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Title:
Emptio - A mobile phone application for self-service shopping in Harald Nyborg.

Theme:
Human Computer Interaction

Project Timeframe:
SW9, 1. September, 2010 - 4. Januar, 2011

Project Group:
d512a

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Abstract:

Shopping is a part of our everyday life and with the current proliferation of mobile phones this report will examine whether Near Field Communication and mobile technology can be utilised to improve self-service shopping. A field study on self-service shopping is conducted with customer interviews and observations in Harald Nyborg. Furthermore, a focus group with the employees is conducted in order to understand their experiences on self-service shopping.

Based on the field study, a design for a proof-of-concept mobile phone application is made to address some of the problems that exist in the current form of self-service shopping. The design consists of a scenario, followed by use cases, requirements and a class diagram. Although the design is not implemented in this report we examine what options we have to implement the design on contemporary mobile platforms. Finally, the design is reflected upon in the conclusion.

Copies: 5

Total Pages: 44

Appendices: 5

Paper Finished: 4th of January 2011

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Preface

This report is written by three software engineering students, currently attending ninth semester at Aalborg University. The course of the project was commenced on the 1st of September 2010 and the report was handed in on the 4th of January 2010.

The focus of the report is the Near Field Communication (NFC) technology and how it can be utilised in the shopping context. The report concentrates on analysis of this technology and a design of an application that utilises this technology in a specific case. The case is conducted in collaboration with Harald Nyborg, in Aalborg and we would like to use this opportunity to thank everyone from Harald Nyborg for their help and effort. We would also like to thank our supervisor Jan Stage for his advice and guidance during this semester.

The report will concentrate on subjects related to computer science and thus it is assumed that the reader has equivalent knowledge in the field of computer science, as that of an ninth semester software student.

Two types of source references are used throughout the report. A reference placed after a period, refers to the given section, and if the reference is placed before a period or in a sentence, it refers to the particular sentence or word. Sources to the references used throughout this report can be found at the end of the report in the bibliography.

Aalborg, January 2011
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Contents

1 Introduction

In the last decade we have seen a phenomenal proliferation of mobile phones. Most people carry one and use them frequently for various tasks. The trend shows that the growth of mobile phone subscriptions has been growing rapidly. The latest statistics from The International Telecommunication Union (October 2010) shows that there will be 5.3 billion mobile subscriptions by the end of 2010 [**?**], see figure 1.1. That is over 70 percent of the world population. These phones are not only used for communication. Lately there is an increasing interest for using mobile phones for interaction with people, places and real world objects. People can use their mobile phones to take pictures of visual markers such as data matrix codes. After recognising the code, the information related to the code is displayed on the phone. GPS positioning is used for various location based services, such as "find nearest restaurants". Other areas of mobile interaction are smart objects such as advertisement posters.

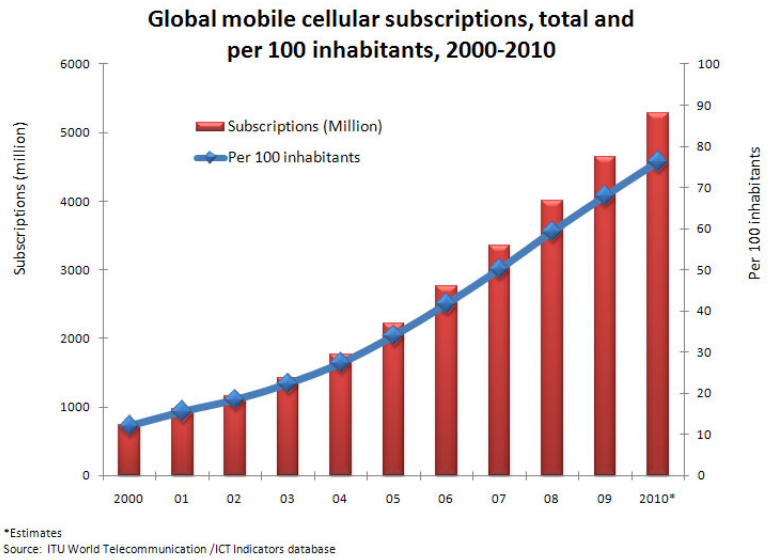


Figure 1.1: Mobile subscriptions for the last decade.

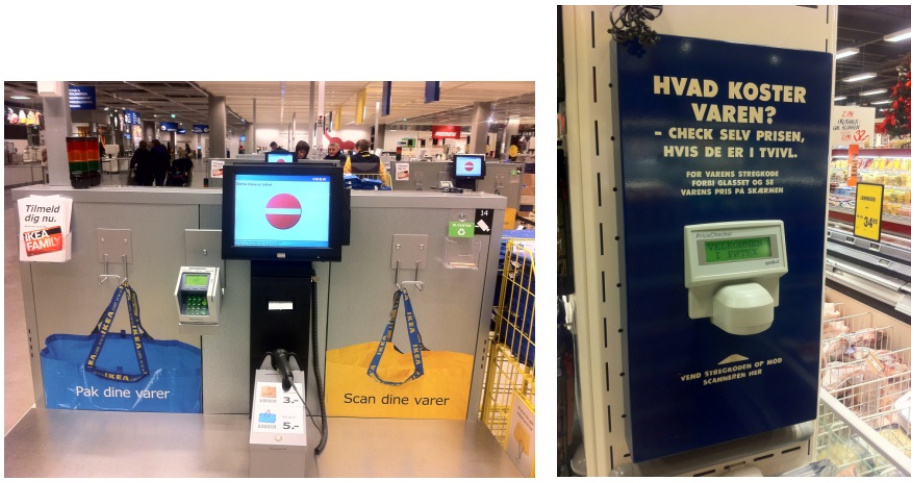
One of the building blocks for this trend in ubiquitous computing and communication, is the easy and natural interaction between humans and technology. Acquiring information, initiating actions, transferring data, performing financial transactions, etc, can be done by touch-based interaction, which is a way of establishing connections and exchanging information between mobile devices just by bringing them close to each other. It is interesting to see how technology can be utilised in different shopping practices.

Shopping is an activity that can be done in different ways. Shoppers can purchase products online from various web sites and have the goods delivered to their home. Customers can also order products from a catalogue via telephone or mail, or order from TV or radio advertisements. The third category is what we call in-store shopping. This is where customers are physically in a store or a supermarket. In-store shopping can be done in various ways, which we chose to name and categorise as *trolley shopping*, *self-service shopping*, and *mixed shopping*. The description is as follows:

Trolley shopping This is known from grocery shopping in supermarkets, where customers are browsing products in the store, selecting them from the shelves or aisles and placing them in a trolley or shopping basket. They then proceed to check-out where they pay for the products. The increasing interactivity is evident today, where one of the areas in which interactive technologies are being introduced is in trolley shopping. Stores, such as IKEA have introduced self-checkout terminals as a supplement to the existing checkout counters. Customers use the bar code scanners to scan their items and when all the items have been successfully scanned, customers pay for their purchases with their credit card, collect their receipt and proceed to the exit. Other stores, such as Bilka and Føtex have installed bar code scanners at various places in the store, where customers can get information about the products. Both of these examples can be seen in figure 1.2. These are examples of how technology can be utilised in a shopping context. Other examples can be seen in Appendix A.

Self-Service shopping In some stores, customers pick up a list and a pencil at the entrance and walk around the store with this list, on which they write specific information for a product they would like to purchase. These products are exhibited in the store, with information such as price, product number, size, etc. Customers write which products they want down on the list made especially for the purpose. This is the practice used by IKEA and Harald Nyborg, and their lists can be seen in Appendix E. Since trolley shopping has evolved with new technology it is interesting to see if new technology also can be introduced to self-service shopping.

Mixed shopping *Mixed shopping* consists of both *Trolley shopping* and *Self-service shopping* in the same shopping practice. Besides having to write products on the list, both IKEA and Harald Nyborg have some products in the store, which can be picked up in a shopping basket or a trolley and paid for at the check-out.



Self-checkout in Ikea

Bar code scanner in Føtex

Figure 1.2: IKEA's self-checkout terminal and a bar code scanner in Føtex store in East Aalborg.

Furthermore, the proliferation of mobile phones with increasing capabilities and new technologies makes it possible to develop applications that introduce more interactivity while shopping. One of these new technologies is the Near Field Communication (NFC). This technology enables seamless wireless communication between devices such as mobiles phones and Radio Frequency Identification (RFID) tags [?].

It enables users to access information and services by simply holding the mobile phone close to objects that are equipped with NFC-compatible tags. With the use of this technology it is not hard to imagine new scenarios in retail shopping. While shopping products in a store, the customer could use the mobile phone to scan products, add them to a virtual shopping basket, place the order and finally pay for the products on the mobile phone. Thus the research question can be summarized as follows:

- Is NFC an appropriate technology for *self-service shopping*?
- Are there problems in some areas of *self-service shopping*?
- Can we design a mobile phone application that addresses the discovered problems of *self-service shopping*?

The following provides an overview of the content in the report.

Chapter 2 describes the technology platform that will be used for the system under development. The focus is on NFC, what this technology is and how it works, and some examples of its usage.

Chapter 3 looks at the shopping practice at Harald Nyborg in Aalborg and presents the field study that was conducted. The field study consists of customer interviews and a focus group with the employees of Harald Nyborg.

Chapter 4 presents the design for our system. The design parts consist of a class diagram, overall use case diagram, use case specifications, state chart diagrams, and other design related elements.

Chapter 5 is a look at how this proof-of-concept can be implemented

Chapter 6 concludes on the research questions presented in the introduction and gives a overall conclusion on the report. Finally, limitations are listed.

Enjoy your reading.

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2
Technology Platform

Over the last couple of years, mobile phones have become a popular platform for developing diverse applications and the current trend of mobile phones can be characterized as a move from a single purpose device to a multi functional device. New technologies like Near Field Communication (NFC) extend the capabilities of mobile phones. Invented by Philips and Sony, NFC is a novel technology developed especially for mobile phones. Together with Nokia, Sony and Philips founded the NFC Forum in 2004 in order to promote short-range wireless connectivity technology [**?**].

This chapter describes what NFC is, its potential and practical uses, and a comparison with other technologies. The decision to focus on NFC is based on our personal interest in this promising technology that is gaining more attention and proliferation, which can be seen in the number of projects around the world involving this technology [**?**]. Big companies like Google, have lately endorsed the use NFC in mobile phones as a form of a digital wallet and see NFC used in various applications. The CEO of Google, Eric Schmidt has lately revealed Nexus S mobile phone featuring built-in NFC functionality [**?**].

2.1 What is NFC?

The Near Field Communication technology is a short-range radio communication technology that relies on touch-based interaction [**?**]. NFC allows users to establish connection and exchange information between NFC-enabled mobile phones and other handheld electronic devices, by holding them close to each other. It enables users, to access content from another device or NFC tag at ranges up to ten centimeters. In other words, touch-based interaction does not necessarily mean devices must physically touch each other. They have to be within range. Thus when we write *touch*, it means that it represents touch-based interaction.

NFC and Radio Frequency Identification (RFID) are often used incorrectly as exchangeable terms. Both technologies use reading devices to gather data stored on passive tags that are attached to objects. NFC is based on the same technology as RFID. This makes NFC devices compatible with existing RFID systems.

A quick comparison of NFC with other wireless technologies like infrared and Bluetooth, can be seen in table 2.1. It should be noted, that the *Range* varies and is not necessarily exact with today's standard, as these four communication technologies are constantly evolving. *Usability* states the original goal for the technology and how easy it is to use. It can be seen that NFC is more human centric, where as Bluetooth is more data centric, since it's original goal was to transfer data between Bluetooth compatible devices. Furthermore, Bluetooth's usability is rated as Medium, since pairing of two devices is necessary in order to establish connection, where as the other technologies do no require any set up in order to communicate. *Selectivity* states how one can "select the other device".

RFID is rated as Partly given, meaning that it is not obvious which device is selected if there are several tags placed close to each other, and the reading device is, e.g., 2 meters away. NFC on the other hand reads tags at close range, and that is why it is rated as Given. By High it is meant that it is it does not require line of sight, and Security rating is described in section 2.4. Infrared needs line of sight in order to establish communication, e.g., a remote for the television, where as Bluetooth needs to go through the process of pairing devices. Although the table might be biased slightly, since it is from the NFC Forum and thus favoring the NFC technology, it still gives a good overview and comparison with other technologies on the market.

	NFC	RFID	IrDa	Bluetooth
Set-up time	< 0.1ms	<0.1ms	~ 0.5s	~ 6 sec
Range	Up to 10cm	Up to 3m	Up to 5m	Up to 30m
Usability	Human centric Easy, intuitive, fast	Item centric Easy	Data centric Easy	Data centric Medium
Selectivity	High, given, security	Partly given	Line of sight	Who are you?

Table 2.1: Comparing NFC to other close range communication technologies (NFC Forum [?])

2.2 Comparing different interaction techniques

The technologies in table 2.1 have different interaction techniques. NFC and RFID rely on touch-based interaction. Pointing is used in infrared and scanning is used with Bluetooth. It is interesting to see which of these interaction techniques is most preferred by users.

Rukzio et al. [?] focus on the interaction between a user and a smart object in the real world. These smart objects are products that have been augmented with different sensors or chips, e.g., a microwave equipped with an RFID chip. A user interacts with a mobile device, and this mobile device interacts with a smart object in the real world. The article presents an analysis and an experimental comparison of three interaction techniques, which they have named as *touching*, *pointing* and *scanning*.

Touching technique is where a user brings his mobile phone into close proximity with the smart object, when he wishes to interact with it. He is then presented with related information on his mobile phone. A common way to implement this interaction technique is to use technologies like RFID and NFC, which means it is not required to physically touch the objects. It is sufficient to bring the mobile phone close to the smart object. By using the *pointing* interaction technique, the user can select a smart object by pointing with a mobile device at it. Lastly *scanning* refers to the use of a wireless scanning method to discover nearby smart objects. These object are then listed on the mobile phone, and selecting on of them results in displaying its services. The analysis showed that the participants in their study preferred the *touching* technique, when they were close to objects. Especially older users preferred this interaction technique, since they wanted to avoid as much input on the mobile phone as possible. Furthermore, *touching* was regarded as the most secure one, the most natural and intuitive, error resistant, and quicker than *pointing* and *scanning*. The other two require more cognitive effort.

This fits well in our a shopping context, where customers are in fact standing close to products when they are browsing them in a store, and together with these other attributes, natural, error-resistant etc, makes it for a good incentive to chose this interaction technique as the main interaction for a shopping related application.

2.3 NFC operation modes

NFC has three communication modes. The first mode is called *Read/Write mode*, where a NFC device reads/writes data from a tag. This is similar to the way RFID works, where a RFID reader device is active and reads a passive RFID tag. In this mode, the NFC device acts as the initiator and the tag as a target. The second mode is called *Peer-to-Peer*, where two devices communicate and exchange data. It is similar to Bluetooth, except that instead of pairing two devices to work together, they can simply be brought close to each other to establish a connection. Lastly, the *Card Emulation* allows the NFC device to emulate a smart card, meaning that the NFC device itself acts as an NFC tag and appears to an external reader the same as a traditional smart card. For instance, the phone can behave as a payment card and be used to purchase goods and services.

2.4 Examples of NFC usage

These modes give rise to different examples where the capabilities of a NFC enabled mobile phone, can be utilised:

- Smart objects: NFC tags can be attached to physical objects such that users can pick up information stored in those tags. For instance a tag can store a product id, a phone number, an URL, etc. A typical use case might be where a user *touches* a smart poster, that has a tag containing an URL that points to the trailer for the movie. SmartTouch was a project in Finland, where the city Oulu had about 1500 tags installed in buses,

bus stops, the theater, a restaurant, and a pub, that could be read by a mobile phone. [?]

- Contactless payment: Due to the short range of communication, NFC technology is an ideal choice for secure transaction, since it is more immune to eavesdropping as well as interferences. Furthermore, man-in-the-middle attacks are not possible to perform [?]. Users can use NFC enabled mobile phones as digital wallets to make payments, the same way they do with their credit card. This type of functionality is already common in Asia, with Japan as the leading country [?]. MasterCard and Visa are both members of the NFC Forum, and both companies have been involved in projects that utilise NFC technology for payment, e.g., MasterCard's PayPass [?] and Visa's payWave [?].
- Transportation: NFC can be integrated in the public transport system, so users can pay for their tickets with their mobile phones, more commonly called e-ticketing. An example of this is the "Touch & Travel" project in Germany in 2008, where Deutsche Bahn, rail operator, had a pilot program where travelers used their mobile phones to *touch* a Touchpoint before entering the train. The passengers were billed once a month. [?]
- Health care: Patients can have NFC tags on their bed, so that the medical staff can quickly get information about the patient, such as what treatments the patient has had, what he is allergic to, etc. Elderly can use NFC-enabled devices to *touch* NFC tags on meal menus to easily select a meal in nursing homes. O2's Homecare system based on NFC is a pilot project, where home care workers can download patient records by *touching* NFC tags installed in the patients' home and patients can as well *touch* these tags to see when the next visit from their care worker is. [?]

These are some of the examples what NFC technology can be used for. For NFC to really take off and be integrated into our everyday lives, the proliferation needs to be more successive. The adaptation has been slow when compared to other technologies integrated into mobile phones, such as the camera.

2.5 Using technology to tag objects

The main contribution of previously mentioned smart objects comes from Want's et al. [?] work on using RFID tags to bridge the physical and virtual worlds. It is the precursor for much of the research involving tagging objects. By augmenting everyday objects with RFID tags, actions that are naturally associated with their form, could be initiated by simply scanning objects. These invisible interfaces as Want calls them, leverages objects of the physical world with the advantages of computational world. For example, by augmenting a book with an RFID tag, and later scanning it with a computational device, an associated virtual document is displayed. It can also be linked to an associated service, such that it is linked to the corresponding web site of an online book seller and is ready to be ordered. In their prototype they demonstrate the augmentation of books, documents, business cards, wrist watches, etc., to establish links to services.

So what about other technologies? Surely NFC is not the only way to tag objects. Bar codes and data matrix codes are another possibility, see figure 2.1. There exists applications for mobile phones that can read both of these codes by the use of the integrated camera. Bar codes have existed for a long time and have been used extensively in grocery stores. They are used to label many commercial products, however the size of these labels is constrained by the scanning technology. Tagging objects in post-process is harder with bar codes and data matrix codes than tagging them with NFC tags. It is also easier to tag objects with more curved shapes, than it is with bar codes and data matrix codes, since they require a flat surface. They also risk the danger of being cut and bar codes require holding the camera at a proper location and angle in order to get a correct scanning. NFC tags have no such requirement and they are more robust. They don't degrade over time and are more resistant to dust and dirt. Furthermore NFC tags have no line of sight requirement.

Figure 2.1: Bar code and data matrix code

Summary

This chapter has given insight into NFC and as such, we see NFC as a promising technology platform to be used in a *self-service shopping*. The card emulation mode, makes it possible to use the mobile phone as a digital wallet for purchasing products, which fits well in the shopping context. Furthermore, products in the store can be tagged with NFC compatible tags, and together with the NFC-enabled mobile phones, we can lay ground for a design of a mobile phone application that utilise NFC for *self-service shopping*. A scenario describing this usage will be given in a later chapter.

3
Field Study

This chapter gives an overview of the case and, furthermore, describes the field studies conducted. The field study of Harald Nyborg (HN) consists of a focus group and a set of customer interviews. Some of the reasoning in this chapter is inspired by *Research Methods* [**?**].

3.1 Case overview

For this project we have made arrangements with HN in Aalborg in order to use them as a case. The HN store is a department store that deals with a wide range of products such as tools, CD-players, kids toys and bicycles, see figure 3.1. The shopping practice in HN is *mixed shopping*, however, it is mainly *self-service shopping* which fits well for our purpose to use them as a case.

Figure 3.1: A Harald Nyborg store.

A sketch of how the inside of the store looks can be seen in figure 3.2. The rectangular boxes marked with an 'S' are shelves with products. Each shelf has an unique number in order to identify it in the store. The 'L' in the box near entrance is where the shopping lists for customers are placed and the box marked with a 'C' is the counter.

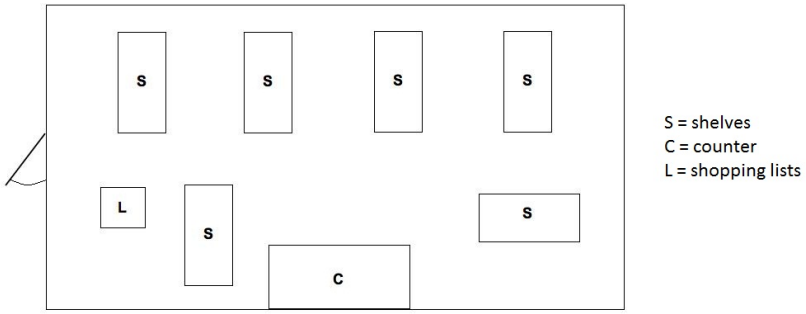

Figure 3.2: A sketch of the inside of a Harald Nyborg store.

Shopping process

The way customers shop in HN is that when they enter the store there is a stand with some shopping lists for the customers. The customers can take one of those shopping lists and use it when browsing the store. All the products in the store have an identification number that the costumers can note down on their shopping list along with the price of the product and the quantity they want. It is also possible to write down the name of the product. When the customer is done browsing she will go to the counter and hand in the shopping list to the one of the store clerks, who then will enter the information on a computer and then give the customer an order number. The storeroom staff then receive a printed list of the order and they then fetch the products on the list and return them to the store counter via a conveyor belt. Then one of the store clerks will check the order number of the returned order and place the order number on a big screen so the costumers know their order is ready for pick up.

We wanted to understand the shopping process at Harald Nyborg and the customers' experience in their natural habitat before designing the system and therefore we opted to have a direct discussion with concerned participants, which in our case were customers and employees. We chose to conduct interviews with the customers and convene a focus group with the employees.

3.2 Customer Interviews and Observations

The interviews were designed as semi-structured interviews. When doing an interview there can be a mismatch between what the interviewees say and what they actually do and therefore we combined the interviews with an observation to be able to filter out some of those situations. This method was chosen, in order to get in the field and observe pros and cons of the current shopping system used at Harald Nyborg, along with getting the customers' insights using a Think-Aloud protocol and interview questionnaires. The interview questionnaire can be seen in Appendix B. Picture 3.3 shows an interview in action. The picture contains two group members, one interviewer, one note-taker, and the customer, which can be seen in the background in blue overalls.

Figure 3.3: Observation of a customer in Harald Nyborg.

The goals for the interviews were as follows:

- At least three customers
- Preferably one young, one middle aged, and one old customer
- Preferably at least one of each gender
- At least one novice and one expert customer

We chose to do interviews because they provide the ability to go deep and get detailed responses from participants, but they also require conversational and observational skills, such as understanding non-verbal cues. These skills require practice and experience to develop. Another incentive for conducting interviews with the customers is, that we get closer to reality when the customers are in the store and are shopping.

Setting

The interviews took place in a Harald Nyborg store located in Skalborg, Aalborg. We set up close to the entrance in order to be visible to the customers.

Participants

All group members participated in the interviews. There were different roles during each interview; interviewer, audio recorder and note-taker. The note-taker was also responsible for taking pictures. The roles were switched in some interviews. Seven interviews were conducted with customers where two of the customers had little experience in shopping at Harald Nyborg and five customers with medium to high experience. The age span was 22-82 years, and the mean age was 46 years, $SD = 19.49$.

Materials

In order to gather data from the customers, paper sheets were used to write information about the customers and notes from the interviewer. A digital camera was used to take pictures and an audio recorder was used to record the audio during the interviews. Coffee and biscuits were also offered to the customers. All group members wore identical t-shirts that reflected that we came from Aalborg University to avoid any misinterpretations.

Procedure

The customer interview session was started by a small meeting with the store manager to let him know that we had arrived and to get his approval of setting up. Then we positioned ourselves close to the store entrance where coffee and biscuits were placed. We then proceeded to intercept incoming customers and ask if we could ask them a few questions. If the customers agreed then we would follow the customer around, observing him during shopping, taking notes and asking questions. After the interviews were completed we spent some time in the store observing customers and their shopping habits.

Data Collection

After the interviews were finished the data collected consisted of audio recordings of each interview, pictures of some of them, notes and information from each interview.

Data Analysis

The data collected was analysed by transcribing each interview and then analysing the transcription. The transcriptions were used to generate ideas for the product in question. Additionally, the notes and customer information was used for idea generation. These ideas were used to generate features for the system under development, discover possible user interactions problems and benefits and, finally, for writing use cases for the system.

3.2.1 Results

The yield of the customer interviews was primarily ideas for the product. We found out that the customers can be categorised; novice customers and expert customers. The novice customers can again be split into 2 sub categories. Some knew the current system at the store and others did not. The expert customers were customers that had great experience of using the current system. The goals that were set for the interviews were all fulfilled. We managed to get seven interviews with customers of various ages and gender. Of the seven people there were two novice customers and five expert customers.

These are the results we got from the interviews and observations:

Problems	**Novices** (2)	**Experts** (5)	**Observations**
1. The shopping list was hard hard to find	✓		✓
2. Customers did not know what the shopping list was for	✓		
3. Products were difficult to find	✓		✓
4. Shopping list was prepared from home		✓	
5. Most customers were men			✓
6. Customers browsed a lot			✓
7. Customers waited approximately 10 minutes while the orders were being processed			✓
8. The average age was high			✓
9. Customers did not have smartphones	✓	✓	

Table 3.1: Results of customer interviews.

1. Both novice customers experienced the problem.

2. Only one of the novice costumers did not know what the shopping list was for.

3. Both novice costumers had problems with finding the products they were looking for. Furthermore, we observed several customers having problems finding products.

4. Three of the five expert costumers had a shopping list prepared from home and the two other knew what products they wanted as well as where they were located.

5. We observed that the majority of customers in the store, at all times, were men.

6. We observed that several customers were browsing the store without buying any products

9. None of the interviewees had smartphones and one of the expert customers did not have a mobile phone.

As seen in table 3.1, the results are divided into novices, experts and observations. The novices and experts results are the results we got from the transcriptions of the interviews, while the observations were what we observed in general at the store as well as while doing the interviews.

3.3 Focus group

Before starting the idea generation for the project, we wanted to have a focus group together with the employees at Harald Nyborg. The focus group was set up together with our contact person at Harald Nyborg. The focus group was needed in order for us to understand the needs, frustrations and concerns the employees might have and what they think the customers might have. Also to ask them, what they would like to able to do, regardless of the limitations of the current technology. Before the focus group, we made an agenda, that can be seen in Appendix C, which contained a list of questions.
The goals of the focus group were as follows:

- Focus group should consist of at least four employees.
- Focus group should consist of employees with experience from the shop counter and employees with experience from stockroom.
- Discover possible problems with the current system.
- To get the employees to generate ideas.

Setting

The focus group took place at the employee canteen in Harald Nyborg, see figure 3.4 The date and time was found through our contact person, which also is the manager of Harald Nyborg in Aalborg. The focus group was held with one person recording audio and taking notes and one interviewer.

Figure 3.4: Focus group with employees of Harald Nyborg.

Participants

The focus group consisted of 2 members of our project group and 10 people from Harald Nyborg, including our contact person. We were lucky to be able to get every person in the store as the focus group was held on a Friday, which

is when most employees are at work, before opening time. However this meant that the focus group was held during their morning break and we only had 25 minutes to complete it. This, in turn, meant that people were relaxing and eating breakfast during the focus group and thus might not be very focused on the focus group as they could have been.

Materials

During the focus group an audio recorder, a digital camera as well as small questionnaires were used to gather data. Furthermore, an agenda was used to keep the focus group on track.

Procedure

The focus group was handled with one group member being the focus group interviewer and the other member recording the audio, taking notes and finally taking pictures of the event. First an introduction to our project was given to help the participants understand what our aim was. Then a brief explanation of how the focus group was going to be held was given. Finally, the actual focus group event started by going through our agenda and asking questions. The focus group was held semi- structured which meant that some questions were asked which were thought of during the focus group. The entire focus group was audio recorded and the transcription can be seen in Appendix D.

Data Collection

After the focus group was held we had gathered the data we wanted and this data consisted of audio recording of the entire focus group and some notes and a few pictures. Most of the employees were very quiet and hard to get to speak and only two people were talkative. Although most were very quiet we got responses from all employees at some point.

Data Analysis

Shortly after the focus group was held, a brief resume was written according to our memory of the event. The audio recording was transcribed to ease the analysis of the data. The transcription was analysed and key elements were extracted from the text. These key elements consist of data useful for generating features for the system. Information such as the problems they have with interpreting the customers' handwriting, mistypings and such was important data we extracted. We also learned that the customers' average age is quite high, which also means that the system we want to develop should take that into account. We also learned that many customers have problems using the shopping list and although this might be related to the customers' average age we still need to take this into account as this might imply that Harald Nyborg customers' can have problems learning how to adopt new technology. Another thing we learned was that the different views of the mobile application should not contain too much data as this might confuse the customers.

3.3.1 Results

The goals for the focus group were all fulfilled. We wanted at least 4 employees with both experience from the shop counter and the storeroom. We got 10 people with experience from all areas of Harald Nyborg. We succeeded in getting the employees in generating ideas for the future system, although they did not generate as many ideas as we had hoped for.

Problems experienced	**By employees**	**By customers**
Shopping list was hard to find		✓
Purpose of shopping list was sometimes unknown		✓
Mistyping the product number	✓	✓
Unreadable handwriting on the shopping list	✓	
Most customers were men		✓
Products were hard to find		✓
Average customer age was high	✓	✓

Table 3.2: Problems experienced by employees.

Table 3.2 is divided into customers and employees, where the customers section is problems existing on the customer side of the shopping process and the employees section is of course problems existing on the employee side. Furthermore, The store manager at Harald Nyborg stated that they are trying to make the store more attractive for a younger audience.

3.4 Reflection on our field study

We had set goals for both the focus group and the interviews and all of these goals were reached. The interviews helped us to understand customers needs and find out if there were any frustrations with current practices. The questions asked were high-level questions so we could find out if there was something the customers would like to do, that they currently are not able to do. Before deciding to conduct interviews, it was obvious to us, that novice customers might have different perspective from expert customers. That is the reason we set the goal to include representatives from both groups, since it would provide a more complete picture of the situation.

The decision to make our interviews semi-structured instead of fully-structured is because, it enables us to dig deeper into interviewees comments and thus achieve both breath and depth. These comments can also lead to questions we have not thought of or overlooked. This flexibility is harder to achieve with fully-structured interviews which follow a rigid script.

One of the weaknesses with our interviews was that we only had a low number of interviewees. With more interviewees we could have gotten a better overview of the severity of the found problems and discovered other problems as well. Another problem was that the interviewers were inexperienced in interviewing and therefore it was difficult to be consistent in flow and performance in the interviews.

For the focus group, the main yield was the problems that the staff at HN have experienced and what they have noticed that the customers have experienced. Focus group suffered from silence and it was hard to get some employees to talk. Interpreting silence is hard, since it can depend on many factors. It can be that the interest in the topic is lacking. There is also the possibility that the participants can be intimidated by their colleagues and thus it is harder to criticise the current system if your boss is sitting next to you. Participants might simply just be bored or even tired. It can also be that our timing was not the best, since it was held during the breakfast, or maybe the focus group was to large.

It is hard to say if we could have gotten a more in-depth conversation if there were fewer participants. Maybe we should have convened the focus groups with five participants and held several sessions as Kruger recommends [**?**, Chp. 8, p. 192]. However, the results we got from the focus group session were more valuable than the results from the interviews, since it raised more ideas for the system and highlighted issues we did not think of, such as employees mistyping product numbers. All in all we think that the focus group session was more successful than the interviews. Even though the data from the session had lower quantity than the interviews, the quality of the data was better.

4
System Design

Based on the results and insights from the previous chapter, the design choices for the system under development are described in this chapter. We have chosen Emptio as the name for the system under development. This inspiration comes from Latin, where the word *emptio* means; buying or a purchase. A description on each of the elements used in designing Emptio, is given. These elements consist of a class diagram, sequence diagram, an overall use diagram, use case specifications, and state chart diagrams. Additionally, this chapter describes the purchasing process with Emptio compared to the current purchasing process.

4.1 Purchasing Scenario

This section describes a scenario of a customer that uses Emptio to shop in a Harald Nyborg (HN) store. The scenario is as follows:

> *A customer enters a HN store and starts browsing around the store. The customer wants to find and read the description of a product he is interested in. He holds his NFC-enabled mobile phone close to a product's tag and the information, e.g., a picture and some descriptive text, for that product is then displayed on his mobile phone. He presses on the button for purchase, and this adds the product to the virtual order list on his mobile phone. Later on, the customer wants to find the physical location of a product in the store. This is achieved by searching for a product in the catalogue on the mobile phone and selecting a product. After finding all desired products the customer chooses to checkout on the application. Upon completing the payment, he is given a queue number. When his queue number is displayed on the screen at the counter, the customer can pick up the items and the purchase is completed.*

This scenario was used to illustrate a typical purchase with Emptio, and it can be seen that it resembles the current purchasing process. It just happens on a mobile phone instead of the customer having to manually write the product numbers down on to a piece of paper. An illustration of the purchasing process can be seen in figure 4.1.

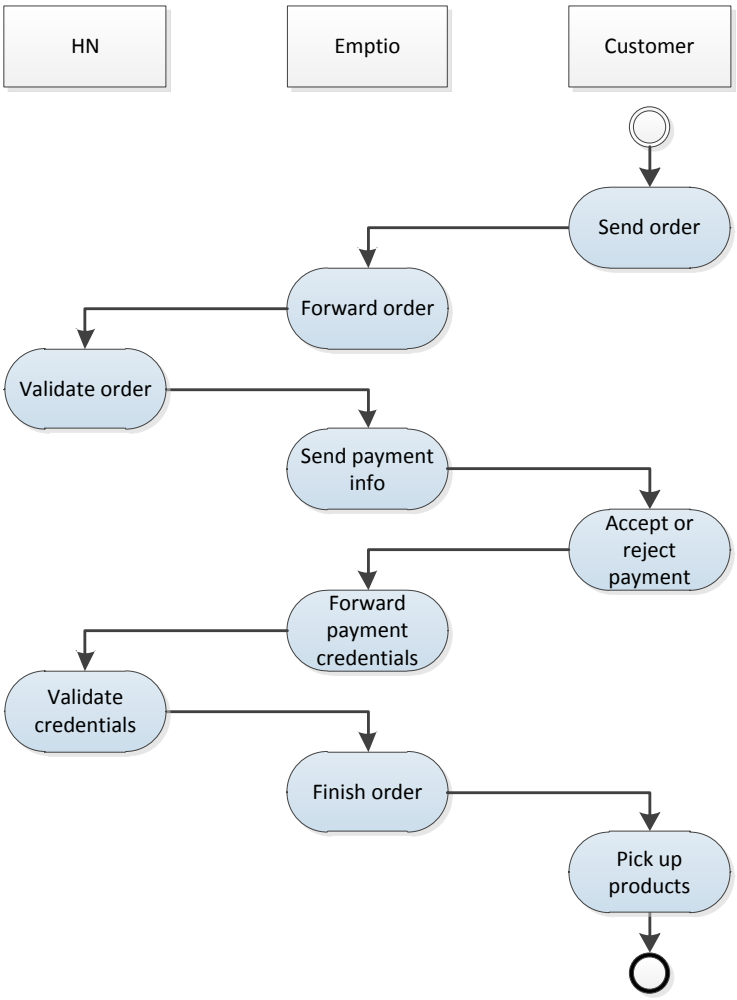

Figure 4.1: The purchasing process.

4.2 User Requirements

This section describes the use cases and the user requirements of Emptio.

4.2.1 Use Cases

Use cases are used to describe a system's behavior as it responds from requests from different stakeholders. The primary actor is the stakeholder who or which initiates an interaction with the system in order to achieve a goal. An actor is a person or another system with a behavior. The system responds to the requests and helps to fulfill the primary actor's goal. A team can use them as a communication device to discuss the upcoming system. Use cases can be used to describe business processes but often they are used to document the behavioral requirements for an application. They simply tell how the system will behave in use.

The use case form used in this report is adopted from Alistair Cockburn and modified slightly. First of all a use case has a *name* and a *number*, so it is easier to refer to them. A *primary actor* is the one having a *goal* to accomplish, and which the system will support. The *scope* identifies the system that we are discussing about, and *level* describes the level that the use case is written to and it can be on of these; summary, user goal, or sub-function. The *preconditions* is what must be satisfied before the use case runs. The *trigger* is an event that starts the use case. The *description* part contains the main scenario in which an actor goes though some action steps and achieves a result where nothing goes wrong. The *extensions* part describes what can fail during different steps in the main scenario. The *sub-variation* part shows alternative steps or flow an actor can take to accomplish his goal.

The overall use case diagram is presented in UML in figure 4.2. The primary actor is the customer in all four use cases depicted in the figure. The following pages contain detailed use case specifications for all the four use cases, and describes the behaviour of the system as the primary actor interacts with it. The use cases specifications are supplemented with state chart diagrams for a visual illustration.

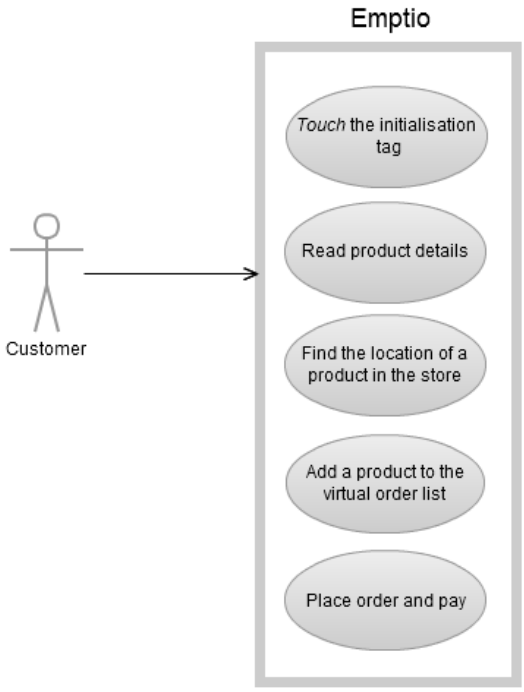

Figure 4.2: Overall use case diagram

Touch the initialisation tag

The state chart diagram for the first use case from figure 4.2 is depicted in figure 4.3. This use case describes what happens when a customer *touches* the initialisation tag. A detailed description can be seen in table 4.1.

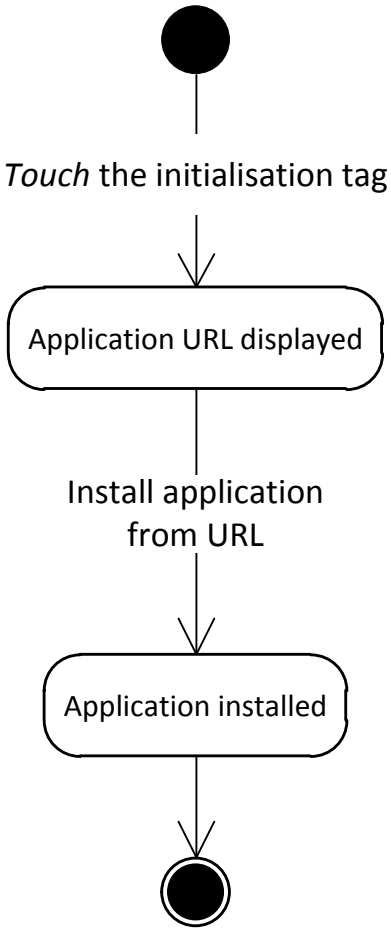

Figure 4.3: State chart diagram for Touch the initialisation tag.

Use Case: 1	***Touch* the initialisation tag.**	
Goal in context	Use the initialisation tag.	
Scope & Level	Emptio, User Goal	
Preconditions	Customer is in the store and has a mobile phone.	
Success End Condition	The customer has *touched* the initialisation tag and the application is downloaded and installed on the mobile phone.	
Failed End Condition	The download and installation of the application has failed.	
Primary, Secondary Actors	Customer	
Trigger	Customer *touched* the initialisation tag with an NFC-enabled mobile phone.	
Description	**Step**	**Action**
	1	Customer's mobile phone opens a URL received from the initialisation tag.
	2	Customer installs the application on the mobile phone.
Extensions	**Step**	**Branching Action**
	1a	Initialisation tag contains the wrong URL.
	1b	The URL points to the correct link but there is no connection to the server.
	2	Customer is unable to install the application.
Performance	*Touching* the initialisation tag and receiving the URL should not take more than 3 seconds.	

Table 4.1: Touch the initialisation tag.

Read product details

The state chart diagram for the second use case from figure 4.2 is depicted in figure 4.4. This use case describes what happens when a customer wants to see the information for a product. A detailed description can be seen in table 4.2.

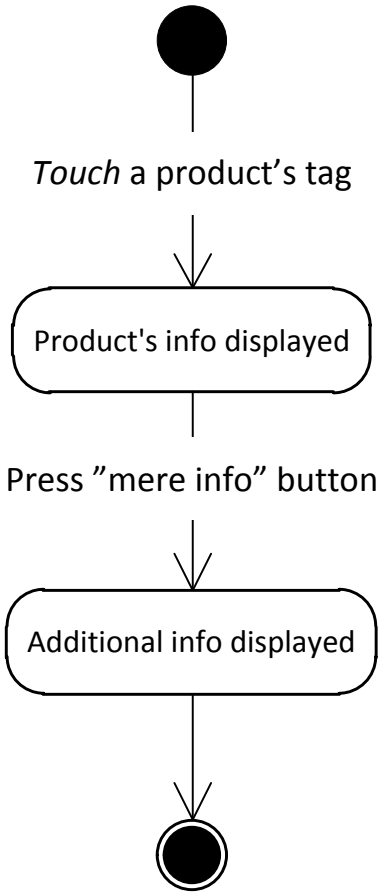

Figure 4.4: State chart diagram for `Read product details`.

Use Case: 2	**Read product details**	
Goal in context	Find and read a product's description.	
Scope & Level	Emptio, User Goal	
Preconditions	Emptio is running and a connection is established to HN's system.	
Success End Condition	The customer has read the desired product's description.	
Failed End Condition	The product's description can not be read.	
Primary, Secondary Actors	Customer	
Trigger	Customer holds an NFC-enabled mobile phone close to a product's tag.	
Description	**Step**	**Action**
	1	Upon identifying a product, the customer is presented with a view that shows basic information for that product.
	2	Customer presses the "More info" button to reveal more details about the product.
	3	The details are then displayed under the basic description.
	4	Customer can now read this extra information.
Extensions	**Step**	**Branching Action**
	1a	Customer is not aware of where the product's tag is.
	1b	Customer is not able to get a successful reading of a product's tag.
	2a	Customer can not see the "More info" button.
	2b	Pressing the "More info" button does not reveal extra info.
	4a	The content is not presented clearly and is cluttered.
Subvariations		**Branching Action**
	1	Customer can also select a product from the catalog.
Performance	Identifying a product and displaying the information for that product should not take more than 3 seconds.	
Open Issues	How to provide the option to compare similar products?	
	How to generate a list of related products?	

Table 4.2: Read product details.

Find the location of a product in the store

The third use case from figure 4.2 describes what happens when a customer wants to find the physical location in the store for a product he is interested in. This can be seen in the state chart diagram in figure 4.5, and a detailed description is in table 4.3.

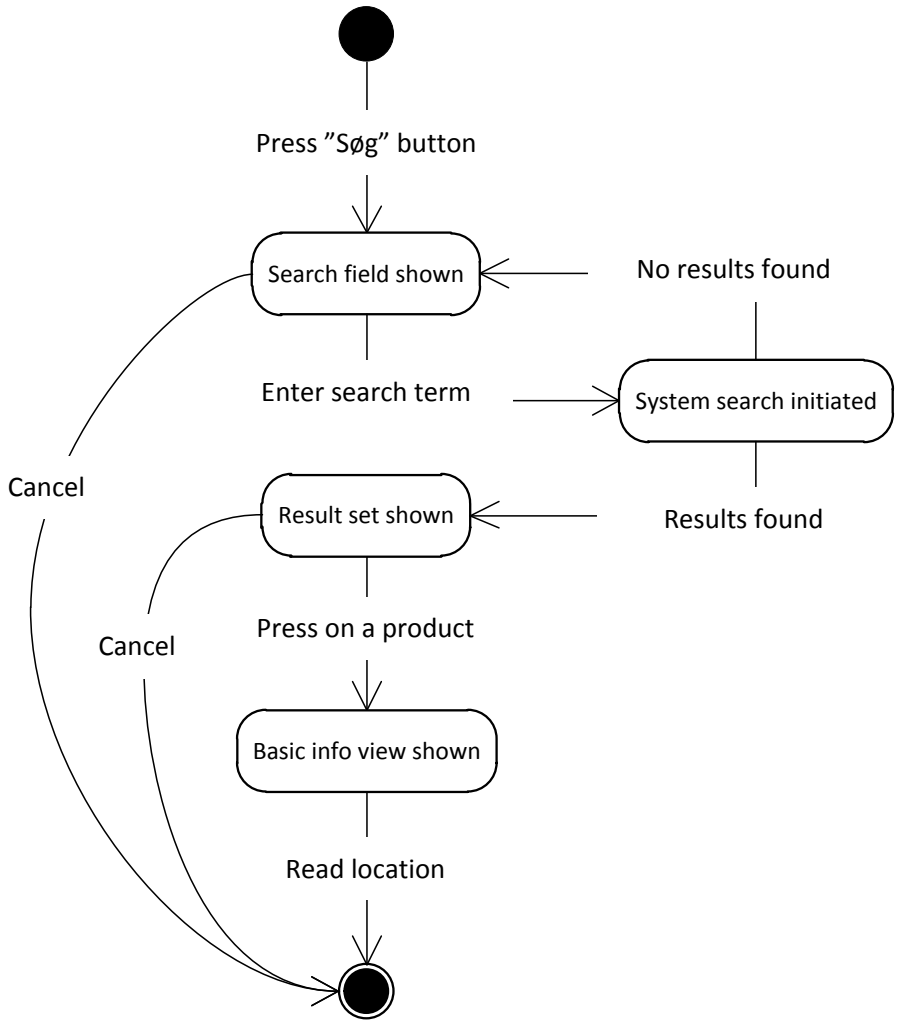

Figure 4.5: State chart diagram for `Find the location of a product in the store.`

Use Case: 3	**Find the location of a product in the store.**	
Goal in context	Help the customer find the location of the product in the store.	
Scope & Level	Emptio, User Goal	
Preconditions	Emptio is running and a connection is established to HN's system. Emptio has a catalogue of the products.	
Success End Condition	The product's location is displayed on the mobile phone.	
Failed End Condition	The location of the product is not shown to the customer.	
Primary, Secondary Actors	Customer	
Trigger	Customer wants to find a product.	
Description	**Step**	**Action**
	1	Customer presses the "Søg" button.
	2	The customer enters the search word.
	3	Emptio searches in its catalogue and displays a list of results.
	4	The customer selects a product from the result list.
	5	The location of the product is shown to the customer.
Extensions	**Step**	**Branching Action**
	1a	Customer can not find the "Søg" button.
	2a	The customer might misspell the search word.
	3a	Emptio might return an empty result set.
	3b	Emptio might falsely return a result set without the wanted product.
	4a	The customer might choose the wrong product.
	5a	The location of the product might be incorrect.
Subvariations		**Branching Action**
	1	Customer can also find a product's location by browsing the catalogue.
Performance	Searching should not take more than 5 seconds.	
Open Issues	What if the location is outdated?	

Table 4.3: Find the location of a product in the store.

Add a product to the virtual order list

For the forth use case from figure 4.2 the state chart diagram in figure 4.6 shows the interaction when a customer decides to add a product to his virtual order list on the mobile phone. Description for this use case is in table 4.4.

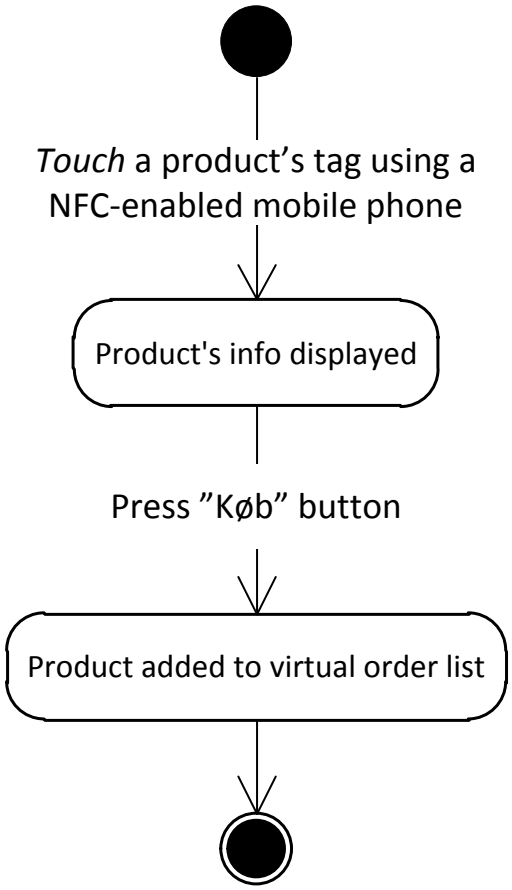

Figure 4.6: State chart diagram for `Add a product to the virtual order list`.

Use Case: 4	**Add a product to the virtual order list**	
Goal in context	A customer wants to add some products to the virtual order list.	
Scope & Level	Emptio, User Goal	
Preconditions	Emptio is running and a connection is established to HN's system.	
Success End Condition	The product is in the virtual order list.	
Failed End Condition	The product can not be added to the virtual order list.	
Primary, Secondary Actors	Customer	
Trigger	Customer *touches* the product's tag with a mobile phone	
Description	**Step**	**Action**
	1	Upon *touching* the product's tag, the customer is presented with a view that shows basic information for that product.
	2	Customer presses the "Køb" button.
	3	The chosen product is than added to the virtual order list on the mobile phone.
	4	Customer is presented with a view that shows the content of the virtual order list.
Extensions	**Step**	**Branching Action**
	1a	Customer is not aware of where the product's tag is.
	1b	Customer is not able to get a successful reading of a product's tag.
	2a	The "Køb" button is not easy to spot.
	3a	No feedback provided when adding a product to the virtual order list.
	4a	The content of the virtual order list does not match what customer has added.
Subvariations		**Branching Action**
	1	Customer can also add a product to the virtual order list by manually entering a product id.
	2	When browsing the product catalog, customer can also add a product to the virtual order list by selecting a product in the catalog.
Performance	Identifying a product and displaying the information for that product should not take more than 3 seconds.	
Open Issues	How to provide the option to change the quantity of products?	

Table 4.4: Add a product to the virtual order list.

Place order and pay

The state diagram 4.7 for the last use case from figure 4.2 describes what happens when a customer decides to checkout. A more detailed description is in table 4.5.

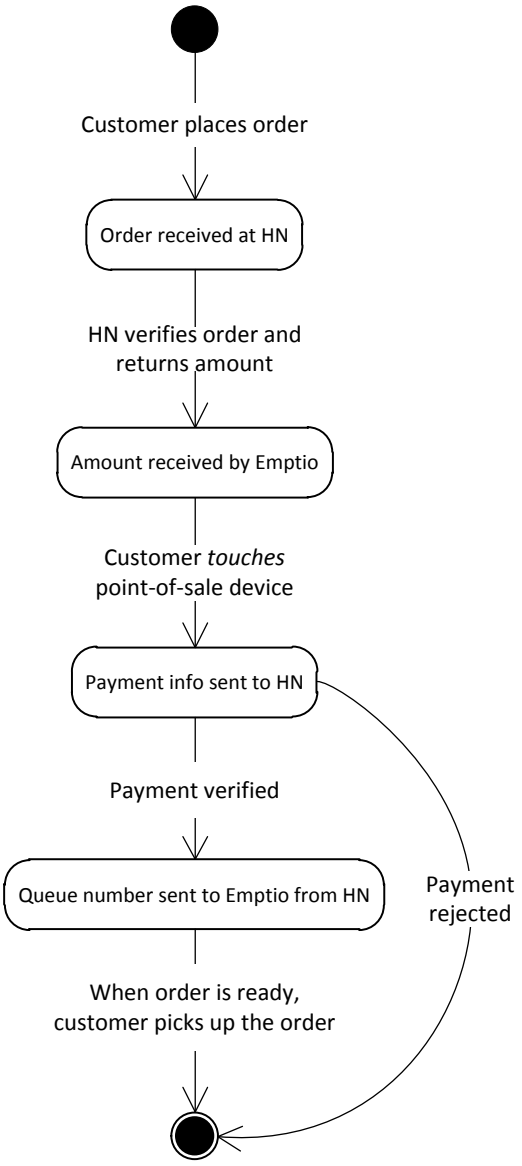

Figure 4.7: State chart diagram for `Place order and pay`.

Use Case: 5	**Place order and pay**	
Goal in context	A customer wants to place an order and pay.	
Scope & Level	Emptio, User Goal	
Preconditions	Emptio is running and the connection to the HN's system is established. The customer's virtual order list is not empty.	
Success End Condition	Customer's order got placed and payment was successful.	
Failed End Condition	Customer's order did not get placed or payment failed.	
Primary, Secondary Actors	Customer	
Trigger	Customer decides to check-out.	
Description	**Step**	**Action**
	1	Customer sends the order from Emptio to HN's system.
	2	HN's system receives order, calculates amount, and finally sends the amount info to Emptio.
	3	Emptio receives the amount and customer pays.
	4	Payment is verified in HN's system.
	5	A queue number is generated in HN's system and sent to Emptio.
	6	The number in the queue is shown on a screen behind the counter when the order is ready for pickup.
	7	Customer walks to the counter and picks up his order.
Extensions	**Step**	**Branching Action**
	1a	Customer tries to send an empty virtual order list.
	2a	Order is not received in HN's system or not all data is received.
	3a	The amount is not received by Emptio.
	4a	The payment is not successful.
	5a	The queue number is not received by Emptio.
Performance	N/A	
Open Issues	How do we ensure, that all data is sent? Can credit card emulation be implemented properly?	

Table 4.5: Place order and pay.

4.2.2 Features

This section covers the features set for the system. The features are divided into *Core* and *Additional*. The *Core* features are the minimal features the system must have in order to function. The *Additional* features are not vital for the system, but make it more enjoyable and generally improve the system. The feature categories also function as a priority as the *Core* features should be added to the system before the *Additional* features.
The features stated in this section are the results of the previous chapter.

Core features

- *Touch* a product in the store to see basic info for a product.
- add product to the virtual order list.
- remove product from the virtual order list.
- change quantity of a product in the virtual order list.
- place order and pay.

Additional features

- a stock status for a product.
- if a product has additional info available, such as power consumption, size, etc., the customer should be able to see it.
- if a product has some related products, they should be displayed (e.g. buying a wall socket, do you have cable, screws etc.).
- a catalogue of the products should be available on the mobile phone, so the user can search for a product by entering e.g. a product's name, or just flick through the pages.
- add products from the catalogue to a virtual order list on the mobile phone before coming to store.
- add products by manually entering the product number.
- show queue number when order has been placed.
- a history of purchases.
- provide a help window that explains how the application is used

4.3 Technical Requirements

This section explains the technical requirements for Emptio, which includes the class diagram and quality goals.

4.3.1 Overview of Emptio

This section gives an overview of Emptio and external systems it interacts with. Figure 4.8 shows overview of the organisation, including Emptio, Harald Nyborg's internal system and the payment system it interacts with.

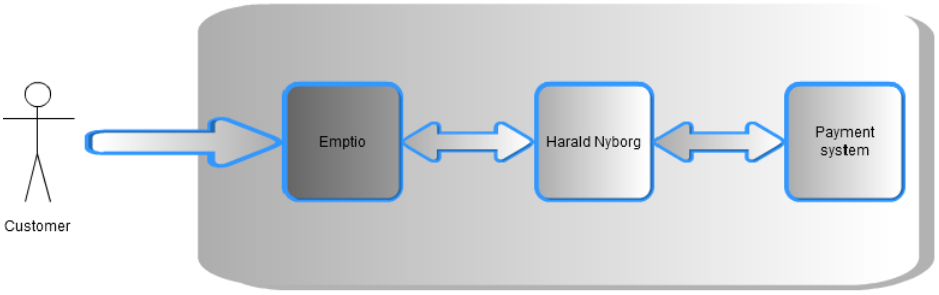

Figure 4.8: Overview of the organisation. Emptio is shaded, meaning that it is the system under development.

Emptio is used directly by the customers. From Emptio there is an interaction with HN's system, where the arrow means, that customers sends information such as payment credentials and the contents of the virtual order list to HN's internal system. From HN's internal system, Emptio receives information such as payment status, a queue number, and stock availability. Lastly, HN sends payment information to the payment system, which then sends a payment status back to HN. In order to provide an NFC-based service, HN's internal system needs to be expanded to provide some back-end services, which it currently does not have. However, since this project is a proof-of-concept, we will not design and implement a back-end system, but rather simulate its services. Furthermore, we do not have access to Harald Nyborg's internal system and are thus not allowed to extend it.

4.3.2 Class Diagram

This section gives an overview of the class diagram that will be used in the application, see figure 4.9. A description of the classes and their relations is given.

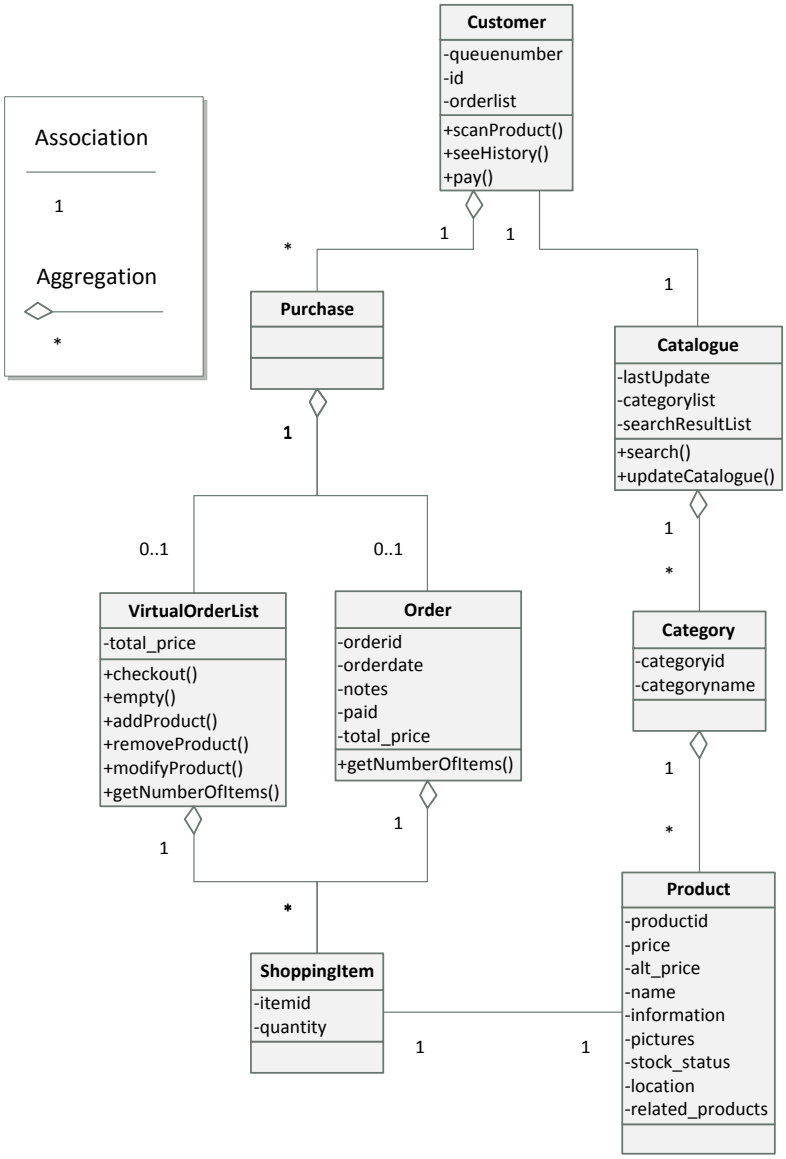

Figure 4.9: Class diagram for Emptio.

First of all we have made a choice to have a catalogue that contains all products in the store. This class will be a singleton, and thus it deploys the *Singleton* pattern [**?**], since only one catalogue object will exist at run-time. Furthermore, this catalogue will have a number of different categories. This class will be responsible for searching products, and so it is convenient that only one object is performing the search of all the products in the store. In order to be up to date, there will be a method to update the catalogue to the latest revision. The `Category` class will represent categories like Tools, House and Garden, Dishwashers, Housekeeping, etc., and will contain all the products of a certain category. For instance, a hammer will be under the Tools category. Due to this

composition, we have made use of the `Hierarchy` pattern [?], which is used to organise objects in different levels. At the top level the `Catalogue` class *has a* `Category`, which in turn *has a* `Product`.

The `Purchase` class and its sub parts are used to model a purchase. A purchase is modeled as first being a virtual order list, then it becomes an order. We have chosen to use the *Sequential Role Pattern* [?], in order to indicate that a purchase goes through several roles. In other words, a purchase can only be in one role; either in the role of a `VirtualOrderList` or an `Order`. The state chart diagram for the `Purchase` class describes its behaviour and can be seen in figure 4.10. A `VirtualOrderList` object gets created when a product is added to it. When the customer's payment succeeds an `Order` object is created. The information contained in the object can then be stored on the mobile phone for future reference by the customer. When the purchase is completed the `Purchase` and its sub parts; `VirtualOrderList` and `Order` objects are closed. The customer can cancel the purchase any time.

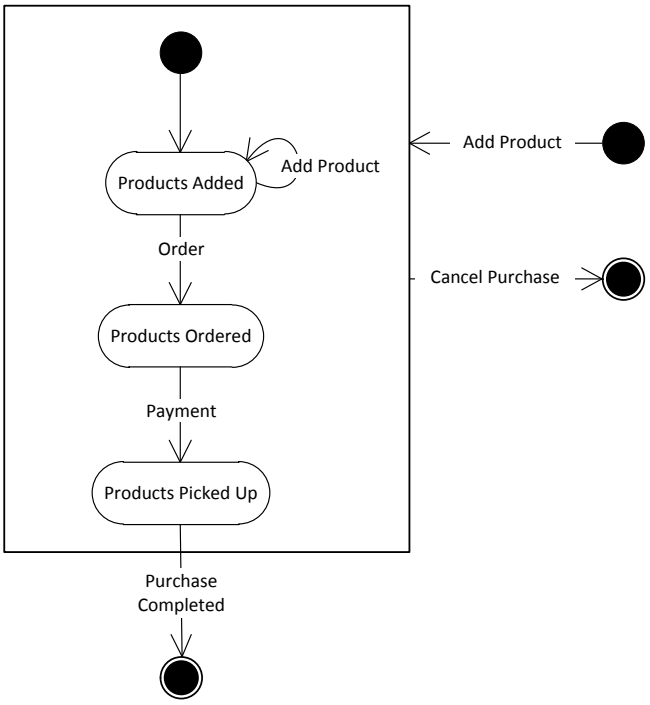

Figure 4.10: State chart diagram for the `Purchase` *class.*

`Catalogue` **class:** The `Catalogue` class contains all the products on the store. It has a categorylist which contains all the `Category` objects and it has a `Search` method which is used to return a set of `Product` objects which contain the search term. The `search` method uses the list of `Category` objects to find the `Product` objects.

`VirtualOrderList` **class:** The `VirtualOrderList` class represents the virtual virtual order list and is used to enable the customer to add products to the virtual order list in the mobile phone. It contains a list of `ShoppingItem` objects, which contain an item id, quantity and a `Product` object. Also the `VirtualOrderList` class contains some methods to maintain the virtual order list, i.e., to remove, add, modify and empty the virtual order list.

`Order` **class:** The `Order` class is used to represent the finalised purchase. It contains all relevant information available after a purchase, i.e., an order date, any possible notes, a paid flag and a list of `ShoppingItem` objects. This is then stored persistently for future references.

4.3.3 Quality Goals

This section describes the quality goals for the system under development. The quality goals can be seen in table 4.6. The quality goals used in this report can be further studied in the OOA&D book[**?**, s. 174].

Criterion	*Very important*	*Important*	*Less important*	*Irrelevant*	*Easily fulfilled*
Usable		✓			
Secure	✓				
Efficient			✓		
Correct			✓		
Reliable	✓				
Maintainable		✓			
Testable		✓			
Flexible			✓		
Comprehensible			✓		
Reusable				✓	
Portable				✓	
Interoperable				✓	

Table 4.6: Quality goals table.

Usable: *The system's adaptability to the organisational, work-related, and technical contexts.* It should be intuitive to use for people who know how to use smartphones, and thus it is rated *Important*. We aim to make it as easy to use as the current shopping list.

Secure: *The precautions against unauthorized access to data and facilities.* Since the system will handle payments and sensitive data from the customers it has been rated *Very Important*.

Efficient: *The economical exploitation of the technical platform's facilities.* Efficiency has been rated *Less Important* as the application will not require any major computations or send or receive large amounts of data.

Correct: *The fulfillment of requirements.* Correctness has been rated *Less Important* since we have a limited development time and we have chosen to focus more on making the application usable and reliable.

Reliable: *The fulfillment of the required precision in function execution.* The precision of the function execution is deemed *Very important* in order to be able to fully test the system, e.g., when a customer *touches* a tag the correct product should be shown on the mobile phone. Total price must be calculated correctly and discounts should be handled correctly.

Maintainable: *The cost of locating and fixing system defects.* Maintainability has been deemed *Important* because it is intertwined with the testable criteria, which we have set to important. Therefore, we strive to get low coupling.

Testable: *The cost of ensuring that the deployed system performs its intended functions.* Since we focus on reliability, making the system testable is deemed *Important*. In order to be sure that the system is reliable, we need to test that it is not inreliable.

Flexible: *The cost of modifying the deployed system.* This is rated as *Less important* since we are focusing on making the system only for Harald Nyborg and not any other stores.

Comprehensible: *The effort needed to obtain a coherent understanding of the system.* Comprehensibility is not to be neglected, however it is still rated *Less important* as we are only three developers on the system and it will not be transferred to another development team.

Reusable: *The potential for using system parts in other related systems.* Reusability is considered *Irrelevant* as this system will only be developed for one platform at a time. There is no standard for targeting multiple platforms at a time.

Portable: *The cost of moving the system to another technical platform.* At the current state, there are no plans of making the system available to other technical platforms and portability has therefore been rated *Irrelevant*.

Interoperable: *The cost of coupling the system to other systems.* As mentioned earlier, this system is to be used with the existing system at HN and it is not meant to work with other systems and therefore interoperability has been rated *Irrelevant*.

5 Implementation

In this chapter we give our thoughts on how we see this proof-of-concept implemented on a mobile platform. During this chapter we look at the current state of mobile phones and their capabilities and which development tools should be used for the development.

5.1 Platform

In the consideration of platform for mobile development there are several major players to take into consideration: iOS, Windows Phone 7, Android and Symbian OS. Additionally, there exists a framework that targets multiple platforms called ELIPS [**?**]. This framework can be used to generate native code for Windows Phone/Mobile, Symbian OS, Android, and iOS amongst others. ELIPS supports features such as making voice calls, accessing the mobile phone's address book, sending SMS and taking pictures with the camera, however it does not currently support NFC and therefore is not applicable. However, if ELIPS were to support NFC in the future it would be a wise choice of development framework because it provides a single toolkit that targets multiple contemporary platforms.

Because our application is a proof-of-concept and we have rated portability as irrelevant in the quality goals section, we have chosen only to develop for a single platform. This means that we can focus on implementing more functionality on one platform instead of implementing less functionality on multiple platforms. To our knowledge, Android is the only platform on which NFC has been announced to be natively supported, from version 2.3. Other platforms will probably follow soon, however, since it has not been announced yet, we have chosen to develop for Android. Additionally, the first NFC enabled smartphones that have already been announced all run on Android, e.g., the Google Nexus S (Android 2.3).

5.2 Development for Android

The recommended way of developing applications for Android is to use the Eclipse IDE [?] with the Android Development Tools (ADT) plugin installed. This plugin adds powerful features related to Android development to the already powerful IDE Eclipse. The ADT adds a *New Android Project* to the Wizard which helps the developer to start up at new project at it practically creates a new project ready to be compiled to an application which can be run on Android straight away.

Furthermore, the ADT adds the possibility to emulate real world devices, such as a mobile phone running Android OS. This gives us the opportunity to test the application while developing and thus making the development more efficient.

Choice of Programming Language

The Android platform offers the developer a lot of languages to develop applications in. These include Java, C#, C++, Ruby and many others. However, Java is the most popular programming language for Android, partly because it is an older, yet powerful language with many existing libraries and is also the best supported language for Android. Based on this we will develop the application using the Java language. This will give us the opportunity to find many resources such as code samples and documentation.

6 Conclusion

First, we conclude on the three research questions raised in the introduction and present the solutions for the problems found. Afterwards, the entire report is concluded upon and, finally, the limitations of the project are presented and discussed.

The first research question from the introduction chapter was:

> **Is NFC an appropriate technology for *self-service shopping*?**

In chapter 2 on page 5 NFC was compared to other technologies, such as RFID, Bluetooth, Infrared, bar codes and data matrices. In this comparison we found some strengths and weaknesses of NFC:

Strengths

- It is easy to use because no setup is required.
- It can be used as digital wallet.
- It is not possible to perform man-in-the-middle attacks.
- It is hard to eavesdrop.
- NFC interaction is similar to bar codes and data matrices.

One of the most important things for NFC to be an appropriate technology is that it can be used as a digital wallet, which enables a user to pay with the same device used for shopping, making the mobile phone an all-in-one device, which means that the whole shopping process can be handled from the mobile phone.

NFC interaction is done by *touching* a product with a NFC enabled device and this interaction is very similar to scanning a bar code with a bar code reader.

Weaknesses

- Although it is difficult to eavesdrop, it is not possible to guarantee an eavesdrop-free communication.
- NFC does not offer encryption possibilities.
- NFC has not seen high proliferation in this part of the world.

Although it is hard to eavesdrop it is not possible to guarantee that data can not be intercepted. However, the eavesdropper has to get within the range of the NFC chip, which is low, in order to eavesdrop.

The NFC chip does not offer any form of encryption of the data. However the data can be encrypted by the device that contains the NFC chip before the NFC chip sends the data.

The second research question from the introduction chapter was:

> **Are there problems in some areas of *self-service shopping***

In order to find problems in the existing purchasing process, we conducted a field study, as seen in 3 on page 10, which consisted of customer interviews and an employee focus group. The problems which were found are listed below. The number of participants was seven (n = 7) and the number in parenthesis for each item below shows how many of the seven participants experienced the problem.

- Some of the customers found the shopping list hard to find. (2)
- Similarly, some customers found the products hard to locate. (2)
- The purpose of the shopping list was unclear to some customers. (1)
- Some customers prepared the shopping list from home. (3)
- Some employees experienced that customers had mistyped product numbers.
- Employees experienced that they occasionally mistyped product numbers into the system.
- Employees could not always read the customers handwriting on the shopping list.
- Customers average age was high.
- Most customers were men.
- Customers browsed the store a lot.
- Customers waited approximately 10 minutes while the orders were being processed.
- Customers did not have smartphones. (7)

The third research question from the introduction chapter was:

> **Can we design a mobile phone application that addresses the discovered problems of *self-service shopping*?**

During the design phase of the project we have tried to address the problems found in the previous research question. Although many problems were addressed and we found possible solutions for them, some of the problems can not be solved with NFC and mobile technologies or were out of scope. These problems are as follows:

- Customers average age was high.
- Most customers were men.
- Customers did not have smartphones.
- Customers browsed the store a lot.

The problems that were addressed successfully are as follows:

Some of the customers found the shopping list hard to find This problem is automatically solved with a mobile application as the shopping list always is in the customer's hand, given that the customer carries the mobile phone.

Some customers found the products hard to locate By using the virtual catalogue, the customers are able to lookup the location of the products in the store. An alternative solution would be to use indoor positioning of products.

The purpose of the shopping list was unclear to some customers This problem is also automatically solved as with the mobile phone, the physical shopping list is not required anymore. However, this might create a new problem in that some customers do not know how to use the virtual order list. This can then be solved with some help functionality on the mobile phone.

Some customers prepared the shopping list from home By having a virtual catalogue of all the available products on the mobile phone, the customers are able to add products from the catalogue to the virtual shopping list from anywhere in the world.

Some employees experienced that customers had mistyped product numbers The problem is eliminated since the product number is not manually typed by the customer, but instead is read from the NFC tag.

Employees experienced that they occasionally mistyped product numbers into the system This problem is also automatically solved as the product number is read from the NFC tag. However, if the tag contains the wrong/unreadable product number it is possible to manually add the product number.

Employees could not always read the customers handwriting on the shopping list The problem is eliminated since the physical shopping list does not exist in Emptio.

Customers waited approximately 10 minutes while the orders were being processed
: This problem cannot be eliminated however the process can be expedited by removing the interaction with the store clerks and paying directly from the phone. This eliminates the queue to the checkout counter, which in turn can shorten the waiting time. However, this is not a guarantee since many factors are in play.

Overall Conclusion

In the System Design chapter we gave a description of how a mobile application can be designed. Even though the *Comprehensible* quality goal was rated as less important, an effort was made to make a good design. We used object-oriented design to structure and describe our system under development, which we chose to call Emptio. As all traditional object-oriented design, we designed objects to model concepts from the real world and tried to make these concepts useful and easy to understand. In real life we have a concept of a shopping list, which we in the design represent as a virtual order list, with its properties and functions. The same applies for other concepts from real life such as order and product. They all have their own object representation in our design.

A good design is also a simple design that is easy to understand and also relies on well-proven design ideas. This was accomplished by the use of design patterns which are a general description of a problem and a solution for that problem. Part of the object-oriented design builds on the idea of reuse, and reuse in this case are design patterns. We have kept the design simple, as it gives a better overview of the system. Furthermore, it does not use over generalization. It is always possible to make a more general version of a class. For instance in our case, the `Customer` could be derived from a more general class Person, but since it does not add any value it was omitted.

We came up with a good design which presents some solutions for the problems in *self-service shopping* found in the field study. This was one of the research questions raised in the introduction and the design will be implemented and tested next semester.

Limitations

A limitation in the interviews was that we only had seven interviewees. This is a very small segment of the customer base in Harald Nyborg and therefore we might have missed problems that exist in the shopping practice. Also, the severity of the discovered problems can not be determined.

In the focus group we also had some limitations. The focus group was held during a lunch break, which meant that the employees might not have been as focused as they could have been and the number of participants was also quite high and perhaps it should have been lower. Furthermore, the store manager also participated in the focus group which could cause some of the employees not to speak up. The subject could have been boring for some of the participants which also might be the reason for the low engagement. Additionally, we only had 25 minutes to complete the focus group.

We had no experience with focus groups and did not conduct a pilot test and this meant that the course of the focus group was not fluent.

A design can always be improved. What we did not do in this project, was to take a step back and compare our design to other alternatives and similar systems. Also, we should have looked more at techniques for idea generation and innovation. Even though we do not have an implementation so that we can evaluate our design, there are techniques such as paper prototyping that we could have utilised. Maybe it could have sparked a new idea or made a design flaw obvious.

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Part I

Appendix

A

Utilising technology in a shopping context

The research community has shown an increasing interest in using ubiquitous technologies to support our shopping activities. Improving customers experience by using emerging technologies is the next phase in the mobile revolution. The following paragraphs shows research in this area.
Irene et al. [?] seeks to trigger remote purchasing of groceries via new forms of HCI in ubiquitous computing. They have conceived a remote grocery shopping process based on touch enabled technologies. A customer can prepare a shopping list on an NFC enabled phone by touching on RFID tags attached on items. He opens the refrigerator, touches the RFID tag on the remaining corn flakes, enters wanted quantity and touches the "buy" icon on the fridge and the order is sent. The results of their experimental research shows that touch-based solutions are highly intuitive and users perceived it as user-friendly and satisfying.

In another paper, two researches are primarily focusing on consumer perceptions of new services and applications. They developed a pervasive retail system called MyGrocer [?]. The idea is, that a customer picks up a shopping cart with a tablet PC and an RFID sensor, which detects products placed in the cart. Every time a product is added to the cart, it is automatically removed from the shopping list on the screen. The system can show description for a product, detailed information, total cost of cart's contents, provide navigation assistance and other features. Participants in the evaluation agreed that using the system reduced their stress levels and they believed it would improve their shopping experience. Constant awareness of total cost, price comparison, navigation system, and smart checkout, where the features that participants found most attractive. iGrocer is another attempt to utilise pervasive computing technologies in grocery shopping [?]. This smart grocery shopping assistant makes use of a mobile phone with a bar code scanner accessory to provide personalised shopping lists, nutrition profile, "add by recipe", and other features similar to MyGrocer.

Similar to MyGrocer, CAST (Context-Aware Shopping Trolley) seeks to enhance the shopping experience in supermarkets [?]. It can show product placement in the store and provide additional information about the individual products. As the customer moves around in the store, the system is reordering the shopping list based on the location of the customer and the proximity of items. When

the customer is nearby a product, the system sends a audio notification through the customer's headset.

While supermarket shopping is an essential and routine type of activity, designing ubiquitous systems that can support the shopping activity and enhance the experience has received substantial interest. This is evident in the number of research papers, that concerns the topic. The research conducted confirms the promise of user-friendly, intuitive, and robust form of interaction on NFC enabled ubiquitous systems.

B

Customer questionnaire

Before the observation begins, ask the customers about following thing:

- Age:
- Name:
- Gender:
- How often do you shop in Harald Nyborg?:

During the observation ask the following questions:

- What do you think of the current shopping process i Harald Nyborg? (Manually entering product ids on a shopping order form)
- Have you experienced any problems with the current shopping process?
- Have you any ideas for improving the current shopping process?
- Do you have a mobile phone? (If yes) Is it a smartphone?
- What do you use it for? To call others, texting, MMS, browsing the Internet, taking pictures?
- Can you imagine that a handheld device could be used for shopping? (mobile phone, PDA or similar)

C

Focus group agenda

Agenda:

1. Introduction to the focus group (Explain about our education and that we are interested in using technology to improve the shopping experience.
2. Questions for the focus group
   - Do you experience problems with the current system?
     - Both as customer and employee
   - Do you experience problems with the customers?
     - read the customers handwriting
     - customers mistype on the shopping list
     - customers do not know how to use the shopping list
3. Questions for "Guided Fantasy"
   - If you could decide freely, how what would should the system be able to do?
   - How would the screen look in certain situations?
     - When you place a product in the shopping basket
     - When you place your order
     - When you click the shopping basket
   - How would you be able to remove products from the shopping basket?
4. Explain our idea for the product

If the focus group stalls give them some topics to talk about:

- Should the customers be able to rate products?
- Should the customers be able to see related products?
- Should the customers be able to see an order history?
- Should the customers be able to see more specific info about products?
- Should the customers be able to see if the products are in stock?
- Should the customers be able to navigate around the shop with the system?

- Should the customers be able to see a catalog of all the products in the store?
- Should the customers be able to search for products?

Note: Give the participants a smartphone so they can imagine the system on it

D

Focus group transcription

[Rasmus] Jeg er Rasmus og det er Tor
Vi er igang med et specialeprojekt hvor vi gerne vil forbedre indkøbsprocessen påden måde I har indkøbsprocessen her hvor I har folk, der selv går rundt og skriver hvad de skal have af varer.
Selvfølgelig tager de ogsåselv, men vi vil forbedre den indkøbsproces med teknologi og vi har tænkt lidt over sådan noget mobilteknologi
Og sådet vi egentlig gerne vil have ud af jer er input til idéer til hvordan det skal foregåog det gør vi med noget der hedder Guided Fantasy. I får egentlig helt selv lov til at komme med idéer til hvordan jeres system skal forbedres.
[HN medarbejder] Hvordan fungerer det?
[Rasmus] Jamen, det fungerer egentlig.. alt efter hvordan.. de idéer vi får udfra jer.. Jeg kommer med noget input og såvil jeg egentlig gerne høre I kunne forestille jeg det skulle fungere
Nu kender I jeres eget system rigtig rigtig godt, går jeg vel udfra, nu når I arbejder her [latter] Og såderfor er vi.. det vi gerne vil gøre er at, hvis det skulle komme op at køre det her, såskulle det selvfølgelig være noget som der ikke ville være nogen påvirkning for jer såI ville køre det samme, påden samme måde sådet egentlig kun ville være kunderne der ville tage deres telefon og bruge den istedet for for at handle ind med.
Sådet skulle egentlig fungere.. et eksempel kunne være at man havde sin telefon som såkunne scanne de der numre istedet for. Sådu fik bare en liste påtelefonen over de varer du havde og såkunne man trykke (køb) og såville I fådet ind påskærmen istedet for de kom med listen, som et eksempel.
Men, det vi egentlig gerne ville vide det var om I har nogen problemer... I oplever nogen problemer som det er lige nu, med det nuværende system.. altså.. ikke at systemet laver fejl, men at når kunden kommer og afleverer sedlen at I ikke kan læse hvad der står.
[HN medarbejder] Det er tit at de komme med forkert bestillingsnummer
[Rasmus] Ja
[HN medarbejder] At vi ikke kan læse hvad de skriver
[HN medarbejder] Især det.. har du ret i
[HN medarbejder] Kæmpe fordel, hvis man kan undgåsådan noget
[Rasmus] Ja, sådan at der ikke er den fejl med at det er kundens håndskrift.. eller at de kan skrive forkert
[HN medarbejder] Ja, lige præcis
[Rasmus] Og så, hvad mere er der.. jo eh, I oplever heller ikke noget internt, når I sender noget udefra disken og såud pålageret.. der opstår heller ikke noget fejl

i kommunikationen eller noget derimellem fordi det hele kører over systemet, eller noget
[HN medarbejder] Nej
[HN medarbejder] Nej.. ikke andet end noget paperjam [latter]
[Rasmus] Hvad med .. er der nogen kunder der kommer op og ikke kan finde ud af at bruge den her seddel, eller?
[HN medarbejder] Ja.. nye kunder, ja
[Rasmus] Altsåde komme op og skal sådan en introduktion til hvordan man går rundt og bruger den
[HN medarbejder] Ja, det kommer.. når konen skal med at handle.. [latter]
[Rasmus] Det var det..
Og såer der sådan at vi godt kunne tænke os at I egentlig bare har frie tøjler til at.. hvis man kunne forestille sig at man havde sådan en telefon.. behøver ikke at være en smartphone [lægger telefonen påbordet] det kunne ogsågodt bare være en almindelig telefon. Når man sågik hen og såscannede sine varer ind eller om man bruger camera til at læse nummeret der står eller der er sådan en lille sender I .. enten med bluetooth eller noget andet såman kunne bare gåhen og sige "bip" når man holdt den op imod varen og fik den ind påskærmen.. hvad man såville fåaf information påskærmen.. Du måogsågodt komme med input hvis du har noget..[til Niels Christian].. hvad man kunne fåaf informationer når man fik sådan en vare ind.. skal der være billede med.. skal der være ekstra tekst.. ligesom I har i jeres katalog.. der står lidt ekstra til nogen af varerne end hvad der står ude ved selve varen.. sådan nogen ting.
Hvad kunne I forestille jer der var ved det her billede.. det her skærmbillede når man nu scannede sine varer ind?
[HN medarbejder] Tror ikke det skulle være for meget til de kunder vi har fordi det ville forvirre dem alt for meget hvis der komme for meget frem
[Rasmus] Ja
[HN medarbejder] Vi har jo mange ældre
[Rasmus] Ja.. det er jo lige det.. vi ved jo ikke hvordan kunderne er herude udover det vi har fået fortalt sådet er det vi ville høre fra jer hvordan I oplever det skal være for kunderne.
[HN medarbejder] Altså.. jeg tror ikke det skal være alt for teknisk for såvil det forvirre dem og såer de væk fordi dét der det kan jeg ikke finde ud af og så..
[Rasmus] Såe.. ligesom det er herude at bare navnet påvaren, og et billede af varen, for eksempel.
[HN medarbejder] Ja
[Rasmus] Og såen pris.. såholde det såsimpelt som muligt
[HN medarbejder] ja.. det tror jeg
[Niels Christian] Kunne det ikke være smart nok hvis de fik samme information som der står i vores hovedkatalog? De behøves jo ikke at fåden vi har i vores online [...]
[HN medarbejder] Det tror jeg da ville besvare spørgsmål, både ude pågulvet og oppe i ordre-[...]
[HN medarbejder] Sådan et sted som [...] tror jeg ville være fint nok [....]
[HN medarbejder] Men det er altid en balancegang..
[HN medarbejder] Det har du fuldstændig ret i.. Det er ogsånoget der bliver arbejdet meget med varemæssigt fra indkøberens side af at vi forsøger påat fåvores kunder yngre og yngre. ogsåselvom vi sælger rollatorer.. [latter].. vi skal jo ramme alle, ikke også?.. men der er hvertfald meget fokus indkøbsmæssigt

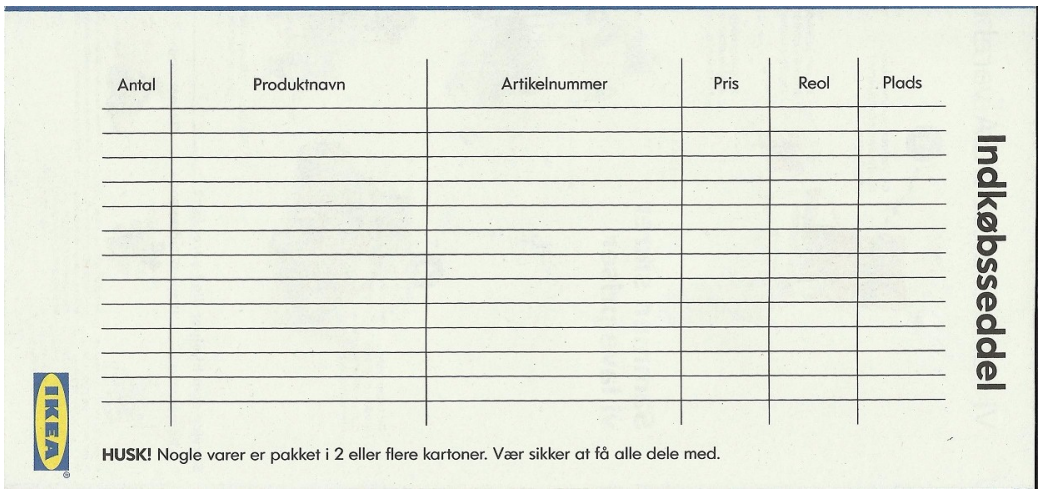
[Rasmus] Man kan såogsåsige at vores produkt det skal heller ikke blive noget der kommer ud i morgen.. det er teknologien heller ikke moden til.. sådet er sådan noget der skal lige gåen årrække af 2-5 år eller sådan noget før det begynder at være modent nok og folk de måske ogsåbegynder at turde at bruge denne her teknologi. Men hvad .. sånu vender vi lige tilbage til det der med skærmbillede.. hvad nu hvis man forestiller sig at man har den der liste af ting man har købt ... hvordan kunne man forestille sig at man skulle bruge telefonen til at købe med.. om man skulle gåop til kassen og såvise den eller skulle man bare have en knap hvor man trykker "send" og såkøbte man og skulle man såbetale over sit abbonement eller har I nogen idéer..
[HN medarbejder] Der kunne være sådan et nummer påselve telefonen hvor vi såslår det nummer ind påskærmen.. det kunne man..
[Ramus] Ja
I har også.. hvordan er det systemet herude når kunderne kommer.. får de sådan et nummer som I kalder op.. eller har I et skilt derude?
[HN medarbejder] Der kommer såsådan et nummer når de afleverer sedlen
[Rasmus] Ja.. ok
Fordi såkunne man såogsåforestille sig at det nummer det fik man bare påskærmen, og så..
Hvad såmed.. de her ting.. når man.. altså, når man tager noget inde påskærmen såskal man selvfølgelig ikke købe det med det samme altså.. scanner.. det kan jo godt være at man bare ville have informationen påproduktet.. såom der skal være.. hvordan man såskal lægge det over i sin indkøbskurv .. hvordan den skal se ud.. hvis I kunne forestille jer det. Jeg ved godt det er meget abstrakt at sidde og forestille sig det ligenu, men hvis I kunne forestille jer at man fik information og der var et lille billede og tekst påhvad det nu var man scannede ind.. opvaskemaskine.. og såen pris.. og såen lille knap hvor man kunne sige.. "Køb" eller et eller andet.. Når man såtrykker påden såfik man en indkøbskurv frem med alle de ting man havde.. skulle det bare være en lang liste eller kunne man forestille sig det skulle se ud påen anden måde såman havde bedre overblik
[HN medarbejder] Nej.. det skulle bare være en liste
[Rasmus] Jeg ved godt det er meget abstract [latter]
Men det er nu sådan noget som det vi havde før.. det er sådan noget vi gerne vil vide.. I har noget intern information og det er det vi gerne vil have ud og det er selvfølgelig svært for jer at vide hvad for noget vi gerne vil vide og det er ogsåsvært for os at fåstillet de rigtige spørgsmål
Hvad med sådan noget at lade kunderne komme med kommentarer til produkterne.. det ved jeg ikke om I har inde påhjemmesiden
[HN medarbejder] [latter] der er nogle enkelte kunder der kommer med kommentarer [....]
[Rasmus] Men.. sådan at når kunderne.. hvis de har købt et produkt pået tidspunkt og de kunne tage programmet med hjem påtelefonen og såkunne de se hvad de havde købt og sågive .. evt. give kommentarer til et produkt eller komme med stjerner alt efter hvor godt det nu virker eller noget.. om det kunne være en ide
[HN medarbejder] [mange samtidigt] Nej.. det tror jeg ikke
[Niels Christian] Altså.. langt de fleste af dekunder der handler herude hos os .. såringer de ikke for at sige at den skruetrækker den var fandme go'.
[Rasmus] Det er fordi at vi oplevede meget da vi stod derude og snakkede med dem at der var rigtig mange der kommer.. det er ikke førstegangs købere.. det

er folk der kommer her rimelig ofte.. sådan en .. en to gange om måneden, hvertfald. Det måvære folk der er glade for at komme tilbage her at købe
[HN medarbejder] Jaja.. selvom de er negative såkommer de alligevel
[Rasmus] Det er jo ogsåaltid nemmere at være negativ end det er at komme med det gode feedback
Det er mere det at det kunne være en mulighed.. men det lyder ikke som om det er der skal være med eller..
[HN medarbejder] [kan ikke tyde hvad personen siger]
[Ramus] Det er såogsånoget man kunne forestille sig at kunne hjælpe med ventetiden da folk ikke skal op i køen for at aflevere de der ting.. men at de bare kunne
[HN medarbejder] ja.. at de køber ved at bare indtaste de her fire cifre påtelefonen
[Rasmus] ja.. eller ogsåat de eventuelt kunne købe tingene undervejs som de finder dem.. at man kunne sige at de kunne lave en .. de finder den skruetrækker de skal have men de ved ogsåat de skal ned og en opvaskemaskine.. sånår de har fundet skruetrækkeren og scanner den ind sålægger de bestillingen allerede der påskuretrækkeren som egentlig er klar såskal de såud at finde vaskemaskinen når det er den der skal bestilles.. sådan at varen er fundet undervejs.. altsådet kunne selvfølgelig godt give..
[Niels Christian] Nej.. jeg tror ikke.. ordren skal findes påén gang for at vi skal kunne holde styr pådet der.. vi prøvede noget lignende pået tidspunkt i Odense hvor kunderne kunne bestille varerne pånettet til afhentning i Odense.. det skulle vi såfinde ud af om det var noget var aktuelt for os [....].. det gik rigtig godt.. ca hver femte ordre blev hentet.. resten kunne de lægge tilbage påplads
[Rasmus] Ok, såkan jeg godt se det..
[Niels Christian] Der var hvertfald rigtig meget arbejde i det... det kørte alligevel i et par måneder
[Rasmus] Og sålige for at runde lidt af.. såvores ide. altsåsådan den færdige ide til produktet.. det er at bruge en teknologi der hedder NFC.. som er en trådløs standard der kan læse småchips.. jeg ved ikke om I har hørt om RFID chips? Der er egentlig bare småchips der koster 20 øre stykket eller sådan noget som man kan sætte i alt og såkan det indeholde en masse information.. og dem kan man såaflæse med forskellige apparater.. og det er såegentlig det der er vores idé .. at kunderne kunne komme med deres mobiltelefoner da fordi fra 2011 skulle der begynde at komme NFC i alle mobiltelefoner og såkan de komme og aflæse et produkt med telefonen og fådenne her information og lave deres indkøbsliste og såbestille.. hvis det såkommer til at virke ordentligt .. såkunne man forestille sig engang at det kunne integreres i sådan et system som I har her.. fordi det er en rigtig god case.. fordi I kører det påden måde.. og sågøre indkøbsprocessen nemmere for kunderne og såsamtidig ogsågøre bestillingsprocessen nemmere for jer at der ikke er ligesåmange fejl sådet måske kan gøres hurtigere
[Niels Christian] Ja vi laver jo ogsåtastefejl når vi står oppe ved ordre.. når vi taster.. det kan jo ikke undgås
[Rasmus] Man kunne ogsåforestille sig at kunderne kunne se lagerstatus påvarerne de vil købe og fåat vide om den er her eller ej..
[Niels Christian] Ja.. det har vi sålidt politik i at det fortæller vi ikke.. altsåkunderne.. der er mange der ringer herud for at spørge.. har I den eller den

pålager.. hvor mange har du.. såspørger man hellere om hvor mange de vil have.. der får man ikke at vide om man har 7 eller 77
[Tor] Her tænker vi bare påom I har varen pålager eller ej og ikke om I har 17 tilbage
[Rasmus] AltsåI har.. I kan godt se hvor mange der burde være herude
[Niels Christian] Ja
[Rasmus] Det er bare en lille grøn pære om den er der eller eller om den ikke er der
Bare sådan at man ikke går rundt i butikken og finder 3 ting der ikke er der og såstår i køi lang tid for at finde ud af at det kan man ikke fåi dag så
[HN medarbejder] Det er jo risikoen
[Rasmus] Nu ved jeg ikke om I har styr på.. altsåI har de her medlemskort.. er der såmulighed for at se..
[Niels Christian] Hvad er det for nogen kort?
[Rasmus] Det ved jeg ikke.. Det var noget.. en brochure jeg såoppe ved kassen
[Niels Christian] Ahh.. det er kunde[...].. det bliver ikke brugt særlig meget
[Rasmus] Ok
[Niels Christian] Det er med en rente på28-29 %.. såer nordjyder sgu ikke såvilde med det
[Rasmus] Ok.. ej ok.. det kan jeg godt se.. [latter]
Jeg såden bare lige og såtroede jeg det var sådan et medlemskort
[Niels Christian] Det er egentlig vores .. ej det har været vores eget kort.. men vi valgte at udlicitere dem da der var for store tab pådem..
Såumiddelbart er ikke den kundegruppe vi er mest interesseret i.. jo vi vil gerne have dem ud.. nu har vi ikke selv tab pådem.. det er meget meget lille
[Rasmus] Det var egentlig bare det vi gerne ville vide.. jeg siger tak for hjælpen og vil lige høre om I lige gider tage sådan en her og lige skrive navn og hvad der nu ellers er på

E

Shopping lists from Harald Nyborg and IKEA



Antal	Produktnavn	Artikelnummer	Pris	Reol	Plads

IKEA

HUSK! Nogle varer er pakket i 2 eller flere kartoner. Vær sikker at få alle dele med.

Indkøbsseddel

Figure E.1: Self-service shopping list from IKEA.

Figure E.2: Self-service shopping list from Harald Nyborg.