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User-Centered Design of Internet of Things enabled applications: The case of the VIZUM app.

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Abstract

User-centered design of Internet of Things enabled applications: The case of the VIZUM app.

This thesis looks at how to implement user-centered design to Internet of Things enabled application with the design development of an application for reservations of parking spaces. It will look at how to apply user-centered design, how the users experience the design with the Internet of Things technology and if there can be made some recommendations for industrial development of these kinds of applications. The thesis presents a user involved design process of an application that includes the development of several prototypes to conduct the research of the objectives. By conducting this design development I will present with findings that supports that there is possible to apply user-centered design to Internet of Things enabled applications and give an evaluation on how users experienced using it. This research presents some recommendations on how to conduct similar research and may be a useful start on how to implement Human-Computer Interaction to the field of Internet of Things in an industrial context.

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Preface

First I want to thank my supervisor Victor Kaptelinin. I am thankful for his guidance, knowledge and support in making this thesis.

Thanks to Bo S. S. Bakke and everyone at Time Park AS for the possibilities and a good partnership in the development of the VIZUM app in this thesis.

Thanks to Jan Erik Evanger and the staff at APX Systems AS also for the possibilities and their work in making the high-fidelity prototype in this thesis a reality.

Thanks to family, friends, and everyone who has contributed in moral support during my work. I also want to make a special thanks to my father. Not just as the CCO of Time Park AS but also as a special person in my life. He has not just supported me through the process with words of encouragement but also has been my partner and customer in the development of the VIZUM app, without his help and interest in discussing technology possibilities in parking for hours this thesis would never have been possible to create.

1 Introduction

The term Internet of Things (IoT) is used in describing a vision of a global infrastructure of networked physical objects and is said to be more than just a vision in the near future (Atzori et al. 2010). The Internet of Thing is partly inspired by the success of Radio-Frequency IDentification (RFID) technology, which is now widely used for tracking and is the best-known aspect of the Internet of Things field. RFID system architecture is marked by a sharp correlation between RFID tags and an extensive infrastructure of networked RFID readers. This system is what makes the tracking of physical objects possible and is often used for confined spaces (Kortuem et al. 2010). This technology is as said, well used and known, but is still often lacking aspects of human interaction with the technology. Research on how to put interactivity in these aspects of technology is on going, but there is still a lack of a strong human-centred perspective on the Internet of Things (Koreshoff et al. 2013). Research also presents issues considering experimental Internet of Things research and how difficulties have presented in evaluation of Internet of Things solutions under realistic conditions in real-world experimental deployments (Gluhak et al. 2011).
By conducting an experimental research of a design development of an Internet of Things enabled application this thesis will present research and findings on how to make an artefact with the RFID system technology interactive. I will in this thesis present related research on the subjects of this development and design an Internet of Things enabled application with user-centered design approaches presented in a real-world experimental deployment. With this experiment I hope to present to the field of Human-Computer Interaction (HCI) with research that can both be used to connect Human-Computer Interaction with the technologies of Internet of Things and present a way of designing for these aspects and technologies in real-world settings.

1.1 Issue and objective

With thoughts on the idea of IoT technologies that is supposed to connect physical objects to make them interact with each other and ideas of Human-Computer Interaction, which focuses on usability and interaction between human and the technology, I wanted in this thesis to create an artefact that could combine the two worlds and give me the opportunity to evaluate the effect that this artefact would have on users. One of the main strengths of the IoT is presented as the effect these technologies will have on our everyday lives (Atzori et al. 2010). With this in mind I also wanted to create an artefact that also could impact an ordinary aspect of our everyday-lives, so I came up with the idea of an app for easier parking. This app would have aspects of the IoT technology RFID and give me the opportunity to make and interactive artefact that could connect users with the technology.

The idea of a parking app has been something I have looked into before and this thesis gave me the opportunity to make it a reality. Why I chose to make an app to present the research was because the use of smart phones and apps has become a part of many people's everyday lives. I wanted to create an artefact that was well known to users to see if the understanding of the technology behind it was more understandable in a setting most users already is comfortable with.

The main purpose of the making of this artefact will be to experiment on how to connect users with technologies in an interactive way and to present this research in an industrial content to relate it to the real-world use. I will focus the development and testing of the artefact on users I know uses these kinds of technologies (smart phones and apps) but I will design a product that can be used by all ages and will try to make is easy to learn and understand for everyone who would have the interest of using this.

Through a design process that includes user testing and customer wishes this thesis from an empirical perspective, map the effectiveness of this kind of experimental research for connecting IoT technologies with HCI research and users experience with it. This thesis will not present an actual product just a prototype of a product that could be presented in a real-world setting. The plan is that this prototype will be

further worked on and later be presented as an actual product in the real-world, but this will demand further user testing and work that this thesis presents.

1.1.1 Target group

This thesis's target group is researchers, practitioners and students in the field of Human-Computer Interaction (HCI). This thesis will work on giving the field of HCI research an industrial perspective on already existing research on how to apply user-centered design to the technologies of Internet of Things.

1.1.2 User group

Since this thesis not only present the readers with research in the field of HCI, but also present the readers with an actual developed application I wanted to clarify the user group of the application before I present with my work and research. This applications user group is not set in a frame of age, but is framed to car owners of all ages with the means to use a mobile application, this meaning car owner with smart objects as for example mobile phones or tablets.

1.1.3 Research Question

This thesis will try to answer these following research questions:

- *Can user-centered design be applied in IoT enabled applications?*
- *How do users experience the complexity of the technology when presented to them?*
- *Can user-centered design experiments be enough to provide recommendations for the real world development of IoT enabled applications?*

1.1.4 Thesis structure

In the work of the design development of the app a literature review with related work and definitions for the aspects of this paper will be presented. There will also be a presentation of industrial content in this thesis; companies that have been working as customer and collaborators and related work in the industry. Chapter 4 will give a general discussion of the methods and principles used for data collection, designing, and prototyping presented in this thesis. Following this the presentation and analysis

of the development and testing on users will be presented. In chapter 7 the final prototype of the app will be presented and analysed with user goals and chapter 8 will conduct a discussion of the research questions, challenges, and further work and finish with a conclusion on the thesis.

2 Related research

The Internet of Things (IoT) is a concept of technology that is rapidly growing in todays society, and is said to be a permanent part of our everyday lives by the year 2025 (Atzori et al. 2010). There is no question that this is the future and already includes technologies that is well introduced today, for example the Radio-Frequency Identification (RFID). The question is if the rest of the information science fields are keeping up with the changes. This chapter will present research related to the work I will present in this thesis. It will include the basic research on IoT and the HCI approach to the technologies described in this research. I will also give you an introduction on the field of HCI and other definitions and research that will be a part of this thesis. I will start by presenting definitions and research in the field of HCI research after this I will present definition and research on IoT and how HCI research is involved in this field. In the end I will present some definitions and research on prototyping techniques that will be used in the design process of this thesis.

2.1 Human-Computer Interaction

Human-computer interaction is speciality area of research in computer science that focuses on cognitive science and human factors engineering. The original concept of HCI is usability this concept was actually developed from the slogan “easy to learn, easy to use”. This slogan is considered somewhat naïve, but the blunt simplicity actually gave HCI a prominent identity in computing. It serves as a help to influence computer science and development of technology more effectively (Carroll 2013).

As described, HCI is an area of research. This research field will have a dominant role in this thesis, but I will also go deeper in one of the practises of HCI, Interaction design.

2.1.1 Interaction design

> *"Designing interactive products to support the way people communicate and interact in their everyday lives"* (Sharp, Rogers, & Preece, 2011).

Interaction design is a design craft that focuses on interaction, but is not a term specific to computers. The sole focus in interaction design is about creating user experiences that helps people work, communicate and interact. Interaction design is accepted as an umbrella term (covering all terms) for several aspects of design, such as interface design, software design, user-centered design, product design, web design, experience design and interactive system design. This way of designing is not a focus on a specific way of doing design but more of how to use a range of methods, techniques and frameworks (Sharp et al., 2011)

2.2 User-centered design

User-centered design will be the key design process in this study. I will use known practises in the field and base my development of the sole purpose of the field.

2.2.1 User-centered design: an introduction

User-centered design (UCD) is a broad term used to describe a design process where end-users influence the process of how the design takes shape. There is several ways in which the user can be involved in the process, but the important concept of UCD is that the user will be involved in one way or another. This term describes both a perspective and a set of methods.

The term user-centered design originated in the 1980s and was described by a man called Donald Norman. The practice became widely used after the publication of the book: User-centered system design: New perspective on Human-computer interaction from 1986. In 1988 Norman developed the idea of UCD with further study and presented four basic suggestions on how a design should be:

1. Make it easy to determine what actions are possible at any moment.
2. Make things visible, including the conceptual model of the system, the alternative actions, and the results of actions.
3. Make it easy to evaluate the current state of the system.

4. Follow natural mappings between intentions and the required actions; between actions and the resulting effect; and between the information that is visible and the interpretation of the system state.

The designers role in a design process is to design a product that makes sure that the user can make sense of the product as intended and that he/her can do this without having to use a lot of time to learn how to. Norman also suggests that there should be seven principles in the design process that facilitate the designer's tasks:

1. Build conceptual models and write manuals that are easily understood, written before the design is implemented and uses knowledge in the world as well as in the head.
2. Simplify the structure of tasks. Do not overload the memory of the users; design so that the product gives aid for remembering and makes sure the users has control over the task.
3. Make things visible. The user should be able to understand what to do next in the application just by seeing the next object (for example a button) for executing an operation.
4. Get the assessments right. Use graphics to make things understandable.
5. Exploit the power of constraints. By using both natural and artificial limitations in the artefact you can give user the feeling of that there is only one thing to do.
6. Design for error. Plan the design for any error that can occur so that the user can be allowed to recover from any possible error made.
7. When all else fails, standardize. Create an international standard if something cannot be designed without mappings (Abras et al. 2004).

2.2.2 User-centered design: methods in the industrial content, what works and what does not.

UCD is not just usability testing or software engineering but are also methods involved in UCD practice.

User-centered design (UCD) appears to be making an impact across the development industry and Vredenburg, Mao, Smith, & Carey (2002) presents a study on how UCD is implemented in the industry. They wanted to study what UCD methods were

actually used in practice, and discovered that many of the methods that are discussed in literature are not used in the industry because of practical issues.
This study present findings that describe 5 UCD methods that where used by most of their respondents (persons with good experience in the UCD field and working in the industry):

- Iterative design
- Usability evaluation
- Task analysis
- Informal expert review
- Field studies

All of these were considered as the most used methods, and all except *informal expert review* were considered the practices that had the best impact in a design process. Many also referred to customer satisfaction as a primary measure they tracked but was also seen as outside of their UCD process. The study concluded with that some of the practices used in industrial development often were based on cost-benefit and that those practises, such as *informal expert review,* seldom gave results that benefitted the projects (Vredenburg et al. 2002).

2.3 Internet of Things (IoT)

The IoT is the idea of physical objects, or "things", such as everyday objects, places and environments interconnected with one another through the Internet. The objects are embedded with electronics, software, sensors, tags, mobile phones etc. This is a concept that will have a high impact on our everyday-life and might change how we react or behave as users (Atzori et al. 2010). I will here present a figure designed by Atzori et al. in their article from 2010. Before I present my work and the aspects of the IoT that I have been working on I wanted to present all the different aspects of the IoT to give a broader understanding of the concept. This figure explains the different sides of the IoT and all the technologies that can be found within this research.

Atzori et al. present this paradigm of IoT to better describe the different visions of the concept. They describe the definitions as hard to grasp because there can be three

different approaches to look at the IoT; "Internet oriented", "Things oriented" and Semantic oriented".

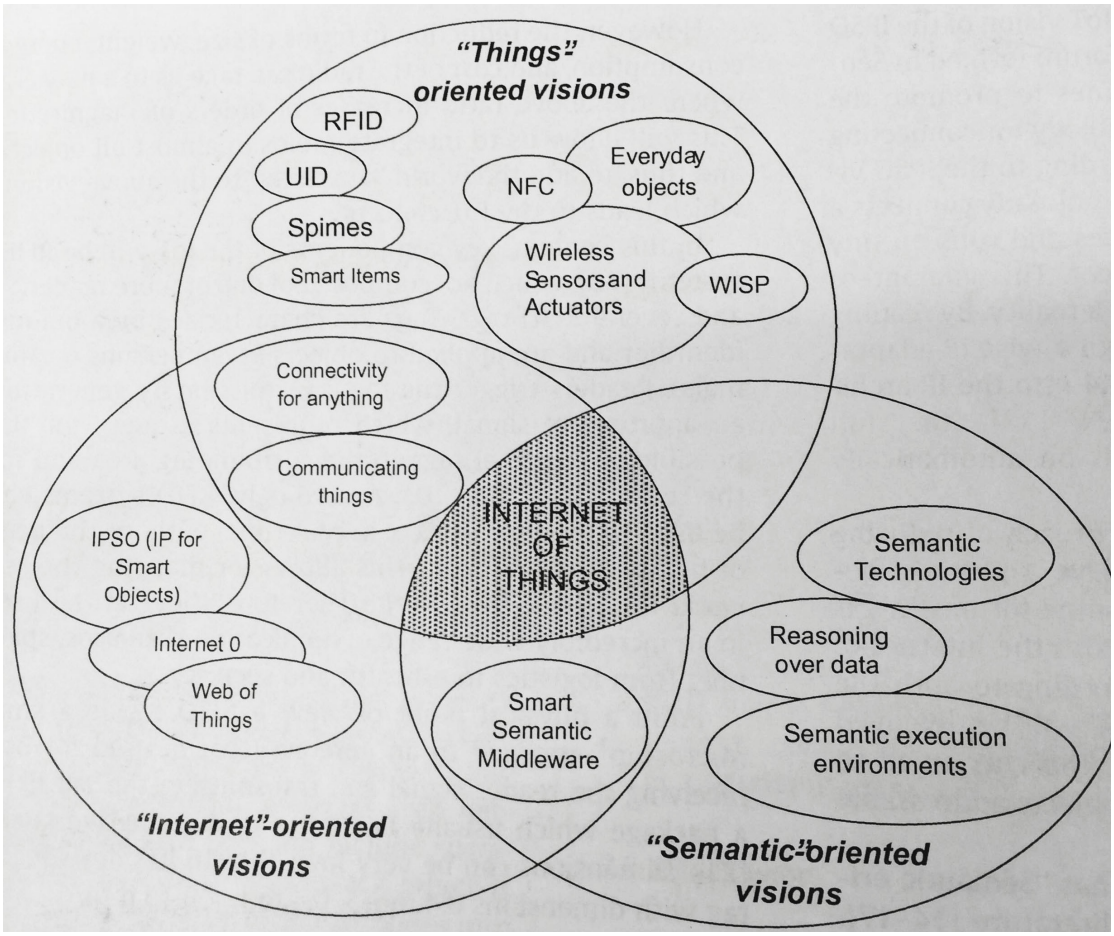

Figure 1: "Internet of Things"

> *""Internet of Things" paradigm as a result of the convergence of different visions."* (Atzori et al. 2010)

"Things oriented": This vision supports the use of the Electronic Product Code (EPC) in conjunction with RFID technology to collect and track sensor data. EPC global framework is based on this vision of unique product identification and tracking (Aggarwal et al. 2013). RFID tags are designed for improving an objects visibility (traceability, awareness of status, location etc.). Among other technologies these is described to represent the "things oriented" approach of IoT and is described as a vision that will bridge the gap between the real world and the digital world.

Sensor Networks, basically nodes communicating wireless and report what they sense back, is said to be able to cooperate with RFID systems. The collaboration

with these two technologies can better track and sense the status of things and therefor is a layer between the “things oriented” and “internet oriented” vision (Atzori et al. 2010).

“Internet oriented”: This vision corresponds with the idea from IPOS alliance. This is a forum formed to promote the idea of Internet Protocol as the network technology for connecting Smart Objects, which are Internet connected. The concept of the “spime” has emerged from this vision. It is still theoretical but I described as an object, which is unique and can be continuously tracked. An example of this is smart objects and for this to work every object would need its own IP-address and therefore there is need for development of the Internet Infrastructure to accommodate this (Aggarwal et al. 2013)

“Semantic oriented”: This vision addresses the issues of data management. This occurred by the enormous flow of information exchanged by smart objects, and all that is available through the web. The idea is to standardize resource descriptions to get a better function of resources available through the web of things. This is more about the separation of the meaning of data (Atzori et al. 2010).

2.3.1 A Human-Centered Internet of Things

Koreshoff et al. presents an article in 2013 on how to approach the IoT with HCI. In this article they present the figure of Atzori et al. on IoT integrated with HCI research. This was done to represent the HCI considerations that need to be taken into account when designing for the IoT. I will present this figure to give an understanding of how HCI can be represented in the IoT and to give an understanding of what my work has been based.

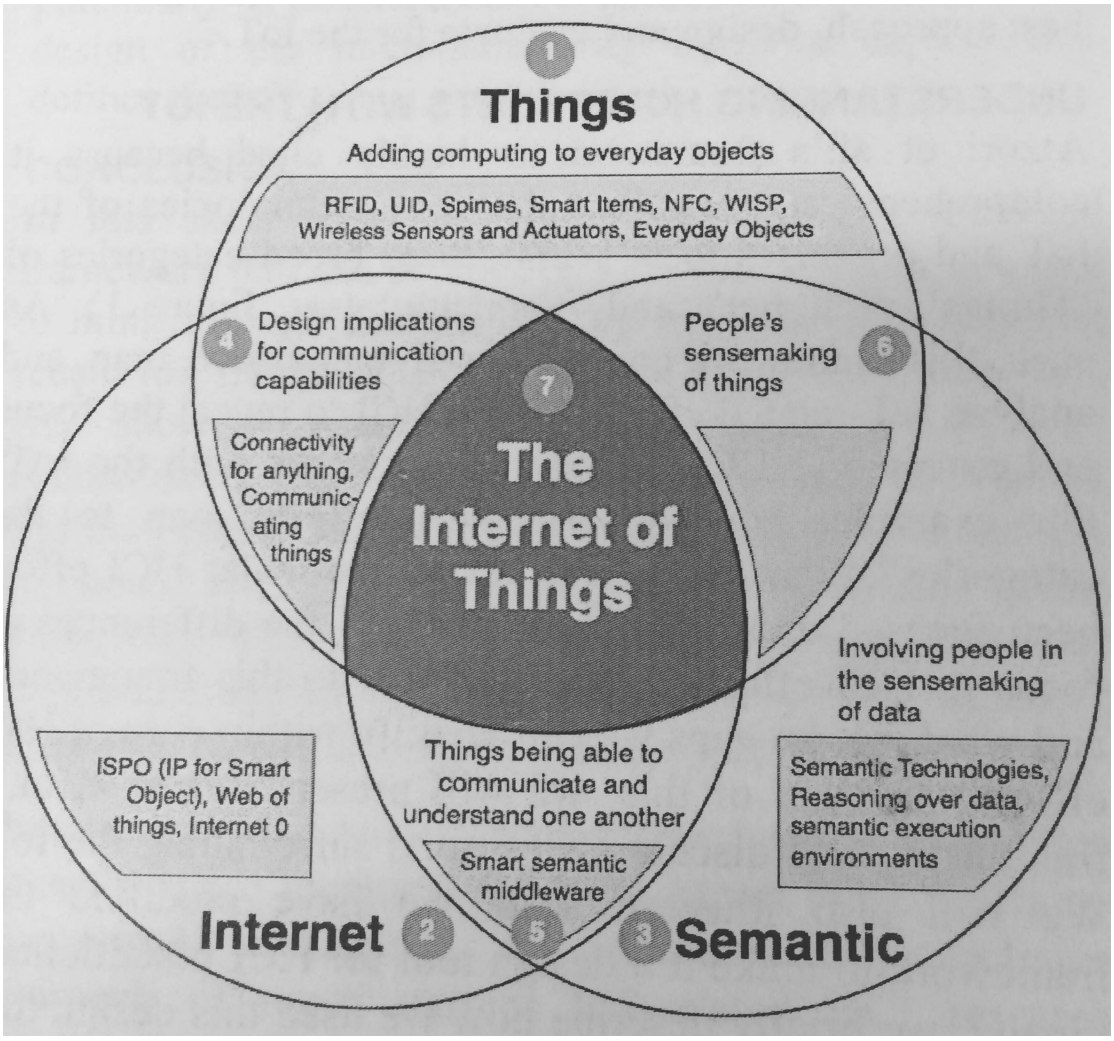

Figure 2: HCI modified "Internet of Things"

> *"Modified version of Atzori et al.'s (2010) "Internet of Things" paradigm."* (Koreshoff et al. 2013)

The modified figure represented in Koreshoff et al. represents the figure presented by Atzori et al. but with an additional overlap and descriptions of both the existing IoT presentation and the HCI research presentation.

The "things oriented" vision in HCI research does not concern so much the objects as the original figure represents. In the HCI perspective they are more interested in the how and what this can become. This Koreshoff et al. presents as the "adding computing to everyday objects". To clarify this means how the computing can be added to everyday objects and how the user can interact with it.

The "internet oriented" vision as described earlier concerns with the protocols and languages that connects and transfers information between the "objects".

Here the HCI research present little interests in the protocols and languages and therefor does not have much to offer this section in the HCI research.

The “semantic oriented” vision is relatively new territory for the HCI research and there is not yet a lot that has been done within this area. There is the awareness of that the computers alone not clearly can represent human intentions, as this is seen as too complex for the computer to program. From this they have represented the “involving people in the sensemaking of data” in the figure. This is to show that the technology alone cannot make meaning of the vast data that exists today.

The “internet/things oriented” vision is similar to the “original” idea, but the HCI research suggests that HCI is more interested in how the properties and limitations of connectivity can impact the design process. This they call “design implications for communication capabilities”.

The “semantic/internet oriented” vision contains the “middleware”. This is described to be software that allows communication between “things”. The HCI literature does not concern the subject of how such technology is achieved much, but focuses more on “thing being able to communicate and understand one another”.

The “things/semantic” vision is not represented in the Atzori et al. diagram for IoT, and was only discussed briefly. It refers to the need of a scalable infrastructure than can semantically process the vast amount of data in the IoT. In HCI literature this vision was well represented. Mostly there was described the focus on how data can affect “people’s sensemaking of things” when everyday objects are embedded with computing. One of the other things the HCI literature concerned themselves with on this subject was how objects react to new incoming information (Koreshoff et al. 2013).

2.4 Design and prototyping techniques for mobile applications

Prototyping can be defined as an activity of making and utilizing prototypes in design. It is representations and manifestations of design ideas (Lim et al. 2008). Lim et al. (2008) present what they call the fundamental prototyping principle:

> *"The purpose of designing a prototype is to find the manifestation that, in its simplest form, will filter the qualities in which the designer is interested without distorting the understanding of the whole."*

As mobile devices today expands with more possibilities of technologies, user experience expands with it. We must look for more ways to create more realistic user experiences in our design ideas. Sá & Churchill (2012) shows a study where they present challenges and findings on prototyping and evaluation techniques for design of mobile augmented reality. HCI research, in terms of the new technologies and services, shows focus on four points that needs to be considered when speaking of design challenges.

1. Multiplicity of contexts
2. The real world settings
3. Simulating real-time services or location-based services
4. The newer features and modalities that mobile devices support

Most HCI and mobile related experiments research present two main prototyping techniques: low-fidelity and high-fidelity prototyping. Studies has also shown that there has been looked into finding a middle ground between these two prototyping techniques that they call mixed-fidelity prototyping. Sá & Churchill (2012) during their research on these challenges and concepts provided with 5 categories that gave them a good way of analysing their results. These categories where:

Probing – triggering imaginations, explore applications, concept and usage.

Concept Validation – presenting general concept and requesting feedback.

Feature Validation – validating features and functionalities.

Usability Testing – addressing usability issues and addressing efficiency and ease of use.

Their conclusion in their paper was that there where both ups and downs with the use of all the prototyping techniques, but that the mixed-fidelity technique gave the best result in their testing. This technique gave the designers good insight in to issues and possibilities that were easily changeable since this prototype do not demand so much time and expense consuming measures to develop as the high-fidelity prototype can do. The high-fidelity prototype is still the one that gives the best opportunities for testing since it always will be a more interactive prototype, but the mixed-fidelity can help the design process on a level that has not before been reach at a so early stage in the process (Sá & Churchill 2012).

2.5 Chapter summary

In this chapter I presented related research on my field of research and provide definitions and explanations on terms I will use in this thesis. I also presented some insight to how I have developed my research and the design development I will be conducting later in this thesis. First I presented with an introduction of the field of HCI and explain what this entails. Here I also give an explanation of design methods and a presentation of interaction design and user-centered design, which will be methods that will be largely used throughout the design development in this thesis. Next I presented with basic research and definitions in the field of IoT. I give an explanation of how research has presented with different visions of the IoT and what vision will be my focus on in this thesis. I also presented with HCI research that is placed in the visions of IoT to present the perspective of where the HCI research stand today in the field of IoT. Last I presented some research on prototyping development, which gives an explanation on how to use prototyping in a design development and also present with some new aspects of the prototyping techniques of today.

I will in my design process take in to consideration the analysis and findings from several of these papers. I will consider the challenges they faced and perhaps take their techniques further to make them fit to my research.

3 Industrial content

The research of this thesis and design development has also been conducted in an industrial content. This meaning that the app has been designed and developed in the light of some companies and other applications that exist in todays market. This chapter will present you with the companies, which have in this development process been operating as costumer and development team. There will also be a short description of the VIZUM project and the technology behind it to give some insight to what the app will be based and designed for. I will also present some industrial work that has been done in the field of interaction design, IoT and parking. I present this as a background explanation of how this project came to be as it is and why I have chosen to do this research the way I did.

3.1 Companies involved in the design process

3.1.1 Time Park

Time Park is a private parking company with over 20 000 parking spaces to offer in east Norway, they are also working with the Norwegian company Thon Hotels and have parking spaces on almost all their properties. They have a vision to be the most technology driven parking company in Norway and are also concerned on the users experience of their services (TimePark AS n.d.).

3.1.1.1 VIZUM

VIZUM is a parking service, which should make parking easier for many people. This service uses a RFID tag that the car owner puts in their car window. This tag is registered on the car and a credit card. When the car owner drives in to a parking lot the tag is registered by the system and all payment will be done automatically on to the credit card that is registered to the RFID tag. So basically the driver can just drive in and out of the parking lot without having to think about tickets or payment (TimePark AS n.d.). The app that is developed in this thesis is an extension of this VIZUM system. The app will have the login of a VIZUM account and provide more features to the system as well as a way to interact with the system.

The RFID technology in VIZUM

In this section I will try to provide you with some information on components of RFID technology. Jan Erik Evanger, Managing Director in APX Systems AS (written in an email 16.11.15) presents the RFID technology used in the VIZUM-project and a general explanation of what RFID is:

"RFID is an abbreviation for Radio Frequency Identification. This is a collective term for several technologies where you store information on a chip. There are different types of chips and frequencies. We distinguishes between these types of chips:

- *Active chips with battery*
- *Passive chips with battery. So-called battery assisted.*
- *Passive chips without battery.*

There are also used different frequencies.
For the VIZUM-chip the frequencies that is used is 868-900 MHz. The standard is called EPC-gen 2. And is clearly the most applied standard in the world. Just this year there was sold up to a million chips.

The chip is programmed after a particular number series. Each chip has a unique number. The chip can also be encrypted.

The VIZUM-chip is special made for windows/car windows.

In the heart of the solution is a computer. This is intended to filter data that is collected from the reader. Additionally it is the computer which monitors when the antennas is to be turned on.

When a car is in the reading zone, the computer communicates to a decoder/encoder. This is an electronic unit, called RFID-reader. It has several gates. One antenna is, via a coaxial cable, connected to one of the gates.
When the antenna is activated it will create an electromagnetic area. When a chip is in the area it will charge / get supplied with energy. The RFID-reader

can then be instructed to what will happen next. Now information from the chip can be retrieved, by means of a protocol from the RFID-reader and via the antenna. There is also possible to write to the chip. In the VIZUM-project the information of the chip is read and the chip gets validated in a central system. If everything is OK the gates in the parking area will open for driving trough.

The solution is very quick, and can read up to 1000 chips in a second."

3.1.2 APX Systems

APX Systems is a company that was formed in 2006. Their work is to develop and deliver system solutions with hardware to other companies, manly in the field of trade and industry. The employees are made up of several people with education and experience in system development, sales and technology.

Their speciality is system integration and has therefore good knowledge on developing solutions for technology as RFID-equipment, Scanners and terminals, robots, GPS etc. (APX Systems AS n.d.)

3.2 Industrial related work

This section will provide you with two industrial related works. One is a Norwegian company that provides mobile solutions for car users. This company uses several solutions and technology that is similar to what I will present in this thesis. The other industrial related work is a study on utilizing RFID for smart parking applications. This study presents the basis of the VIZUM system and provides a good light on what the starting point of this thesis is based on. I present these two to shed a light on where my work can be put and related in the sense of the real world.

3.2.1 EasyPark mobile parking

EasyPark is a company who is focusing on delivering mobile solutions for car users in Norway. They have designed a mobile app, which works as a pay meter. This application service is delivered to several private and public parking companies in

Norway and in several countries in Europe. The application works so that users can register an account with EasyPark and pay for parking with you mobile phone. The payment gets registered with the users account and EasyPark directs the money to the parking companies. The uses decides when to start and stop the payment for the parking and users can also make a work account for paying for parking while at work. The app uses localization services on the users mobile to find a parking space for users (EasyPark AS n.d.).

3.2.1.1 Park and Pay - Volvo cars and EasyPark

Park and Pay is an app for Volvo cars (with Sensus Connect and Sensus Navigation), which will help you find available parking and let you pay for it in the app. This app is integrated in the navigation system in the car and when you have found a available parking space you can pay for it with the system in the car (Volvo Car Corporation n.d.).

The Norwegian supplier EasyPark delivers this system in Europe and Scandinavia. You will have to have an account with EasyPark to use this system and you can have different accounts for both work- and private related parking (Skillebæk, 2014).

3.2.2 RFID for easier parking

This is a study presented by Zeydin Pala & Nihat Inanc (2009) on utilizing RFID for smart parking application.

Radio Frequency Identification (RFID) is a technology that helps to identify objects through radio waves. It consists of several technologies such as, tags, readers, computer networks, and systems like databases and middleware. To implement RFID technology in parking lots presents some advantages both as user and owner of lot. It requires no personnel, fees are collected automatically, less maintenance costs, tags can be used repeatedly, lower error rate, and quicker check-in and check-out.

The test they present in this paper test the system developed for cars to check-in and check-out of parking lots. They tested the range of the reader, if it could read several chips simultaneously, and what would happen if some unforeseen events happened

such as, if someone had not paid or gotten in without properly being read. They present the study with result that proves that completely automatized parking lots is possible in the future. This system will provide the opportunity to eliminate traffic-jams in parking lots since the system no longer will need to check parking tickets.

3.3 Chapter summary

In this chapter I have presented with the industrial content of my research. First the companies that are a part of the design development are presented. Here there is also provided some insight to what the VIZUM projects is and a short description of the technology behind it. This was presented to give you a picture of the background and the basis of the app that will be designed in this thesis. After this I presented some research and other products that exist in todays marked. This is presented to connect my research to the real world artefacts and to shed some light on why this design development has been conducted the way I have chosen in this thesis.
This research and design development has been done in focus of how it will be considered in the real world. The intention is to present a study and a product that can be compared to products that is already out on the marked. I also present some related work in the industrial content to provide a place in the world for my research and product.

4 Methods

In this chapter I will present the methods and research on methods that I have and will use in my study. First of all I will present a description on what a literature review is, which is used for the first part of this thesis. Next I will present with the methods for data collection. I will describe the difference between the various methods, their names, definitions and explanation of why they are usually used in these sorts of settings. There will also be a presentation of good research ethics. In the end I will present with some definition and explanations of prototyping techniques that will be used in the designing of the app in this thesis.
Most of these methods are common for conducting research for collecting of data and therefore is used in my study for the best data collecting possibilities. The prototype

methods include the main methods of prototyping but also the mixed-fidelity technique presented earlier in this thesis, combined with other prototyping methods.

4.1 Literature review

In this thesis I present a literature review for the previous work that has been done in this field of research. A literature review is used for two purposes. First you use the literature review to explore literature to find an idea for a research topic and to identify where more research is needed. Secondly the review is used to present the topic of research. This is used as a method to support a claim of new material, that the work that has been done is worthwhile and not just repeated work of others. There is also possible to actually repeat work, but then it has to be a deliberate reason for this (Oates 2006).

4.2 Data collecting methods

4.2.1 Quantitative Data

Quantitative data means data based on numbers. This is a mostly used method of research for collecting data from experiments and surveys and the idea is to look for patterns and draw conclusions. Usually there are techniques used to visualise the data collected techniques as tables, charts and graphs (Oates 2006). This thesis only uses one method of quantitative data collection, a questionnaire, and I have used tables to present the findings.

4.2.1.1 Questionnaire

A questionnaire is designed as a pre-defined set of questions with a predetermined order. It is often sent out to a sample of people for answering to be returned to the researcher for analysing. This data collecting method is associated with the survey research method. There are two approaches for this type of data collecting; it can either be self-administrated or researcher-administrated. Self-administrated means that the respondent answers the questions of the questionnaire by them self and the researcher is not involved in the process until the answers have been sent in for analysis. Researcher-administrated means that the researcher asks the respondent the

questions one by one, and writes down the answers for them. This approach is more like a structured interview and can either be administrated over the phone or face-to-face. The questionnaire is a widely used data collecting method in research and is a good way to collect data from a big number of people. It is also a good choice if you only want brief and standardized data collected (Oates 2006).

4.2.2 Qualitative data

Qualitative data is all data collected that is non-numeric, this include; words, images, sounds etc. This method is mostly seen in interviews, case studies, diary writing etc. (Oates 2006). There is possible to present qualitative data in numeric form, but this is not always meaningful (Sharp, Rogers, & Preece 2011). There is also possible to use qualitative research methods to collect qualitative data, for example in my own survey where one of the questions was a comment field where the question was open to write comments and thoughts. This question will not be represented in the data collection since this was put in the questionnaire for the costumer and will not have any affect on the research I have been doing in this thesis.

4.2.2.1 Methods used in the design test

The design test was based on more than one data collecting method. This section will present the information on the qualitative methods and the next section will present more in detail the prototyping method that is used with the other methods to conduct the design test of the app.

The qualitative data collecting methods used in the design test was a mix of group-interview and observation. Interview is a qualitative data collecting method that has three approaches, structured, semi-structured and unstructured. The interview is a particular kind of conversation between people and is based on a set of assumptions we do not find in a normal conversation. These assumptions usually are that one of the conservationists, the researcher, is looking to gain some specific information from the conversation. Therefore this kind of conversations is often planned with an agenda to lead the conversation in the right direction. This kind of data collecting method is mostly used to obtain detailed information, ask questions that can be complex and/or open-ended, explore emotions, expressions and feelings that needs to be seen and

expressed in action, it is also sometimes used to investigate sensitive issues or personal information (Oates 2006).

As described over there are three approaches to conducting an interview, I will shortly describe how all approaches work to give a deeper understanding of how the interview process can be conducted, but the method I used in my thesis was a structured interview.

Structured interview: This approach uses a pre-determined/standardized layout for questions. This means that all the questions in the interview are determined before the interview starts and are identical for every respondent. The questions are red out loud and written down by the researcher. There are none conversation besides the questions, with maybe the exception of some clarifications. **Semi-structured interview:** This approach also uses a set of pre-determined questions and an underlying theme, but in an interview like this there is possibilities to change the order of the questions depending of the flow of the conversation and there is also the possibility to ask additional questions if the conversation brings up other issues than what is prepared for. **Unstructured interviews:** This approach is an interview conversation where the researcher has less control. Here you present the topic/issue and let the interviewees develop ideas and let them talk more freely. The interviewer take notes and tries to not interrupt to much (Oates 2006).

4.2.3 Research ethics

In every research case there is a concern of the people involved in the research. My thesis is no different and even though my research does not have much sensitive data collection, (the meaning of sensitive in this purpose is personal information; address, phone number, religion etc.) I have collected some and have had to take this into consideration.

The participants of my research have rights. These rights are:

- Right not to participate
- Right to withdraw

- Right to give informed consent; This means that if the person agree to participate they will only do so when they have been fully informed on the purpose of the research, how it is to be done and what their involvement in the research is.
- Right to anonymity
- Right to confidentiality

(Oates 2006)

In my thesis there are two cases of data collection. One is a questionnaire, second is a form of a group interview. Both of these cases has been conducted with the awareness of the participant and have followed the basic of these rights.

The questionnaire was delivered to the participants by social media, mail or a link to an Internet page. With this there was no possibility for me to ask for a written consent, but merely make it clear that it was voluntary to answer. The participants were informed that the data collected was for a master thesis and what the thesis was about. They were informed that all information collected would only be used for the theses and statistics for the company Time Park AS. All personal information (their email address) would only be used for sending them their prize for participation. They were also notified that it was voluntary to write down their email addresses.

In the design test of the prototype all participants were delivered a page with information on the test, which the participants could consent to. This described the prototype and the test and also what the information would be used for.

4.3 Prototypes in HCI

A prototype is used in the field of human-computer interaction (HCI) as a term to signify a specific kind of object used in the design process. It is seen as a tool to stimulate reflections and designers use them to frame, refine, and discover possibilities in a design space. This is actually different from an engineer's perspective where they use the prototype to identify and satisfy requirements (Lim et al. 2008). In this theses the focus is on the design process and so the prototypes have been used for this purpose.

Low-fidelity and high-fidelity prototyping is considered the two main prototyping approaches in HCI and prototyping literature. In the intent of making a middle ground between these two prototyping approaches researchers have tried to develop an approach they call mixed-fidelity (Sá & Churchill 2012). In this thesis I have tried this approach to see if this could help the participants to easier understand how the app actually would work. There is several ways to test a mixed-fidelity prototype, but I was interested in the participant's subjective feel of the prototype, and therefore ended up making a prototype that they could actually "use". This is also described as experienced prototyping.

4.3.1 Low-fidelity:

Low-fidelity prototypes are the first step in prototyping, and do not usually look very much like the finished product. The material used for making a low-fidelity prototype is mostly paper or cardboard and are usually drawings of how the design is intended too look like, some methods of this prototyping technique is storyboarding and sketching. This is how low-fidelity differs from high-fidelity prototypes. This is also a good way to start the design process because this technique is quick, cheap and easy to change (Sharp et al. 2011).

The low-fidelity prototype for this project was designed on paper. The idea of how the pages in the app should look like was drawn up to be presented to the customer, and to better have an idea of how to present the questions of the survey made for this project.

4.3.2 High-fidelity

High-fidelity prototyping is a prototyping technique that, in differ to low-fidelity, uses materials that would usually be in a final product. For example a software system or in this case a fully functional app. There are discussions on the subject of usefulness of high-fidelity since this is an expensive and time-consuming technique (Sharp et al. 2011). What I wanted to present as an end product of this thesis can be simulated in other prototyping techniques like in low-fidelity prototypes or a prototype technique

called mixed-fidelity, which will be further explained later in this chapter. But I wanted in this thesis to make a fully functional app that could be tested further (beyond this theses) in its intended setting. This is not something that could better be simulated by any of the other techniques.

4.3.3 Mixed-fidelity

Low-fidelity and high-fidelity prototyping is considered the two main prototyping approaches in HCI and prototyping literature. In the intent of making a middle ground between these two prototyping approaches researchers have tried to develop an approach they call mixed-fidelity. This is where you take aspects of both low- and high-fidelity prototyping approaches for a more visual and/or interactive prototype and a less time and cost consuming prototype, for example with a video of the product (Sá & Churchill 2012). In this thesis I have tried this approach to give the test objects a better understanding of the product, but I wanted to not just focus on the design, but also the feel of the design. So I have also used the method of experience prototyping to test my mixed-fidelity prototype.

4.3.4 Experience prototyping

Experience prototyping is basically the idea that a participant is meant to get an idea of how an artefact is supposed to work. It is a representation of an artefact, like any prototype, that designed to understand, explore or communicate what it might be like to engage with the design of the artefact. This can include design prototyping techniques such as storyboards, scenarios, video etc. This is very like any mixed-fidelity prototype, but in experience prototyping there is a focus on the methods that allow the participant to experience it for themselves rather than witnessing a demonstration. Experience is subjective, and therefore will an experience prototype maybe give a more subjective evaluation of a design (Buchenau et al. 2000).

4.4 Chapter summary

In this chapter I have presented a general discussion on the methods that I have used in this thesis to present, collect and conduct my research. I presented with a description of what a literature review was and data collection methods that will be

used in the design process of the app in this thesis. They were chosen based on their abilities for specific data collection possibilities in each stage of the process as the discussion provided insight on. I also presented with some information on research ethics and how this has been applied to my study. Lastly I presented with some prototyping techniques. Both commonly used and some new and lesser used from research. I will later explain as the design process is presented how these methods has been used in the development.

5 Data collecting and design process

This chapter will present the work I have done on the design development of the app. I will step by step take you through the process of the data collecting, the making of the requirements, the making of the prototypes and the testing of the app. First I will present my first data collection from users (or potential users) a questionnaire. I explain how this questionnaire was developed and present with the questions that were asked. After this I will present each question with the answers that were given by the respondents. Before I start presenting the prototypes I will also give a brief explanation of all the prototypes together to show the difference of each stage of the development. After this I present the first three prototypes and explain how each was developed and what the uses of them were, here I will also present some design tools that was used to develop and present the prototypes. Next I present the user test of the last prototype. I explain how the test was conducted and what methods were used to develop it; I also present the questions that were asked each respondent. In the end I will present each question with a summary of the answers that were given by the respondents in two sessions.

5.1 Questionnaire

As described earlier in the thesis a questionnaire is a method for collecting data. My questionnaire was developed to collect information about the interest for the development of my product. I felt it would be necessary to investigate if my idea even was an interest with car owners. It was also used to collecting data for a list of requirements that would be needed for the design of the prototypes.

Time Park and APX systems helped in this department to deliver my survey to my target audience. My survey was delivered to all of VIZUM clients e-mails, on cars on one of the airports where Time Park own the parking and was shared on social media (specifically on Facebook). The VIZUM clients are known owners of cars and are already in an easier parking program, I also wanted to target a group of people who was not certain to own a car or even had connections to the VIZUM program. This way I could get an idea of the interest of my product from both targeted audience and other car owners. This is why I made the same survey for both groups and analysed the results separately.

5.1.1 The questionnaire and findings

Translated from Norwegian.

Question 1 (answer required): Do you own a car, or have access to another person's car?
Question 2 (answer required): If there was developed a product, which made it possible you to book a parking space, is this something that you would use?
Question 3 (answer optional): When do you think it would be relevant for you to use this product?
Here the subjects were asked to check for the most relevant places for them.

- When you are traveling
- When you are going to a meeting
- A busy day at the mall
- A regular day at the mall
- A trip to the city
- To work
- Other: write your own comment

Question 4 (answer optional): This kind of reservation will cost money beyond the regular parking fees (a fee for holding the parking space). What is the largest amount you would pay for this product?
Question 5 (answer optional): In which way can parking be made easier for you?
This question is not that relevant for the thesis, but was relevant for the parking

company Time Park AS. In the answers the test subjects actually gave me some useful ideas that were implemented in the app.

Last we asked for the subjects e-mail addresses. This was optional and was so we could send the subjects a thank you for participating. All the subjects who gave their e-mail address were sent a ticket for a week worth of free parking.

5.1.1.1 Survey 1: VIZUM and airport subjects

186 people answered this survey. The questions and answers were translated form Norwegian to English in this representation.

Question 1 (answer required): Do you own a car, or have access to another person's car?

Figure 3: Questionnaire 1 - Question 1

This question in the survey was required for the respondents to answer. If any respondents answered that they did not have any access to a car they would not be eligible for this study and would not be able to answer any more of the questionnaire.

This was enforced so that all the data collected would be from respondents that owned a car.

Question 2 (answer required): If there was developed a product, which made it possible you to book a parking space, is this something that you would use?

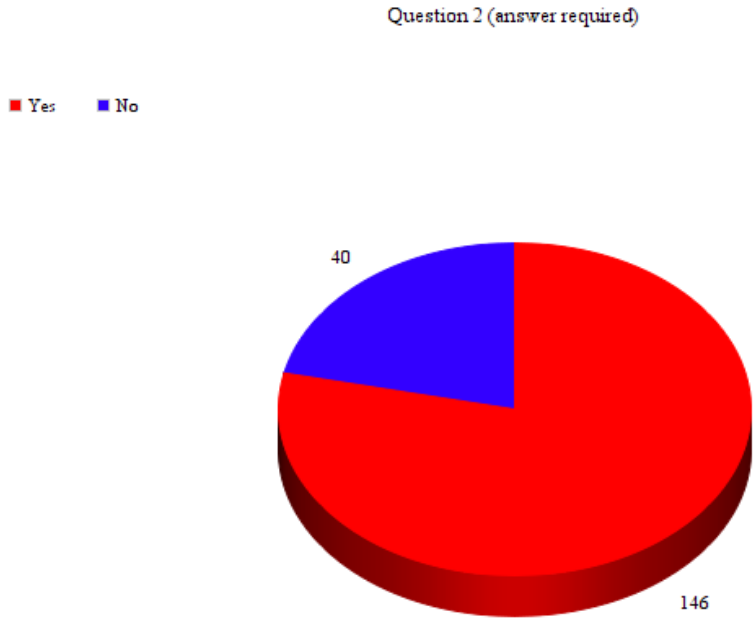

Figure 4: Questionnaire 1 - Question 2

This question also required an answer from the respondents. This was because if any respondents did not think this was an interesting artefact they would be done with the questionnaire. There were 40 respondents to this questionnaire that did not want to use this kind of artefact. These respondents were then done with the questions and would not be counted for the nest part of the questionnaire.

Question 3 (answer optional): When do you think it would be relevant for you to use this product?

Here the subjects were asked to check for the most relevant places for them.

- When you are traveling
- When you are going to a meeting
- A busy day at the mall

- A regular day at the mall
- A trip to the city
- To work
- Other: write your own comment

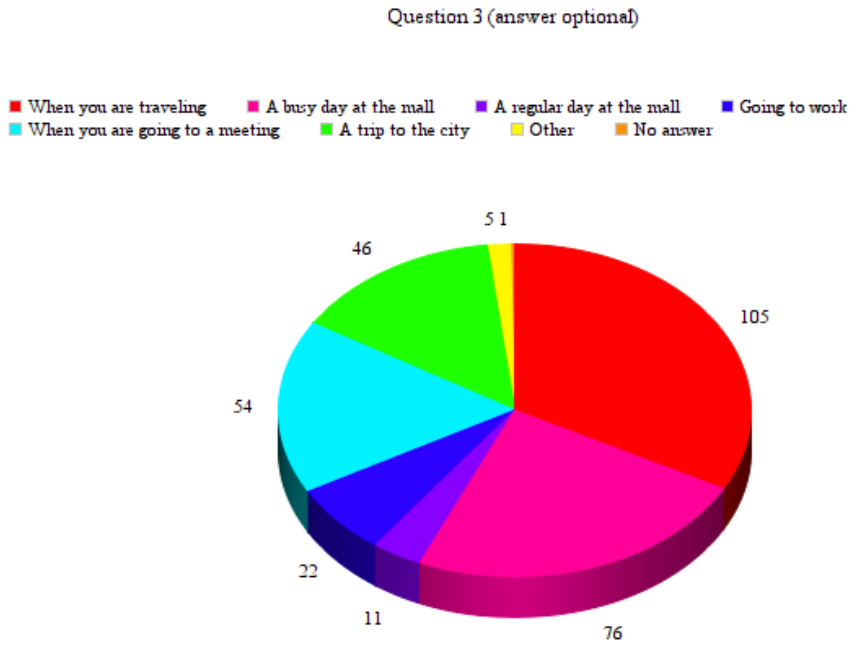

Figure 5: Questionnaire 1 - Question 3

This question was optional for the respondents. The sole purpose of this survey was to collect the data on and to see if there was an actual interest with car owners for this artefact. This question and the next ones are more for collecting information for some aspects of the app and to get an idea of what the respondents wish form an app like this. This question was also a multiple-choice alternative question. So the respondents could check boxes for more than one alternative. The graph over represents how many checks each alterative got in total.

Question 4 (answer optional): This kind of reservation will cost money beyond the regular parking fees (a fee for holding the parking space). What is the largest amount you would pay for this product?

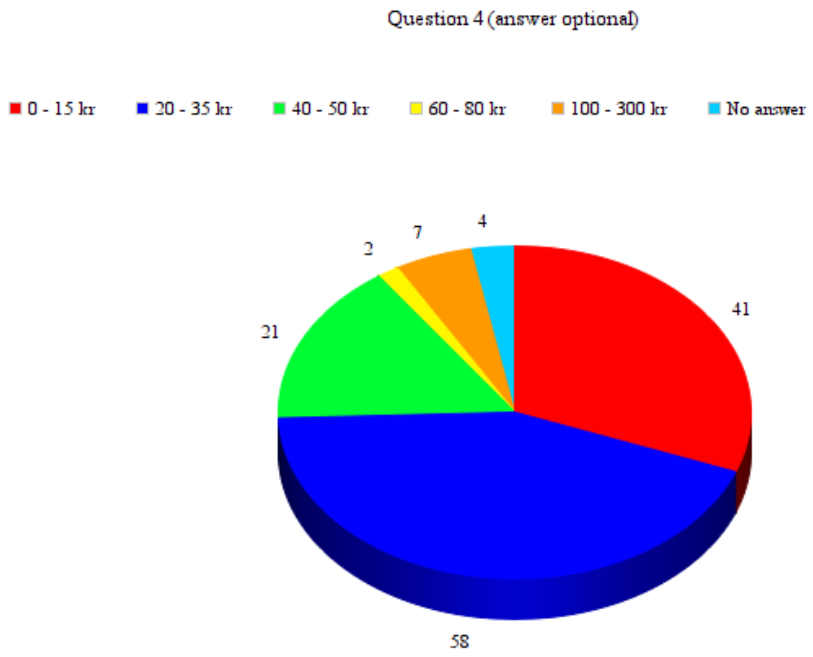

Figure 6: Questionnaire 1 - Question 4

This question was presented to the respondents for the purpose of getting an idea of how much money this could cost. This was so that I could know how simple or how extravagant I could be in the planning of the development of the app. In this question the respondents could write in any number they felt comfortable with paying and the graph over represents collections of what they wrote.

5.1.1.2 Survey 2: Social media subjects

100 people answered this survey. The questions and answers were translated form Norwegian to English in this representation.
This survey was designed a bit differently than the last one, because of some restrictions in the design of the service used and with this there was a possibility to see if there also was any interest for this app amongst people who did not own a car. This survey would not stop for the respondents that answered no on the first two questions, but was told to answer the first two questions and not the rest of the questionnaire.

Question 1 (answer required): Do you own a car, or have access to another person's car?

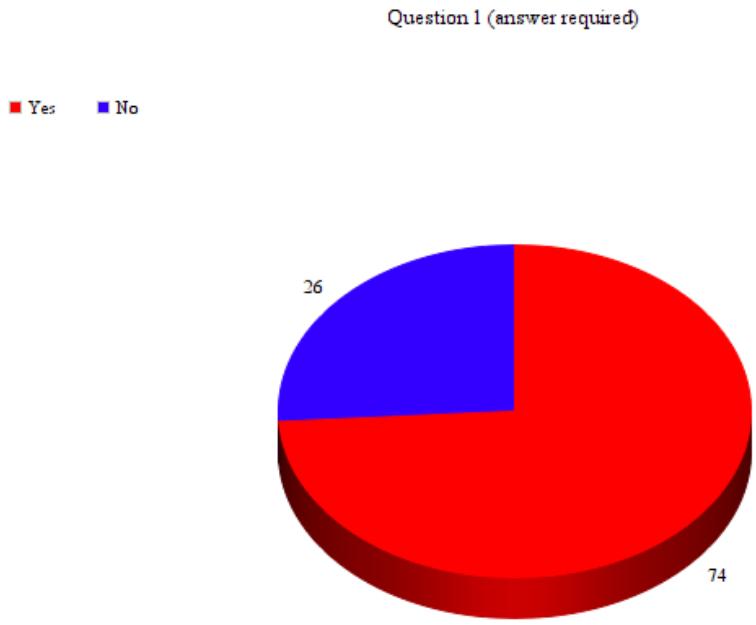

Figure 7: Questionnaire 2 - Question 1

This question was required for the respondents to answer. This questionnaire was, as described earlier, different from the one for the VIZUM costumers. Here the respondents were able to move further in the questionnaire and respond even though they did not have any access to a car.

Question 2 (answer required): If there was developed a product, which made it possible you to book a parking space, is this something that you would use?

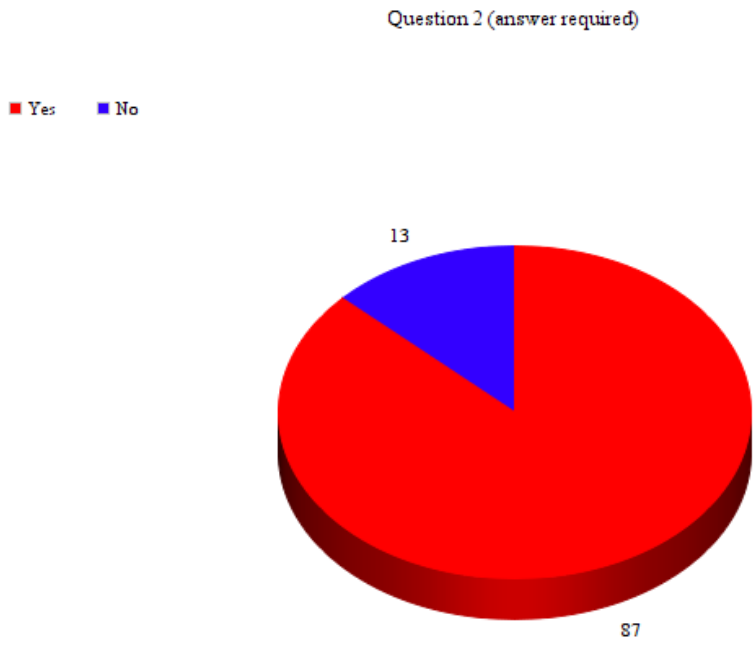

Figure 8: Questionnaire 2 - Question 2

This question was also required for the respondents to answer. We can see in this graph that there are actually some of the respondents who do not have access to a car that could be interested in this application. This is information that we did not have access to in the last questionnaire and can be seen as an interest beyond our user group.

Question 3 (answer optional): When do you think it would be relevant for you to use this product?

Here the subjects were asked to check for the most relevant places for them.

- When you are traveling
- When you are going to a meeting
- A busy day at the mall
- A regular day at the mall
- A trip to the city
- To work
- Other: write your own comment

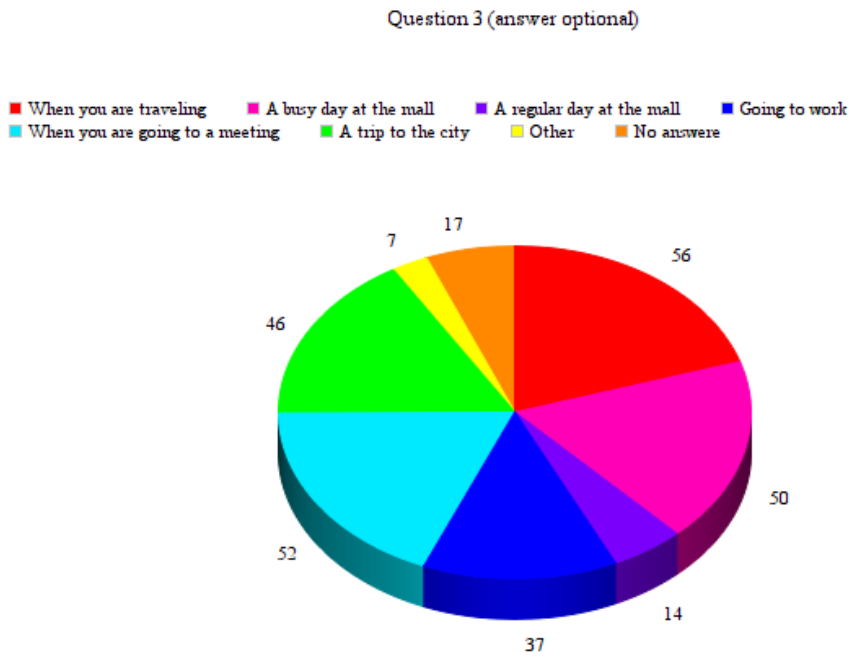

Figure 9: Questionnaire 2 - Question 3

This question was optional but only 17 people skipped it. This was also a multiple-choice question and the respondents could check more than one box. This question was to get an idea of where the respondents would use the app and if it was interesting enough to actually be used in several situations. Like in the previous questionnaire there are some locations that have more interest than others, but there is interest in use in all of the suggested locations. This gave us the basis of the design of an artifact that could be used in all of the parking lots and not just for specific parking groups.

Question 4 (answer optional): This kind of reservation will cost money beyond the regular parking fees (a fee for holding the parking space). What is the largest amount you would pay for this product?

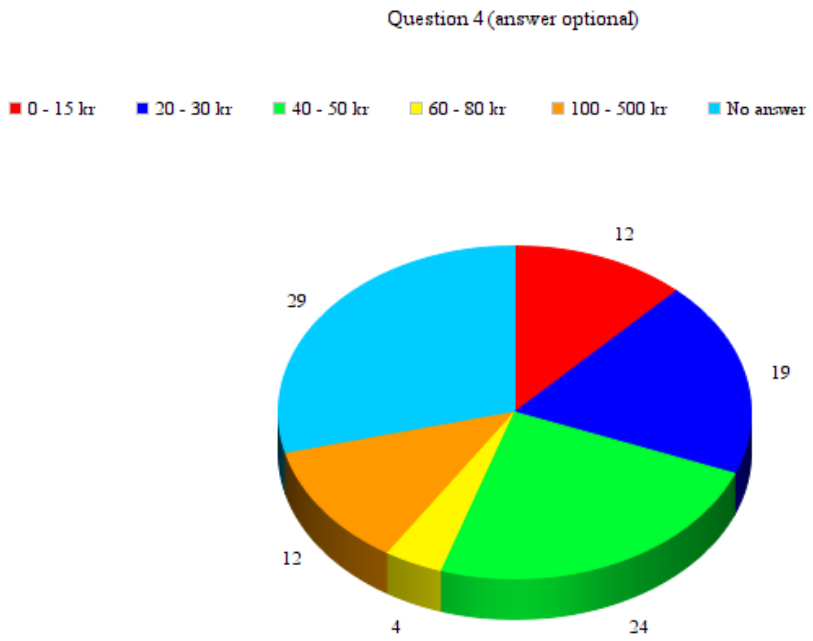

Figure 10: Questionnaire 2 - Question 4

This question was to get an idea of how much people were willing to pay for the app. This could give us an idea of how much recourse that was needed for the development and how much the respondents expected of this app. There were 29 people who did not answer this question, but we still got an ide of the expectations of the respondents.

There was also one last question in both questionnaires asking the respondents to write down what they would want in an app like this. This question gave a lot of responses. This question was presented to give the respondents an opportunity to give some insights from their perspective and also for me to get some ideas for what the user group would want to have in this kind of app. I decided to not include all of the answers in this thesis. Because not all of it will be used in the design process and there are almost 200 responses to this question. I will present the point that made an impression and were used to formulate the requirements. Many of the respondents asked for a page in the app to show the demand of the parking lots. How many is parked in the parking lot at one time of the day and so on. There were also some who said they would use this if it was very simple and was not to difficult to use. They wanted to easily understand where they could use it and that it would not take to long to use.

5.2 Design requirements

The requirements for this project was constructed in a meeting with the client, Bo S. S. Bakke from Time Park AS and the managing director of the development team, Jan Erik Evanger from APX Systems AS (In the offices of APX systems AS, 18.02.15). These requirements were developed for the design and development of the prototypes and were constructed with the questionnaire responses, customer wishes and a general idea that I had of how the design should look. There were also used usability goals to define what it was that we wished for this app. Usability is the term that describes that interactive products are easy to learn, effective to use, and also enjoyable for the users (Sharp et al. 2011). These usability goals will later in the thesis be presented and answered with examples form the last prototype.

- The app should be able to let the user search for areas and addresses for parking spaces and show a list of the search results.
- The app should be able to give basic information on a parking space such as: name, address, area and if there are free spaces for parking.
- The app should be able to reserve a parking space for the user.
    - The app should be able to reserve parking space ether from specific time or right away.
    - The app should be able to generate information to the user on where and when the parking space is reserved.
- The app should have a favourites page where users can list their most used parking spaces.
- The app should reflect the company Time Park AS in design.
- The app could have a demand page that shows the user how many have parked on one parking area in the last hours.
    - The app could have a demand page that also shows the user how many have parked in a parking area in the last week.
- The app could have an log in page
- The app could have a page that shows the reservations that have been done in the app.

This is the original set of requirements for the app. They where during the prototype and development process changed some what, but this will be further described and discussed in this chapter. The requirements that says "should" is the requirements that are vital aspects for the design and development and the requirements that says "could" are aspects that is wanted but is not vital. The requirements were designed from what the customer wished in their application and by what respondents to the questionnaire gave as responses to the last question. The last question of the questionnaire is not represented in this thesis because there were almost 200 responses and not all of them were fitting for this kind of project, but some of their responses were and these have been listed in the requirements. Many respondents said that what they wanted in an app like this would be that it was simple and would not have many attributes. Many also asked for addresses for their GPS, or that the app it self had a GPS function. There where also some who was interested in I demand page in this app, this meaning that they could see how many cars which had parked on one specific parking lot that day fro example. We tried to consider all the wishes of the respondents but also stay in focus of the main issue of the development, the reservation.

Table 1: Summary of the prototypes

	Level of fidelity	Presented for users	Basic description	Possibilities for interaction
Prototype 1	Low-fidelity	No	Paper-based simple representation. Missing a lot of requirements.	No
Prototype 2	Low-fidelity	No	Computer-based simple representation. Missing some requirements.	No
Prototype 3	Mixed-fidelity	Yes	Computer-based pictures with hyperlinks to interact with. Missing none requirements.	Yes
Prototype 4	High-fidelity	No	Developed working app. Missing one requirement.	Yes

5.3 Prototype 1 – low fidelity

As described earlier I have chosen to use several approaches for prototyping development and started with a low-fidelity drawing of how I imagined the app to look like. These drawings do not represent all of the pages of the app, but more of a representation of how most of it would look like. This prototype was made so that the customer easier could imagine what was made for them so they could comment on positioning and color choices. The idea of the app is based on Time Park's slogan, which is "Easier parking". With this I wanted to make the app as simple as possible, with the use of strait lines, minimum of text and colors that a user easy could relate to. The colors are based on the Time Park logo and white, red and green was used as representation for parking lots that are "full" or "free". These were chosen from the idea of a traffic light. Traffic lights are universal and is based on that when the light is green you can drive and when it is red you have to stop. I thought by using colors that were already used in in the world of cars it would be easier for the user to understand without much explanation.

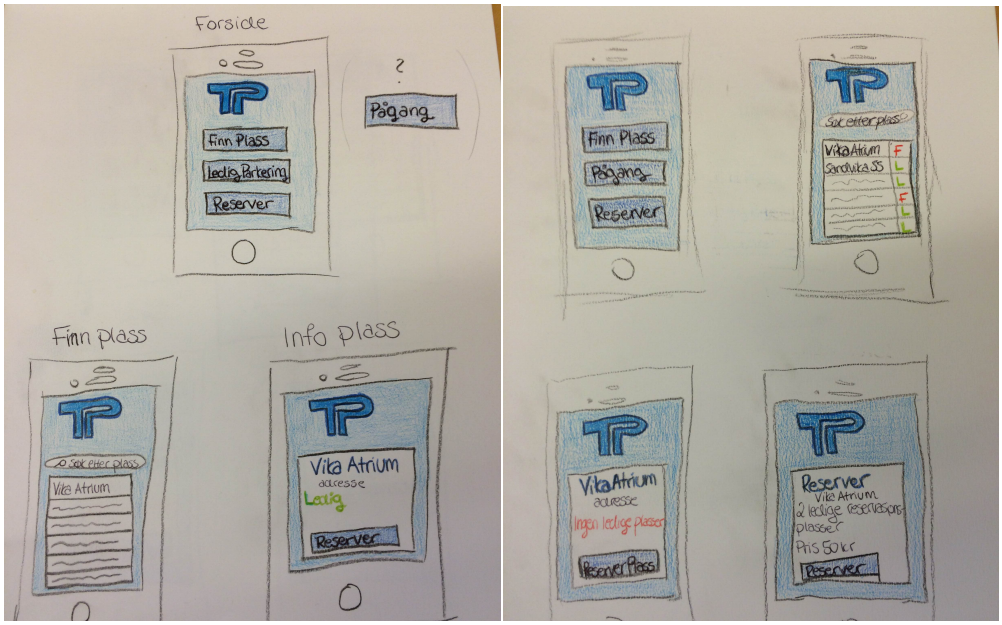

Figure 11: Prototype 1 - low-fidelity 1

This prototype do not include as said all aspects of the requirements, but since I was working with an industrial costumer I wanted to give them an outline of the basics

before starting the process of the detailed design. This representation describes the basics and vital aspects of the requirements.
For bigger representations of Prototype 1, see attachment A.

5.4 Design tools

5.4.1 Photoshop

Adobe Photoshop is a photo editor tool used mostly for editing photos, but can also be used to make designs. This tool was developed by Adobe for windows and OS X computers (Adobe Photoshop 2015).

5.4.2 Illustrator

Adobe Illustrated was developed in the same manner as Photoshop, but this tool was constructed more for design purposes. This tool is a vector drawing program and is mostly used for drawing illustrations, logos, diagrams etc. (Adobe Illustrator 2015). By combining these two programs I could draw boxes, decide right colour balances and put them all together in one picture. It was important to me that I could make a design that was as close to the actual app as possible for testing and I believe these tools made that possible.

5.4.3 InVision

InVision is a tool used for making more interactive prototypes. This is used with the designs I made in Photoshop/Illustrated and puts every page together to show how the app would look like. The idea is to set up each page with hotspots witch then will link to other pages in the app. This would make it easier for a user/tester to understand what would happen if they pressed a button or a place on the screen (InVision n.d.).

I set up the pages of the design in InVision and made hotspots for every button or clickable object in the app and downloaded the InVision app to my phone. With this the design of my app was shown on a phone screen and had “clickable” buttons and objects ready for users to try. This will be further described in the section about the design test. For the design development of the next prototypes I will have used Photoshop and Illustrator for the representation of the prototypes.

5.5 Prototype 2 – low-fidelity 2

Figure 12: Prototype 2 - low-fidelity 2

This is the second of the two low-fidelity prototypes and is actually just the first prototype designed on a computer with the design tools Photoshop and Illustrated. This prototype was meant to be mixed-fidelity and tested on users but, after this was made the customer decided they wanted the app to be associated with VIZUM and not the company it self. This is when VIZUM was implemented in the design of the app. This design is based on the vital requirements listed and not so much the "could" part of the requirements, except for the demand page. After the decision was made to change the design, there was no point in including the rest of the requirements and therefore never made it to this representation.

For bigger representations of prototype 2, see attachment B.

5.6 Prototype 3 – mixed-fidelity

Figure 13: Prototype 3 - mixed-fidelity

This mixed-fidelity prototype was changed in several ways from the original design and is also the prototype, which would be tested on users. The customer wanted this apps design to collaborate with the VIZUM system, which was the basis of the technology of this app in the first place. With this the design changed. The colours had to match the logo of the already existing system, therefore the app is now blue, yellow and white. The colours of the free and taken parking spaces still use the traffic light system from previous design. Also the logo of VIZUM did not have the same soft edges as the Time Park logo, and I therefore chose to design the boxes to match this. So this app does not have rounded edges. In the design of this prototype I used the same design tools as in the computer-based low-fidelity prototype, Photoshop and Illustrated. The purpose of a mixed-fidelity prototype is to bridge the gap between the low- and high-fidelity prototypes to try and find a way to more efficiently test the design (Sá & Churchill 2012). This is where I introduced the InVision app as a design tool and a part of the method to conduct my design test. This tool made it possible for me to take a low-fidelity prototype and present it as more interactive than a basic picture. The InVision app presents the pictures in its order and gives the pictures hyperlinks that leads them to the next step (picture). In this way any test subjects can interact with the app in a way that is beyond the abilities of an low-fidelity prototype but is not as consuming to make as a high-fidelity prototype. This is how I was able to conduct my design test, which contained an experienced prototyping session followed by a group interview.

For bigger representations of prototype 3, see attachment C.

5.7 Design test

The design test of this thesis combined the methods of group interview and experienced prototyping.

Experienced prototyping as described earlier in the thesis, is a prototype made to give an user the opportunity of a prototype they can interact with and that gives the user the feeling of the works of the artefact. With this method I used the InVision app to present to the users the design of the app. Every user either had this app on their phone or used my phone to test the design.

The interview and testing was conducted in two sessions. Session one was with 6 people from the age between 18-25. None of these test subjects had tried VIZUM before joining this test. Session two was with 5 people from the age between 29-45. All of these test subjects were VIZUM users before this test. I wanted two different age groups in this design test to get the input form two different driving groups and I also wanted to see if the interest for this app were different between groups of non users and users of VIZUM.

The sessions were conducted where we started with the testing of the app. All the member of the group was given time to explore the design and make up an impression of the app. After this there would be an open discussion on what they thought about the design and the feel of the app. The interview of this session was a structured interview. This is a pre-determined set of questions that will be identical for every interview object (Oats 2006). The members of both sessions were after testing and discussion handed these questions for answering.

Translated from Norwegian

Question 1: How was your user experience of this app in general (was it ok? Was it anything annoying with it? Did you have a good of bad experience with it?)?

Question 2: Is it easy to understand what this app is for?

Question 3: Is it easy for you to understand which buttons to push to get to where you want to go?

Question 4: Is there anything with this app that is hard for you to understand?

Question 5: Is there anything with this app that you feel is unnecessary or superfluous?

Question 6: Is there anything, which is not represented in this app that you wish would be in it?

Question 7: How do you generally feel about the design of this app (was it ok? Was it anything annoying with it? Did you have a good or bad experience with it?)?

Question 8: Is everything easy to see (for example the buttons)?

Question 9: Do you feel the colors used fit this app?

Question 10: Is there anything with this design that you feel is unnecessary or superfluous?

Question 11: Is there anything, which is not represented in the design that you wish that was there (colors, placements, buttons, information etc.)?

5.7.1 Session one

This session was conducted 25.08.15. The six test subjects were collected from a shopping mall in Bærum, Akershus. These test subjects were selected based on two sole purposes, their age and that they had never used the VIZUM system before.

The test subjects were given the app to explore and had an open discussion afterwards on their experience. They were told before the interview that we wanted their honest opinion on the app and their suggestions on how in their opinion it could be different in a better way. I hoped that this test could give me an idea of how the app is experienced by users and maybe develop the app further to include something they feel that this app should have. If the test subject was unsure of something or had any questions I wanted them to write it down. Most of their questions were answered during the discussion, but this was interesting for me to try and answer in the app design. Below follows a summary of what all the respondents from session one had to say.

Question 1: How was your user experience of this app in general (was it ok? Was it anything annoying with it? Did you have a good of bad experience with it?)?
Four of the test subjects had a good experience with the app generally, one had an ok experience and the last one did not categorize it as good or bad.

Question 2: Is it easy to understand what this app is for? All six felt that it was easy to understand what the app was for. One suggested that it might have been smart to have an information page to explain the app for new users.

Question 3: Is it easy for you to understand which buttons to push to get to where you want to go? All the test subjects felt that the app was easy to navigate.

Question 4: Is there anything with this app that is hard for you to understand? None of the test subjects felt that any aspects of the app were difficult to understand.

Question 5: Is there anything with this app that you feel is unnecessary or superfluous? Five of the test subjects said that they did not feel that there was anything unnecessary with the app. There was one test subject that did not write his answer down for this question and therefor his answer will not be considered here.

Question 6: Is there anything, which is not represented in this app that you wish would be in it? Two of the test subjects did not have anything they felt was needed in this app besides what was there. One wanted information on how she could get help if something unforeseen happened with here assigned spot. One answered this question with another question, and also missed some information on how everything works and prices. One said yes that it was something that he was missing and that was a button for nearby alternatives. There was one test subject that did not write his answer down for this question and therefor his answer will not be considered here.

Question 7: How do you generally feel about the design of this app (was it ok? Was it anything annoying with it? Did you have a good of bad experience with it?)? Two test subjects felt the design was very nice. Two test subjects felt that the colours were a bit strong and one felt that it looked a bit unprofessional. All through the test subjects gave an impression of that the design was perfectly fine but did not give any big impression.

Question 8: Is everything easy to see (for example the buttons)? All the test subjects felt that the ascetically every thing was easy to see.

Question 9: Do you feel the colors used fit this app? On this question there were very different reactions. Two of the test subjects felt that the colours were too strong.

One felt that it was just ok. Three felt that the colours was good and said that it fitted the paring theme, fitted the app and that it was pleasing to the eye.

Question 10: Is there anything with this design that you feel is unnecessary or superfluous? Five of the test subjects said that there was nothing unnecessary with the design of the app. One felt that the bright colours were unnecessary and that it should look more modern.

Question 11: Is there anything, which is not represented in the design that you wish that was there (colors, placements, buttons, information etc.)? One respondent felt that maybe the logo of the parking company should have been more visible so people could know where this app can be used. Two would have liked to see the app in different colours. One wished a help button and another wished a location service button to search for parking.

5.7.2 Session two

This session was conducted in the same manner as session one and these subjects were given the same information and requests as the others. This session was conducted 28.08.15 and the test subjects were collected from the existing pool of the VIZUM costumers. This session was designed to collect data from respondents that already had an insight to what this system provides. This was done to collect data on user experience just as session one, but to also see if there was any difference in the experience between the respondents from each sessions. Below follows a summary of what all the respondents of session two had to say.

Question 1: How was your user experience of this app in general (was it ok? Was it anything annoying with it? Did you have a good of bad experience with it?)? Four out of five gave the impression of that they all had a good first experience with the app, and one categorized it as ok.

Question 2: Is it easy to understand what this app is for? All the subjects said that they easily could understand what this app was meant to do.

Question 3: Is it easy for you to understand which buttons to push to get to where you want to go? All the subjects said it was easy for them to understand where you were supposed to go in the app to where they wanted to go.

Question 4: Is there anything with this app that is hard for you to understand? None of the subjects felt they had any problems with understanding how to use the app.

Question 5: Is there anything with this app that you feel is unnecessary or superfluous? Four of the subjects had nothing to comment on this question. One of the subjects felt that he was scared to accidently push the home button during the reservation part of the app and wondered if that was maybe something that could be hidden during that particular process.

Question 6: Is there anything, which is not represented in this app that you wish would be in it? One subject suggested that we used location services in the app to locate nearby parking spaces, one suggested a button for automatic log in, one suggested information on what to do if your assigned parking space is occupied, and the last two had nothing they wished to add at this point.

Question 7: How do you generally feel about the design of this app (was it ok? Was it anything annoying with it? Did you have a good of bad experience with it?)? All the subjects felt the design was good and easy.

Question 8: Is everything easy to see (for example the buttons)? All the subjects felt everything was easy to see end find in the app.

Question 9: Do you feel the colors used fit this app? All the subjects felt the colors fitted the app, but one felt it reminded her a bit of the Swedish flag.

Question 10: Is there anything with this design that you feel is unnecessary or superfluous? None of the subjects felt they had anything more to add at this point; one referred to his answer in question five, about hiding the home button.

Question 11: Is there anything, which is not represented in the design that you wish that was there (colors, placements, buttons, information etc.)? Four had

nothing they felt was missing in this stage. One felt that it should be an cancel button for the reservation in case someone made a mistake or pressed the buttons too quickly. He also posed some questions on the limitations of the app and that this maybe could be explained in the app.

This design test was conducted after the design of the app was ready. This gave me the opportunity to investigate if the requirements for the app were good enough before starting the development of the high-fidelity prototype. I also wanted to see if the subjects of the test could give some pointers to what other needs they would have added to this kind of application.

5.8 Summary

This chapter has presented you with the findings of my questionnaire and my user test. I have also presented you the course of the design development of the app from the low-fidelity prototype method to the mixed-fidelity prototype method. First the questionnaire was presented, how it was conducted and the answers from the respondents. After this the design requirements of the design development was presented with an explanation of how these were used in the process. I also after this presented a brief explanation of all the prototypes developed in this thesis and how they differ from each other. Next the three first prototypes and design tools where presented. Here an explanation was given on how and why the prototypes where made. In the end of the chapter the user test (design test) was presented. Here there was presented a description on how the user test was conducted and what methods were used to conduct it. After this a summary of the answers for the respondents of each session of the user test was presented. The tests were conducted to collect data for the design development, but I also wanted to investigate issues and limitations of the app in the sense of my study. The next chapter will present you with evaluations and discussions of my findings in this chapter.

6 Results and analysis

In this chapter will present the result of the design process. I will present the last prototype that was developed in this process and describe the design as a result of my

design development. I will also present the usability goals I set for this design process and use the user test and the last prototype to answer the questions asked in the usability goals.

6.1 Prototype 4 – high fidelity

Figure 14: Prototype 4 – High-fidelity

This high-fidelity prototype is the result of the design process conducted in this thesis. This prototype includes aspects from every step of the way, and has also some new aspects that were applied after the user testing of the last prototype. First the demand page is not included in this representation; it is not deleted from the app. There was clearly a wish from subjects from the questionnaire that this was included in the app, but alas the technology for this specific wish is not yet fully developed. For future development this can again be included when the technology is ready. Second there were wishes from several test subjects to include more information and one that suggested a button to cancel a reservation.

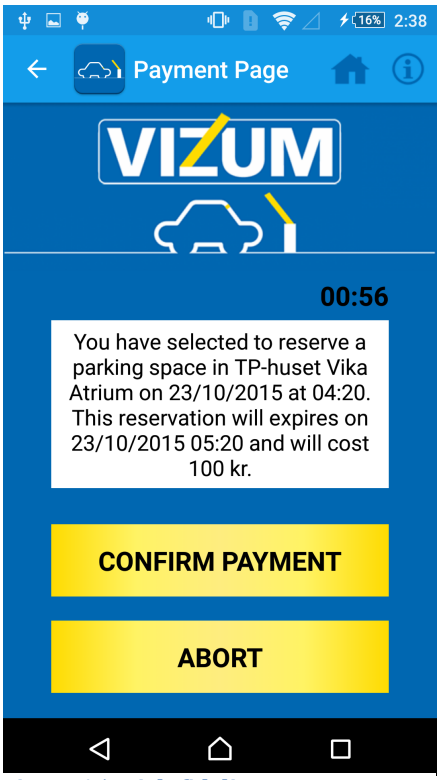

Figure 15: High-fidelity prototype – Reservation summary

Figure 15 is called the "Reservation summary". This page of the app takes in to consideration that the user may need the possibility to decide if they want to go further and pay for the parking space or if they want to abort the reservation. They are given one minute to decide. On this page the user is also presented with information on their reservation such as, where, when, the cost and the time and date of expiration of the reservation they are about to make. More information on whom to call and what to do if something unforeseen happens is presented in the information button (the "i" in the upper right corner).

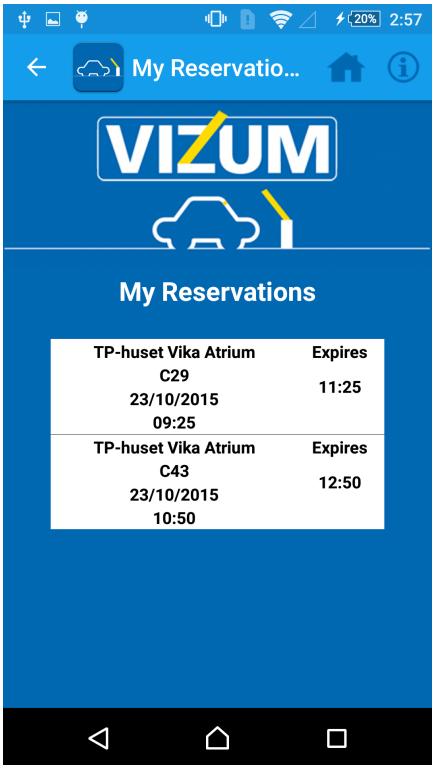

Figure 16: High-fidelity prototype – My Reservations

Figure 16 was not specified directly by the test subjects but was included also on the basis of the suggestion of more information on the app. This page just gives the users the option to have more

control over the reservations that have been made. This can be useful for users that have several reservations at one time or for those who have reserved a spot some time in advanced. The page lists the reservations that are active and present the user with information on which parking lot and space that is reserved and also time and date of the reservation. It also gives the time of expiration on the reservation.

The app also was designed to include that it would remember one user's login information for 6 months at a time. This is not represented in the design, but was a suggestion from one of the test subjects and therefore was seen as an important part to the user experience of the app.

For bigger representations of prototype 4, see attachment D.

6.2 Usability goals

Usability is the term that describes that interactive products are easy to learn, effective to use, and also enjoyable for the users. It is the efforts of optimizing interactivity so the user can carry out their everyday lives with the interactive product. Usability can be divided in several goals for designing. These goals are usually described in questions that the designer will answer during the design process. By answering these questions the designer can be alerted to problems and conflicts (Sharp et al. 2011). I will here present the definition of every usability question, my goals for the design process and a description on how this is represented in the app and if the design test conducted helped in giving an users perspective on if these goals are met.

1. Effectiveness – this is a very general term, but describes how good a product is at doing what it is supposed to do.
    a. The question for the VIZUM app was: *Is the app capable of allowing users to reserve parking spaces, search for parking lots, and access the information they need to make a decision for reservation?*

The app fulfils the demand of being able to reserve a parking space for the user and provide needed information on the reserved space as shown in figure 17. The app also allows the user to search for parking lots and have an information field (also shown in figure 17) for how to contact support and descriptions on the use of the app (this will

not be included in the prototype that I present here, because the text is not yet written, but will be done before further testing). The app has as few components as possible to make it work as it is supposed to do and with this it should be easy to learn. The majority of the test subject from the design test stated that the app was easy to use and understand.

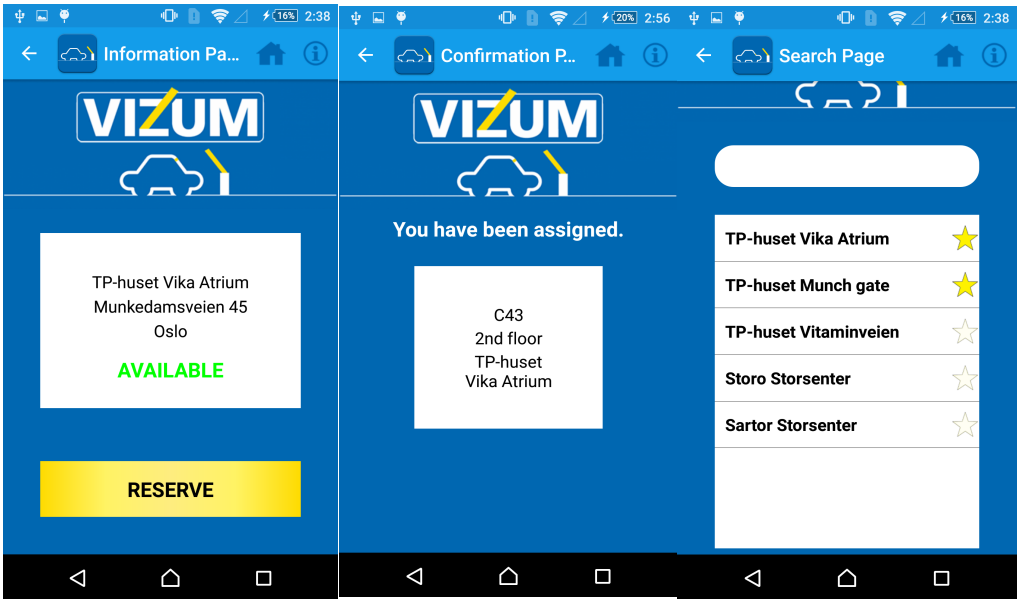

Figure 17: High-fidelity prototype – Reserve a parking space/Reserve confirmation/Find parking

2. Efficiency – this term describes how a product can support users in carrying out their tasks.
    a. *Once a user have learned how to use the app is there a high level of productivity? Will this app be easy and quick to use for the users?*

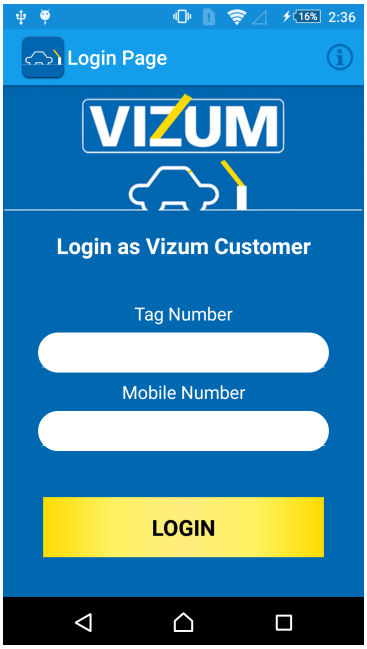

Figure 18: High-fidelity prototype – Log in

The bottom line for the design of this app was that it was supposed to be easy to learn and use. The idea is that a user is supposed to use this app not only in advance but also as a tool in the moment. There are not many components to this app and I feel the efficiency is as optimal as possible considering the steps that have to be taken to reserve a parking space.

First I can point out the **log in,** which is sown in figure 18: Here a user is expected to log in to their VIZUM account through a phone number and the tag number of

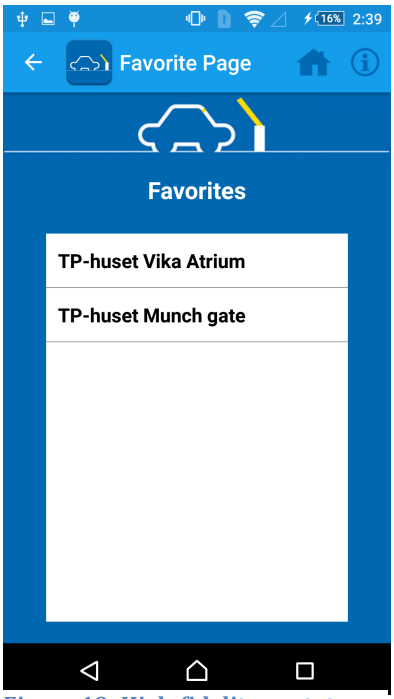

Figure 19: High-fidelity prototype – Favorites

their RFID-chip. When this process I finished the app will remember this login for 6 months. With this the user will not have to log in every singe time they use the app.

The **favourites page** (shown in figure 19) lets the user save their most used parking lots so that for next reservation they do not always have to search for the parking lots.

The app is supposed to be easy to learn and with the small number of components in this design there should be easy for the user to use it efficiently once the learning process is over.

3. Safety – This term describes the measures considered to protect users against dangerous or unwanted conditions and situations.

   a. *What errors are possible to happen during the use of this app and what measures can we take to prevent or to make it easy to recover from the errors?*

The app actually presented it self with some unwanted situations and some possible unsafe data collecting. This we have to take in to consideration. Some problems were easy to predict. The payment for the reservation for example was an aspect to consider. Luckily this was not a hard fix. The VIZUM-program already operates with payment for parking and has set up a payment service with PayEx. PayEx is a payment service, which is well established in Europe (PayEx Group 2015). Whit this system we had an easy access to include in the app and we could ensure the users safety considering their cards and payment information. The next issue was the **log in page** (see figure 18)**.** Here we had to consider more than just safety, such as log in information that also had to be easy to remember. With this the app firstly was designed to use the username and password delivered to all VIZUM costumers, but this was actually not numbers and letters that were easy to remember. The final prototype therefore was set to have log in with a telephone number and a chip number. This ensures security for personal information, since these are two things that is not secret information.

4. Utility – This term describes how the product provides the right kind of functionality so users can actually do what they want and need to do.
    a. *Does this app provide the appropriate set of functions needed for the users to perform the tasks of the app as is needed.*

This term is difficult to know for sure, but this is why a design test was conducted to see if the functions and the design of the app were understandable for the users. The subject of the study mostly gave the impression of that the app was easily understandable and that the functions of the app took you to where you wanted to go (see chapter 5). There were also some comments on other aspects of the app that could be introduced to make the app better most of these would not improve the utility of the app, except the comment on more information. As said before this part of the app was not yet ready for the design test, but on test subject gave me an good impression of what more than just information on the app that could be included in the information page. This will absolutely improve the utility of the app and will be taken in to consideration during future work. The app as it is now has simple, big buttons to steer the user in the right direction. The main theme of the app is the reservation part of it, and this is what the users are manly supposed to use the app for. I think this is clear and that the app has the appropriate set functions for the user to do this action (see figure 20).

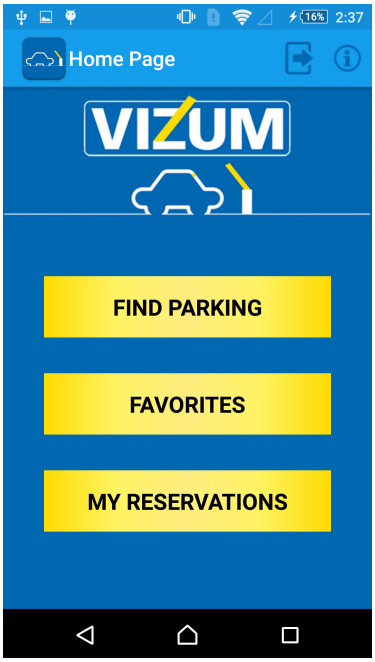

Figure 20: High-fidelity prototype – Home

5. Learnability – This term describes the ability of the product to be easy to learn.
    a. *Is the app as it is easy to learn just by exploring the functions and trying out buttons*? *Is it possible for the users to learn how to use this app without explanations?*

This part of the usability goals was one of the things all the test subjects seemed very certain of. All of them had little discussion on this part of the test and concluded on that it did not take them long to feel confidant on how to work the app.

6. Memorability – this term describes how easy it is to remember how to use the product. This will be very important for products that are not used often.
    a. *Does the app have any functions that help the user to easily remember how to use it? Especially for the users who will not be using the app frequently.*

This question has not an exact answer to be presented from the study, but the established notion that the app is in fact easy to use and easy to learn can present an explanation to this question. The design focus has been to make an easy app not just because of easiness it self, but so this would become an app that would be easy also to remember. The user group of the app is basically all car owners and this will include car owners of all ages. It will be important that the app is easy to remember not just for less frequently user but also for people who maybe do not see as well as they used to. The functions that is provided to make the app easy to remember is that there is as little buttons and text as possible in the design. To test if this is actually enough would demand a longer study and was sadly not possible to do in this thesis.

6.3 Chapter summary

In this chapter I have presented the finished work of the design and prototype development of this thesis. I have given a description of how this last high-fidelity prototype ended up as it did and I have given some explanations on new aspects of the app that presented it self after the user test. In the end of the chapter I gave and detailed presentation of my user goals for the design process and also explained how I have tried to answer all of these goals with examples and representations from the user test and the high-fidelity prototype.

7 Discussion

In this chapter I will discuss the challenges and limitations of a user-centered research perspective to IoT enabled applications, and I will discuss the research questions with the work that has been done with this research. Firs I will present the research questions one by one and discuss how they can be answered I light of the work that has been done in this thesis. After this I will present some challenges and limitation discovered during the development of this research. I will first present challenges and

limitation considering the research aspect of this thesis and then present the challenges and limitation that presented them selves during the design and prototype development.

7.1 Research questions

7.1.1 Research question 1

Can user-centered design be applied in IoT enabled applications?
The research of Koreshoff et al., (2013) in HIC and the IoT has already presented that research has been done in the field of design and IoT technologies. I wanted with this thesis to put it in practise as well as the research. User-centered design has simple steps of how to design from a users perspective and many of which I have tried to implement in the design and prototype development process. It seems that this approach of designing has worked well with the design of the app it self and that the respondents of the design test seems to understand the works of it. It seems that the designing of this app has in a way, simplified the complexity of the technology and that the users main focus could now be more about the interaction with the system instead of just being a part of it.

7.1.2 Research question 2

How do users experience the complexity of the technology when presented to them?

As said in the previous section it seems the users has responded well to this presentation of an IoT enabled application. The idea has been to provide and application which enables both technologies and visions of IoT and HCI research. Since both IoT and HCI has a vision of presenting artefacts and research on how to make users everyday lives easier in some way I have tried to present a study and an artefact that can combine the two fields closer together in this way. The design test in this thesis provides a picture of how users may respond to this kind of application, and most results of the study show that they understand the concept and enjoy interacting with it. There are also some respondents who would like to understand more and hade some questions on how the system would work in a lager sense. This meaning how

the app would work in the real world setting. Sadly there was not time to complete a lager case study on how the app and parking system would work when tried out together. This a possibility for further work and I believe that a study on this also can provide more insight on how an application can shrink the gap between IoT and HCI, and also maybe provide some more insight on if this app can give users a better understanding of the complexity of the technologies involved in this kind of application.

7.1.3 Research question 3

Can user-centered design experiments be enough to provide recommendations for the real world development of IoT enabled applications?

This thesis has presented some research and an experiment on how to use user-centered design in developing IoT enabled artefacts. I believe that since this thesis has conducted the research with the focus on the design development in an industrial content, this is actually a good way to start to provide some recommendations for how to take this research further. The challenge is that the IoT is a broad term for a number of technologies and as both Atzori et al., (2010) and Koreshoff et al., (2013) points out in their articles, there are also a large number of combinations of the technologies and focuses. I believe that this thesis maybe can provide with some recommendations on how to use user-centered design methods, research and devices that are already adapted in users everyday lives to take advantage of some the technologies provided by the IoT. But I also believe that this thesis cannot provide recommendations for every aspect of the technologies of the IoT.

7.2 Challenges and limitations

This section will present you with some thoughts I have on challenges and limitations with my research. I will first discuss shortly how I find the research challenging and after this I will discuss the challenges and limitations I went trough with the design development in this thesis.

7.2.1 Challenges in research

The IoT is a relatively new field of research and provides us with a very complex and broad presentation of what it actually contains. Some challenges to a study like this is to narrow the field to something tangible that can be put into the HCI perspective. This thesis has presented a design development of an application containing IoT technologies; this has provided some findings that can be challenging. Challenges such as: how to make abstractive technologies connective and understandable. With this I mean that the field of IoT is as said a broad and complex field, which strive to make technology that is connected to several visions. To discuss the vision that is presented in this thesis, the things oriented vision. Here the idea is to connect things with each other through the technology. The technology is there and as I have provided in this thesis there is possibilities that we can also use design to connect people further with the thing and the technology. Some challenges to consider here is how to actually make this progress with all visions of the IoT. It needs to be more studies on this kind of designing and if there is some possibility of universal design that can be applied to several or all visions of the IoT. One challenge that presented it self was how much to include the user in the technology, how the RFID system actually worked. I chose to not include the users too much in the process of how the system actually worked and focused more on how their experience with the app was. With this the respondents of the user test actually had several questions on the system but did not quite understand when an explanation was given to them. This presents questions on how much a user actually should be included in the process.

Other challenges in research on this matter are how new it is. The involvement of HCI research in the IoT needs to be further studied both in the light of how they connect as research fields and how to implement it in the industrial content of the real world. There was much information to read on the matter of the IoT and HCI together but there was not much research to choose from. This made it hard for me to find a starting ground of my own research and I struggled with this for some time.

7.2.2 Challenges in the design and prototype development

The development of the actual design of the app in this thesis was actually changed a couple of times as you have seen in the presentations of the prototypes. Some of the

challenges in this design process were that I was not just designing an artefact with the involvement of users but also a customer. The changing of the design was a wish from the customer, Time Park AS who after a while wanted an app that reflected the VIZUM project and not their actual company. This was one of the small challenges of the design process since this change had little impact on the requirements and only took about a day to change. With this I did not have to start the prototype development from scratch, I just took the basic ideas from the first and second prototype to develop the mixed-fidelity prototype.

Some problems I encountered which I was not prepared for how to conduct the questionnaire and user test. Looking back at it now I would have done some changes with the questions. The questionnaire for example had some questions that where to open and therefor easily misinterpreted by the respondents. This gave me some answers that I could not use for this project. Of course it also gave me some information that was useful, but not exactly planned for that exact stage. The user test was planned better than the questionnaire, but did not present with much useable data in the end. These questions too easily answered with yes or no, which gave me little to work with in the end. This challenge I feel presented it self because of my inexperience with this kind of study, which I probably nothing I could have fixed at the time, but is something, as said, I would have done a bit differently looking back at it now.

One other challenge of the design development was also the making of the requirements. As explained some changes was made on the requirements during the development of the prototypes. First the requirements were developed with the costumer, the developer of the high-fidelity prototype and me. Here the basics where discussed of what we wanted to give users, what users wished from the app and what we actually could create. Some requirements were changed, such as the one that suggest that the app should reflect Time Park AS in design. It still does since VISUM is a part of the company, but the app now reflects more the VIZUM logo than anything else. In the finished high-fidelity prototype the demand page is now gone. This is actually a requirement that supposed to be implemented later on. This was excluded form the latest prototype because Time Park AS did not feel ready to present

this to users. They have few parking lots with this information available and felt that it should not be in the app before they could present this information on all of their parking lots.

7.3 Chapter summary

This chapter has presented with the last discussions of my work in this thesis. I have presented each research question and explained how these have been answered during the work and study of the thesis. Lastly I presented some challenges and limitations that presented it self during the research and development in this thesis.

8 Conclusion and further work

This chapter will present you with my thoughts on how to further take this research and design development. I will also conclude the work of this thesis.

8.1 Further work

There are several aspects of the application that can be further studied and developed in the app that is provided in this thesis. First of all I would have liked to do another test of the application. This test would have more focus on use of the app than the design. do a case study on the app in a real world setting in a parking lot to disclose how the app would actually be used by the user in a less controlled setting and if there would be some unforeseen issues or challenges that did not present it self in the design faze, which I am sure it will be. This would also provide more information for this research and maybe eliminate some limitations or maybe provide it with new ones.

Another aspect to consider in further work would be to implement the app as a part of the car it self, like Volvo has done with the Park and Pay app (presented in chapter 3). Apple is also developing something they call CarPlay, which is an integration of the iOS system in the system of the car (Apple Inc. 2015). This could be a possibility to actually have the app in the car as it is.

The development of the demand page is also an aspect that should be a future goal. This was a specific wish from the questionnaire form potential users and a requirement of the design development.
Future research on this subject would be to see if aspects of my research could be implemented in other IoT technologies and look for more ways to connect HCI and users in the world of developing technologies.

8.2 Conclusion

In this thesis there has been developed an app that tries to connect users to an inactive technology of the IoT by using design method to include users in the technology and make them interact with it. This was presented to answer the questions presented earlier in this thesis, such as if user-centered design methods could be applied to these technologies, if this could make some recommendations for real-world development, and if users felt more understanding for the complexity of the technologies.
This kind of research made it necessary to present research previously done in the fields of IoT, HCI, and products and research in an industrial content. This research presents the building stone of where to start the process of implementing the differing technologies and method into each field.
The development was conducted by using user-centered design methods to give the development some structure and give the development the baseline of the focus on how the users would influence the research and development. During the development of the design and prototype there were several methods of data collection and design tools used to present the work and information. The thesis follows the basic lines of a user-centered design process to present the work in a straightforwardly manner.
The making of the prototypes followed the basic lines of a prototype development process with the use of low- and high-fidelity prototyping techniques, it also used a newer method called mixed-fidelity to ensure good user testing possibilities before making of the high-fidelity prototype.
In the work of this thesis and design development there also where a large focus on design principles and users goals. The reason this was a focus was so that a good design development could be conducted and that a user really where in the focus the whole time. This gave the abilities to evaluate the work in a good manner and have goals and guidelines to follow during the development.

When the user testing and high-fidelity prototype was finished the research questions could be answered. These questions were answered by looking at the process of development, the results of the user goals and the design test. The results of this process presented that the users were positive to the app that was developed and gave the impression that they would use and easily understand it. They also presented some questions and preservations on how the app actually would work in the real-world. This signifies that the development and research on this matter is not done with this thesis and that there are still several aspects to consider regarding the recommendations this app can present with.

This thesis can present findings on that there is possible to apply user-centered design to an Internet of Things enabled application. It can also conclude that this method of interaction with the technology actually is interesting to users and that it can present some good ways to include the user in making their everyday lives easier in some way. This is not research that can establish any sound recommendations on how to develop these kinds of IoT enabled applications, but can be seen as a start on the process and can maybe give some sound recommendations for applications that use similar technologies as in this development. The world of the Internet of Things technologies is big and new, but this thesis has hopefully given some inspiration on how to continue the research on how to include the users and design in the development of the newer technologies of tomorrow.

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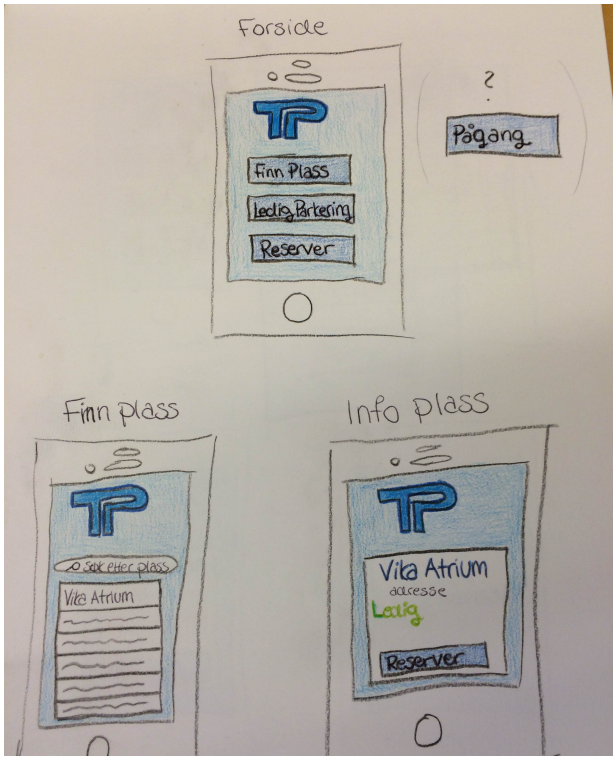
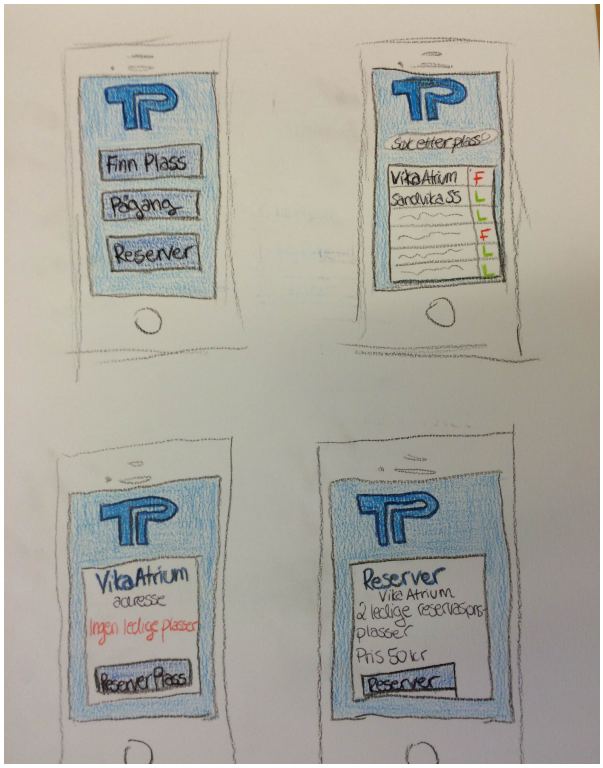
Attachments

Attachment A: Prototype 1 – low-fidelity

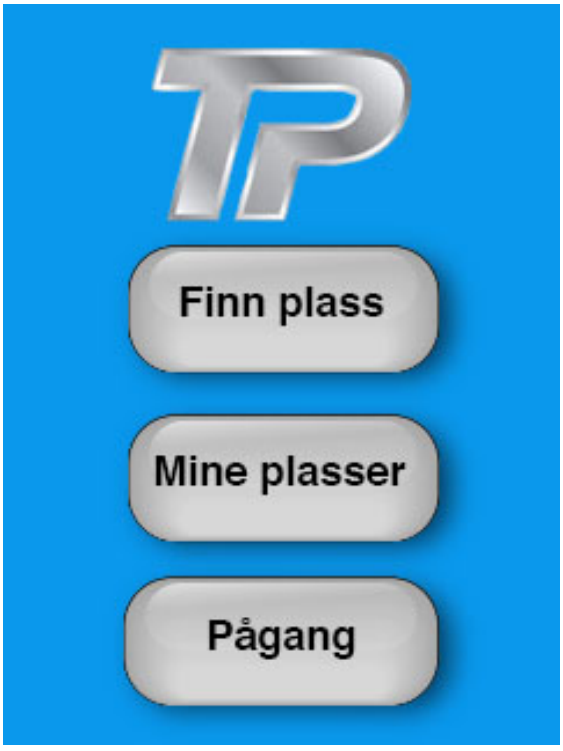




Attachment B: Prototype 2 – Low-fidelity

Splash Screen

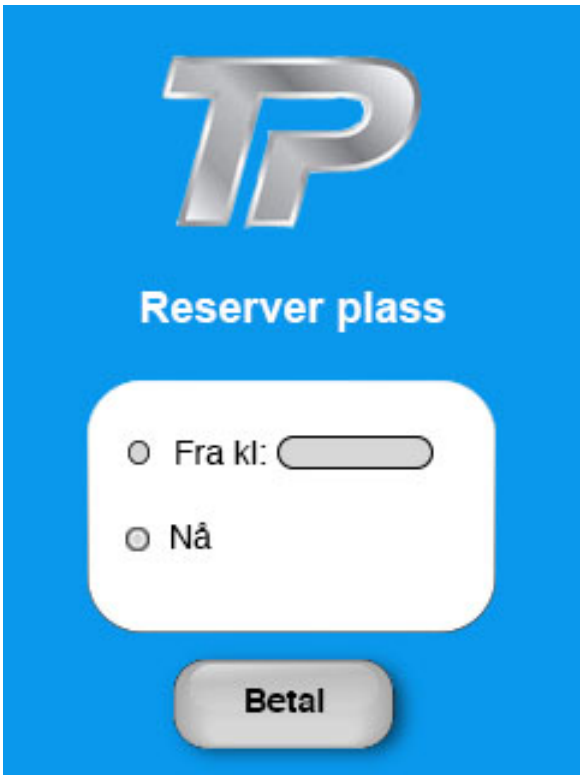
Main Page



Find Parking

Parking information

Reserve parking space



Favourites

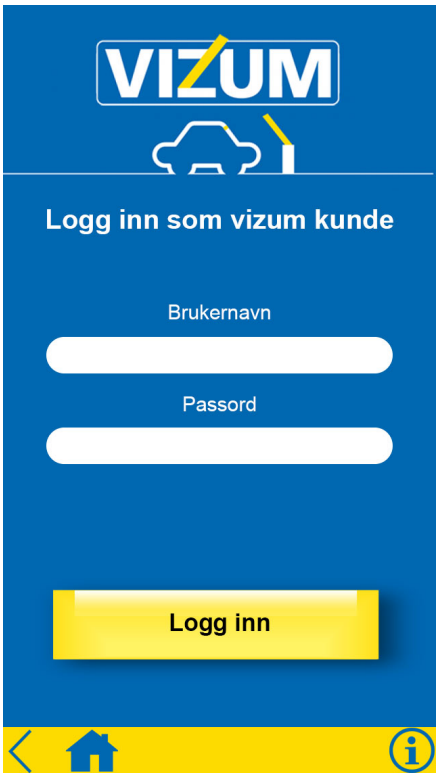
Search demand

Demand

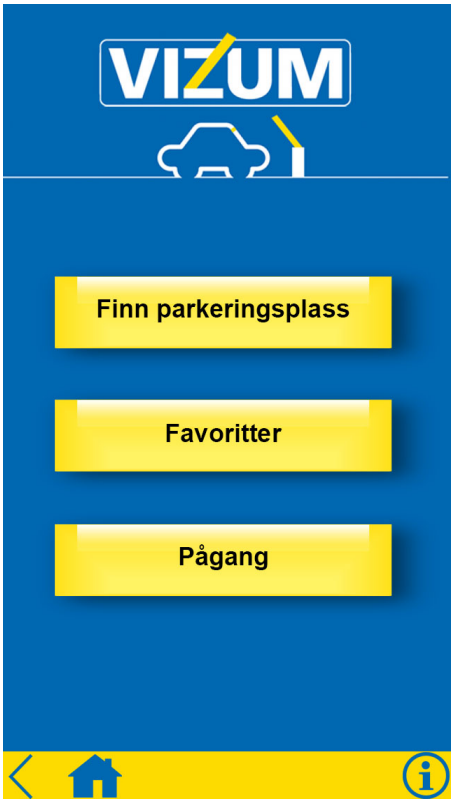
Attachment C: Mixed-fidelity

Splash Screen

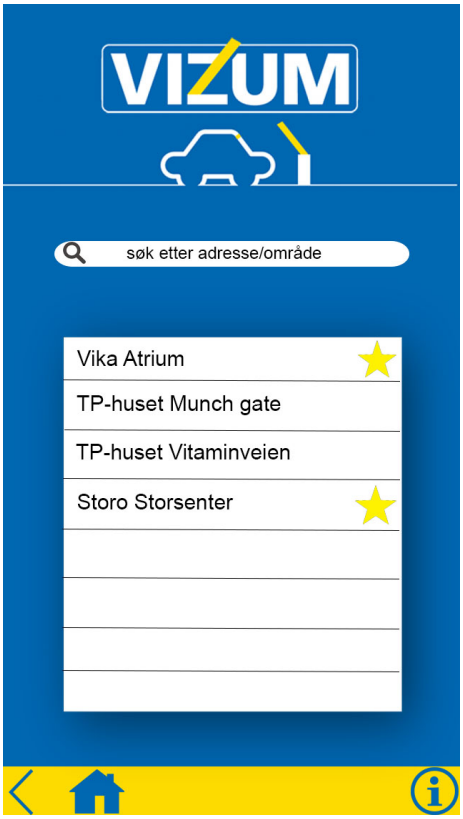
Login



Home



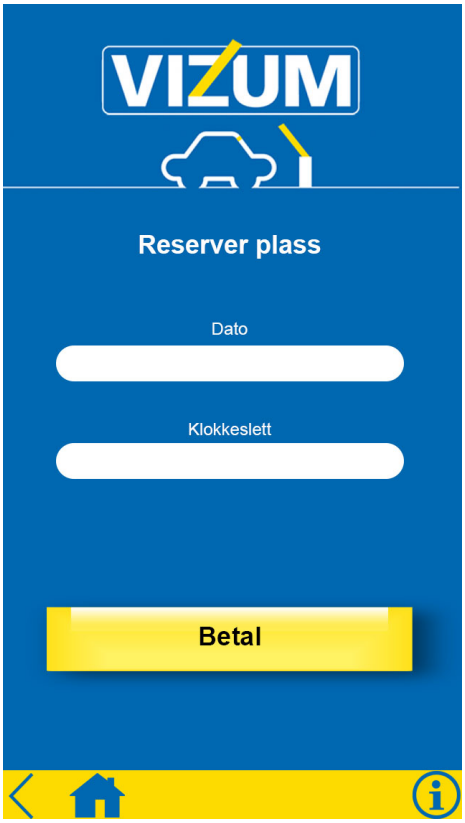
Search parking



Parking information

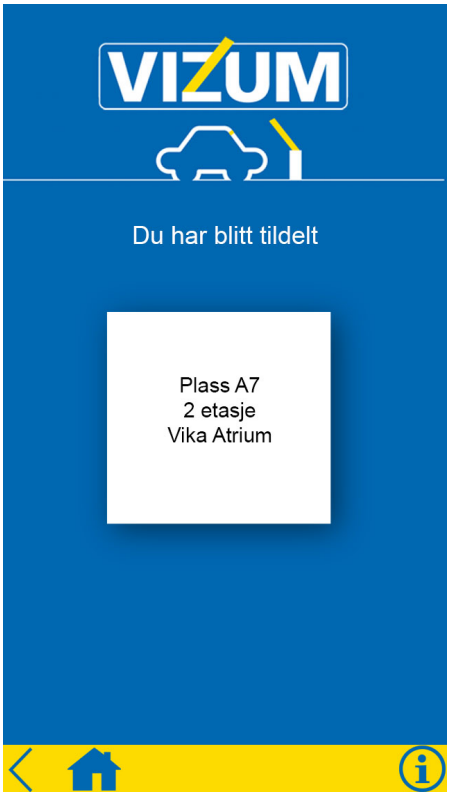
Reserve parking

Reserve date + time



Reserve now

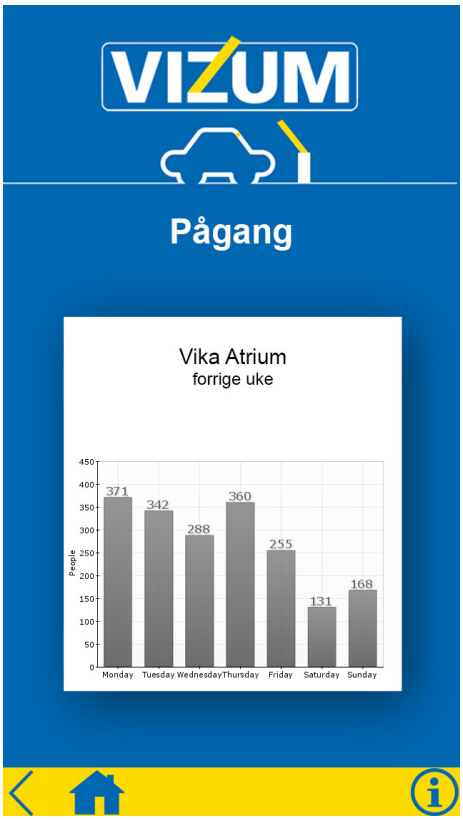
Reservation information



Favourites

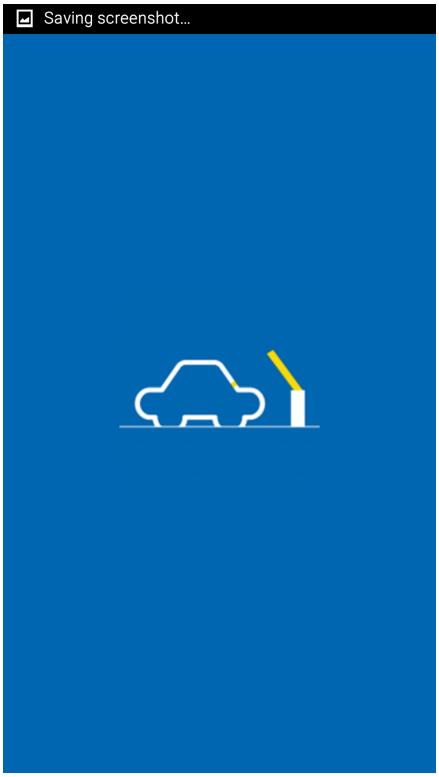
Search demand

Demand

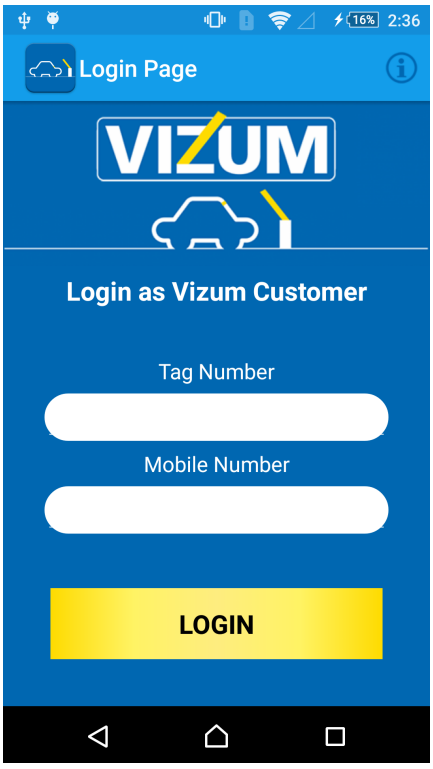


Attachment D: Prototype 4 – High-fidelity

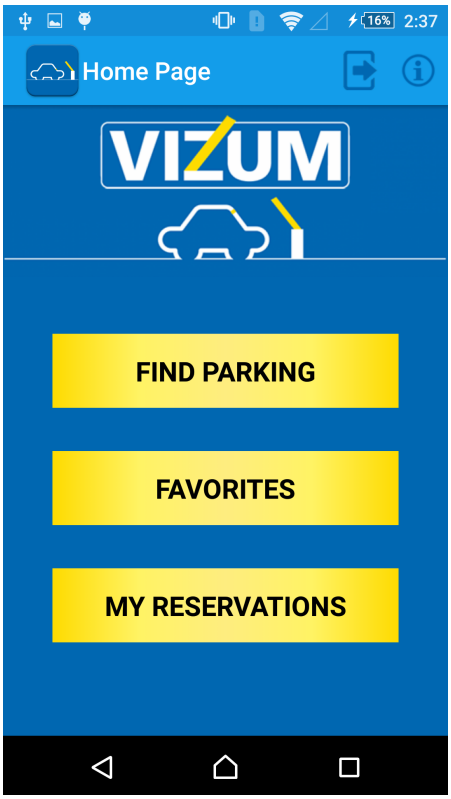
Splash screen



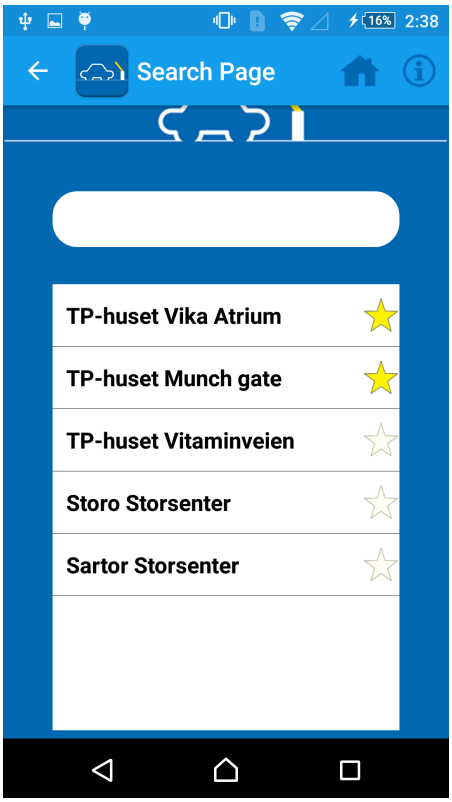
Login



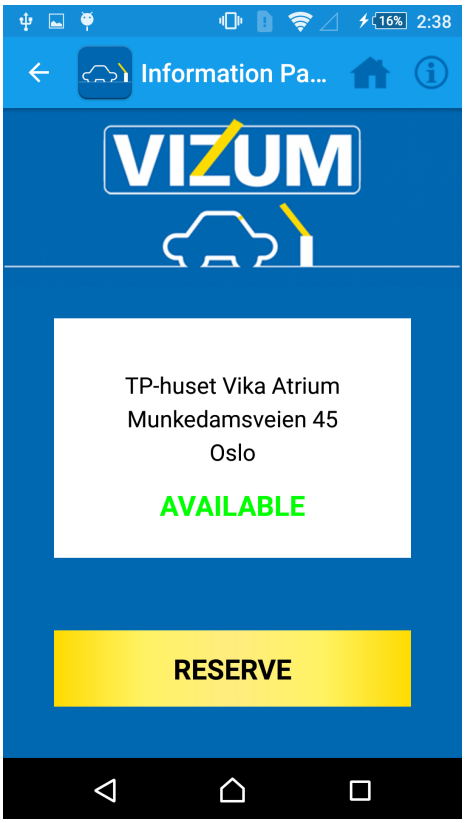
Home



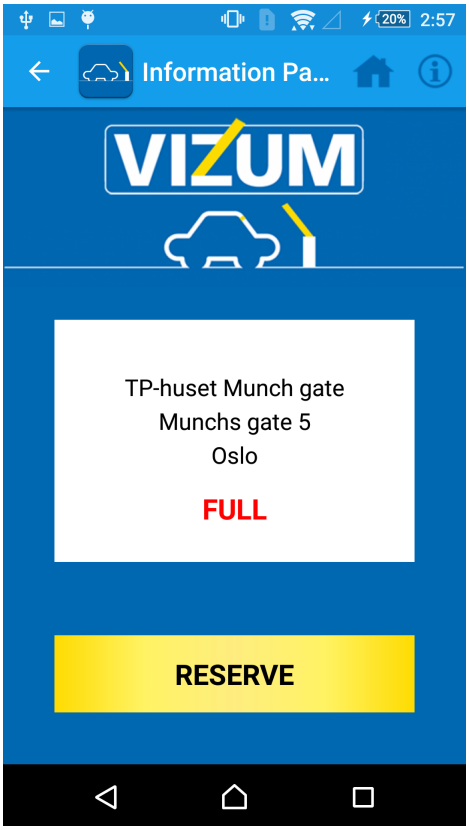
Search parking



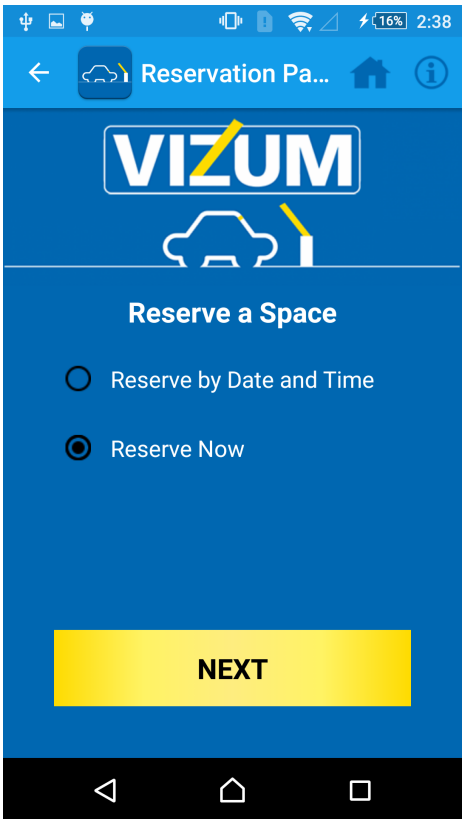
Reserve a parking space



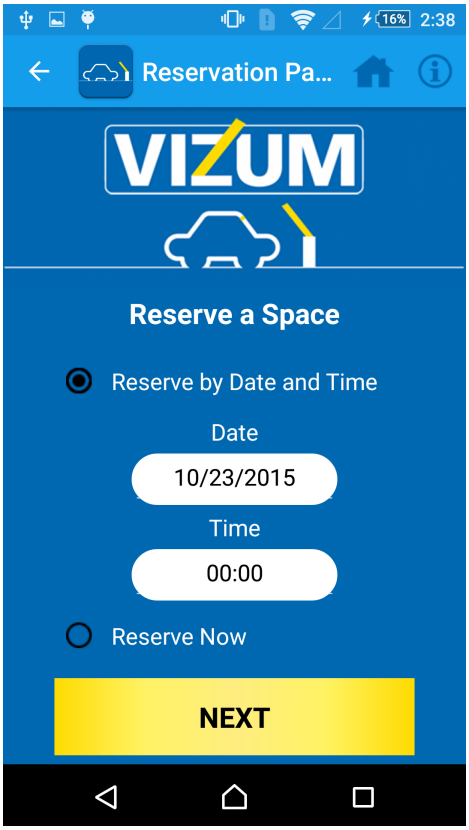
Reserve a parking space full



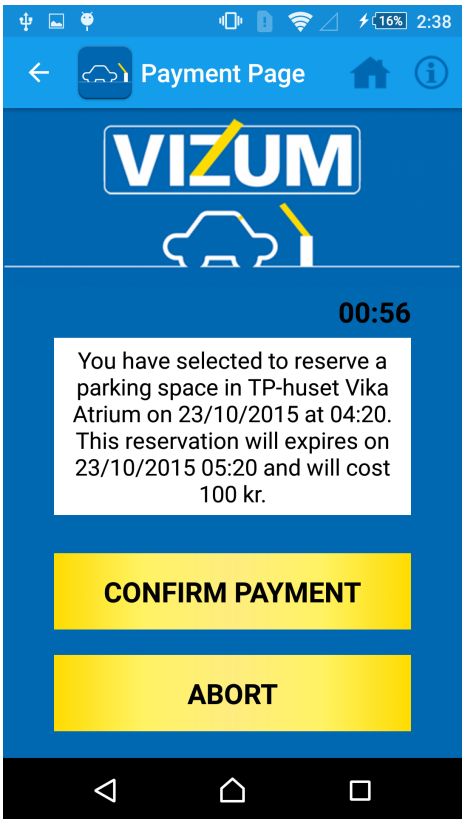
Reserve now



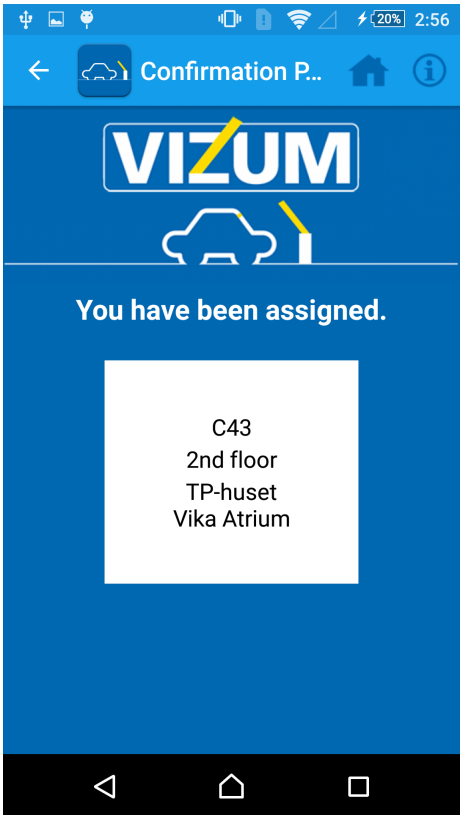
Select date and time



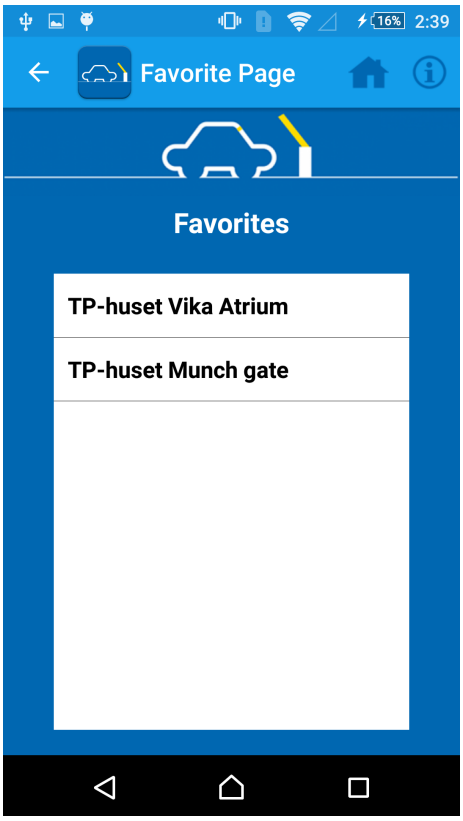
Reservation summary



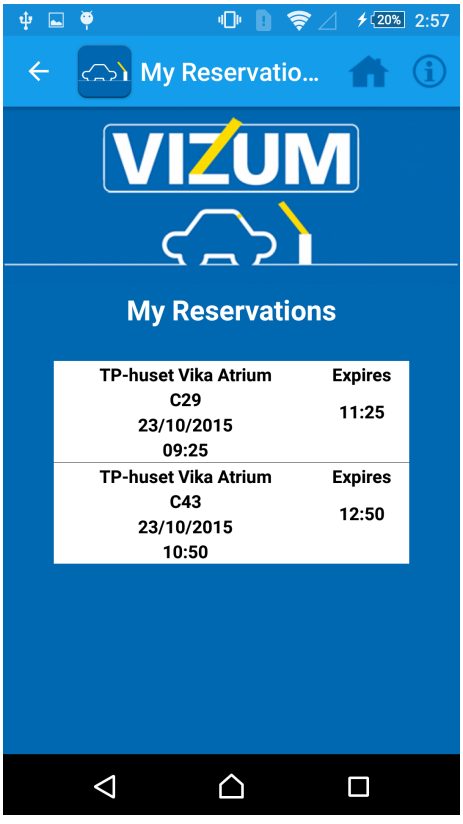
Reservation confirmation



Favourites



My Reservations



Attachment E: Approval from NSD

Norsk samfunnsvitenskapelig datatjeneste AS
NORWEGIAN SOCIAL SCIENCE DATA SERVICES

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Norway
Tel: +47-55 58 21 17
Fax: +47-55 58 96 50
nsd@nsd.uib.no
www.nsd.uib.no
Org.nr. 985 321 884

Victor Kaptelinin
Institutt for informasjons- og medievitenskap
Universitetet i Bergen
Fosswinckelsgate 6
5007 BERGEN

Vår dato: 07.12.2015 Vår ref: 45817/3/LT Deres dato: Deres ref:

TILBAKEMELDING PÅ MELDING OM BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 25.11.2015. Meldingen gjelder prosjektet:

45817	*Forsking som omhandler design av en applikasjon. Informasjon som skal innhentes er fra testobjekter som deltar i spørreundersøkelse og intervju*
Daglig ansvarlig	*Victor Kaptelinin*
Student	*Kristina Bakke*

Det fremgår at prosjektet allerede er påbegynt ved at informasjon er gitt til utvalget og datainnsamling er påbegynt. Personvernombudet finner dette beklagelig, og minner om at prosjekter som omfattes av meldeplikten skal meldes senest 30 dager før oppstart. Personvernombudet har vurdert prosjektet og finner at behandlingen av personopplysninger omfattes av meldeplikten iht. personopplysningsloven forskrifter § 31/§ 7.27.

Prosjektvurdering
Utvalget er gitt skriftlig informasjon og deltakelse har vært ensbetydende med returnering av skjema/aktiv deltakelse. Personvernombudet finner at informasjonen som har vært gitt er noe mangelfull. Det har ikke blitt opplyst om bl.a. navn og kontaktinformasjon til veileder og daglig ansvarlig professor Victor Kaptelinin, hva som skal skje med innsamlede opplysninger ved prosjektslutt, samt dato for anonymisering av innsamlede opplysninger.

Personvernombudet legger derfor til grunn for sin godkjenning av prosjektet at prosjektleder sender et kort informasjonsskriv til utvalget med status for prosjektet som bla. gir informasjon om at datamaterialet er anonymisert. Vi ber om at kopi av skrivet sendes personvernombudet (personvernombudet@nsd.no, med prosjektnummer).

Forventet prosjektslutt er 15.12.2015. Ifølge prosjektmeldingen skal innsamlede opplysninger da anonymiseres.
Anonymisering innebærer å bearbeide datamaterialet slik at ingen enkeltpersoner kan gjenkjennes. Det gjøres ved å:
- slette direkte personopplysninger (som navn/koblingsnøkkel)

Avdelingskontorer / *District Offices:*
OSLO: NSD, Universitetet i Oslo, Postboks 1055 Blindern, 0316 Oslo, Tel: +47-22 85 52 11, nsd@uio.no
TRONDHEIM: NSD, Norges teknisk-naturvitenskapelige universitet, 7491 Trondheim, Tel: +47-73 59 19 07, kyrre.svarva@svt.ntnu.no
TROMSØ: NSD, HSL, Universitetet i Tromsø, 9037 Tromsø, Tel: +47-77 64 61 53, solvi.anderssen@uit.no

-slette/omskrive indirekte personopplysninger (identifiserende sammenstilling av bakgrunnsopplysninger som f.eks. bosted/arbeidssted, alder og kjønn)

Vi gjør oppmerksom på at også databehandler SurveyMonkey må slette personopplysninger tilknyttet prosjektet i sine systemer. Dette inkluderer eventuelle logger og koblinger mellom IP-/epostadresser og besvarelser.

Avslutning
Personvernombudets vurdering forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldeskjemaet, korrespondanse med personvernombudet, samt personopplysningsloven med forskrifter.

Det gjøres oppmerksom på at det skal gis ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernombudets vurdering. Endringsmeldinger gis via et eget skjema, http://www.nsd.uib.no/personvern/meldeplikt/skjema.html. Det skal også gis melding etter tre år dersom prosjektet fortsatt pågår. Meldinger skal skje skriftlig til ombudet.

Personvernombudet har lagt ut opplysninger om prosjektet i en offentlig database, http://pvo.nsd.no/prosjekt.

Personvernombudet vil ved prosjektets avslutning, 15.12.2015, rette en henvendelse angående status for behandlingen av personopplysninger.

Ta gjerne kontakt dersom noe er uklart.

Vennlig hilsen

Katrine Utaaker Segadal

Lis Tenold

Kopi:
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