might need to delete active modules instead of adding them.
Post condition	None

START YOUR TV

The third use case describes the process of starting your TV. The actor is anyone who comes across the system no earlier experience is expected.

Use case name	Start your TV
Summary	The user wants to start the TV
Actor	Anyone
Precondition	The user has created and configured a remote control to fit his/hers TV. The iPhone is ready to use with the app downloaded to the phone. The hardware is on and ready to use.
Description	<ol style="list-style-type: none"> 1. The user starts the app 2. Enter the remote control from the Tab bar 3. Press <i>'On'</i> to start the TV
Alternatives	None
Post condition	None

6.3.2 HIERARCHICAL TASK ANALYSIS

To make a deeper analysis of the cases described in section 6.3.1 a hierarchical task analysis (HTA) was made. The HTA is a method created to find all subtasks of the described task. This will lead to an even deeper understanding of the system and illogical or unnecessary steps will be uncovered.

CREATE A NEW REMOTE CONTROL

The analysis of the first case, *create a new remote control*, revealed 17 steps that needed to be cleared in order to complete the task. The task were at first divided into three subtasks, *start the app*, *create new remote control* and *install device*. The first subtask is a standard operation and cannot be simplified. The third subtask can be seen as a standalone task, but have been included to show the most complex variant of the main task. For the second subtask, some unnecessary steps were deleted, e.g. press 'Done' after choosing icon from library. The final HTA can be seen in Figure 6.29.

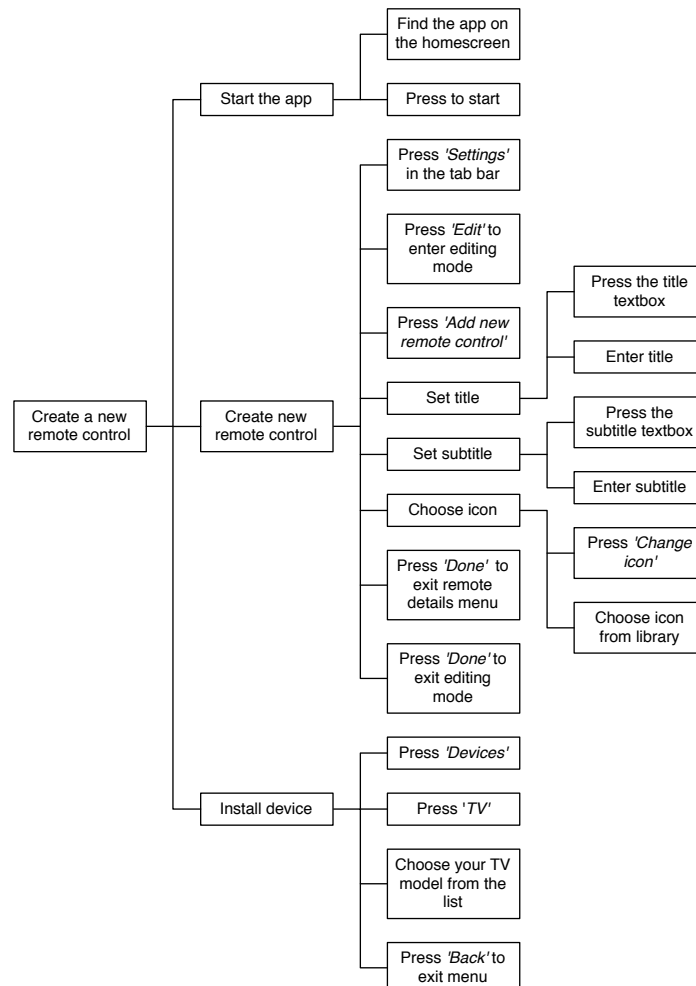


Figure 6.29 - Hierarchical task analysis for creating a new remote control

CONFIGURE THE REMOTE CONTROL

The second HTA, *configure the remote control*, revealed 17 steps. The task was first divided into five subtasks, *start the app*, *enter the remote settings menu*, *add active modules*, *configure active module* and *go to the configured remote*. The first subtask is as aforementioned a standard operation. The second subtask describes the navigation in the app, which follows a standard navigation system created by Apple. The third subtask is done in three steps, where the user first enters the editing mode, add modules and then exits the editing mode. This step could be reduced by simply give the user the possibility to add modules outside the editing mode. But by entering the editing mode, the user can remove modules and change order of the modules as well and therefore was the other solution discarded. The fourth subtask was simplified by deleting a step, before one needed to press 'Done' after choosing module. The final HTA can be seen in Figure 6.30

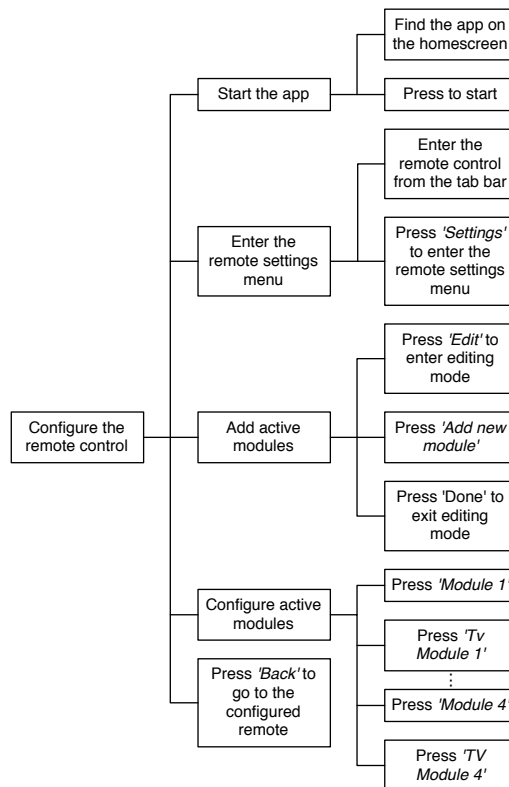


Figure 6.30 - Hierarchical task analysis for configuring the remote control

START YOUR TV

The third HTA, *start your TV*, revealed only 4 steps, showing how simple this task really is. The task is divided into two subtasks, the standard operation *start the app* and *start the TV*. The second subtask has a simple navigate step and the last step is to press the on button. The HTA (Figure 6.31) lead to no simplifications.

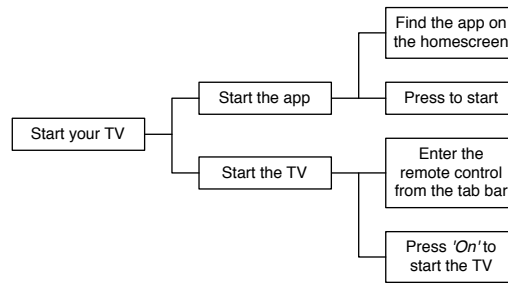


Figure 6.31 - Hierarchical task analysis for starting your TV

6.3.3 THE SYSTEM DESCRIPTION

The results of the system level design describe how the product is built up. The subsystems are described generally, such as the construction of the modules and how the settings menus are built up. A description of how the user is intended to use the system is also described and certain optimisations in user experience can be made from this information.

COMMUNICATION

The chosen way of communicating with the hardware is through Wi-Fi. The hardware can send and receive data through its Wi-Fi module. This enables the sending of IR and RF codes to and from the iPhone, it is important to both be able to send a command and also receive new codes through the install-feature.

The hardware is also able to connect to the Internet, this enables it to receive commands from an iPhone that is not connected to it directly. This means that the iPhone will be able to control devices at home from anywhere as long as it can connect to the Internet.

NAVIGATION INTERFACE

The navigation between controls will take place with a tab bar interface at the bottom of the screen (see Figure 6.11). When a tab is pressed the selected remote control is immediately presented to the user, a change of colour indicates which remote control that is chosen. The user can easily add more remote controls through the settings menu and can also reorder them in the standardised More-menu. Each remote control is represented by a user defined icon and title in the tab bar.

Through the settings menu the user is able to add and remove controls as well as edit existing controls. The menu will give the user control over the name and the remote control's icon that is shown in the tab bar.

In the settings menu the user can define the specific brand and model name of the devices that will be controlled. This sets up the control with the right IR-commands for the right buttons.

The app has the option of giving feedback, in the form of sounds and vibrations, to the user when a button is pressed. In the menu these feedback options can be turned on and off.

The menu also has an About-page where credits, like the creators of the app, are named.

REMOTE CONTROL INTERFACE

The remote control interface will consist of two parts, a navigation bar and the remote control. The title of the remote control will be presented in the navigation bar, which is located on the top of the screen. There will also be an edit button, taking the user to the remote control settings menu. The remote control has its foundation in the different modules described in the following part.

MODULES

The modules are created with an ergonomic layout, where buttons within the same area are presented in each module. The user can add and delete modules to fit his/hers needs. The modules are created in collaboration with a focus group and should cover the needs of all possible users. Buttons has been distributed between the modules with focus on how they relate to each other and how common their usages are. To sort buttons within the modules and make the interface more ergonomic, the gestalt laws has been applied. Examples of this can be seen in Figure 6.32, Figure 6.33 and Figure 6.34.



Figure 6.32 - Gestalt laws example 1

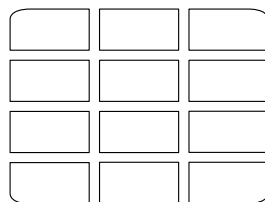


Figure 6.33 - Gestalt laws example 2

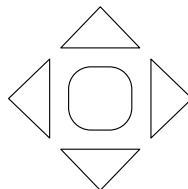


Figure 6.34 - Gestalt laws example 3

To save internal memory on the phone and make the app run smooth, standard modules were created and reused in more than one remote control, see Figure 6.35. The standard modules decreased the amount of modules from 13 to 7; see Table 6.14. To be able to still provide an ergonomic layout within the modules, buttons were made easy to change appearance.

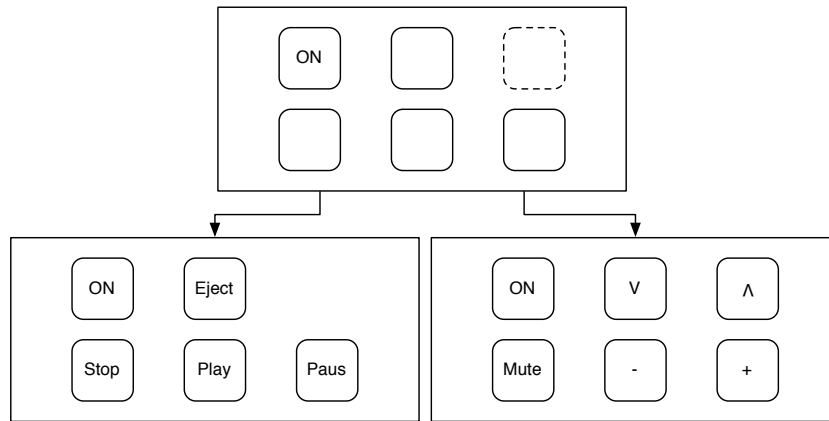


Figure 6.35 - Illustration of how a standard module is used in both the TV and the DVD remote control

Table 6.14 - Comparison of modules without standard interface and with standard interface

Without standard modules		With standard modules	
Module	Area of use	Module	Area of use
1	TV Module 1	1	TV Module 1 and DVD Module 1
2	TV Module 2	2	TV Module 2, Receiver Module 2 and DVD module 4
3	TV Module 3	3	TV Module 3, Receiver Module 3 and DVD Module 3
4	TV Module 4	4	TV Module 4 and Receiver Module 4
5	Receiver Module 1	5	Receiver Module 1
6	Receiver Module 2	6	DVD module 2
7	Receiver Module 3	7	Power Switch Module
8	Receiver Module 4		
9	DVD module 1		
10	DVD module 2		
11	DVD module 3		
12	DVD module 4		
13	Power Switch Module		

TV/Digital box

The TV/digital box remote control consists of 28 buttons divided on four modules. The distribution and an outline for the layout can be seen below (Figure 6.36, Figure 6.37, Figure 6.38 and Figure 6.39).

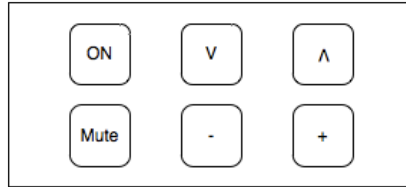


Figure 6.36 – TV module 1 with On/Off, Mute, Volume up/down and Channel up/down buttons

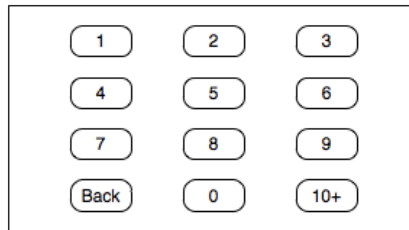


Figure 6.37 - TV Module 2 with Number pad and Channel back buttons

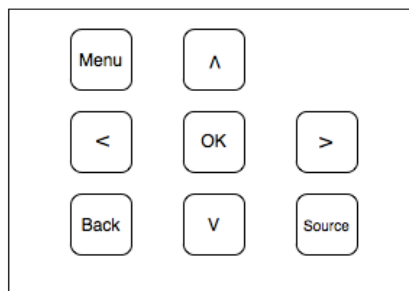


Figure 6.38 - TV Module 3 with OK, Directional pad, Source, Menu and Back buttons



Figure 6.39 - TV Module 4 with Info and EPG buttons

Receiver

The Receiver remote control consists of 34 buttons divided on four modules. The distribution and an outline for the layout can be seen below (Figure 6.40, Figure 6.41, Figure 6.42 and Figure 6.43).

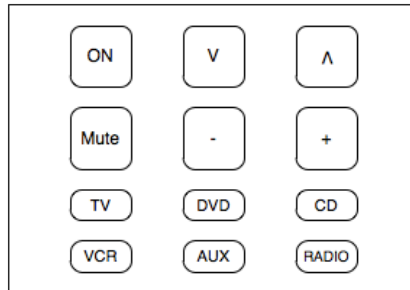


Figure 6.40 - Receiver Module 1 with On/Off, Mute, Volume up/down, Source: TV, DVD, CD, VCR, AUX and Radio buttons

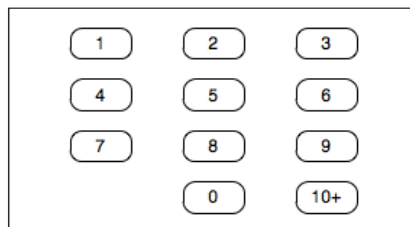


Figure 6.41 - Receiver Module 2 with Number pad buttons

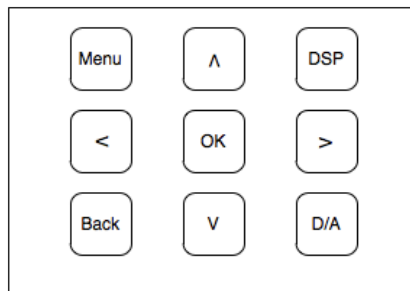


Figure 6.42 - Receiver Module 3 with OK, Directional pad, DSP and Digital/Analog buttons

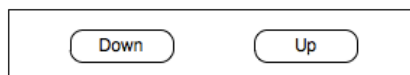


Figure 6.43 - Receiver Module 4 with Tune up/down buttons

DVD

The DVD remote control consists of 32 buttons divided on four modules. The distribution and an outline for the layout can be seen below (Figure 6.44, Figure 6.45, Figure 6.46 and Figure 6.47).

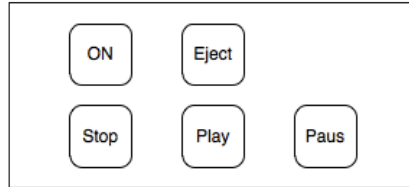


Figure 6.44 - DVD Module 1 with On/Off, Eject, Play, Pause and Stop buttons

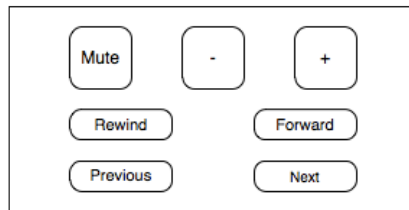


Figure 6.45 - DVD Module 2 with Mute, Volume up/down, Chapter next/previous and Forward/rewind buttons

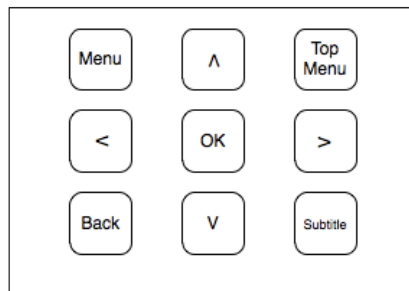


Figure 6.46 - DVD Module 3 with OK, Directional pad, Menu, Top Menu, Back and Subtitle buttons

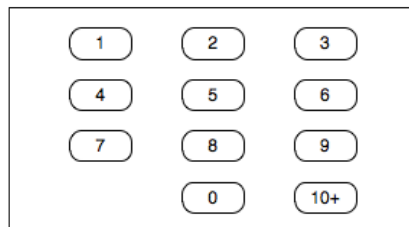


Figure 6.47 - DVD Module 4 with Number Pad buttons

Power switch

The power switch module consists of 2 buttons and a title. An outline for the layout can be seen below (Figure 6.48).

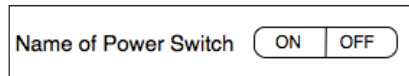


Figure 6.48 – Power Switch Module with on and off buttons

REMOTE CONTROL SETTINGS

Each remote control has its own settings menu, making it possible to customise the remote control to fit its purpose. The remote control settings menu can be reached from the remote control by pressing a settings button. The menu consists of two sections, active modules and gestures.

Active Modules

The active modules section displays the names of the modules in use. In this section the user has the ability to change, activate or deactivate modules.

Gestures

In the gesture section the user will be able to turn gestures on and off. The user will also get information about the functionality of the gesture function, see Table 6.15.

Table 6.15 - The possible gestures with its functions

Gesture	Function
Swipe left	Channel up
Swipe right	Channel down
Two fingers swipe up	Volume up
Two fingers swipe down	Volume down

INSTALLATION

The installation of new remote controls can be made either by copying the signal from an existing remote control or by using a pre-made protocol with all codes included.

PROTOCOL

To install the remote control through protocols the user just needs to select the right device from a list. If the device is missing from the list, it is not pre-supported. In that case the user can use the record button installation method.

RECORD BUTTON

To install the remote control using the record button installation method the user needs to assign each button at a time. To record the IR-code the user presses the button to assign on the iPhone. The iPhone will then present a message telling the user that the button is unassigned and ask if the user wants to create new recording, see Figure 6.49. Pressing yes activates the recording mode, now the user presses the button to be recorded on the original remote control while it is aimed towards the product's hardware where an IR-receiver will pick up the code. The code will then be sent for storage to the iPhone and the button is ready to use.

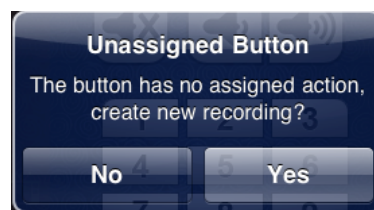


Figure 6.49 – Unassigned button pressed

6.4 RESULT OF DETAIL DESIGN

In the detail design the findings from the system level design are used and the general design of the subsystems is developed in detail.

6.4.1 SETTINGS MENU

The general settings menu gives the user control over the remote controls shown in the tab bar. Figure 6.50 shows the initial menu screen, here all the remote controls can be seen as well as settings to enable macros, EPG and timer in preparation for a possible implementation of those features. In the lower part of the menu a reset button can be seen, this returns the remote control settings to an original state that is defined in a property list that can only be altered in Xcode.



Figure 6.50 – Initial menu screen

In Figure 6.51 below the structure of the settings menu is presented. The first stage is the initial screen, when either a new control is created or an existing control is chosen the user is taken to a screen where name, details and an icon can be chosen. The last level of the menu system is presented when the user wishes to choose an icon for the remote control. Only the name and the icon will be shown in the tab bar, the details only show additional information in the settings menu.

In accordance to the iPhone guidelines for developers there is always a back or cancel button that can take the user to the previous menu level.



Figure 6.51 – Structure of settings menu

6.4.2 USER CONFIGURATIONS

To make the app customisable for the user the user configurations must be saved. The iPhone has a space of memory reserved for that purpose, called *User defaults*. This space allows the app to save either an array or a dictionary containing user data.

The remote control app needs to save data about settings and created remote controls. This is done using the *user defaults*, where a dictionary file is saved. The dictionary file is structured as seen in Figure 6.52. To make it possible to reset the app to a reconfigured state, a copy of the standard user configuration dictionary will always be retained.

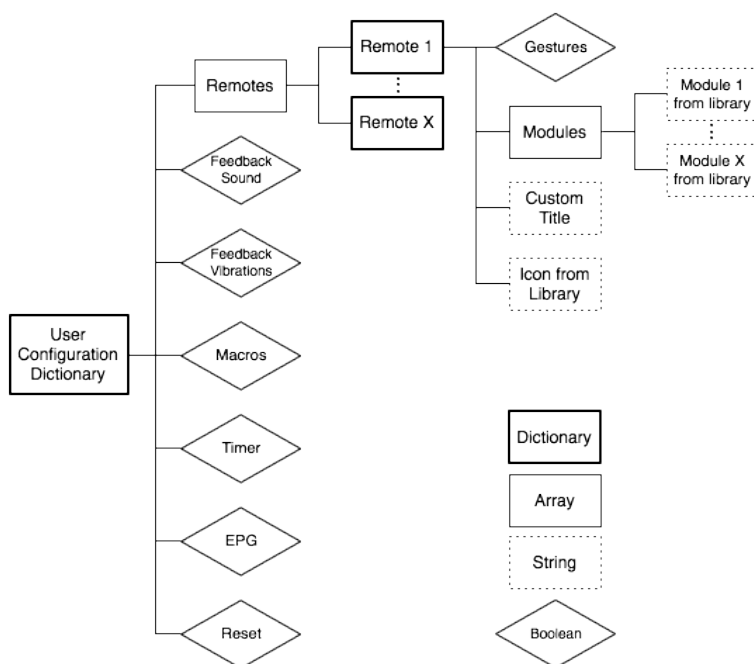


Figure 6.52 - An illustration of the user configuration dictionary

6.4.3 THE REMOTE CONTROL DESIGN

The interface has been designed with cognitive ergonomics as its highest priority. The Gestalt laws heavily influence the design of the remote control, these laws tell designers how to design and group buttons in order to make their function obvious.

The other very important aspect when designing an interface is to keep industry standards. Most remote controls on the market have a certain look and are used in a certain way. So to make the user feel instantly at home it is important to conform to these standards and make the remote look and feel the same as a normal remote control.

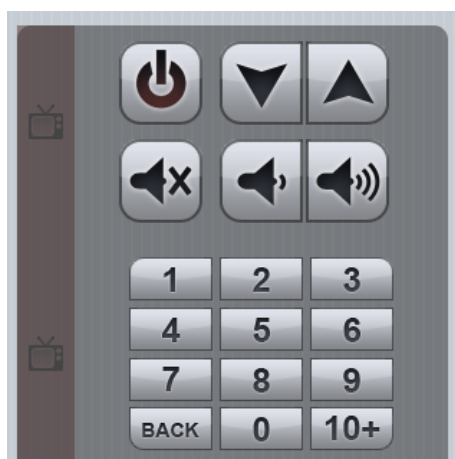


Figure 6.53 - TV-modules

The design of the buttons can be seen in Figure 6.53. The upper buttons are grouped after function, so for example the volume buttons are paired and the outer corners are rounded to form one shape from two buttons. The number

pad has smaller buttons and rounded corners to show that they belong together and has a similar function. The smaller buttons also help differentiate this module from the others. Buttons are also designed to look like a real remote control which explains the shape of the number buttons and the placement of the on/off button.



Figure 6.54 - Directional Buttons

In Figure 6.54 an example of the directional buttons can be seen. In accordance with the Gestalt laws the buttons forms of arrows suggests navigation in certain directions. They are also grouped to show that they are used in the same context.

6.5 PROPOSED SOLUTION

The complete proposed solution consists of iPhone software that communicates with the hardware through a local Wi-Fi network. The hardware forwards the signal to the devices using radio frequency or infrared signals. An illustration can be seen in Figure 6.55. The software can be divided into the parts navigation, the remote controls and the settings menu.

The navigation is done with a tab bar that gives an easy overview of all the controls. Tabs can be added, deleted, reordered and named in the main settings menu. An icon is also assigned to each tab to easily tell them apart. The navigation is also done through buttons in the navigation bar that displays back and cancel buttons as well as a settings button for every control.

The remotes are built up of modules that the user chooses in the remote control settings menu. The modules can be mixed, so a TV module and a DVD module can be seen on the same remote. The modules can be added, deleted and reordered but the content of each module cannot be changed. Each module contains groups of buttons belonging together; the buttons are designed in such a way that the purpose of the buttons is obvious to the user.

The adding of a new control is done in a table view. In the normal state of the table view the existing controls can be seen. When the user presses edit in the navigation bar the controls can be removed and a plus sign can be pressed to add a control. The installation of the buttons for the new controls can be done in two ways, either by downloading a protocol with all the buttons for a specific device or by copying each button individually.

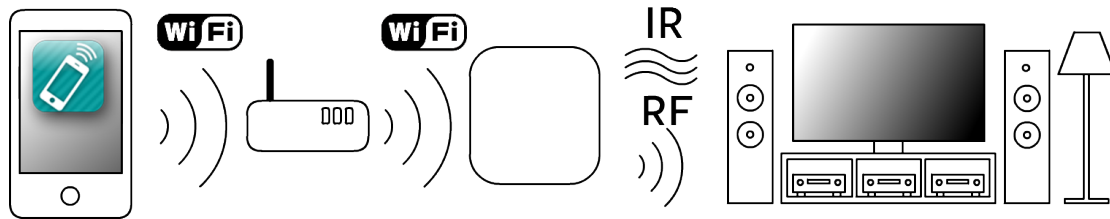


Figure 6.55 - An overview over the proposed solution

6.6 RESULT OF TESTING AND REFINEMENT

This chapter describes the testing of the software and the outcomes in form of complements and refinements.

6.6.1 TESTING AND EVALUATION OF THE SOFTWARE

The testing of the software has been a continuous process during the development work. But to finalise the testing process a complete testing session was conducted. The session was done with the members of both the software group and the hardware group. All aspects of the software were to be tested and evaluated. The test was conducted using the requirement specification as a structure and with the project goal in mind.

The result of the testing session was some minor bug fixes and the discovery of illogical navigation features, e.g. how the modal views and navigation controllers are used.

6.6.2 TRIAL ROUNDS WITH FOCUS GROUP

The trial rounds were made using same focus group used during the development process. The trial rounds started with a short introduction to the developed software and moved on to start the trials. During the trials the members of the focus group got a version of the software running on a simulator. To enhance the result of the trial rounds the focus group was given tasks to perform, e.g. *'In excess of the existing remote controls, create a new remote control and add the modules you would like to have on your remote control'*. To further enhance the result, the development group brought up the expressed needs found during the first focus group meeting. The expressed needs were *recognisable, clean & simple, adaptable, overview and easy/fast access*.

The result of the trial rounds were positive with the confirmation that the expressed needs of the focus group has been fully met and the result did in some cases exceeded their imaginations. The trial rounds did result in some new features to clarify the state of the remote control for the user, e.g. the unassigned buttons should be marked and the module names should always be presented with an inventory list.

6.7 RESULT OF VERIFICATION

The verification of the product is done using the verification method of each requirement and the fulfilled desires. In this section the result of the verification will be presented.

6.7.1 REQUIREMENT VERIFICATION

The requirement verification is done for each requirement. All requirements should be evaluated and fulfilled.

- The system should have some kind of navigation system
 - ✓ The system uses a Tab bar navigation system
- Navigation between at least 4 remote controls
 - ✓ The navigation system has no limits in the amount of remote controls it could handle
- Settings menu
 - ✓ The system provides a settings menu for the hole app and one for each remote control
- Support at least the ten most common buttons
 - ✓ The modules are designed to support 28 TV buttons, 34 receiver buttons, 32 DVD buttons and 2 power switch buttons
- Interface for TV
 - ✓ An interface for the TV remote control is integrated
- Interface for receiver
 - ✓ An interface for the receiver remote control is integrated
- Interface for DVD
 - ✓ An interface for the DVD remote control is integrated
- Interface for power switches
 - ✓ An interface for the power switch remote control is integrated
- Control at least 4 devices
 - ✓ The remote control app can control 1 TV, 1 receiver, 1 DVD and unlimited amount of power switches
- Communication modes: Wi-Fi, Bluetooth, USB-port or 3.5 audio input
 - ✓ The system communicates with the hardware through Wi-Fi connection
- Free of charge
 - ✓ The price of the product will be free
- No extra hardware needed
 - ✓ The system only utilises the iPhone hardware and the hardware provided by the hardware group

6.7.2 VERIFICATION OF THE FULFILLED DESIRES

The verification of the desires is only done for each fulfilled desire. The desires have been fulfilled following the order of their relative weight, see Table 6.7.

- Installation – Record button
 - ✓ The system can receive data and assign it to a specific button
- Interface for digital TV box
 - ✓ The TV remote control interface has buttons to support digital TV boxes
- The system should be intuitive
 - ✓ The system has been designed using the theory and methods of cognitive ergonomics and a focus group has been verifying the result.
- Give feedback to user interaction
 - ✓ The system provides visual and audio feedback
- Overview mode
 - ✓ The Tab bar navigation system provides a overview over the installed remote controls
- Recognisable interface
 - ✓ The Tab bar navigation system is standard on iPhones and used in many apps. The remote control interface is similar to standard remote controls.
- Use without watching
 - ✓ The system is designed with large buttons and clean interface
- As few user interactions as possible to change the remote
 - ✓ The top 4 remotes are only one click away, the rest can be found in a list and are only 2 clicks away
- Modifiable interface
 - ✓ The remote control interface is built on modules, the modules can be added, deleted or moved
- No limit in amount of remote controls
 - ✓ The system has no limits in the amount of remote controls
- Support as many buttons as possible
 - ✓ The modules are designed to support 28 TV buttons, 34 receiver buttons, 32 DVD buttons and 2 power switch buttons

7 THE SUSTAINABLE ASPECT

In this chapter the sustainable aspect of the product will be discussed. The discussion will treat the three dimensions of sustainability, *environmental*, *social* and *economical*.

7.1 THE ENVIRONMENTAL DIMENSION

The purpose of the developed product is to gather the control for a large number of electrical appliances in the home, thus replacing traditional remote controls. The realisation of this could lead to environmental improvements such as lowering the consumption of batteries. The developed product will also use less material and components than its competitors as it utilises the hardware of the iPhone. Components such as large screens and powerful processors will not be needed, making it favourable for the environment.

Another aspect could be if the product can help the user to plan the usage of the appliances in the home. It could be to turn on/off lights at specific times or turn off the TV if it has been on for more than three hours, thus lowering the energy consumption.

7.2 THE SOCIAL DIMENSION

By utilising the power of the iPhone the social dimension of the sustainability could be improved. The touch screen interface could improve the usability of the remote control; hence giving access to a larger range of users. This could be obtained by making larger buttons for older users or a fun and easy to use interface for children. By making the remote control fully adaptable it could attract an even larger range of users.

The large memory of the iPhone can also be utilised to serve as a database, collecting statistics about the users' routines. The statistics can then be used to schedule a show that the user might want to see every week and maybe sync with the iPhone calendar. This type of planning could also be used to turn on lights when the user is away on vacation, this could prevent a break-in by fooling thieves that someone is at home.

Another aspect on the planning feature could be parental control. This can be used to turn off the TV at a specific time every night or to lock specific channels with inappropriate material.

The iPhone also has the possibility to provide Internet connection, which could enable features such as Facebook and Twitter sharing. Thus making it possible

to share what show or movie you are watching or maybe find out what your friends are watching right now.

A downside of the developed product is that the home with all its users will be dependent on having an iPhone close by. If the device breaks or gets lost the users will lose the remote control for all their appliances.

7.3 THE ECONOMICAL DIMENSION

One of the key features of the developed product is how it utilises the iPhone hardware with its interface and computing power. This could make the product favourable in an economical aspect. The remote control app can also easily be updated to fit the needs of future users and keep the remote control up to date, hence prolonging the lifetime of the product.

The investment of the developed product is in the hardware, the iPhone app will come free of charge. As the hardware uses standard Wi-Fi connection to connect to the iPhone it is possible to create software for future phones without updating the hardware.

An economical downside is if the user creates a need for more iPhones to use as remote controls. It could be a family with only one member owning an iPhone, when that member is away, the family will have no remote control.

8 DISCUSSION

This chapter will discuss the result of the project, the methods used and the project approach.

8.1 THE RESULT OF THE PROJECT

The project resulted in a prototype of the software, which has been evaluated and verified against the requirements. The prototype did pass the verification and did even fulfil the most important desires, all this within the time frame of the project. But, could the project been done in half the time if the group would have had less focus on fulfilling the desires? Probably no. The product development process is complex and the knowledge of the developer team will increase throughout the project. Shortening the duration of the project would force the team to take decision with less knowledge and decrease the quality of the result.

8.2 PROJECT APPROACH

The choices made before the project often affect the result more than anything. Therefore it is of great interest to discuss whether anything could have been done differently and the effect that would have had on the result.

The first choice was the members of the group, however this could not have been done differently because the group formed before the purpose of the project was formed. It could have been useful to have more specialized knowledge about programming and software development, but altogether the members' broad knowledge of product development was far more important.

How to divide the work between the two groups was not obvious in the beginning. Since all group members had the same background and wanted to be involved in as many parts of the projects as possible, it was decided to split the work between hardware and software but still work closely together to learn from each other's work. The project group was assigned a common office where very close cooperation would be possible. This has not only benefited the result of the project but also greatly enhanced the learning experience for everyone in the group.

Another important issue was the choice of supervisor for the project. It could be argued that a supervisor with more experience would have been more fitting, but since the project was very focused on product development a supervisor with that knowledge was more beneficial. If more software development knowledge was needed it would be possible to retrieve that information from experts on other institutions. At some points in the project it would have been

useful with easier access to experts in programming, but most of the time a quick Google search would solve the problem.

Another way to solve the needed expertise could have been to find a company to work with. This would have restricted our freedom but could possibly have provided us with expertise and also resources to invest in the product. But in hindsight none of those benefits have been missed and the freedom to make all the decisions within the project group has benefited the project more.

Early in the project it was decided to limit the scope to just the iPhone instead of all smartphones. This was made to avoid the need to program in two languages instead of one, and it was also made to make the interface fit perfectly to one operating system instead of having to adjust to several interface guidelines.

8.3 THE METHODS USED

The methods used in this project are state of the art product development methods. But the focus of the methods is on hardware and not software development. This made it very important to choose the right methods and to modify them to fit the project. The choice of methods can have been done differently, but there is no best way. As the result of the project was successful, the choice of methods could be seen as successful as well.

With the experience of this project, would the same methods have been chosen today? The same methods would probably been chosen, but how to apply them might have been changed. Focus groups were used to some extent during this project. But this method could have given more to the project if it was used regularly even earlier in the process. This would have helped the group to keep the focus of the project and supported the decision process.

The market analysis could also benefit the project more if more time and resources were given. The result of the market analysis was interesting and did affect the result of the project to a great extent. But the result of the market analysis could be misleading if the selection group did not reflect the market. The selection group had an age distribution around 25 years old, but the market of smartphones has an age distribution around 30 years old. The sample size of the questionnaire was a total of 260 people. A bigger sample should give a better view over the market, which could have changed the direction of the project. But the questionnaire was followed by interviews and statistical research that should prevent any misleading data.

9 CONCLUSION

The purpose of the project was to develop a universal remote control for home appliances. The product successfully fulfils all the requirements and the most important desires.

The plan for the project was followed successfully throughout the process and the choices made in the beginning turned out to be the right ones. The communication between the two groups worked out perfectly due to the co-location in the project office. Through this communication the group members learned a lot and got a wider perspective of the whole product.

The decision to limit the project to the iPhone gave the opportunity to create a more specific and in the end a better product.

The methods of the product development process were chosen with care and tailored to fit the project. This resulted in a smooth process and with just a slight modification, such as more regular focus group meetings, the process could be even better.

10 REMAINING DEVELOPMENT WORK

The result of the project is a prototype of the software with the key features enabled. But the product is not ready for the market, there are still some development work left to do.

The communication between software prototype and the hardware is done using a webpage created by the hardware. This is not the optimal communication mode, as it demands the hardware to include a webserver. The earlier described Wi-Fi solution with Bonjour will make the connection both easy to set up and use, with no extra demand on the hardware. Therefore it should be included in the full version of the product.

During the concept selection phase of the development process, it was clear how the gesture feature could enhance the remote control concept; see Table 6.13. This feature should be implemented in the full version. But to make the feature attractive, the behaviour of users and the logic of gestures should be examined.

To make the product more attractive to a larger range of users, the remote control could be made more customisable. This can easily be done by adding more modules or even make it possible for users to create custom modules. But the demand for making the remote control more customisable is unknown and should be further investigated when the product is in use.

Another way to make the remote control more customisable is to make it possible to change the appearance, e.g. by changing themes, backgrounds, buttons, colours, etc.

In the beginning of the development process desires and their relative importance were established. This was used as a checklist during the development process, where each fulfilled desire could be checked. In the verification phase the fulfilled desires were verified, the result can be seen in Table 4.1 where the fulfilled desires are greyed out. This list should work as a checklist for the remaining part of the development process and the next step should be to implement the macro functionality.

Table 10.1 – Remaining desires sorted by the relative importance

Desires	Weight
Installation - Record button	8,5%
Interface for digital tv box	8,1%
The system should be intuitive	7,6%
Give feedback to user interaction	7,2%
Overview mode	6,0%
Recognizable interface	6,0%
Use without watching	5,6%
As Few user interactions as possible to change remote	5,4%
Modifiable interface	5,2%
No limit in amount of remotes	5,2%
Play/Record Macros	5,0%
Support as mant buttons as possible	3,3%
EPG - TV-guide	3,3%
EPG - Click to watch	3,1%
Interface for HTPC	2,5%
Support as many protocols as possible	2,5%
Interface for projector	2,3%
Interface for projector screen	2,1%
Be able to connect to hardware through Internet	1,9%
Interface for X-box	1,7%
Interface for PS3	1,6%
Interface for Mac	1,4%
EPG - Click to plan	1,4%
EPG - Click to record	1,0%
Timer - Plan start	0,8%
Timer - Timer Start	0,6%
Timer - Plan stop	0,4%
Timer - Timer stop	0,2%
Sum	100%

In addition to the above mentioned development work, the software needs the continuing process of bug fixing and optimising. These processes are never completed and should therefore always be kept in mind of the developer.

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APPENDIX A – THE REQUIREMENT SPECIFICATION

ID:	Type:	Requirement:	Validation:	Evaluation/Verification:
Navigation system				
N1	D	Overview mode	Get a quicklook over the available remotes	Engineering assessment
N2	D	No limit in amount of remotes	To replace the remotes of all your devices	Engineering assessment
N3	D	The system should be intuitive	Minimize the effort demanded by the user to understand the software	Focus group evaluation
N4	D	As few user interactions as possible to change remote	Limit the effort needed in interacting with the remote	Engineering assessment
N5	D	Use without watching	Limit the effort needed in interacting with the remote	Simulations
N6	D	Recognizable interface	Minimize the effort demanded by the user to understand the software	App benchmarking
N7	R	The system should have some kind of navigation system	Enable the navigation between controls to enable the use of more than one	Engineering assessment
N8	R	Navigation between at least 4 remotes	To replace 4 remotes	Engineering assessment
N9	R	Settings menu	The user should have a place were he/she can change the settings	Engineering assessment
Remote control system				
R1	D	Modifiable interface	The user should be able to modify the interface to match his/hers needs	Engineering assessment
R2	D	The system should be intuitive	Minimize the effort demanded by the user to understand the software	Focus group evaluation
R3	D	Interface for Digital-box	Enable controlling of a Digital-box	Engineering assessment
R4	D	Interface for HTPC	Enable controlling of a HTPC	Engineering assessment
R5	D	Interface for Projector	Enable controlling of a projector	Engineering assessment
R6	D	Interface for Projector screen	Enable controlling of a projector screen	Engineering assessment
R7	D	Interface for X-box	Enable controlling of an X-box	Engineering assessment
R8	D	Interface for PS3	Enable controlling of a PS3	Engineering assessment
R9	D	Interface for Mac	Enable controlling of a Mac	Engineering assessment
R10	D	Support as many buttons as possible	Give full support for all possible functions of a device	Engineering assessment
R11	D	Use without watching	Limit the effort needed in interacting with the remote	Simulations
R12	D	Give feedback to user interaction	Respond to the user's interaction to confirm that the interaction registered	Focus group evaluation
R13	D	Recognizable interface	Minimize the effort demanded by the user to understand the software	App benchmarking
R14	R	Support at least the ten most common buttons	Give adequate control to the user for the most common functions	Engineering assessment
R15	R	Interface for TV	Enable controlling of a television	Engineering assessment
R16	R	Interface for receiver	Enable controlling of a sound system (receiver)	Engineering assessment
R17	R	Interface for DVD	Enable controlling of a DVD	Engineering assessment
R18	R	Interface for power switches	Enable controlling of power switches such as light switches	Engineering assessment

Overall system and additional functionality

O1	D	Installation – record button	Control all functions on every remote	Engineering assessment
O2	D	Record macros	Record a series of device events to later replay at the user's command	Engineering assessment
O3	D	Play macros	Make a series of devices turn on simultaneously for quick access to the devices and to reduce effort from the user	Engineering assessment
O4	D	Connect hardware through internet	Remotely access devices functionality	Engineering assessment
O5	D	EPG – TV-guide	To get an overview of contents of TV-channels at the moment	Engineering assessment
O6	D	EPG – Click to watch	Quickly get access to a channel of interest	Engineering assessment
O7	D	EPG – Click to plan	Enable the TV to conveniently power on in connection to a TV-event	Engineering assessment
O8	D	EPG – Click to record	Enable a recording device to start in connection to a TV-event for the user to watch at a later time	Engineering assessment
O9	D	Timer – Timer start	Enable a device to power on after a set period of time for the convenience of the user	Engineering assessment
O10	D	Timer – Timer stop	Enable a device to power off after a set period of time for the convenience of the user	Engineering assessment
O11	D	Timer – Plan start	Enable a device to power on at a set date and time for the convenience of the user	Engineering assessment
O12	D	Timer – Plan stop	Enable a device to power off at a set date and time for the convenience of the user	Engineering assessment
O13	D	Support as many protocols as possible	Install all common models easy	Assessment
O14	R	Control at least 4 devices	To replace 4 remotes	Engineering assessment
O15	R	Communication modes: Wi-Fi, Bluetooth, USB-port or 3.5 audio input	Enable different connection possibilities to the communication station	Engineering assessment
O16	R	Price free	Offer the software free of charge	Assessment
O17	R	No Extra Hardware needed	Limit the need of hardware to only the iPhone for communication with the station	Engineering assessment
O18	R	Installation - download protocol	Install the most common models easy	Engineering assessment

R = Requirement

D = Desire

APPENDIX B – THE QUESTIONNAIRE

Frågeformulär

2011-05-05 14.14

Frågeformulär

Din ålder

Ditt kön Man
 Kvinna

Har du iPhone, iPod Touch, iPad eller Androidmobil?
([lista över Androidmobiler](#)) Ja
 Nej
 Nej, men planerar att skaffa

Har du trådlöst nätverk hemma? Ja
 Nej

Har du TV? Ja
 Nej

Har du digitalTV-box? Ja
 Nej

Har du DVD- eller Blu-ray-spelare? Ja
 Nej

Har du stereo/ljudsystem med fjärrkontroll? Ja
 Ja, inbyggd i min DVD-/Blu-ray
 Nej

Har du [HTPC](#) med fjärrkontroll? Ja
 Nej

Har du någon annan sorts mediabox (Apple TV, Boxee, Squeezebox eller liknande)? Ja
 Nej

Har du projektor? Ja
 Nej

Har du projektorduk som kan styras med fjärrkontroll? Ja
 Nej

Har du fjärrkontroll för styrning av belysning, markiser, air condition eller liknande? Ja
 Nej

Om ja, vilket märke på fjärrkontrollen?

Har du någon övrig utrustning med fjärrkontroll?

Har du en universalfjärrkontroll?

- Ja
 Nej

Om nej, varför inte?

- För dyrt
 Har inget behov
 Tror inte att det skulle fungera
 Annan anledning

Om ja, vilka prylar styr du med den? (flera kan väljas)

- | | |
|--|---------------------------------------|
| <input type="checkbox"/> TV | <input type="checkbox"/> Blu-ray |
| <input type="checkbox"/> Ljudsystem | <input type="checkbox"/> Mediabox |
| <input type="checkbox"/> DigitalTV-box | <input type="checkbox"/> Projektor |
| <input type="checkbox"/> HTPC | <input type="checkbox"/> Projektorduk |
| <input type="checkbox"/> DVD | <input type="checkbox"/> Belysning |
| | <input type="checkbox"/> Annat |

Vad har du för fjärrkontroll (märke/modell)?

Extra frågor

Inget krav, men vi skulle verkligen uppskatta om du svarar även på så många av dessa som möjligt, så utförligt som du känner för.

Du som har en universalfjärrkontroll:

Vad tycker du fungerar bra med den?

Vad tycker du fungerar mindre bra med den?

Vilka funktioner använder du mest?

Finns det några funktioner du sällan eller aldrig använder?

Finns det något du saknar på den?

Har du något förslag på hur den skulle kunna göras bättre?

Du som inte har en universalfjärrkontroll:

Vad skulle kunna få dig att köpa en?

Din Emailadress

Ifall det skulle vara några oklarheter i dina svar så kontakter vi dig gärna. Fyll i din emailadress om du tycker detta är okej.

Email:

APPENDIX C – THE INTERVIEW TEMPLATE

Vikta

- Billigare än alternativen
- Enkel att installera
- Tilltalande design
- Hög kvalitet/driftsäker
- Lätt att använda
- Fungerar på alla prylar
- Bluetooth/PS3
- Inbyggd i smartphone
- Färre knappar

1. Har du en smartphone?
 - a. Vilken modell?
2. Skulle du vilja ha en smartphone och vilken modell i så fall?
3. Vad har du för elektronik hemma som använder sig av fjärrkontroll? (TV, stereo, TV-box, HTPC, DVD, Blu-ray, Mediabox, Projektorduk, Belysning...)
4. Vilka är de vanligaste situationerna fjärrkontrollen används i? (Titta på tv, film...)
 - a. Vilka knappar används i dessa situationer?
5. Vad är en universalfjärrkontroll för dig?
6. Har du en universalfjärrkontroll eller skulle vilja ha?

Jag har en universalfjärrkontroll

7. Vilken modell?
8. Hur upplever du den?
 - a. Är du nöjd?
 - b. Vad funkar bra?
 - c. Vad funkar dåligt?
9. Vilken elektronik styr du med universalfjärrkontrollen idag?
 - a. Varför styr du inte fler saker med den?
10. Har din universalfjärrkontroll macron (förklara vad macron är)?
 - a. Hur använder du dina macron?
11. Finns det några funktioner som du inte använder?
12. Vilka funktioner väntar du dig av en universalfjärrkontroll?
 - a. Grundläggande?
 - b. De lilla extra?

13. Finns det några problem med din universalfjärrkontroll du har idag?
14. Hur fungerar användargränssnittet din universalfjärrkontroll har idag?
15. Skulle en smartphone-lösning vara attraktiv?
 - a. Hur skulle den lösningen se ut?

Jag har inte en universalfjärrkontroll men skulle vilja ha

16. Varför har du inte en nu?
17. Vilken typ skulle du vara intresserad av i så fall? (touch, "den simplaste", osv.)
18. Skulle en smartphone-lösning vara attraktiv?
 - a. Hur skulle den lösningen se ut?
19. Vilka funktioner väntar du dig av en universalfjärrkontroll?
 - a. Grundläggande?
 - b. De lilla extra?
20. Förslag eller idéer för lösningar?

Jag har inte en universalfjärrkontroll och vill inte ha någon

21. Varför vill du inte ha en universalfjärrkontroll?
22. Finns det något som skulle kunna vända dig?
23. Skulle en smartphone-lösning kunna få dig att vilja ha en universalfjärrkontroll?
 - a. Hur skulle den lösningen se ut?

Om en kommunikationsenhet skulle placeras i rummet:

1. Hur vill du att den skulle se ut
2. -> inte större än en router, men inte för liten heller
3. Skulle du vilja att den smälter in eller sticker ut
4. -> passa in, placera vid TVn, gömma med en diod som sticker fram
5. Hur ofta kan du tänka dig att byta batteri eller ladda enheten
6. -> halvår
7. Skulle du hellre föredra att den drivs med sladd
8. Skulle du vilja ha indikationslampor för att veta om den är igång eller ansluten
9. -> en lampa som byter färg när den är igång/ansluten till iPhone. blinkar till när man trycker på en knapp på fjärrkontrollen
10. Om inte hur skulle du vilja veta ifall den är igång eller inte