Challenges in context-aware mobile information systems:

A digital shopping assistant

Aalborg university 2004 - 10th semester Informatics

Project title: Challenges in context-aware mobile information systems: A digital shopping assistant

Project elaborated at Aalborg University

Project period: 02/02-2004 to 10/06-2004

Supervisor: Jan Stage Ph.D.

Number of pages: 104

Number of copies: 7

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Synopsis

In this project we engage some of the challenges within the area of context-aware mobile information systems. We have chosen a practical approach on the basis of a case study: A digital shopping assistant. We have focused on developing an indoor positioning system. It is developed on the basis of an article study and a prototyping approach. Guidelines for selecting a suitable technology have been provided.

We have also engaged in the task of defining requirements for the digital shopping assistant. For this task we have used 3 existing software development methods. The methods used are Contextual Design, M.U.S.T and eXtreme programming. Each method is used for creating a list of requirements and a prototype. The main requirements from the 3 methods will be discussed and a list of primary requirements for a digital shopping assistant will be elaborated. Furthermore the prototypes will be evaluated.

The methods were suitable for uncovering *relevant* information in the context of shopping. However they were not well suited for uncovering requirements that made the digital shopping assistant *context-aware*. For this reason we introduce a technique that aids the developer in finding context-aware capabilities by focusing on the *activities* that the user is engaged with. This can be used for limiting the amount of interaction needed for the device to support the activity.

Preface

This report is the result of the work done on the Informatics education 10th semester, within the topic of context-aware mobile information systems.

During the work on the 9th semester we had a thesis that the OOA&D method had limitation for developing context-aware systems. We explored this issue, but did not come to a satisfactory result, which would make the creation of context-aware systems easier.

During this semester we have engaged in the challenge of developing a specific context-aware system. This was split into two research questions. The first question is based on how to determine the location of a user in an indoor environment.

To answer this question we have made an article study and implemented a simple but effective solution and provided guidelines for others who wish to pursue this task.

The second research question involves identifying requirements for a context-aware digital shopping assistant. In order to answer this question we produced three different sets of requirements using three existing software development methods: M.U.S.T, Contextual Design and eXtreme Programming. Throughout each development process, the developer has documented the problems encountered in a diary. In the report these problems are discussed in order to identify whether the problems are related to context-awareness. Each developer has implemented a prototype that demonstrates the basic requirements and each prototype has been evaluated with several users, in order to gain as much feedback and validation on the requirements. We have combined the requirements from each method and then elaborated a list of primary requirements for a digital shopping assistant. Based on the knowledge gained from working with the methods, we have created guidelines for developing context-aware information systems.

For further reading about the three development methods there is an extensive appendix, which will provide a description of the methods, usage and diaries from the development.

We would like to thank Jan Stage for his guidance during the project and Laurits Bach Sørensen from Hewlett-Packard for lending us equipment, which made the testing possible.

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1 Introduction

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."

[Mark Weiser, The Computer for the 21st Century]

Weiser, founder of Ubiquitous computing, put forth a vision in the early nineties that in the future a proliferation of devices at varying scales, ranging in size from hand-held personal devices to yard scale shared devices would occur [2]. This vision has indeed occurred with the emergence of PocketPCs, tablets, laptops and electronic whiteboards.

During the last decade mobile devices have become more commonly used and different types of mobile devices have emerged to create new markets and application possibilities. In this project we will refer to mobile devices as being *handheld* devices such as smart phones and personal digital assistants. The proliferation of mobile devices has gradually provided people with the ability to have access to information at *anytime* and *anywhere* [1]. For the past decade, researcher's within mobile HCI[1] has addressed the challenge of overcoming this information dilemma; we want to have access to information *anytime* and *anywhere*, meaning that the device on which to access this information has to be mobile. A mobile device is not suitable for presenting large amounts of information, because of the following limitations:

Limited display size

According to Kärkkäinen and Laarni [3], the display size of mobile devices is much smaller than desktop computers, the amount of information which is visible at a time is dramatically

[1] Mobile HCI provides a forum for academics and practitioners to discuss the challenges and potential solutions for effective interaction with mobile systems and services [Mobile HCI 2003].

reduced. As a result, the number of sub-pages must be larger, or the content must be reorganized or modified. *Small displays* with short lines slow down the reading speed by disrupting the normal pattern of eye movement. Moreover, since the amount of information, which can be displayed on the screen at one time, is limited, much time is spent manually scrolling or paging the text [3]. When transforming a large amount of information to mobile formats a critical task is to reduce the amount of information and to make the content more focused [13].

Limited input and control measures

Mobile devices often have limited input capabilities. On a PocketPC the user can input text and control functions with a stylus[2] and a set of control buttons. The virtual keyboard and/or handwriting recognition software is very slow compared to a desktop keyboard and mouse. Moreover, because of the small display size, a lot of scrolling and paging is required when reading large amounts of information. Compared to desktop computers, more interaction is required to read the same amount of information on a mobile device [13].

Limited processing capability

Although the processing capabilities are becoming increasingly faster in most mobile devices, it is still not recommended to use large images or animations. Furthermore the storage is not capable of storing large video files [13].

Environment

An additional constraint is the environment in which the mobile device is used. Direct sunlight can reduce screen brightness, making it harder to read text. Furthermore in some public areas it is necessary to be quiet. As a result the sound capabilities of the mobile device can not be used [13]. In a desktop environment it is possible to assume that the user is sitting down, with few other disturbing tasks getting in the way of what the user is trying to achieve. When using handheld mobile devices the user may be driving a car or walking the streets, and such tasks will divide their attention and limit their resources for interacting with the computer [14].

[2] Stylus = a pen for interacting with the device.

Addressing the limitations

The presence of the limitations of mobile devices puts forth a challenge for reducing the amount of *relevant* information available to us, because information is only valuable once we have read it, and constructed a useful meaning [Qvortrup 2001: p.196-204]. Weiser also acknowledged that there is more information available at our fingertips during a walk in the woods than in any computer system, yet people find a walk among trees relaxing and computers frustrating. Machines that fit the human environment instead of forcing humans to enter theirs will make using a computer as refreshing as taking a walk in the woods [2]. But what does it mean that machines should fit the human environment? In HCI research the goal has been to develop information systems that implicitly know what the user wants to do. This is only possible if the device has some sort of awareness of the user's current actions and desires. Therefore efforts have been made into the development of information systems, which uses information about the *context* of the user, in order to provide information or services that is *relevant* to the user [4,5,6], also called *Context-Aware Computing*. Some of the research done in this field addresses the limitations of mobile devices, by making information systems adapt to the environment in which the user is situated. For instance knowing the location (in the real world) of the user allows the application to provide the user with information and services that are tailored to the user's context and preferences. Context-aware applications are a possible solution for addressing some of the limitations of mobile devices. The information dilemma can be addressed, because the device is able to provide the user with *relevant* information. Furthermore the need for interacting with the device to perform a certain task can be minimized or removed, if the device itself is able to foresee what the user is trying to achieve by having knowledge of the users context. An example of a well known context-aware application is a context-aware tour-guide that offers visitors information tailored to their preferences and the environment [15, 4, 16].

We find *context-aware computing* an interesting approach for addressing the limitations of mobile devices. Therefore the scope of this project is to investigate into the challenges and solutions in the development of a context-aware mobile information system. This leads to the following definition of the problem:

Problem definition

What are the challenges in the development of a specific context-aware mobile information system?

We choose to investigate into the challenges by using a practical case study. According to the definition of the problem, the development must encompass the development of a mobile context-aware information system. In the following section a case that fulfils this criterion will be presented.

1.1 Case description

In the previous semester we developed a *location-aware* mobile chat system similar to Microsoft Messenger. This system differed from existing chat systems by including context-awareness. Users had the possibility of seeing the location of contacts on a map, and be able to receive notice if any contacts were nearby. The system also had another type of user; the information provider. The information provider had the possibility of placing virtual advertisements that had a specific target group and was related to a physical location in the real world. If a user entered and matched the target group of a virtual advertisement, they would receive the advert on their mobile device.
Through the development of the chat system, we became motivated to develop a mobile shopping assistant that is *context-aware*.

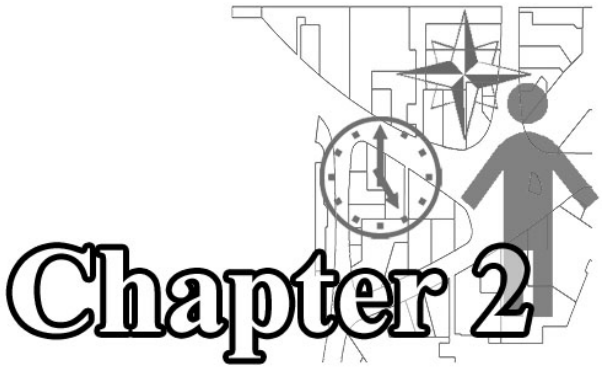
The initial idea was that the shopping assistant should be able to provide the shopper with digital advertisements based on the user's location and preferences. Bearing this case in mind we contacted Hewlett Packard[3] (HP) with the intention of establishing collaboration. On a meeting we agreed to participate in a collaboration project with HP (hardware provider), JJ-Netting[4] (network consultant) and Bruuns Galleri[5] (shopping mall). The following guidelines were agreed upon at the meeting:

1. The digital shopping assistant should be implemented on a *HP PocketPC* in order to support mobility within Bruuns Galleri.

[3] http://www.hp.dk
[4] http://www.jj-netting.dk
[5] http://www.bruunsgalleri.dk/

2. The digital shopping assistant should be able to supply the shopper with *advertisements according to user's interests*. It should be possible to present advertisements with pictures, videos and sounds.
3. As a minimum the digital shopping assistant should be location aware, meaning that the *location determination* must function *indoor*.
4. The indoor positioning system should be *inexpensive* and virtually *invisible* in the environment.
5. A running prototype should be presented to journalists the 18/6-2004.

Because the problem definition is very broad, we will investigate further into the challenges of *context-awareness* in the next chapter, in order to narrow down the scope.



2 Context-Awareness

Much debate has occurred and is still taking place about the meaning of *context-awareness*. In order to think about how to use context within information systems, it is important to understand what context-awareness is [6].

When people talk with each other they are quite successful in explaining ideas and reacting properly in specific situations. This is because of our understanding of context. We share a rich language, have a common understanding of the world and an implicit understanding of everyday situations.

This understanding of context does unfortunately not transfer to computers very easily. Therefore when humans interact with computers it is done on their terms. In traditional HCI[6], users do not have a lot of options for providing input to computers and the options they have are very limited. If we can increase the computer's understanding of the context in which it operates, we can increase the richness of the dialog between humans and computers and make it possible to develop more useful services, which are tailored to the user and the context [9, 10]. But since computers cannot understand context, and even less understand implicit context, it is necessary to have a very explicit understanding of context. This leads to determining which parts of *context* are important to know about, in order to determine what information is relevant.

2.1 Context

According to the Oxford dictionary context is defined as:

> "*The situation in which something happens and that helps you to understand it*"
>
> [Oxford 1995]

This definition is to abstract to be used in the field of context-aware computing. There have been many attempts to develop a definition of context to use in this field [10]. In the

[6] Human Computer Interaction

following we will look at some of these and subsequently describe our understanding of context.

Schilit and Theimer, the pioneers of context-aware computing referred to the term *context* as *location, nearby people and objects*, and *changes to those objects*. They considered where you are, whom you are with, and what resources are nearby to be important aspects of context [7, 8]. The problem with this definition is that it does not encompass the environment or the activity that the user is engaged in as important.
Others have used examples in defining context. For instance Ryan et al. [17] defines context as the user's location, environment, identity and time, which is information "*…that can be used not only to tag information as it is collected, but also to enable selective responses such as triggering alarms or retrieving information relevant to the task at hand*".
Dey [19] enumerates context as the user's emotional state, focus of attention, location and orientation, date and time, objects and people in the user's environment. Both Ryan et al.'s and Dey's definitions are very hard to apply in practice, especially if the developer has some doubt whether a specific factor, that are not included in these definitions, should be considered a *relevant* part of context that a system should be aware of.
Other definitions simply defines context by providing synonyms, such as *environment* or *situation*.
In this category some regard context as the user's environment. Others describes context as the application's environment. Brown [20] defines context as *elements* of the user's environment that the application knows about. We find elements to be to broad a criterion for any practical use, since almost anything could be relevant in this perspective.
Among other classifications of context, Schilit et al. propose [18] the following classification of context information:

- **Computing Context -** Available processors, devices accessible for the user, input and display, network capacity, connectivity, and cost of computing.
- **User Context -** The user's profile, location and nearby people.
- **Physical Context –** Lighting, noise level, traffic conditions, temperature.

These forms of context information may be utilized in an immediate way, or may be processed from a historical perspective. Historical context information is where computing-, user- and physical context are stored across a time span. Potential usage of this information could be to establish patterns in the environment which can be used for later adaptation in a context-aware application.
This classification of context is closer to a definition that is useable in practice. However it still uses examples in its description, which makes it hard to estimate whether some object is

part of the classification. For instance there is no way of determining whether a blackboard could be considered relevant in this classification.

Abowd and Mynatt calls a complete definition of context "*illusive*" and instead presents 5 *"W´s"* of context, which is a set of relevant information to consider for any context-aware information system [12]:

Who	The "Who" describes the identity of the current user including information such as preferences, sex, name, age etc.
What	The "What" of context includes information about what the user is doing. This includes understanding the activity the user is engaged in.
Where	The "Where" describes the user's location, but can also include heading, speed, etc.
When	"When" might be time of day, but could also include information such as time of year or time elapsed since some event. The latter can give an indication of patterns in the user's behaviour.
Why	The "Why" is a bit different. "Why" describes the reason for a person's specific behaviour. This can in many ways be determined from the other contextual information available. For instance, if a person goes near a sculpture in a museum it might be because he is interested in learning more about it.

The 5 "*W's"* of context, are all closely related to the *User Context* in Schilit et al.'s classification, in the sense that they focus on perceiving relevant context-information about the *user*. If a system has knowledge about these 5 "W" it would be able to tailor relevant information to the user. Moreover knowing about what the user is trying to achieve can aid the system in minimizing the need for user interaction, which is essential for improving the cumbersome and limited input methods available on today's mobile devices.
Abowd and Mynatt point out, that many applications still only uses at the small subset of the context concerned with location and user identity [4].
The 5 "W" presented by Abowd and Mynatt is a good starting point for understanding and determining which information about the context is relevant to consider when designing a context-aware information system.

Understanding of context:
The 5 "W's" will be used as our understanding of *context* in this project, however we believe that in order for a system to be called context-aware, it needs to know about at least two of the 'W's and the system should be able to automatic derive information about each "W" from the context, without any user interaction. The better the system derives this information automatically, the more *context-aware* the system is perceived.

It is essential that the computer get an understanding of our context, so that it can adapt to the changing context as easy as humans do. The most basic contextual factor is location. Many of the other aspects of context-awareness can be derived from the knowledge of the location. For example if a computer merely knows what room it is in, it can adapt its behaviour in significant ways without requiring any artificial intelligence. As Mark Wieser stated [2]:

> "*Little is more basic to human perception than physical juxtaposition, and so ubiquitous computers must know where they* (humans) *are*."
>
> [Mark Weiser, 1991]

According to Weiser, the most fundamental perception humans have of context is knowing where we are. Likewise as a starting point computers should gain an equal understanding of their location, so they may adapt their behaviour accordingly. However systems that only incorporate knowledge about the user's location are called *location aware* systems. The challenges in this area are easily overcome while being outdoor where the use of GPS[7] is possible. For the past few years researchers has turned their attention towards indoor positioning systems, since the technology is beginning to support this ability[26, 27]. Still the technology is at an early state and some of the earlier research projects used quite cumbersome approaches for positioning [16, 18], which is unlike Weiser what defined as the *calm age* (Invisible computers) [2]. As the technology keeps maturing, so does the future commercial values for these positioning systems. However, so far the majority of indoor positioning systems are still only being tested in office environment or research labs [16, 22, 23, 31, 32]. We therefore wish to pursue the challenges within this area and develop an indoor positioning system. This leads to the research question:

Research question 1:
What are the challenges and solutions in determining the location of the user in an indoor environment?

[7] GPS = Global Positioning System

However knowing about the context of a system is not enough when developing a system. It is just as important to know what to do with this information. Without precise information on what the users are hoping to achieve, it is difficult to identify suitable services or sub-services that may fulfil (in part or fully) their information needs [6]. As mentioned in the introduction[8] the value of context-aware systems is their ability to reduce the amount of information available for the user to what is the *relevant* in the given situation. In order to determine what the relevant information is, it is necessary understand the actual context for which the developed system shall function. This involves understanding the functionality the user needs in the given context. Furthermore it is equally important to understand how these functionalities should be presented and structured for the user. Therefore we wish to address the challenge of identifying user requirements for specific context-aware mobile information system. This leads to a second research question:

Research question 2:
How can requirements for a context-aware shopping assistant be identified?

User requirement describe any function, constraint or other property that must be provided to satisfy the user's need. Therefore the requirements describe how a future digital shopping assistant can help users achieve their goals effectively, efficiently and with satisfaction in their context of use [35].
Having narrowed down the focus to the research questions above, we will describe how the research questions will be addressed in the following section.

2.2 Method

In order to order answer the research questions we have chosen a practical and qualitative approach on the basis of a case-study.

2.2.1 Research question 1

In order to answer the first research question we will develop an indoor positioning system. Through the process we will gain experience in challenges in determining the user's location.

[8] See introduction, Chapter 1

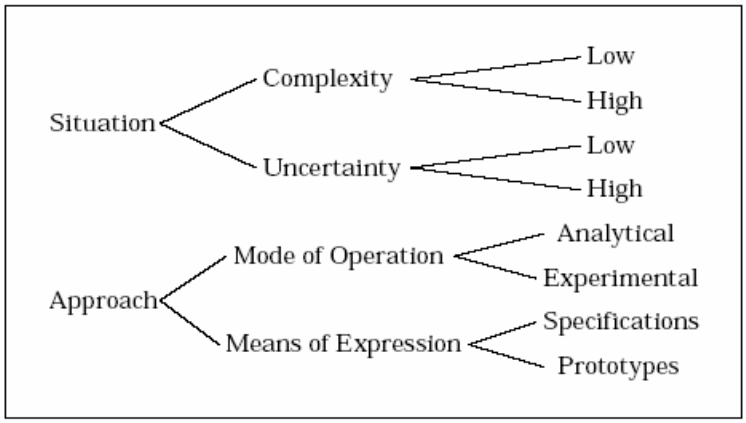


Figure 1 Situational characteristics and basic approaches to software design [5].

If you find yourself in the development of a system that has a high level of complexity with a high level of uncertainty, an experimental mode of operation should be used. The means of operation should be prototypes.

No prior knowledge on how to develop an indoor positioning system was present in the group, and we knew that the task of developing such a system was a complex task. However as previously mentioned, there has been increasing focus on how to develop indoor positioning systems and many articles have been written on different approaches for indoor positioning using various hardware technologies for location determination. Therefore in order to gain insight into the challenges and solutions for developing an indoor positioning system, we choose an *analytical approach* by conducting an article study on this subject. The article study will discuss the advantages and disadvantages of each technology enabling us to choose the technology which is best suited for the case and fulfils the guidelines that were agreed upon at the initial meeting[9]. Furthermore the article study will aid us in choosing an approach for designing a location determination algorithm.

Once the technology and positioning algorithm has been chosen the actual implementation will be carried out. Since the uncertainty within this area is high, we choose an experimental procedure for the development phase, meaning that we will use an iterative approach.

The process of developing an indoor positioning system will be described in chapter 3, which also will include the answer to research question 1.

[9] See Case section 1.1.

2.2.2 Research question 2

To answer research question 2, we choose to investigate into the use of three existing development methods for requirements elicitation. Using multiple development methods will allow us to have a broader perspective in our investigation, because each development method will introduce a different approach for requirement elicitation. Throughout the development using each method we will document problems encountered. Since we are unaware of how context-awareness requirements should be identified by each method, we choose to thoroughly investigate all problems encountered. Instead of *only* describing the requirements found in each method, we choose to implement three prototypes. Using prototypes will enable us to evaluate to what extend each prototype meets the demands of the users [35]. In the evaluations we will focus on evaluating the functionality provided by each prototype. Chapter 4 will further describe how these evaluations were conducted.

Choosing methods

To get an equal starting point the criteria's for selecting the development methods are as follows:

1. They shall be well documented, meaning that they shall be described in a book.
2. No prior experience in developing with the methods is allowed.
3. All methods shall include users in the requirement elicitation.

By using the above criteria we select the following methods:

1. M.U.S.T. [10] method
2. Contextual Design[11] method
3. eXtreme Programming[12] method

The three methods will be divided among the developers. Throughout the process of developing the three prototypes, the developers will not be allowed to discuss any aspects of the methods with each other. This is chosen to prohibit any influence between the methods, which can have an impact on the requirements and prototypes subsequently produced.

[10] See MUST method, Appendix A

[11] See Contextual Design, Appendix B

[12] See eXtreme Programming, Appendix C

Documentation

Embarking on the process of developing any computerized information system yields a lot of practical and methodological experience [34]. This experience was very important to this project, since it allowed us to investigate more thoroughly into the use of each method for requirement elicitation, when it is used for a system that needs to be context-aware. For that reason we choose to document the process of each development method in a diary, to avoid forgetting about important details about their use. From previous experience with writing diaries, we knew that a checklist had to be created. The checklist[13] should function as a guide when writing the diaries, which will force the developer to reflect upon the use of each problem encountered.

[13] See checklist, Appendix E

3 Indoor Location

In this chapter we will present the development of an indoor positioning system, in order to answer research question 1. The development process is explained below.

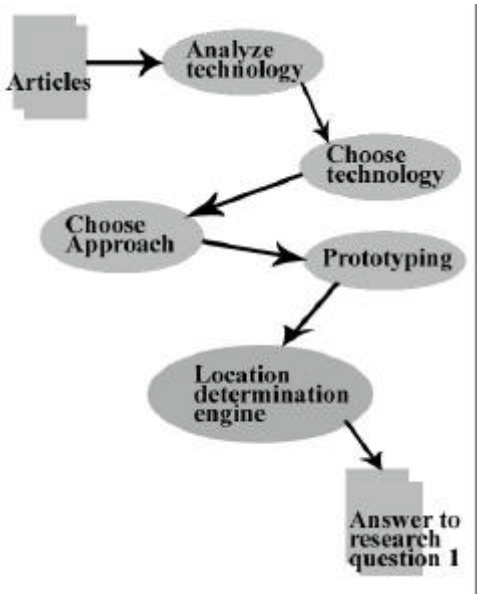


Figure 2 Overview of the process

It was chosen to begin with an article study to get an overview of the technologies. Each positioning technology has benefits and limitations, which influenced the choice of technology used for developing the positioning system. The criteria used for selecting technology will be explained below. With each technology there are several different approaches that can be used for indoor positioning. An approach was chosen and the prototyping phase began. This phase continued until an acceptable positioning system was developed.

The following criteria were used in selecting the technology and positioning approach:

Criterion	Description
Hardware availability	The technology chosen must be easy to *obtain*, *use* and *install* in the environment.
Location determination accuracy	The technology and approach for using the technology, must offer an *accuracy of minimum 10 meters*, in order to be of any use for the case.
Price	The technology chosen must be *inexpensive*, however it should *cover a large area* like Bruuns Galleri, in order to follow the guidelines mentioned in the case.
Visibility	The technology must have a *minimal impact on the environment*, since it will be installed in a commercial area. This was one of the guidelines mentioned in the case.
Prototype must run on HP PocketPC	The technology must *function with a HP PocketPC*, in order to follow the guidelines mentioned in the case.
Time frame	Since the timeframe is limited in this project, the positioning system must be implemented in *less than 2 months*.

Table 1 Criteria used for selecting technology and approach.

An additional and overall requirement for the technology is that it must support *automatic sensoring* of the user's location. This means that *no* interaction from the user is required, in order to inform him of his location. Having set the criteria for selecting the technology and approach, we began the article study.

3.1 Positioning technologies

This section will provide a description of some of the technologies, which are available for developing an indoor positioning system. The advantages and disadvantages will be discussed, in order to get a basis for deciding, which technology to choose.

3.1.1 GPS Pseudolites

GPS positioning based systems have already proven their usability in many different applications, but they all have one thing in common: They function outdoor. Using GPS to position indoor is not possible, but some workarounds have been proposed.
The basic idea is to position "fake satellites" within a building and make the GPS client think these are real satellites. This is done by having four pseudolites in each room, where the positioning system should function. This technology has been tested by Seoul National University[14], where they achieved a precision of a few centimeters.

[14] http://gps.snu.ac.kr/research/pseudolite/indoor_eng.htm

The disadvantage is that most buildings are composed of many smaller rooms and the amount of pseudolites would become large, since there is a need for four pseudolites in each room. Secondly these pseudolite systems are incompatible with the existing GPS system, which makes it impossible to use real satellites concurrently with the pseudolites [28].

3.1.2 Infrared

Infrared technology is commonly used in household appliances such as remote controls for the televisions, amplifiers etc. This technology works by installing senders at in each room. These senders send out their own unique ID at a given interval. The receivers are located on the people or objects, which the system must be able to locate. These receivers are equipped with small computers, which are able to decipher the signals received and determine their location from the unique ID.
The benefit of this technology is that the signals are characterized by having non-interference characteristics from other electronic devices. Furthermore the accuracy gained from this technology is in the range of few centimeters [30].
The disadvantages are that it requires very little obstruction to block the infrared signal. A thin piece of clothing is often enough. Furthermore this signal is directional and has limited range of approximately 10-15 meters, consequently the *senders* is visible in the environment. Moreover a huge amount of senders would be required, and it would become expensive if it should be used to cover an entire shopping mall [26].

3.1.3 Active beacons

This technology uses independent transmitters which are distributed throughout the area, where the positioning system must function. Each transmitter sends out both an ultrasound and a radio signal. The principle of determining the distance from a transmitter is determined by calculating the difference between the two signals. The radio signal travels at the speed of light, while the ultrasound signal travels at the speed of sound. By measuring the delay between the radio signal and the ultrasound signal the distance from the beacon can be calculated. If this is done with three or more beacons, it is possible to calculate the user's location using triangulation, if the system has knowledge of each beacons exact location.
The advantages to this system are that radio- and ultrasound signals are hard to obstruct. Therefore it does not suffer from the line-of-sight problem like infrared. Furthermore and the technology has an accuracy of approximately 30 centimeters.
The disadvantages are that the system relies on a large amount of special hardware to be installed in the context and on the device, which also makes it an expensive solution [27].

3.1.4 Bluetooth

Bluetooth was originally created to delimit the user from cables and to create an easy to use interface between various devices. Bluetooth has a short range of about 10 meters[15]. The idea of this system is to position Bluetooth beacons in the area where the location based service is needed. The user's location is then determined by calculating the signal strength and signal quality, to estimate the range from each Bluetooth beacon. This technology has a precision of approximately 2 meters. The advantage to this system is that the Bluetooth devices can easily be used for two way communication and there are already multiple devices on the market which use Bluetooth, including the HP PocketPC used in this project.
The disadvantages to this approach, is that Bluetooth has such a short range and therefore it is necessary to have a large amount of beacons, which will become expensive [29].

3.1.5 W-LAN Positioning

The technology relies on the signal strength from an access point. The signal strength can vary depending on noise and static obstacles, such as walls, people etc. This proves that the signal strength is a poor choice, when trying to triangulate the location of the user.
The advantage to this technology is that it uses cheap existing technology, which might already be present at the location where the services are supposed to function. It also makes two way communications easy, since the hardware was designed specifically for this purpose. Furthermore the technology can transmit data over long distances, ranging from 50 meters indoor to 100 meters outdoor.
The disadvantages are that the technology used produces less accurate positioning accuracy compared to some of the other technologies. It has an accuracy of a few meters, depending on the approach chosen for positioning [21] [25] [31].

3.1.6 Other technologies

There are other approaches to take when trying to create an indoor positioning system. Some are based on vision systems, which are mostly used in robotics research [33]. Other technologies rely on sensors on the human body, which will record the walking speed and direction and determine the location based on these recordings. These types of positioning systems will be disregarded in this project. It must be a system, which uses available and easy to use technology. Furthermore the positioning system must be implemented in less than 2 months.

[15] http://www.winnetmag.com/MobileWireless/Article/ArticleID/24980/MobileWireless_24980.html

3.1.7 The chosen technology

According to the criteria[16] introduced in the beginning of this chapter, we chose the W-LAN technology. This choice is based on several reasons. The technology is usable with the HP PocketPC. Furthermore the technology does not require the same amount of *beacons* in the context, because of the large range supplied by access points, as a result the technology can provide a positioning system for a reasonable price and effort, compared to some of the other technologies. The signal of W-LAN is not as easy to obstruct as infrared or GPS pseudolites, thereby the access points can be hidden, which will reduce the noticeable impact the positioning system has on the environment. Additionally W-LAN offers an acceptable accuracy within a few meters.

3.2 Approaches using the technology

There are basically three approaches one can use for estimating a user's location, when using the W-LAN technology. In the following, we will shortly describe each approach and subsequently explain which one we chose.

3.2.1 The perimeter approach

For large areas it is possible to estimate the location using a single access point. This is a simple system which will only be able to tell which access point the user is closest to. This approach will have accuracy, which will be far too low for a mall. This is due to the fact that an access point has a range of about 50 meters indoor, before it will loose the signal and switch to an access point with better signal. Basically the user can move within the diameter of the perimeter, which is 100 meters and never change position.

3.2.2 The triangulation approach

Another option is to use a triangulation approach. The idea behind this system is to calculate the distance to three or more access points based on the received signal strength and then determine the user's location by using mathematical triangulation. This approach has an accuracy of about 2-3 meters if the environment is static. However it can suffer from limitations, when working in areas where the environment is undergoing continual changes such as humans obstructing the signal, shopping stands being moved etc. This is because W-LAN signals are reflected by all surfaces, which results in varying signal strength values and consequently will make the location determination less accurate. The approach is more

[16] See criteria, Table 1 page 18.

expensive compared to the first solution, since it requires at least three access points in range of the receiving device at all times.
[23] [25].

3.2.3 The learning based approach

The third option is to use a system, which is based on previously recorded locations and determine the user location based on a database [27]. This approach relies on a user teaching the system all the locations, which are of interest. These samples are stored in the database along with the respective location. When a user receives the signal strength values, they are compared to the signal strength values in the database and the closest match is found. In the learning based approach the system does not need to know the location of the access points, but it needs to have three access points in range at any given user location, in order to give precise location estimation. The accuracy provided by this approach is in the vicinity of 3 meters. Since the approach relies on learning points taken during a setup phase, changes in the environment can demand a re-calibration of the system. Furthermore the setup phase can be time consuming, since learning points must be gathered from every location that the system needs to know about.

The *perimeter approach* was abandoned because the accuracy was too low for the given case. The *triangulation approach* and the *learning based approach* seemed feasible for the ongoing case, because they had accuracy in the vicinity of a few meters. However we needed to determine exactly what impact the environment had on the precision obtained, since a mall is typically populated and highly dynamic compared to office environments, which is used as test-beds in most articles. In order to determine this impact we conducted three tests [25] [31].

The experiment started by determining how accurately the distance from a single access point could be determined, in order to estimate the accuracy.

3.2.3.1 Test 1

A radio signal is dominated by reflections caused by the surfaces within a building and the signal therefore reaches its destination via multiple sources [21]. It was suspected that this multi path phenomenon would have an impact on the signal strength and therefore an experiment was conducted in order to test this hypothesis.

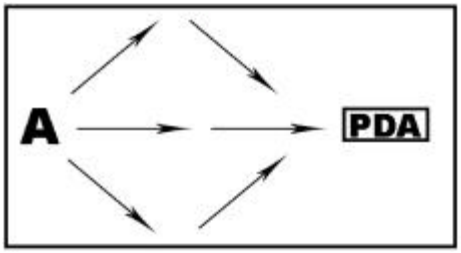


Figure 3 The PocketPC is moved towards the access point to determine signal strength reliability.

The experiment was conducted in a room which was 12 by 8 meters. The PocketPC was positioned in one end of the room and the access point in the other end. The first thing noticed was that the signal strength was not static. It had a span of about 10DB on a scale where -10DB is excellent and -90DB is poor. Since the Decibel-scale is logarithmic a drop of 10DB in signal strength is *very* significant[17]. Nonetheless when moving towards the access point the signal strength became increasingly better, this indicated that positioning is feasible. Secondly it was tested how the orientation of the user had an impact on the signal strength [22].

3.2.3.2 Test 2

In the second test it was examined how the obstruction of a human body would influence the signal strength, since a mall is likely to be highly populated. The experiment was conducted by having a person turn around with the PocketPC in front of him. Signal strength values were collected over a period of two minutes. At 0 degrees the person was faced directly towards the access point. The person then rotated 45 degrees clockwise and a new series of data were collected. This continued until the person had completed the 360 degrees rotation. The result was as follows:

0 degrees:	from -22DB to -30DB
45 degrees:	from -25DB to -33DB
90 degrees:	from -26DB to -38DB
135 degrees:	from -25DB to -33DB
180 degrees:	from -31DB to -42DB
225 degrees:	from -26DB to -35DB
270 degrees:	from -31DB to -39DB
315 degrees:	from -26DB to -34DB

Signal strengths gathered during rotation of the person

[17] http://www.phys.unsw.edu.au/~jw/dB.html

The data indicated that the rotation had an impact on the signal strength received. If the device is at 0 degrees it ranges from -22DB to -30DB, but as soon as it is rotated 180 degrees it ranges from -31DB to -42DB. These two orientations do not have a subset of signal strengths in common. The gathered information indicates that it is difficult to determine the distance from a single access point, with an accuracy that is acceptable for triangulation, since the variance of signal strength is large and can ultimately affect the calculated distance.

3.2.3.3 Test 3

A similar experiment was conducted to determine if the orientation of the antenna on the PocketPC would have an influence on the signal strength. To test how the PocketPC's antenna's orientation impacted on the received signal strength, the PocketPC was positioned on a table, which was located at the same distance from the access point as the person had been. This test gave similar values in comparison to the previous test. Therefore it was determined that the influence of the rotation and the user blocking direct access to an access point was so closely related, that it would not be possible to distinguish between them.

3.2.4 Selection of approach

It was chosen to use the *learning based approach.* The results of the three tests indicated that whether staying at the same location, blocking the signal with a human body or rotating the device, would give similar deviation in signal strength. It is exactly those occurrences we would expect in a mall that is highly populated. The triangulation approach is complex to develop with these variations and it would not be possible to implement within the given timeframe [32]. A similar accuracy could be obtained with the learning based approach, which is easier to implement [Ekahau].

3.3 Prototyping phase

The first task of the prototyping phase was to elaborate an object system capable of storing information about access points and signal strength values which should be related to a location.

3.3.1 Elaborating an object system

According to the *learning based approach*, 3 or more access points are required to determine a user's position. The collected signal strength values would have to be stored in a database

for later comparison. In order to avoid confusion, it is necessary to distinguish between two types of signal strength values:

- **Teach point:** A collection of signal strength values gathered from three or more access points. Many teach points are used as reference to one particular location.
- **Sample point:** A collection of signal strength values gathered from three or more access points. Sample points are used to determine the current location by comparing them to teach points residing in the database.

The difference between teach – and sample points is illustrated below.

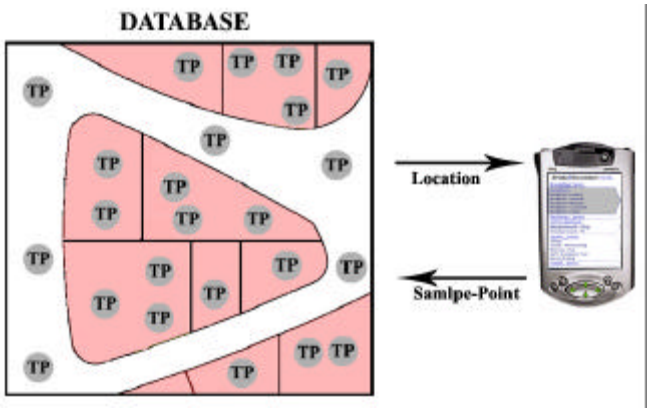


Figure 4 Illustration of the learning based approach. TP means teach point, they are stored in a database and is related to a particular location.

Figure 4 demonstrates that positioning can only be determined at the locations related to each teach point, therefore the more teach points the better accuracy. Before creating an ER-diagram an analysis of the problem domain is needed in order to identify the required objects.

Object	Description
Area	An area is a location like “Aalborg Storcenter” or “Bruuns Galleri”. Its task is to store the overall information such as name and a bitmap of the area.
Zone	A zone is the smallest possible area, in which the system must be able to localize the user within. A zone could be a store or even a part of a larger store, which would make it possible to distinguish between different commodity groups. A zone stores information about its layout and its name. The layout is a list of points used for a graphical representation of the zone. The list of points is drawn as a polygon.
Teach point	A teach-point is a collection of minimum three signal strengths and mac-addresses collected from the access points, which is stored in the database for comparison reasons, when a user sends a location request.

Access point	An access point is commonly known as the W-LAN device, which users have to connect to, in order to gain access to the Internet. This is also the case in this project. But in the database an access point is composed of a mac-address[18] and signal strength.
Sample point	A sample-point is much like a teach-point. It is also a collection of signal strengths and mac-addresses, but this is used when a user sends a location request to the database.

Table 1 Objects needed to model a class diagram.

The identification of these objects, created the basis for elaborating a class diagram:

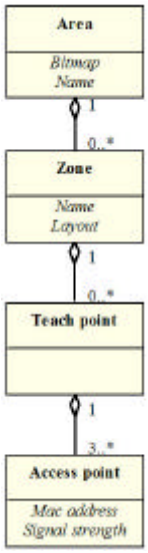


Figure 5 Class diagram

The first object is an *Area*. This object will store the name and a bitmap of the location where the system is functioning. An area will then be divided into *Zones* to make the database able to distinguish between different locations. Testing the size of the zones will be done at a later stage in the process. Each zone has a name, which makes it distinguishable from the other zones, and a zone layout. These zones have a collection of *Teach points*. Teach points will enable the system to do an estimation of the user's location. Each of these teach-points contains a list of *Access points* which are within range. Each access point is stored with the mac-address and the signal strength value.

This object system will ensure an architecture, where it is easy to search for information related to determining the user location.

[18] A mac-address is a unique ID, which is used to distinguish between two hardware devices

3.3.2 Iteration 1

It was decided to create a solution using client-server architecture. This was done for multiple reasons. The primary reason was that the system needed the ability to handle changes in the context. This could be new advertisements or a zone that has to change as stores moves or closes. It was decided to have this information stored at a single location, instead of having to update multiple applications. Secondarily by having a centralized server offered the opportunity to survey all locations of clients, while at the same time limiting the amount of computational load and required storage on the clients.

3.3.2.1 Server application

Using the class diagram shown in Figure 5, we developed a server application capable of storing the required information. This enabled the possibility of teaching the server teach-point from each zone.

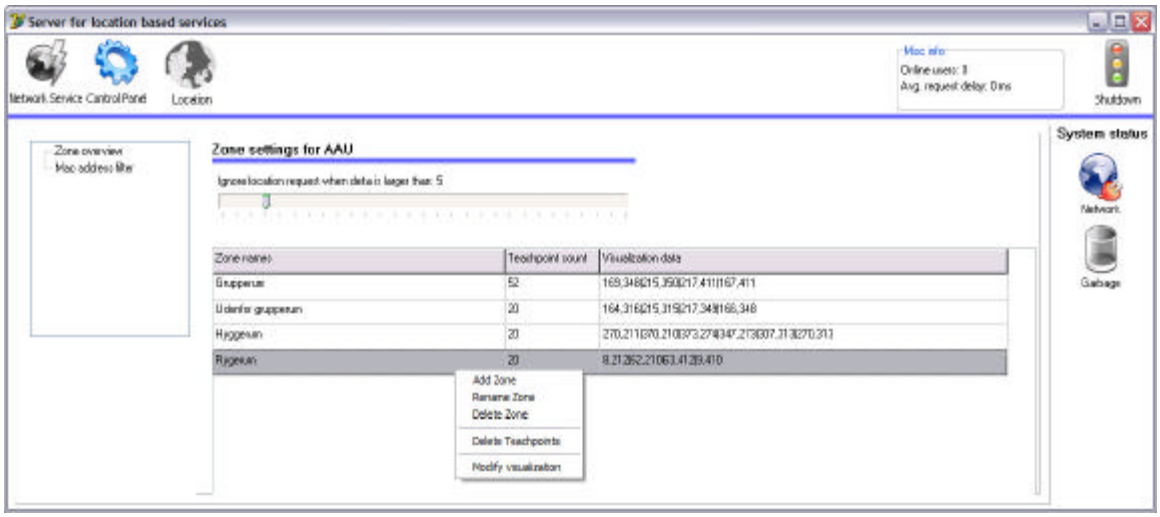


Figure 6 Server application showing zone overview

The screenshot in Figure 6 shows a screenshot of the server, with four zones created. On this screen is it possible to create, modify and remove all information related to zones. On this screen it is possible to see how many teach points each zone has. Furthermore the layouts for each zone are represented as text. The server also stores the mac-address filter, which is a list of mac-addresses representing those access points that clients shall include in their gathering of teach points.

A map of AAU's E3 section was used for illustration purposes and is shown in Figure 7. It was used to visualize the location of each zone and thereby aid determining how well the area was covered by zones.

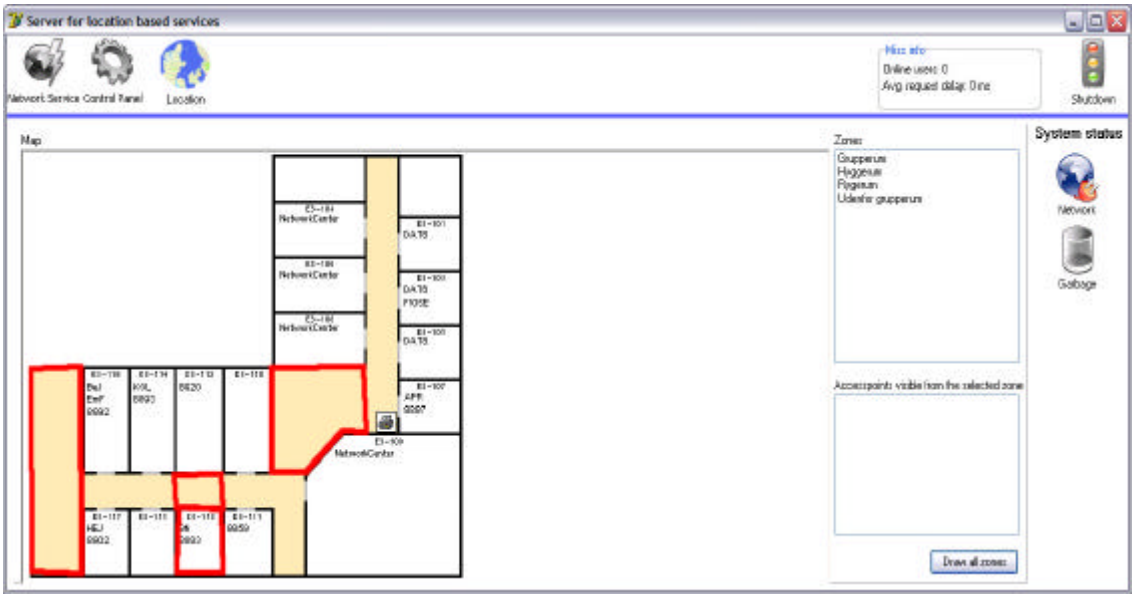


Figure 7 Server application showing the E3 building with 4 zones visualized.

Initially the goal was to draw zones in some areas only. The locations on the map not covered by a zone, should at best remain *unknown* when location requests is send from the clients, while being in these areas. If a shop decides to set up its own W-LAN, it would make positioning in this area impossible without the filter being installed, because the new will be in the sample-points sent from the client, but not in any of the teach-points.

3.3.2.2 Client application

The first task was to teach the system information about each zone. An application was developed on a PocketPC using the MS .NET compact framework. The application should be able to train the server by sending teach-points and have sufficient functionality to be able to test the localization algorithm afterwards. A user was positioned in the center of a zone and started sending teach-points to the server.

Figure 8 PocketPC Sample Point Taker showing how teach-points are being collected

The illustration in Figure 8 shows how the application is progressing in the task of sending teach-points to the server application. The user must rotate 360 degrees over a period, which is similar to the time the progress bar takes to complete its task. That would ensure that the server application gathered teach-points from all possible user orientations. The process continues until each zone has about 20 or more teach-points. The system was ready to receive location requests from the client application, but the location determining algorithm still needed to be created.

3.3.2.3 The location determination algorithm

The basic idea was to develop an algorithm, which would compare the received sample-point to the complete list of teach-points and then find the teach-point, which was most similar to the sample-point received. It was decided that neither teach-points nor sample-points should be accepted by the server, if they contained less than three access points.

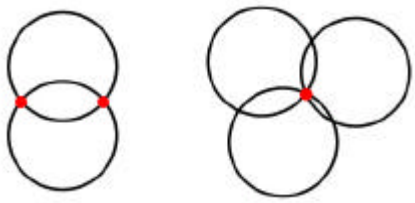


Figure 9 Possible location using two or three access points

As illustrated in Figure 9, if the system allowed teach-points of two access points, there would be the possibility of two zones containing the exact same signal strength values and it would become impossible to distinguish between them. This meant that no matter where the user was located, there must be 3 or more access points within range. This presented a challenge, since the system would have to be able to compare sample-points and teach-points, which could have a different amount of access-points, but with different mac-addresses, which indicate that it is not the same physical access point.

The next challenge was to decide how to filter those teach-points away, that is of no concern given the incoming sample point (location request). Most of the studies done in positioning via W-LAN [23] [21] have used a complex mathematical approach such as using a Bayesian network, to determine the best possible location [23]. The algorithm used in this project is based on the idea that a simple comparison is sufficient to distinguish between the zones. The algorithm is based on 6 steps of sorting and calculation in order to return the best possible location match:

Algorithm steps:

1. Remove all teach-points, which have different amount of access-points compared to the sample-point.

2. Remove all teach-points, which have different access points (different mac-addresses) compared to the sample-point.

3. For each teach-point and sample-point with identical mac-addresses subtract the signal strength values and store the absolute value[19] in a variable called *Delta*.

4. Examine which teach-point has the smallest delta value.

5. Return the zone name from the teach-point with the smallest delta plus the zone layout used for a graphical representation.

Since the algorithm starts by discarding all teach-points, which do not contain the desired amount of access points, it is vital to have a functioning mac-address filter in the system. This filter must enable the system discard access points which were not present when the system was trained, since they could influence the algorithm.
The algorithm then continues by examining if the teach-points have the same mac-addresses as the sample-point. This will enable the server to disregard all teach-points, which are located at a large distance from the region where the user is positioned.
The remaining teach-points contain the same amount of access points with identical mac-addresses. The final step is to determine, which of the remaining teach-points, is the best match.
To do this the server calculates a delta value *for each* teach-point.

Teach-point	The sample-point
Mac-address 1 signal strength -28	Mac-address 1 signal strength -30
Mac-address 2 signal strength -45	Mac-address 2 signal strength -47
Mac-address 3 signal strength -56	Mac-address 3 signal strength -54

Mac-address 1	-28 - -30 = 2
Mac-address 2	-45 - -47 = 2
Mac-address 3	-56 - -54 = -2

Abs(2) + Abs(2) + Abs(-2) = 6

The delta value is calculated by subtracting the signal strength value from the sample-point from the signal strength value from the teach-point and then applying the absolute value.

1.1.1.1 **19** The absolute value measures the distance a number is away from the origin (zero). Plus or minus is discarded

The server compares each of the teach-points. For every comparison it checks if the difference between the two delta values is smaller than the previous comparison. If this is true, it will remember the teach-point with the smallest difference. Once the list of teach-points has been narrowed down to one, it will return the zone name and the delta difference to the client application.
The *delta difference* is variable on the server application. It is possible to change this setting in order to determine how accurate a sample-point has to be in comparison to a teach-point, in order to reply the client with a zone name. This variable (delta difference) basically determines the zone size in relation to the position the user had, when training the system. To distinguish between small and large zones it can be a necessity to train the system on multiple locations within one large zone. If this delta difference value is very high (20 or more) it will become almost impossible for a user to be located between zones.
The first prototype consisting of a server and a client had been developed. The following sections explain two iterations of testing the prototype.

3.3.3 Iteration 2

The client application had the task of sending sample-points to the server, which the server should try to estimate. The PocketPC was able to collect data from the W-LAN adapter every 400ms, which was more than adequate. It was decided to create more accurate results by calculating a sample-point from the average of three sample-points, before sending the information to the server. This would cause considerable delay, but the answer/reply speed was still under 2 seconds, which is sufficient for determining which zone a user is located within.
Having taken this decision presented a new problem. Situations could arise where the amount of access points differed in the three samples taken to provide the average. This problem was overcome by examining each sample-point taken and compare it to the one(s) already stored. If it differed in the amount of access-points, the previous samples were thrown away and the new sample was stored. This can result in delays before sending new sample-points to the server, but has proven to be an adequate solution.
When testing a developer was given a PocketPC and started walking back and forth between the zones. It became apparent that the algorithm on the server functioned very well and it could at best distinguish between two rooms, if the user was standing in a doorway and held the PocketPC in a straight arm. The left arm was the zone within the group room and right arm was the zone outside the group room.

3.3.4 Iteration 3

The next iteration involved testing if the same accuracy could be achieved in a large room, with no obstacles to separate the signal strength values. This proved less accurate and an accuracy of about 4 meters was achieved. However, if the user was located between two zones it created an unacceptable amount of switching back and forth between the two zones and a new solution would have to be devised.

Figure 10 Possible zone flickering

It was chosen to make the server capable of remembering the last location of the user. This could be used to prevent flickering between zones, since it was now possible to have a zone transition phase. The idea was that each time a client sends a location request, the server would calculate the zone, but only reply if the location was equal to the last location stored from that user. If the calculated zone was not equal to the one already stored, the server would send the stored zone name to the user and update the stored value to the new zone name.

Zone name calculated		**Zone name returned**
…	…	…
Zone A	Ok	Zone A
Zone A	Ok	Zone A
Zone B	Transition	Zone A
Zone A	Transition	Zone A
Zone B	Transition	Zone A
Zone B	Zone change	Zone B
Zone A	Transition	Zone B

Zone flickering prevention

This implementation had the disadvantage that a zone transition will have a small delay, but has proven very resilient in the prevention of zone flickering. To further prevent zone flickering it has proven successful to send teach-points to the server, positioned in the middle of a zone. This gives less chance of teach-points from different zones having conflicting data values.

We developed an indoor positioning system capable of positioning a user within zones of 4 meters. The system can update the user's location every 2 seconds. In the following section we will answer the first research question[20].

3.4 Evaluation of process

The process began by conducting an article study, which helped provide an overview of the possible technologies, which could be used for indoor positioning. Each technology was considered according to a set of criteria, which was set up before the article study began. In this section we will discuss these criteria, in order to identify the *challenges* that are related to them. Finally we will answer research question 1.

3.4.1 Criteria vs. Technology

From the article study and development of an indoor positioning system, we have gained an understanding that a decision on, which technology to use, had to be made at an early state in the development. In order to choose this technology, one must thoroughly consider which criteria the development is dependant on. In our case, we elaborated a list of criteria that our development was dependant on. This set of criteria will decide, which *challenges* the development will face.
We have elaborated a table, which can be used as guidance for choosing a suitable technology to use for developing an indoor positioning system. It is important to mention that the table is elaborated on the basis of *our case*, which must cover a large area. If the area is small the table might look different.

	Hardware availability	**Price (for large coverage)**	**Accuracy**	**Visibility in the environment**	**Function with PocketPC**	**Time frame needed**
GPS Pseudolites	Very low Custom made	Very Expensive	Few centimeters	Medium	Possible	Large
Infrared	High	Cheap	Few centimeters	High	Possible	Large
Active beacons	Very low Custom made	Cheap	30 centimeters	High	Impossible	Large
Bluetooth	High	Expensive	2 meters	Medium	Possible	Average
W-LAN	Very high					
The perimeter approach		Very cheap	50-100 meters	Very low	Possible	Short
The triangulation approach		Cheap	2-3 meters	Low	Possible	Large
The learning based approach		Cheap	3-5 meters	Low	Possible	Average

Table 2 Overview of positioning technologies and degree in which they fulfils our set of criteria.

[20] See research question 1 section 2.2.1.

The information gathered in Table 2 is based on the knowledge we have gained from the article study and development of an indoor positioning system using W-LAN technology. From the table it is possible to derive two dominant criteria that the *accuracy* of the positioning system is dependant on; *price* and *timeframe.* The accuracy can be as precise as a few centimetres, if sufficiently fund and time is present. Furthermore, having this accuracy will make it more likely to calculate *speed* and the user's *orientation*. Nonetheless, since we chose W-LAN technology, we can only answer research question 1 with respect to this technology. Other *challenges* may occur when using a different technology.

3.4.2 Challenges and solutions in indoor positioning

Research question 1: What are the challenges and solutions in determining the location of the user in an indoor environment?

Working with location determination using W-LAN is a complex task. Gathering completely accurate information about a user is difficult using this technology. In the following sections we will provide an overview of some of the *challenges* as well as some of the future work, which should be addressed, in order to improve positioning systems based on W-LAN technology.

3.4.2.1 Accuracy

Accuracy is one of the *main challenges* related to indoor location determination. The accuracy of our system is about 4 meters and this makes it impossible to distinguish between different aisles within a store. The system will be able to guide the user to a *zone* inside the store, where an item is located. The user can still find it difficult to find a specific product. However, the obtained accuracy of 4 meters is sufficient for this prototype and will result in less server load, since most of the calculations presented by other researchers are not present in this application. The benefit is that the server will be able to handle more clients, since each will produce less server load.

3.4.2.2 W-LAN cards

There are some *challenges* related to the hardware we used. The main problem arises in each different brand of W-LAN card. During most of the project only one brand W-LAN card was available, but at a later stage it was a necessity to have two, in order to speed up the development. It became apparent that two different brands of W-LAN card have different signal strength reception values, while being on the exact same location. This difference could be as much as 30DB, which makes it impossible to determine the location of the user who is

equipped with a W-LAN card, the system has not been trained with. However the server could be modified to allow teaching with different brands of W-LAN card. This would require a much larger training phase for the system, but it would correct the problem.
This problem could also be eliminated in the future by creating standards for W-LAN signal strength reception values, which would make all brands of W-LAN cards provide the same signal strength values [25].

3.4.2.3 Access points

Another *challenge* we faced during the development were the access points used. Access points are far from optimal to use for indoor positioning systems. Two identical access points can vary in signal strength. This means that all teach-points would have to be deleted, if an access point is replaced. It is not a simple matter of changing the mac-addresses to the same value as the old access point as one would expect. The result is that many zones would have to be retrained. This could also be overcome by making sure the system only uses access points of a high quality, where the signal strength is virtually the same on all devices. This would delimit the need of retraining the system, since the new access point installed, will have the same signal strength as the old access point.
Another disadvantage the access points have, and the technology used in general, is that the human body can influence the signal[21]. The amount of people within a mall can cause large deviations over time and this could influence the accuracy. A simple way to ensure this aspect has the least possible impact, is to position the access points as high as possible. This would make the signal travel more vertically, compared to having the access points positioned at ground level, which would make the signal travel horizontally and through more obstacles.
Another solution could be to train the system multiple times; with *small*, *average* and *large* population inside the mall. The positioning system could use specific trained lists, according to the amount of shoppers currently present in the mall.

3.4.2.4 User orientation

Having based the system on W-LAN technology, has limited the possibility of determining the user orientation. It is possible to determine the user orientation when *moving* from zone to zone. But when the user remains within a zone there is no way of telling, which direction he is facing. This delimits the possibility of determining, which products the user is looking at. If the PocketPC was equipped with a digital compass, this addition would be easy to incorporate into the system.

[21] Test 2 in this chapter elaborates this issue

3.4.2.5 Speed

Determining the user's *speed*, is a challenging task using W-LAN, due to the accuracy that can be obtained using this technology. It would be possible to derive the speed when the user is moving from zone to zone, but the result will be highly inaccurate. If the user is running it becomes even harder to determine, because the signal strength values obtained from the access points will differ considerably.

3.4.2.6 Approach

The approach taken has revealed that it is not necessary to create complex mathematic models, in order to develop an indoor positioning system using W-LAN technology. Using a mathematical triangulation approach is likely to increase the location determination accuracy, but the accuracy achieved in this project is still comparable to most of the positioning system that have already been developed [21] [22] [24].

Many of the limitations mentioned in this chapter are likely to be overcome in the future. The indoor positioning system developed in this project offers accuracy, which is sufficient to investigate how the target group will embrace this type of context-aware information system and the system could be modified to handle many of the obstacles encountered, but this is beyond the scope of the project. There are many cases to explore where our system is likely to function with today's equipment, for example airports, office environments, public commercial areas and tourist attractions.

4 Evaluation of methods

In the following sections each of the three methods are discussed separately, based on the developers experience and the diaries[22] made during the development process. The focus is on problems where the method did not offer any help during the process. We will use the problems identified for evaluating if the methods can be used for requirements elicitation for a context-aware digital shopping assistant. Feedback from the users regarding the prototypes is also included in each section. Following the evaluations of the three methods, we will discuss the findings in order to determine, whether the problems encountered is related to context-awareness.

The demands for the prototypes were that each one should demonstrate the most important requirements for the system in terms of functionality and design. Furthermore the prototypes should not exceed the capabilities of the developed positioning system, meaning that the designs should not rely on a better accuracy than the positioning system provides. The purpose of the evaluations of the prototypes was to get comments from the users regarding the included functionality in each prototype. Furthermore the users were asked about the navigation, text and colour. The users were presented with all the prototypes but in different order. Table 3 is a matrix that shows in which order the prototypes were evaluated.

Users	First prototype	Second prototype	Third prototype
M.U.S.T users	XP prototype	M.U.S.T. prototype	CD prototype
C.D. users	M.U.S.T. prototype	CD prototype	XP prototype
XP user	CD prototype	XP prototype	M.U.S.T. prototype

Table 3 Evaluation order

[22] See diary structure, Appendix E.

The evaluations were done home at the participants, not in the context, because of the focus on functionality and not usability. We wanted to know how useable the prototypes would be in a shopping situation, given the included functionality.

4.1 The M.U.S.T. method

This section highlights the findings from the use of the M.U.S.T. method and describes how the prototype is implemented. The section will also include discussions on the usage of the method.
In Appendix A a complete description of the development done using the M.U.S.T. method can be found along with a very general overview of the method and the diaries written during the development.

4.1.1 The method

The M.U.S.T. method is developed by Keld Bødker, Finn Kensing and Jesper Simonsen and is described in the book "Professionel IT-forundersøgelse" [Bødker et al. 2000]. The M.U.S.T. method is very focused on how the new IT-system will alter the organization and how it can be made to fulfil the different strategies in the company. Since the focus is on organization and strategies in this, only a small part of the method is relevant for the purpose of identifying the user requirements for a digital shopping assistant.
The M.U.S.T. method is divided into four phases, which each has a different focus. The phases are:

- The preparation phase
- The focus phase
- The absorption phase
- The innovation phase

The only phase of the preliminary study that focuses on finding the above mentioned requirements is the innovation phase. A description of the innovation phase can be found In Appendix A.1.4. The innovation phase includes the following activities, which can be used:

- Plan the innovation phase
- Market survey
- Develop and collect ideas
- Mock-ups and prototypes
- Mapping of qualification needs
- Analysis of consequences
- Strategy and plan for the realization
- Report

The activities “develop and collect ideas” and “mock-ups and prototypes” are the two activities that focus on the task of getting the user needs and developing visions for the complete change at hand [Bødker et al 2000, p. 183]. Therefore these are selected as the activities to use. The purpose of activity “develop and collect ideas” is to collect all the ideas to new functionality that the future users might have and further develop these ideas. In the activity “Mock-ups and prototypes”, the purpose is to illustrate some of the functionalities discussed in “develop and collect ideas” for the future users and thereby get some feedback on the design.

The method suggests using one of the following techniques in the activities:

- **Interview / In-situ interview** An interview with the future user of the system about what functionality it should include. In-situ means that the interview takes place during the actual work process, meaning in the actual context where the work process takes place.
- **Workshop** A workshop gathers the project group and if necessary some future users in order to discuss what functionality the system should include.
- **Future workshop** The future workshop is a technique used when a large number of people should contribute with ideas. The result is a common suggestion for a change to a situation.
- **Experiments with prototypes** This technique tries to develop ideas for an IT-system to a prototype and test these in order to find a good design.

4.1.2 Using the method

From the understanding of these activities the IT-designer[23] felt that the future workshop activity would be the most beneficiary. The future workshop was chosen for its ability to get around all of the aspects, which the M.U.S.T. method suggests. It was designed to cover both the absorption phase and the innovation phase of the preliminary study.

> *“The activity suggests the use of a workshop to get the information and this sound like a good approach. In a workshop it would also be possible to integrate some of the intentions of the prior phases of the preliminary study.”*
>
> [Appendix A.3 Diary, 15/3- 10/4]

This is not a part of the M.U.S.T. method, but is necessary since the activity “develop and collect ideas” is taken out of the context, in which it is supposed to be used it was necessary. If the activity were done as a part of a complete preliminary study the participants of the workshop would have a better idea of the system that they should discuss, than they do when

[23] IT-designer is the name of the person who performs the preliminary study.

the activity is done alone. This is primarily because of the activities done prior to the activity "develop and collect ideas" and because the participants have been involved in the describing the goal for the complete preliminary study.

4.1.3 Participants

Five participants were selected for the workshop. They all knew each other prior to the workshop, which was deliberately chosen.

> "*This is done in order to reduce the time the participants might need to become comfortably with each other and the situation. This is also a part of the M.U.S.T method (establish the project group socially).*"
>
> [Appendix A.3 Diary, 11/4]

A questionnaire and a short presentation were prepared. Neither the questionnaire nor the presentation is a part of the M.U.S.T. method. The questionnaire was made in order to get some demographic data about the participants, which will be presented below and the presentation was created to help the participants better understand the purpose of the workshop.

The demographics about the participants are briefly described in Table 4. Further information about each participant can be found in Appendix A[24].

Participant	Age	Sex	Shopping	Grocery shopping
A	24	Male	3-4 times a week	2-3 times a week
B	22	Female	2-3 times a week	2-3 times a week
C	62	Male	1-2 times a week	Once a week
D	54	Female	Every 2nd week	3-4 times a week
E	28	Female	Once a week	3-4 times a week

Table 4 Overview of the participants

4.1.4 Workshop

An overview of the course of the workshop can be found in Table 5. The overview also contains the estimated time usage of each part. All the participants took part in the workshop at the same time. The workshop was divided into three. Each part had a slightly different focus. This was chosen in order to partly replicate some of prior activities from a complete preliminary study. The first part of the workshop is held in order to get a basic understanding

[24] See demographics, Appendix A section A.2.2

of shopping today, which then led to ideas for functionalities for a shopping assistant. These ideas were further developed though discussions in part two. In the last part the participants then had to be very specific about what they wanted in a prototype.

Part	Topic	Time estimated
Part One	Introduction to the workshop. Discussion about shopping today.	1 hour
Break		10 minutes
Part Two	Problems with shopping today and ideas on how a PocketPC application (shopping assistant) could benefit the user.	1 hour
Break		10 minutes
Part Three	Identify design criteria for a prototype. Discuss preliminary design ideas.	1 hour

Table 5 Overview of the workshop

4.1.4.1 Part 1

The first part of the workshop focussed on how shopping was done today. In the beginning some complications were experienced. The participants were not very engaged in the activity and the IT-designer had to lead the discussion and bring up the topics. More than once the participants had to be addressed individually to get them to talk.

> "*It was harder to get started than anticipated, even though the participants selected for the workshop all knew each other before the workshop. The participants were somewhat withholding at first and the IT-designer had to direct the discussion.* "
>
> [Appendix A.3 Diary, 25/4]

This was not something the method prepared the IT-designer for or had any techniques to help with. This might be a general issue with the technique "workshop". Especially when the participants are not entirely sure on what is expected of them. The M.U.S.T. method only provides some suggestions on how to structure the workshop and on how the course of the workshop could be documented.

> "*…none of these (techniques) seemed very profitable during the workshop, so the IT-designer quickly decided to abandon these and just document the discussion in a summary.*"
>
> [Appendix A.3 Diary, 25/4]

The method had some suggestions on which techniques to use for the documentation of the workshop, but none of these seemed to be able to describe the participants' ideas. Therefore it was decided to elaborate a summery as means of documentation. In that way the method is

very flexible and it did not create any problems using a summery for documenting the workshop.
The problems with the participants not being very engaged also quickly disappeared when the discussions got started. The results of the first part were a broad understanding on how shopping were done today and the fact that shopping could be divided into two; grocery shopping and regular shopping. The differences between the two kinds of shopping were also discussed[25].

4.1.4.2 Part 2

In the second part of the workshop the focus was changed to how the shopping experience discussed in the first part could be improved and what the requirements for a shopping assistant could be. This part is the actual innovation phase, where ideas to a shopping assistant were discussed.

> "*The first part of the workshop, which focused on shopping today, gave a good foundation for discussions on how to improve the experience and what a Shopping Assistant should be able to do.*"
>
> [Appendix A.3 Diary, 25/4]

The result of the second part of the workshop was a list of functions that the participants in the workshop would like a shopping assistant to include. The list of functions is shown below and is not in any particular order.

- Shopping list
- Individual advertisements based on profiles
- Guidance to the offers
- Offers should either come as the shopping area was entered or when outside the store
- Waiting time at the queues
- Price comparison
- Product information
- Calling for assistance
- Virtual number system
- Very important that the customer gets an advantage

All the items on this list are described further in Appendix A[26]. It is worth noticing that many of the proposed ideas related to the idea of an advertisement.

> "*It seemed like the participants saw this as the primary function in the application. Many of the other ideas were founded on a basis of advertisement.*"
>
> [Appendix A.3 Diary, Date: 25/4]

[25] See Part One, Appendix A, section A.2.4.1.
[26] See Part Two, Appendix A, section A.2.4.2.

During the discussion on what the requirements for a shopping assistant should be it is noticeable that most of the ideas are about giving the shopper access to more information and not so much on how existing work habits can be transferred to the application. This is probably because of the "loose" nature of the workshop, where suggested ideas are not discussed in a structured way. In stead it ends up with a large number of ideas.

Another very interesting thing about the list, worth mentioning here, is the last item. Here the participants express their position on what could convince them to use such a system. They express that if they will get some benefits that might not be available elsewhere, they would very likely use the systems. These benefits could be offers, that only applies to customers using the system but it could also be benefits that are not of an economic character, like time saving functionalities. This is probably a result of the participants understanding of shopping and might have been different if there had been used other participants.

4.1.4.3 Part 3

Following this list the participants also generated a prioritized list of functions they would like to see in a prototype. This list consists of four items and is seen below. Further details can be found in Appendix A[27].

Requirement	Description
Personalized advertisements with a possible filter	It would be OK to receive advertisements on the PDA as long as they were based on the individual profile of each shopper. This means that the shoppers only want advertisements for something they have an interest in. The advertisements could for instance be daily offers that are not shown elsewhere. It is important that the application include a filter so it can be turned off.
Way-finder to specific offers	When the PDA showed an advertisement or a special offer it should include some visualization of where the offer could be found. This could be with some textual description or visualization of the route from the current position of the user to the shop that has the offer. This could also include distance and walking time. It would not be necessary to include this information as standard, but it should be possible to get very easily.
Product information	There should be a way of getting product specification on the PDA, for instance specifications for the TV. It is not always possible to get all the facts from the single article or the description next to it. The product information could either be shown after selecting the item from a list or by entering some product code. The PDA could also include a barcode scanner of an RFID reader. It should also be possible to store the product description on a sort of quick access list, so that it would be easy to compare different brands of products.

[27] See Part Three, Appendix A, section A.2.4.3.

Price comparison	One feature that really was appreciated by all at the workshop was to have some sort of price comparison function. That way when the advertisements are shown the shopper could quickly asses whether the offer really are cheap or not. This could be very much like the price comparison databases on the internet.

Table 6 Requirements for the digital shopping assistant

An interesting element in the prioritized list that should be emphasized is that it does not include any items relating specific to grocery shopping. This was unexpected since the IT-designer believed that a shopping list would be essential in this sort application. Whether this is a fault in the method or just a coincidence of the selected users and their understanding of the context for the application are unknown. It might be because the method does not follow up on the proposed ideas. It is left for the IT-designer and the participants to remember and decide which ideas should be in focus. This sets some demands for the participants since they might have to make a strong argument for a specific idea to be considered.

> "*It is worth noticing that in the prioritizing process the participants primarily focused on regular shopping. This means that ideas that support the activity 'grocery shopping' will not be included in the prototype design. It was expected that ideas such as the shopping list would play a prominent part in the application.*"
>
> [Appendix A.3 Diary, 25/4]

The primary context related element is the personalized advertisement and the Way-finder. This might indicate that the participants in the workshop did not fully grasp the possibilities of a context-aware system. They thought of context primarily as location and therefore the system could primarily help them in finding things. This was not realized by the IT-designer at the time and therefore not something that was addressed.

In part three of the workshop the participants also made a very general list of GUI criteria, which the prototype should contain. This was the closest the workshop came to making actual designs. These criteria can be seen below:

- **Interaction of the PDA must not be to small** (All items must have a certain size)
- **One hand interaction of the PDA** (Buttons should be sufficiently large for thumb use)
- **Perhaps no need for interaction when shopping** (As little interacting during the actual shopping as possible)

It is these general GUI criteria along with the prioritized list of functions that the prototypes have been developed from.

4.1.5 Design

The M.U.S.T. method only offers help with the design of the prototype in the innovation phase, more specific in the activity “experiment with prototypes”. This activity tries to create some basic designs and experiment with these, by creating and evaluating a mock-up. The results are then used in a new mock-up, until the right design is found. The main design philosophy has been to achieve one-hand operation on the main tasks. This is done by having big buttons and minimal interaction, as requested by the participants of the workshop.

Figure 11 shows the final mock-ups created and their relations in a navigation diagram. The main screen is the first screen the user will see. From this he can go to the Map screen, the Product Information screen or the Price Comparison screen. The Advertisement is a bit special, since it is not a screen one can navigate to. It appears when a shopper enters an area, which the advertisement is linked to.

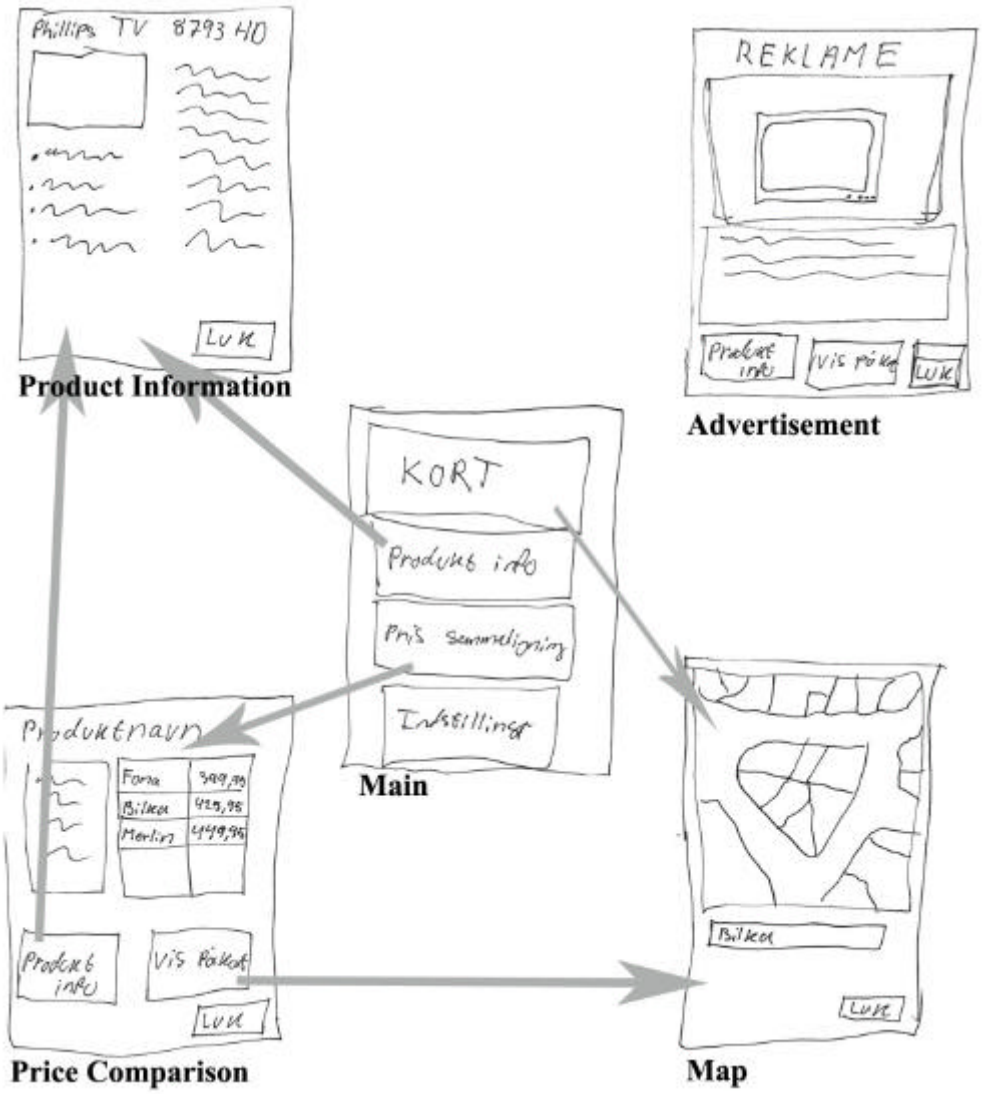


Figure 11 Navigation diagram for the mock-ups

4.1.6 Implementation & evaluation

The actual screens from the implemented prototype are shown in Appendix A, section A.2.6. The main difference between the mock-ups and the implemented prototype is the *Product Selection* screen.

Some small compromises were made between the mock-ups and the actual implementation. These primarily consisted of problems in fitting the elements on the screen and still having large enough buttons to keep the one-hand operation with for instance a thumb. Another minor problem was getting the standard components in Visual Studio .NET 2003 to look and behave as intended in the mock-ups. This is primarily a cosmetic problem and does not change the basic idea behind.

After the development each prototype were evaluated by all the users in the three tests. In Appendix D the results from the evaluations are presented in three tables. In the following the most important statements will be presented along with the screen they concern.

Figure 12 Product Selection

Product selection: The *Product Selection* screen was necessary in order to select the actual product in both *Price Comparison* and *Product Information*. As this screen does not actually reflect a user need there is no mock-up of this. The screen suffers in the way that the navigation on this screen is somewhat difficult because the standard elements used could not be resized. Furthermore some of the selections should be made based on available context-information.

User comments: Some users commented that they would rather have a search option instead of the chosen approach. The users did not understand this screen at first. This might relate to the fact that only the first item in each box actually worked.

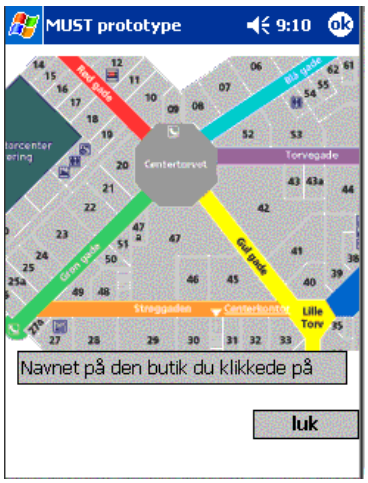


Figure 13 The Map page

Map: On the map screen it is possible to see an overview of the mall. By clicking on a store the name is shown below the map. It is possible to drag the map, in order to see other parts.

User comments: The *Map* screen was a bit more problematic. Generally the users needed some sort of indication of their current location on the map. They would also like to see things like exits, toilets, information stands, etc. on the map. This would preferably be with icons. The size of text used on the map should also be larger. Most users had trouble reading the information.
A zoom function was also preferred. This might help with the trouble of reading information on the map.

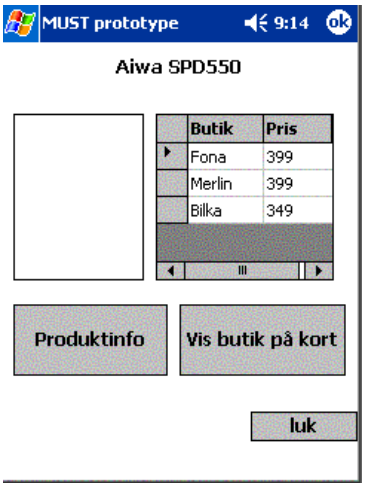


Figure 14 Price Comparison

Price comparison: On the Price comparison screen it is possible to compare different shops prices on a specific product. Furthermore it is possible to get more information about each shop by clicking on shop name.
The "Produktinfo" button should lead to the Product Information screen and show more about the actual product. The "Vis butik på kort" button should show the selected store on the map. Neither of these two buttons have any functionality in the prototype.

User comments: The users all thought the *Price Comparison* was a good function and was only mentioned with positive statements.

Figure 15 Product Information

Product Information: The Product Information screen should show information about a specific product. The information should include a picture.

User comments: Several users thought the *Product Information* screen did not show enough information and consequently could not understand the purpose of the screen. Information about quality or qualitative information should be available on this screen.

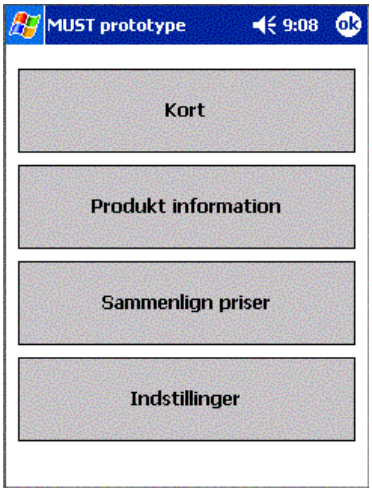


Figure 16 The Main screen

Main: The Main screen is the first screen the user sees in the prototype. It does not present any information, just buttons leading to information.

User comments: The users generally found the navigation easy and clear. Some commented that it might even be more easy and understandable if the buttons contained icons.
But both the use of fonts and their sizes were satisfactory.

Many users asked for the shopping list. This is an essential part of a shopping assistant and should be included. Even the users, who had prioritized the functions for this prototype, demanded it. They expressed that they had taken this form for functionality for granted, and therefore did not put it on the prioritized list. This indicates that there might be a problem, with the method at this point. The method does not, as mentioned earlier, ensure that all important ideas is discussed and used. Also the method has no techniques for checking whether the participants have a common understanding of an idea. The fact that the participants had taken an idea as the shopping list for granted, and therefore did not mention it makes the IT-designer wonder if there are other aspects, which did not get mentioned either.

4.2 The Contextual Design method

This section will describe and discuss highlights from the development process and usage of the Contextual Design method. In Appendix B a complete description of the development using the method can be found along with a very general description of the method. Appendix B will also contain a development diary and some empirical data, which was used during the development.

The Contextual Design method is elaborated by Hugh Beyer and Karen Holtzblatt and is described in the book "Contextual Design – Defining Customer-Centered Systems" [Beyer&Holtzblatt 1998].
The Contextual Design is an approach to defining software and hardware systems that collects multiple customer-centered techniques into an integrated design[28] process [Beyer&Hottzblatt 1998: p. 3]. The method focussed on grounding development decisions on user data. Contextual Design makes data gathered from customers the base criteria for deciding both requirements and design decisions. This is done by making the core design problem focus on how customers will work in the future [Beyer&Holtzblatt 1998: p. 3]. The main thesis in the method is:

> *"Whether software only, or software and hardware combined, the system creates an environment for its users to work in; it's up to the team to ensure that the environment fits the flow of their work."*
>
> [Beyer&Holtzblatt 1998: p. 4]

When developing a system, you are not just developing the system, you are developing a new way of working. The following techniques are encompassed by the method[29]:

- Contextual Inquiries – *Interviews taking place in the context.*

[28] Contextual Design defines the term *design* as: conceiving and planning a system.
[29] For a further description of the method see Appendix B.1.

- Work Models – *Flow, Sequence, Artifact, Physical and Cultural models.*
- Consolidation – *Consolidation of work models reveals common structures.*
- Work Redesign – *Technology required, Storyboards used for visioning a new system.*
- User Environment Design – *Reveals related functions in different parts of the system.*
- Paper Prototyping – *Used for testing and iterating with prototypes.*

The following techniques were used from the Contextual Design method:

- Contextual Inquiry
- Work Models – Cultural model excluded
- Work redesign

Instead of using the technique called paper prototyping, a running prototype on a PocketPC was implemented.

4.2.1 Preparation for Contextual Inquiries

Contextual Inquiries were chosen for their ability to provide the developer with detailed insight into the work practice of shopping in malls. It was decided to do 2 Contextual Inquiries with 4 participants:

Participant	Age	Sex	Shopping	Shopping in malls
A	29	Female	2 times a week	Twice a month
B	34	Male	2 times a week	Twice a month
C	54	Female	3-5 times a week	Once a month
D	59	Male	3-5 times a week	Once a month

Table 7 Demographic information about the selected participants.[30]

> *"…the entire customer base is not represented in the participants gathered for the contextual Inquiry's. For example teenagers, singles and senior citizens are not represented in the group of participants chosen for the Inquiries."*
>
> [Appendix B.4 Diary, 29/03]

According to the method the focus of the development was considered narrow, because only the role of a shopper was important to the focus. Nonetheless 6-10 interviews should be conducted with each participant. This is problematic, since it is time consuming to do a

[30] For further demographic details see Appendix B, section B.2.1

contextual inquiry and each contextual inquiry yields an enormous amount of data, which has to be analyzed through work models. Consequently it was chosen to do 2 inquiries using 2 participants in each.
It was deliberately chosen to use couples in the inquiries, since it was expected that coordination is an essential part of shopping during the preparation- and shopping phase. Using two participants in each inquiry allowed the test-leader to observe how the participants organize and coordinate themselves when shopping. Normally a standard contextual inquiry involves the test-leader and *one* participant. According to the method it is enough to reveal the work practice of individuals in an organization [Beyer&Holtzblatt 1998: p. 74-78]. However, it was expected that shopping habits would differ whether shopping alone or shopping together, therefore it was chosen to use couples in the inquiries. Identifying how solo-shopping was done required some interviews. The method offered no help on deciding *when* to conduct the contextual inquiries.

> *"It was deliberately arranged at a particular weekday early in the morning, to limit the amount of other shoppers present in the mall, which could be disturbing for the ongoing inquiry."*
>
> [Appendix B.4 Diary, 29/3]

The advantage was that the amount of shoppers was limited, which was expected to improve the quality of the observation. It would be less disturbing for the ongoing inquiry and it would make it easier to focus the attention on the participants. Moreover the level of background noise would be lower, which was expected to improve the quality of the recorded data. The disadvantage was that the participants usually shops during the weekends. Setting the inquiry on a less crowded weekday would set up an unnatural environment. This indicates that the developer must thoroughly consider what is important to the focus, because the context of the inquiries can limit or disrupt the observation phase, which is supposed to reveal details about unarticulated needs.

Contextual Design uses a focus statement, which should help keep contextual inquiries on track. A Focus Statement[31] was elaborated prior to the contextual inquiries.

> *"According to the descriptions in the book, there is no adequate example of how focus statements should look."*
>
> [Appendix B.4 Diary, 1/4]

Comparing the focus statements with semi-structured interviews helped understand what focus statements should accomplish. This required some experience in conducting preparations for semi-structured interviews. An acceptable amount of important subjects was obtained by brainstorming about shopping in general. This was done without *any* help from the method. These subjects were divided into two areas of shopping; *preparation phase* and

[31] See Focus statement, Appendix B.3.1.

shopping phase. In each phase the participants were supposed to reveal how the work practice was conducted, when being alone or as couples.

4.2.2 Contextual Inquiries

Two contextual inquiries were performed as illustrated below. The inquiries were conducted in a shopping mall in Vejle.

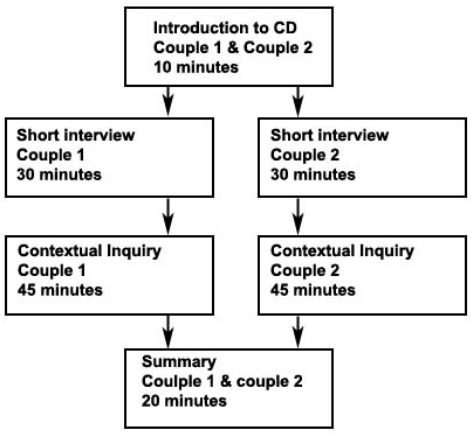


Figure 17 The course of the Contextual Inquiries

Details of the *preparation phase* were revealed by conducting an initial short semi-structured interview with each couple, using the focus statement as reference. Normally this is *not* part of Contextual Design, but it would be too time consuming to do contextual inquiries in this phase. The test-leader was well aware, that subjects in the focus statement could set the agenda for the day and affect the focus of the inquiries. This could limit the amount of unarticulated needs that the participants had, especially during the interviews.

> *"The relationship model worked surprisingly well. After a very short period of time, the participants began to articulate details about their shopping."*
>
> [Appendix B.4 Diary, 2/4]

The relationship model presented by the method ensured that this was not a problem[32].

When the initial short interviews were completed the actual inquiries began. They focused primarily on the *shopping phase*. The test-leader observed each couple in turn doing their shopping as they would normally do. During the observation, notes were taken by hand and statements given by the participants were recorded on a dictaphone. According to the method the developer should audiotape these interviews, but videotape is rarely worth the extra trouble [Beyer&Holtzblatt 1998: p. 74]. The method suggests that the developer should record each inquiry on tape, take notes, ask questions, spot sequences and collect important artifacts

[32] See method description Appendix B.1.

concurrently[33]. All these activities collect data that should be used for elaborating work models afterwards.

> *"…it is difficult to do good recording, when the interviewed person is constantly moving around in a noisy environment."*
>
> [Appendix B.4 Diary, 2/4]

It was problematic to perform all these activities concurrently. The participants were constantly moving around inside the grocery store. Furthermore the level of background noise was loud, even though the inquiries were conducted at a time of day, where a limited amount of shoppers were present. Better recording equipment[34] could almost certainly improve the recording quality and support the observation phase better. The test-leader would have preferred to have an assistant that was in charge of recording the events as they unfolded. This would possible have allowed the test-leader to focus on the activities directly related to the participants, rather than having to deal with recording devices. Nonetheless there is an indication, that the method has some limitations when it comes to performing *mobile* contextual inquiries.

Although it was *difficult* to conduct the inquiries in a context where the participants move around, the outcome of the inquiries was very good. The most important aspects of the contextual inquiries which differentiate this technique from a traditional interview, is summarized in the following quote:

> *"Many details about shopping were revealed by observing the participants doing their shopping. Some of those details were not articulated during the initial short interview. It also revealed statements given by the participants during the initial interview, which was not entirely correct according to the way they were shopping."*
>
> [Appendix B.4 Diary, 2/4]

If developers have to rely on data from interviews or other approaches, where they do not observe the actual work taking place, it can have an impact on the designs subsequently produced. Therefore contextual inquiry is considered a good approach for identifying unarticulated needs as well as verifying particular statements through observation.

> *"A quick enumeration showed that 7 out of 10 people (Counted from 20 shoppers passing by) carried a shopping list in their hand. This supports the idea that an electronic shopping list could be feasible."*
>
> [Appendix B.4 Diary, 2/4]

When observing the participants doing shopping in the context, one could not help but notice other aspects of the context as well. Although the enumeration was not statistically valid, it indicates that being in the context and *seeing the work*, can be an advantage compared to standard interviews or workshops. The disadvantage is that if the initial interviews had not

[33] See method description Appendix B.1.

[34] ClipOn microphones attached to the participants would likely improve the quality.

taken place, details about the preparation phase, solo-shopping and common shopping habits would not have been revealed. This indicates that contextual inquiries have a narrow focus. However it investigates the focus of the work practice very detailed. It is very beneficial in uncovering problems that exists in the context, which should be solved/better supported by a new system.

At the end of the contextual inquiries an interview was held with all the participants. The participants were presented with possible design ideas for a shopping assistant[35].

> *"When the participants were presented with design ideas for a digital shopping assistant, they highly prioritized those features, which were directly related to the problems they encountered during the inquiries."*
>
> [Appendix B.4 Diary, 2/4]

There was a close relation between how design ideas were prioritized by the participants and the problems that was encountered during the inquiries. This indicates that contextual inquiries are very problem oriented, because other design ideas could have come up or have been prioritized differently, if other problems had occurred during the inquiries. The inquiries have a narrow focus and are problem oriented, however they investigates specific aspects of the context *in detail*, the environment and the people of the system being developed. This is probably why many contextual inquiries are required to sufficiently provide knowledge about the whole customer base.

4.2.3 Summary of contextual inquiries

According to the method, the recorded data should be sufficient to supply the elaboration of the work models.

> *"Unfortunately the recorded data was of such bad quality, due to the noisy environment in which it was recorded, that it was discarded."*
>
> [Appendix B.4 Diary, 13/4]

Instead it was chosen to summarize the data collected in the Contextual Inquiry according to the focus statement previously mentioned in a separate document[36]. This is normally not a part of the contextual design method, but it is found necessary in order to avoid missing important details due to inadequate quality in the recorded data.

> *"When writing down the summary of the inquiries it became apparent how detailed the information about the practice of shopping was."*
>
> [Appendix B.4 Diary, 13/4]

[35] See Focus statement Appendix B.3.1.

[36] See Summary of Contextual Inquiries Appendix B.3.2.

The information gathered in the inquiries was so detailed, that it was hard to determine what the most important aspects were, because no prior experience with elaboration of work models was present. Therefore many details were written down, in order to avoid losing detail, which could be important for the design. Consequently the summary got extensive.

4.2.4 Flow models

Two flow models[37] were elaborated. It was decided to elaborate a flow model for both the preparation- and shopping phase, because the participants stated that they sometimes had problems coordinating in both phases.

> *"It was unproblematic to identify the elements that should be present in the flow models, because fortunately the summary of the contextual inquires was very detailed in its description."*
>
> [Appendix B.4 Diary, 29/4]

If the summary of the contextual inquiries had been imprecise, it would have been difficult to elaborate these models, since it required very detailed information. The summary particularly contained information on the individuals and their responsibilities, the communication between them, artifacts used in the work and breakdowns[38] in communication.

> *"The models lacked a way to model that any given set of responsibilities can be distributed among several individuals."*
>
> [Appendix B.4 Diary, 29/4]

The flow models showed that responsibilities are distributed differently depending on the number of individuals participating in both the preparation- and shopping phase. This distribution could not be contained in one model. However, it was chosen to model the case where two individuals are involved in the process.

[37] See flow models Appendix B.2.3.1.

[38] *Breakdowns* are defined as problems in achieving a certain intent, represented as a lightning bolt in all work models.

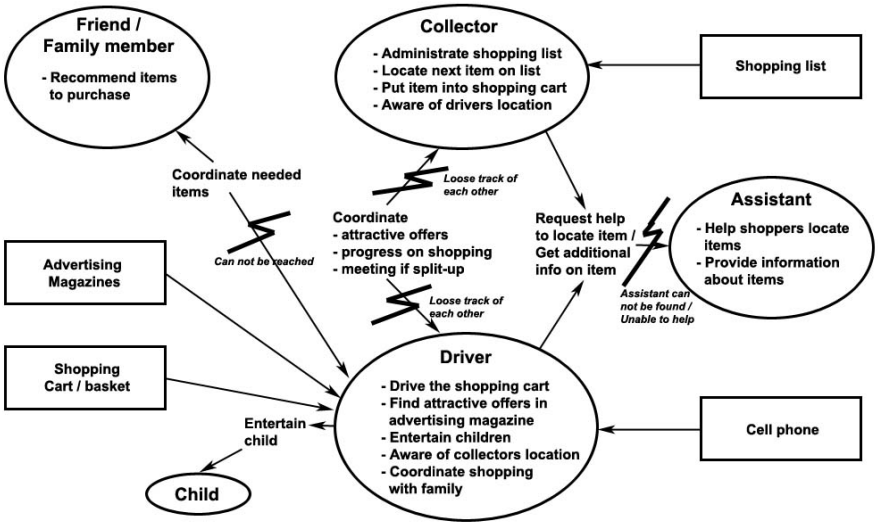


Figure 18 Flow model of the shopping phase.

From this model, it was possible to combine the roles of the *collector* and *driver* into a set of responsibilities that the solo-shopper is responsible for carrying out[39].

> *"The models lacked some way of illustrating how artifacts occasionally are passed around between the individuals in the model."*
>
> [Appendix B.4 Diary, 29/4]

The most important artifact was the shopping list. This artifact was closely related to how the responsibilities were distributed among the participants. But the flow models were unable to model, that the shopping list is not always used by the one creating it.

The flow models were very applicable in determining *who* was involved with shopping and *how* coordination was done between them. Furthermore the flow models revealed *when* and *how* coordination issues would appear.

4.2.5 Sequence models

Sequence models[40] were among the most applicable work models in the development of the digital shopping assistant. Sequence models revealed the detailed steps, which are required in the preparation- and shopping phase. According to the method the sequences were supposed to be collected during the inquiries, but due to the high degree of mobility it was very difficult. Instead the summary of the contextual inquiries was used. During the elaboration of the sequence models it became apparent that there were different triggers when doing the actual shopping; *specific item needed* and *provisions needed.* Therefore according to the method, it was necessary to elaborate two sequence models for the *shopping phase.*

[39] See roles in flow models, Appendix B.2.3.1

[40] See sequence model Appendix B.2.3.2.

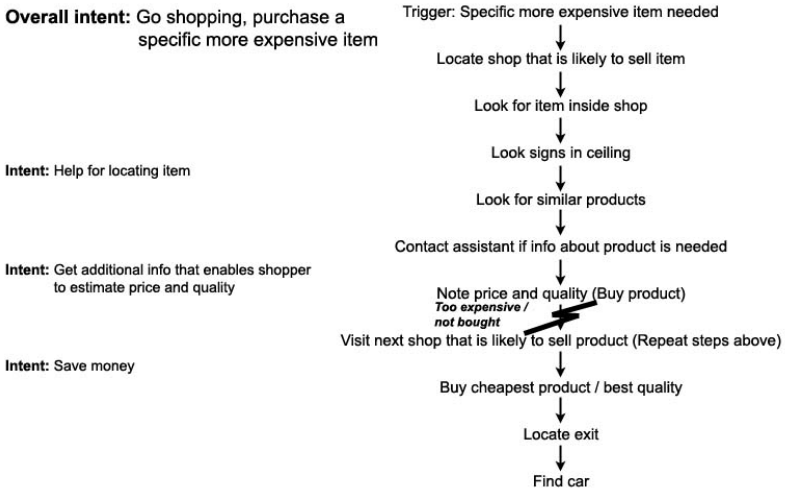


Figure 19 Sequence model of the shopping phase. The trigger to this sequence is the need for a specific item.

Writing the secondary intents on the left side of the model provided a way of understanding *why* the participants were taking each step.

> *"… one condition for the success of a new system, is that the system must support the secondary intents […] they define what people are trying to achieve. Therefore, sequence models can function as a checklist of supported features in a new technology."*
>
> [Appendix B.4 Diary, 1/5]

The secondary intents should be supported by the digital shopping assistant. In order to improve the work practice of shopping it was necessary to eliminate as many steps as possible from the sequence models [Beyer&Hotlzblatt 1998: p. 259].

> "*The sequence model has no way of showing if a subset of steps is looped several times. This was depicted by inserting a step that said 'Repeat doing …. Until …'. "*
>
> [Appendix B.4 Diary, 1/5]

However it would be more expressive to the model, if one draws an arrow from the end of a looping sequence to the beginning of the sequence, and adding a condition, which describes the loop.

4.2.6 Artifact models

The most important artifact used, throughout the preparation- and shopping phase, was the shopping list. Two shopping lists were gathered from the participants at the end of the contextual inquiries, and these were used in the elaboration of 2 artifact models[41].

[41] See artifact models Appendix B.2.3.3.

> *"…it was a clear advantage that the actual shopping lists were brought for closer examination, since they revealed the need for informal annotations. They also revealed that it should be possible to mark items purchased on the list."*
>
> [Appendix B.4 Diary, 10/5]

The artifact models revealed that *informal annotations* were written on the shopping list. They also revealed that items on the list were arranged according to commodity groups. Furthermore the informal annotations written on the right side of one of the shopping lists indicated a need for separating this information from the actual list. The artifact model was very beneficial in aiding design decisions of a virtual shopping list.

4.2.7 Physical model

The physical model was less applicable in the development of the digital shopping assistant. The physical model technique only supports the analysis of one work environment.

> *"Shoppers tend to choose different malls for shopping, consequently the physical environment changes and the physical model does not account for changing environments."*
>
> [Appendix B.4 Diary, 11/5]

The physical layout of the environment is likely to change according to the mall that the shopper chooses to visit. The method provided no help identifying similarities between several different environments. Nevertheless, in order to benefit from the physical model it was necessary to analyze several different layouts[42], and draw similarities between these. Each layout was examined to identify *breakdowns* caused by the environment. The result of this analysis was that the environment could cause problems when locating products, shops or people inside the mall.

4.2.8 Work redesign

Two techniques were used in the design phase (Work Redesign); *priming the brain* and *storyboards.* When using the technique called *priming the brain,* the developer must brainstorm two lists; *technology* and *starting points*[43]. The list of technology currently present in the mall was elaborated and helped understand what services could be provided by the system.

> *"The method lacks some kind of mechanism that allows the developer to consider, which parts of a subsystem have influence…."*
>
> [Appendix B.4 Diary, 12/5]

[42] See different layouts of malls Appendix B.3.3.

[43] See technology- and starting point list Appendix B.2.4.1.

The indoor positioning system had some limitations. It is capable of positioning the user inside zones of 8 meters in diameter. This meant that the subsystem had an impact on the design decisions taken at this point in the development and the method did not offer any activities to analyze the subsystem's influence. Instead it was chosen to take the influence of the subsystem into account when elaborating the list of *starting points.*
The design ideas that had been prioritized at the end of the inquiries, were used as a *starting point list* for the vision of the new system.

> *"…all features* (Design ideas) *suggested are the results of problems encountered in the real world, which can be enhanced/avoided using the capability of the digital shopping assistant."*
>
> [Appendix B.4 Diary, 12/5]

The starting point list was affected by the problems, which were encountered during the inquiries and by the aspect of shopping, which is related to grocery shopping. The starting point list was revisited with the knowledge that had been gained from the elaboration of the work models, the technology list and the influence of the subsystem. The list of proposed features for the digital shopping assistant, helped think about possible solutions for overcoming the break downs present in the work models. The following list of requirements was the result of *priming the brain:*

Functionality	**Description**
Shopping list	The shopping list should be updateable from the Internet by family members. Furthermore the system should be able to arrange the shopping list according to commodity group, and supply the list with relevant offers. The list should be colorized according to commodity group. It must be possible to direct the shopper toward each commodity group on the map. It must be possible to add additional notes to the shopping list.
Map	The map should visualize both the map, the user's location and provide directions. Directions should be done with an arrow pointing in the direction of a zone.
Search	It should be possible to search for products and shops within the mall, and these should be visualized on the map as zones.
Profile	The shopper should be able to add their preferences in order to aid the system in tailoring advertisements accordingly. The profile should contain the interests of the shopper.
Request Assistance	The shopper must be able to call an assistant for help.
Awareness of partner	The system must be able to show friends, partner or family members on map. It must be able to make an appointment of a meeting.

Table 8 Requirements for the digital shopping assistant.

Some of the initial design ideas were removed from the starting point list. Furthermore some of the low prioritized design ideas were implemented, because the work models verified that they were needed.

Storyboards aim to capture the work practice as it is re-designed, including interactions with the system, interactions with other people and manual steps.[44] The storyboards were excellent at depicting the vision of the new system and illustrating thoughts and motives behind the design decisions made in the vision. During the elaboration of the work models two overall tasks were discovered; the task of preparing to go shopping and the task of doing the actual shopping. In both tasks several breakdowns were occurring, hence it was decided to redesign both phases. According to the method, storyboards should depict all interactions done with the new system and therefore the storyboards should depict UI-interfaces as well.

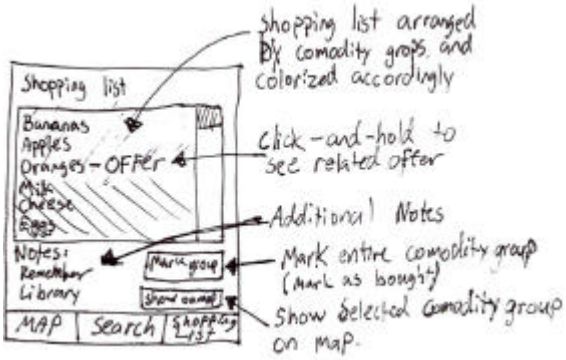


Figure 20 Storyboard of the shopping list.

Previous experience in designing user interfaces for mobile devices had been gained prior to elaborating the storyboards. This knowledge contributed in the design of the UI-storyboards.

> *"When designing on a piece of paper it was hard to estimate how much screen real estate was consumed."*
>
> [Appendix B.4 Diary, 13/5]

Although previous experience was present, it was hard to estimate how much space was used in each screen. Consequently, some re-design was done during the implementation of the prototype. Nonetheless the majority of the UI-storyboards were followed quite accurately during the implementation.

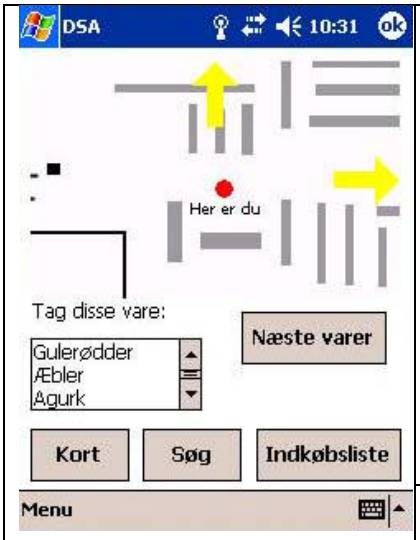
4.2.9 Implementation

The implementation of the prototype was done using Visual Studio.NET 2003 for a PocketPC. In the following table a list of screenshots will be presented along with a description and user comments.

[44] See storyboards Appendix B.2.4.2.

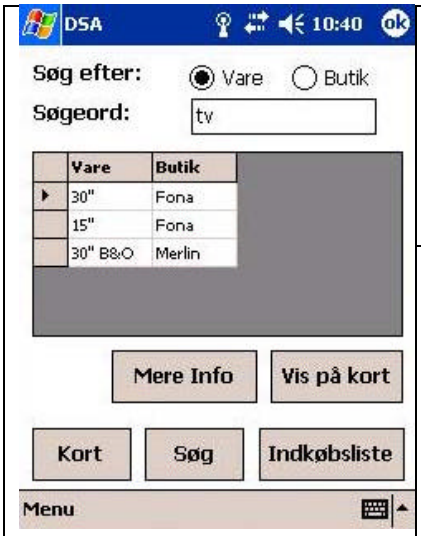
Shopping list: The top most item has a related offer marked by an icon. When the user Click-and-hold on the item, a related offer will appear. The list is arranged according to commodity group, and colorized accordingly. Additional notes have been separated from the list and placed in the bottom. The button "Markér gruppe", strike out the selected commodity group that has been selected in the list. When pressing the "Vis på kort" button, the next screenshot will appear.

User Comments: The users liked the colours on the shopping list. They understood that each commodity group was represented with a different colour. They also liked that they were able to get offers related to their shopping list. Only one user noticed the additional notes placed beneath the shopping list, and he suggested it should be represented as a post it's instead. The button "Markér gruppe" was not understood by any users. Some suggested that it should be called "Put I kurv", since most people are familiar with this term. The text size was good and readable.



Map: The shopper's location is marked with a blinking red dot centred on the map. The arrows indicate that the items must be located to the north-east. The list-box below shows the items that must be grabbed at the next commodity group zone. The directional arrows could have been implemented using vector, and a higher direction-accuracy would have been gained. If the user presses the "Næste varer" button, the items related to the commodity group in which he is located will be striked out on the shopping list, and directions to the next commodity group will be provided.

User Comments: Most users did not understand the arrows. In a final product it is necessary to improve the quality, by having only one arrow point directly in the right direction. All users liked the functionality of getting help to locate the items on their shopping list.



Search: *TV* has been entered as search keyword. The list of results is seen below. When marking an item, it can be shown on the map. Additional info is also available. However this needed a new window because of limited screen space.

User Comments: The users generally liked the search function, it was simple and straight forward. However some users had problems in entering a search keyword, because they did not understand the virtual keyboard that popped up when the search box got focus.

Profile: The shopper should supply the system with their sex and age. Moreover they can specify whether they would like all related advertisements upon arrival at the mall, or if they would like them in front of the relevant shop. They can specify their interests through the use of the combo box, which holds several categories. Once a category is selected, subcategories will appear below. They can check those boxes which matches their interests.

User Comments: The users thought the profile was very good. No changes were suggested.

Map – Advertisement found: An advertisement that is tailored to the user's preferences has been found. A button appears that enable the shopper to view the advert. During the implementation phase it was decided that zoom-functionality was necessary, because of the limited display size. However the actual zoom functionality was not implemented.

User Comments: Several users did not discover that a related offer was presented once they got near shop number 47, even though they were told to try and position themselves at that location. This indicates that advertisements should be "Pushed" instead of being presented (Pulled). The users needed the zoom functionality, they thought the map was too small.

Advertisement: A typical advert. The user is provided with the option of getting the owner-shop of the advert shown on the map.

User Comments: No comments.

4.3 The XP method

This chapter will feature a description of the knowledge gained from using the XP method. This will involve decisions made by the developer and how these influenced the work and a description of how the customer's points of view affected the prototype.
Further details of the work done, can be found in the appendix C.1 to C.4:
The XP method differs from most other methods since it does not rely on diagrams and charts as a means of documentation. The code itself is the documentation.
This aspect caused some confusion, since previous experiences in software development had involved working with diagrams, charts etc. Having read "eXtreme Programming eXplained" by Kent Beck created the basis for deciding how the method should be used.

4.3.1 Getting a customer

Getting a customer seemed like an easy task.

> "Since every person is accustomed to shopping the choice of finding a suitable person was easy."
>
> [Appendix C.4 Diary, 11/04]

Age	Sex	Grocery shopping
25	Female	3 times a week

The customer needed to gain knowledge of story making and this seemed like an easy task, since it involved writing text in a normal natural language. The XP method does not supply information about how to train a customer to get sufficient knowledge to participate actively in the development. The approach taken was to create an introduction to the work process and

the method. This was started by explaining some of the possibilities of the application. It then continued by talking about the stories and how they should be used. This proved to be a bad idea since the customer got confused.

> *"She had a hard time understanding how the stories could be transformed into an IT-system. It seemed like she was very focused on the creation of the GUI, which might have frightened her a bit, since she might not have felt competent in this area."*
>
> [Appendix C.4 Diary, 12/04]

She had problems understanding how the stories should be used to develop the application. She argued that the stories could not help create a program. In order to make the customer more comfortable it was decided to delimit the customer from what the stories should be used for at this time.

This led to the conclusion that the customer might have been overwhelmed by the information about the entire process.

The customer and the developer realized that they had diverse timetables and that new meeting would be impossible in the near future. The developer then decided to recruit a new customer.

This time it was chosen to get a customer[45] with more experience in computers, which would hopefully remove some of the application development fear the previous customer seemed to have.

Age	Sex	Grocery shopping
30	Male	1-2 times a week

The new customer seemed enthusiastic about the idea of helping develop a prototype, but he was unaware of how a PocketPC functioned. This might pose a problem and decided to lend him a PocketPC, which he could familiarize himself with, before the actual work with the method could begin.

This time a different approach was taken with the customer.

> *"Having discussed the customer's role and introducing him to stories etc. has insured the developer that this customer is more qualified than the previous customer (the woman). It may be because the developer knew what was important to not to tell about the method. It was chosen to tell the customer more about the stories and get him to grasp this, before the developer even mentioned how these stories should be used to create a program."*
>
> [Appendix C.4 Diary, 15/04]
>
> *"The developer was aware that it could be difficult for someone to understand their job as customer, but this did not seem to be the case with my new customer."*
>
> [Appendix C.4 Diary, 15/04]

This new approach of limiting the customer from knowledge about how the stories would be used seemed to help the customer understand his task better. The XP method does not provide

[45] See Appendix C.4 for further details about the customer.

information about how a customer should be introduced to the method and this presented time consuming problems. It is not guaranteed that the approach taken with the second customer was optimal, but it seemed to help with the understanding of the work. This can represent a problem in the continued work and it is up to the developer to make all the decisions on how to get the most possible information from the customer. The method does not aid in this task, which is far from optimal.

4.3.2 Brainstorming

The developer and customer started by discussing the ideas for the system and what problems the customer could experience when shopping. This is not something the method proposes, but it seemed like a good idea, in order to establish a common understanding of shopping.

> *"His girlfriend and him seem very organized in their shopping habits and very focused on the products they buy."*
>
> [Appendix C.4 Diary, 15/04]

This was considered an advantage, since it provided a customer, who was aware of the "obstacles" that must be overcome when shopping.
The developer thought the customer would then have a good knowledge of all the elements which the system could aid the user in doing. The developer was not aware that the customers view on shopping might limit him from determining some functionality which would aid shoppers, who were browsing through stores.
The result of the brainstorming was a list of functionality which the customer felt was a necessity for the future application[46]. This served as the foundation for the data collection (creating stories) in the XP method.
The list is likely to represent the functionality of the prototype and is created by one developer and one customer. If it had been a different customer it could have provided an entirely different functionality. This could result in an entirely different system. Having a single customer to represent the shopping domain might prove to be inadequate. It shows that there might be problems when creating a system for multiple users with different behaviour and shopping habits, when only using a single customer as the XP method dictates.

4.3.3 Creating stories

The following day the brainstorm was continued briefly and the developer explained that all the ideas must be written down as stories. The customer appeared to fully understand this task and was given the material to create the stories on.

[46] Appendix C.2.3

> *"The customer found it difficult to create the story cards and it took about 15 minutes before he started writing. He was confused about how to write them and even though the developer told him that it should be written in natural language, he found this hard to grasp."*
>
> [Appendix C.4 Diary, 16/04]

Again the XP method did not provide the developer with sufficient information about the task at hand. It was chosen to look upon the stories as a means of remembering the ideas and later clarify some of the uncertainties when discussing the task cards.
The developer felt that he failed in making the customer understand his task, but the problem was easily corrected by helping the customer develop the first story.

> *"..he created all the stories very rapidly, even though he often wanted to debate the functionality with the developer."*
>
> [Appendix C.4 Diary, 16/04]

It seemed the customer had understood the task, but the speed which the remaining stories were created, could have resulted in the loss of valuable details. The developer chose to accept the stories and then provide more details when the task cards were created from the stories. This decision was mainly based on keeping it simple for the customer. Had the developer chosen to make the customer specify more details it might have confused him again, but it could also have limited the amount of uncertainties which is likely to be present. It was chosen to create the tasks and debate these with the customer, to make sure they both still had the same understanding of the system.

4.3.4 Creating tasks

Most of the work done on the tasks was done solely by the developer. This caused some confusion, since the developer felt he already had a good foundation for creating the system, based on the stories. He decided to split each story into smaller parts, which would only include a single aspect on the actual prototype[47]. The XP method specifies vaguely that a story can be divided into tasks if it is too complicated to implement. It was chosen to divide all the stories since the developer was unaware of what "too complicated" actually meant. Secondly it was considered an interesting aspect to see which tasks the customer wanted in each release.
When the tasks were completed the developer showed them to the customer, to ensure that he had not misinterpreted the meaning of the stories. This did not provide the developer with new ideas or an improved overview of the system. It appeared that the stories had supplied sufficient information for the developer, which enabled him to remember the remaining functionality / ideas, which was not documented.

[47] Appendix C.3.2

The customer then placed each task in any of the three releases[48] as dictated by the method. Once this was done the developer examined the three releases in order to examine if it was possible to implement release one, without having to rely on any functionality from release two or three. It proved impossible because the customer wanted map zoom before the map (in release two) was implemented[49]. The developer explained it to the customer, but it was discovered that the developer and the customer looked differently upon the map functionality.

> *"He wanted a map of the mall, which would be with very little details and should only provide an overview. The other map should have much more details and should only show one store at a time. This map should be zoomable."*
>
> [Appendix C.4 Diary, 17/04]

Having discovered that made the implementation easier, since the developer would have created the map differently from the customer's expectations. The developer had not anticipated that dividing the tasks into the three releases would reveal any differences in the way the developer and the customer perceived the functionality. It was expected that the releases would create boundaries for which tasks were possible to implement. The developer was pleased about this discovery, but it also worried him.

> *"The developer is worried that there might be other aspects of the tasks where the customer and the developer don't have a common understanding, but the developer does not anticipate any bigger problems."*
>
> [Appendix C.4 Diary, 17/04]

At this stage it was unsure whether this was the only element the customer and the developer looked differently upon. All the information from the brainstorm, stories and tasks had been discussed on several occasions and discussing this again seemed pointless. Again the XP method did not provide a tool or guidelines to make sure the people involved had a common understanding of the application which they were creating in cooperation. Table 9 Requirements for the digital shopping assistantTable 9 shows the requirements that should be included in the first release.

Requirement	**Description**
Product information	The system must be able to help the user find product information / reviews
Shopping list	It must be possible to enter information by speech. The system must aid the user in finding specific products and locations. The system must be able to categorize the shopping list.
Special offers/activities	The system must provide information about events and special offers. The system must support user preferences, which can influence the popup information and advertisement.

[48] Appendix C.3.2.1 – C.3.2.3

[49] Appendix C.3.2.2

Notification	It should be possible to see the amount of people / length of the queue in a mall without going there.
Map	The large stores must feature a map on which you are able to zoom in on certain areas

Table 9 Requirements for the digital shopping assistant

In order to provide a tool to clarify if there were any other misunderstandings it was chosen to debate the GUI[50], which is also suggested by the XP method.

4.3.5 Debating the future GUI

Once all the tasks were completed it was decided to discuss the GUI. It was believed that this discussion would clarify some of the concerns on how the functionality should be visualized on the GUI. Moreover it also provided information, on which functions should be easy accessible.

> *"This was topics like map and shopping list. The customer wanted fast access to this functionality, no matter what other parts of the application he was using."*
>
> [Appendix C.4 Diary, 30/04]

The discussion was continued, but the customer did not provide more information the developer could use to create the GUI. The customer seemed to talk more about *what* functionality he wanted in the application, rather than *how* he wanted it created.

> *"During this work the developer has become aware that the customer must have a good imagination to see all the possibilities in the creation of a GUI."*
>
> [Appendix C.4 Diary, 30/04]

Based on this observation it had become apparent that a customer must also be able to visualize his ideas as a prototype, in order to aid the developers during the later phases in the method. The prototype being developed does not have role models which are commonly used and know by the customer. This could make it difficult for the customer to imagine a GUI for the prototype. If the project had involved making a program which had multiple role models it might have been easier for the customer to create a GUI based on the best ideas from other role models. The XP method does not discuss or aid the developers in this aspect.

4.3.6 Creating the GUI

The design of the GUI was up to the developer. Very little knowledge about this, from the customer had been gained. The customer wanted fast access to the shopping list and the map. But there were still decisions to make regarding the remaining functionality.

[50] Graphical User Interface

> *"The developer often felt that there was information, which could have been elaborated even further between the customer and himself. The developer can not put his finger on anything particular, but it is harder to go from a task description to a GUI layout than anticipated."*
>
> [Appendix C.4 Diary, 02/05]

The developer felt he had to make these types of decisions during the entire programming phase, which made him unsure, whether the GUI was created, like the customer had anticipated. Sadly the amount of time the customer could participate was limited and the developer had to create most of the GUI alone. This was not considered a problem since the customer had found it difficult to visualize the GUI and had expected the developer to create this based on his experience in this field. These two opinions were considered conflicting. The developer wanted more from the customer and the customer felt this was the developer's task. The method does not supply any information about how this dilemma should be overcome and very little was done to make the two involved people work closer together. This was both because of the limited timeframe and because the developer felt confident, he could create the GUI alone.

4.3.7 Feedback on the GUI

The developer felt he had made many decisions regarding the layout of the GUI. He was sure that the customer would not blindly accept this design and was looking forward to the feedback. This was the area where the XP method would distinguish itself from other methods, since it provided rapid feedback on the development.
It was explained to the customer that the functionality from release one was created and he should try out the application and when he felt ready, changes should be debated.
The customer seemed to understand the application rapidly. Some functionality he understood right away, while he stumbled a bit more to find other types of functionality.
The customer explained how he liked the map feature.

> *"The user had no problems understanding the difference between the red and the blue boxes and he explained this because the red was much smaller."*
>
> [Appendix C.4 Diary, 05/05]

This actually made the developer aware that he had made a graphical misrepresentation on the prototype. In reality two zones would have approximately the same size, but while programming it the developer had looked differently upon the two areas; One as a persons' location and the other as the location of a store. The result was two zones with diverse sizes.

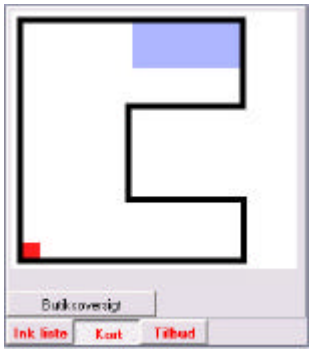


Figure 21 The map on the XP prototype

This discovery showed that the feedback from the customer was good in a sense that it provided information, which should be resolved in the second release.

This finding could have been left uncorrected during the entire implementation phase, if the customer had not been involved. Having this fast feedback which the XP method proposes has proven valuable in this case.

> *"It was almost impossible to make the customer say anything negative about the application and the developer got the feeling that he felt he had to come up with new ideas if he told the developer he didn't like some of it."*
>
> [Appendix C.4 Diary, 05/05]

The ideas of the method seemed to fail when a discussion was initiated. The customer was satisfied with the layout and functionality.

It was tried, asking more specific questions about the GUI to provoke the customer to say something negative about the GUI. It was explained that the customer did not need to propose any new design or functionality if there was something he did not like, but the customer did not change his mind.

This indicated that the customer found it difficult to criticize the work he had participated in, even though it was his "job". Discovering this at such a late stage in the development does not provide many options for the developer. It is impossible in the beginning of a project to determine if a customer contains all the necessary skills.

This indicated that there are multiple aspects, which an XP customer must posses. It can be difficult for the members of an XP team to determine if the customer contains all the necessary skill. The XP method only discusses how the customer should function. It does not give guidelines to the type of person which is required. Finding a suitable XP customer has proven harder than anticipated.

4.3.8 Developers point of view on the XP method

The XP method has some advantages despite the problems encountered. The customer is still a good asset. It was easy to debate functionality and turn these into stories, which meant that most of the data collection is done rapidly. On the downside it was easy to get carried away and forget to look back upon certain aspects. It seemed like the work was progressing and the customers requirements did not create situations where redesign would be necessary, which the developer had anticipated.
The actual work resembled the waterfall model, more than the spiral model as the developer had anticipated. XP has many key words like: *courage* [Beck 2001, p. 32], *throw away code* [Beck 2001, p. 33] *and take chances*, but the developer never felt this was a necessity. This might be because the project was so small, that it was not necessary or it might be that the developer was not skilled enough to start discussions about the proper topics, or it might be that the customer was poorly chosen.
Every time a problem was encountered on fx. introducing the customer to method, level of detail in stories or creating the GUI, the developer wanted to consult the method. This did not help since the XP literature lacks depth and it is up to the developer to make decisions regarding the future work throughout the entire process.

4.3.9 Evaluation of the prototype

The prototype created will be described and discussed based on the feedback from the users from all three methods. The following illustration highlights some of the navigational possibilities in the prototype.

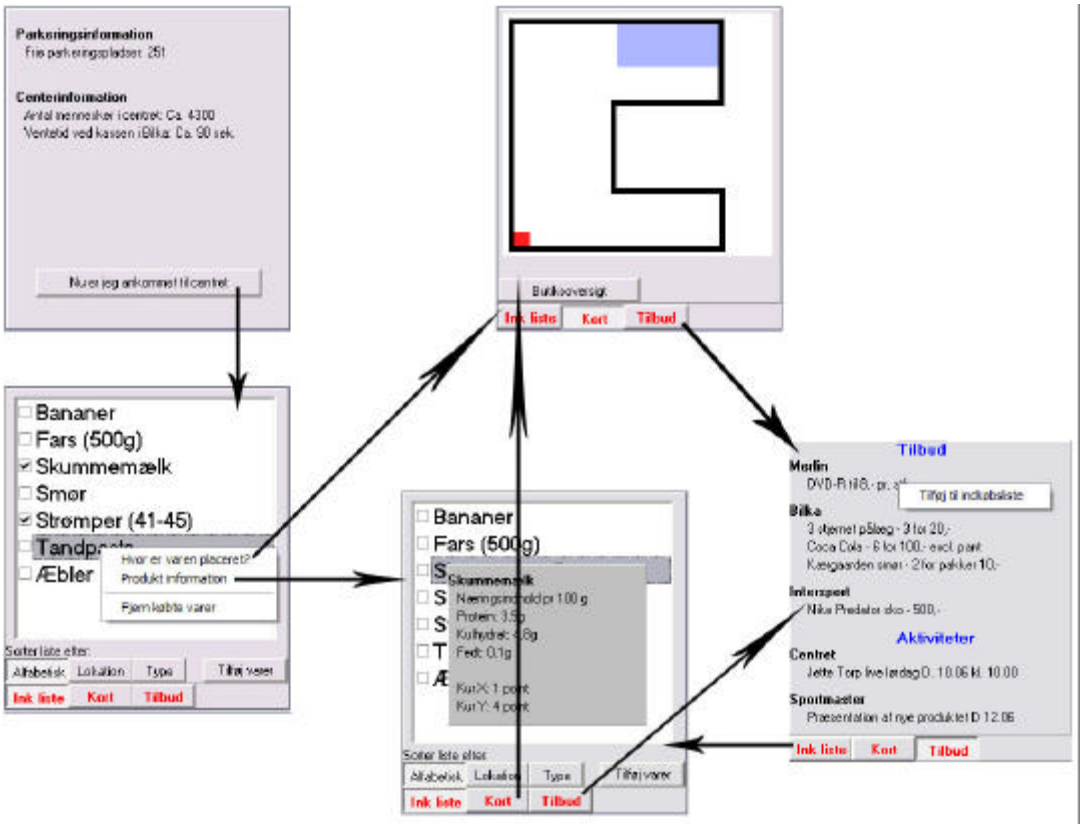


Figure 22 Navigation in the XP prototype

This section will feature some of the feedback which the XP prototype received.

The section will only provide feedback on the parts of the application which caused problems for the users or which they did not like.

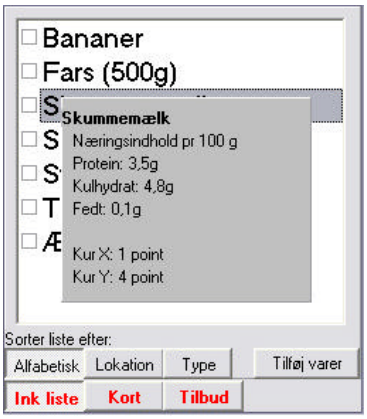


Figure 23
Product information

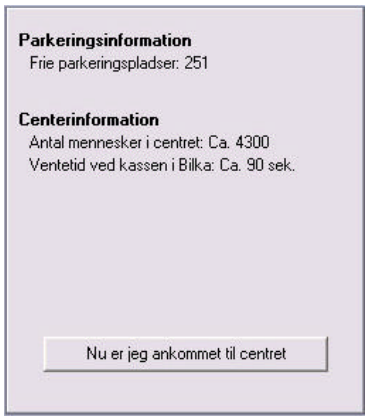


Figure 24
Population in the mall

Figure 25
Special offers and activities

The overall criticism of the prototype was mainly based on the size of the text messages. Most of the users decided that the shopping list was too large while the remaining text was too small. This was a decision made solely by the developer. It was decided to keep the text size small for menus, information etc. while the shopping list should be large. This was because

this list should be easy to read, even if the PocketPC was mounted on a shopping card. It was mainly because the developer felt that shopping was a hands busy eyes busy activity.
The map on Figure 21 which was used in the XP prototype was created from scratch and does not show the layout of a mall. The developer felt it would be adequate for the prototype, to show the idea behind the map. It showed some of the basic ideas which the map should feature. The functionality is similar to the other prototypes which the users were shown, but this map was disliked by all users. Basically the map contains the same functionality as the two other prototypes, but it clarifies the importance of nice looking graphics. The users might not have disliked it, if this prototype had used similar graphics.
Figure 23 contains information about the shopping list and extended product information. The evaluation showed that most of the users liked this option and mostly the women found the diet information especially good. Some users disliked that the small panel did not disappear when they clicked other menus. They had to click the panel, to make it disappear. This issue could be resolved by using a timer, to make the panel disappear after a few seconds, but it could also disappear when the device encountered changes in the context and wanted to visualize new information to the user.
Figure 24 shows an overview of the mall population in text format. Many of the users like the idea, but found the information difficult to relate to. It was difficult for them to know if the amount of people in the mall was high or low. Some extended information is necessary. It can display information about minimum-, average- and peak population in the mall. This would help the users relate to the information since it can be difficult only to relate to an amount of people. Further information would be a necessity on this screen and it is considered worth keeping by the users.
Figure 25 shows an overview of special offers and activities in the mall. Some of the users like the overview of activities, but disliked the special offers. They explained that an entire mall would contain large amounts of special offers at any given time and that this type of listing would be to long and boring to browse through. This screen must clearly be redesigned. An option would be to only visualize information based on user profiles, which would delimit the users from some information, but this is not a guarantee that the amount of information/advertisements will become small enough for the user. Some of the information could be categorized by the system and the user could browse the advertisement by categories (food, clothing, sport etc.).

4.4 Summery

Having evaluated each development method, we have identified a number a problems. None of the problems identified during the development with each method are related to context-awareness.

M.U.S.T. method

In the M.U.S.T. method the main problems identified were related to the use of the method. There were problems with getting the participants to discuss at first. There were also problems in using the suggested techniques. The identification of requirements went well and many requirements were identified. The main problem in this area is due the unstructured nature of a workshop. The participants quickly took the discussion in one direction, namely away from grocery shopping. This resulted in a requirement such as a shopping list was abandoned for others on the prioritized list. This cannot be seen as a problem related to context-awareness, since this is a general problem with technique workshop. The problems identified regarding the design and implementation is not related to context-awareness either. Here the main problem was get the designs implemented on the small screen of the PocketPC.

Contextual design method

None of the problems encountered during the development using the Contextual Design method, can be directly related to context-awareness. The problems that were encountered during the contextual inquiries were caused by the fact, that the participants were mobile inside the mall, which made it hard to record the data. During the elaboration of the work models some problems were encountered. The most significant problem was the physical model, which did not support that the physical layout of the environment is likely to change according to the mall that the shopper chooses to visit. Again it was mobility that posed a problem. Elaborating storyboards was difficult because of the small form factor of the PocketPC. Although previous experience was present, it was hard to estimate how much space was used in each screen.

eXtreme Programming method

The problems encountered during the XP method mainly related to the customer. In order to have a successful XP development there is a need for a customer who has an extensive knowledge about shopping and who is able to look upon the process with criticism. That type of customer was not present in the development and the process lacked reflections on how well the prototype was progressing. Most of the requirements discovered are related to information. The customer saw the device as a means to get information which would

otherwise be impossible to collect while shopping. The requirements did not reflect how the digital shopping assistant could aid him in the actual task of shopping. It seemed the customer was more interested in adding additional requirements rather than aiding with the ones which already exist in the shopping context.

The lack of requirements related to context-awareness has made it impossible to compare the methods regarding this aspect. It is a necessity to investigate context-awareness and determine how it influences software development.

5 Requirements for a digital shopping assistant

This chapter will summarize the requirements from the prototypes and elaborate the primary requirements for a context-aware mobile digital shopping assistant, based on the knowledge gained from working with the methods and the feedback provided by the users.
The work will be divided into two separate sections.

- The main requirements from the three methods will be discussed.
- The secondary requirements will be discussed based on the feedback from the three existing prototypes.

The result will be a detailed list of requirements, which contain the best elements from each prototype.

5.1 Combined requirements

This section will provide an overview of the main requirements from each prototype. These requirements are listed below.

Contextual Design	M.U.S.T	XP
Map	Guidance to the offers	Map
Search	Product information / search	Product information
Shopping list	Advertisement based on profiles	Shopping list
Profile	Price comparison	Special offers/activities
Request assistance		Weight loosing systems
Awareness of partner		Notification

Table XX. Main requirements from the three methods

The first task is to establish common names for the requirements and list these.

In both Contextual Design and XP it was a distinct requirement to have a map of the mall, but in M.U.S.T the map was defined as a way to find something, either by text or illustration. This requirement will be known as *map* in the future set of requirements.
All three prioritized lists also contained requirements about product- and shop information (Search, Product information / search, Product information). This requirement will be labeled *Product/shop information*.
Finally the three prioritized lists contained a requirement for a profile. Both Contextual Design and M.U.S.T have main requirements which contain profiles. The *Special offers/activities* in *XP* is based on the ability to see information based on a profile and is therefore included[51]. This requirement involves getting *tailored advertisement* based on the profile. Finally the notification requirement will be known as *mall population*. The remaining requirements will keep their names.

	Contextual Design	**M.U.S.T**	**XP**
1	Map	Map	Map
2	Product/shop information	Product/shop information	Product/shop information
3	Tailored advertisement	Tailored advertisement	Tailored advertisement
4	Shopping list		Shopping list
5	Request assistance		
6	Awareness of partner		
7		Price comparison	
8			Weight loosing systems
9			Mall population

Table 10 Requirements table.

5.2 List of Primary requirements

Having gathered the requirements in a table has provided an overview and it is now possible to determine what the primary list of requirements for the system is. These will be listed below and elaborated.

- Map
- Tailored advertisement
- Shopping list
- Product/shop information

[51] Appendix C.3.2.1

5.2.1 Map

The map requirement is considered primary, since it involves guiding the users physically within the mall, which is the aspects, which makes our system distinguish itself.
This requirement was implemented in all three prototypes and the users supplied sufficient feedback, in order to gain a better understanding of what is needed on the map.
The decision of how a map should be constructed will be based on the user's feedback from the three existing prototypes.

- *The map should contain a zoom function. This will help provide an overview and detailed information*
- *The map should clearly show where the user is located*
- *There should be visualization arrows which guide the users to specific locations*
- *Exits and toilets should be clearly marked on the map*
- *Specific locations should be marked with text specifying what it is*
- *The map should be able to visualize item- and shop locations*

The users stated that the map on Contextual Design and M.U.S.T was good, but it needed some additional information. "*Cannot see where one is*", "*Needs zoom on the map*" and "*Map should show toilets and exits*". The map used in both these prototypes was the same bitmap, which showed the layout of an actual mall. The users found the layout easy to relate to and this was not commented. In the XP prototype the map was a "home made" illustration which was far more simple. The users stated that "*Map is not good*" (stated by multiple users) and "*Needs text messages on the map*". Basically the functionality was the same as the two other prototypes. This leads to the conclusion that the map must be easy to relate to.

5.2.2 Tailored advertisement

Tailored advertisement is also considered a primary requirement since it involves tailoring information to the individual user. The requirement differs from the other requirements in this list. The users see wanted to get advertisement which is tailored to them. Only the Contextual Design prototype had an actual implementation of a profile, which will make the tailoring possible and feedback will only be based on this. The visualization of the profile contained large amounts of criteria, which were sorted to limit the users from seeing it all at once.

- *Include age and sex as main criteria*
- *Specify many criteria. The users will enter information, because they can see the relevance*
- *Many criteria is good, but only present a few at any given time*
- *Group the criteria in lists sorted by interests and hobbies*

- *Do not bother the users with their profile, when doing shopping. Hide the information in a sub menu*

The profile created seemed to be liked by the users: "*Profile is very good*". It contained huge amounts of criteria, but they were well sorted in groups of hobbies and interests which the users liked. There were no arguments against the large amount of criteria.

5.2.3 Shopping list

The shopping list is a primary requirement, since it is one of the features where the system can aid the users in both memory and shopping speed, by showing the user where items are located on the map.
This requirement was only present in two of the methods used, but it was explained by many users that the M.U.S.T requirements should have contained it. Even the participants who had helped create the M.U.S.T prototype argued that it should have been a present feature. This requirement is considered one of the most important, since the users provided large amounts of feedback and seemed to look at it as a "must have". Based on the prototypes the following criteria for this requirement have been elaborated:

- *It should be possible to sort items in the same way as they are physically located within a store (by commodity groups)*
- *Using colors to highlight groups is a good idea, but should use the same colors as the store.*
- *It should be possible to mark items as being bought*
- *Removing items which are already in the cart is a good idea*
- *Highlight items if they are on sale, or a similar product is (use icons)*
- *Add new items should be easily accessible on the GUI*
- *Additional notes are a good idea*

This requirement is considered important for the future prototype "*Need shopping list*" (multiple users). The feedback has revealed, that they like the advantages it provides compared to a written text message. They do not need to bring a pen to mark items, which they have placed in the cart: "*Good with mark items on the shopping list*". Furthermore the shopping list should provide information about the items on the list, which is on sale. The users seemed to like this feature: "*Likes that one can see the offers on the shopping list*".
The evaluation of the prototypes also indicated that the users wanted the ability to add items to the list, even though they were already shopping. This feature was present in one prototype, but was missing in another. This was commented by the users and they wanted this option to be available. Finally one of the prototypes had an option of marking all the items in a commodity group of groceries. This was labeled *marker varer*, which was misunderstood by

the users: "*marker varer was not understood*". This function should be labeled *put i kurv*, which was a well known term for the user who proposed the name.

5.2.4 Product/shop information

The requirement must provide the users with information about products and shops within the mall.

This requirement should provide:

- *Search should be fast and require limited interaction*
- *Should be easily accessible*
- *Information about products should be short but adequate*
- *Good idea to visualize locations on the map.*
- *Extended information about weight loosing diets is a good idea on groceries (will be elaborated in: Weight loosing systems)*
- *Compare prices on single product from multiple stores should be possible (will be elaborated in: Price comparison)*

The users seemed to like this function, but some argued that they found the purpose of the function difficult to understand "*not clear what the purpose of product info is*". This indicates that the function should have further options, which could benefit the user. This is the information such as *weight loosing systems* and *Price comparison* "*Following search there shall be an option to compare products*". Having the search function will make the other two functions easier to use.

5.3 Secondary requirements

The list of primary requirements has been discussed and it is now possible to elaborate the secondary requirements. The secondary requirements will be the remaining requirements from Table 10. These requirements are considered secondary because it is possible to place them as sub-requirements for the main requirements, except for one requirement.

- Request assistance (Map)
- Awareness of partner (Map)
- Price comparison (Product/shop information / Shopping list)
- Weight loosing systems (Product/shop information / Shopping list)
- Mall population

The requirement which is not possible to position as a sub-requirement is the *mall information*. This requirement involves the ability to see information about the mall without going there. This is considered secondary because it is not vital for the system.

5.3.1 Request assistance

This requirement was based on problems encountered during the Contextual Design inquiry, the users had during their shopping trip. They encountered problems, which they could not solve themselves and wanted help from an assistant.
The idea is that the system must be able to call for assistance from an assistant in the grocery store. The system should provide the following feedback to the user:

- *Tell user to wait in the area*
- *Provide feedback to the user when the assistant will arrive*

This requirement was only discovered by one method and was implemented in a sub menu. The function only worked while the users were located within, which they seemed to fully understand.
The requirement was discovered during the contextual inquiries, which both XP and M.U.S.T did not contain. The requirement is also considered important and should be contained in the future list of requirements.

5.3.2 Awareness of partner

The requirement was based on actual knowledge gained from the contextual inquiries. Two of the participants managed to loose track of each other during the shopping.

- *Make partner/friend/child visible on the map*
- *Should be able to arrange meeting location at a given time*

This was implemented in the Contextual Design prototype as the possibility to arrange meeting on specific locations which could be selected be clicking on the map. Furthermore each user should also have the option of seeing his or her partner on the map, which will make it possible to walk right over to the person, without the need for a meeting.
This requirement was also discovered by the Contextual Design method based on the contextual inquiries. This should also be included in a future prototype, since it had already been demonstrated that there is a potential need for this type of functionality.

5.3.3 Price comparison

This requirement was considered a good idea by many of the users. The idea is to compare a single product on prices from multiple stores.

- *Searching for the product should be fast and easy (elaborated in: Search)*

Once some of the users had seen the M.U.S.T prototype they argued that the other prototypes should also contain this functionality: "*Needed price comparison*". The actual implementation was considered a good idea and the users argued: "*Likes compare prices*" and "*Price comparison is good*".
This indicated that the users wanted this feature in the future prototype. They could see that this function provided an overview of product prices, which would be very hard to get without using the system.

5.3.4 Weight loosing systems

This requirement was implemented as an extra feature on product information. The idea sprung from the XP method, because the customer had encountered problems doing calculations, to determine if he was allowed to eat the product or not.

- *Short and precise information from 2-3 of the most known weight loosing systems*
- *Should be selectable if users wants the information or not*

Many of the other user commented on this feature and they were all positive: "*Likes info on diets*". This requirement distinguishes itself from the remaining requirements, since it is not considered relevant for all users. Most users are not interested in this information and therefore it should be possible to delimit the user from this information.

5.3.5 Mall information

This requirement involves information which should be present before going to the mall. The XP user argued that if there were too many customers within the mall he did not want to go there and drove home.

- *Should be present outside mall*
- *Should provide information about the number of people in the mall*
- *Information should be presented in a way which makes it easy for the users to relate to*
- *Should provide information about events in the mall*

It is important that this information is presented in a way that the users can relate to: "*Good info on first screen but hard to relate to"*. The amount of people will not provide sufficient information. Additional information about maximum-, average- and minimum population will aid in this task: "*Good idea with intro*".
This requirement is not considered as important as mo'st of the previous requirements. The idea of having the information present before going shopping is considered a good way of helping people with planning, but a shopping mall can have very large changes in population

over time within a single day. Therefore the system could provide the user with information which is inaccurate, once the user arrives at the mall.

6 Context-awareness revisited

In this chapter we will categorize our prototypes in order to determine whether they can be considered to be context-aware. For this purpose we introduce a way of categorizing context-aware applications and use this on the prototypes. We will subsequently discuss the results and present a way of aiding the developer in the development of a context-aware application.

Dey and Abowd describes *Activity*, *Identity*, *Location* and *Time* as the primary context types for characterizing a situation [10]. These types relates very closely to the *What*, *Who*, *Where* and *When* presented in chapter 2. As we mentioned in chapter 2, the *Why* is somewhat special compared to the other "W's" since it is not something that can be measured, but can be derived from information obtained from the others.
They follow this description with an attempt to make a categorization of features for context-aware applications. This is done on the basis of two earlier attempts to make such a taxonomy. Dey and Abowd presents a categorization that includes the following three categories:

1. *Presentation* of context
2. Automatic *execution* of a service
3. *Tagging* of context for later retrieval

Presentation of context covers the idea of presenting relevant information or services based on the current context. An example could be presentation of the shopping list when the user enters a grocery store.
Automatic execution is described as the system's ability to automatic execute a commands based on the user's context. An illustration could be the 'pushing' of an advertisement based on the user's profile and location.

The third category is *Tagging of context*. This category relates to the ability to associate digital data with the user's context. The user can view the data if he is in the same context. For instance, the user can create a virtual note providing a review of a specific product or shop and attach it to the product or shop. When another user enters the same location, he will be able to see the virtual note left at that location.
We have categorized our prototypes according to Dey and Abowd's classification. The result can be seen in Table 11. Under the Context type heading in the table the following abbreviations has been used:

- A corresponds to *Activity*
- I corresponds to *Identity*
- L corresponds to *Location*
- T corresponds to *Time*

Under the Context-aware category we have used

- P for *Presentation of context*
- E for *Execution of context*
- T for *Tagging of context*

Prototype	Context type				Context-aware category		
	A	I	L	T	P	E	T
M.U.S.T. prototype		X	X		X	X	
Contextual Design prototype		X	X	X	X	X	
eXtreme Programming prototype			X		X	X	

Table 11 Categorization of prototypes

The M.U.S.T. prototype includes the context types *identity* and *location*. *Identity* is used in pushing advertisements based on the specific user's profile and the *location* is used determining when to push the advertisements and to give directions to the user.
The Contextual Design prototype includes *identity*, *location* and *time*. It uses *identity* and *location* in the same way as the M.U.S.T. prototype, but instead of pushing advertisements it just makes them available to the user. It also uses *location* in order to display the user's current location on the map. The Contextual Design prototype includes the context types *time* in order to determine when to notify a partner of a meeting.
The eXtreme Programming prototype uses knowledge of the context type *location* in order to determine where the user is located.

Based on the attempt to classify the prototypes, we gained an understanding that the prototypes included very limited context. The prototypes primarily used the context types:

location and *identity*. Furthermore the prototypes mainly *presented* information based on the context. The M.U.S.T. prototype only included *automatic execution* in its ability to push an advertisement based on the *location* and *profile*. The CD prototype only used *automatic execution* in the notification based on time and location. The XP prototype includes *automatic execution of services* in the mall info screen, which automatic disappears when the user enters the mall. All the prototypes included *presentation* in their functionality to show products location on the map.

Many ideas for improvements have surfaced during our attempt to categorize our prototypes. For instance, storing information about the user's previous shopping list can be used to derive new ones. For example, if the user usually buys milk and butter when shopping, these items could be added automatically upon creating a new shopping list. This will reduce the interaction needed when creating a new shopping list.
This discovery might be a result of the methods missing ability to force the developers to consider contextual factors. We believe that a very explicit understanding of context-awareness must be present at the developer in order to fully take advantage of the possibilities that context-awareness gives.
But the methods still lacks means to get the developer to consider where and when context-awareness can be included. We believe that a good starting point is to focus on the changes in context. For instance, when the user changes his *activity*, it is likely that he needs new information, or other information has become relevant.

We will propose a procedure that can aid the developer, when developing context-aware applications. This procedure is meant to support the developer in considering how context-awareness should be included. The procedure includes some of the considerations we believe would have helped us in getting more context-awareness into our prototypes.

- Identify activities
- For each activity
    - Identify start and end an activity
    - Can this activity be interrupted by other activities?
    - What is the intention of the activity?
    - What is the outcome of this activity?
    - Which artifacts are important?
    - Does location of the user have any influence?
    - Does identity of the user have any influence?
    - Does time have any influence?
    - Are there others involved, who have influence on the activity?
    - Can problems occur during this activity?
- Are there relations between activities?
- Are there activities that do not have any relations?

Identify activities

In this phase we want the developer to identify relevant activities that should be supported by the application. We define activities to be an overall action that has an intention and an outcome. Identification of activities can be done using existing software development methods. We have found Contextual Design's sequence models [Beyer&Holtzblatt 1998: p. 96] to correspond very well to our understanding of activities and therefore we find Contextual Design to be particular good for this phase.
During our development we identified the activities: *Preparation for grocery shopping*, *grocery shopping*, *shopping without the intention of buying* and *shopping for one expensive item.*

After having identified a number of activities the developer should now look at each activity and consider the following:

Identify start and end of an activity

It is relevant to identify *start* of an activity, because this information might indicate a change from another activity. Identifying the *end* of an activity might indicate that a new activity will commence.
An example from our case could be the start and end of *grocery shopping*. The start is at the moment the user enters the grocery store. The end of grocery shopping could be identified as when the user leaves the store or when all items on the shopping list is bought, at which time he may change activity, for example locate his car.

Can this activity be interrupted by other activities?

When a user is engaged in an activity, it can be relevant to remind him about another activity. The user may also suddenly change activity himself, interrupting the current activity.
An example could be a context-aware shopping assistant that notifies the user, if he is leaving the mall without having bought all items on a shopping list.
An example of when the user suddenly changes activity himself could be when he is *shopping without the intention of buying* and he starts *grocery shopping*.

What is the intention of this activity?

The identification of the overall intention (the reason for doing the activity in the first place) gives some very important clues to how the user could be aided. The intention of an activity must always be supported by the system, whereas the specific steps needed in the activity can vary. An activity can have several overall intentions.

The overall intentions of *grocery shopping* could be to save money and restock the refrigerator.

What is the outcome of this activity?
Identifying the outcome of the activity is often closely related to the intention of the activity. The outcome of *preparation for grocery shopping* is very likely to be an shopping list.

Which artifacts are important?
The developer should identify which artifacts the user needs for this activity. Furthermore he should investigate into important and/or relevant information that might be conceived in the artifact. This information is often the *relevant* information that the context-aware application should provide during the specific activity.
An example of an artifact in *shopping without the intention of buying* could be advertisements. The relevant information could be which pants are on sale, or other advertisements that the user be interested in.

Does location of the user have any influence?
With this question we want the developer to consider whether information about the user's location could influence the behaviour of the system in this activity. The developer must think thoroughly whether the system should perform some action based on the location of the user. Location could be very relevant in our system in the activity. With the knowledge of the user's location we can give him advertisements from the stores he is passing, when he is *shopping without the intention of buying*. We could also use knowledge of location to determine when the user enters the grocery store or guide him to specific store.

Does identity of the user have any influence?
As with the question about location, the developer must consider whether information about the user's identity could influence the behaviour of the system in the activity. Identity covers everything that is known about the user. This information could be knowledge about the name of the user, sex, age etc. but identity could also be accumulated information about the user such as numbers of visits in a specific store.
An example of how identity can be used, is the ability to only show relevant advertisements for the user. For instance if the user is interested in computers, the system could show him advertisements from the computer store as he passes.

Does time has any influence?
The developer must consider whether information about time could influence the activity. Time is not just the time of day, but should be understood broader. Time also covers time of year, day of week or time elapsed since some specific event.
By knowing about time the system could inform the user that he has to go grocery shopping now, because the grocery store is closing soon.

Are there others involved, who has influence on the activity?
With this question we want to make the developer consider whether other people can have influence the way the system should perform in the activity.
For instance if a group of students are having a meeting with their supervisor, a context-aware mobile phone would automatically mute the phone.

Can problems occur during this activity?
With this last question we want to have the developer identify, which problems could occur during the activity and subsequently consider how the system could aid the user in avoiding such problems.
Problems that might occur during *grocery shopping* could be that the store is sold out of a specific item. As a way to help the user in such a situation the system could suggest alternatives for the item.

Having considered and described each activity we now focus on the relations between the activities. An activity can be dependent on another. This could for instance be artifacts created in one activity are needed in another.

Are there relations between activities?
Many activities are related in some way. An activity often has a preparation or is the preparation for another activity. After identifying the activities the developer should consider whether there are some activities that are related in some way.
In our case, there are a dependency between the activity *preparation for grocery shopping* and *grocery shopping*.

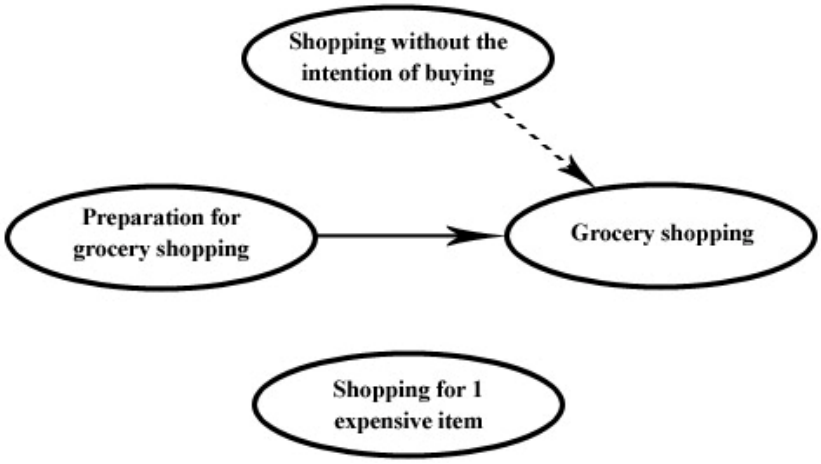


Figure 26 Relations between activities

In Figure 26 we have illustrated the relations between *grocery shopping*, *shopping without the intention of buying* and *shopping for one expensive item.* During the *preparation for grocery shopping* activity, a shopping list is created. This shopping list is needed in the *grocery shopping* activity. This is shown with a solid arrow. Therefore there is a relation between these activities. The *shopping without the intention of buying* activity can be interrupted by the *grocery shopping* activity, as previously mentioned in the examples. This is indicated by a dotted arrow in order to distinguish it from a relation.
Whenever a *relation* or *interruption* between activities is identified the developer must consider whether the change in activity should result in an *automatic execution of a service* or another *presentation of relevant information* is needed.
An example where it could be beneficial to interrupt the current activity is when a user is *shopping without the intention of buying* and he is passing a post office and his shopping list includes a stamps. The system should suggest that he buys the stamps now.
Also the idea of automatically showing the shopping list, when entering for instance Bilka would reduce the interaction needed with the digital shopping assistant.

By going through all of these considerations we believe that the developer will be in a much better position for implementing context-awareness in an application. But we are also of the belief that the analysis using this list should be complemented by developing prototypes and evaluating these at an early stage. We believe that evaluating prototypes with users gives invaluable feedback, which cannot be found during an analysis.

7 Conclusion

During this semester we have engaged in some of the challenges within context-aware mobile information systems. The scope led to two research questions which we will answer in the following section. We will also answer the problem definition. Subsequently we will discuss some of the limitations related to our work as well as present ideas for further work.

7.1 Research questions

7.1.1 Research question 1

What are the challenges and solutions in determining the location of the user in an indoor environment?

The first challenge encountered was to choose which technology to use. In order to choose this technology one must thoroughly consider which criteria the development is dependent on. This set of criteria will decide which challenges the developer will face. Based on an article study we elaborated a table, which can be used as guidance for choosing a suitable technology given a set of criteria. The biggest challenge encountered was accuracy. However this is dominated by two dependent criteria; Price and available development time. We choose to use W-LAN, which poses a number of challenges. The hardware is not designed for this specific purpose and the radio signals are far from reliable. They create large variations in a static environment. This makes triangulation difficult and therefore a learning based approach was taken. We have achieved an accuracy of 4 meters, which makes user orientation and speed virtually impossible to determine. Nonetheless we choose a simple approach and used a simple algorithm for determining the user's location, compared to other complex mathematical approaches.

7.1.2 Research question 2

How can requirements for a context-aware shopping assistant be identified?

To get a broad perspective on this question we choose to use three existing software development methods; M.U.S.T, Contextual Design and eXtreme Programming for requirements elicitation. These methods were divided among the members of the group, who each developed a version of a context-aware digital shopping assistant, which were evaluated by users. Since we were unaware of how context-awareness requirements should be identified by each method, we choose to thoroughly investigate all problems encountered. Some problems were encountered, but these were not related to context-awareness. The majority of the problems encountered were related to mobility. Each method provided us with set of requirements that defined what *relevant* information was in the context of shopping. Each set of requirements were combined into primary and secondary requirements for a shopping assistant. However, none of the requirements made the digital shopping assistant *context-aware.* On the contrary, we discovered that the developed prototypes were only *location-aware,* by using a categorization-technique of context-aware systems provided by Dey and Abowd. Based on this discovery, it became apparent that we needed a technique that would enable a developer to consider more thoroughly how context-aware capabilities can be used in the applications. We elaborated a technique that is capable of bringing focus to the *activities* that the user is engaged with. This technique allows the developer to consider whether some activity should demand a *presentation of context* or the *automatic execution of a service.* This contribution remains unverified.

Problem definition

What are the challenges in the development of a specific context-aware mobile information system?

In this project we have used a case study as basis for developing a *digital shopping assistant*. We have focussed on two challenges; locating the user in an indoor environment and requirements elicitation for a context-aware digital shopping assistant.
In developing an indoor positioning system using W-LAN we encountered several challenges. The main challenge was set by the case. Having a populated indoor environment makes it hard to achieve accuracy since the hardware is not designed for this specific purpose and the radio signals are far from reliable. They create large variations even in a static environment. This makes triangulation difficult and therefore a learning based approach was taken. We have achieved an accuracy of 4 meters, which makes user orientation and speed virtually impossible to determine. For the task of developing a shopping assistant-prototype the accuracy is sufficient, however we believe that there will be a need for better accuracy in the future. The challenge of improving the accuracy is not up to the software developers. The hardware industry has to acknowledge this need, and produce hardware specifically designed for this purpose. More importantly, they have to develop positioning technologies that support a wide range of existing mobile devices, in order to promote the development of more context-aware information systems.

We have also focussed on requirements elicitation for a context-aware digital shopping assistant. To get a broad perspective in this area, we choose to use three existing software development methods; M.U.S.T, Contextual Design and eXtreme Programming for requirements elicitation. We developed three independent set of requirements and prototypes using the three methods. In our work we discovered that that the methods actually provided us with knowledge on what is *relevant* information in the context of shopping. However none of the prototypes included enough context-aware capabilities, they were only location-aware. The methods all used participatory design, and it was very beneficial in uncovering what is *relevant* for the user in the given context. However they did not provide us with sufficient knowledge on how to use context-aware capabilities to *limit* the amount interaction on the mobile device. We elaborated a technique that is capable of bringing focus to the *activities* that the user is engaged with. This technique allows the developer to consider whether some activity should demand a *presentation of context* or the *automatic execution of a service*, which can be used in conjunction with existing development methods, for uncovering context-aware requirements.

7.2 Limitations

This section will discuss some of the limitations in this project.

We wanted to explore how well existing participatory design methods coped with the task of making a context-aware shopping assistant. This was done by using three existing software development methods for requirements elicitation and development of prototype. Each method was unknown to us from the beginning and the first task was to gain an understanding of the method. This presented difficulties during each separate development process and it is likely that it would have helped, if there were more people working on each method. Due to the limited timeframe and because we wanted the development done undependably, this was not possible.
Secondly each method was depending on user participation and due to the limited timeframe, it was necessary to delimit the amount of users. Having more users and a more diversified group of user, would likely have helped discover more aspects and problems that the users endure while shopping. All the users who participated in the development had something specific they wanted added. Having more users is likely to have revealed even more requirements, which would have aided in creating a better digital shopping assistant. We found the requirements based on qualitative user participation. Quantitative research methods would most likely reveal additional requirements, however there is still a need for prioritizing the most important ones.

Each method resulted in a prototype based on the primary requirements. Having continued the work to a second iteration of prototyping or even further is also likely to have helped discover additional requirements or aspects of context-awareness that should be included in the digital shopping assistant. However, the three list of requirements obtained, indicated that we have found 4 essential requirements.

The participants were not aware of the full potential of context-aware mobile information systems, since there are no role models in their perception of IT-Technology to guide the ideas toward a digital shopping assistant. This was not optimal and the users that was used in the evaluations should have been thoroughly explained how a PocketPC works and which possibilities can be provided by adding context-awareness. This would likely have provided us with more requirements.

7.3 Further work

7.3.1 Addressing shortcomings of the three methods

Throughout this project we have developed a digital shopping assistant using three existing development methods. We have identified a number of shortcomings within different areas of each method, when it comes to developing mobile information systems. These shortcomings existed primarily because we developed for a mobile device, which is related to a high degree of user movement. We also discovered that the methods did not aid us in making the shopping assistant context-aware. Further research within the development methods we used must be conducted to address the shortcomings.

7.3.2 Activity, Time and Why

During this project we have mainly focused on *identity* and *location*, which is only a part of context. Further work could be conducted in *activity, time* and *why*. A study in this field is likely to introduce new obstacles/findings, which should be elaborated.

7.3.3 User requirements

We have collected the user requirements from a digital shopping assistant based on shoppers' requirements. A finished product would contain requirements from other users. Among these are the stores employees and the mall owners. It is likely to present a new range of problems if work was conducted in order to elaborate these users' requirements.
During this project we have taken advertisements for granted. This is not investigated and some stores might not want their advertisements in the system, because it is too difficult to create them or they do not regard it is worth the effort. Findings like these could be a major setback for a digital shopping assistant.

7.3.4 Guidelines

We have discovered that context-awareness is not a set of rules, which can be combined with existing methods, but we are confident that our guidelines will help developers go further in developing context-aware application. Nevertheless we believe that the best overall approach is to test prototypes in the context and examine where the application should execute and/or present information for the user. A combination of our guidelines and prototyping might prove time saving. Further work in this study is be possible.

7.3.5 Collecting requirements

We have mainly worked on collecting requirements for a context aware mobile shopping assistant. Our process stopped at the evaluation of the prototypes, which was not done in the context. Our work could be continued by developing better prototypes and testing these in the context. This is where the challenge of collecting the requirements for context awareness is occurring.

7.3.6 Evaluation

There is a general issue with evaluating applications for mobile devices. The majority of the participants used through the development with the three methods, did not have any experience in using and controlling such devices. Although we only evaluated the prototypes with regards to functionality, it became apparent that some users had problems understanding and controlling the device. It indicates that instead of focussing on the actual application, the user was focussing on controlling the device. This can prevent the developer in getting the feedback he is interested in. On the other hand, if the focus is on usability, it can be an advantage to evaluate with an inexperienced user. This dilemma could be explored further.

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Mobile HCI provides a forum for academics and practitioners to discuss the challenges and potential solutions for effective interaction with mobile systems and services. It covers the design, evaluation and application of techniques and approaches for all mobile computing devices and services. MOBILE HCI started as an international workshop (held in Glasgow in 98, in Edinburgh at INTERACT 99, in Lille at IHM-HCI-2001). Due to its continuous growth, it successfully became a full conference with the 2002 edition (held in Pisa).

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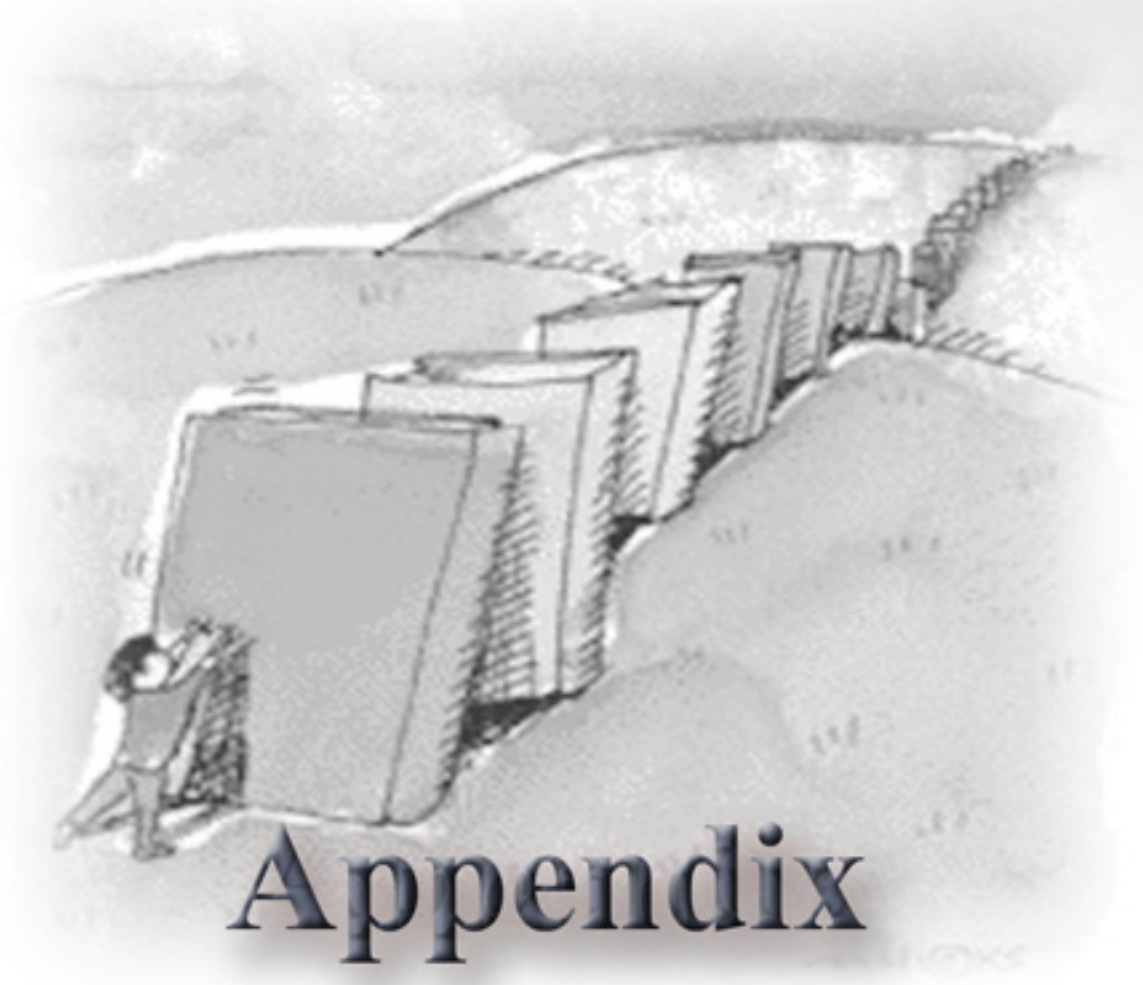
Ekahau's software-based positioning and site survey technologies are based on over 10 years of research. Unlike the competing positioning technologies, Ekahau does not apply propagation or triangulation methods that suffer from radio wave multipathing, scattering, and attenuation effects. Instead for collection of radio network sample points from different site locations is used. Each sample point contains received signal intensity (RSSI) and the related map coordinates, stored in an area-specific Positioning Model for accurate tracking. Ekahau offers accuracy of: Up to 1 meter (3½ feet) average accuracy (indoors, 5-7 access point signals, no interference). Up to 2-3 meter (10 feet) average accuracy (indoors, 3-5 access point signals, no interference).

Challenges in context-aware mobile information systems:

A digital shopping assistant



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Appendix A - The MUST method

A.1 Method description

The M.U.S.T. method is developed by Keld Bødker, Finn Kensing and Jesper Simonsen and is described in the book “Professionel IT-forundersøgelse” [Bødker et al. 2000].
The method is aimed at IT-designers and others with IT-qualifications, who are planning and carrying out a preliminary study. An IT preliminary study stretches from the first idea for a change in the company until there is a carefully prepared vision for the complete change at hand. The result of a preliminary study can be both reports and prototypes.

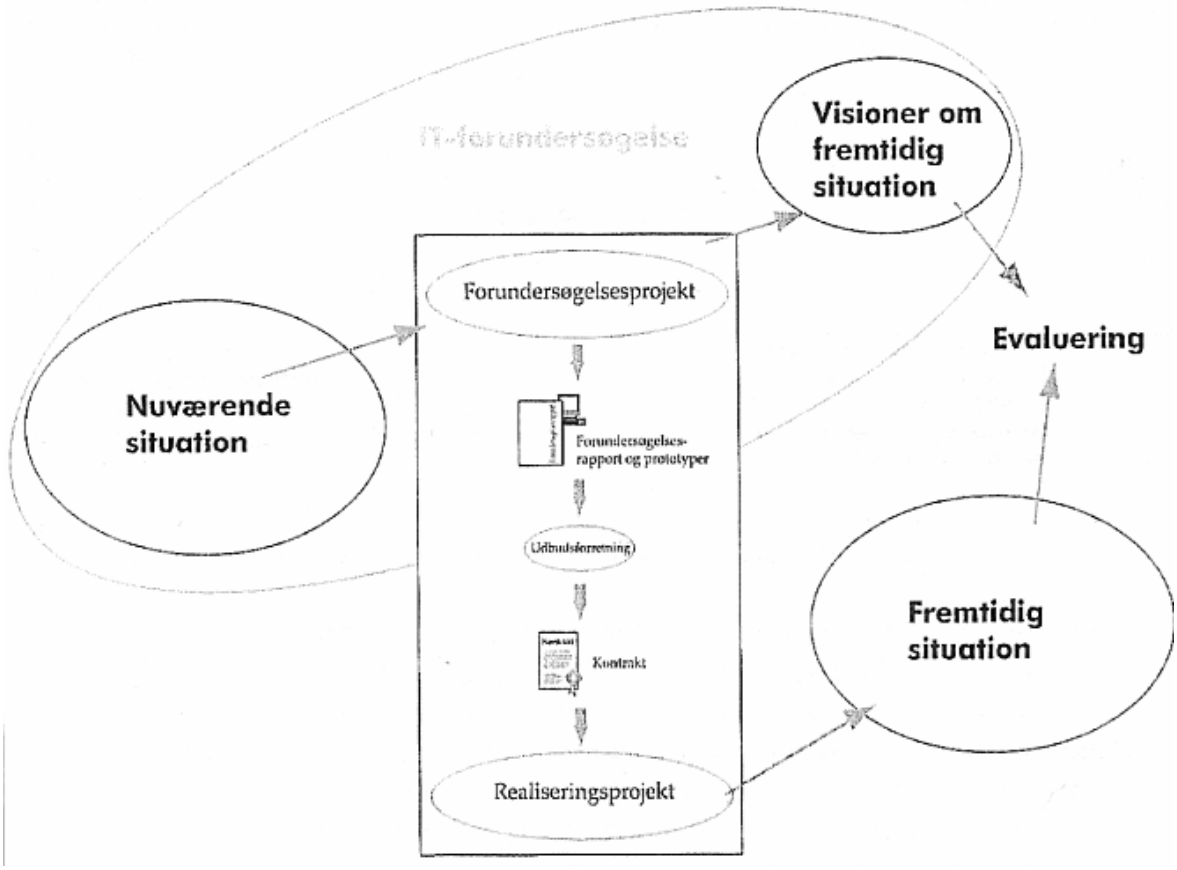


Figure 1 Role of the preliminary study in an IT-project

The method describes some important elements in the preliminary study. It also provides four principles which the preliminary study must incorporate. The four principles are:

- The principle of a joint vision – Must see how an IT-project can influence all parts of the organization.
- The principle of real user-participation – Representatives of the future of the users must participate in the study.
- The principle of work must be experienced – To gain an understanding of the work the best way is to experience it first hand.
- The principle of anchoring – Is about informing and creating understanding for the goals, visions and plans.

The M.U.S.T. method is divided into four phases which the preliminary study can be organized into and planned after. Each phase consists of several activities.
The four phases are: The preparation phase, the focus phase, the absorption phase and the innovation phase. Each phase is described further in the following:

A.1.1 The preparation phase

The purpose of the preparation phase is to clarify and create commitment about the starting point and the conditions for the preliminary study.

This is done by following some of the activities listed below

- Plan the preparation phase
- Create an overview
- Define the task
- Identify the critical factors
- Clarify the focus phase
- Organize the project
- Select participants
- Map interested partners
- Start the anchoring of the project
- Establish the project group socially
- Formulate the basis of the project
- Plan the course of the project

The activities in the preparation phase aims at getting the whole preliminary study well started. The result of the preparation phase is a project foundation and a plan for the rest of the preliminary study. The result of the preparation phase is documented in a short report which among other things includes a description of the background and argumentation for performing a preliminary study. The report should also include a description of the study including the questions the study should clarify as well as how the preliminary study should document the findings, for instance in a report, as a requirements specification or prototypes. But the preparation phase should also clarify factors such as economic and technical limits, critical factors, resources and who might also be affected by the IT-project.
The technique which is suggested for planning is “baseline plan”, which is a certain way of presenting the different task at hand. To get an overview document analysis, freehand drawing of certain workflows and interviews are suggested. The definition of the task is often done by using discussion and negotiation. If it is necessary some key persons in management can also

be interviewed. To support the task of identifying the critical factors the method suggests using SWOT analysis.

A.1.2 The focus phase

The purpose of this phase is to identify and clarify the situation, the surroundings and the business strategy of the company.

The activities that can be used in this phase are:

- Analysis of the surroundings
- Analysis of the business strategy
- Analysis of the IT strategy
- Innovative technology analysis
- Select the work areas of the project
- Formulate a strategy analysis rapport

The focus phase includes an identification and analysis of the company's surroundings, such as customers, suppliers and competitors. The result is a strategy analysis report, which summarizes and prioritizes the work areas the rest of the preliminary study should focus on.

The techniques used in the analysis could be document analysis, interviews with representatives as well as SWOT and function-analysis.

A.1.3 The absorption phase

In this phase the purpose is to prioritize the goals, problems and needs for the innovation phase. This is done by examining the chosen work areas and understanding the current work practice. In this phase the principles of work must be experienced and real user participation are important.
The motivation for examining current work practice is that the ways things are done now is often relevant to the IT-design.

The activities in this phase include:

- Plan the absorption phase
- Data-collection
- Analysis
- Presentation
- Consider revising the focus for this phase
- Report

One of the key elements in data-collection is to experience work practice, the primary technique for this is observation. As observation is very resource demanding it is often beneficial to single out the work situations where observation would be most beneficial. Techniques for selecting the work situations could be interviews supplemented with

document analysis. But in situations were the project group has the needed overview of the work process, a workshop with the members of the project group can be used instead. The results of such a workshop are work situations that it would be most beneficial to examine further through observation, in-situ interviews or think aloud experiments.
In situations where it is not possible to use observation, techniques like think aloud experiments and incited reflection can be used.
The analysis will partly be done in the head of each member of the project group and partly in common like workshop with an analytic aim. The M.U.S.T. method recommends the following guidelines when performing the analysis:

- Keep on to the primary information.
- Make data, considerations and results visible.
- Involve the company or the department in the considerations not just the results.

The activity called presentation is about preserve the results of the considerations done in the analysis. This is often done on workshops where all the collected data is analyzed and grouped or split into different subjects according to the focus for the preliminary study. Finally the project group makes a report which summarizes essential characteristics of the work practice and lists goals, problems and needs found as well as ideas to solutions.

A.1.4 The innovation phase

The innovation phase is the end of the preliminary study. It is in this phase the project group develop the visions about the complete change. This includes the IT-system's function, interface and technical platform as well as the organization of the work and the qualifications needed in the employees. The innovation phase also includes an assessment of the advantages, disadvantages and costs which the visions would have for the company. This phase gives the decision makers a foundation on which to make the final decision on whether or not the project should be carried out.

The activities in this phase are:

- Plan the innovation phase
- Market survey
- Develop and collect ideas
- Mock-ups and prototypes
- Mapping of qualification needs
- Analysis of consequences
- Strategy and plan for the realization
- Report

The planning of this phase is done by using baseline planning. By doing a market survey it can be determined if there are any systems on the market that can live up to the needs found in the absorption phase. This can be done by reading sales material and reviews or by visiting

other companies that is somewhat similar to the current one. Next step is to get the systems demonstrated preferably in realistic surroundings with real data in order to get better grounds for the evaluation. This could be followed by an exchange of experiences about the introduction of system, problems, advantages and such.
For the activity of developing and collecting ideas the workshop is the preferable technique. The starting point can either be ideas and demands for the organization of the work or demands to the technology. The choice is often governed by the management. In both cases techniques such as virtual mapping, drawings, collages and scenarios can be used in the process of developing and documenting ideas.
Following the activity of developing and collecting ideas it can be very beneficial to experiment with mock-ups or prototypes since they are very effective techniques to visualize and simulate chosen parts of the visions IT-systems. Paper based mock-ups can be used as a tool in workshops that simulates solution to specific tasks. Prototypes are often used when the preliminary study is pointing at developing new IT-systems instead of using standard systems. For both prototypes and mock-ups it is important that the testing is done in as realistic surroundings as possible in order to give the best result.
The mapping of qualification needs is an activity that ensures that the future users gains adequate qualifications to use the new technology. The result of this activity should be a complete plan for the education needed.
As for the analysis of consequences the purpose is to map and document the advantages and disadvantages that is can be seen at this point of the project. The starting point for this activity could be the description of the proposed systems and the scenarios for the use.
As a result of the prior activities in this phase a strategy and a plan for the realization of the visions should be made. This should include risk management, how the project might be divided into smaller parts, how these parts depend on each other and other. Often the baseline plan is used as a mean of documentation.

The result of the complete preliminary design is a report and possible a prototype which can be used in an invitation to submit tenders.

A.2 Development using the method

This section will describe the collection of user-needs using the activities described in the M.U.S.T. method. The M.U.S.T. method is developed by Keld Bødker, Finn Kensing and Jesper Simonsen and is described in the book “Professionel IT-forundersøgelse”. The goal is to create a prototype that can be evaluated.
Because of the limited time at hand and the nature of the project, the analysis will be based on a workshop, which purpose is to “develop and collect ideas”, which is one of the primary activities in the fourth phase of the M.U.S.T. method, the innovation phase [Bødker et al. 2000: p183-208]. The purpose of the activity “develop and collect ideas” is to take the ideas identified during the former activities and collect and further develop these. As the activity has been taken out of the original context of the M.U.S.T. method, there are no former activities. This analysis will be based solely on ideas produced on the workshop. Subsequent a prototype will be developed from the specifications identified during this workshop. This will be elaborated further in the sections design and implementation.

A.2.1 Preparation

The M.U.S.T. method does not offer any specific guidelines for selecting the participants for such a workshop, although it does specify some suggestions for the members of the project group. The members of the project group should be users of the future system with some experience in the field that the preliminary study is covering. They should also have the respect and trust of their colleges and be very engaged in the project at hand. The last suggestion is that they must neither be very fascinated nor afraid of new technology [Bødker et al. 2000: p119-121]. For the workshop activity the M.U.S.T. method also suggests to involve other users that are not in the project group [Bødker et al. 2000: p197]. Given the task of designing a prototype for shopping assistance using some mobile technology five participants were selected and their demographics are described below.

The preparation for the workshop primarily consisted of coordinating with all participants on a day to perform the workshop and getting a room.
A couple of days before the workshop a small questionnaire were created in order to get some demographic data about the participants. A short presentation about the context for the workshop was also prepared in advance in order for the participants to better understand the task ahead. This were done so that the participants had a better chance of understanding the context of the workshop and also what was expected of them.

A.2.2 Demographics

The data was collected with 5 participants. The participants were selected as typical shoppers with no special knowledge of the method or technology.

Participant	Age	Sex	Shopping	Grocery shopping
A	24	Male	3-4 times a week	2-3 times a week
B	22	Female	2-3 times a week	2-3 times a week
C	62	Male	1-2 times a week	Once a week
D	54	Female	Every 2nd week	3-4 times a week
E	28	Female	Once a week	3-4 times a week

Table 1

A.2.2.1 Participant A

Participant A is a 24 year old male who lives with his girlfriend in the centre of town. His is a student of Aalborg University, where he is studying communication. When he shops it is often when he passes by the shop on his way to some other destination. It is mostly in the centre of town near his home.

A.2.2.2 Participant B

Participant B is a 22 year old female living downtown Aalborg with her boyfriend. She is studying to become a nurse. She often shops when she has some time to pass with her friends, for instances the waiting time between busses.

A.2.2.3 Participant C

Participant C is a 62 year old male living in suburbs of Odense with his wife. He is working at a pharmacy in a large shopping mall in Odense. He primarily shops when he is in “city”, but also as a part of his grocery shopping.

A.2.2.4 Participant D

Participant D is a 54 year old female living in the suburbs of Odense with her husband. She is a School teacher. When she shops she does it as a social event, with her husband or as a mean to get away from the daily chores.

A.2.2.5 Participant E

Participant E is a 28 year old female living near the university in Aalborg with her boyfriend. She is studying to become a schoolteacher. She shops both in "city" and in shopping malls. Often it is only Window-shopping.

A.2.3 Location

The workshop took place in a seminary room at Aalborg Universitet between 12.30 and 16.00 April 26. 2004. The seminary room was chosen because of the size. But it was also chosen in order to have access to white-boards and to avoid distractions that might occur, if the workshop were held at home.

A.2.4 The workshop

The M.U.S.T. method describes several techniques that can be used during the workshop. For the task of describing the current work practice it suggest using drawings, collages or scenarios. But none of these seemed sufficient in describing the task of shopping. Since the goal of the workshop was to get a prioritized list of ideas to be implemented in the prototype it was chosen to document the workshop by writing down a summary during the workshop. This was done by the IT-designer.

The workshop was divided into 3 parts. Each part had a different topic. Table 2 gives an overview of the course of the workshop. All participants in the workshop were present during the whole workshop and their only job was to discuss the different topics.

Part	Topic	Time estimated
Part One	Introduction to the workshop. Discussion about shopping today.	1 hour
Break		10 minutes
Part Two	Problems with shopping today and ideas on how to a PDA	1 hour

	application (shopping assistant) could benefit the user.	
Break		10 minutes
Part Three	Identify design criteria for a prototype. Discuss preliminary design ideas.	1 hour

Table 2 Overview of the workshop

A.2.4.1 Part One

In the first part of the workshop the participants were introduced to the workshop and how the day should progress. This was followed by a short questionnaire in order to get some demographic data about the participants.

Following these introductive topics the workshop focused on how shopping were done today. It quickly became clear that the participant all had a similar understanding about the term shopping. It was divided into two different types of shopping, ‘grocery shopping’ and ‘regular shopping’.
The term ‘grocery shopping’ covers the everyday shopping at a supermarket or grocer. The one doing the shopping often has a shopping list with all the items on it. On the other hand ‘regular shopping’ covers the more spontaneous form of shopping, were one does not has a specific purpose for the shopping. When doing grocery shopping the participants agreed that they would go to some extend to avoid regular shopping. This is done in order to avoid spending to much money on stuff not really needed and is done by for instance limiting the grocery shopping to once a week and then buying as much as possible at this time and only what is already on the list. Another reason for avoiding regular shopping is the time factor. Many sees the grocery shopping as something that needs to be done quickly and without to many distraction. It is described as a boring and tedious chore that would be nice to avoid. The shopping list is often used as a tool to avoid the distractions when doing the shopping. The shopping list keeps the on doing the shopping focussed on what is needed. The shopping list is prepared at home and lists the grocery needed. Some of the participants expressed that they used advertising folders when preparing a shopping list and some did not look at these at all. Some of the participants also used advertising folders as a sort of entertainment, which they browsed through as soon as it arrives.

On the other hand regular shopping is something one chooses to do. There can be many reasons for going shopping. Some does it to spend time, for instance when waiting for a bus, others goes shopping as a mean to get away from the daily chores. The participants all agreed that shopping often were made into a trip. A shopping trip often includes lunch or stops at a café for beer. Shopping trips are often planned several days in advance and is described by the participants as enjoyable and something they like doing. Shopping is often with the purpose

of getting some specialized commodity, such as clothes, a TV or other non-grocery commodities. The participants are more willing to spend time shopping and they do not need to buy something straight away, but spends more time considering whether or not the item is needed.

The participants all thought that they were easier to influence when they were doing regular shopping than doing grocery shopping. This was properly a result of the nature of the grocery shopping, which is often done in a rush without time for interpreting the advertisements and also to some extend the mood one was in when doing grocery shopping. As mentioned before, grocery shopping is an event that needs to done as quickly and as cheap as possible as it is often considered a tedious chore.

A.2.4.2 Part Two

The second part of the workshop focused on the problems with shopping today and ideas on how a PDA application (Shopping assistant) could benefit the user. This was done by performing a joint brainstorm and afterwards discussing the topics found. Ideas on how the shopping experience could be improved with a digital shopping assistant were also discussed.

During this part the following ideas were suggested. They are not listed in any particular order.

- Shopping list

  A shopping list that could be made on the main computer at home and then transferred to the PDA before the shopping began. The shopping list should be able to be ordered by price, placement of the item in the store or number of shops needed to visit to get all the items on the list.
- Individual advertisements based on profiles

  It would be OK to receive advertisements on the PDA as long as they were based on the individual profile of each shopper. This means that the shoppers only want advertisements for something they have an interest in. The advertisements could for instance be daily offers that are not shown elsewhere.

  It is important that the application include a filter so it can be turned off.
- Guidance to the offers

  When the PDA showed an advertisement or a special offer it should include some visualization of where the offer could be found. This could be with some textual description or visualization of the route from the current position of the user to the shop that has the offer. This could also include distance and walking time. It would

not be necessary to include this information as standard, but it should be possible to get very easily.

- Offers should either come as the shopping area was entered or when outside the store

  Some of the participants in the workshop also expressed that they would rather receive the personal offers when entering the shopping centre or area instead of when passing the individual store. This was a concern as the participant wanted to plan the shopping experience ahead.

- Waiting time at the queues

  This feature was primarily thought of when the system was used in big supermarkets like Bilka and such. The PDA should indicate the current estimated waiting time at the queues. That way the shopper could choose whether or not to continue shopping or leave now.

- Price comparison

  One feature that really was appreciated by all at the workshop was to have some sort of price comparison function. That way when the advertisements are shown the shopper could quickly asses whether the offer really are cheap or not. This could be very much like the price comparison databases on the internet.

- Product information

  There should be a way of getting product specification on the PDA, for instance specifications for the TV. It is not always possible to get all the facts from the single article or the description next to it.

  The product information could either be shown after selecting the item from a list or by entering some product code. The PDA could also include a barcode scanner of an RFID reader. It should also be possible to store the product description on a sort of quick access list, so that it would be easy to compare different brands of products.

- Calling for assistance

  This feature should make it easy to call a shopping assistant to the area in which the user is. This is often needed in large supermarkets where there are few assistants compared to the size of the shop and the number of customers. The feature might even make it possible to specify the type of assistance needed, so that the right shopping assistant would come. For instance when the user need some help with the specification for a computer a shopping assistant with knowledge about computers could be requested.

- Virtual number system

  The virtual number system should function alongside the number systems that are used today. But instead of staying in the store until it ones turn, the system should

alert the user when his or hers number is next. This system would primarily apply to shops where there can be long queues like post offices, ticket sales or pharmacies.

- Very important that the customer gets an advantage

  The participants in the workshop all agreed that it is very important there are some advantages for the user of system in order for it to be used and be successful. These advantages should primarily be economic. This could be special offers that only appear on the system and not to others.

A.2.4.3 Part Three

In the third part of the workshop some design criteria for a prototype were identified. The criteria were split into two, general usability criteria and criteria for which functions the prototype should include. The criteria for functions were found through a discussion on which of the suggested idea would be best and how they should be prioritized. The prioritized list is shown below.

1. Personalized advertisements with a possible filter
2. Way-finder to specific offers
3. Product information
4. Price comparison

The general usability criteria were briefly discussed, but since the workshop participants didn't have much knowledge on PDA's and how they worked the criteria listed below cannot be taken as a complete list, but merely as some suggestions, that the participants found appropriate.

- Interaction of the PDA must not be to small
- One hand interaction of the PDA
- Perhaps no need for interaction when shopping
- Storage of the PDA

It was primarily the older participants in the workshop who expressed that the operation of the PDA should not be too small. This might be because of poorer eyesight or because they are not as used to this kind of technology.
All the participants agreed that since shopping is an eyes and hands busy task, the operation of the PDA should possible with only one hand and since the device should be context aware it might be possible to avoid the need for interaction when shopping. This would be much preferable for the participants.
There was some concern about having the PDA with, when shopping. The main problems were what to do with the PDA, when it was not needed. You would have to use this in a quite

different way than the way most people use a for instance a shopping list today. Often when the shopping list is not needed it is just put in a pocket without much concern about how or if it gets damaged. This would have to change, with a PDA. All the participants expressed however that they would do so, if the gain was big enough.

A.2.5 Design of the prototype

The only help with design the M.U.S.T. method offers is in the activity experiment with prototypes. Here the M.U.S.T. method suggests that the project group makes mock-ups and experiments with these. The idea is to implement the functionality identified in the analysis. The design is done by creating some paper mock-ups and experimenting with these until the shown design is found.

Figure 1
Mock-up of the Main screen

Figure 2
Mock-up of Map screen

The mock-ups shown above are the main screen and the map screen. Since the participants in the workshop expressed that they would like to be able to navigate the through the application with just one hand, the buttons are made as big as possible. The philosophy behind the Main screen is to provide easy access to the different parts of the application. The four button on the Main screen each leads to a new screen.

The first button “KORT” leads to the Map screen shown in Figure 1. The map screen should show different things depending on the prior action. If the prior action was to select the “KORT” button on the Main screen the map shows the user’s current position. If the Map screen is shown as a result of the “Vis på kort” button on the advertisement or the Price Comparison screen, the map should highlight the actual shop. This is done with a different colour than the background. The map is clickable, so that the user can click on any given shop and get its name. The name will be shown below in a textbox. The map is also moveable so

the user can view different parts of the shopping centre. The “LUK” button at the bottom right should lead back to the Main screen.

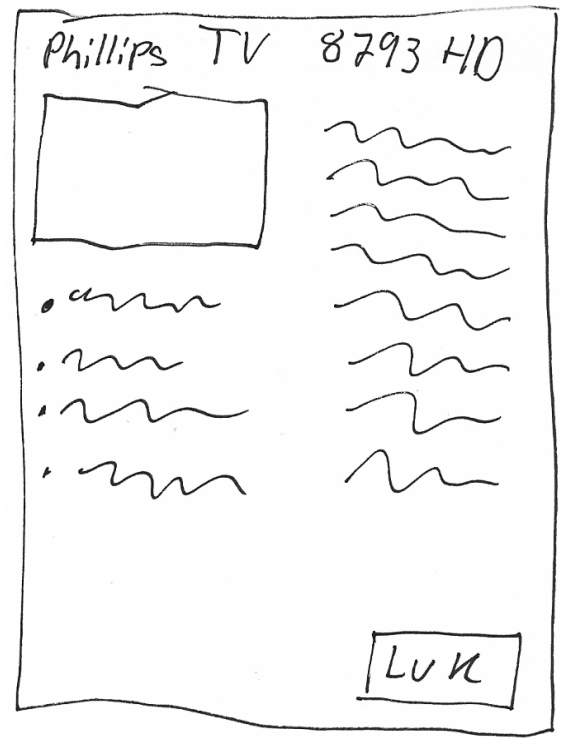


Figure 3
Mock-up of the Product Information Screen

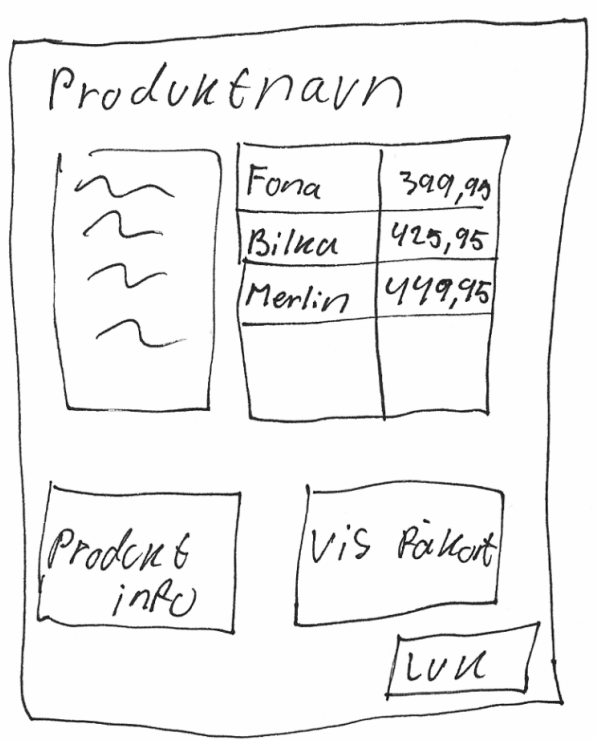


Figure 4
Mock-up of the Price Comparison Screen

The Figure 3 above shows a mock-up of the Product Information screen. This screen features the name of the current product at the top. Just below the product name there is a picture of the current product, in order to help the user identify the product in the store and give him a way of see the design. Below the picture should be a list of facts. On the right is a textual description of the product. The text on the page should be sufficiently big so the user easily can read the text. As with the Map screen the “LUK” button returns the user to the Main screen.

The mock-up in Figure 4 shows the Price Comparison screen. This screen also has the name of the current product at the top. On the right hand side of the screen there is a table showing all the shops that has this particular product and what the price is in each shop. Selecting a shop in the table gives a short textual description to the left. This could be information about the shop such as different warranties or other advantages the shop offers. By selecting a shop in the table the button “Vis på kort” appears under the table. This buttons takes the user to the Map screen and highlights the selected shop on the map. The button “Produkt Information” takes the user to the Product Information screen, which will show the user more about the product.

Figure 5
Mock-up of the Advertisement screen

The Advertisement mock-up in Figure 5 consists of a title line that indicates that this is an advertisement. Below there is room for a picture or video showing the product in question. The lower part of the screen consists of a textual description of the product and the location of the store that has the offer. At the bottom is three buttons. The “Produkt Information” button takes the user the Product Information screen, which will show more about the actual product. The “Vis på kort” will show the Map screen and highlight the shop that gives the offer. The “LUK” button leads the user back to the Main screen.

A.2.6 Implementation of the prototype

The implementation was done in Visual Studio .NET 2003 in the language C#. Below the actual implementation of the mock-ups from the design is shown.

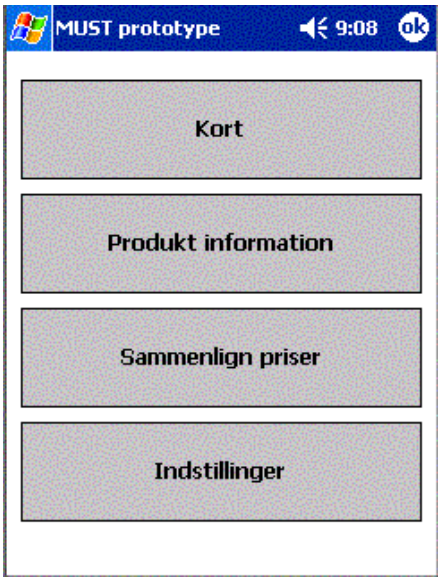


Figure 6 The main screen

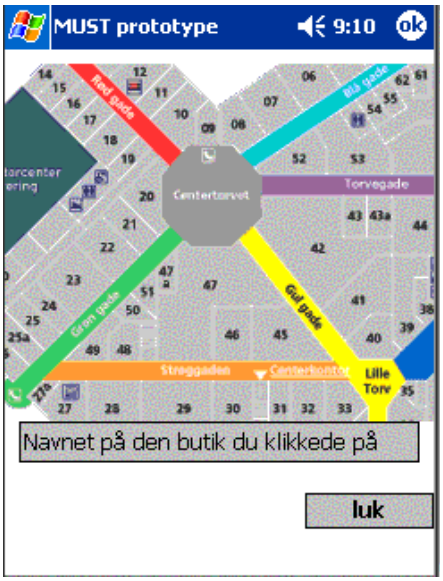


Figure 7 The Map page

Figure 8 Product selection

The only new thing added between the mock-ups and the actual implementation is the Product selection screen shown in Figure 8. This screen was necessary in order to select the actual product in both Price comparison and product information. As this screen does not actually reflect a user need there were no mock-up of this. The screen suffers in the way that the navigation this screen is somewhat difficult because the standard elements used could not be resized. Furthermore some of the selections should be made based on available context-information. This would be possible in several ways. For instance knowledge about the area in which the user is situated could give a clue about what products he is looking at.

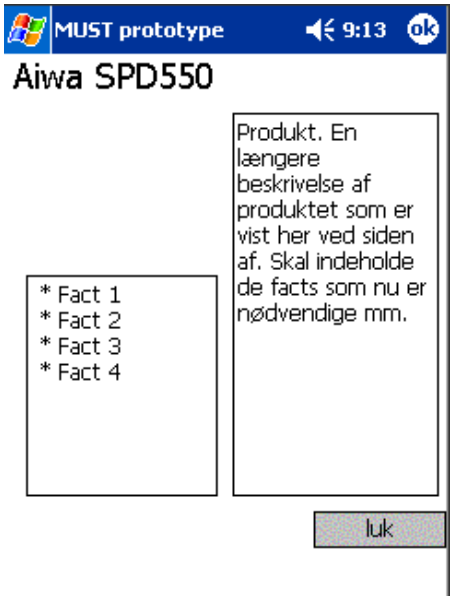


Figure 9 Product information

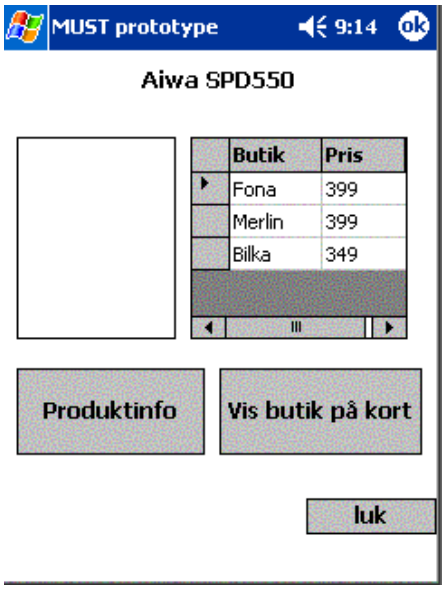


Figure 10 Price comparison

Figure 11 Advertisement

There were some compromises made between the mock-ups and the actual implementation. The main problems were with fitting all information on the screen and still having big enough buttons and text for one hand operation. Also some problems with certain components of the Visual Studio created a difference between the mock-ups and the actual implementations. These are primarily cosmetic and will still give the basic idea about the functionality.

A.3 Diary

Date: 15/3 - 10/4

Phase: Gaining understanding of method

Participants: IT-designer

Initial understanding: It is a method that can help designers and decision makers in describing an IT-system.

Work performed: Reading the method and a considering how to use it.

Time usage: 10 days

Actual understanding: It is a very extensive method, that focuses on if and how a possible new IT system can and should be used in the organization. It consists of several phases and each phase has a set of activities, which can be used to get an understanding of the phase. The four phases in the preliminary study are the preparation phase, the focus phase, the absorption phase and the innovation phase.

Applicability of outcome: Cannot be determined at this point.

Reflection: During the attempt to understand the method it is very difficult to imagine how the method should be used in a real case. Many of the chapters seem irrelevant for this case.

All the chapters on strategy analysis cannot be used when the system is not developed for an organization of some sort. This makes it very hard to find a starting point for the process.

Furthermore the fact that the whole method is based on all work should be done in teams, makes it even harder to use it, since the IT-designer won't have anybody to discuss findings and problems with.

The innovation phase seems like the most appropriate for our case. It includes some activities for identifying and developing ideas and prototypes. These are the "develop and collect ideas" and "experiment with prototypes".

The activity “develop and collect ideas” will be used as the primary activity for identifying user needs. The activity suggests the use of a workshop to get the information and this sound like a good approach. In a workshop it would also be possible to integrate some of the intentions of the prior phases of the preliminary study.

Planned progress tomorrow:

Misc.: Additional notes or thoughts. Materials from today’s work can be included.

Date: 11/4

Phase: Finding test participants

Participants: The IT-designer

Initial understanding: According to the method the participants for the workshop should be the members of the project group currently engaged in the preliminary study. These members should be persons which should be using the system that are being developed. So the initial understanding is to get 4-5 persons who all shop regularly.

Work performed: Contacting possible test participants and coordinating on a date on which the workshop could be held. The contact were made be phone or in a single case by asking directly. Since two of the participants did not live in Aalborg it mostly depended on when they could come to Aalborg. They had already planned a trip to Nordjylland on the 23-25 / 4 – 2004 so it was decided to hold the workshop on 25/4 – 2004.

Time usage: About an hour were used for contacting all participants.

Actual understanding: No problems with the initial understanding encountered.

Applicability of outcome: None in this phase.

Reflection: All the selected participants know each other and are selected for that reason. This is done in order to reduce the time the participants might need to become comfortably with each other and the situation. This is also a part of the M.U.S.T method (establish the project group socially). Some considerations have gone into the fact that none of the participants are especially focused on new technology and therefore might have problems seeing some of the potential of context-aware mobile systems. These considerations however have not been found to be a major concern since the participants thereby represents the major part of the future users and the method explicitly write that the participants should neither be very interested nor afraid of new technology..

Planned progress tomorrow: The next step is preparation for the workshop. This will be done a couple of days before the actual workshop. This includes creation of a small questionnaire to get some demographic data about the participants, creation of an agenda for the day, room reservation and preparation of a small introduction.

Misc.: Additional notes or thoughts. Materials from today's work can be included.
Date: 23/4

Phase: Empirical data collection

Participants: IT-designer.

Initial understanding: Even though the method does not describe an actual preparation before the workshop the IT-designer felt that it was necessary to introduce the participants to the overall project and the workshop activity. Further more in order to get some demographic data a very short questionnaire would be good

Work performed: An agenda with a short description of each part of the workshop and a questionnaire with questions about age, place of living and a couple about shopping were made.
The agenda includes three parts which seems like a good way to cover the task getting the user needs in accordance with the intentions of the preliminary study.
The three parts of the workshop has the following focuses:

1. How is shopping done today
2. How can shopping be improved
3. Design criteria for the PDA application

Time usage: Around 3 hours

Actual understanding: Since the method does not describe a preparation before the workshop, no problems with the understanding have been encountered.

Applicability of outcome: Even though the method does not have preparation before the workshop, the agenda and the questionnaire seems very relevant, but cannot be assessed at this moment.

Reflection: The preparation phase before the workshop is properly not a part of the method because the participants in the workshop all know the tasks at hand and what they must be used for. When using the method outside a research project there is no need for demographic data about the participants, so this is properly why this is not included.

Since the workshop have been taken out of the context of the preliminary study, it is necessary to get the participants on the right track. Give them some context of the workshop. This will be done by holding a short presentation. Following this presentation the intention is that the participants should discuss how shopping is done today. This will hopefully give them a basis for coming up with some ideas for how the shopping experience can be improved.

Planned progress tomorrow: The actual workshop will be held next. The date is 25/4 – 2004.

Misc.:

Date: 25/4

Phase: Empirical data collection & Analysis

Participants: IT-designer and 5 workshop participants representing general future users.

Initial understanding: The workshop should be able to provide the IT-designer with enough information, so that he could go on with the task of creating a prototype of the system. The information can be obtained by first discussing how the current work practice and then follow this by a discussion on the problems of the current work practice including ideas on how to help this.
These ideas should finally be prioritized and form a basis for the discussion about the design of the prototype. Some mock-ups should be made in this last phase.
It is estimated that the workshop would take about 3 hours plus some breaks in between.

Work performed: The workshop began around 12.30 where the participants were led to the seminary room. After getting everyone comfortable by getting drinks and such, the participants were shortly introduced to the project and the workshop activity. This was done by the IT-designer and was followed by a short questionnaire for the participants.
Following the completion of the questionnaires the discussion about shopping and how this was done today began. The IT-designer documented the findings of the discussion by writing a summery during the discussion. After a little slow start, where the IT-designer did most of the talking, the participants began to be more involved. Especially in the second part where the focus was on new ideas for a shopping assistant, were there a lot of discussion, and many ideas were presented. Unfortunately this took longer than expected and therefore there were not very much time for the last part of the workshop. So the ideas were just prioritized, but no discussion on the actual design was done.

Time usage: Around 4 hours where used on the workshop.

Actual understanding: The workshop seemed like a very good way of identifying some of the user-needs. The tools provided by the M.U.S.T. method did not however seem very appropriate for the task of describing the outcome. None of the participants felt that they could use a drawing or a collage in describing how shopping was done and due to the lack of time, the IT-designer decided that the creation of scenarios would be to time consuming compared to the amount of extra information gained.
The workshop was more time consuming than expected.

Applicability of outcome: A list of functions/user needs were created and the four most important were listed. This seems very relevant. Unfortunately the part of discussing actual designs was not completed and this might be a problem later on, when developing the prototype.

Reflection: The workshop worked quite well and did give a list of functionality which was the goal. It was harder to get started than anticipated, even though the participants selected for the workshop all knew each other before the workshop. The participants were somewhat withholding at first and the IT-designer had to direct the discussion. But after some time, the participants loosed up and began discussing freely. This was not something the method in any way took care of. It solely relies on the IT-designers experience.

The method describes several techniques that can be used during the workshop in order to capture essential parts of the problems. Among these were drawings, collages, communication models and others. But none of these seemed very profitable during the workshop, so the IT-designer quickly decided to abandon these and just document the discussion in a summery. The problems with the different proposed techniques were that neither the IT-designer nor the workshop participants see how they could be used for the purpose of getting the needed data.

The first part of the workshop, which focused on shopping today, gave a good foundation for the second part. In this discussions on how to improve the experience and what a Shopping Assistant should be able to do was in focus. Many different ideas was presented and discussed. The ideas proposed both related to grocery shopping and regular shopping. Many of the ideas however related to the idea of a personalized advertisement. It seemed like the participants saw this as the primary function in the application. Many of the other ideas were founded on a basis of advertisement.

The first two parts of the workshop took longer than anticipated. This resulted in that the last planed part was rushed and did not give all the information anticipated. This might pose a problem later, when designing the prototype, since the IT-designer will lack some data. The data that are missing is data about the actual user interface. How the different functions should be placed and how they should look. This will now be entirely up to the IT-designer.

It is worth noticing that in the prioritizing process the participants primarily focused on regular shopping. This means that ideas that support the activity ‘grocery shopping’ will not be included in the prototype design. It was expected that ideas such as the shopping list would play a prominent part in the application.

Planned progress tomorrow: Next step is to describe the listed functionalities in greater detail and to create a prototype on that basis.

Misc.:

Date: 4/5

Phase: Analysis

Participants: IT-designer

Initial understanding: The data should be written down and each item on the functionality list should have a textual description.

Work performed: Textual description of each of the functionalities on the list.

Time usage: 2-3 hours

Actual understanding: Since the method is not very specific on how the data should be presented there is no difference in the understanding.

Applicability of outcome: The textual description of the functionality should be very useful when the prototype is to be implemented.

Reflection: The textual description was not that hard to do. It was based on the summery created during the workshop and the memory of the IT-designer.

For some of the descriptions the IT-designer could have benefited if he had access to the participants in order to clarify some ideas.

Planned progress tomorrow: Design and implementation of the prototype.

Misc.: Additional notes or thoughts. Materials from today's work can be included.

Date: 12/5

Phase: Design & Implementation of prototype

Participants: IT-designer

Initial understanding: The method does not directly support a design phase. Some GUI design could be found during a workshop where the IT-designer and the rest of the project group discuss and experiments with ideas. It just suggests that the prototype should include important aspects of the functionality. The Prototype is a good way to make abstract discussion on functionality more concrete.

Work performed: Mock-ups on paper and implementation of these in Visual Studio .NET 2003.

Time usage: 8 hours

Actual understanding: Since the workshop never got around to creating the actual mock-ups, the IT-designer had to create these alone on the basis of his understanding of GUI design for PDA and the overall design criteria expressed on the workshop.

Applicability of outcome: Mock-ups of the primary screens of the applications was made using a prototype a like approach. These gave a good basis for the actual implementation.

Reflection: The fact that the workshop never got around to creating mock-ups posed a bit of a problem since the mock-up quickly became a reflection of the IT-designers understanding and decisions instead of a joint understanding between the participants.

The designs were made with the overall design criteria in mind. This means that every button should be sufficiently large so they could be operated with a thumb or a finger. Another of the overall criteria that were considered on each screen was that the text should be large enough to be easily read.

Some problems were encountered when the mock-ups had to be implemented. Most of these were problems with fitting all the items on the small screen and still keeping big enough buttons for one hand operation. These problems were dealt with by shrinking the buttons or the text size so it could fit.

There were also some problems encountered when using the standard components of Visual Studio. These problems were also just cosmetic and were not addressed in any particular way.

Planned progress tomorrow:

Misc.: Additional notes or thoughts. Materials from today's work can be included.

Appendix B - Contextual Design

B.1 Method description

This section will describe the development method called *"Contextual Design"* by Hugh Beyer and Karen Holtzblatt [Beyer&Holtzblatt]. A short introduction to the method will be given. Afterwards the six main activities of the methods will be described:

1. **Contextual Inquires** – *Gathering customer data, talk to customers while they work*
2. **Work Modelling** – *Analysis and modelling, represent people's work in diagrams*
3. **Consolidation** – *Analysis, Pulling individual models together to see work of all customers*
4. **Work Redesign** – *Design, Create a corporate response to the customers' issues*
5. **User environment design** – *Design, Structure the system work model to fit the work*
6. **Paper Prototyping** – *Evaluation, Test your ideas with users through paper prototypes*

B.1.1 Introduction to Contextual Design

Contextual design (CD) is optimized for large, complex systems, though it has been successfully used on small projects as well. However every situation is unique and Contextual Design should be tailored accordingly. The different techniques presented in the book form a coherent design process, but the techniques also represent a framework for thinking. If an organization has techniques which are found valuable, they should replace CD's techniques at the appropriate place in the process [Beyer&Holtzblatt 1998, p. 25].
Contextual Design is a methodology that uses a different starting point than traditionally software development methods that primarily focus on the engineering aspect of the development process. Usually these methods have an introduction on defining requirements (Requirements engineering), and then the developers have to conduct detailed discussions of object modelling and data flow diagrams etc. According to the authors of CD, a detailed investigation that decides what to build, and how the end product will affect all related activities in the context, is missing. CD makes data gathered from customers the base criteria for deciding these requirements and design decisions, by making the core design problem focus around how customers will work in the future [Beyer&Holtzblatt 1998, p. 3]. The main thesis in the method is:

> *"Whether software only, or software and hardware combined, the system creates an environment for its users to work in; it's up to the team to ensure that the environment fits the flow of their work."*
>
> [Beyer&Holtzblatt 1998, p. 4]

When developing a system, you are not just developing the system, you are developing a new way of working. This requires a technique that enables the developers to observe how people currently work, so the optimal redesign of work practice can be discovered [Beyer&Holtzblatt 1998, p. 21]. Contextual Inquiry is a technique to reveal the work practice that is present in the context of the system being developed, and use this knowledge to develop a new system, taking the problems of the current work practice into account.

B.1.2 Contextual Inquiry

Contextual Inquiry is the ***core part*** of CD. The technique gathers the customer data that should reveal all detailed aspects of work practice. The idea is that so much of the actual work practice cannot be articulated even by those who do it, you have to *see the work* [Beyer&Holtzblatt 1998, p. 37]. Thereby Contextual Inquiry differs from other methods that are user-centered[1] and uses a traditional interview to reveal work practice, by setting the interview to take place in the context, the workplace of the customer *while they work*. It is a field study technique that studies a few carefully selected individuals in depth to gain a fuller understanding of the work practice across all customers. Before an actual Contextual Inquiry can take place, some preparations have to be made. A *focus statement* is elaborated beforehand, which will help the interviewer keep the contextual inquiries on track. The focus statement is a checklist of important aspects of work, which need attention during the inquiries. Around 16-20 Contextual Inquiries should be performed, with a diversified group of future users of the system.

Contextual Inquiry is based on a set of principles that allow it to be tailored to each situation that a project encounters:

- **Context:** Team members observe people as they work and inquire into actions as they unfold to understand their motivations and strategy. The interviewer and customer develop a shared interpretation of the work through discussion. The session is recorded on a device with Dictaphone capability.
- **Focus:** Focus gives the interviewer a way to keep the conversation on topics that are useful and relevant without taking control entirely away from the customer (The focus statement) [Beyer&Holtzblatt 1998, p. 41-66].
- **Partnership:** The goal of partnership is to make the customer and developer collaborators in understanding the work of the customer. The traditional interviewer/interviewee relationship model should be avoided, because that puts too

[1] An example could be the XP method that uses an on-site customer to derive requirements and user needs [Beck 2001].

much control in the hands of the interviewer. Likewise the master/apprentice model should be avoided, because that gives the customer too much control. Contrary the relationship model should lie between the two.

- **Interpretation:** The design is built upon interpretation of facts. Interpretation is the chain of reasoning that turns a fact into a design idea. Therefore the final design of the system is the end product of a chain of reasoning. Since reasoning's come from the interview, it is important to check with the customer whether the interpretation is correct. This can be done by rephrasing the subject currently in focus, or by making suggestions about a particular design idea. This will provide the interviewer with immediate feedback on their interpretation of the customer data. Furthermore notes are taken, and possible future solutions are suggested.

Once the interviews are done, *Team interpretation sessions* bring the design team together to hear (Playback of the recorded interview) the whole story of each interview and capture the insights and learning relevant to their design problem. Through these discussions the team captures issues and draw work models, which develops a shared view of the customer and their needs [Beyer&Holtzblatt 1998, p. 126-136]. One set of work models for each customer interviewed should be elaborated.

B.1.3 Work Models

Work models capture the work of individuals and organizations in diagrams. Five models provide different perspectives on the context of how work is done and they represent key aspects of work that developers need to account for in their design [Beyer&Holtzblatt 1998, p. 89]. Through the elaboration of work models, several problems (Break Downs)[2] will be surface in the current context, which needs to be solved with the re-design of the work practice at a later state in the process. These 5 work models will shortly be explained:

1. **Flow model:** Captures communication and coordination. Flow may consist of informal talk and coordination, or it may consist of passing artifacts. An artifact may be physical such as a document or message, or it may be conceptual.
2. **Sequence model:** Shows the detailed steps performed to accomplish a task. Sequence models supply the low-level, step-by-step information on how work is done that designers need to make design decisions upon. They are a map to the work that the system being developed will change. Drafts of sequence models are elaborated during the interviews.

[2] *Break Downs* is defined as problems related to: communication or coordination, performing a task, using an artifact, interference from the physical environment.

3. **Artifact model:** Shows how artifacts are used and structured in doing the work.
4. **Cultural model:** Captures culture and policy.
5. **Physical model:** Shows the physical environment as it supports the work.

Once these work models have been elaborated, the *Break Downs* of individuals have been brought to the surface. Each set of work models is revisited in the consolidation phase, in order to get a . *Consolidation* brings data from individual customer interviews together so the team can see common pattern and structure without losing individual variation.

B.1.4 Consolidation

Consolidation brings data from individual customers together, so the developing team should see common patterns and structures without losing individual variation. The challenge is to design for a population, but meet the needs of individuals. [Beyer&Holtzblatt 1998, p. 139]. Consolidation involves two activities:

- **Consolidated work models** bring together each different type of work model separately, to reveal common strategies and intents while retaining and organizing individual differences.
- **The affinity diagram** brings together issues (Break downs) and insights across all customers into a wall-sized, hierarchical diagram to reveal the scope of the problem in the work domain. The affinity diagram organizes the individual notes captured during interpretation sessions into a hierarchy revealing common issues and themes. It assembles and consolidates data that did not fit into the work models and serve to retain design ideas.
  Therefore affinity diagramming is a categorization method, where numerous ideas are sorted into categories based on the natural relationship (affinity) between the ideas. The team thus organizes all ideas into themes, providing a bridge from Contextual Inquiry data to design [Beyer&Holtzblatt 1998, p. 154-162].

Together, the *affinity diagram* and *consolidated work models* should produce a single picture of the customer population a design will address. They should provide the team a focus for the design conversation, showing what is important in the work and guide the structuring of a coherent response with features supported by the new system.

B.1.5 Work Redesign

Work redesign uses the consolidated data to drive conversations about how to improve work by using technology to support the new work practice. In work redesign there are two important activities; *priming the brain* and *story boards.*
The activity that should support the elaboration of a vision for the new system is called *priming the brain* [Beyer&Holtzblatt 1998, p. 276]. To create the vision the developers must brainstorm two lists:

- **Technology** The technology required to solve the current work problems, with the new system. The list should encompass existing technologies available in the context as well.
- **Starting points** Design ideas that have been captured during the contextual inquiries, and work modelling and affinity diagram. This list should be revisited by developers, where pros and cons of each design idea are written.

A vision might encompass more than the team can ship in one iteration/one version.
The redesigned work practice is captured in a vision, a story of how customers will do their work in the new work practice related to the vision. A vision includes the system, its delivery, and support structures to make the new work practice successful. The team develops the details of the vision in *storyboards*, 'freeze-frame' sketches capturing scenarios of how people will work with the new system. The storyboards should reveal interactions with the system as well, which means that UI-sketch should be drawn [Beyer&Holtzblatt 1998, p. 287-291].

B.1.6 User Environment Design

The new system should have the appropriate function and structure to support a natural work flow.
The User Environment Design (UED) captures what the authors refer to as "*the floor plan*" of the new system. It shows each part of the system, how it supports the user's work, what function is available in that part, and how the user gets to and from other parts of the system, without tying this structure to any particular user interface, rather it is similar to an object model. As reference the team can use the storyboards created earlier in the process to create an UED [Beyer&Holtzblatt 1998, p. 307-345].

B.1.7 Paper Prototyping

According to the authors testing is an important part of any systems development. It is generally accepted that the sooner problems are found, the less it costs to fix them. Therefore

it is important to test and iterate a design early, before anyone gets invested in the design and before spending time writing code [Beyer&Holtzblatt 1998, p. 307-345].

In the technique *paper prototyping*, the developer elaborates rough mockups of the system using Post-its to represent windows, dialog boxes, buttons, and menus. The design team tests these prototypes with users in *their workplace*, replaying real work events in the proposed system. When the user discovers problems, they and the designers redesign the prototype together to fit their needs. Rough paper prototypes of the system design test the structures of a User Environment Design and initial user interface ideas before anything is committed to code. The team uses several paper prototype sessions to improve the system and drive detailed user interface design [Beyer&Holtzblatt 1998, p. 367-377].

B.2 Development using the method

This section will describe the analysis phase using the Contextual Design method. The section will begin with describing the process of collecting data about users and their context using an activity called Contextual Inquiry. Afterwards an analysis on the collected data will be conducted using a set of work models presented in the Contextual design method. Subsequently the re-design of the current work-practice will be carried out using storyboards in the design phase. In the implementation phase a prototype will be developed, using the UI-storyboards from the design phase.

B.2.1 Contextual Inquiries

The overall task of contextual inquiries is to reveal common work practice among a carefully selected subset of the customer base. The activity aims to reveal details about current work practice, which can be used to draw models that are common to the entire customer base. According to the method, the best way of revealing details in the current work practice, is to observe the user doing their current work in the context, and have them explain the details and structure as the work is carried out [Beyer&Holtzblatt 1998, p. 36-46].

The description of the contextual inquiries will be twofold. First the preparation process of the inquiries will be described, as well as present demographic information about the participants. Finally the section will clarify how the actual contextual inquiries were carried out.

Preparation

Before the Contextual Inquiries could take place some preparations were made. The first part is to decide *who* to interview. In general the test-leader should interview 2-3 customers[3] in each role identified as important to the focus. Unless the focus is very narrow, 10-20 interviews should be conducted to cover the work practice [Beyer&Holtzblatt 1998, p. 76].

> *"The focus of the contextual inquiries is narrow, because only the role of a shopper is important to the focus."*
>
> [Diary Appendix B, 29/3]

Therefore the data was gathered with 4 test participants, which consisted of two couples. The two couples were divided into two groups, since their shopping habits involved their partner to some extent. Below is demographic information about the participants:

- **Couple nr 1:** The first couple lives in Billund with their 2 year old child. The female (A) is 29 years old and works as a stewardess for Maersk, while the male (B) is 34 years old and works as a pilot in the same concern. Their workplace is less than 5 kilometres from their home. They have one automobile and one bicycle available as means of transportation. Shopping in malls is done approximately 10 percent of the times. The frequency varies depending on type and amount of groceries needed. Most often shopping in malls is done, if they need a large amount of provisions or if they need an item that can not be bought at other stores. Often a large amount of groceries from the refrigerated counter is bought because of the cheap prices. When there are a limited amount of provisions in their deep freezer, they consider another visit to the mall. When visiting a mall, they often bring their 2 year old child and therefore they often go shopping together.

- **Couple nr 2:** The second couple live near Fredericia. They have 2 children, which have moved away from home several years ago. The female (C) is 54 years old and works as accountancy assistant for Told&Skat in Vejle, while the male (D) is 59 years old and works as maintenance manager at Danisco Ingredients in Haderslev. This couple owns 2 automobiles since their workplaces lie in two different directions from where they live.
  This couple rarely shops at malls. They only use malls, when they need to buy items on sale that can not be bought at other stores. They rarely shop provisions when being at malls, but it occasionally occurs when a large amount of groceries is needed for a dinner party. It also occurs when they need to buy provisions for sailing a longer period of time. Most often this couple shops on a day to day basis, meaning a high frequency of shopping with few groceries being bought. When shopping in malls it is

[3] Customer refers to anyone who uses or depends on the system being developed. [Beyer&Holtzblatt 1998, p. 2]

often in the weekends and they tend to go together. This happens approximately once a month.

The participants were told that they had to prepare themselves for shopping as they would normally do, meaning that no prior shopping should be made in the days before the Inquiry, since this would limit the amount of goods being bought during the Inquiry and could minimize the amount of data collected from the inquiry.

A focus statement[4] was elaborated to help keeping the contextual interviews on track. The subjects of the focus statement were elaborated in such a manner that they would aim to cover different aspects of shopping such as: preparation, the course of shopping, shopping habits, communication etc. These subjects should help the participants to think thoroughly about the details of shopping, instead of summarizing the course of shopping. This in turn would help the test-leader reveal unarticulated needs.

Location

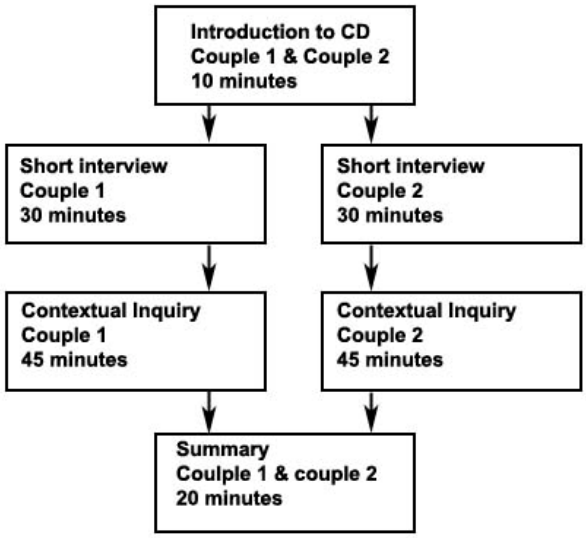
The contextual inquires took place at a large shopping mall in Vejle Friday April 2. 2004 between 10.00 AM-1.00 PM. The actual shopping mall Bruuns Galleri was not used, because all the participants live far from Aarhus. Moreover it was regarded less important that the inquiry took place in this particular mall, since the concept of shopping is more or less the same in any mall.

The contextual inquiries were recorded on a device with Dictaphone capability. Moreover notes were taken by hand throughout the inquiries, in order to avoid possible data loss, because of poor recording quality due to the noisy environment in which the inquiries took place.

[4] See Appendix B, p. 56

B.2.2 The course of the Contextual Inquiries

The contextual interviews were conducted in the manner illustrated below:



Figur 1 The course of the Contextual Inquiries

Introduction to Contextual Design - 10 minutes

The contextual interviews began with a brief introduction. Both couples were given a brief introduction to the Contextual design method, and how this method should be applied in the context of shopping at a small café in the mall. They were told about the master/apprentice relationship that should guide the course of the day.

Short interview – 30 minutes pr. Couple

According to the focus statement it was regarded very important how the participants prepare themselves for shopping. The couple not being interviewed were asked to leave the café in order to avoid the statements influencing each other. The participants were asked to interrupt without restraint, should they have any statement or comments to unfold.

Contextual Inquiry – 45 minutes pr. Couple

Subsequently both interviews were conducted, the actual contextual inquiry took place. Once again a contextual inquiry was done with each couple in turn.

At each contextual inquiry the participants started shopping as they would normally do. Meanwhile, the test-leader made observations and asked questions regarding the details of

shopping. These observations were noted on paper. During the inquiry the test-leader continuously performed interpretations on the details of shopping. The observations of structure and interpretations of their meaning were shared with the participants, in order to verify that they were correct.

Summary – 20 minutes

At the end of both contextual inquires, both couples were presented with early hypothesis about possible design ideas for a shopping assistant. These design ideas were based upon prior preparations contained in the focus statement and interpretation of observations made during the interviews and contextual inquiries.

The design ideas covered different features that could be supported by a future digital shopping assistant[5]. Each feature was commented/verified by the participants, and several other features were suggested as well.

[5] See Appendix B, p. 56

B.2.3 Analysis of collected data

This section will contain the analysis of the data collected through Contextual Inquiry. This phase of the development involves the elaboration of 5 work models, which captures the work of individuals and organizations in diagrams. The work models represent the key aspects of work that design teams need to account for in their designs, by providing different perspectives on how work is done [Beyer&Holtzblatt 1998, p. 89-90]:

- **The flow model** - Captures communication and coordination
- **The sequence model** - Shows the detailed steps performed to accomplish a task
- **The artifact model** - Shows how artifacts are used and structured in doing the work
- **The cultural model** - Captures culture and policy
- **The physical model** - Shows the physical environment as it supports the work

These models should help the developer investigate into the context of the work environment. They are intended to show the perspective of an *individual*[6], not how an entire organization carries out work. The *cultural model* will *not* be elaborated, since a shopper is not a part of any organization which is affected by a culture or policy that is of interest to this project. The contextual inquiries indicated that there was indeed similarity between the way shopping was carried out by the participants. Therefore it was chosen to elaborate the work models in such a manner, that they would aim to cover the common perspectives of the individuals that participated in the inquiries, instead of making a set of work models for each participant. The elaboration would be more difficult, however fewer models needed to be drawn.

According to the method, the recorded data should be sufficient to supply the elaboration of the work models. Unfortunately the recorded data was of such bad quality, due to the noisy environment in which it was recorded, that it was discarded. Instead it was chosen to summarize the data collected in the Contextual Inquiry according to the focus statement previously mentioned in a separate document [See Appendix B, p. 76]. The summary of the contextual inquiries will be used throughout the elaboration of the 4 work models.

[6] A customer that has participated in a Contextual Inquiry, however only represents one *individual* within the organization.

B.2.3.1 The flow model

The flow model is the first model that is used for gaining insight into the context of the workplace. It should reveal how people's roles are defined, and how they communicate to get the work done. The inquiries clearly indicated that shopping involved two phases; the *preparation phase* and the *shopping phase*. It was chosen to elaborate a flow model for each phase in order to simplify both the model and the process of creating it. The summary of the contextual inquiries [See Appendix B, p. 76] will be used for identifying the elements that should be present in the models:

B.2.3.1.1 Preparation phase

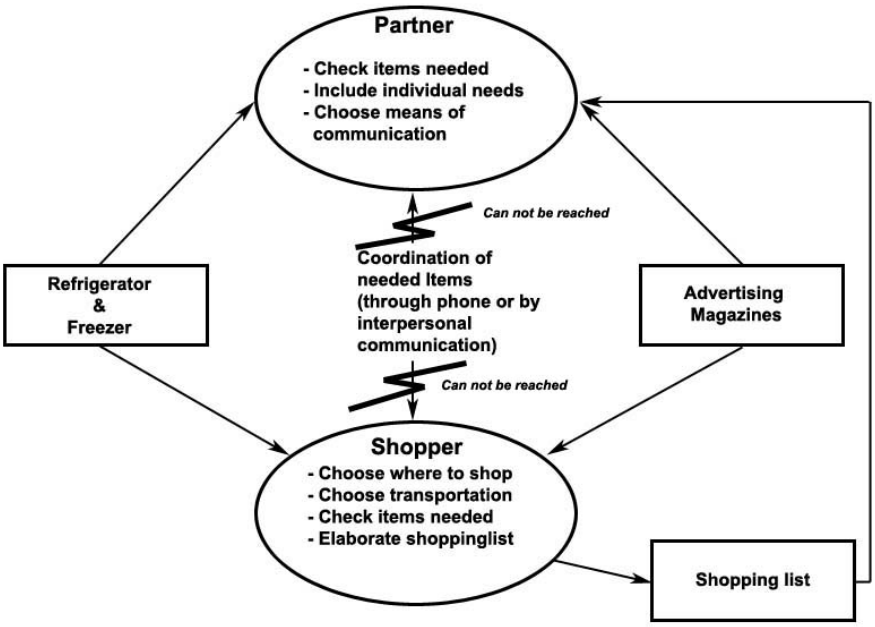


Figure 2 Flow model for the preparation phase. Circles represent individuals. Boxes represent artifacts. The arrows illustrate which artifacts are used by the individuals. Communication/coordination is illustrated by the text combined with arrows that shows the involved individuals.

According to the two interviews held at the beginning of the Contextual Inquiries, the preparation phase was very similar among the participants. The preparation phase can involve one or more individuals[7]. Sometimes both are involved in the creation of the shopping list, in which case they need to coordinate the contents of the shopping list. One individual is responsible for the actual shopping, while the other functions as a partner.

Roles	Responsibilities
Partner	Responsible for helping the shopper on the creation of a shopping list. This includes deciding which items are needed, adding individual needs and communicate this information to the shopper. Sometimes the communication is done through phone.
Shopper	Responsible for gathering the information needed to elaborate a shopping list. This includes deciding where to go shopping and which transportation to use. Furthermore the shopper should check for items needed and coordinate with the partner on the contents on the shopping list. Finally elaborate a shopping list.

Table 3 Roles of individuals during the preparation phase.

The task of checking what is currently needed in the household is accomplished using varies artifacts within the household. The content of the *refrigerator* and *freezer* is used for deciding

[7] For the sake of simplicity, we assume that there are at most two persons involved.

which provisions need to be bought. Sometimes these needs are compared with an *advertising magazine* from the particular mall, and offers concerning the current needs are identified. In this process several other provisions may be added to the list, if the offers are found attractive. When an individual has elaborated a *shopping list* it is sometimes handed over to another individual responsible for doing the actual shopping.

Artifacts	Description
Refrigerator & freezer	These artifacts contain any number of provisions. If the stock of any particular grocery is low or missing, this helps identifying needed items.
Advertising magazines	These artifacts contain a lot of currently available offers on different groceries. Any number of these artifacts may be used for identifying attractive offers.
Shopping list	This artifact contains a list of items to be bought. It is written by hand on a small piece of paper, because the size makes it easier to carry around when shopping.

Table 4 Artifacts used during the preparation phase.

The individuals involved in the preparation process need to coordinate what to buy, which can require some communication. This communication can be interpersonal or through the use of phone calls. Breakdowns[8] can occur in this communication, if they cannot reach each other by phone. Consequently this can influence the success of the actual shopping, if some items are missing on the list or both individuals buys the same items. The following communication topic is present in the preparation phase:

Communication topic	Purpose
Coordination of items needed	This communication topic can be discussed interpersonally or by the use of phone. Regardless of the channel in which the communication takes place, the outcome should be information that can be used to elaborate a shopping list or enable an individual to do shopping. Breakdowns can occur if they cannot reach each other by phone. The coordination could also be done by passing a shopping list to the individual responsible for shopping.

Table 5 Communication topics in the preparation phase.

[8] Breakdowns are defined as problems in communication or coordination, represented as a lightning bolt in Figure 12.

B.2.3.1.2 The shopping phase

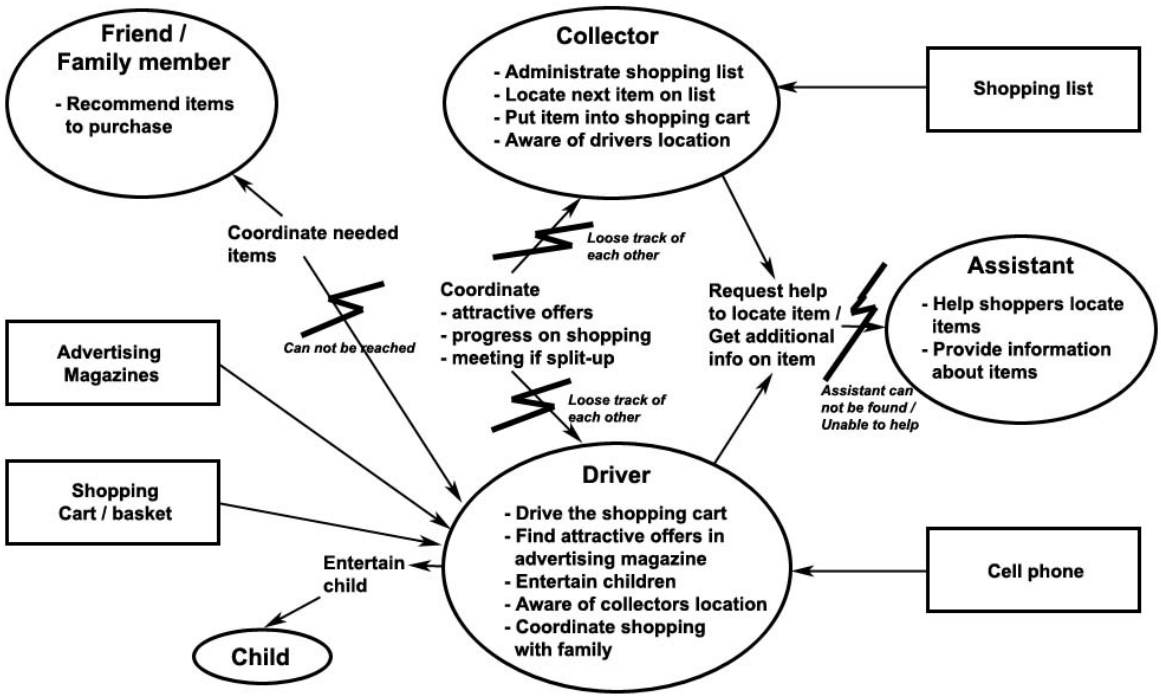


Figure 12 Flow model for the shopping phase. Combining the responsibilities of the *collector* and *driver* models the set of responsibilities of a solo-shopper.

During the contextual inquiries the couples were shopping as pairs, however according to the interviews this is not always the case. Nonetheless, whether individuals are shopping alone or together, it does not change the overall pattern of the work practice. During the inquiries it was observed that when shopping in pairs, they often divide the task into two sets of responsibilities; one of them acts as a *collector* of groceries, while the other acts as a *driver* of the shopping cart.
When shopping alone, the individual is responsible for carrying out both roles.

The solo-shopper introduces additional roles present in the shopping phase. It can be necessary for the shopper to coordinate with *family members* on what to buy, if proper preparations have not been carried out in advance. This is often achieved through the use of a cell phone. During the inquiries it was observed that the participants were using a cell phone to talk to *friends* while shopping and sometimes recommendations on products can influence the course of shopping as well. Regardless of whom the shopper calls during the shopping phase, a *family member* or a *friend* has the same responsibility – to recommend products to

buy. Therefore only one role needs to depict this in the flow model. *Assistants* within the mall can be used to help shoppers locate needed items within the mall, or help the shoppers get more thorough information on a given product, thereby supporting the decision on whether to buy the product. Finally, in the inquiries it was observed that the driver acts as an entertainer for children. If the child is very young, it is placed in the seat of the shopping cart. They can require a lot of attention from both parents, and even more for the solo-shopper.

Roles	**Responsibilities**
Collector	Administrate the contents of the shopping list. This includes tracking the progress of the list and locating the next item, as well as ensuring all items are bought. Furthermore the collector must be aware of the location of the driver, in order to avoid losing track of each other.
Driver	Drive the shopping cart around in the mall. Sometimes the driver acquires an advertising magazine at the entrance to the mall, and goes through this paper while doing the shopping looking for special bargains. If children are brought for shopping, the driver is responsible for entertaining them. The driver must also be aware of the collector's location. In the case where shopping is done alone, the driver has the responsibility of coordinating the shopping list and to acquire a list of needed items from the rest of the family. This can be accomplished through the use of a cell phone.
Family member/friend	Recommend products to buy to the individual who is carrying out shopping.
Assistant	Help shoppers locate particular items. Furthermore they must be able to supply the shoppers with detailed information on products, which can help shoppers determine whether to buy the product or not.
Children	Children need to be entertained by the driver throughout the course of shopping.

Table 6 Roles of individuals during the shopping phase.

The work practice of shopping involves the use of several different artifacts. When provisions are very low in the household, a shopping list is often prepared in advance. The *shopping list* acts as a reminder on items to purchase for the collector. As previously mentioned, shoppers tend to use *cell phones* to coordinate with family members or friends on products to buy. The cell phone is regarded as a safety net in the sense that if no proper preparations have been made in advance, the cell phone is used to communicate and update the contents of the shopping list. A *shopping cart/basket* is used depending on the amount of items on the shopping list. Furthermore if a very young child is brought along for shopping, this may influence whether the shopping cart is preferred. Finally the inquiries indicated that the *advertising magazines* at the entrance of the mall, is used by some shoppers to find appropriate offers. These offers can be associated to an item on the shopping list, or it can affect the shopper to buy additional products.

Artifacts	Description
Shopping list	It is a handwritten a list of items to be bought. It is created by an individual during the preparation phase, and it is used by the collector during the shopping phase. According to the inquiries, the shopping list is sometimes handed over to another individual responsible for the actual shopping during the preparation phase.
Cell phone	Used for coordinating the contents of the shopping list with others.
Shopping cart/basket	Used for storing groceries for easy transport around the mall. Occasionally the shopping cart is also used for transportation of children.
Advertising magazines	These artifacts contain a lot of currently available offers on different groceries. Any number of these artifacts may be used for identifying attractive offers.

Table 7 Artifacts used during the shopping phase.

Whether the individuals are shopping alone or as pairs, some coordination with other individuals needs to be conducted. If the solo-shopper is not properly prepared, he needs to coordinate with family or friends on what to buy, which is often achieved through cell phone. Breakdowns can occur in this process, if they can not be reached. Consequently this can influence the success of the actual shopping, if some items are missing on the list or both individuals buys the same items. The driver was using the cell phone to talk to a friend about a product during the inquires. When shopping as pairs the coordination process becomes even more complex. Although the responsibilities are divided among them, shopping two people yield more coordination. The driver has to coordinate attractive offers with the collector. The collector needs to inform the driver on the progress on the shopping, meaning guiding the driver to the next item. If they split up, they need to coordinate where to meet later on. During the inquiries one of the couples lost track of each other. Therefore breakdowns can occur, if the collector and driver loose track of each other. During the inquiries it was observed, that one of the couples had difficulty locating a particular product. When they finally found it, they needed additional information from an assistant working in that department. Unfortunately the assistant was unable to help them. Nonetheless, this indicates that shoppers request help from assistants inside the mall concerning both the location of particular items and additional information about these items as well. Breakdowns can occur in this process if they are unable to locate an assistant, or if the assistant is unable to help.

Communication topic	Purpose
Coordinate needed items	Can only be discussed by phone because this involves an individual that is not present in the mall at the time of shopping. The outcome should be information that can be used to decide what to buy. Breakdowns can occur if they cannot reach

	each other by phone.
Coordination between collector and driver	Involves the coordination on the progress of shopping as well as meetings if the driver and collector split up. Furthermore attractive offers are discussed and a decision is taken whether to buy an item or not. Breakdowns can occur if they lose track of each others location.
Request help	Involves an assistant and a shopper, meaning that it can be the driver, collector or both. A request for help takes place if the shopper needs help to find a particular item, or if additional information about a product is required. Breakdowns can occur if the shopper can not locate the assistant, or if the assistant is unable to help.

Table 8 Communication topics during the shopping phase.

B.2.3.2 The sequence model

The sequence model is the second model that is used for gaining insight into the context of the workplace. Sequence models should reveal the low-level, step-by-step information on how work is actually done that designers need to make detailed design decisions [Beyer&Holtzblatt: p. 97]. The actions people take in doing their work reveal their strategy, their intent, and what matters to them. Therefore according to the method, understanding the real *intent* is the key to improving the work practice of shopping.
This section will contain three sequence models covering both the preparation phase and the shopping phase. The information needed to elaborate the sequence model covering the preparation phase, is based on the initial short interviews conducted at the beginning of the contextual inquiries, whereas the contextual inquiries will be used for the two latter sequence models [See Appendix B, p. ??].

B.2.3.2.1 Preparation phase

Figure 13 Sequence model for the preparation phase

The sequence model in Figure 13 indicates that the intent of a preparation phase for shopping is to make a shopping list in order to avoid forgetting what to purchase. The trigger for this task is the recognition of low stock on provisions in the household. The steps that are needed to elaborate a shopping list, is to identify which items are needed. This is done by checking the refrigerator and freezer for missing items, and adding them to the shopping list. Sometimes individuals use advertising magazines to spot relevant[9] offers, these offers are then added to the list. This indicates an intent of saving money. Family members need to be involved in this process, and they can be contacted by phone, if they are not around at the time of the preparation. Breakdowns can occur if they can not be reached. Sometimes the shopping list is arranged by the physical locations of the items, which makes it more manageable. Breakdowns can occur if they are unfamiliar with the layout of the mall. Finally the shopping list is assigned to an individual responsible for the actual shopping.

B.2.3.2.2 Shopping phase

[9] By relevant we mean an offer that satisfies a certain need, i.e. if meat is required for the evening dinner, then the individuals will have an eye out for related offers on this item. However other offers may be added as well.

The contextual inquiries revealed that there are two different triggers that can affect the way individuals do shopping. One of them is low stock on provisions while the other is shopping for one particular and more expensive item. Given that the triggers are different, the contextual inquiries revealed the steps of accomplishing the task of shopping are somewhat different as well. Therefore two sequence models will be elaborated in order to show their differences.

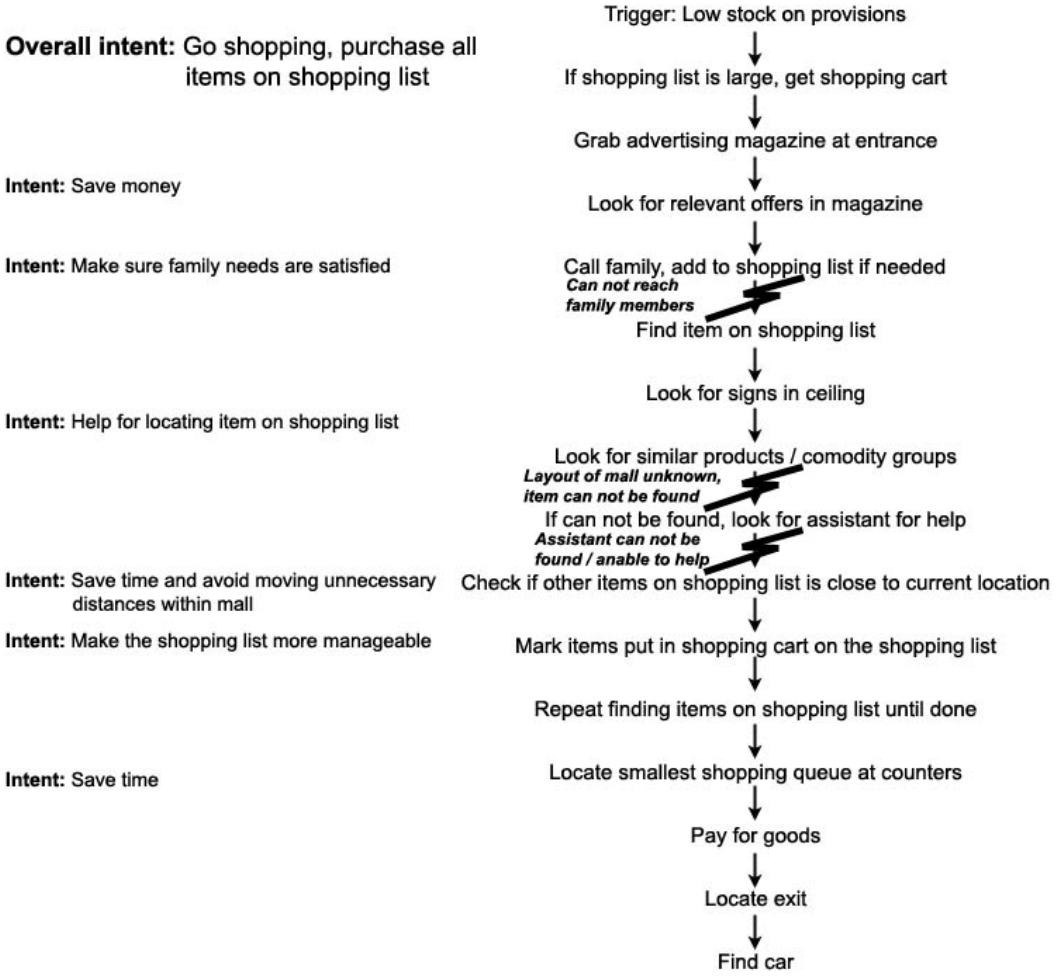


Figure 14 Sequence model for shopping phase, multiple items needed.

The sequence model in Figure 14 shows the steps that are taken when shopping for multiple items in a mall, which is triggered by low stocks on provisions. If the shopping list is large, shoppers will get a shopping cart before entering the mall. When entering the mall, some shoppers will grab an advertising magazine and look for relevant offers while shopping simultaneously. This shows an intent of wanting to save money. If shopping alone without any preparation done in advance, the shopper will contact other family members in order to satisfy their individual needs. Break downs can occur in this communication, if the family members can not be reached. When shoppers begin looking for the items on the shopping list,

the inquires showed that they would accomplish this by looking at signs in the ceiling, or by spotting similar products or commodity groups within the mall. Break downs occur if an item can not be found, and therefore the shopper sometimes tries to locate an assistant to point him in the right direction. Likewise breakdowns can occur in this process if the assistant can not be. When an item on the shopping list is located, the shopping list is examined to see, if other items on the list could be located close to the current location. This reveals an intent of trying to avoid moving unnecessary distances within the mall. Occasionally the items in the cart are marked on the shopping list, in order to make the shopping list more manageable. This process is repeated until all the items on the list are put into the cart, at which time the shopper begins moving towards the counters. Once at the counters the smallest shopping queue is located to save time. After the goods have been purchased, the shopper will move towards exit and try and locate their car at the parking lot.

If the trigger is different, meaning that a particular more expensive item is needed, the sequence of steps is different from the ones shown above:

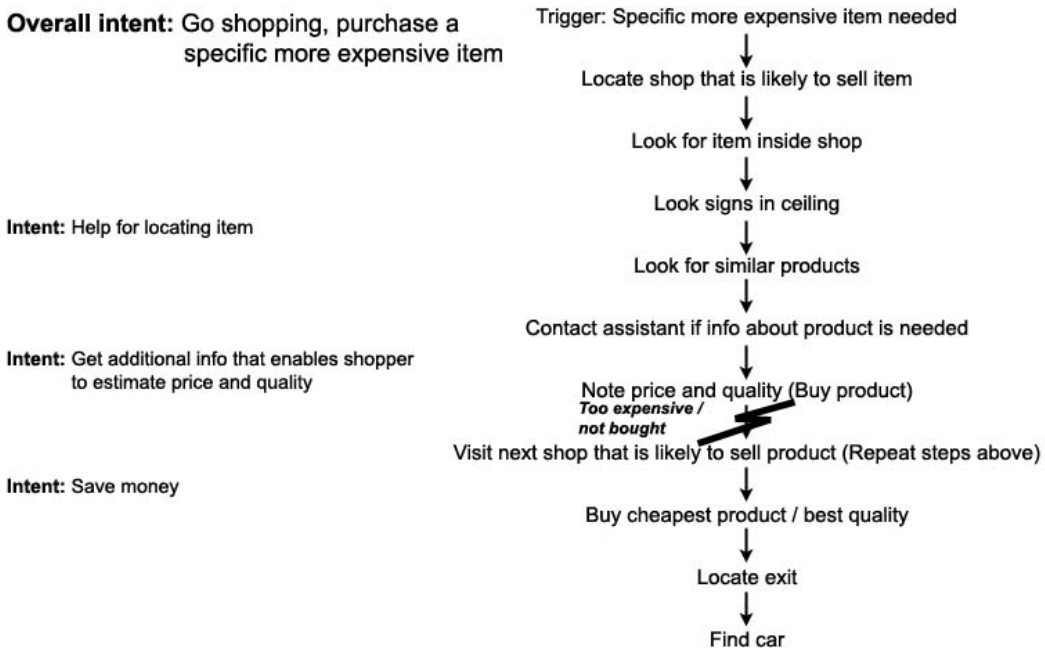


Figure 15 Sequence model for shopping phase, single more expensive product needed.

The sequence model in Figure 15 shows the steps that are taken when shopping for a single more expensive product in a mall, which is triggered by a certain need for that particular item. The steps taken in this model is different, because it does not require a shopping list to ensure the item is purchased. Furthermore it does not require a shopping cart. Once inside the mall, the shopper will try and locate a shop that sells the particular item, based on his knowledge

about the products that the shops are selling. Once inside the shop, he will use the same pattern as illustrated in the previous sequence model, meaning he will look for signs in the ceiling and similar products on the shelves. If the information about the product is not detailed enough to make a decision on whether to purchase the item, an assistant is contacted to fill out any missing information. This intent shows that when buying such a product, it is important to the shopper that detailed information about the product is available. If the product is too expensive, or not what was expected or the item could not be found, break downs can occur that forces the shopper to look for the item in other shops inside the mall. Based on the offers that have been examined in the shops visited, the shopper now evaluates the quality and price to determine if -and where to buy the product. Finally the shopper locates the exit and finds his car.

B.2.3.3 The artifact model

The artifact model is the third model that is used for gaining insight into the context of the workplace. According to the method, artifacts are tangible things people create or use to help them get their work done. They are manipulated in the sequence models and passed between people in the flow model. When people use artifacts, they build their way of thinking and working into the artifact and this can be revealed through an analysis of the structure, information content, informal annotations and presentation of the artifact [Beyer&Holtzblatt 1998, p. 102-106].
In this section an artifact model will be elaborated. The flow – and sequence models revealed a very important artifact to the course of shopping, namely the *shopping list*. During the contextual inquiries the participants had brought a shopping list, which will support the elaboration of the artifact model.

At the short interview conducted at the beginning of the contextual inquiries, the participants were asked questions about the elaboration and appearance of the shopping list. The participants stated that it was of great help, if the shopping list was arranged by the physical location of items inside the store, however this requires knowledge of the inventory of the store. If this knowledge is not present the participants preferred that the list should be sorted by commodity groups.

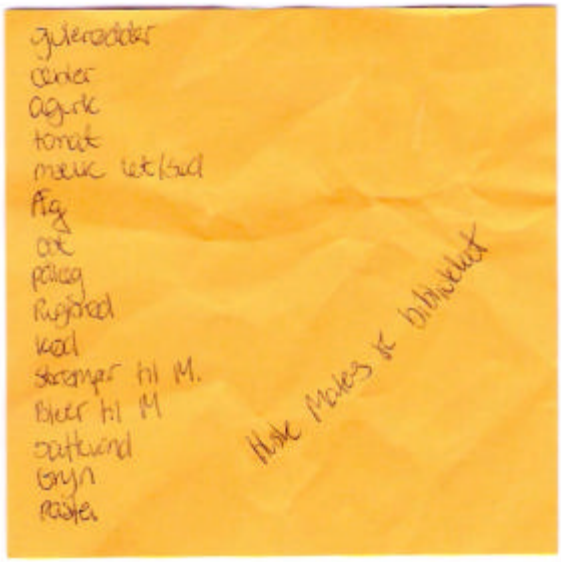


Figure 16 A shopping list gathered during the contextual inquiries.

The physical model of the first shopping list indicates that it is small. It is *presented* this way because it makes it more manageable while shopping. The *presentation* reveals that a list of items to be bought is present on the left side, while *informal annotations* are written on the right side. The size of the letters is small, indicating that it is not difficult to read while doing the actual shopping. The order of the items on the left side of the shopping list is not random. The first four items is vegetables, while the next five items is milk – and bread products. Two items is concerned with children's clothes. The last three items are randomly arranged, probably because they have no association with the other items on the list. This observation indicates that the shopping list is in fact *structured* in such a manner, that the items is ordered by commodity groups, which will make it easier for the shopper to do the actual shopping. By using this approach, physical zones inside the shop will be associated with a set of items on the list. The *informal annotations* written on the right side of the shopping list indicate a need for separating this information from the actual list. The text says, that the library and Matas should be remembered, meaning that the shopper must remember to pay a visit here.

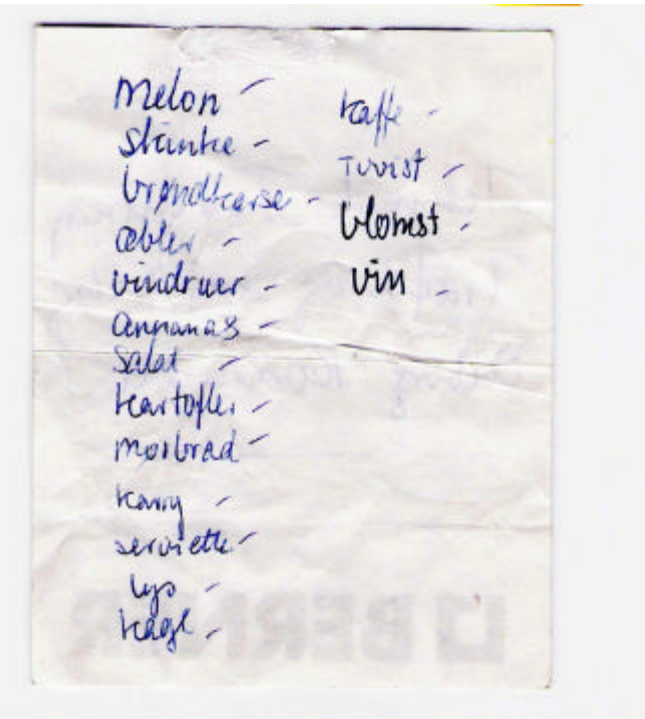


Figure 17 Another shopping list gathered during the inquiries.

The second shopping list is very similar to the first one, because it is almost the same size and it also contains a list of handwritten items. However two differences are immediately discovered. This shopping list does not have any *informal notes* only a list of items. Furthermore each item on the list has a mark. It was noticed during the inquiries, that these marks was made after each item was put into the shopping cart, in order to make the list more manageable. The last difference is the random order of items on the list. A shopping list has the following characteristics, which should be considered in the design:

Characteristics	**Description**
Small	A shopping list is small, because that makes it more manageable during the actual shopping phase.
Handwritten	A shopping list is often handwritten. According to the participants the process of creating it is easier, and faster if it is written by hand.
Items to purchase	A shopping list contains a list of items that can be arranged according to commodity groups. It is preferable if the order of the commodity groups matches the fastest route of their respective physical location inside the mall.
Additional notes	A shopping list can contain additional notes.
Marks	When doing the actual shopping, some shopper´s mark the items that have been put into the shopping cart, in order to make the list more manageable.

Table 9 Characteristics of the artifact shopping list.

B.2.3.4 The physical model

The physical model is the fourth model that is used for gaining insight into the context of the workplace. Work unfolds in a physical environment that either supports the work or gets in the way. Studying the users' workplace ensures that the system accounts for the physical environment. A physical model is a caricature of the work place annotated to show how the space is used by looking at places, structures, movement, artifacts and breakdowns [Beyer&Holtzblatt 1998, p. 115-120].

In this section a physical model will be elaborated. During the contextual inquiries the environment of the mall was mapped onto a piece of paper. Notes were written on the drawing showing aspects that were associated with breakdowns. The drawing and the summary of the contextual inquiries will be used to elaborate the physical model. The physical model that is elaborated in this section only represents the work environment of one mall.

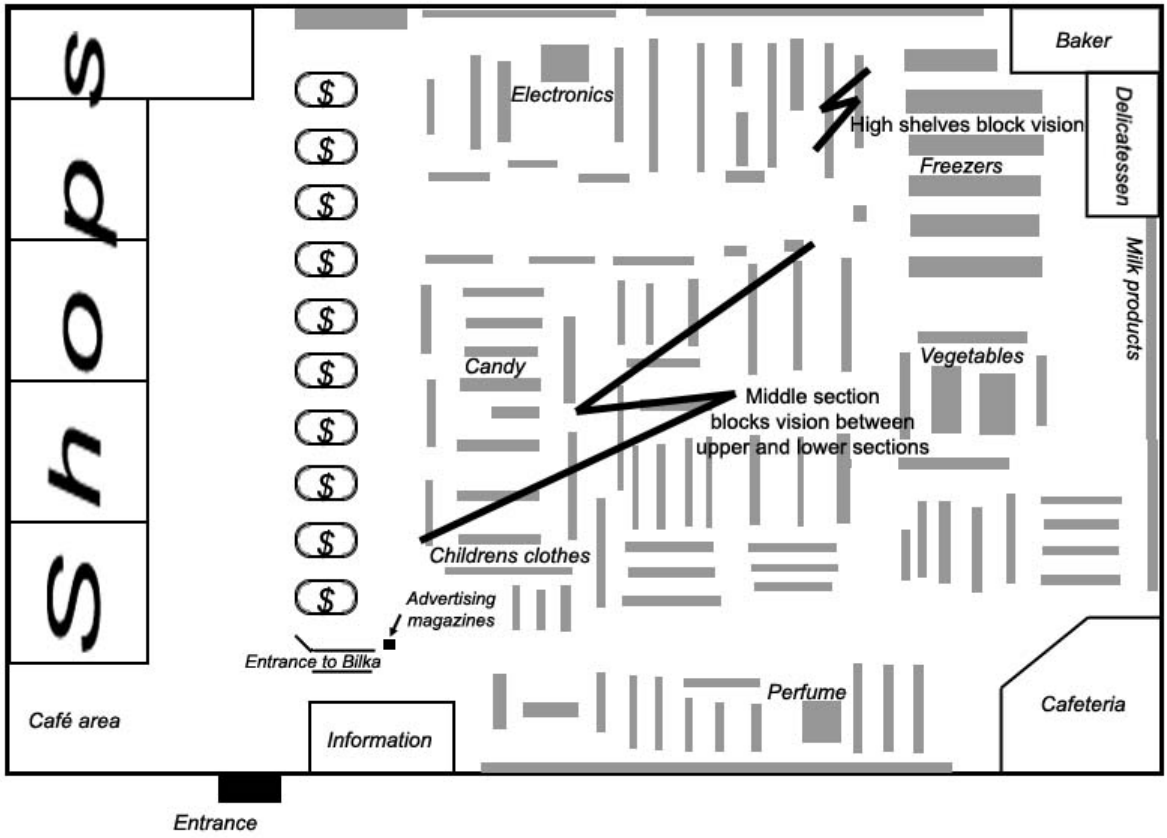


Figure 18 Physical model of Bilka Vejle.

The physical layout of the mall that was chosen for the inquiries is not similar to other malls[10]. Other malls have more small shops than is present in the physical model. However it is common that malls have one large grocery store, like the one present in the physical model.

[10] Two other layouts of shopping malls are presented in Appendix B, p. 66.

The *structure* of the model shows that related items are placed next to each other in *zones*[11]. Yet the interviews conducted in the beginning of the inquiries indicated, that it could be difficult to locate items. The problem became apparent during the inquiries, where it was observed that two of the participants had a hard time locating the electronic department. They were located near the perfume department when they began looking for the electronic department. The middle section of the store complicated the search for the electronic department, since it blocked the vision making the signs of the electronic department impossible to see. Consequently it took them more than 7 minutes to locate the department and they almost gave up along the way. Therefore a *breakdown* occurred, since the *structure* of the building did not support the shopper with any help on finding the electronic department. Another example of the physical environment getting in the way, was during the inquiries when two of the participants lost track of each other. This happened in the *freezer* area. One of them went to get an item on the other side of some very tall shelves, while the other was shopping at the freezers. The tall shelves blocked the shopper's visions, making it harder to be aware of each others location. Therefore a *breakdown* occurred, since the physical layout of the mall interfered with the shopping taking place. The interviews revealed that having many small shops inside a mall, makes it more difficult to locate a shop that sells a specific product. However this was not confirmed during the inquiries, since the mall did not have many shops.
The physical environment of the mall in which the enquiries took place, has the following characteristics:

Characteristics	**Description**
Large grocery store	A mall often has a large grocery store. The grocery store is divided into smaller zones or departments in which items that are related are placed. Often these zones contain products of a particular commodity group.
Shops	One of the characteristics of a mall is often the amount of smaller shops located inside. Each shop is often selling a specific line of products such as electronic appliances, kitchen utensils, fruits, cheese, candy etc.
Structure	The structure of a mall is sometimes hindering shopper´s in locating items they need to purchase. Inside the larger grocery store, the participants had a hard time locating items that was blocked by the middle section of the store. Moreover tall shelves could block the vision of shopper's, which lead to the shoppers loosing track of each other. Smaller shops can also be hard to locate, if the structure blocks the vision when looking for them. Both structure inside the grocery store, and the general structure of the mall can result in break downs occurring.

Table 10 Characteristics of the physical environment.

[11] In the physical model (Figure 18) some of these zones are marked by text.

B.2.4 Design using Contextual Design

This section will describe the design phase using the Contextual Design method. The section will begin with describing how to get from the analysis to the design. Afterwards two lists will be elaborated containing *technology* and *starting points*. The description will include features for a digital shopping assistant suggested by the participants during the contextual inquiries. These features will be compared with the understanding that was gained through the elaboration of the work models, in order to determine their relevance in the design. Finally the elaboration of story boards will be carried out. Storyboards depict the re-design of the current work practice of shopping, as well as the graphical user interface of the prototype.

B.2.4.1 Priming the brain

From the analysis using the contextual design method, a very detailed understanding of the current work practice of shopping has been gained. Especially problems related to preparation- and shopping phase were uncovered during the elaboration of the work models. The next step is to use this data to drive the design of the system, which will improve the current work practice of shopping. According to the method the process of improving the current work practice is a challenge that involves both design for the whole population, but at the same time meet the needs of the individuals [Beyer&Holtzblatt 1998, p. 139]. As a starting point for this process, the method offered an activity called *priming the brain*. In this activity the developer should brainstorm 2 lists:

- **Technology** The technology available/required to solve work problems in the new system.
- **Starting points** Design ideas that have been captured during the contextual inquiries and during the elaboration of work models.

[Beyer&Holtzblatt 1998, p. 276]

These lists will be elaborated and commented in the following sections.

B.2.4.1.1 Technology

A list of technology is straight forward to create, since the information needed to create this list is already known from the development of the positioning system. The fact that the positioning system is running on a central server and uses access points to determine the user's location, makes it possible to serve the digital shopping assistants with Internet. Moreover it is possible to provide additional services in terms of electronic advertisements, electronic shopping list, search for items inside mall etc. The latter requires that the server has a database that contains information on all products inside the mall. This could include

information about: location, price, quality, picture, customer satisfaction etc. It is found necessary to include some details from the positioning system developed beforehand, because the accuracy that the positioning system can deliver will influence the design decisions. This means that the technology available is not the only aspect important for the vision, sub components for the system can influence the design as well.

Positioning system

The positioning system, that delivers the location of the user to the prototype-client being designed in this section, is capable of positioning with an accuracy of 4 meters as illustrated below:

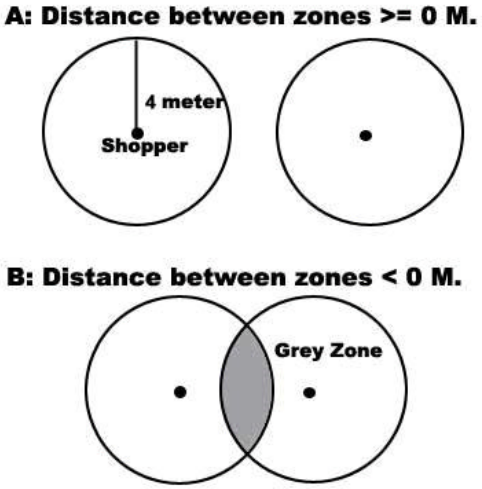


Figure 19 The positioning accuracy of the Positioning system. If zones overlap as illustrated in B, there is a grey zone in which positioning can not be determined.

Figure 19 illustrates that since the accuracy of the user can be determined down to zones of 8 meters in diameter, it is not possible to locate the shopper if some of these zones overlap (See B in Figure 19). Given this accuracy it is clearly impossible to direct a shopper towards a specific item inside the mall. However it is feasible to supply the shopper with directions towards the zone (Commodity group), in which the item is located. The positioning system could not determine the direction the user is heading (North, East, West, South), which makes it impossible to give directions towards a zone, as it is normally done with a compass. The map can not be rotated according to the direction the shopper is heading. As a result, the shopper will have to look at the map for landmarks, and compare those to the real world, in order to follow a direction illustrated on the map.

This can be summarized into the follow list of technology being available in the context:

- **Server** – Provides positioning capability that has an accuracy of 8 meter-zones, orientation is not possible to retrieve. The server also provides Internet and additional services.
- **Access points –** Provides network connectivity everywhere in the mall and allows for indoor location determination to be possible.
- **PDA –** A PDA is required by the user. PDA must have a W-LAN card for the positioning system to be aware of the user's location.

B.2.4.1.2 Starting points

This list is supposed to capture some of the most important starting points that have captured the imagination of the developer. The list illustrates a good starting point of ideas that have been captured during the contextual inquiries [Beyer&Holtzblatt 1998, p. 277].
At the end of both contextual inquires, both couples were presented with early hypothesis about possible design ideas for a shopping assistant. These design ideas were based upon prior preparations contained in the focus statement[12] and interpretation of observations made during the interviews and contextual inquiries. The design ideas covered different features that could be supported by a future digital shopping assistant. Each feature was commented/verified by the participants, and several other features were suggested as well. The design ideas were presented, in order to verify their priority, their relevance and the quality of each solution. These features were discussed at the end of the contextual inquiry and were arranged according to their priority by the participants. In the following these features will be described.

1: Location of items/products within the mall, help on finding them
During both the interviews and the inquiries, the participants articulated, that one of the most annoying parts of shopping, is not being able to find a needed item. When this feature was suggested to them, they seemed very fond of the idea. *B* stated that if the shopping list was digital on some sort of device, it would be of great help if it could show him where to go on a map. This feature was of top priority for all the participants.

2: Tailored advertisements
As previously mentioned in summary of the contextual inquiries, the participants had articulated thoughts on advertisements. As described they would like to have access to tailored advertisements, because the amount of advertisements in a mall could be overwhelming. It was not anticipated in advance, that shoppers would add personal preferences to the device, which would enable the device to tailor advertisements to the

[12] See focus statement Appendix B, p. 56.

shoppers need. Surprisingly the participants began to suggest several criteria's that could be included to determine if an advertisement had any relevance. Among these was the following:

- Personal hobbies – suggested by *D*
- Shopping list offers (Offers that are relevant to the shopping list at hand) – suggested by *B*
- Clothing styles – Suggested by *C*
- Family interest – Suggested by *A*

The participants were asked when they would like to receive these advertisements on their device. Surprisingly 2 of them would like to get them when entering the mall, whereas (*C* and *B*) would like to receive them when in front of the relevant shop. *D* suggested that it would be a good idea to make both solutions possible. They agreed that it would be perfect if they could somehow tell the device what kind of advertisements they wanted to receive e.g. adults clothes, children's clothes, sailing, electronics etc. *D* also said, that too often he would miss out on a good bargain, and that he would like to avoid that.

3: Electronic shopping list which can be updated from the Internet by your partner

C and *D* thought of this feature as being very supportive to their coordination. However *B* was a little bit sceptical about it. He articulated that if an electronic shopping list should be of any success, it had to be **easy** for them to elaborate it. He did not approve of the fact that he would have to turn on computer to enable him to create the shopping list. *A* agreed on this matter. Nevertheless *B* stated that it would save him from having to call the partner to coordinate the contents of the list.

According to the participants, the shopping list should be arranged by the physical location of items inside the mall. This would make it easier to do the actual shopping.

4: Call for assistance

This feature was suggested by the participants themselves. The initial interviews and the inquiries showed a need for being able to locate assistants inside the mall. According to the observations made during the inquiries it could be very difficult to locate an assistant. It should be possible to call for an assistant inside the grocery store.

5: Customer product satisfaction

This feature was suggested by *B*. Since he bought a lot of products based on recommendations from friends, he found it very valuable to get customer product satisfaction information that would support his decision whether to buy the product or not. *D* thought it would be a good idea, because they would most often visit malls to buy one particular more expensive item.

6: Awareness of acquaintances currently present in the mall
This feature was presented by the developer, but the participants showed no interest in the functionality. *B* stated that if the feature was present, it should be possible to set some kind of visibility parameter. He explained that he was not interested in letting acquaintances know of his location at every visit. He would like the ability of turning of "Big Brother".
However all the participants thought that it would be a good idea that the device was *aware of children's* current location inside the mall. *A* and *B* stated that when their child got older, it would be a safety net that would ensure them to not loose track of him.
D expressed that it would be very good if he was able to see where *C* was inside the mall. He expressed that very often they loose track of each other even though they had made an appointment where to meet. He suggested that it could be support with some commando-language. By pressing the map, and choosing "meet here in 10 minutes", the device would make sure she would meet him at that zone on the map.

7: Internet access
The participants were not convinced that internet access would be used on such small devices. They believed that it would be useful if the device was larger, like a laptop computer. *B* expressed that they would visit malls in order to do shopping, not to surf on the Internet.

8: IP-phone technology – free calls within the centre
Being able to call from within the mall was not a top priority. The participants stated that free calls would be great, but absolutely not a *must*.

The list of prioritized features will function as starting point for the design of the digital shopping assistant using story boards.

B.2.4.2 Storyboards

Storyboards aims to capture the work practice as it is re-designed including interactions with the system, interactions with other people and manual steps [Beyer&Holtzblatt 1998, p. 287-291]. In the design of these storyboards, it is important to come across all breakdowns that have been identified in the work models. That will tell the developer what to address. The developer should think thoroughly about these break downs, and try and eliminate them in the re-design of the system [Beyer&Holtzblatt 1998, p. 287-291]. Therefore the flow models should be revisited while elaborating the story boards in the following manner:

Flow models depicts communication topics, responsibilities of individuals involved, and break downs occurring in the collaboration between the individuals. These break downs should be removed in the re-design.

Sequence models provide the developer with an *overall intent* of performing of specific task. The overall intent must be supported by the system, which means that the digital shopping assistant must support both the task of preparing for shopping and for doing the actual shopping.
The sequence models provide the developer with insight into the *secondary intents* of what the user is trying to achieve taking each step in the sequence. All *secondary intents* must be supported in the re-design, but at the same time, the developer should try and eliminate as many steps as possible in the sequence models, by making the re-design handle some of the steps [Beyer&Holtzblatt 1998, p. 171].

- Support all *Overall intents of each model*
- Support all *Secondary intents of each model*
- Eliminate unnecessary *steps* needed to perform a task

Artifact model will describe how artifacts are created, and used in the work. Important artifacts should be present in the design, and details of the presentation should be captured in the design as well [Beyer&Holtzblatt 1998, p. 178-183].

Physical model illustrated break downs caused by the physical environment [Beyer&Holtzblatt 1998, p. 185-190]. In the design of the digital shopping assistant no changes to the physical environment will be suggested, since it is beyond the scope of this project. Nonetheless, break downs occurred because of the physical layout that made locating an item hard, or caused participants to loose track of each other. These break downs suggest that the *search*- and *awareness of partner* functionality is highly relevant, to overcome some of the obstacles that the physical model presents.

Breakdowns were present in both the preparation- and the shopping phase, re-design will affect both phases. Interactions are done with the digital shopping assistant, therefore the storyboards should depict this interaction as well. For that reason, the following storyboards should be drawn:

- Preparation phase
- Shopping phase
- UI Design

B.2.4.2.1 Preparation phase

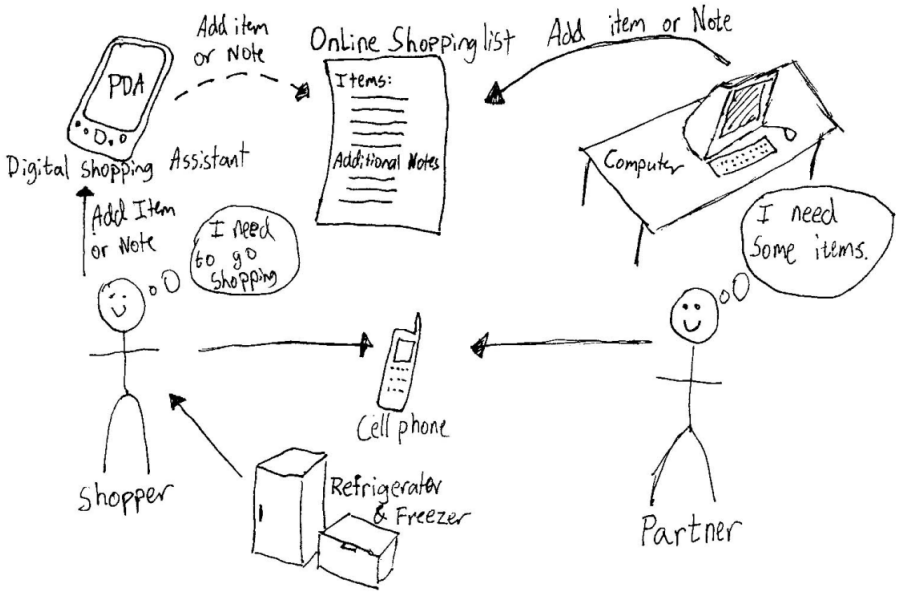


Figure 20 Storyboard of re-designed preparation phase.

In Figure 20 the re-designed work practice of the preparation phase is illustrated in a story board. From the elaboration of the flow model of the preparation phase[13], it was learned that communication breakdowns occurred when family members was unable to reach each other by phone. In order to avoid these break downs with the new system, an additional coordination method is introduced. Since access points provide Internet accessibility, it is possible to use the Internet for storing a common shopping list for a household online. That will enable the shopper to add missing items to a shopping list on the digital shopping assistant or a stationary computer. If an Internet connection is available, the shopping list is made accessible online for others to modify. If an Internet connection is not available, the partner can call the shopper through phone to recommend additional products to buy. By supplying two ways of coordinating the contents of the shopping list, it is less likely that breakdowns will occur in communication during the preparation phase. The sequence model of the preparation phase[14] further showed, that breakdowns can occur when trying to arrange the items on the shopping list according to the physical layout of the mall. If the contents of the shopping list are digitally made available on the Internet, it should be possible for the system to compare and arrange those items according to a database containing information about products within the mall. Thereby the shopper is relieved of this step in the sequence model and one more break down is avoided.

[13] See Flow model Appendix B page 33
[14] See Sequence model Appendix B page 37

B.2.4.2.2 Shopping phase

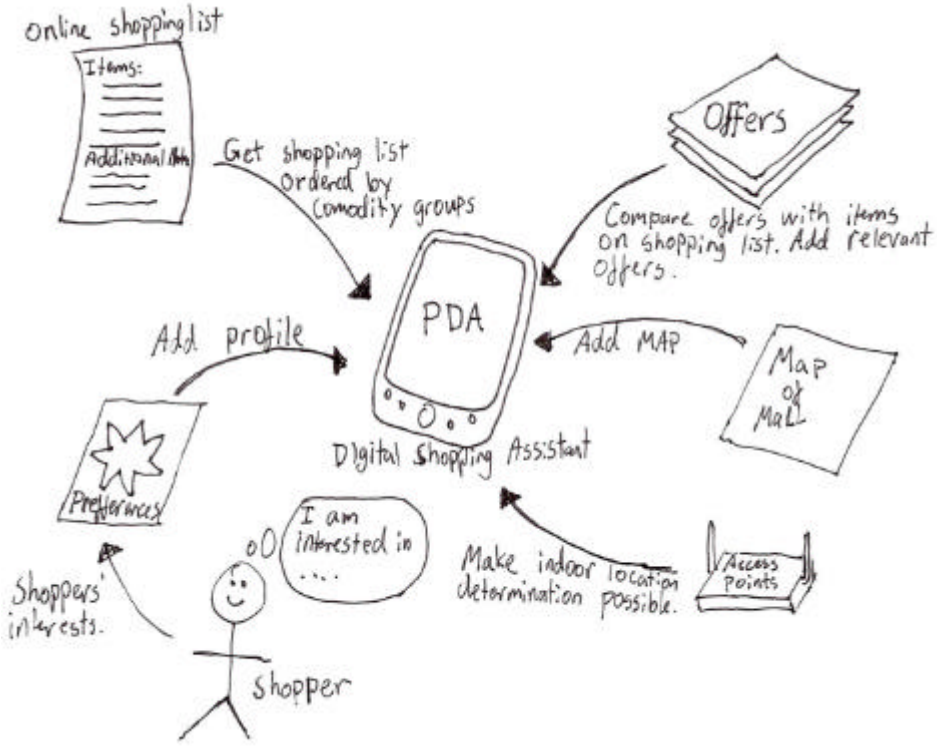


Figure 21 Storyboard of re-designed shopping phase.

In Figure 21 the re-designed work practice of the shopping phase is illustrated in a story board. The contextual inquiries showed that the participants were willing to add information about their interests, in order to support the system in providing tailored advertisements. Therefore the shopper should add their profile to the digital shopping assistant. When the shopper arrives at the mall, the shopping list, which was created during the shopping phase, is arranged according to commodity groups and made available on the digital shopping assistant. If a family member is needs to add a specific item, this can be added through the Internet and the shopping list is automatically updated. Thereby a coordination breakdown is less likely to occur. If the shops in the mall have offers that is tailored to a certain target group, these will be compared with the profile previously entered and relevant offers are sent to the shopper. Furthermore these offers can be compared to the items on the shopping list and the shopper can find offers that are related to the items that he is going to buy, thereby supporting the intent of saving money in the sequence models[15]. According to the inquiries one of the most annoying parts of shopping was not being able to find a particular item. This break down occurred in both sequence models of the shopping phase. However it is possible to aid the user in this task by supplying a map of the mall upon arrival. Since indoor location

[15] See sequence models Appendix B page 37 and 38.

determination is possible through the use of access points, it is possible to position the shopper on the map. It is also possible to aid the user in locating both the items on the shopping list -and other products of interest within the mall, since information about all products is available in the database. When the user is shopping, he will be able to see in which direction he must walk to get the next item on the shopping list. Since the items are ordered according to commodity group it is likely that several items can be grabbed at the same location, thereby minimizing interactions with the digital shopping assistant. If the item can not be located, the system should provide the shopper with easier access to help. This can be achieved by enabling the shopper to request an assistant for help. Since the system is aware of all digital shopping assistant's within the vicinity, it must be possible to supply the assistant with the location of the shopper who needs help.
One of the break downs identified in the flow model of the shopping phase was if the shoppers loose track of their partner. When shopping together it should be possible to see the location of your partner on the map, however this requires that both shoppers have a digital shopping assistant. It must also be possible to make an appointment on a meeting.
The two storyboards that depict both the preparation- and the shopping phase have explained the overall functionality that should be available in the design of the digital shopping assistant. These functionalities can be summarized into the following main categories:

Functionality	**Description**
Shopping list	The shopping list should be updateable from the Internet by family members. Furthermore the system should be able to arrange the shopping list according to commodity group, and supply the list with relevant offers. The list should be colorized according to commodity group. It must be possible to direct the shopper toward each commodity group on the map. It must be possible to add additional notes to the shopping list.
Map	The map should visualize both the map, the user's location and provide directions. Directions should be done with arrows pointing in the direction of a zone.
Search	It should be possible to search for products and shops within the mall, and these should be visualized on the map as zones.
Profile	The shopper should be able to add their preferences in order to aid the system in tailoring advertisements accordingly. The profile should contain the interests of the shopper.
Request Assistance	The shopper must be able to call an assistant for help.
Awareness of partner	The system must be able to show friends, partner or family members on map. It must be able to make an appointment of a meeting.

Table 11 Table of main functionalities that must be available in the design.

When comparing this list of main functionalities with the *starting point list*, one can see that several functionalities have been eliminated, namely *customer product satisfaction, Internet*

access and *IP-phone technology*. These functionalities/services were eliminated because they were not prioritized highly by the participants. However, *Awareness of acquaintances currently present in the mall,* which had a low priority among the participants, was included in the design (Awareness of partner). It was included in the design, because break downs occurred during the shopping phase, when the participants lost track of each other.

B.2.4.2.3 User Interface Design

During the inquiries it was observed that shopping is an eye-busy and hand-busy task. In order to support this, it was chosen to keep the interactions required to get information from the digital shopping assistant, at a minimum. It was suspected that the stylus[16] would require a lot of attention, and would make the interaction with the digital shopping assistant cumbersome in the context of shopping. The stylus would require both hands; one for holding the PDA and one for navigating with the stylus. Therefore it was chosen to make all buttons in the user interface large, in order to make one-hand operation possible.
Furthermore large buttons would make the text of the buttons easier to read, since a larger font size could be used. The same aspect applies for the text of labels and lists. In order to better support that shopping is eye-busy task, it required that the user interface is easy to understand, well arranged and readable. Therefore it was chosen to use large font sizes for all elements in the user interface.
According to Table 11 the 3 main functionalities are *shopping list*, *map* and *search*. It was assumed that these functionalities are also the ones, which will be most frequently used. Therefore it was chosen to make these functionalities visible at all times in the design, by presenting them with buttons in the bottom on the screen. The reason why it was chosen to place them in the bottom of the screen, is because if they had been placed in the top, the hand would cover a lot of the screen when they are being pressed. Consequently it would be hard for the user to determine if the digital shopping assistant had acknowledged his command, since the hands would cover the area that supplies him with feedback.

The functionalities described in Table 11 will be illustrated in storyboards that depict the user interface design. Only *shopping list, map and search* will be shown here.

[16] The stylus is a pen which is used to control a PDA.

Shopping list

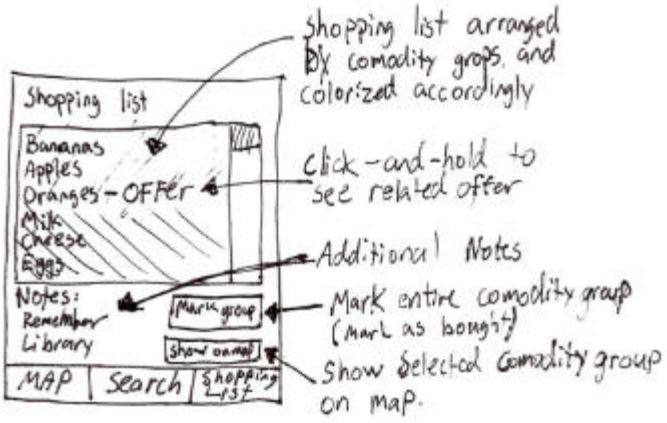


Figure 22 Storyboard illustrating the UI for the shopping list.

The analysis of artifact model showed that a shopping list has the following characteristics: *small, handwritten, list of items to purchase, arranged according to commodity group* and *additional notes.* With the exception of *handwritten,* the shopping list in this design will have similar characteristics, in order to aid the user's interpretation of the design. Upon arrival in the mall, the items on the shopping list is arranged and colorized according to commodity groups. If a relevant offer is available, this is marked on the shopping list and it is possible for the user to view the contents by click-and-hold interaction. Additional notes are added to the bottom of the list. If a commodity group is selected on the list, the shopper can mark the group as bought or show the commodity on the map with directions on how to get there. In the bottom of the screen the main functionalities is presented with large buttons map, search and shopping list.

Map

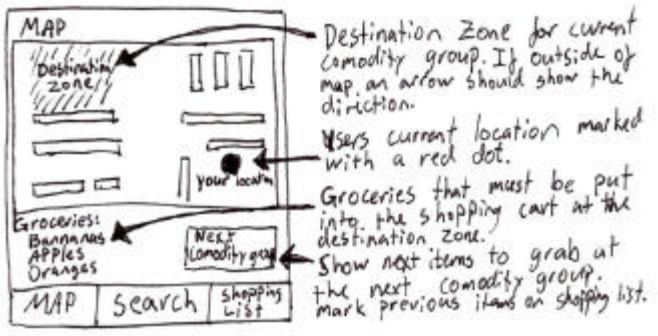


Figure 23 Story board illustrating the UI of the map.

Once the shopper has selected a commodity group and chosen *show on map* the map is showed. The destination zone for the commodity group is marked on the map. If the zone is outside of the map, an arrow must aid the shopper in determining in which direction to walk.

The item's that must be grabbed at the destination location is available at the bottom of the screen. This minimizes the interaction needed, because if they had not been placed there, the shopper is forced to switch back to the shopping list upon arrival at the location of the commodity group, in order to see which item to grab. The button *next commodity group* shows the direction for the next commodity for the shopping list, and the items belonging to the previous commodity group is marked on the shopping list, in order to make it more manageable.

Search

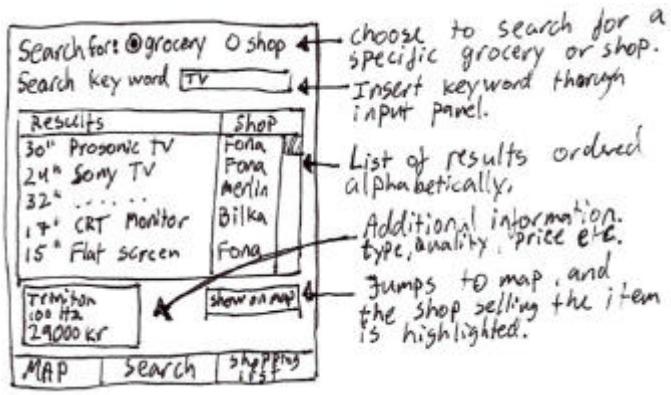


Figure 24 Story board illustrating the UI for the search functionality.

It should be possible to search for a product or shop within the mall. The shopper can choose what to search for, and enter a search keyword. The results will be listed below ordered alphabetically. If a result item is marked, additional info should be available below the list. *Show on map* jumps to the map, and the shop selling the product is highlighted.

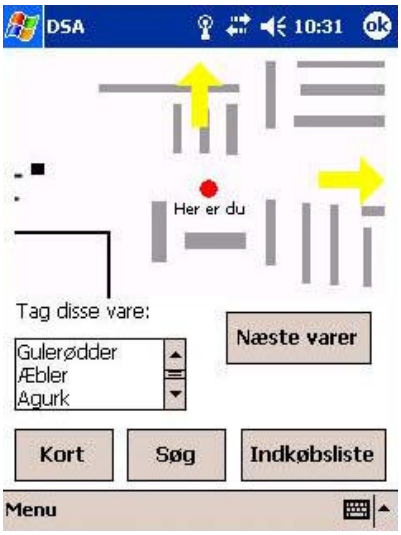
The functionality *Profile* and *Request assistance* should be available from a menu, since they are not used very often. Thereby screen real estate is kept at a minimum for these functionalities.

B.2.5 Implementation using Contextual Design

This section will describe the implementation phase of a prototype. The section will feature several screenshots of a developed prototype. Each screenshot will be commented.

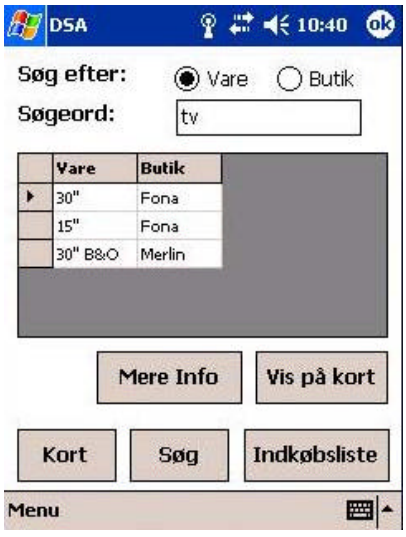
Shopping list

The shopping list is shown above. The top most item has a related offer marked by an icon. The user is able to click-and-hold on the item, to get the related offer displayed. At the bottom three bottoms illustrate the main functionality namely map, search and shopping list. These buttons will be present in all windows and therefore serve as means of switching functionality. All buttons in the design has been made large, in order to support the fact that shopping is a hands- and eye busy task.



Map

The shopper's location is marked with a blinking red dot centred on the map. The arrows indicate that the items must be located to the north-east. The list-box below shows the items that must be grabbed at the next commodity group zone. The directional arrows could have been implemented using vector, and a higher direction-quality would have been gained. However it was difficult to implement.



Search

Tv has been entered as search keyword. The list of results is seen below. After entering each character in the search box, the search results will be narrowed down accordingly. This makes search require less interaction, since if entering a *"t"*, the results will only include those results that starts with a *"t"*. When marking an item, it can be shown on the map. Additional info is also available. However this needed a new window because of limited screen space.

Profile

The shopper should supply the system with their sex and age. Moreover they can specify whether they would like all related advertisements upon arrival at the mall, or if they would like them in front of the relevant shop. They can specify their interests through the use of the combo box, which holds several categories. Once a category is selected, subcategories will appear below. They can check those boxes which matches their interests.

Map – Advertisement found

An advertisement that is tailored to the user's preferences has been found. A button appears that enable the shopper to view the advert. During the implementation phase it was decided that zoom-functionality was necessary, because of the limited display size.

Advertisement

A typical advert. The user is provided with the option of getting the owner-shop of the advert shown on the map.

B.3 Empirical data

B.3.1 Focus statement for Contextual Inquiries

Frequency of using malls

- How often do you use shopping centre?

- What is the primary reason you use them?
  - The amount of shops collected at one place?
  - The prices?

- What is most important, the small or the large shops?

Preparation before shopping

- Do you make a shopping list?
  - How does it look?
    - Is it small or large?
  - Arrangement:
    - Is the items arranged by their physical location in the mall?
    - By memory and intuition when the list was elaborated?
    - By groceries or hardware goods?
    - Not arranged?
  - Is it always the same person elaborating the list?
    - Is the list elaborated together?

- Do you look in commercial papers (tilbudsaviser) before shopping?
  - Do you shop with these offerings in mind?

- Do you occasionally buy other goods not on the shopping list, or items you did not plan to buy before going shopping?

- How do you find the things you need?

The course of shopping

- Which transportation is used to and from the mall?

- How long time is spent shopping?
  - Which factors can delay you from doing the shopping in the planned period of time?

- What are the most annoying parts of shopping?
  - Parking
  - Shopping queues

  - Not being able to find an item on the shopping list
  - Etc.

- Do you use a shopping cart when shopping?
  - When do you use it?
  - How do you find it?

- Do you compare the prices on the items you need in different shops before buying them?
  - If no, why not?
  - If yes, how is this accomplished?

- Do you shop alone or with others?
  - Do you go together?
  - If you separate, how do you find each other again?

- Where do you keep the shopping list?
  - How often do you look at the shopping list?
    - After each item that has been put in to the shopping cart?
    - Do you mark the items already purchased on list?
  - Can the shopping list be disturbing, or is it a good guide?

- How do you locate the placement of commodity groups (vare grupper) within the mall?
  - Do you know the placement because you have been here before?
  - Do you use signs?
  - Do you look for other goods similar to the item you are looking for?

Communication when shopping

- Do you communicate with others while shopping through cell phone for updating or conferring with your partner about the content of the shopping list?

- When do you use assistants within the mall?

- Do you meet acquaintances while shopping?
  - Are you interested in knowing if there are any of your friends currently in the mall?

Advertising signs

- How do you react when seeing advertising signs in front of the shop?
  - Do you notice them?
  - Do you do impulse buying
    - What triggers you to do so?

- Do you notice if the advertising sign is addressed to you, your partner or both?

- Do you buy products based on these signs?

- Would you like advertisements that are tailored for your criteria's, such as your age, your interests, your clothing style, your favourite fruits etc.?

A digital shopping assistant

- Tailored advertisements
    - Upon arrival to the mall?
    - In front of the relevant shop?

- Location of goods within the mall, help on finding them?

- Electronic shopping list which can be updated from the Internet by your partner?
    - How should the shopping list be arranged?

- Awareness of acquaintances currently present in the mall?
    - Awareness of the location of your partner or child in the centre?

- Internet access ?

- IP-phone technology – free calls within the centre

- Other Ideas...

B.3.2 Summary of Contextual Inquiry

This section will summarize the data collected in the Contextual Inquiry according to the focus statement previously mentioned. This is normally not a part of the contextual design method, but it is found necessary in order to avoid missing important details due to inadequate quality in the recorded data. Statements given by each couple will be arranged according to the subjects included in the focus statement. The data needed for writing this summary is obtained from the interviews and the inquiries, as illustrated below:

Subject of focus statement	Data used from Interview	Data used from inquires
Frequency of using malls	Yes	
Preparation before shopping	Yes	
The course of shopping	Yes	Yes
Communication when shopping	Yes	Yes
Advertising signs	Yes	Yes
A digital shopping assistant	yes	Yes

Table 12 Table showing what kind of data was used to summarize the subjects in the focus statement.

B.3.2.1 Frequency of using malls

This subject in the focus statement had the purpose of revealing how often malls are used for shopping and what triggers the participants to use them.

Couple nr 1 (Female A: 29 years, Male B: 34 years)

Shopping in malls is done approximately 10 percent of the times. The frequency varies depending on type and amount of groceries needed. Most often shopping in malls is done, if they need a large amount of provisions or if they need an item that can not be bought at other stores. Often a large amount of groceries from the refrigerated counter is bought because of the cheap prices. When there are a limited amount of provisions in their deep freezer, they consider another visit to the mall. When visiting a mall, they often bring their 2 year old child and therefore they often go shopping together.

Couple nr 2 (Female C: 54 years, Male D: 59 years)

This couple rarely shops at malls. They only use malls, when they need to buy items on sale that can not be bought at other stores. They rarely shop provisions when being at malls, but it occasionally occurs when a large amount of groceries is needed for a dinner party. It also occurs when they need to buy provisions for sailing a longer period of time. Most often this couple shops on a day to day basis, meaning a high frequency of shopping with few groceries

being bought. When they shop at malls it is often in the weekends and they tend to go together. This happens approximately once a month.

B.3.2.2 Preparation before shopping

This subject of the focus statement should reveal how the participants usually prepare themselves for shopping. This involves elaboration of shopping list, mutual coordination, transportation and overall use and usefulness of shopping list. Details on use of the shopping list when doing the actual shopping will be revealed in section B.3.2.3.

Couple nr 1 (Female A: 29 years, Male B: 34 years)

As pilot and stewardess the couple work irregular hours, and shopping-coordination is done ad-hoc according to their individual schedules. They go shopping together with their child when it is decided that a larger amount of groceries is needed. Most frequently shopping is done individually when shopping groceries at a daily basis. They have one automobile available, which is frequently used as transportation for shopping. Occasionally shopping is done by means of a bicycle, but this transportation is only used when few groceries need to be bought from the local store.

A shopping list is elaborated almost every time they go shopping. Sometimes the list is prepared individually, but most often it is elaborated together. They have a hard time figuring out what to buy when they are shopping, if they have not prepared a shopping list in advance. *B* felt it was annoying to be unprepared for shopping, because it prolongs the amount of time spent shopping. Most often it is *A* who writes down the items they need, and it is also her, who carries the list when doing the actual shopping. She prefers the paper on which the list is written to be small, since it enables her to have the list in her hand throughout the course of shopping. The items are arranged by their physical location inside the store, when they are shopping at the local store. But when they are shopping at larger malls, the list is often arranged by their memory when creating it, or by the order in which they occurs when reading the commercial papers for that particular mall. But these commercial papers are only used about 10 percent of the times. The paper is looked through each page, and cheap offers are compared to their need for provisions. If a cheap offer is found needed, it is added to the list. They look in the refrigerator every time the list is prepared in order to identify needed groceries.

Couple nr 2 (Female C: 54 years, Male D: 59 years)
This couple owns 2 automobiles since their workplaces lie in two different directions from where they live. Therefore they rarely shop together during the weekdays however this occasionally occurs during weekends. The shopping-coordination is done ad-hoc, sometimes both are involved, but most often the female does the preparations for shopping. The shopping list is then assigned to one of them.

A shopping list is elaborated almost every time they go shopping. However they have a slightly different approach for the elaboration and use of the list compared to the first couple. Since this couple have workplaces that lie in two different directions from where they live, it is necessary to coordinate who is doing the shopping, to avoid buying the same groceries. Most often the list is prepared by *C* a day in advance before going shopping. *C* finds the list most useful when shopping for a dinner party, but when shopping for the everyday groceries, she can often remember what to buy, but this depends on the amount of provisions needed. She prefers the list to be ordered by type of grocery, because that makes it easier for her to grab the groceries systematically according to their location in the mall. In most occasions the shopping is done individually by the person that was assigned the list on their way home from work. If the shopping list has not been prepared beforehand, coordination on groceries is done through phone while being at work. At some occasions both need to go shopping, if certain groceries are regarded better quality at a different store than the one responsible for shopping is going to shop at. They only look in commercial papers if they need a specific item. This item is often a more expensive one, and therefore the amount of shops in a mall, helps them identify the cheapest product easily. They like having the option of comparing quality and prizes in different shops.

B.3.2.3 The course of shopping

This subject in the focus statement should reveal how a course of shopping usually unfolds. This includes details about the use of the shopping list, time spent, use of shopping cart, people involved and means of transportation. The contextual inquiries will support the following statements, because numerous observations was done while observing the actual shopping taking place, that will aid the interpretation.

Couple nr 1 (Female A: 29 years, Male B: 34 years)

This couple often brings their 2 year old child when shopping in malls and therefore they use their automobile as transportation. When few groceries need to be bought the bicycle is often used. Usually a couple of hours are spent shopping, but it can be prolonged if they have not prepared themselves, or if they have a hard time finding a required grocery. *B* expressed that it was extremely annoying when being unable to find an item within the mall and getting assistance is often hard, because the assistants can be hard to locate or they often look busy. *A* agreed on this matter, and supplied the statement by saying that if she spend more than 10 minutes looking for a particular item she often gives up.

Sometimes when they go shopping in malls, they split up in order to pursue their own shopping interests. When this happens they make an appointment where to meet. Usually the one that spend less time in a shop goes to the shop where the partner is residing.

They always use a shopping cart when shopping. Their child is positioned in the seat of the shopping cart, while they take turns in driving the cart around the mall. The one driving the cart usually takes a commercial paper at the entrance to the mall, and goes through this paper while doing the shopping looking for special bargains. Furthermore the driver of the cart is responsible that the child is entertained. In the mean time the one not driving the cart does the actual shopping. Therefore the one not driving the cart has the shopping list in the hand, and coordinates the other where to drive the cart. Usually it is *B* driving the cart, while *A* does the actual shopping.

In the interview *A* stated that she usually do all the shopping first and synchronizes the items in her basket/cart with her shopping list just before she checks out at the counter. However it was observed during the Inquiry, that the shopping list was used more often than that. In fact she used it approximately one time every three items bought. She did not mark the items that were already bought on the list, because she felt that she could easily remember it. However it was observed, that she would use her thumb to cover the last item on the list, which would aid her determining the progress of the shopping. During the inquiries it was also observed that *A* and *B* got so far away from each other, that they had a hard time finding each other. This happened when *A* went to get an item far away from their location, while *B* went to get

another item on list. While being in the mall they had a hard time finding children's clothes and a particular type of meat. When finding the next item on the list, they primarily used the signs hanging from the ceiling.

Couple nr 2 (Female C: 54 years, Male D: 59 years)

As previously mentioned this couple often shops separately and uses a car as transportation. According to the statements given during the interview, *C* and *D* agreed that shopping usually takes 20 minutes when shopping on a daily basis, however when shopping together during weekends it would take about two hours, because it is different items that is bought. *D* expressed that *C* could prolong the visit to the mall, if she had to look at women's clothes. When this happens they usually split up, and make an appointment on where to meet in ten minutes. Although an agreement on this matter has been made, it occasionally occurs that they can not find each other. *D* also expressed that the most annoying part is not being able to find what you are looking for. *A* agreed on this matter and further stated that the shopping queues can be very annoying.

When doing the actual shopping *D* would drive the shopping cart, while *C* had the shopping list in her hand. She marked each item on the shopping list with a pencil as they were put into the cart. She felt that would ensure her that they did not forget to buy all the items on the list. The items on the list were located systematically according to their physical location in the mall, not according to the succession on the list.

During the inquiries the top priorities on the shopping list were a 17" flat screen monitor and a scartcable for their newly acquired DVD-player. When they had bought their provisions they started looking for these items. It was observed that they looked for similar items on the shelves to try and locate the items. Eventually the location was found, but it took more than 7 minutes and they almost gave up along the way. When they found the section containing scartcables, they had doubts about what kind of scartcable to buy. They could not remember if their TV had one or two scart-ports at the back. They knew the model of the television, which they assumed was a known model to any assistant working in the mall. Therefore they started looking for an assistant, which could aid them in determining the type of scart cable to acquire. They had a hard time locating an assistant, but when they eventually found one, he was unable to help them. There were asked if Internet access could help them on this matter. They replied that it would most likely help them, but still it was to troublesome a process, they would rather wait and solve the puzzle themselves, meaning a better preparation had to be made in order to purchase the right cable. Since they were already in the electronic section, they started looking for a 17" flat screen monitor. They were unable to find any monitor, which had a larger display than 15", and eventually gave up on this purchase. However a

DVD movie, that was not a part of their shopping list, was put into the cart. *D* bought the DVD because he had previously seen the movie and he would like to see it again.

B.3.2.4 Communication when shopping

This subject in the focus statement should reveal what kind of communication takes place while shopping. Moreover it was also supposed to reveal to what extent, communication with an assistant is likely to happen.

Couple nr 1 (Female A: 29 years, Male B: 34 years)

This couple uses a cell phone very often to coordinate with their partner on what to buy, while being in the mall. It happens most frequently, if they have not elaborated a shopping list in advance.

During the inquiries it was observed that *B* was talking to a friend for about five minutes through cell phone. The communication took place while driving the cart around, which indicates that concurrently tasks can be performed while shopping.

Both *A* and *B* agreed that they frequently communicate with assistants, in order to get help on locating a particular item within the mall. Sometimes they communicate with assistants in order to get information about a specific product, but this happens rarely.

Occasionally this couple meets acquaintances while shopping. *A* expressed that it is only coincidence when this happen, no prior arrangement with others is done prior to shopping. They agreed that meeting acquaintances is supposed to be coincidence, and they would not be interested in knowing if anyone were nearby, unless they had the possibility to control their own visibility. *B* did not like the idea of being monitored by others and compared it with Big Brother.

Couple nr 2 (Female C: 54 years, Male D: 59 years)

As previously mentioned, this couples workplaces lie in two different directions from where they live. Consequently a lot of coordination concerning what to buy has to be done. Therefore they often use a cell phone to coordinate with their partner on what to buy while shopping. *D* expressed that it sometimes was annoying to phone while shopping. However he felt it was necessary, because they have experienced the case, when both get home from work and they have bought the same groceries.

D also articulated that most frequently communication with assistants is done, in order to get help on locating a particular item. However, sometimes he uses assistants in order to get offers or information about a specific product. *C* expressed that she uses assistants in order to

get help on locating a grocery, but this happens very rarely because she often has a hard time locating them.
Occasionally this couple meets acquaintances while shopping. They agreed that when this occurs, they sometimes go to a café and have a drink with them. They would like to know if any friends are currently in the mall.

B.3.2.5 Advertising signs

This subject in the focus statement had the purpose of revealing, which effect advertising signs had on the course of shopping. Moreover it should enable the participant to consider, whether they would like tailored advertisements that are addressed to their interests and preferences.

Couple nr 1 (Female A: 29 years, Male B: 34 years)
A stated that advertising signs could awaken her curiosity when shopping. If she notices an advertising sign with a good bargain, which is addressed to her or her family, she often examines the offer in order to determine if she should buy it. Sometimes that triggers her to do impulse buying, meaning that the purchased item is not on her shopping list. *B* agreed with *A* on this matter, but further explained that the amount of advertising signs could sometimes be overwhelming, consequently not all signs that is equally important/relevant are noticed. He also expressed, that it is more likely that he would do impulse buying, if the offer is related to a product that his friends has bought. He called this "Trial and error" and explained that if a friend had bought a product, which he had recommended to *B*, then it would have an impact on his decision whether to buy the product or not.
During the inquiries it was noticed that *B* bought a computer game that was not on the shopping list. He expressed that he had seen an in-game movie from the game, and one of his friends had bought it and had recommended it to *B*.
A and *B* agreed that if all the advertising signs were tailored to their preferences they would susceptible to their attention, because the amount of advertising signs would no longer be overwhelming.

Couple nr 2 (Female C: 54 years, Male D: 59 years)
As previously mentioned this couple often visits malls in order to buy a specific product, often a more expensive one. *D* stated that when he is inside a mall, he is determined to find the product that he needs, and therefore he only looks for advertising signs offering this product. However he was aware of the fact, that this means he would miss out on a good offer/bargain. *C* did not agree on this matter. She expressed that although they were looking

for a specific product, she would take time to shop for some clothes. Therefore she would notice advertising signs that were addressed to both of them.
During the inquiries *D* bought a DVD-movie that was not a part of their shopping list. *D* bought the DVD because he had previously seen the movie and he would like to see it again. It was noticed that the actual sign did not trigger him to buy the product, however the amount of DVD stacked up in a big pile got his attention. From previous shopping experience, *D* stated that he had bought cheap older movies, and they are often displayed in a similar way. Both *C* and *D* agreed that they would like advertisements that are tailored to their preferences. *D* particularly desired that the offers would be tailored for his interests.

B.3.2.6 A digital shopping assistant

At the end of both contextual inquires, both couples were presented with early hypothesis about possible design ideas for a shopping assistant. These design ideas were based upon prior preparations contained in the focus statement and interpretation of observations made during the interviews and contextual inquiries. The design ideas covered different features that could be supported by a future digital shopping assistant. Each feature was commented/verified by the participants, and several other features were suggested as well. The design ideas were presented, in order to verify their priority, their relevance and the quality of each solution. All 4 participants took part in this interview simultaneously. They were also told about the possibilities of current technology. This included indoor location determination, internet access, maps of malls etc.

This section will be divided according to features discussed during the interview. They will be numbered according to the way they were prioritized by the participants (1 = highest priority).

1: Location of goods within the mall, help on finding them
During both the interviews and the inquiries, the participants articulated, that one of the most annoying parts of shopping, is not being able to find a needed item. When this feature was suggested to them, they seemed very fond of the idea. *B* stated that if the shopping list was digital on some sort of device, it would be of great help if it could show him where to go on a map. This feature was of top priority for the participants.

2: Tailored advertisements
As previously mentioned in the section above (Advertising signs), the participants had articulated thoughts on advertisements. As described they would like to have access to tailored advertisements, because the amount of advertisements in a mall could be

overwhelming. It was not anticipated in advance, that shoppers would add personal preferences to the device, which would enable the device to tailor advertisements to the shoppers need. Surprisingly the participants began to suggest several criteria's that could be included to determine if an advertisement had any relevance. Among these was the following:

- Personal hobbies – suggested by *D*
- Shopping list offers (Offers that are relevant to the shopping list at hand) – suggested by *B*
- Clothing styles – Suggested by *C*
- Family interest – Suggested by *A*

The participants were asked when they would like to receive these advertisements on their device. Surprisingly 2 of them would like to get them when entering the mall, whereas (*C* and *B*) would like to receive them when in front of the relevant shop. *D* suggested that it would be a good idea to make both solutions possible. They agreed that it would be perfect if they could somehow tell the device what kind of advertisements they wanted to receive e.g. adults clothes, children's clothes, sailing, electronics etc. *D* also said, that too often he would miss out on a good bargain, and that he would like to avoid that.

3: Electronic shopping list which can be updated from the Internet by your partner

C and *D* thought of this feature as being very supportive to their coordination. However *B* was a little bit sceptical about it. He articulated that if an electronic shopping list should be of any success, it had to be **easy** for them to elaborate it. He did not approve of the fact that he would have to turn on computer to enable him to create the shopping list. *A* agreed on this matter. Nevertheless *B* stated that it would save him from having to call the partner to coordinate the contents of the list.

According to the participants, the shopping list should be arranged by the physical location of items inside the mall. This would make it easier to do the actual shopping.

4: Call for assistance

This feature was suggested by the participants themselves. The initial interviews and the inquiries showed a need for being able to locate assistants inside the mall. According to the observations made during the inquiries it could be very difficult to locate an assistant. It should be possible to call for an assistant inside the grocery store.

5: Customer product satisfaction

This feature was suggested by *B*. Since he bought a lot of products based on recommendations from friends, he found it very valuable to get customer product satisfaction information that

would support his decision whether to buy the product or not. *D* thought it would be a good idea, because they would most often visit malls to buy one particular more expensive item.

6: Awareness of acquaintances currently present in the mall

This feature was presented, but the participants showed no interest in the functionality. *B* stated that if the feature was present, it should be possible to set some kind of visibility parameter. He explained that he was not interested in letting acquaintances know of his location at every visit. He would like the ability of turning of "Big Brother".

However all the participants thought that it would be a good idea that the device was *aware of children's* current location inside the mall. *A* and *B* stated that when their child got older, it would be a safety net that would ensure them to not loose track of him.

D expressed that it would be very good if he was able to see where *C* was inside the mall. He expressed that very often they loose track of each other even though they had made an appointment where to meet. He suggested that it could be support with some commando-language. By pressing the map, and choosing "meet here in 10 minutes", the device would make sure she would meet him at that zone on the map.

7: Internet access

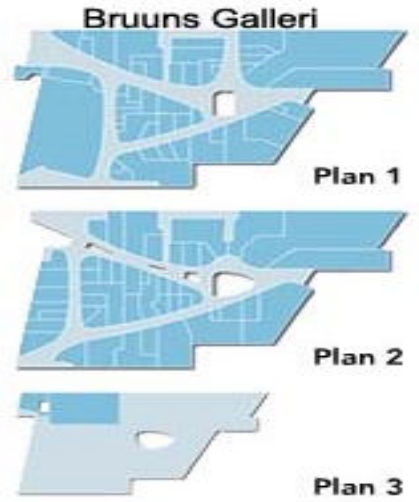
The participants were not convinced that internet access would be used on such small devices. They believed that it would be useful if the device was larger, like a laptop computer. *B* expressed that they would visit malls in order to do shopping, not to surf on the Internet.

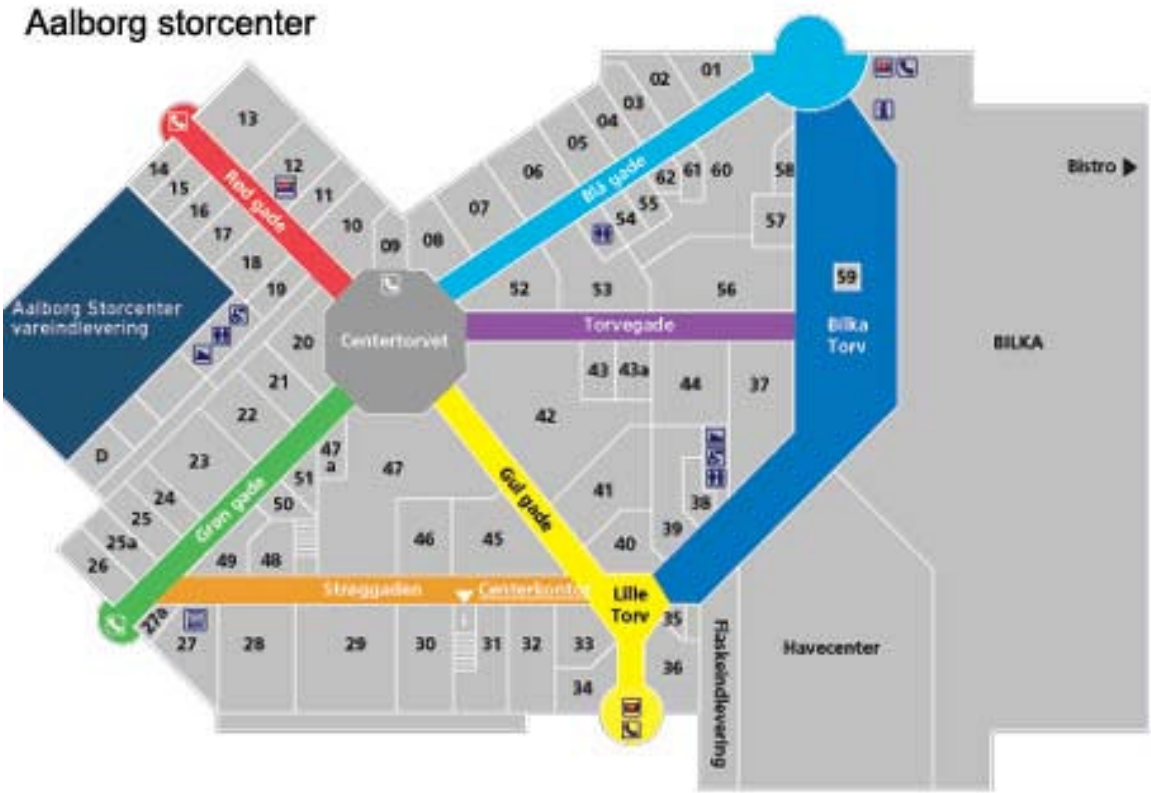
8: IP-phone technology – free calls within the centre

Being able to call from within the mall was not a top priority. The participants stated that free calls would be great, but absolutely not a *must*.

B.3.3 Layouts of malls

Two layouts of shopping malls, Bruuns Galleri and Aalborg Storcenter.





B.4 Diary

Date: 29/3

Phase: Finding test participants

Work performed: Participants for a Contextual Inquiry was contacted, and a date for the actual Contextual Inquiry to take place was set.
The participants were told that they had to prepare themselves for shopping as they would normally do, meaning that no prior shopping should be made in the days before the Inquiry, since this would limit the amount of goods being bought during the Inquiry and could minimize the amount of data collected from the inquiry.

Participants: The test leader

Initial understanding: An understanding has been gained from the method that covers how to choose *who* to interview. In general the test-leader should interview 2-3 customers in each role identified as important to the focus. Unless the focus is very narrow, 10-20 interviews should be conducted to cover the work practice.
The customers chosen for the interview to show the common underlying structure that cuts across the customer base, the test leader should choose very different customers, rather than studying similar customers to confirm what is learned.

Time usage: Some days before speaking to the participants, was used to consider who to contact. Approximately 1 hour was used to gather 4 participants.

Actual understanding: As starting point the aim of the Contextual Inquiry was to reveal which features should be provided in a digital shopping assistant. This assessment would be done by revealing the common underlying structure of shopping.
The focus of the Contextual Inquiry is narrow, because the purpose is to reveal the common underlying structure of shopping. The focus of the contextual inquiries is narrow, because only the role of a shopper is important to the focus. It was chosen to gather only 4 participants for the Contextual Inquiry. The participants should differ in age and shopping habits.

Applicability of outcome: The applicability of the outcome cannot be assessed until the Contextual Inquiry has been conducted. Only at this time would it be possible to determine the applicability of the data, which the chosen participants would give.

Reflection:
The participants consisted of 2 couples:

- **Couple nr 1:** male, 34 years & female, 29 years – with 1 child
- **Couple nr 2:** male 58 years & female, 54 years

Further demographics will be present in the report. Although the participants was different in age and shopping habits, a more thorough reflection would reveal the fact that the entire customer base is not represented in the participants gathered for the contextual Inquiry's. For example teenagers, singles and senior citizens are not represented in the group of participants chosen for the Inquiries. It would be more representative to the entire customer base, if these participants were be included in the Contextual Inquiries. However this would naturally yield more data to analyze and therefore it was chosen not to include them, since the amount of time available to us is limited.

The time of the actual contextual inquiry was set to a Friday morning (10.00 AM). It was deliberately arranged at a particular weekday early in the morning, to limit the amount of other shoppers present in the mall, which could be disturbing for the ongoing inquiry. There are both advantages and disadvantages conveyed with this choice. The advantage is that hopefully the amount of shoppers will be limited which will likely improved the quality of the recorded data, both in terms of the digital recording device, but also the attention during the observation will probably be better. However the disadvantage is that if the participants usually shops during the weekends, setting the inquiry on a less crowded weekday will set up an unnatural environment. This could influence the way they are shopping. Nonetheless it was chosen to set up an environment that would aid the conduction of the inquiry, due to the fact that the quality of the data was regarded most important. Having an observer (The test leader) looking at the way you are shopping is already an unnatural environment.

Planned progress tomorrow:
The next step is the contextual Inquiry, which is set to Friday April 2 at 10.00 AM. Before the actual Inquiry can take place, an elaboration of a focus statement will be done, in order to guide the focus of the contextual inquiries. Hopefully more important aspects would be revealed.

Date: 1/4

Phase: Empirical data collection

Work performed: A focus statement to keep the interviews on track

Participants: The test leader

Initial understanding: A focus statement is used to keep the Contextual Inquiry on track by keeping the focus. The initial focus in the focus statement should expand through inquiry into the work during the Contextual Inquiry.

Time usage: 3 hours was spent elaborating the focus statement.

Actual understanding: focus statement is similar to a semi structured interview. It is used to keep the Contextual Inquiry on track by helping keeping the focus. It is similar to a semi structured interview, because it must be able to inquiry into important aspects of the work practice that should be articulated during the inquiries.

Applicability of outcome: The applicability of the focus statement was good. It helped organizing thoughts in subjects on paper. The subjects would eventually reveal common underlying structure of shopping.

Reflection: According to the descriptions in the book, there is no adequate example, of how focus statements should look. Seeing the similarity between semi structured interviews and focus statements helped understand what focus statements should try and accomplish. However this requires some experience in conducting preparations for interviews.
The last subject of the focus statement contained ideas about which features to include in a shopping assistant. These ideas have been carefully considered in the group, and they have been presented to HP. Therefore they are described in the focus statement to verify their relevance. The reason why they were placed last in the focus statement, is that we want the participants to freely articulate their needs first. Afterwards an attempt to compare the user needs with the features just mentioned, would make the participants think about possible solutions to support shopping. These solutions are not necessarily those ideas that we had.

Due to the limited time available an inquiry into the elaboration of a shopping list will not be conducted. Since contextual inquiries is about observing *the work as it happens*, the test

leader are not entirely true to the contextual design method at this particular subject. However details on this subject are **very** important to the design for a digital shopping assistant. Therefore it was chosen to do a short interview at the beginning of the day of the Contextual Inquiry. This interview should reveal details about the shopping habits of the participants, as well as preparations done beforehand. This detailed information could not be brought to the surface without an inquiry, if the contextual design method should be followed to its fullest.

Planned progress tomorrow: The Contextual Inquiries take place tomorrow at 10.00 AM.

Misc.: Some experience in preparing interviews is required to elaborate focus statements. The focus statement can be found in Appendix B.3.1.

Date: 2/4

Phase: Empirical data collection

Work performed: 2 Contextual Inquiries with 4 test participants

Participants: The test leader and 4 test participants.

Initial understanding: Contextual Inquiries are the core of contextual design, so approximately two weeks was spend reading and understanding how they should be performed and what kind of relationship should be present between the test leader and the test participants. The relationship model should be the master/apprentice model, but still giving the "apprentice" the ability to control the focus of the inquiry. Each contextual inquiry should be recorded on tape for later processing.

Time usage: The 2 contextual inquiries lasted 3 hours, from 10.00 AM to 1.00 PM.

Actual understanding: The course of the day would begin with a short introduction to the contextual design method. In this introduction the participants was told about the master/apprentice model which should guide the relationship between the test leader and the participants. This was done in order to make the participants aware of the importance of articulating details about shopping. They were told that they should act as *masters* of shopping, and that their foremost assignment was to teach the test leader (*the apprentice*) how to do shopping. The participants were divided into two pairs. Afterwards an interview about shopping was done with each pair, in order to make the participants think about the details of shopping. Two contextual interviews were then performed while observing both couples doing their shopping according to their shopping list.

Applicability of outcome: The applicability of the contextual inquiry was better than expected. Particularly, details about the use of shopping lists were revealed that will enable the developer to do a better design. Other details were discovered but these will not be mentioned here.

Reflection: The relationship model worked surprisingly well. After a very short period of time, the participants began to articulate details about their shopping. The inquiry revealed very different shopping habits, which mean that a shopping assistant should support different approaches to do both preparations before shopping and to the actual shopping.

Both contextual inquiries were recorded on a device with Dictaphone capability, however it was questionable if this recorded data could be of any use, considering the amount of noise present at a mall. Moreover it is difficult to do good recording, when the interviewed person is constantly moving around in a noisy environment. If the test leader has to move around with the participant recording with a microphone, this would take away the attention that the test leader has to pay to the details, thereby minimizing the observation that could reveal details that are not articulated by the participant. Therefore extremely short notes were taken by hand to minimize data loss, should the recorded data be too blurred due to the noisiness in the mall. This indicates a weakness in the method. Contextual Design introduces a customer-centered approach by gathering customer data from the field and using it to drive the definition of a product or process. But when the *customer (*participant*)* constantly moves around in a noisy area, it gets more difficult to record the data.

During the contextual inquiries the actual shopping of the 2 couples was observed as well. The observed data in this case is not captured, since video recording was not used. In fact, the contextual design method does not suggest the use of video recording because: "*It is rarely worth the extra trouble*". Since the observation is very important to the way the test leader interprets the data, it is peculiar why they do not recommend to video record the sessions. This would help the developer later, when models of the work details need to be elaborated. However it would most likely require a test assistant who is capable of using the video camera. If the test leader was to perform both the inquiry and the video recording, it would probably take too much of his attention away from the important details.

Many details about shopping were revealed by observing the participants doing their shopping. Some of those details were not articulated during the initial short interview. It also revealed statements given by the participants during the initial interview, which was not entirely correct according to the way they were shopping. Keeping that in mind, this could have an impact on the designs subsequently produced, if developers have to rely on data from interviews or other approaches, where they do not observe the actual work taking place. Therefore contextual inquiry is considered a good approach for identifying unarticulated needs as well as aiding verifying particular statements through observation. However a clear disadvantage is the fact that if the initial short interview had not taken place, the common shopping habits would not have been revealed. This indicates that contextual inquiries has a narrow focus, however investigates the focus of the work practice very detailed. It is very beneficial in uncovering problems that exist in the context, which should be solved eventually.

When the participants were presented with design ideas for a digital shopping assistant, they highly prioritized those features, which were directly related to the problems they encountered during the inquiries. Therefore the inquiries are very problem oriented, because other design ideas could have come up or have been prioritized differently, if other problems had occurred during the inquiries. Therefore inquiries have a narrow focus, however investigates in detail specific aspects of the context, the environment and the people of the system being developed. This is probably also why very many contextual inquiries are required to sufficiently provide knowledge about the hole customer base.

When participants doing their shopping one could not help to observe how other people was doing their shopping in the mall. A quick enumeration showed that 7 out of 10 people (Counted from 20 shoppers passing by) carried a shopping list in their hand. This supports the idea that an electronic shopping list could be feasible.

“Seeing the work” being done is regarded as a very good way of finding small details that can be used in the design. The test leader believe that contextual inquiries are very fruitful compared to a standard interview.

Planned progress tomorrow: Some kind of summary should be elaborated to avoid forgetting details revealed during the interview if the recorded data is unrecognizable. This should be done soon, preferably after the upcoming weekend.

Misc.:

Date: 13/4

Phase: Empirical data collection

Participants: Test-leader

Work performed: A summary of the Contextual Inquires [See Appendix B.3.2]

Misc.: Due to extensive amount of work devoted into the design of the location engine, it has been 10 days since the contextual inquiries was performed. After the two contextual inquiries were over, the recorded data was played back through the device that was used for the recording of the interviews. Unfortunately the recorded data was of such bad quality, due to the noisy environment in which it was recorded, that it was discarded.

Initial understanding: Normally a summary is not done from the recorded data in the contextual design method. Instead the developer should extract information for interpretation from the recorded data, which will allow him to elaborate different models to describe all the details of the work. Therefore the activity of elaborating a summary is an addition to the contextual design method.

Actual understanding: Since the recorded data was discarded, it was chosen to elaborate a summary of the 2 contextual inquiries, in order to avoid possible data loss due to the test leader forgetting about details during the inquiries. Luckily this summary should be easy to elaborate since notes were taken by hand during the inquiries.

Time usage: 16 days were spent making the summary. However this does not reflect the actual time usage, because many days were spent working on the position engine during this period. In fact, it is estimated that the time usage for this task, was in *the vicinity of 20 hours*. However it is worth mentioning, that it was not anticipated prior to starting the elaboration of the summary that it would take this long. It is believed that this is due to the many details revealed during the inquiries.

Applicability of outcome: It was relieving getting something written down about the details that were learned during the inquiries. Before this summary was elaborated, it was frustrating to imagine how the models should be carried out, without any recorded data, to base the decisions and interpretations on.

Reflection: The first thing that was reflected upon was how this resumé should be elaborated. From previous experience with writing summaries on interviews, it became clear that this kind of summaries on interviews can be done in several ways. One could do a summary that refers what has been said at the interview, or it could be summarized through an opinion extract that summarizes opinions articulated on different subjects. Since a focus statement was elaborated prior to the contextual inquiries that contains subjects of focus, the opinion extract method was chosen.

The second thing reflected upon was concerning the inquiries. During the contextual inquiries the actual shopping of the 2 couples was observed as well. The observed data in this case is not captured, since video recording was not used (Refer Diary 2/4). So this *observed data* needed to be recorded in some way in the summary elaborated today.

It was chosen to supply the statements articulated by the participants on the subject “The course of shopping”, because some statements where different from the way they were conducting the actual shopping.

When writing down the summary of the inquiries it became apparent how detailed the information about the practice of shopping was. The information was so detailed, that it was hard to determine what the most important aspects was, since no modeling had been made using these data in the contextual design method. Therefore many details were written down, in order to avoid forgetting them, should they be important to the design. Consequently the summary got very extensive.

Planned progress tomorrow: The elaboration of work models can finally begin. It is estimated, that tomorrow, the elaboration of the Flow model should be conducted.

Date: 29/4

Phase: Analysis

Participants: Test-leader

Work performed: Flow model

Misc.:

Initial understanding: The flow model should reveal how people's roles are defined, and how they communicate to get the work done, therefore it should reveal how shopping is coordinated.

Actual understanding: Some understanding of the flow model was a little rough. But when the actual diagrams were depicted it became clearer what the models should depict/show. However it is a clear advantage to do these models, if you have some experience in advance.

Time usage: 13 hours – the flow model took twice the amount of time to elaborate, than was initially expected. It is believed that this is because no prior experience could aid the elaboration.

Applicability of outcome: The flow model is very good at determining responsibilities, communication/coordination issues (Break downs), and what roles artifacts has in the work practice. The amount of information contained in the models is huge, and it shall be interesting to see how this is narrowed down in some way.

Reflection:
It was unproblematic to identify the elements that should be present in the flow models, because fortunately the summary of the contextual inquires was very detailed in its description.

The first problem encountered concerned the number of flow models encountered. Should there be a flow model for both the preparation phase and the actual shopping phase?, or should both phases be contained in one model? It was chosen to elaborate one for each Phase, because it would make it easier and more illustrative.

The second question that arose, was whether a flow model should be elaborated for each couple, since they had, in some degree, different ways of doing the actual preparation Phase:. It was chosen to do one model to cover both of them, since the elaboration of two would require too much efforts and time.

The models lacked some way of illustrating how artifacts *occasionally* are passed around between the individuals in the model. Fx. The shopping list is an artifact that can be passed to another person responsible for the actual shopping, but this does not always happen.

The models lacked a way to model that any given responsibilities can be distributed among several individuals. Fx. If an individual is shopping alone, the responsibilities are as follows:

- **Shopper**: is responsible for:
  - Administrate shopping list
  - Locate next item on list
  - Drive shopping cart
  - Put item into shopping cart
  - Entertain children
  - Coordinate shopping with family or friends
  - Find attractive offers in advertising magazine

However when shopping 2 or more, the responsibilities of a shopper are distributed among the participants, thereby 2 roles appear; the *Collector* and the *Driver*:

- **Collector:** is responsible for:
  - Administrate shopping list
  - Locate next item on list
  - Put item into shopping cart
  - Aware of drivers location (To avoid losing track of each other)
- **Driver:** is responsible for:
  - Drive shopping cart
  - Find attractive offers in advertising magazine
  - Entertain children
  - Coordinate shopping with family or friends
  - Aware of Collectors location (To avoid losing track of each other)

It was chosen to compensate for this, by writing thoroughly about the responsibilities of both, and stating that they are combined into the responsibilities of one individual, if the shopping is done alone. That way, it was avoided to have to elaborate two flow models; one for a single shopper and one for shopping in pairs.

Planned progress tomorrow: The flow model took 1 day more than anticipated, so the next step is to make sequence models, which is planned to be finished tomorrow.

Date: 1/5

Phase: Analysis

Participants: Test-leader

Work performed: 3 sequence models

Misc.:

Initial understanding: When work unfolds in time, it becomes a sequence of actions to take to achieve a certain intent. Sequence models reveal the detailed steps that are required to do a particular task. It is low-level detailed step-by-step information that describes how the work is actually done.

Actual understanding: The way sequence models should look was depicted very well in the book. However it was not explained in the sections containing the contextual inquiries that the *steps* people take should be collected during the inquiries. Fortunately notes were taken by hand during the inquiries and these notes were used to write the summary. It was possible to identify these steps from the summary, but only because the summary was very detailed.

Time usage: 12 hours – the sequence models took longer than expected, due to the fact that it was necessary to elaborate 3 models, because the task of shopping depends on what you are shopping for. Therefore 1 sequence model for the preparation phase and 2 models for the shopping phase was conducted.

Applicability of outcome: The flow model is very good at determining responsibilities, communication/coordination issues (Break downs), and what roles artifacts has in the work practice. The amount of information contained in the models is huge, and it shall be interesting to see how this is narrowed down in some way.

Reflection:
Sequence models was quiet easy to elaborate, because very detailed information was available from the contextual inquires, and the models in the book described how the models should look in great details.

However the first problem encountered was the understanding, that if there are two different triggers, which causes a sequence of actions, one can not model this in the same sequence model. When this happens, you have to draw 2 models; one for each trigger.

A second problem was encountered as well. The sequence model has no way of showing if a subset of steps is looped several times. This was depicted by inserting a step that said “Repeat doing …. Until …”. However it would be more expressive to the model, if one draws an arrow from the end of a looping sequence to the beginning of the sequence, and adding a condition that describes how many times the loop occurs.

Writing the secondary intents on the left side of the model, provides a way of understanding why people are taking the steps they do. It is believed, that one condition for the success of a new system, is that the system must support the secondary intents at all cost. Because they define what people are trying to achieve. Therefore, sequence models can function as a checklist of supported features in a new technology.

Planned progress tomorrow: The artifact model is done tomorrow. Hopefully this can be done in 8 hours.

Date: 10/5

Phase: Analysis

Participants: Test-leader

Work performed: 2 artifact models

Misc.:

Initial understanding: The artifact models forces the developer into a detailed analysis of the artifacts that are important to the work practice. By looking at the presentation, structure, information content, and informal annotations this activity ensures that every element hidden in the artifact is unrevealed.

Actual understanding: The way artifact models should look was depicted in the book. However it looked like a drawing of an artifact, not a photocopy. However in the book it is explained that a photocopy can be used, which would make it easier to elaborate.
It was chosen that the only important artifact for the shopping Phase: was the shopping list. The cell phone, shopping cart and advertising magazines will not be analyzed.

Time usage: 6 hours – The artifacts models took shorter time than expected. This is probably because they have been carefully examined, and their role has been made explicit in the flow- and sequence models.

Applicability of outcome: The contextual inquiries were very good at revealing details on the actual use of a shopping list. However it was a clear advantage that the actual shopping list was brought for closer examination, since it revealed the need for informal annotations. It also revealed that it should be possible to mark items purchased on the list. The artifact model was a good starting point for designing a virtual shopping list.

Reflection: Artifact models were easy to elaborate, however it would be interesting to have access to more shopping lists that are different from the ones brought for the inquiries. Maybe some people have better ideas on how they can support the shopping Phase:.

Planned progress tomorrow: The physical model is done tomorrow.

Date: 11/5

Phase: Analysis

Participants: Test-leader
Work performed: A physical model

Misc.: Two additional layouts of malls was necessary to include, in order to show the differences between the layout and structure of malls. These have been placed in Appendix B.3.3.

Initial understanding: The physical model forces the developer into a detailed analysis of the
Work environment, which either supports the work or gets in the way. By looking at places, structures, layout, movement and breakdown, it should be possible to identify pros and cons in the work environment.

Actual understanding: The Physical model is presented with a caricature of the workplace, attached with extraneous details that are important to the project focus. It is believed that identifying *breakdowns* in the environment is the most important aspect of this model.

Time usage: 6 hours

Applicability of outcome: The physical model did *not* provide anything of use, that was not discovered during the inquiries. Nevertheless, it is believed that a physical model could function as documentation.

Reflection: The physical model is supposed to reveal aspects of the work environment that hinder the work taking place. The physical model technique only supports the analysis of one work environment. Shoppers tend to choose different malls for shopping, consequently the physical environment changes and the physical model does not account for changing environments. In this particular project, it is the case that people shop at different malls, that have different layouts. The number of small shops is not the same, the layout differs as well. However, by looking at the layout of several malls, should enable the developer to draw similarities between them. This was found necessary in this project, because the mall chosen for the inquiries, only has one very large grocery store, and only few small shops. On the contrary to Bruuns Galleri, which has many small shops, but only a medium grocery store.

Aalborg Storcenter has many small shops and it also has a large grocery store. So malls are very different.

Planned progress tomorrow: The design Phase: starts.

Date: 12/5

Phase: Design

Participants: Test-leader

Work performed: Making a vision for the new system (Priming the brain).

Initial understanding: To create the vision the developers must brainstorm two lists:

- **Technology** The technology required to solve work problems in the new system.
- **Starting points** Design ideas that have been captured during the contextual inquiries, and elaboration of work models.

Technology

For the task of designing the digital shopping assistant, it was necessary to include information about the positioning system, since the accuracy of the positioning system, would affect the design of the system. The positioning system is capable of positioning the user accurately inside zones of 10 meters in diameter. This means, that we can only use it for showing commodity groups on the map, not for locating a specific item inside a shop. Moreover the positioning system can not return the orientation of the user (North, East, South, West), which means that directions according to the direction the user is heading can not be given. The user has to identify landmark on the map and relate them to the real world, in order to head in the right direction.

The fact that the positioning system is running on a central server and uses access points to determine the user's location, makes it possible to serve the digital shopping assistants with Internet. Moreover it is possible to provide additional services in terms of electronic advertisements, electronic shopping list, search for items inside mall etc. The latter requires that the server has a database that contains information on all products inside the mall. This could include information about: location, price, quality, picture, customer satisfaction etc.

- **Server** – Provides positioning capability, Internet, additional services.
- **Access points –** Provides network connectivity everywhere in the center.
- **PDA –** A PDA is required by the user. PDA must have a W-LAN card.

Starting point

In the end of the contextual inquiries a list of features supported by the digital shopping assistant was created by the users. These features were arranged according to priority. The features are listed below:

1: Location of goods within the mall, help on finding them (Search) – Requires information on all items currently sold at the mall. This includes information about price, location, selling shop, additional information.
2: Tailored advertisements – requires a profile of the user, their interests in particular.
3: Electronic shopping list which can be updated from the Internet by your partner – requires that the partner has Internet access
4: Call for assistance – Requires a computer at the assistants boot. At this computer some client software should run, in order to show where the shopper is calling help from. This is beyond the scope of this project, however it could easily be implemented.
5: Customer product satisfaction – Requires that customers are willing to add information about a product he/she has bought. This is beyond the scope of this project.
6: Awareness of acquaintances currently present in the mall – Requires that both people have a PDA. Their current location should be sent to the server, and the server should be aware of who should be monitored.
7: Internet access – requires nothing, the technology is present.
8: IP-phone technology – Was of no interest to the participants.

1,2,3,4 should be considered in the design, since they are the highly prioritized requirements of the system.
Misc.:

Actual understanding: This is all about summarizing what have been learned. Then add the hardware that is existent in the context. From this knowledge a creative process begins by creating a vision for the system.

Time usage: 8 hours

Applicability of outcome: The list of current technology helped understand what services could be provided by the system. The list of proposed features for the digital shopping assistant, helped think about possible solutions for overcoming the break downs present in the work models.

Reflection:
The list of available hardware was easy to elaborate, since all the information was available beforehand. The list of hardware was implicit available from the development of the positioning system. However it was not straightforward that the accuracy and orientation of the positioning system would have an impact, of how/if the features could be designed. The

method lacks some kind of mechanism that allows the developer to consider, which parts of a subsystem has an influence on the list of starting points.

The list of starting points containing features, which were suggested by the participants, was related to the problems that were encountered during the shopping Phase: of the contextual inquiries. Particularly 1,2,3,4 were related to problems encountered in the context of shopping (See summary of contextual inquiries).
It is questionable if these features had been suggested, had the problems not occurred. If different problems occurred, would the same features have been suggested? Moreover the list was very affected by the aspect of shopping that is related to grocery shopping, because the participants had brought a shopping list that contained groceries in a high degree. Nonetheless all features suggested is the results of problems encountered in the real world, which can be enhanced/avoided using the capability of the digital shopping assistant. It requires the digital shopping assistant to be aware of the user's location, user's profile, goods available in the mall (their location in particular), layout of mall, user's shopping list and advertisements currently offered by the shops inside the mall.

The method offered no examples of how these lists should look.

Planned progress tomorrow: The elaboration of storyboards that depicts the new system.

Date: 13/5

Phase: Design

Participants: Test-leader

Work performed: Storyboards of preparation Phase, shopping Phase, and 3 storyboards of UI Design.

Initial understanding: Storyboards should depict the re-design of the system. It shows how the new work practice will be done. More specifically they capture the new procedure for doing a task pictorially. However this includes interaction with the system, and therefore UI-design should be captured in the storyboards as well. The concept of storyboards was known beforehand, which made it easily to understand its purpose. Moreover several examples were present in the book.

Misc.:

Actual understanding: During the elaboration of the work models two overall tasks was discovered; the task of preparing to go shopping and the task of doing the actual shopping. In the re-design the shopper will have to interact with the system and therefore UI-design should be depicted in the storyboards as well.

Time usage: 8 hours

Applicability of outcome: The storyboards were very useful during the implementation Phase, and they were followed quite accurately.

Reflection:
The storyboards were very good at depicting the vision of the new system. They are very good at illustrating the thoughts and motives behind the design decisions made in the vision.

The storyboards had some limitations. When designing on a piece of paper it was hard to estimate how much screen real estate was consumed. The implementation phase showed that some of the storyboards had too much information, which could not be contained in one screen. Consequently some re-design was done during the implementation.

Previous experience in designing user interfaces for mobile devices had been gained. This knowledge has contributed in the design of the UI-storyboards. However, had this knowledge not been present, it is believed that the developer could easily depict too much functionality in each screen. Consequently, the storyboards will be less efficient in aiding the developer during the implementation Phase:.

Planned progress tomorrow: The implementation phase begins.

Date: 14/5

Phase: Implementation of prototype

Participants: Developer

Work performed: A prototype was developed

Initial understanding: Storyboards should be used to aid the design of each screen of the prototype. The following functionality should be implemented:

Functionality	**Description**
Shopping list	The shopping list should be updateable from the Internet by family members. Furthermore the system should be able to arrange the shopping list according to commodity group, and supply the list with relevant offers. The list should be colorized according to commodity group. It must be possible to direct the shopper toward each commodity group on the map. It must be possible to add additional notes to the shopping list.
Map	The map should visualize both the map, the user's location and provide directions. Directions should be done with arrows pointing in the direction of a zone.
Search	It should be possible to search for products and shops within the mall, and these should be visualized on the map as zones.
Profile	The shopper should be able to add their preferences in order to aid the system in tailoring advertisements accordingly. The profile should contain the interests of the shopper.
Request Assistance	The shopper must be able to call an assistant for help.
Awareness of partner	The system must be able to show friends, partner or family members on map. It must be able to make an appointment of a meeting.

Misc.:

Actual understanding:

Time usage: 40 hours – It took 3 days to complete the development of the prototype. That is two days more than expected.

Applicability of outcome: The most important functionality has been implemented. Common functionality such as add, remove or modify has not been implemented.

Reflection:
The storyboards had some limitations. When designing on a piece of paper it was hard to estimate how much screen real estate was consumed. The implementation phase showed that some of the storyboards had too much information, which could not be contained in one screen. Consequently some re-design was done during the implementation.

The arrow directing the user in the right direction, consisted of one or two arrows. Vectors was not used, because they are hard to implement.

“Additional notes” of the shopping list was implemented using a panel. However if the notes is more than 4 words, this will not be sufficient to hold all information. A textbox will have to be used.

Planned progress tomorrow: none.

Appendix C - eXtreme Programming

C.1 Method description

The XP method is designed to be a method which is best suited for smaller application development. Compared to other methods it relies on having the code as documentation and a customer present during the entire development phase. The following text will provide an insight on how the XP method functions and how the work proceeds.

The idea in XP lies in the four values:

- Communication
- Simplicity
- Feedback
- Courage

It is through these values that Beck reasons about the possibilities and boundaries which XP contains. The four values are long term goals which must be upheld at a group level, in order to achieve success. If work is not done according to these criteria, there is a risk what the individual will fall back on its own personal short term goals, which is usually the work process the person is accustomed to.

C.1.1 Communication

One of the main ingredients in XP is communication. Problems occur in many projects due to lack or to little communication between the developers, management and the customers. Beck introduces multiple disciplines which should increase the communication and make it more understandable:

- Customer presence
- Metaphor
- The planning game
- Pair programming

C.1.2 Simplicity

XP relies on keeping the work and the product as simple as possible. The team coach must ask: "*What is the simplest thing that could possibly work*". Beck argues that having a work

flow which is simple is difficult. The programmers will tend to look at aspects which they will have to implement in two to three weeks and prepare the code for this, which is against the principle of XP. Beck 'bets' that: "*It is better to do a simple thing today and pay a little more tomorrow to change it if it needs it, than to do a complicated thing today that may never be used anyway*" [Beck 2001, p. 31].
Finally Beck argues that communication and simplicity have a mutually supporting relationship. The more you communicate, the better the understanding of the problem. This will help insure simplicity.

C.1.3 Feedback

XP view on a system is opposite of many other development methods. Normally a manager will have to ask the developers how the implementation is progressing, but in the XP method he must ask the system itself [Beck 2001, p. 32]. Beck argues that having the system testable at an early stage will provide the necessary feedback for all the parties involved and that feedback works in cooperation with simplicity and communication. The more feedback you get the easier it is to communicate and thereby keep it simple.

C.1.4 Courage

The last of the four values which XP is based on is courage. Courage is a conception that covers both and team as well as the individual. Courage comes from the ability to dare to throw away large amount of work. If some elements don't work they must be thrown away instead of patching it together [Beck 2001, p. 33].
Courage is defined as being able to take calculated risks and to dare to experiment in the XP method. Decisions can be taken without thorough consideration and this implies that the involved parties must have courage.
This is one of the radical changes in contrast to traditional software development where the analysis- and design phase is much more in focus. The XP method tries to minimize the time spent on these phases and throws itself into an experimental implementation phase. [Beck 2001, p. 32-33].

These criteria's are seen as a recipe for success, but Beck argues that it can be difficult to maintain this philosophy when the team becomes stressed [Beck p37]. In order to prevent the development team from falling back into old habits Beck introduces multiple principles, which will aid the development team and prevent this from happening.

- Rapid feedback
- Assume simplicity
- Incremental change
- Embrace change
- Quality work

The principles aid in adding substance to the values, which Beck argues are to vague to give much help in deciding which practice to use. The principles make the values more concrete [Beck 2001, chapter 8].

C.1.5 The Customer

One of the important main principles of XP is the presence of the customer during the entire development phase. By having the customer present in the development team it is easy to get answers to problems and make decisions regarding future work because all involved parties are present. This is to oblige with the changing demands from the customer, which often arise during a long term development phase. The customer can be a representative, with good insight on the problem domain, from the business the system is being developed for. The customer must posses the knowledge and decision making skills, which makes him capable of prioritizing what is relevant for the project. Because the customer is represented in the development team from the beginning of the project it should make it easier to eliminate errors and misunderstandings before the consequences become high.
To eliminate misunderstandings in the communication between the customer and the developer, a metaphor for the system is created. This serves the purpose of creating a common reference for the developers, management and the customer. By planning as a group the communication between the customer and the developers is in the high seat. XP tries to minimize the misunderstandings, which often occur in the understanding of the customers needs.

C.1.6 The planning game

After having created a common understanding/reference Beck introduces the planning game [Beck 2001, chapter15]. This discipline aims towards involving both the customer and the developer in the planning phase, to ensure unity in the aspects regarding size of the project and an estimation of the timetable for each task. The difference between conventional software development and XP is that the timetable management and estimation is, to a much

higher degree, the responsibility of the developers and the customer in contrast to the management.

C.1.7 Stories

The customer's main function is to write stories, which are a description of all the individual activities he does during his work. These stories are written in a natural language.

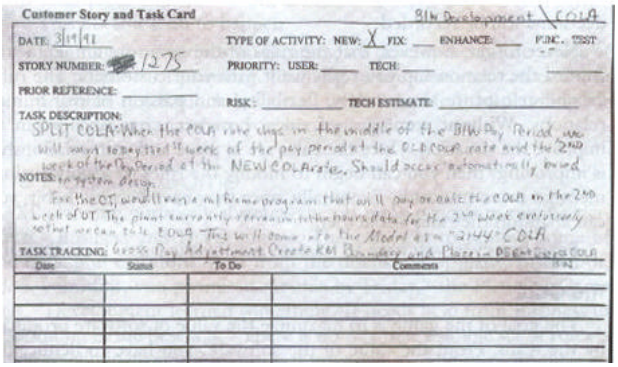


Figure 25 An XP story

Each story is then presented to the developers and discussed. This is done in order to ensure all involved parties have the same understanding of the story and uncover new aspects. The story is then estimated by the development team. This involves determining how easily it can be implemented and to determine if it is necessary to divide the story into smaller parts in order to simplify it and make estimation easier.

C.1.8 Tasks

When all stories have been estimated it gives the development team a preliminary idea of how much time is needed for each story and thereby an idea of the amount of time it will take to create the entire system. The stories are then divided into smaller more manageable tasks, which are easier to estimate.

The total amount of tasks is then presented. It is then up to the individual developer to take responsibility for a specific task. When a developer has chosen a task he must estimate how long it will take to solve. Responsibility and control is therefore based on the individual instead of management [Beck 2001, chapter 15].

After this the tasks are categorized by the developers by how well they can estimate the time table for each story. The customer then picks the tasks which should be present in the following release.

If changes occur in the customer needs, the specification must then be altered. The communication failure often occurs in the changing demands/needs of the customer or in the interpretation of the written specifications. This is why the XP method relies on having the customer present in order to cope with the changing need as early as possible.
This is also why the XP method only estimates a few weeks ahead. The idea behind this short planning is to use more resources on the verification of the customer needs and to be forthcoming to any changes.

The XP method also introduces other aspects which influence the way the team works. Among these are pair programming and testing, which the method relies heavily upon. Bots these activities are introduced to aid the team in removing errors as early in the development as possible.

C.1.9 Pair programming

Pair programming is also used by other development methods, but is an essential part of the XP philosophy. Pair programming works, as the name states, by two people sitting down at the same computer, to solve a task as a team.

> *"Developers must be able to see each other, hear each other when someone asks questions and be capable of overhearing discussions which they can contribute to or gain knowledge from."*
>
> [Beck 2001, p. 72]

That is why XP demands an open office environment where communication is easy. The tables must be positioned to permit pair programming and at the same time they most face each other, so the attention to the other developers is heightened. In this open office environment there must be room to be alone, but the space required for this is secondary to the public area. Another aspect which the XP environment most poses is a comfortable area for meetings and relaxation.
Another aspect of XP is simplicity. By focusing on the necessary functionality for the product it will become easier to survey. This is done by ensuring that the focus must be on the functionality which is a necessity for the present release and not on speculation on upcoming releases. This will ensure that the possibility of misunderstandings is diminished when the developers are communicating about the product.

C.1.10 Test

XP does the opposite of many other method regarding tests. In XP you test before you implement. You have to formulate the conditions, which must be fulfilled in order for the task

to completed (unit test, test case) [Beck 2001, p. 126]. After this you try to implement a solution that will fulfil the conditions. It is in this phase that the experimentation with different solutions to the problem is done. If solution proposals are not approved in the system integration the developer must be willing and courageous enough to start again from scratch.

C.1.11 The office environment

The XP method introduces rules for the office. The office environment must be set up in a way that enables pair programming and to ensure all parties involved has an overview of everyone else. The space in the office must be created for the group. Individual space is also required, but it is secondary. The office should be setup with the development team in the middle and all other people involved around these.
If it is impossible to create the environment Beck argues what XP should not be attempted [Beck 2001, p. 78].

C.2 Development using the method

This section will feature a presentation of the work done in order to create a prototype by using the XP method by Kent Beck. The work process will be split in the following sections:

Preparation
- The participant

Analysis
- Data collection – Creating stories
- Analysis of data – Tasks

Design and implementation
- Debating the future GUI
- Creating release one

The preparation will be a description of the preliminary work done in order to start the development this will feature a description of the external participants, who are involved in the creation of this prototype. The analysis phase will feature a description of the work done in order to create stories.
The analysis will feature an elaboration of how the developer went from the having gathered the data from the stories and splitting these into tasks, which will aid in the creation of the prototype. The design and implementation phase will feature the work done in order to get from the tasks and onto having a working prototype.

C.2.1 Preparation

Getting to know the method involved brushing up on the different aspects of the method, where the focus was on the stories and task cards. The XP method has some guidelines for the developers [Beck 2001, p. 29] which are communication, simplicity, feedback and courage. Some of these values seem more important than others for this project.
This project will never evolve beyond a prototype, which has the benefit of making the function- and model layer less relevant. It is only the GUI which is important to test. In order to create the best possible GUI, communication and feedback from the customer is still very important. Simplicity is also important since the GUI must be created with this in focus and the tasks the customer must accomplish, must also seem as simple as possible, to avoid getting him confused.
Courage deals with aspects about having the courage to throw away large amounts of code, if it should fail to meet the demands instead of patching it together [Beck 2001, p. 32]. This is

also less relevant since the code, that will be written only serves the purpose of making a GUI test possible. The courage in this development comes from larges changes in the GUI, if the customer wants that, but this seems like a much smaller task, compared to throwing away actual code.
The first important aspect of the XP method is finding a suitable customer. The customer must be an expert in shopping, but since every person has shopped hundreds of times, it is important to find a person, who is capable of seeing the concept of shopping from a broader perspective. This will hopefully enable him to create stories, which do not seem relevant for him, but could be beneficial to others. Regardless of what person who is the customer, it could be a necessity to have a focus group meeting to get the customer to have a better idea of how other people do their shopping and what their needs where. It was decided to wait and see how much the customer could contribute before scheduling a focus group meeting.

C.2.2 The participant

The preparation phase lasted longer than expected because there was a change in customer. The first customer and the developer had different timetables which made it impossible to arrange meeting in the near future. The method can't be blamed for this since it provided the developer with guidelines for the customer, which was not met.
This is documented in the diary [Appendix C.4 Diary, 15/4] and will not be elaborated any further, but the knowledge gained from working with her will be used to avoid making the same mistakes with the new customer.
The choice of customer was a person who has a curious nature and one who can understand the type of product, which is going to be developed. The customer used is a man age 28, who works as a schoolteacher about 30 kilometers from where he lives. He owns a car and uses this everyday to work. He is very interested in computers and makes sure he is always up to date on hardware as well as software.
Mobile devices are not very interesting in his opinion, since he does not see any potential in these devices yet. He does own a mobile phone, but only uses it as a regular phone and is not concerned with cameras or any other functionality in this device. When he was introduced to the XP method, the idea for the product and the information about his task, he seemed enthusiastic and had multiple ideas for a product.
The customer has explained what when he goes shopping he considers it more to be a task than a joyful trip. He does not like to shop when the mall is packed with people and explained that he, on more than one occasion turn around and went home, when he saw the amount of cars in the parking lot in front of the mall. His girlfriend and him seem very organized and take turns to do the shopping. If it is his turn to do the shopping he will have a shopping list

with him when he goes to work. This enables him to do the shopping on the way home from work. If there is anything missing on the list his girlfriend will call or send an SMS to make sure he buys the missing items. His girlfriend has recently been on a diet, where they had to examine all the groceries for the amount of certain ingredients. This proved a tiresome task since not all groceries had this information available, but it could be calculated from the information which was always there.
To strengthen the customers knowledge of mobile devices he was lend a PDA, which he has to familiarize himself with. The developer hoped this would enable the customer to see both the possibilities as well as the limitations of the device and therefore make it easier to talk about the possibilities of the prototype.

The time used to prepare for this method:

Getting a customer:	1 hour
Making a presentation of the customers task:	3 hours
Explaining the method:	4 hours
Re-explaining the method:	5 hours
Total time used to introduce the customer to the work:	13 hours

Compared to other methods, XP relies heavily on the user/customer and he must understand his job in the development team. Other methods like OOA&D delimit the users from having actual knowledge of the method, which enables them to have a much faster integration of external people if this should be needed for testing or determining functionality etc.

C.2.3 Analysis

The analysis phase will feature a description of how each individual task was performed during the analysis. This involves finding an external participant, who will function as customer and the work performed in order to create stories as well as dividing these into tasks.

C.2.3.1 Data collection – Creating stories

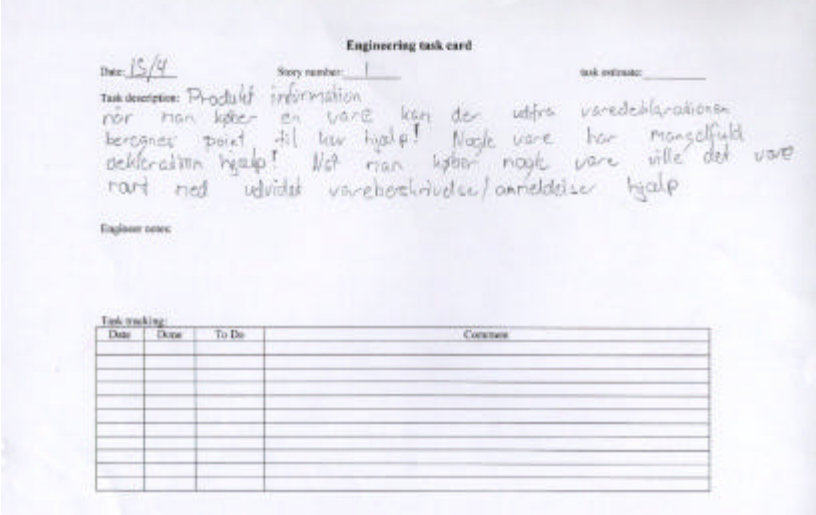
Since there had been some problems getting the first customer to grasp the concept of stories a different approach was used. The developer and customer started by making a brainstorm of what that the possibilities of the system where. This was made easy since the customer was now familiar with a PDA's possibilities and limitations.
This brainstorm was written down and would act as a startup platform for the task of creating stories.

The result of the brainstorm was a system which should be able to deal with these aspects of shopping:

- Product information
- Shopping list
- Special offers/activities within the mall
- Real-time notification of events and special offers
- Map
- Grocery comparison
- Parking
- External information (news, stock, sport)
- Surveillance of- and communication with children
- Aid in finding special/rare products

The customer now had a concept of how the system should be able to aid users when they go shopping and it seemed like the right time to introduce him to the method, since he was now considered an expert in shopping by the developer.

The task of getting the customer to understand his part in the development was easier than anticipated and lasted about five hours [Appendix C.4 Diary, 15/4]. This time was used both for brainstorming ideas and to explain the work involved to him.
The following day the customer and the developer started working on stories. This was done in two phases. First the brainstorming was further elaborated and each time there was enough material to create a story the customer was instructed to create one.
The customer was instructed to do this alone, but would have the developer right there, if he had any questions. This seemed to cause the customer some problems in the beginning, since he was not sure how they should be written semantically. It was explained to him that he should write them in normal language and he was given a few examples. The first story was then written by both the customer and the developer in close cooperation, which seemed to aid the customer in his understanding of the actual work.
It soon became apparent that the customer needed the developers help to create the remaining stories, because he felt many of the ideas were created by both him and the developer.
The developer again used some time to explain to the customer what his task was and that each story would be further elaborated at a later stage and that he should not be afraid to write anything wrong. All ideas were acceptable. This seemed to give the customer some renewed self confidence and he started making the stories.
The remaining stories were created without the help from the developer, but the customer often showed completed stories to the developer as a means of confirmation.


Engineering task card

Date: 15/4 Story number: 1 task estimate:

Task description: Produkt information
nar man køber en vare kan der udfra varedeklarationen beregnes point til hvor hyalp! Nogle vare har mangelfuld deklaration hyalp! Nar man køber nogle vare ville det vare rart med udvidet vareoplysninger/anmeldelser hyalp

Engineer notes:

Task tracking:

Date	Done	To Do	Comment

Figure 26 Story card 01 – Product information

It seemed like this approach was good, since it had provided input from both the customer as well as the developer from the initial brainstorming. The developer could often anticipate specific functionality which should be added, which was proposed and debated. This ensured that the customer and the developer had the same understanding of the system. The result was 10 stories which dealt with different aspects of the system [Appendix C, p. 130].

C.2.3.2 Analysis of data – Tasks

Once the stories had been created by the customer and the developer, it was up to the developer to split the stories into smaller parts, which would be easier to have as a reference, when trying to implement the product.
Splitting up the stories seemed like a straight forward process and the goal was to split these into parts that were small enough to only deal with one aspect of the GUI, to make the process of going from tasks to implementation easier.
The developer felt that having the GUI as the implementation goal, would make the burden of creating the model- and function layer less relevant and the developer only has to worry about the GUI design of the product.
Each story was examined by the developer in order to determine how many tasks it was necessary to divide them into. The first story (Product information) was split into the following tasks:

Task 1

The system must be able to help the user find product information / reviews.

> When a user looks at an interesting item, which can seem almost impossible to determine the quality of, the system must help the user find information about the

item. This could be reviews on WWW or detailed information from the product manufacturer.

Task 2

Groceries with missing/incomplete declarations should be accessible through the system.

The customer explained that some information on groceries is determined by law, but there is also some other relevant information that isn't there on all products. This information can be calculated from the remaining information, but is not found on as many products as he desires. The system must aid the user in calculating/acquiring the missing information.

Task 3

The system must be able to calculate score systems from misc. weight loosing systems.

Some information on the groceries can be used to calculate how much you should buy of each product in order to stay within the tolerance parameters of any given weight loosing system. The system must aid the user in this task.

Task 4

All groceries must be categorized by the system.

Often a shopping list is not categorized. The system must be able to sort the list by all kinds of criteria. Sorting must contain alphabetical sorting to aid the user in checking if item "X" is on the list. The system must also be able to do sorting by location in the store, to speed up time usage and to minimize walking distance and have the option of sorting by item type (fruit, clothing, etc.).

These tasks were then debated with the customer to ensure that the developer fully understood the customer's ideas and that no information was missing. They created a short description for each task. This process helped the team develop an even better understanding of each others ideas.

This phase in the development lead the developer with the difficult task of remembering large amounts of information which had been discussed on several occasions, but was never written down. This lead the developer to believe that the stories had been insufficient or lacking the desired level of detail. The developer still felt he had a good understanding of the different parts of the system which had been debated and felt he added more functionality than he actually forgot to include.

Once the task of was completed the developer re-examined each task and made estimations of how much time each task would take to implement. This was more difficult than first imagined since it would not be a necessity to worry about the function- and model layer,

which would reduce the implementation. All the tasks ended up being estimated between 15 and 120 minutes each.
The developer then had the task of figuring out how many releases were necessary for the implementation phase. It was decided that 3 tasks would be adequate for this product. This was primarily based on the knowledge of the XP method and not on that the developer felt he could implement during a single release.
All the tasks where then represented to the customer and it was now his task to divide the tasks between the stories.

C.2.3.3 The customer distributes tasks between the three releases

Most of this was done purely from the customers personal interests, which he also explained. It was then up to the developer to determine if any of the releases would contain any tasks which could not be implemented because they were depending on other tasks which would not be implemented in the present release[17].
About one hour was used to examining each release and determine if the releases were possible to create or if there were any tasks, which couldn't be created before some other task was made. Only one task in the first release presented a problem. The customer wanted the zoom function implemented before the map function, which was in release two [Appendix C, p. 137].

Task from release 1

- The large stores must feature a map on which you are able to zoom in on certain areas

Task from release 2

- There must be a map of the mall

It seemed like it was impossible to implement a zoom function on each store in the mall, before a working map was implemented on the mall itself. The developer explained this to the customer

This was debated and the team realized that they had different ideas of how this should actually work. The developer thought the customer wanted one map of the mall which should be zoomable, but this was not the case. The customer wanted one map of the mall with very little details. This map should only be used to find his way around the mall. The customer wanted a separate map for each store within the mall. His idea was that each store should

[17] Appendix C, p. 104 - 108 for an overview of each release

maintain their own map and provide new maps, when they update their inventory or more items around within the store. If the store was very large this map should be zoomable to enable the user to see detailed information about a specific area in a store.
This finding will shorten the development, since the developer and the customer had different perceptions of this regardless of the stories and tasks which were already written. If this finding had not been discovered this early the developer would have used a long time to implement a map which would not function like the customer expected and this would have to be remade, which is time consuming.
The developer expressed that this finding has made him realize that there might be other tasks, where he and the customer appear to have a common understanding of the functionality, but do differ in how they would like to see the end result. This might result in some redoing when the implementation begins.
The analysis phase was completed faster than expected and no big problems occurred. Below is a list of the activities and the time spent on each.

Time usage

During the work with the XP method each phase was estimated in time usage. For further details look in appendix C.4

Understanding of method:	6 hours
Finding test participants:	14 hours
Empirical data collection:	7 hours
Analysis:	12 hours
Design:	6 hours
Implementation:	14 hours
Total time:	59 hours

When the work on the XP method was initiated the developer felt he was going to have large amounts of implementation, while such aspects as the analysis and design would require very little time consumption. This assumption was proven inaccurate during the work.
Finding the participant was one of the most time consuming tasks the developer had to complete. This was both because the first customer and the developer had incompatible timetables and she had to be replaced, but also because it required large amounts of work to get the second customer to fully understand his task. This was a surprise for the developer since he did not anticipate what it would require what much time. The developer had expected that a customer would be happy knowing only about the stories and that he would accept to be limited from the rest of the method. Each customer was not contempt by knowing a little about the method, they wanted to know why they had to do the stories and how these would be used. This proved to be time consuming, but it also provided the customer with a better understanding of the method, which the developer felt was beneficial.

The implementation phase itself, had only lasted about one forth of the development time which also surprised the developer. He thought that the actual implementation would begin right away and last through the entire process. This was not the case since the customer had to create the stories before the development could continue. The decision of creating the stories first was the developer's idea. He wanted the opportunity to divide stories / tasks between releases in order to include the most possible activities from the XP method.

C.2.4 Design and implementation

This section will feature a description of the work done in order to go from the analysis to an application prototype using the XP method.
The XP method does not rely on diagrams or charts to aid in the design phase. The code itself is the documentation for the application [Beck 2001, p. 62].
This prototype will only feature the GUI and very little actual code will be written. Only the code necessary to show certain features on the GUI will be implemented.
This decision enabled the developer to focus on the GUI and not worry about the architecture of the application, which could result in huge changes if it was not created correctly from the beginning and would be unable to meet future demands from the tasks in release two and three.
The developer had worked with application development on small displays before and had knowledge about information squeezing and was aware that most standard components found in RAD[18] tools are somewhat different when working with small displays. These components were then showed to the customer, which should also have an understanding of the possibilities when working with a small display.
The developer started by re-examining all the tasks from release one and tried to find elements which could be grouped together on the GUI.
The first discovery was the function of having the possibility to see certain information before going to the mall. It seemed like a good idea to have this as a startup screen on the application since this information could determine if the customer would go shopping or not. This decision was based purely on the developer's opinion. This screen should not been showed if the user started the application within a mall, since he could then visually determine the amount of people.

[18] Rapid application development

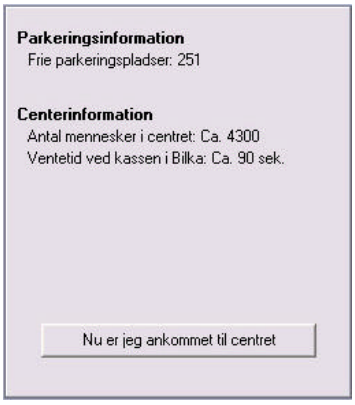


Figure 27 Startup screenshot of the XP prototype

As the screenshot indicates this information is related to the amount of people who are present in the mall at the present moment. If the customer finds this information satisfactory he can go shopping and continue to the next screen on the application. The customer explained that he liked this feature since it was easy to access and he proposed that the information would not be visible if he started the program when he was in the mall, since it would not be necessary when he was already there. If he does not remove the screen himself the system will remove it once he is within the mall.
After this had been implemented it was time to examine the tasks again. The tasks were sorted and the developer felt that there should be three specific functions available from the main menu.

- Shopping list
- Map
- Special offers / events

This menu was based on the customers desire to have the shopping list and the map and on the developers idea of having the special offers and events present.
A menu with these three buttons was then located on the bottom of the screen.
The developer made them as small as possible in order to embrace more functionality from release two and three. The developer felt that there might be a need for more functionality which should be available from the main screen.
The tasks in release one was then sorted and each task was positioned in each of the three menus if possible. It seemed obvious to implement the shopping list since the customer had placed three tasks in release one, which all dealt with the shopping list[19]:

- It must be possible to enter information by speech
- The system must aid the user in finding specific products and locations

[19] A further elaboration of each task can be found in appendix YY

- The system must be able to categorize the shopping list

The customer had explained that the PDA was an annoying tool when he had to enter text messages. This had given him the idea that he should be able to enter the shopping list items by speech. This functionality is very time consuming and will not be featured in the prototype. The remaining functionality regarding the shopping list is implemented and can be seen on Figure 28.

Figure 28 Shopping list screenshot of the XP Prototype

The screenshot displays a list of groceries which the user must purchase. The application will help the user with different types of sorting. For an overview of the items there is an alphabetical sorting, which will make the user able to see if certain items are missing. The second sorting is by location. This will enable the user to minimize his walking distance within a store. The shopping list will automatically display the items from the zone the user is located in at the top of the list. This should prevent the user from running back and forth. The last type of sorting is by type. In reality this will be closely related to the sorting by location, since most stores have positioned groceries of the same types in the vicinity of each other.
The context menu which is visible can be used on any item on the shopping list. It has two functions which are related to the items and one function which will aid the user in making the shopping list less confusing to look at.
The last function “Fjern købte varer” is simple. The user has the ability to mark each item when it has been added to the cart. If the user wants to remove these items which are already bought he can do this by using this function. This function is based on the developer’s idea of making the shopping list as simple as possible. This is done by removing the items which are already purchased.
The two other functions are supposed to aid the user with extra information related to each product. The first will show the location of the product on the map and the second will display extra information about the chosen product, which will show extra information about the

product related to weight loosing systems etc. This task is located in release two, but the developer thought it would be easy to implement now, since he was already working on the shopping list.
When the customer was presented with this screenshot he seemed to be familiar with the functionality, but had a hard time finding the extra information located in the context menu. But as soon as he clicked the name of an item it appeared and he seemed content with this function. He also expressed that he liked the big size letters on the shopping list which was easy to read from a distance, so he could just glare at it from his hip and then put it back in his pocket.
The customer then went on to press “Hvor er varen placeret?” which sent him to a different screen.

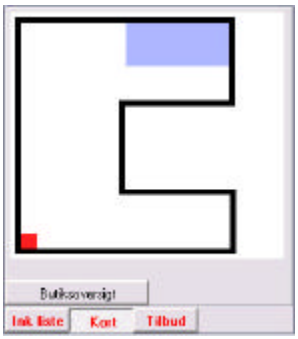


Figure 29 Map screenshot of the XP Prototype

This screenshot shows a map of a fictive store, where the user’s location is represented as a red square and the location of the item/store he is searching for, is displayed as a blue square. The user explained that the colours were easy to understand since there was such a big difference in size.
This actually presented a problem since the two squares will be of equal size in reality and the difference between the two squares could become less obvious. This should be remade, to aid the user when the two areas are of equal size.
In general the user showed a good skill in using the application, but had some problems finding certain functionality, which he knew was implemented, but as soon as he found it he seemed content on the functionality.
The developer was worried about this, since he felt this was one of the aspects where XP would differ most from other methods, since it had all been created in so close cooperation between the customer and the developer. The developer felt that the GUI would be the work done by both parties, but had the feeling that he created it and the customer just agreed in everything he did, which was not how the method describes the teamwork. This could be because it is such a small application and that the customer really did not have any comments

and it could be because the customer had no application development experience and found it hard to see how and of the functionality could be created differently, even though he did not like it as it is now. This was discussed, but the customer did not change his opinion about any of the functionality.

The design and implementation phase has been composed of these phases and the duration has been:

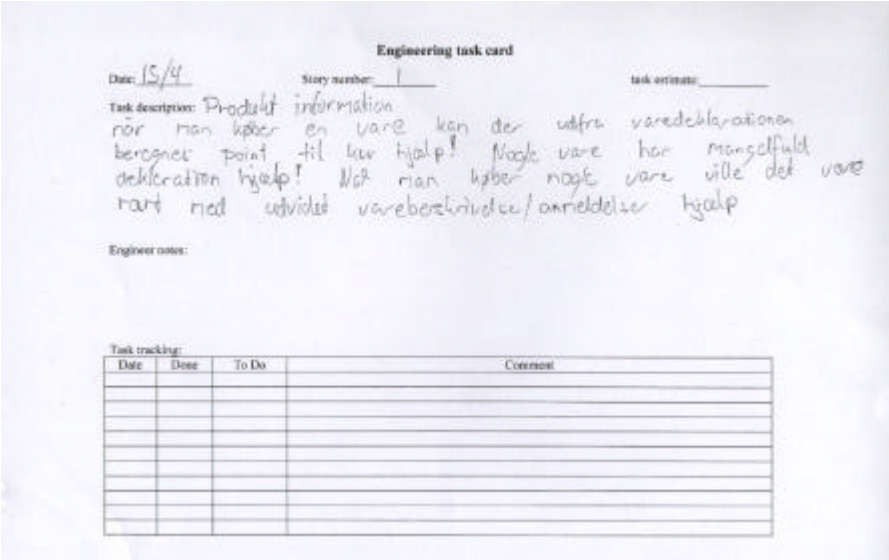
GUI discussion:	2 hours
Implementation:	14 hours
GUI discussion:	3 hours
Total time used for design and implementation:	19 hours

Total time used

Preparation:	13 hours
Analysis:	21 hours
Design and implementation:	19 hours
Total:	53 hours

C.3 Empirical data

C.3.1 Complete list of XP Stories



Engineering task card

Date: 15/4 Story number: 1 task estimate:

Task description: Produkt information
når man køber en vare kan der udfra varedeklarationen beregnes point til kur hjælp! Nogle vare har mangelfuld deklaration hjælp! Når man køber nogle vare ville det være rart med udvidet vareberetning/anmeldelse hjælp

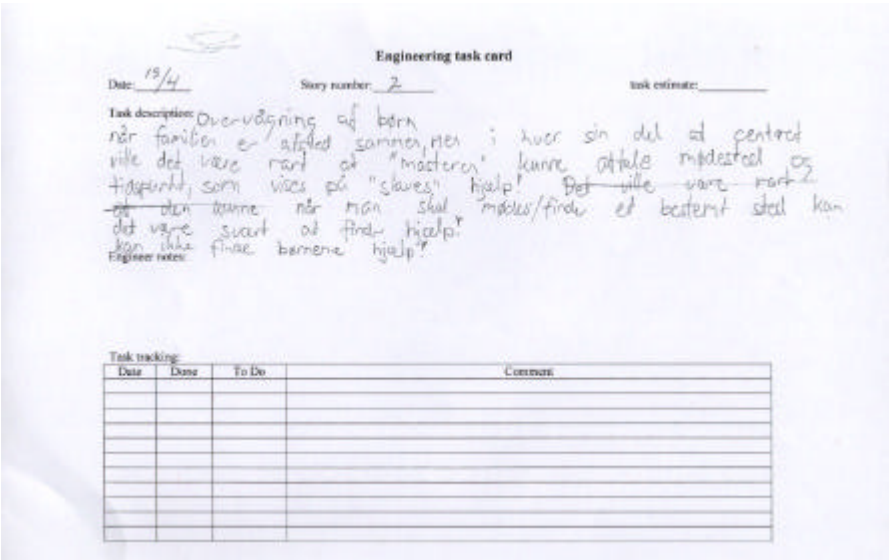
Engineer notes:

Task tracking:

Date	Done	To Do	Comment

Story 1: Product information.

The customer has encountered problems when shopping. Sometimes there is not enough information available on the groceries. He wants the system to provide extended information about the products.



Engineering task card

Date: 19/4 Story number: 2 task estimate:

Task description: Overvågning af børn
når familien er afsted sammen, men i hver sin del af centret ville det være rart at "mesteren" kunne afsøge midlertid, som vises på "skærm" hjælp! ~~Det ville være rart~~ ~~at den kunne~~ når man skal møde/finde et bestemt sted kan det være svært at finde hjælp!
kan ikke finde børnene hjælp!

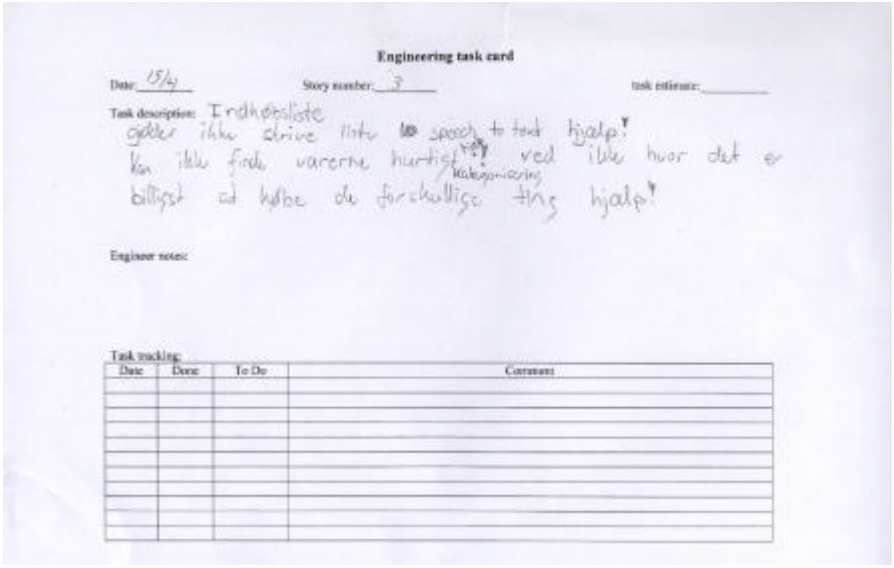
Engineer notes:

Task tracking:

Date	Done	To Do	Comment

Story 2: Surveillance of children.

The customer has an idea of how parents can find it hard to keep track of where their children are located. He would like the system to help these parents arrange meeting positions and show the children how to get there.



Engineering task card

Date: 15/4 Story number: 3 task estimate:

Task description: Indkøbsliste
gider ikke skrive lister ☹ speech to text hjælp!
kan ikke finde varerne hurtigst? ved ikke hvor det er
billigst at købe de forskellige ting hjælp!
kategorisering

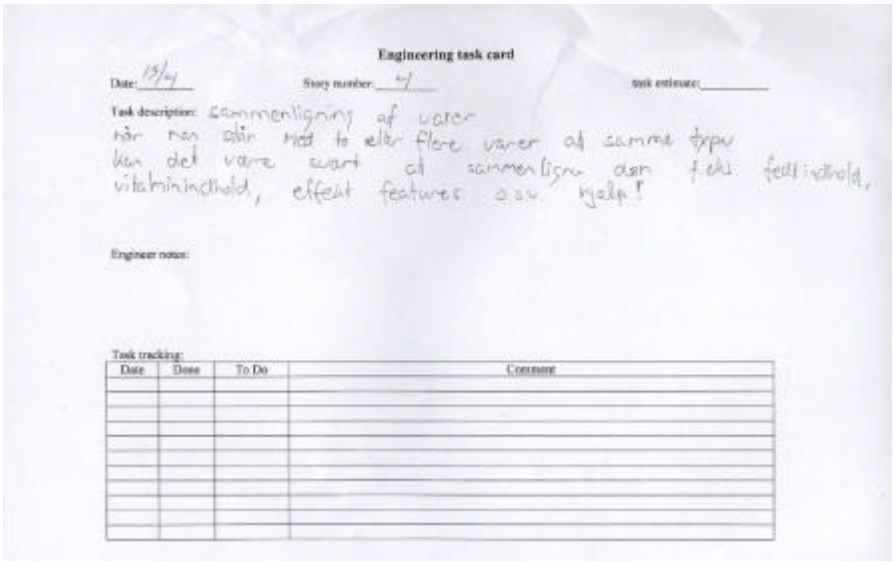
Engineer notes:

Task tracking:

Date	Done	To Do	Comment

Story 3: Shopping list

The customer has complained how he hates writing shopping lists and he would like the system, to aid him in this task. He would like the system to function like a dictaphone. He also explains that he does not like having to search for groceries and that he would like the system to aid him in finding these items. Furthermore the system must aid him in finding the shops with the best prices for any certain item.



Engineering task card

Date: 15/4 Story number: 4 task estimate:

Task description: sammenligning af varer
når man står med to eller flere varer af samme type
kan det være svært at sammenligne osv f.eks. fedt indhold,
vitamin indhold, effekt features osv hjælp!

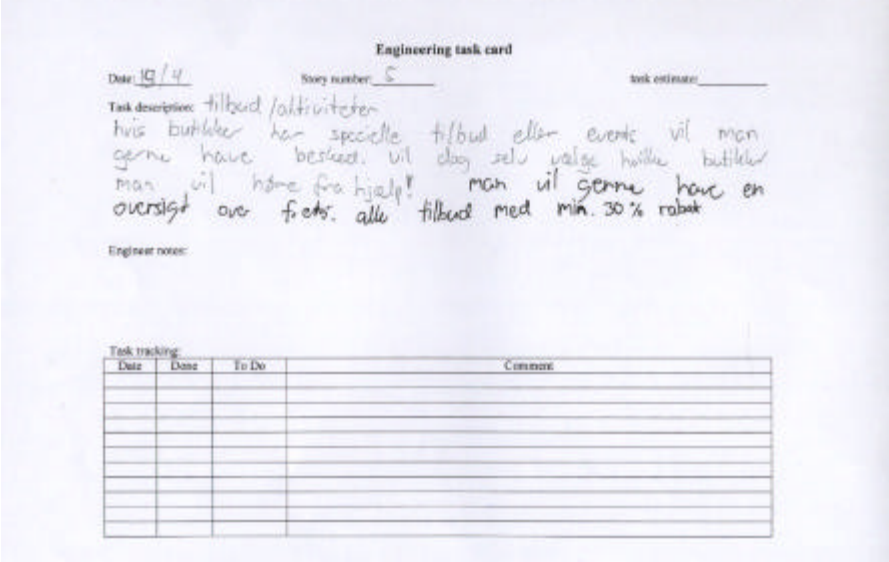
Engineer notes:

Task tracking:

Date	Done	To Do	Comment

Story 4: Comparison of groceries

The customer finds it hard to compare groceries. He would like the system to aid him in comparing groceries on fat, vitamins, minerals etc.



Engineering task card

Date: 19/4 Story number: 5 task estimate:

Task description: tilbud/aktiviteter
hvis butikker har specielle tilbud eller events vil man gerne have besked. vil dog selv vælge hvilke butikker man vil høre fra hjælp! man vil gerne have en oversigt over f.eks. alle tilbud med min. 30 % rabat

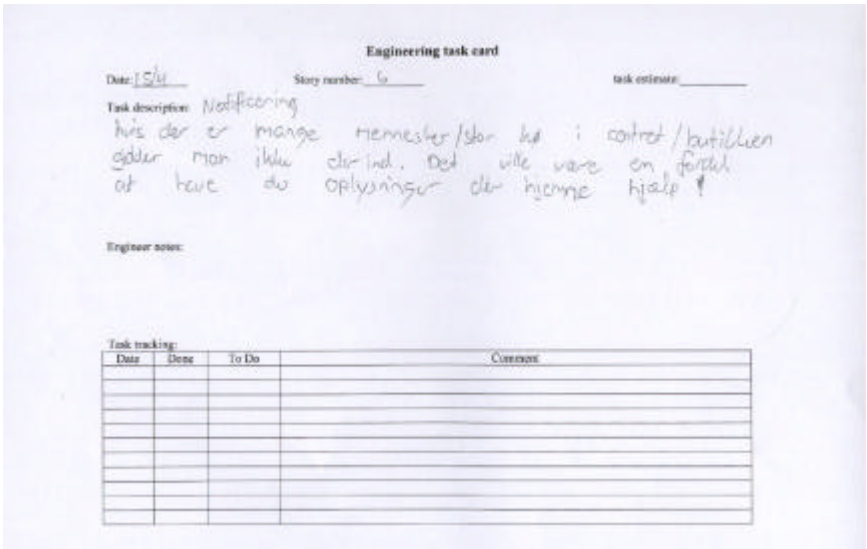
Engineer notes:

Task tracking:

Date	Done	To Do	Comment

Story 5: Offers / activities

The customer would like the system to provide information about when certain shops have any offers or special events. He wants to be able to turn this information on and off. He would also like a option to check all offers in the mall that meet criteria X. This could fx. be all items with 30% off or more.



Engineering task card

Date: 15/4 Story number: 6 task estimate:

Task description: Notificering
hvis der er mange mennesker/biler ind i centret/butikken også man ikke ser ind. Det ville være en fordel at have de oplysninger der kunne hjælp!

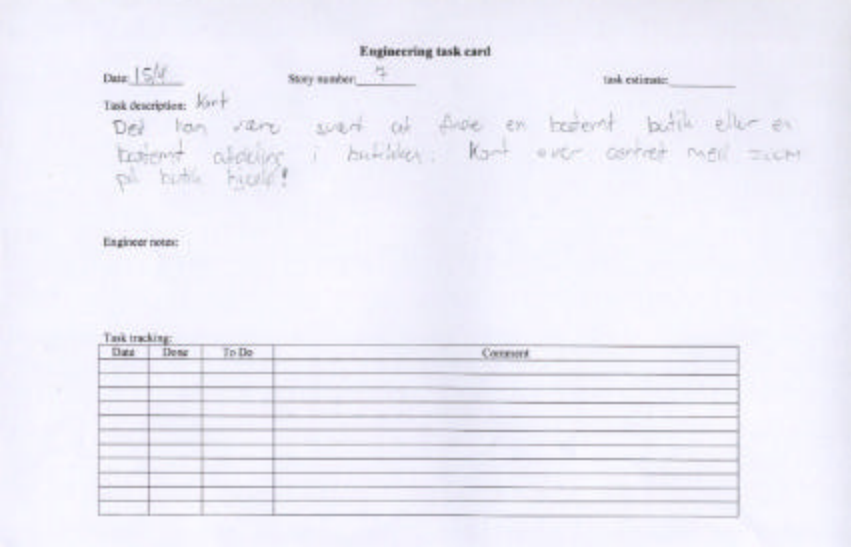
Engineer notes:

Task tracking:

Date	Done	To Do	Comment

Story 6: Notification

The customer does not like to go shopping when the mall is crowded. He would like the system to provide him information about the amount of cars in the parking lot and how many people are within the mall.



Engineering task card

Date: 15/4 Story number: 7 task estimate:

Task description: kort

Det kan være svært at finde en bestemt butik eller en bestemt afdeling i butikken. Kort over centret med zoom på butik hjælp!

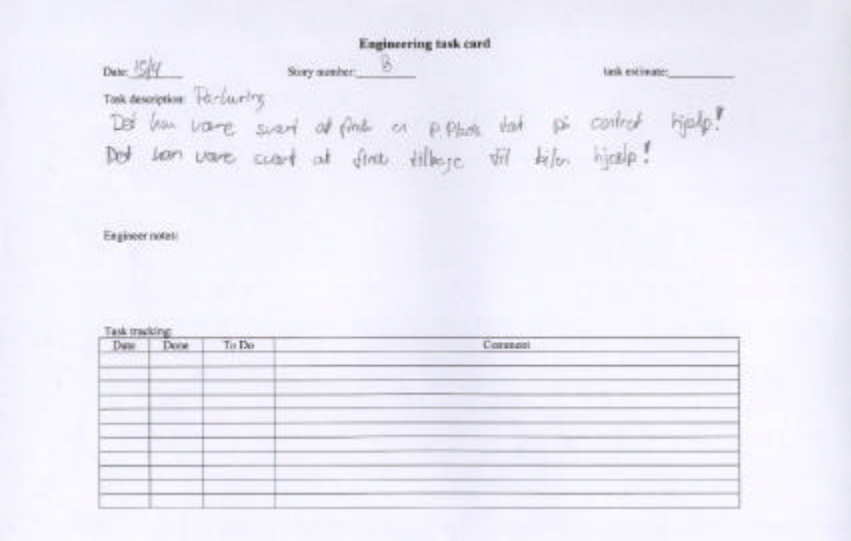
Engineer notes:

Task tracking:

Date	Done	To Do	Comment

Story 7: Map

The customer can find it hard to located certain shops or departments within a shop. He would like a map of the mall with a zoom function to aid him.



Engineering task card

Date: 15/4 Story number: 8 task estimate:

Task description: Parkering

Det kan være svært at finde en p-plads tæt på centret hjælp!

Det kan være svært at finde tilbage til bilen hjælp!

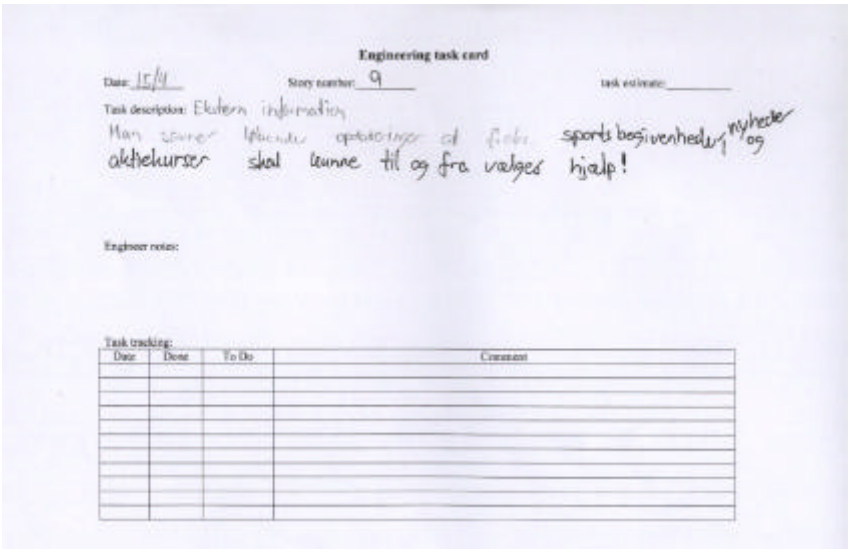
Engineer notes:

Task tracking:

Date	Done	To Do	Comment

Story 8: Parking

The customer often finds it hard to find a parking lot near an entrance to the mall. He would like the system to aid him in this function. Furthermore the system has to be able to guide him back to the car, when he is done shopping.



Engineering task card

Date: 15/4 Story number: 9 task estimate:

Task description: Ekstern information

Man ønsker information omkring at finde sports begivenheder, nyheder og aktiekurser skal kunne til og fra vælges hjælp!

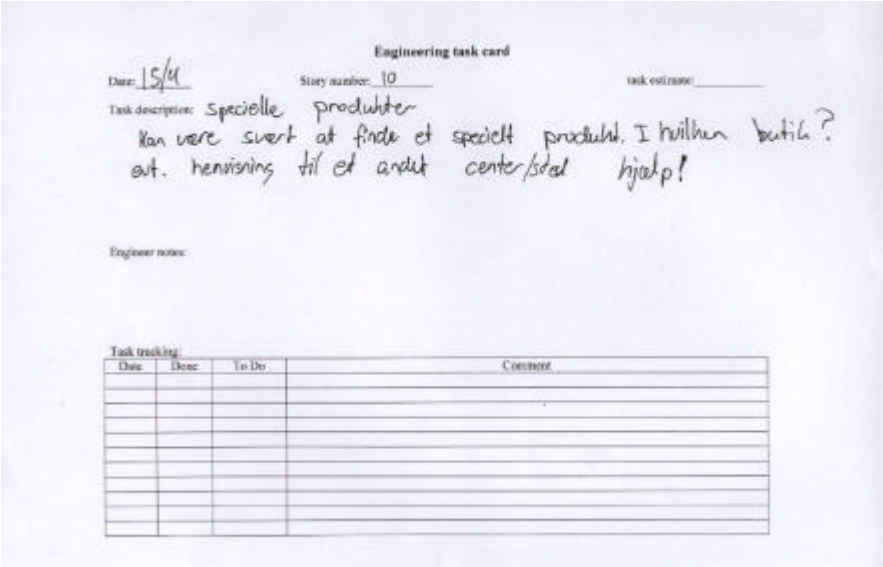
Engineer notes:

Task tracking:

Date	Done	To Do	Comment

Story 9: External information

The customer wants the system to be able to provide him with information from outside the mall. This is sports, news and stocks. He wants the ability to turn this option on and off.



Engineering task card

Date: 15/4 Story number: 10 task estimate:

Task description: Specielle produkter

Kan være svært at finde et specielt produkt. I hvilken butik? evt. henvisning til et andet center/sted hjælp!

Engineer notes:

Task tracking:

Date	Done	To Do	Comment

Story 10: Special products

The customer can often find it hard to locate a specific product and is sometimes not even sure which shop has the product. He would like the system to provide information about the location and even tell him about other mall’s which has the product if it does not exist in the mall he is in.

C.3.2 Complete list of tasks with description

Tasks
The tasks have been divided into 3 releases. The customer has rated each task and placed them accordingly in the release he found suitable. Below is a complete list of the tasks with time estimation and a short description.

C.3.2.1 Release 1

Product information (Time: 120 minutes)

- The system must be able to help the user find product information / reviews

When a user looks at an interesting item, which can seem almost impossible to determine the quality of, the system must help the user find information about the item. This could be reviews on WWW or detailed information from the product manufacturer.

Shopping list (Time: 30 minutes)

- It must be possible to enter information by speech

The user felt that a PDA was a somewhat annoying tool for typing a complete shopping list on and he would like the possibility to enter the information by speech. He was fully aware that this technology still had a long way to go, but he felt that it was easier to correct the errors it made, compared to writing it all himself.

Shopping list (Time: 90 minutes)

- The system must aid the user in finding specific products and locations

When a user is standing in a large store it can be hard to determine where a specific product is located. The system must aid the user in the direction of this product.

Shopping list (Time: 30 minutes)

- The system must be able to categorize the shopping list

The user explained that it was common for him to run back and forth between two departments in a store because the shopping list was unsorted. He wanted the software to aid him in the sorting and categorize the items on the shopping list by their physical location in the store.

Special offers/activities (Time: 60 minutes)

- The system must provide information about events and special offers

The customer explained that he did not like browsing through multiple stores to find good prices and special offers and often felt that he missed out on the great price reductions. He wanted the system to bring him all this information when ever he felt like it. This will function much like a price catalogue.

Special offers/activities (Time: 30 minutes)

- The system must support user preferences, which can influence the popup information and advertisement

The customer was concerned with the possibility of the user getting so many popup advertisements than it would become tiresome for the users. He explained that he didn't like commercials, because so little of them featured something he wanted. Because of this he would like the option of user preferences, where he could enter age, sex, interests and so forth, which would then delimit him from most advertisement and only show him information he was interested in.

Notification (Time: 45 minutes)

- It should be possible to see the amount of people / length of the queue in a mall without going there

The customer explained that he did not like shopping when the mall was to crowded and had on more than one occasion gone back home as soon as he saw the amount of cars in the parking lot. He would like an option where he could see the amount of people in the mall, before he decided to go shopping or not.

Map (Time: 120 minutes)

- The large stores must feature a map on which you are able to zoom in on certain areas

This map functionality only deals with the individual shops. These shops have a diverse size and the map function should be able to show all the shops in the same scale. In order to have the best possible use of the screen size it is then a necessity to implement a zoom function. This is due to the fact that the customer wants to be able to zoom in on a specific part of a store. Each store must have their own map which they must keep updated.

C.3.2.2 Release 2

Product information (Time: 90 minutes)

- Groceries with missing/incomplete declarations should be accessible through the system

The customer explained that some information on groceries is determined by law, but there is also some other relevant information that isn't there on all products. This information can be calculated from the information that must be there, but is not found on as many products which he desires. The system must aid the user in calculating/acquiring the missing information.

Product information (Time: 120 minutes)

- The system must be able to calculate score systems from misc. weight loosing systems

Some information on the groceries can be used to calculate how much you should buy of each product in order to stay within the tolerance parameters of any given weight loosing system. The system must aid the user in this task.

Shopping list (Time: 60 minutes)

- The system must be able to give advice on prices and tell where the user can get a specific product the cheapest

There are often specific products, which can be bought from multiple stores within a specific mall. The system must aid the user in finding the cheapest store for the product.

Grocery comparison (Time: 120 minutes)

- The system must be able to compare groceries on fat, vitamins and so forth

When you buy two or more similar products the system must be able to compare the products on a diversity of information such as fat, minerals, vitamins and proteins.

Special offers/activities (Time: 90 minutes)

- The system must be able to show an overview of special offers from user preferences (this could be all groceries with 30% off)

The user must be able so specify requirements on advertisement he wants to see right now. This can range from a specific brand on sale, Sport gear on sale or a complete list of everything with 30% of, etc.

Map (Time: 60 minutes)

- The product must have a map of the mall

This map function must have a complete overview of the mall and have a low degree of detail. The map is meant to by a guide on where each store is located and on how to get from A to B.

Parking (Time: 30 minutes)

- The system must aid in finding a suitable parking lot

If the mall has several entrances the system must be able to provide information on where the user can park the closest to an entrance.

External information (Time: 120 minutes)

- The system must be able to provide the user with information about news, sport and stocks.

The customer wanted the system to provide him with information about “the outside world”. If something exciting happened in sports, finance or news he would like to receive this information in real-time. This should be done by creating references to web pages and displaying these.

External information (Time: 10 minutes)

- The user must be able to turn external information on/off

The external information (sports, stock and news) must be selectable. The user must have preferences where he can determine which information he wants to see and the option of turning the popup functionality on and off.

C.3.2.3 Release 3

Product information (Time: 60 minutes)

- All groceries must be categorized by the system

Often a shopping list is not categorized. The system must be able to sort the list by all kinds of criteria. Sorting must contain alphabetical sorting to aid the user in checking if item “X” is on the list. The system must also be able to do sorting by location in the store, to speed up time usage and to minimize walking distance and have the option of sorting by item type (fruit, clothing, etc.).

Surveillance of children (Time: 120 minutes)

- The product must have a master and slave mode(in the same program), where the parents(masters) can send information to the children(slaves)

There must be a feature where one application can identify another and send messages back and forth between the applications. This should work like a very simple chat system.

Surveillance of children (Time: 60 minutes)

- It should be possible to arrange a meeting between master and slaves which should be viewable on the map

The master application must be able to send information to the slave applications and tell them where they all should meet and what time they should all be there.

Surveillance of children (Time: 90 minutes)

- A guide to the meeting location must be present

If a meeting is arranged the system must be able to provide the user with information about getting there on the overview map of the mall.

Surveillance of children (Time: 120 minutes)

- The master must be able to see the location of the slaves(children)

The master application, which is supposed to be used by the parents, must have an option to see the location of the slave applications on the overview map. This could be implemented as a small dot on the map image or as a small text label showing the location.

Parking (Time: 30 minutes)

- The system must be able to direct the user back to the car

When a user enters a mall he will be located in a zone, which is close to the exit. The system must remember this zone to be able to guide the user back to the car if the user has lost his sense of direction when he wants to get home.

Special products (Time: 60 minutes)

- The system must aid the user in finding special/rare products

If the user is looking for a product of any sort which is rare and thereby hard to find, the system must aid the user in determining a store where the product can be purchased.

Special products (Time: 20 minutes)

- If a rare product doesn’t exist in the mall, the system must be able to tell if the product exist in another mall which is also using this system

If the product doesn’t exist within the mall, the system should be able to tell the user if it exists in any other mall which is using the system.

C.4 Diary

Date: 10/4

Phase: Gaining understanding of method

Participants: The developer

Initial understanding: The XP method

Work performed: Reading “Introduktion til Extreme programmering” by Kent Beck

Time usage: 6 hours

Actual understanding:

Applicability of outcome: The developer has gained an understanding of the XP method and based on this information he has decided which aspects are important and which he will discard.
There are two important tools in the method which the developer will use to create the prototype.
Stories: These are created by the customer in a natural language and should describe aspects of the system which the prototype must aid a user in completing.
Tasks: The developer has to create tasks from the stories in order to have a foundation for beginning the actual work on the prototype. These stories should be a further elaboration of the aspects in a story.

Reflection: The method relies heavily on a customer and this person should be recruited soon. XP has some key values when creating software. These will be discarded since this development phase will never evolve beyond a prototype.
The developer has gained an understanding of two key aspects in the method which are stories and tasks. These tools will aid him in getting a perspective of how the prototype should be designed.

Planned progress tomorrow: Getting a customer
Misc.: -

Date: 11/4

Phase: Finding test participants
Getting started

Participants: The customer is a woman age 26. She has an education as a dental assistant, which she worked as for about a year, but this became tiresome for her. Recently she has begun an education as a kindergarten teacher.

Initial understanding: This day has been concerned with the choice of finding a suitable customer. The person chosen is a woman in the 20'th.

Work performed: First of all a customer had to be found. Then the developer used the day making a crash course in the XP method, which will provide the customer with the information she needs in order to fulfill his task. It is vital for the success of the method that the customer fully understands the work which she should do in order to aid me the most in creating the best possible prototype. The developer is not sure how to make this XP course, since the method does not aid in this task. It was chosen only to tell the customer about the aspects which concern her. This involves story making and how the developer will use these to create the system.

Time usage: Getting a customer: 1 hour
Creating a crash course for XP customers: 3 hours.

Actual understanding: When doing the actual work/activity that day, one can encounter problems because of poor understanding of the method being used. It is vital that the developer has a great understanding of the work which concerns the customer in order not to mislead her.

Applicability of outcome: A customer who understands her task.

Reflection: Since every person is accustomed to shopping the choice of finding a suitable person was easy. The developer's main concern is that the customer will have a limited view on the possibilities of a system and will try to get a focus group to debate the system, which should help the customer get a better understanding of the possibilities. This is because the developer assumes that people all look differently at shopping. Some enjoy it while others see

it as a tiresome and stressing experience and hopefully the finished product will be able to support both types of users.

Planned progress tomorrow: The developer will visit the customer and try to explain the XP method to her.

Misc.: -

Date: 12/4

Phase: Finding test participants
The customer must understand her task

Participants: The customer

Initial understanding:

Work performed: The developer has used the day explaining the method which has proven harder than expected

Time usage: Explaining the XP method: 4 hours

Actual understanding: Making stories seemed (to the developer) like a great way to get someone with very limited knowledge of IT-systems to participate in the creation of a system, but the customer found it very hard to understand how this information could be used. This might cause problems in the future.

Applicability of outcome: -

Reflection: The customer focused a lot on the creation of the system which she did not need to. The developer might have explained too much about what her work should be used for instead of focusing entirely on what she should do. She had a hard time understanding how the stories of her tasks could be transformed into an IT-system. It seemed like she was very focused on the creation of the GUI, which might have frightened her a bit, since she might not have felt competent in this area. The developer explained to her that she did not have to worry about this and that he would make the GUI and all she had to do, was try it and see if she wanted something changed or not. During this work the developer has become aware that the customer must have a good imagination to see all the possibilities in the creation of a GUI.

Planned progress tomorrow: The developer must try to get a few people to participate in a focus group meeting to get the customer to get an even better idea of the possibilities that exist in this system. Since the developer has already discussed most of his own ideas for the system and the customer is aware of these he thinks it would be better to the focus group

meeting without himself, since he can influence the meeting with his ideas and maybe put a damper on the discussion.

Misc.: -

Date: 15/4

Phase: Finding test participants
Getting a new customer

Participants: The customer. A male, age 30, who is a schoolteacher and is highly motivated to use a PC. He likes to test and read about the functionality of new devices (graphics cards, hard disks etc.) for the PC platform, but has never owned a PDA. To help him gain more understanding of the PDA's potential he borrowed one from the developer, so he could familiarize himself with the device. The customer works about 30 kilometers from where he lives and often has a shopping list with him to work, if he is the one doing the shopping on the given day. His girlfriend and him seem very organized in their shopping habits and very focused on the products they buy, since she is on a diet where every item must meet certain demands before she can eat them.

Initial understanding:

Work performed: The original customer (the woman) and I had different timetables and it seemed harder and harder to arrange meetings, so I have chosen to get a new customer. I have used this day to introduce the customer to the method, which didn't seem to cause any problems for him or me.
The first task was getting the customer to become an expert. This was done by brainstorming how the system could be used in a mall. This lasted about 2 hours.

Time usage: Getting the customer: 1 hour
Explaining the method: 5 hours

Actual understanding: The developer was aware that it could be difficult for someone to understand their job as customer, but this did not seem to be the case with my new customer.

Applicability of outcome: -

Reflection: Having discussed the customer's role and introducing him to stories etc. has insured the developer that this customer is more qualified than my previous customer (the woman). It may be because the developer knew what was important to tell about the method. It was choose to tell the customer more about the stories and get him to grasp this, before the

developer even mentioned how these stories should be used to create the program. This seemed a much better way, since it didn't seem to give the customer any problems.
The developer had not even finished telling the customer about the method before he started telling about misc. ideas he has for the system. It seemed like the developer was now the one holding back, which the developer thinks is great.

Planned progress tomorrow: Creating stories with the customer

Misc.: -

Date: 16/4

Phase: Empirical data collection
Making all the stories

Participants: The customer

Initial understanding:

Work performed: We worked on making stories. This started out as a brainstorm where all ideas where discussed and nothing was dismissed. The customer seemed very enthusiastic and was even able to find product ideas which were of no use to him (children monitoring and car parking (he didn't mind walking)). He was very aware that some people think of shopping in a different way than him. He likes to get his shopping done fast and does all the product research at home, where he thought others might do their research within the stores.

Time usage: Creating the required material: 1 hour
Work on stories: 6 hours

Actual understanding: The customer must create stories, both from yesterdays brainstorming and from any new ideas he might have.

Applicability of outcome: 10 stories were created which all dealt with different aspects of the system. These stories can be found in Appendix C, p. 130.

Reflection: The customer found it difficult to create the story cards and it took about 15 minutes before he started writing. He was confused about how to write them and even though the developer told him that it should be written in natural language, he found this hard to grasp. At this stage the developer had already told him about how the stories should be divided into tasks and he felt that he had to do something to aid the developer in this. As soon as the developer explained him how he should do it, there was no problems and he created all the stories very rapidly, even though the customer often wanted to debate the functionality with the developer.
All the stories created seem to deal with different aspects of the product. The developer does not anticipate that they will conflict when he starts programming.
The speed of which the stories were created was very fast and where might be elements which the customer has forgotten to include from the brainstorm.

Planned progress tomorrow: Creating tasks from the 10 stories.

Misc.: Stories are added at the end of the diary. They are all created in Danish to avoid making it harder for the customer than it already is.

Date: 17/4

Phase: Analysis
Creating tasks and getting the customer to divide these into 3 releases

Initial understanding: Today the developer must first divide all the stories into smaller tasks which are better suited for making the prototype. The developer has decided to make three releases. Each task must then be estimated by how much time it will take to implement.

Work performed: The developer started by splitting each story into as many tasks as he found suitable. This was done to make the implementation easier. All the stories where then estimated by the developer to get an overview of how long each task would take to implement. This time estimation was not done with focus on a finished product, but on the time it would take to make a functional GUI with very little functionality.
These tasks were then laid out individually on a table for the customer, who was not present yet.
When the customer arrived it was explained to him what the developer had done and that it was now his job to figure out which tasks were the most important and divide them into releases.

Time usage: The developer used the first 5 hours transforming all the tasks into smaller stories and estimating these. These stories where then discussed with the customer in order to give him a better idea of how they were split into smaller pieces tasks. This lasted about 3 hours.
Then this was done the customer separated the tasks into 3 releases which was discussed. This lasted 4 hours. (10 hours)

Applicability of outcome: All the stories were divided into 3 releases which contained 8, 9 and 8 tasks respectively.

Participants: the customer

Actual understanding:

Reflection: When the user had to divide the tasks into the three releases the developer told him that he should decide on what was the most important and that he decided, but there

could occur some problems that we had to discuss. It would not be possible to have zoom implemented before the map was implemented.
This did not seem to cause him any problems when it was discussed, since he did not look upon the finished system they way the developer did. He did not expect the product to have a map of the entire mall which would be zoomable. He wanted a map of the mall, which would be with very little details and should only provide an overview. The other map should have much more details and should only show one store at a time. This map should be zoomable. The developer is worried that there might be other aspects of the tasks where the customer and him do not have a common understanding, but the developer do not anticipate any big problems.

Planned progress tomorrow: All the tasks are now split into 3 releases and the developer will begin working on the tasks from the first release in order to create the GUI.

Misc.: The task of estimating each task seemed like guessing. The developer has estimated all the stories to last 2 hours or less, since only the GUI has to be created. The function- and model layer are not important for this prototype. The tasks can be found in Appendix C, p. 135.

The releases are shown below. The columns names are Story name, Task name, estimated time respectively.

Release 1

Product information	The system must be able to help the user find product information / reviews	120
Shopping list	It must be possible to enter information by speech	30
Shopping list	The system must aid the user in finding specific products and locations	90
Shopping list	The system must be able to categorize the shopping list	30
Special offers/activities	The system must provide information about events and special offers	60
Special offers/activities	The system must support user preferences which can influence the popup information and advertisement	30
Notification	It should be possible to see the amount of people / length of the queue in a mall without going there	45
Map	The larger stores must have a detailed map of the departments and this should be zoom able on the map	120

Release 2

Product information	Groceries with missing declaration should be accessible through the system	90
Product information	The system must be able to calculate score systems from misc. weight loosing systems	120
Shopping list	The system must be able to give advice on prices and tell there the user can get a specific product the cheapest	60
Grocery comparison	The system must be able to compare groceries on fat, vitamins and so forth	120
Special offers/activities	The system must be able to show an overview of special offers from user preferences (this could be all groceries with 30% off)	90
Map	The product must have a map of the mall	60
Parking	The system must aid in finding a suitable parking lot	30
External information	The system must be able to provide the user with information about news, sport and stocks.	120
External information	The user must be able to turn external information on/off	10

Release 3

Product information	All groceries must be categorized by the system	60
Surveillance of children	The product must have a master and slave mode(in the same program), where the parents(masters) can send information to the children(slaves)	120
Surveillance of children	It should be possible to arrange a meeting between master and slaves which should be viewable on the map	60
Surveillance of children	A guide to the meeting location must be present	90
Surveillance of children	The master must be able to see the location of the slaves(children)	120

Date: 30/4

Phase: Design / Taking the first steps toward a GUI

Participants: The customer

Initial understanding: The developer does not anticipate any technical problems when creating the graphical user interface, but before the actual work begins he would like to debate the overall idea for the GUI with the customer. The developer is not sure if he wants a common layout with standard components as seen in windows and most RAD tools, or if he wants some kind of special graphics. The developer anticipates both advantages and disadvantages to both layouts. The graphically enhanced version will maybe have a better appeal to new because of the “fancy” look on the GUI, but this could also interfere with the speed and functionality in which the user can interact with the application and on how much information can be squeezed together on the screen.

Work performed: Debating the GUI with the customer.
Time usage: 2 hours

Actual understanding:

Applicability of outcome: It seems the user and developer agreed on the GUI. He was not interested in “fancy” layout. It seemed like he was more interested in having fast access to the desired information. They ended up talking more about the different Graphical components which could help divide the different parts of the functionality on the GUI. He was not aware of all the possibilities and was showed many of the options in a RAD tool.

Reflection: The discussion has saved the developer from a lot of guessing when the development finally begins. He is now aware of the overall graphical look the application should have.
The discussion has proven even more useful than anticipated. Even though the developer had not planned it, they also ended up discussing how the different functionality should be separated on the GUI. This was topics like map and shopping list. The customer wanted fast access to this functionality, no matter what other parts of the application he was using.

Planned progress tomorrow: Starting implementation
Misc.:

Date: 02/5

Phase: Implementation
Implementation of release 1

Participants:

Initial understanding: The tasks are already divided into 3 releases and the developer should be able to start implementation without any difficulties.

Work performed: Implementation of the first release

Time usage: 14 hours

Actual understanding: The GUI is starting to “come alive”

Applicability of outcome: A working prototype, with the functionality from release 1. Some aspect will not be implemented. This is functionality like voice communication. This is not considered important and will be much to time consuming.

Reflection: The developer often felt that there was information, which could have been elaborated even further between the customer and himself. The developer can not put his finger on anything particular, but it is harder to go from a task description to a GUI layout than anticipated. The developer was unable to determine which of the functions were the most important for the user and which were less important. This could influence the main screen of the application. Should it be the map or should it be the shopping list?
The choice was to create the shopping list on the main screen since this function is used the most in the developer’s opinion. The map only becomes interesting when there is something they cannot find what they are looking for.
The developer had the idea that the shopping list should have the possibility to mark items as the customer put these into the carts. But since this technology has more options than a piece of paper it seemed a good idea to be able to remove items which had been found. This was done by having an extra function to remove the items. The first idea was to remove the items as soon as the customer marked them, but this was discarded since it would present problems in retrieving them again if he clicked the wrong items or double clicked (2 items would be removed).

Planned progress tomorrow: Debating the GUI with the customer

Misc.:

Date: 05/5

Phase: Design
Debating release 1 with the customer

Participants:

Initial understanding: The customer must now give his point of view on the GUI to insure that everything is made to his satisfaction.

Work performed: Debating the GUI with the customer.

Time usage: 4 hours

Actual understanding: The customer's feedback on elements of the GUI which he does not like or fail to understand will aid in making the GUI better.

Applicability of outcome: Map was easy to grasp since there was such a big difference in size between the red box (user) and the blue box (the requested zone)

Reflection: The user had no problems understanding the difference between the red and the blue boxes on the map and he explained this because the red was much smaller. This is a GUI flaw since the zones would be of equal size. The difference might not have been obvious if they were of equal size.
The developer felt the user understood the application and how each function was implemented. Some functions he found right away, while he stumbled a bit more to find other functions. It was almost impossible to make him say anything negative about the application and the developer got the feeling that the customer felt he had to come up with new ideas if he told the developer he did not like some of it. This was discussed, but it changed nothing. The customer continued to say everything on the GUI was ok.

Planned progress tomorrow:

Misc.:

Appendix D - Evaluation results

All of the prototypes were evaluated by the users. The users saw all the prototypes but in different order. The following matrix show in what order the prototypes was evaluated.

Users	First prototype	Second prototype	Third prototype
M.U.S.T users	XP prototype	M.U.S.T. prototype	CD prototype
C.D. users	M.U.S.T. prototype	CD prototype	XP prototype
XP user	CD prototype	XP prototype	M.U.S.T. prototype

Table 13 Evaluation order

The following three tables show the results of the evaluation of the three prototypes. The table includes user statements as well as assessments on the scale from 1 – 10, where 1 is lowest and 10 is highest.

Participant	Navigation	Text	Functionality	Color	Would use
Male 34 years Female 29 years	Clear. Easier with icons. **(8)**	Is readable. Good size, good font. (Maybe a little to small) **(9)**	Not clear what the purpose of product info is. Needs shopping list. Needs exits, information etc. on map. **(8)**	Color is OK. Not too many colors. Use icons. **(8)**	**(5)**
Male 58 years Female 54 years	Understood buttons. Wants a search like google. **(7)**	Text on map to small. Ok on other pages. Division is clear. **(8)**	Cannot see where one is. Needs direction on map. Product comparison is good. Product info should show something on quality. **(6-7)**	Map is good. White and grey is good. **(9)**	**(7)**
Male 30 years	Very easy. **(9)**	As they should be. Does not consider people with poor eyesight. **(9)**	Product information and Price comparison is good. **(9)**	A little more color. The “LUK” button should distinguish it self. **(7)**	**(3)**
Male 24 years Female 22 years Female 28 years	Easy – very clear. Good overview on map. Difficult to understand product selection at first. **(8)**	Ok Small on map. **(8-9)**	Needs zoom on map. Needs to show where I am on map. Needs shopping list. Likes compare prices. **(8)**	Good. **(8)**	**(6)**
Overall score	**(8)**	**(8.6)**	**(7.9)**	**(8)**	**(5.25)**

Table 14 Evaluation of the MUST prototype

Participant	Navigation	Text	Functionality	Color	Would use
Male 34 years Female 29 years	The order of buttons should be: “Kort”, “Indkøbsliste”, “Søg” “Marker gruppe” should be “I vogn” or similar terms used on the net. **(9)**	Text on map unreadable. Good on shopping list. **(9)**	Notes seem confusing. Map should show exits and toilets. Needs add item to shopping list. **(9)**	Icon (T) was quickly comprehended. Notes like post-its. **(9)**	**(7)**
Male 58 years Female 54 years	The three buttons below was a problem. Simple after the understanding was achieved. **(9)**	Text was readable. **(7)**	Needed price comparison. Needs more product info. Following search there shall be a option to compare products. **(8)**	Good color in shopping list. **(7)**	**(8)**
Male 30 years	Simple **(8)**	Sufficiently. There can be difference in users. **(10)**	Speech to text. Likes that one can see the offers on the shopping list. **(8)**	Neutral. Likes that the colors represents categories. **(9)**	**(2)**
Male 24 years Female 22 years Female 28 years	Too many options. A bit confusing Did not understand arrows at first. **(7-8)**	Ok Maybe a bit bigger. **(8-9)**	Likes search function, zoom, call for help. Profile is very good. “Marker varer” was not understood. **(9)**	Good. Understood that each product group had its own color and that those colors were used in Bilka. **(8-9)**	**(7-8)**
Overall score	**(8.4)**	**(8.6)**	**(8.5)**	**(8.4)**	**(6.1)**

Table 15 Evaluation of the CD prototype

Participant	Navigation	Text	Functionality	Color	Would use
Male 34 years Female 29 years	Does not understand sorting of shopping list. Not logic. **(5)**	To small on buttons. Good on shopping list. **(6)**	Good idea with intro. Needs toilets. Needs search for products. **(6)**	Does not understand the color of the buttons at the bottom. **(6)**	**(2)**
Male 58 years Female 54 years	The word "Lokation" is not good. Clicks on "Navigation" in order to show an item from shopping list. Needs directions on map. **(4)**	Too small. **(8)**	Likes product information and info on diets. Map not good. **(5)**	OK **(8)**	**(6)**
Male 30 years	Remove bought items. Simple is good. **(9)**	Shopping list to big. The rest is fine **(8)**	Needs text messages on map. One long list of offers not good, to boring. **(9)**	Menu should not be red. **(7)**	**(1)**
Male 24 years Female 22 years Female 28 years	OK Info pop-up should disappear, when another screen is selected. **(6)**	OK **(8-9)**	Good info on first screen, but hard to relate to. Good with overview of activities/offers. Product info good. Map not good. Mark items on shopping list is good. Likes add item. **(6)**	Boring. Did not understand the red buttons. **(5)**	**(2)**
Overall score	**(6)**	**(7.75)**	**(6.5)**	**(6.5)**	**(2.75)**

Table 16 Evaluation of the XP prototype

Appendix E - Diary structure

In our diaries we had the following subjects to consider:

- **Phase:** The phase in the development this particular activity belongs to.
- **Participants:** Participants involved in the activity.
- **Initial understanding:** A description of the understanding one has required by reading about the method on the particular subject encountered that day.
- **Work performed:** Description of the work performed that day.
- **Time usage:** Time is used on the different tasks performed.
- **Actual understanding:** When doing the actual work/activity that day, one can encounter problems because of poor understanding of the method being used.
- **Applicability of outcome:** If models/diagrams/analysis has been made during the day, an assessment of their relevance is determined.
- **Reflection:** At the end of the day a reflection on the work is done. Problems encountered and possible solutions suggested.
- **Planned progress tomorrow:** The plan for tomorrow.
- **Misc.:** Additional notes or thoughts. Materials from today's work can be included.

The following phases will guide the process of using each of the three methods.

- **Gaining understanding of method** The first phase encompasses gaining an understanding of the method. Furthermore this phase includes the selection of appropriate activities to use from the method.
- **Finding test participants** The second phase is concerned with selecting and finding test participants and coordinating a specific date for data collection. This must be done according to the guidelines outlined by the method.
- **Empirical data collection** The third phase encompasses the task of collecting empirical data from users.
- **Analysis** The fourth phase is concerned with the analysis of the data collected in phase 3. Moreover models will be elaborated during this phase.
- **Design** This phase encompasses the entire design phase. That includes the elaboration of models, and drawing of UI-sketches.
- **Implementation of prototype** The fifth phase is concerned with the implementation of the prototype.