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Usability Challenges for Contactless Mobile Payment at a Physical Point of Sale

Central Themes and Trade-offs

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Problem Description

The thesis is done in cooperation with Telenor R&I (Research & Inovation) as part of the project "Tap2Pay". The goal of this project is to introduce a system for mobile payment with NFC technology. The focus of the thesis will be on usability challenges that must be taken into account in designing such systems. Prototype systems will be developed and tested with real users in IDI´s usability laboratory at NSEP. Through these tests and post-test interviews a set of usability challenges for such systems will be elicited.

Assignment given: 15. January 2009
Supervisor: Dag Svanæs, IDI

Abstract

This thesis was written in cooperation with Telenor as part of the project "Tap2Pay". The goal was to investigate usablity challenges for contactless mobile payment at a physical point of sale and identify central themes and trade-offs. To acheive this a two iterations of a prototype was developed, based on an analysis of the payment situation. These iterations were used in one workshop each.

After analyzing the results from the workshop, a strong card metaphor was identified as a central theme. The card metaphor had a great influence on the users' preferred solutions. Card selection routines was also a central theme.

There is also a genuine trade-off between efficiency and confidence. The users are likely to lack confidence in the security of efficent solutions, but in order to increase confidence, efficiency must be sacrificed.

Preface

This thesis is my master thesis which was written in the 10th and final semester of the Master of Technology education in computer science at The Norwegian University of Science and Technology (NTNU).

The thesis was written in cooperation with Telenor R&I (Research & Innovation) as part of the project "Tap2Pay". The goal of "Tap2Pay" is to introduce a system for mobile payment with NFC technology.

I would thank my supervisors, Dag Svanæs and Yngve Dahl, for their guidance as well as Terje Røsand for his technical assistance and for acting as the wizard in the first workshop

I would also like to thank all those who participated in the workshops as well as my family for support and proofreading.

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Chapter 1

Introduction

This chapter introduces the work that has been done; it gives the context of the thesis, describes the motivation behind it, and defines a problem definition. Finally an overview of the report structure is given.

1.1 Motivation and Background

The thesis was written as part of a Telenor project to introduce a system for contactless mobile payment at a physical point of sale. This thesis focuses on the usability challenges of such a system and aims to identify related themes and trade-offs. This will be achieved by analyzing the payment situation as well as using prototyping and workshops to get feedback from potential users.

Contacless mobile payment at a physical point of sale means payment at a checkout counter (the physical point of sale) of a store by tapping a mobile phone on a contactless reader. The technology that makes this possible is Near Field Communication (NFC) which is an extension of the same standard used by RFID (Radio Frequency Identification) and contactless cards.

Since the 90's when mobile phones became widespread, people have become used to always being available. People expect to be able to reach friends and co-workers anytime and anywhere. As a result people started bringing their phone everywhere. In the beginning the mobile phone was just that, a phone that was mobile. Later the mobile phone has become much more, today it is a camera, mp3-player, radio, watch, calendar and so on. Now the phone has the potential to become a wallet as well. Many people usually only bring three things with them when leaving the house. That is their key to the house, their wallet and their phone. NFC enabled phones can potentially eliminate the wallet from that list. Instead of physical plastic cards in a wallet, the phone could act as a wallet with virtual cards in it.

The benefit of transforming the physical card into a virtual card on a mobile phone is that it reduces the amount of stuff an average person has to carry and keep track off. Since paying with the phone is contactless, it is also quicker and

easier to use. Conventional plastic cards has to be swiped or inserted into the payment terminal's reader slot. Since there are no standard design on these payment terminals, it is often difficult and confusing to determine where the reader slot is and what the correct orientation is. Contactless cards or phones do not have to be swiped or inserted into a reader, but can simply be tapped or waved in close proximity to it.

When taking something physical and making it abstract there are bound to be some challenges. Plastic cards are selected by physically taking it out of the wallet. With a virtual card the user looses this direct physical manipulation. Instead the user has to navigate a menu on the phone to select a virtual card. This is one of the usability challenges of virtual cards.

1.2 Problem Definition

This thesis aims to address the user interaction aspect of contactless mobile payment at a physical point of sale. The following are the research questions:

1. What are the most important dimensions of the design space for contactless mobile payment at a physical point of sale?

2. Which technological solutions and underlying metaphor do the users prefer?

3. What are the central themes and trade-offs that emerge from the users arguments?

1.3 Method and Research Design

The first research question is answered in chapter 4 *Payment at a Physical Point of Sale*. The second and third research questions is answered in chapter 12 *Analysis of the Results* on the basis of the results from the workshops (chapters 8 and 11)

The research method used in the workshops are described in the method section of the workshop chapters (5.1, 6.2 and 9.2). The method used for analyzing the results from the workshops are described in section 5.5.

1.4 Report Outline

Chapter 1 Introduction Introduces the project and its domain and context.

Chapter 2 Technological Overview Gives a short description of the technologies which make contactless mobile payment possible.

Chapter 3 Background Presents some relevant theory to the usability challenges of this project.

Chapter 4 Payment at a Physical Point of Sale Describes and analyzes the problem space of this thesis, which is payment at a physical point of sale. The first research question is then answered by deducing the dimensions of the design space for a solution.

Chapter 5 The Workshops Describes the workshops in general, including the setting, method and devices used.

Chapter 6 Workshop no. 1 Describes the first workshop in detail

Chapter 7 Prototype and Mockup Used in Workshop no. 1 Presents the prototype and mockup made for the first workshop.

Chapter 8 Results from Workshop no. 1 Describes the results from the first workshop

Chapter 9 Workshop no. 2 Describes the second workshop in more detail

Chapter 10 Prototype and Mockup Used in Workshop no. 2 Presents the prototype and mockup made for the second workshop.

Chapter 11 Results from Workshop no. 2 Describes the results from the second workshop

Chapter 12 Analysis of the Results Presents an analysis of the results of the workshops and answers second and third research questions.

Chapter 13 Conclusions Concludes the report by summarizing the findings.

Chapter 2

Technological Overview

On todays bank card the card information is stored on the magnetic stripe or on the integrated circuit chip on a smart card. This information on a chip is read by a reader who makes contact with electrical connectors on the chip. And the magnetic stripe is read by physical contact as it is swiped past a reading head.

This chapter describes the technologies that will be used to make contactless mobile payment possible. NFC which will make the payment contactless and UICC which will store the card information.

2.1 NFC

Near Field Communication (NFC) is a very short-range radio communication technology. It is basically an extension of the ISO/IEC 14443 proximity card standard, which is implemented by contactless cards using RFID. Since both NFC and ISO/IEC 14443 communicate via magnetic field induction on the 13.56 MHz radio frequency, NFC is compatible with existing ISO/IEC 14443 contactless infrastructure [6]. An NFC device has a loop antenna which generates a radio-wave field. When two devices are brought within each others field the two devices can communicate via magnetic inductive coupling. NFC devices can be active or passive. Active devices have an internal power supply whereas the passive device does not. Smart cards, smart posters and such are generally passive, while point of sale readers and mobile phones are typically active. For two devices to communicate at least one of them must be active. When brought close inductive coupling causes a passive device to absorb energy from the active device. Once the passive device is "woken up" it can modulate the active device's field and thus transfer data. Active devices can also act as the passive device. There are three use cases for an active device such as a mobile phone [5].

- Reader: The phone is the active device that reads a passive device such as smart poster.

- Card emulation: The phone acts as the passive device and can be read by a point of sale reader.
- Peer 2 peer: Two way communication is achieved by two devices who alternate as the active device which "reads" the other.

NFC communication is initiated by bringing two devices close to each other. The radio-wave field of the active device powers up the passive device and data is transferred instantly. There is no need for time costly connection setup and handshaking. NFC is capable of data rates up to 424kbps [5, 6].

An NFC enabled phone will have a build in loop antenna and an NFC chip.

Figure 2.1: An NFC enabled phone tapped to a NFC reader

2.2 UICC

Universal Integrated Circuit Card (UICC) is a replacement for the traditional SIM card. Both the UICC and the old SIM card are smart card i.e they have an embedded integrated circuit, just like smart cards used as bank cards. While the old SIM cards only have room for one application, which is Subscriber Identity

Module (SIM) application, the newer UICC smart cards can facilitate multiple applications. The UICC can therefore run the SIM application as well as storing bank card information. The UICC is secure and guarantees the confidentiality of the sensitive card information. When a payment is initiated by tapping the phone on the point of sale terminal, the UICC will run the payment application which handles the payment logic and send the appropriate keys and information to the payment terminal via the NFC antenna that is build in to the phone. Each card will have its own payment application for which the bank card issuer can rent space for on the UICC by paying a fee to the mobile network operator who issues the UICC.

Chapter 3

Background

This chapter introduces usability principles and guidelines that designers should keep in mind when designing a user interface (or any inanimate object). These principles focus on how the human mind works and how to design something that feels natural for the user.

3.1 The Seven Stages of Action

When humans interact with objects, they go through a seven stage process called the seven stages of action. These stages can be split into stages of execution and stages of evaluation [4]. The stages of execution is what we do to execute an action, i.e. do something. When this is done we observe and evaluate the outcome of our action. (see fig. 3.1)

1. Form a goal
2. Form an intention
3. Specify an action
4. Execute the action
5. Perceive the state of the object
6. Interpret the state
7. Evaluate the outcome

The first stage of action is to formulate a goal. Norman uses the example of a person sitting in a chair. While reading a book, day turns to dusk and it gets darker. The goal is to get more light. To achieve this, the goal must be turned into an intention to press the switch of a nearby lamp. This intention must then be translated to an action sequence. In this example the action is to stretch out a hand and extend a finger to press the button on the switch. The last

stage of execution is then to actually perform this sequence. After the action is performed the person would perceive the state of his world, that is he would see that it has become lighter. This perception is then interpreted; the lamp is turned on. The outcome is then evaluated according to the original goal. In this example the goal was to get more light which was also the outcome of the executed action. The goal is achieved, and he can return to his book. Had the action not achieved his goal (perhaps the lamp was not plugged in), the stages must have been repeated and refined.

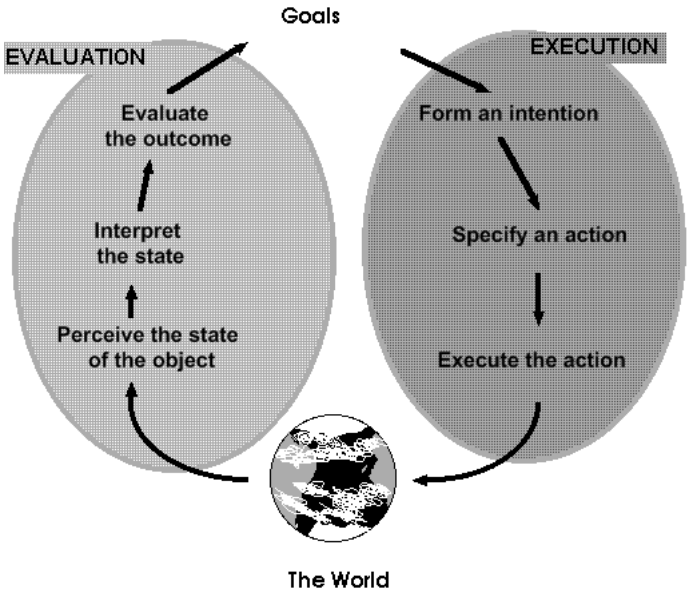

Figure 3.1: The seven stages of action

The gap between the users goal and the available actions to achieve this goal is known as the "Gulf of Execution"[4]. Similarly the amount of effort needed to interpret the state of an object and evaluate if intentions are achieved, is known as the "Gulf of Evaluation" [4]. To make an object or system usable the designers need to bridge these gulfs.

3.2 Metaphors and Conceptual Models

A conceptual model is a high-level description of how the system works [3]. All users will subconsciously form a model or understanding of how the system works. If the system is poorly designed the users conceptual model might not match the designers conceptual model. Metaphors are an important part of the conceptual model, as the human mind understand something new by relating the new to something already known [1]. This is why metaphors are important, they drastically reduce the learning curve. By using explicit metaphors the

designer helps ensure the user shape a conceptual model of the system that is similar to the designer's. When the designer and user share the conceptual model the gulfs of execution and evaluation is bridged.

3.3 Prototyping

Prototyping is the act of creating a prototype. Prototypes are commonly made for many different reasons. The word prototype is used differently in different disciplines of engineering. Interaction designers refer to simulations of user dialog and program behavior as prototypes [2]. The purpose of the prototypes made for this thesis is to explore ways to implement new functionality.

Chapter 4

Payment at a Physical Point of Sale

This chapter describes the problem space, which in this thesis is payment at a physical point of sale. The payment situation will be broken down and the payment activity will be analyzed. The dimensions of the payment situation that are relevant for contactless mobile payment is discussed. This chapter aims to answer the first research question: What are the most important dimensions of the design space for contactless mobile payment at a physical point of sale?

4.1 The Payment Situation

In order to design a system it is important to understand the situation in which it will be used. In this thesis that situation is the payment situation in which a product is payed for at a physical point of sale.

4.1.1 Setting and Devices

The setting of a typical payment situation is at the counter of store or service provider. On top of this counter sits a payment terminal which is the primary device encountered in a payment situation. The payment terminal has a card reader and keypad for entering the PIN as well as a small display. The interaction with the payment terminal is among other things described in the following sections as it varies depending on the means of payment. The payment dialog is presented on the terminal. The payment dialog is the exchange of messages and input between the point of sale system (via the terminal) and the user. The notes connected to each state in the state diagram in fig. 4.1 shows the standard payment dialog of common payment terminal. Note that the transition in the state diagram is roughly equivalent to the activities in the activity diagram for magnetic stripe card payment (fig. 4.4)

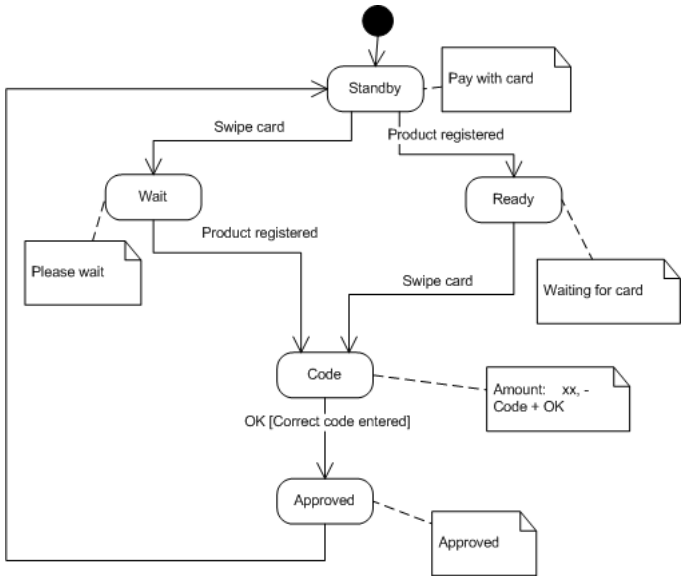

Figure 4.1: State diagram showing the standard behavior and payment dialog of a payment terminal

4.1.2 Actors

The payment situation usually involves two people, the Customer and the Cashier. The Customer is someone who is purchasing a product or service. He (or she) will likely approach the counter carrying the product(s) he has selected throughout the store. He will then present the product(s) to the Cashier, which is situated behind the counter. The Cashier will register the product(s) in the point of sale system and inform the Customer of the price. The Customer will then pay for the product(s) and can take his product(s) and leave. This is illustrated in the activity diagram in fig. 4.2.

4.1.3 The Payment

The `Prepare means of payment` and `Pay for product` actions of fig. 4.2 can be decomposed to show how the actions differ with the means of payment. The means of payment analyzed here are good old fashioned *cash*; plastic debit/credit cards with a magnetic *stripe* or *chip*, as commonly used today; and the possible future solution of contactless *mobile* payment. The activity diagrams in figures 4.3 through 4.6 shows the decomposed actions. The accept signal called `Product registered` in these diagrams will trigger when the Cashier has finished registering the products as shown in fig.4.2.

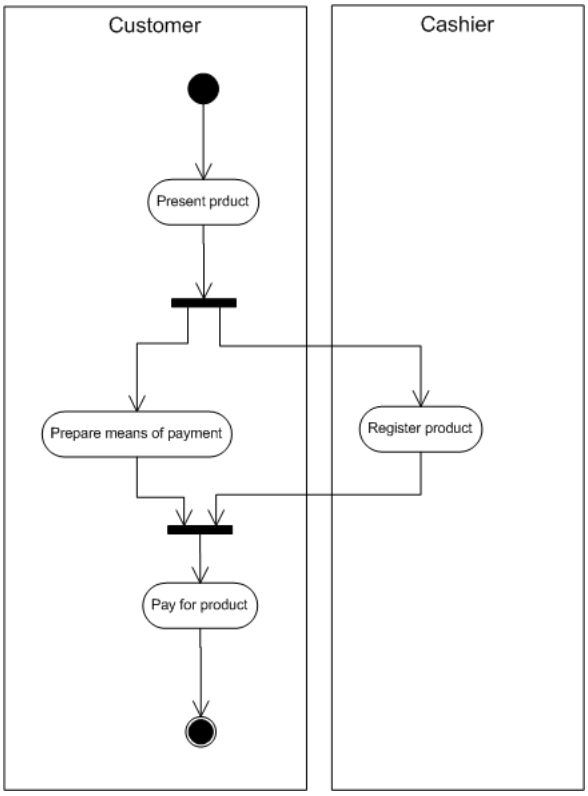

Figure 4.2: Activity diagram showing the steps of a generic payment situation

Using Cash

Using cash is very simple, the Customer will simply take the required amount of bills and coins out of the wallet and hand it to the Cashier. If the Customer does not have the exact amount, he will receive change from the Cashier and put it in the wallet.

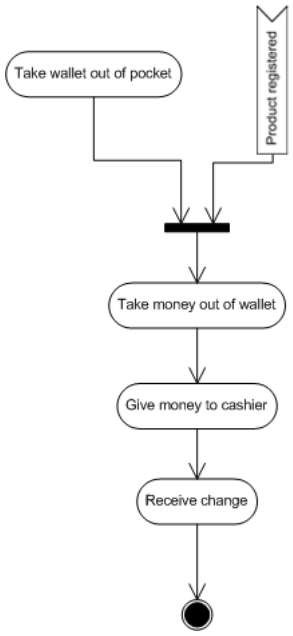

Figure 4.3: Activity diagram showing payment using cash

Using Plastic Card

Magnetic Stripe The most common way to pay for something today is by using a plastic card. The older type of plastic cards and the type that most users are used to are the magnetic stripe card. To pay with such a card the Customer will select the desired plastic card by taking it out of the wallet. The card must then be read by the payment terminal that sits on the top of the counter. This is achieved by swiping the magnetic stripe past a reading head. The Customer must ensure that the magnetic stripe faces the reading head. The location of this reader and the required orientation of the card, often varies form terminal to terminal.

Confusion is especially common with regards to the orientation of the card. Should the card be swiped with the stripe facing left or right, toward or away from the Customer? There is no standard answer to this question, in fact the answer varies not only from manufacturer to manufacturer but often also between different models from the same manufacturer. Small icons may offer

subtle hint, but few customers are even aware of them. The ultimate proof of these icons not working, is the fact that many stores put homemade signs near the reader to inform the customer in plain text what the correct orientation is.

When the Customer has figured out the correct orientation and swiped the card, the payment terminal will ask the Customer to enter a PIN and confirm by pressing `OK`.

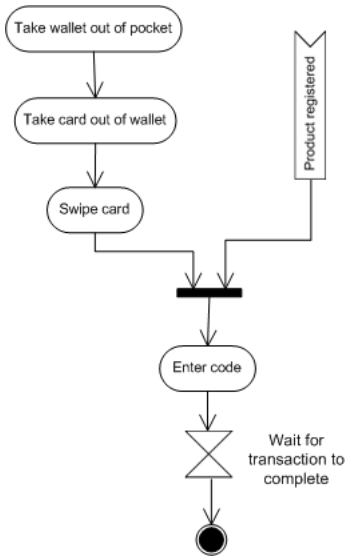

Figure 4.4: Activity diagram showing payment using a plastic magnetic stripe card

Chip Card Newer and more secure cards use an integrated circuit chip, and are often called smart cards of chip cards. This type of cards were just introduced but are quickly gaining ground as it is considered a security upgrade compared to the old magnetic stripe. To pay with a chip card the Customer will select the desired plastic card by taking it out of the wallet. The card must then be read by the payment terminal that sits on the top of the counter. A chip card must be inserted into a reader slot. This requires the Customer to ensure that the chip is facing the right way.

As with the magnetic stripe reader there is no standard location on the terminal or required orientation. Further more the chip reader slot is not necessarily located anywhere near the magnetic stripe reader. Often the slot is even located on the side or bottom of the terminal in such a way that it is not immediately visible. The orientation problem and the small icons are common also with the chip card. In addition it is not always clear whether the card should be swiped or inserted (Most chip cards also have a magnetic stripe). In some stores (where the POS system is not ready for chip cards) the chip slot is taped over forcing the customers to use the magnetic stripe. Sometimes the terminal's

display will inform the Customer the correct orientation of the magnetic stripe by for instance telling the Customer to "swipe the card with the stripe to the right". This message however is misleading for customers with a chip card, as customers with a chip card will only be told to insert their chip if they try to swipe their card.

When the chip is inserted correctly, the terminal will ask the Customer to enter a PIN and confirm by pressing "OK". The Customer must then wait for the transaction to complete before removing the card from the terminal and put it back in the wallet. An error will occur if the Customer removes the card too early, and an audible alert will remind the Customer if he forgets to remove the card at all. Some terminals will also produce an error if the card is inserted too early

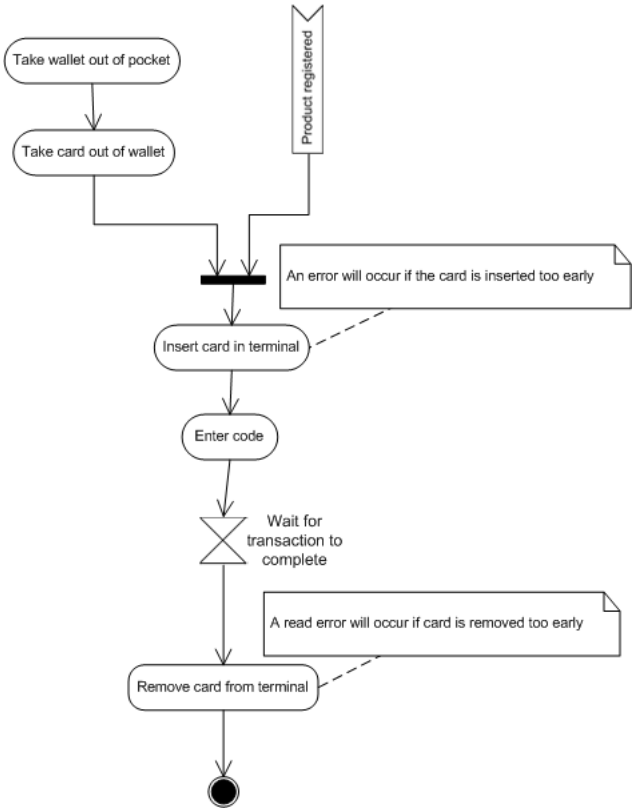

Figure 4.5: Activity diagram showing payment using a plastic chip card

Using a Phone

Contactless mobile payment will resemble plastic card payment. But instead of a wallet there is a phone (with a wallet application) and the cards are intangible.

Cards will have to be selected electronically on the mobile phone. Once a card is selected, the contactless reader will be able to read the card once the phone is within close proximity of it. The reader does not require contact for the duration of the transaction, such as the chip card does. Thus the contactless payment is more similar to payment with a magnetic stripe card. This eliminates the possibility for making mistakes such as removing the card too early or leaving the card behind.

The most significant change in the payment activity will be the `Select card on phone`-action. The loss of a tangible card and direct manipulation will make the gulfs of execution and evaluation wider and harder to bridge (cf. section 3.1).

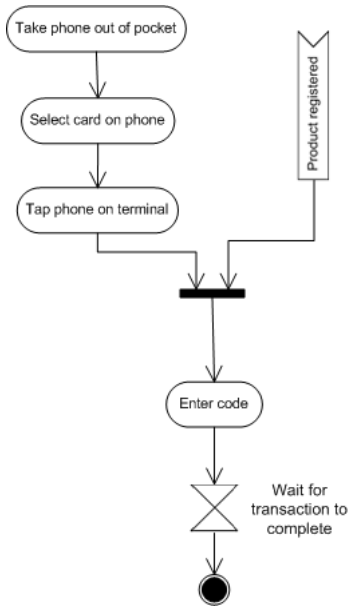

Figure 4.6: Activity diagram showing a generic contactless mobile payment

4.2 Analysis

Contactless payment is intended to speed up the transaction and minimize the effort needed. Contactless plastic cards are already used extensively in mass transit where efficiency is important. There is even a contactless mobile system in use in Japan. Such contactless plastic cards can be read without even removing it from the wallet (the card is read through the fabric of the wallet) and the mobile equivalent does not require any action on the phone. Since the mass transit cards are prepaid there is no need for a PIN. This makes for a smooth and efficient fare collection. Some vending machines also accept such

cards as payment. However, bigger purchases in a store has some additional challenges. Since the purchases are bigger and more expensive a prepaid system is inconvenient, as it would have to be recharged repeatedly. Thus, payments is done with a credit or debit card which usually require a PIN. The PIN is an additional step that slows the transaction down but adds a level of security and confidence. Furthermore if there are multiple cards in the wallet, the contactless reader will not know which card to read and the customer will have to pull the card out of the wallet after all. The same applies for mobile phones, multiple cards cannot be active at once.

Card selection is consequently a dimension in the problem space as is the question of PIN or no PIN. The introduction of another device in to the payment situation, raises a two additional question: What role should the mobile phone play in the payment situation and what role should the wallet application on the phone play?

4.2.1 Card Selection

Assuming there are multiple cards available, both plastic cards and virtual cards has to be selected before payment. If there is only one card available then no selection has to be made and this dimension is irrelevant. However many people have several different payment cards in their wallet. Thus, if contactless mobile payment wants to replace the wallet, the issue of card selection must be addressed.

One of the possible variables of card selection on a mobile phone, is *when* a card should be selected. Most people know which card they will use before coming to the counter to pay. Card selection is often dictated by habit and routine. Today, despite knowing way in advance which card will be selected, the actual card selection (i.e. taking the card out of the wallet) is done at the time of payment. For physical cards this is pretty much the only option. With virtual cards on a mobile phone on the other hand, a second option is made possible. On a mobile phone a card can be pre-selected in addition to be selected at the time of payment.

When assessing how and when cards should be selected it is important to understand *why* they are selected. There is a reason why people carry several different payment cards around in their wallet. The cards are used for different purposes. People may have one card for private use (charged to a private account), one for work related purchases (charged to an employer's corporate account) and one for household purchases (charged to a joint account). They may even have separate credit and debit cards for each of the mentioned usages. Access cards and membership cards are also stacking up in people's wallets (in addition to the already mentioned mass transit cards), but this is not the focus of this thesis (although it is a possible area of application for the NFC technology). Despite all these different cards there are usually one card that are used more often than the others (This is often the private debit card). This can be thought of as the *default card*.

Designating a default card on a mobile phone can be done prior to payment.

When the time of payment comes, the default card will be pre-selected. A pre-selected default card is quick and effortless to use at the time of payment, as long as the default card is the card that the Customer intends to use. With a pre-selected card it is not necessary to select a card at the time of payment. This selection is done earlier, such as at home before going shopping or when the cards is first installed and the wallet application set up. If no card is designated as a default card, a card must be selected at payment time.

This means that there is two basic design alternatives for card selection:

A: Designating a default card, i.e. pre-select a card.

B: Having no pre-select default card, i.e. select a card at payment time.

4.2.2 PIN or PIN-less

As mentioned, prepaid mass transit cards which does not require a PIN is very efficient. However the PIN is there for a reason. It is there to prevent theft and fraud and is meant to ensure that the person using the card is in fact the owner of the card. A prepaid card holds limited amount of money so if it is lost or stolen only this amount is lost. The loss of a debit card charged to one's account on the other hand can have much more severe consequences if the thief is able to empty the account. Without a PIN there is no safeguard against such an event. The PIN is therefore necessary, at least for larger purchases.

As payment cards become more and more pervasive, they are used for smaller and smaller purchases. When payment cards were first introduced they were mostly used for bigger purchases. The smaller purchases were still done with cash. Nowadays people are hardly carrying cash anymore and payment cards are used for all purchases no matter how small. Small purchases are often done in a different context than larger purchases. A snack or a gum, for example, are often bought on the run, in a nearby kiosk between errands or on the way to something. In such a context efficiency might be important.

Although PIN-less payment is not an option for larger purchases, it may be an option for smaller purchases. Some sort of limit for when a PIN must be entered or not, is a way to combine the security of a PIN and the efficiency of PIN-less payments. Small purchases, done on the run, can be completed fast, while large purchases were time is not big a factor still requires a PIN. If the card (or the phone with the card) is stolen, the thief cannot empty the account with large purchases and the owner of the card will have time to notify the card issuer and have the card canceled.

After PIN-less payment for all purchases has been eliminated as an alternative, we are left with these two design alternatives for entering a PIN:

A: PIN must be entered for all purchases.

B: PIN-less payment for small purchases.

4.2.3 The Role of the Phone

The role of the plastic payment card in a payment situation is pretty much set. The plastic card is a dead object. It is completely passive in the interactions in a payment situation and does not participate in the payment dialog. A mobile phone on the other hand has the ability to actively interact through messages displayed on the screen and keypad input. Thus, which role the phone plays in a payment situation is not given. The phone will have to interact with the user during card selection, but whether it participate in the payment dialog is question that must be answered.

An active phone can display the same messages as the payment terminal does and perhaps more. During card selection the users focus is on the phone (where the card selection is done). With the payment dialog on the phone the user can continue to focus on the phone. The PIN must, however, be entered on the terminal (if it must be entered at all that is). This constraint is likely to be mandated by banks and card issuers, as they cannot guarantee for the security past the payment terminal. Entering a PIN on the phone would require an active connection between the phone and the terminal beyond the short NFC-communication when the phone is tapped. This communication may not be secure, and would require additional infrastructure.

An inactive phone would not participate in the payment dialog. After a card is selected on the phone, the phone will purely play the part as the "plastic" card. The main advantage of an inactive phone is simplicity and the similarity with plastic cards.

Thus, the design alternatives when it comes to the role of the phone is:

A: Active phone: The phone participates in the payment dialog

B: Inactive phone: The phone is just a "plastic" card.

4.2.4 The role of the Wallet Application

Paying with a contactless plastic card can be done with the card still in the wallet or by taking the card out of the wallet. The role of the wallet application on the phone represents the equivalent choice with contactless mobile payment. The equivalent of paying without taking the card out of the wallet would be to tap the phone without explicitly opening the wallet application.

Contactless mobile payment may require the wallet application to be explicitly opened (i.e. run in the foreground) or the wallet application can run in the background. In case of the former, the card will not be read if the application is not open and active. In case of the former, the card may be read even if the phone is in standby mode. The former is the same as having to remove the plastic card from the wallet, while the latter is the same as leaving the card in the wallet.

Leaving the card in the wallet or leaving the phone in standby mode when paying is quicker and easier than having to open the wallet or wallet application. However, without opening the wallet or wallet application, no clue as to which

card is active can be given, i.e. the status of the system is not visible. This might be a problem with multiple cards in the wallet.

The design alternatives for the role of the wallet application is:

A: Foreground: Wallet application must be explicitly opened

B: Background: Cards can be read for standby mode.

4.3 Conclusion: The Dimensions of the Design Space

Card selection, PIN or PIN-less, the role of the phone and the role of the wallet application are the most important dimensions of the design space, as deduced in the previous section and summarized in table 4.1 . This answers the first research question and serves as a basis for the design of the prototypes and the focus of the workshops. The results form these workshops will in turn help answer the remaining questions.

Dimensions	Design Alternatives
Card selection	A: Pre-selected card
	B: Select at payment time
PIN or PIN-less	A: PIN required
	B: PIN-less purchase
The role of the phone	A: Inactive phone
	B: Active phone
The role of the wallet application	A: Open in the foreground
	B: Running in the background

Table 4.1: The dimensions of the design space and corresponding design alternatives

Chapter 5

The Workshops

This chapter describes the two workshops that were arranged. This chapter focuses on the common setting and structure, while chapters 6 and 9 will describe the details of workshop no. 1 and 2, respectively.

5.1 Method

In both workshops a small number of potential users were invited to test a prototype of the contactless mobile payment system in a simulated payment situation and discuss their experience and thoughts on contactless mobile payment. The workshops were divided into three parts.

1. Introduction

2. Role-playing with participants acting out payment scenarios at a physical point of sale, using a prototype and mockups.

3. Discussion and summary of the participants' experience with contactless mobile payment and their suggestions for further developments.

In the introduction the participants were introduced to the concept of contactless mobile payment and the prototype and mockups that would be used during the simulated payment situation. Then the participants were given a set of tasks which they would have to accomplish using the prototype and mockups. The tasks as described further in chapters 6 and 9, were designed to test the different design alternatives deduced in section 4.2. Finally the participants and the facilitators discussed various aspects of contactless mobile payment. These discussions were conducted like semi-structured group interviews. The participants were asked open-ended questions about their experience with and feelings toward the various aspects of contactless mobile payment and the prototype solutions. The participants were encouraged to elaborate among themselves.

5.2 Setting

The workshops were held at NSEP's[1] usability lab. This is a controlled laboratory environment. The laboratory is custom-designed for usability evaluations of mobile ICT and has high-fidelity video and audio recording equipment, which allows user interaction with multiple screen-based interfaces and physical aspects of interaction to be studied in parallel. The lab was set up to resemble a counter in an average store. The counter had a mockup payment terminal on top of it and the user were given a mockup of a capable phone (see section 5.3) with a prototype wallet application installed (a different prototype were used for each of the two workshops, see chapter 7 and chapter 10). The products they were tasked with buying were also made available.

5.3 Devices and Mockups

A mockup is a model of a device used for demonstrating or testing. Mockups and prototypes are not always clearly distinguished. However, this thesis distinguishes between the two as follows: The devices and programs (or part of programs) that only emulate behavior of other known devices are called mockups, where as the prototype is only the part which does not only emulate, but introduces something new. In this case the prototype is the wallet application, while the payment terminal, the contactless (NFC) reader and the NFC enabled phone (including the standby and menu screens) are mockups.

Figure 5.1: The payment terminal which acted as a model for the mockup

[1] The Norwegian Electronic Health Records Research Centre

5.3.1 Payment Terminal

The payment terminal mockup was made as a Windows application that was displayed on a touch screen laying horizontally on top of the counter (fig. 5.2). The terminal application ran on a desktop computer which was placed underneath the counter. The registration of the product as done by the Cashier was simulated by pressing a key on the keyboard of the same computer. An actual payment terminal was not used since it was not available, and because some of the dialog and user interaction had to happen on the payment terminal as well, and this required the possibility to manipulate the standard dialog.

The mockup featured a standard numpad and three functional buttons. The three functional buttons were a green `OK`-button, a red `Cancel`-button and a yellow `Clear`-button. The terminal in fig. 5.1 was used as a model. The displayed text is copied from the ingenico i6400 as observed in a local store. The state diagram in fig. 5.3 shows the standard behavior when used with a stripe card. The notes connected to the various states in the diagram, indicate the text displayed at that state[2]. The behavior of the mockups used in the workshops differs slightly in order to facilitate some new functions that may be introduced with contactless mobile payment. These differences are described in sections 7.2 and 10.2.

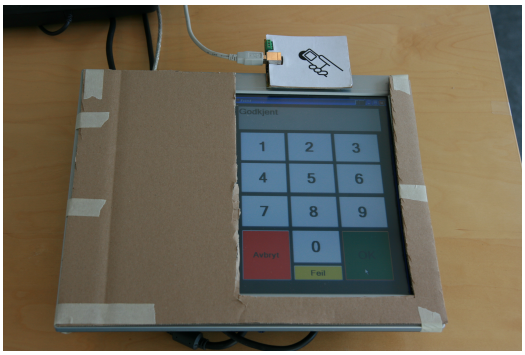

Figure 5.2: The terminal mockup on top of the counter

An RFID-reader was used in place of an NFC-reader as the contactless reader. This was done because the NFC technology was deemed too difficult to work with at this early stage, and because there are only a very few NFC readers on the marked. The RFID-reader was connected via USB to the same computer that ran the terminal application. A piece or cardboard was used to cover up the bare reader. On this cardboard was an icon of a hand tapping a phone. Cardboard also covered the unused parts of the touch screen.

[2]The text is translated form Norwegian

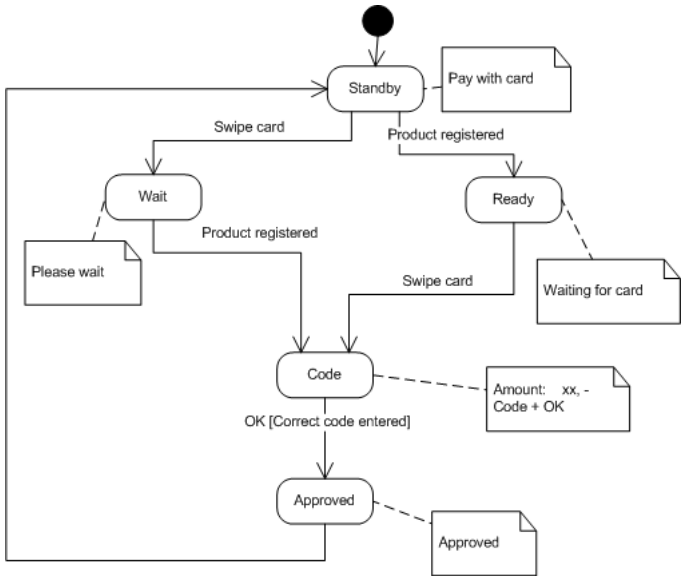

Figure 5.3: State diagram showing the standard behavior of a payment terminal

5.3.2 Phone

An HTC S740 was used in place of an NFC-enabled phone. Although the HTC S740 is a rather advanced phone including Windows Mobile and a slide out QWERTY-keyboard, it looks very much like an average phone. It has a standard num-pad[3], D-pad[4] and soft-buttons and the QWERTY-keyboard was never presented to, nor revealed by the user.

For each workshop, an application was installed on the phone. These applications contained a mockup of a standard phone OS (specifically the standby screen and the OS menu) which emulated the look of an average phone GUI and hid the advanced features normally not found on an average phone (such as the Windows Mobile OS). The phone was presented to the users after the application was opened and the phone appeared to be in standby mode. Each application also contained a prototype of the wallet application (see chapters 7 and 10 for details). A small RFID-tag was discreetly glued onto the back of the phone which could be read by the RFID reader on the terminal mockup. This was done because the NFC technology was deemed too difficult to work with at this early stage, and because there are only a very few NFC enabled mobile phones on the marked.

[3] Num-pad = numerical pad
[4] D-pad = directional pad

Figure 5.4: The HTC S740 with the mockup standby screen

5.4 Output

The entire workshop was filmed by three roof mounted cameras, the sound was recorded by a roof mounted microphone and the screen output of both the phone and the payment terminal was captured. Fig. 5.5 shows an example of the video output. The parts of this screenshot numbered 1 through 3 is the camera output from the three roof mounted cameras used to film the workshop. The phone and payment terminal displays as mirrored are shown in part 4 and 5 respectively.

5.5 Analysis Method

An ad hoc qualitative method was used for analyzing the results of the workshops. After the workshops the recorded video was reviewed and recurring themes and arguments from the discussions were identified. The execution of the payment scenarios were studied to confirm that the users' arguments were backed up by their actions.

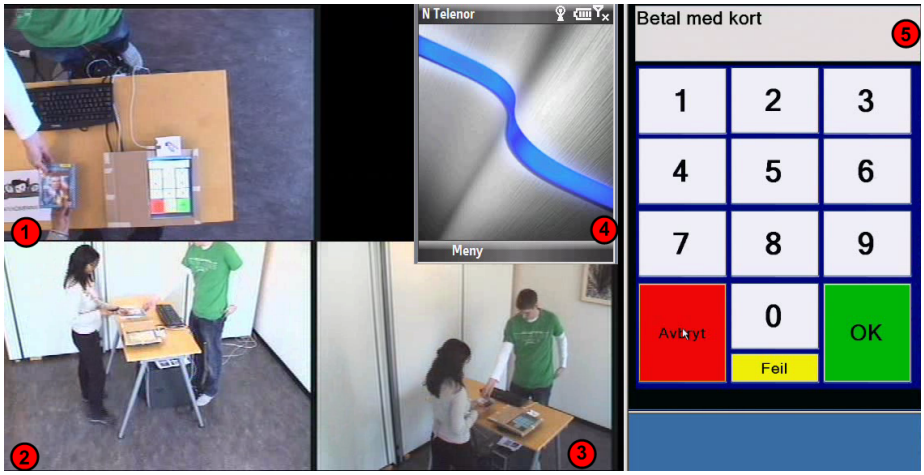

Figure 5.5: The captured camera and screen output

Chapter 6

Workshop No.1

This chapter describes the first workshop which was conducted November 26th, 2008 at the usability lab at NSEP.

6.1 Focus and Goal

This workshop focused on

- The dialog between the payment system and the users, and which role the mobile phone should play in this context.
- The relevance of different card selection options on the mobile phone (Pre-selected default card, selection at payment time and selecting a non-default card before the impeding payment).
- Means to enhance mobile payment applications.
- The extent to which the participant felt that the concept of contactless mobile payments at physical points of sale presents a attractive alternative to plastic payment cards.

6.2 Methods

The workshop was conducted as described in chapter 5, with one group of four participants. The participants were Ph.D students and researchers from NSEP in their late twenties, early thirties. There were one woman and three men. During the role-playing session they were given several tasks, and took turns performing these tasks (described in section 6.3), while the other participants watched. Each task was performed by all participants before the next task was given. All tasks involved purchasing a product using contactless mobile payment. The tasks varied slightly to test the various aspects of payment as analyzed in section 4.2. The participants were provided a phone (as described in section 5.3) with three cards installed on it.

6.3 Execution

The tasks given to the participants were based on three usage scenarios for card selection. These scenarios are in turn based on the design alternatives in subsection 4.2.1.

6.3.1 Usage Scenarios for Card Selection

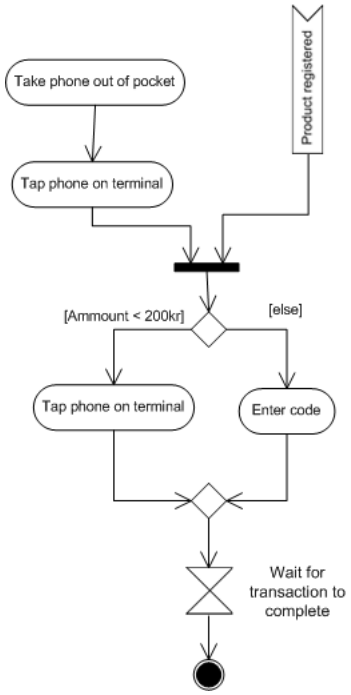

Figure 6.1: Activity diagram showing payment using prototype no. 1 with preselected card

Pre-selected Default Card The first scenario is based on design alternative A: Designating a default card. In this scenario one of three cards on the phone was designated as the default card, and the participants were instructed to use the pre-selected default card. This scenario is typical for when the customer has one card that are used for most or all transactions.

Select Card During Payment The second scenario is based on design alternative B: Select a card at payment time. In this scenario none of the three cards were designated as a default card and the participants were instructed to select a card at payment time. This scenario might occur if the customer does

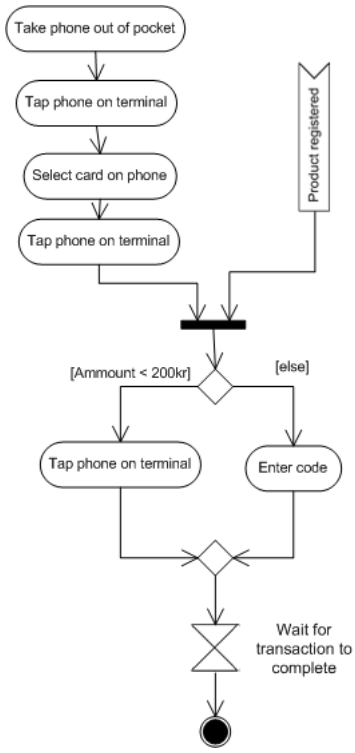

Figure 6.2: Activity diagram showing payment using prototype no. 1, where card is chosen during payment

not use the same card for most transactions. The customer might use several different cards for a variety of different situations and does not feel it is natural to have a pre-selected default card.

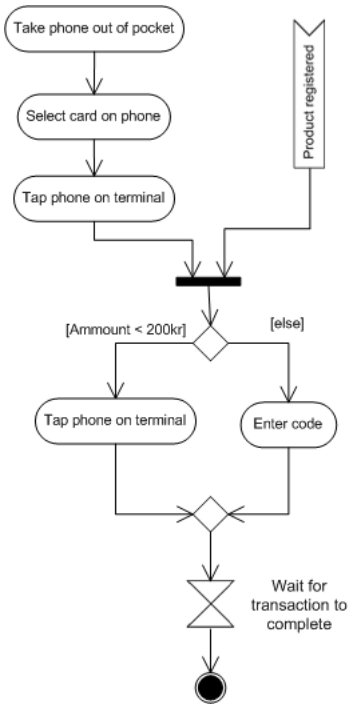

Figure 6.3: Activity diagram showing payment using prototype no. 1, where a different card than the default card is selected

Select a Different Card than the Pre-selected Default Card The third scenario is a combination of design alternative A and B. In this scenario one card is designated as a default card (A), however the participants were instructed to pay with a different card. This card would have to be selected at payment time (B). This scenario will occur if the customer wants to use the default card for a majority of transactions but not the upcoming payment. The active card should revert back to the default card after the payment with the other card is complete.

6.3.2 PIN or PIN-less

For each card selection scenario, the participants were instructed to buy two products, a blu-ray movie (priced at 249 NOK.) and a magazine (priced at 69 NOK). These products were bought separately, and the pricing were set so that the movie requires a PIN, while the magazine purchase is PIN-less.

Telenor has suggested an upper limit of 200 NOK per transaction for PIN-less purchases. This corresponds to the two design alternatives for PIN or PIN-less from subsection 4.2.2.

PIN-less Confirmation When designing a PIN-less solution, there were some concerns that it would provide no visibility of status and no emergency exit before the transaction was complete. If the phone is tapped with a pre-selected card, and no PIN is required, the transaction would complete immediately. This leaves the user without an opportunity to cancel the transaction (in case the user realizes that the wrong card was pre-selected or any other reason). The PIN-less task was thus run twice. Once where the PIN-less payment required the Customer to tap the phone again to confirm the payment, and once where no confirmation was necessary.

6.3.3 The Role of the Phone

All tasks were run with an active phone (design alternative A), where the phone participated in the payment dialog (see subsection 7.1.2). However the first task (1a in the list below) was run once with an inactive phone (design alternative B), before all other tasks.

6.3.4 Overview of the Tasks

To sum up, these tasks were given:

1a* Inactive phone (otherwise identical to 1a)

1. Use pre-selected default card
   (a) Buy movie (requires PIN)
   (b) Buy magazine (PIN-less)
      i. No confirmation
      ii. Tap to confirm
2. Select card at payment time
   (a) Buy movie (requires PIN)
   (b) Buy magazine (PIN-less)
      i. No confirmation
      ii. Tap to confirm
3. Select another card than the default card.
   (a) Buy movie (requires PIN)
   (b) Buy magazine (PIN-less)
      i. No confirmation
      ii. Tap to confirm

Chapter 7

Prototype and Mockup Used in Workshop No. 1

This chapter describes the prototype of the wallet application, and the payment terminal mockup that was used in the first workshop. The prototype was developed as a MIDlet using Java Micro Edition.

7.1 The wallet application

The wallet application prototype can be split into two parts. The card selection menu and the payment dialog. The menu is used to configure the wallet, by selecting which card will be used as the default card or if there should be no default card. The menu is essentially used to set the desired state of the wallet before the payment situation occurs. The user interaction that occurs during the payment situation is the payment dialog.

7.1.1 The Card Selection Menu

The main screen of the wallet application shows all cards available on the phone. The cards are arranged in a radio button group. The checked radio button indicates which card is the default card. There is also a radio button for selecting card at the time of payment, i.e. not having a default card [1]. A link under the radio button group leads to a screen that lets the user select a different card than the default card, to be used at an upcoming payment[2](see fig.7.1). When selecting a card for an upcoming payment, the user is presented with a screen as shown in fig 7.2. The user selects a card by highlighting it a pressing `select`. The phone then displays the card's logo and a message indicating that the card

[1]This option was not revealed until the select card during payment-scenario was acted out

[2]This option was not revealed until the select different card that the default card-scenario was acted out

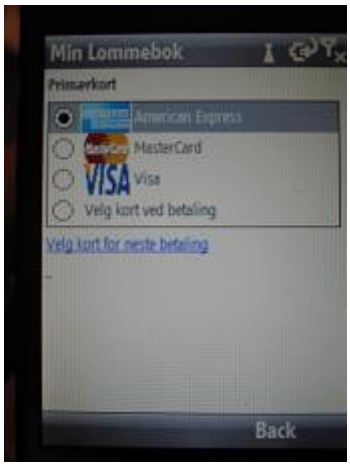

Figure 7.1: The main screen of the wallet application

is ready. This is analogous to taking a plastic card out of the wallet and holding it in your hand, ready to pay.

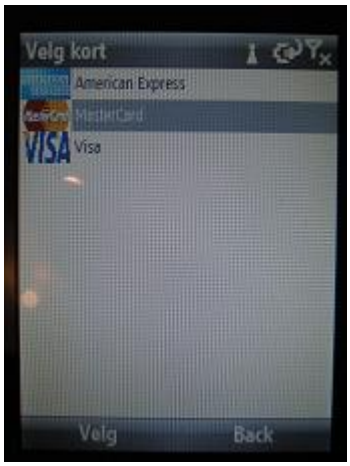

Figure 7.2: Screen for selecting card for the upcoming payment

7.1.2 The Payment dialog

The dialog that appears after the phone is tapped depends primarily on two factors:

1. Is a card selected?
2. What is the amount due?

(1)If a card is not selected the user will be prompted to select one through the same interface as a card is selected for an upcoming payment (see fig.7.2). The scenarios of subsection 6.3.1 illustrate the context for when a card is selected or not. (2) If the amount due is more than 200 kroner the user will be prompted to enter the PIN on the terminal. If the amount due is less than 200 kroner a PIN is not necessary. The prototype can be set up with one of two alternative dialogs for amounts that do not require PIN. One alternative displays the logo of the selected card and the amount due and prompts the user to tap the phone again to confirm the transaction. The second alternative is to accept the payment without any confirmation and just display a message on the phone that says "transaction complete". A wizard of oz method was used to trigger the payment dialog on the phone when the users tapped the phone to the payment terminal. This was done due to technical difficulties. The dialog that is described here was not triggered in the task were the phone was supposed to be inactive.

7.2 Terminal

The mockup payment terminal used in workshop no. 1 was created as described in 5.3.1. The dialog was changed slightly, compared to the standard dialog, to accommodate the scenarios and the payment dialog of the prototype (see 7.1.2). Fig. 7.3 shows the behavior of the terminal as used in Workshop no. 1.

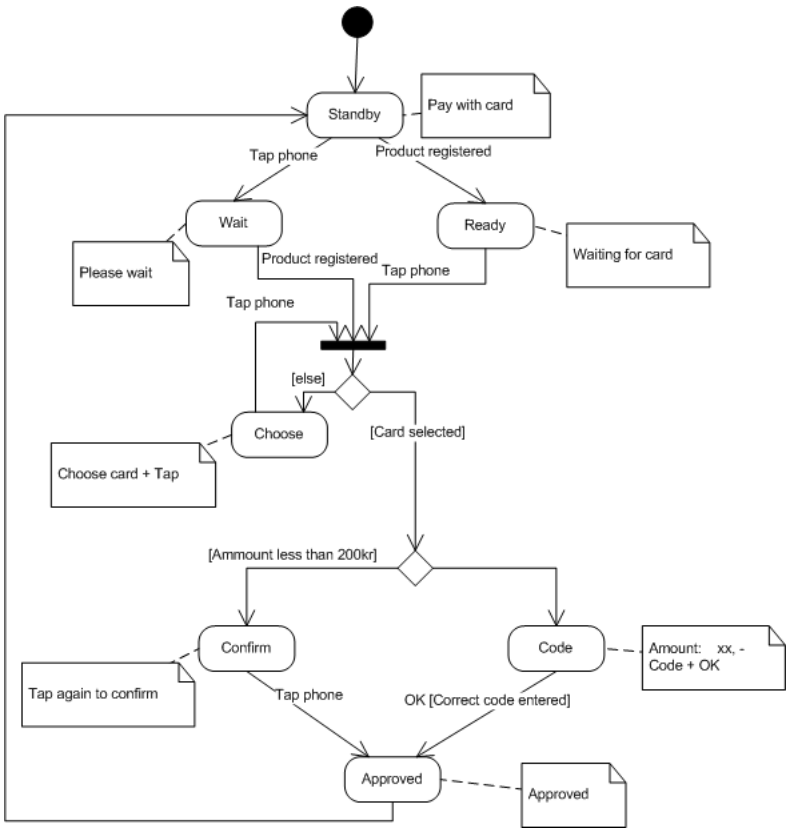

Figure 7.3: State diagram showing the behavior of the mockup used in Workshop no. 1

Chapter 8

Results from Workshop No. 1

This chapter describes the results from workshop no. 1. These results are the product of the various tasks and the following discussions.

8.1 The Role of the Phone

The role of the phone was tested with an inactive phone (task 1a*) vs an active phone (all other tasks). During the post-test discussions all participants expressed dissatisfaction with having to deal with two devices at once. All participants agreed that information and instructions as part of the payment dialog should only be displayed on the device were input was expected. Since the PIN must be entered on the terminal (for security and legal reasons) not all input can be entered on the phone. Thus the terminal should be the only device that participates in the payment dialog. This alternative is further supported by its similarities with plastic cards. In fact an active phone causes a break with the card metaphor that are otherwise used extensively. As one participants put it "it is unnatural to look at the phone all the time, I'm holding a card". In other words, the workshop clearly indicated that the phone should not participate in the payment dialog and be just as inactive as a plastic card (Design alternative B in subsection 4.2.3)

8.2 Card Selection

The card selection was tested using the three usage scenarios: pre-selected card (task 1) vs. card selected at payment time (task 2) vs selecting a different card than the default card (task 3). All participants stated that they have a card that they use for most or all transactions. All participants said that they would, or might, designate this as a default card if given the opportunity. They also noted that an option for selecting a different card would be required (for the few purchases were they do not use the default card). This means that all usage scenarios are relevant. The workshop did however indicate several usability

issues with the prototype with regards to card selection. Although the details of the prototype was not the focus of this workshop, it does reveal an area of possible usability issues.

8.3 PIN or PIN-less

PIN required (tasks a) vs PIN-less (tasks b) were tested once for each card selection task. The participants were divided with regards to the possibility of PIN-less payments. They felt that an upper limit per transaction was insufficient. They were concerned that a thief could inflict great damage with repeated transactions just below the limit (200 NOK). Therefore the participants suggested an upper limit per day as well. Such a limit would put a roof on the total amount charged through PIN-less transactions per day. With such a limit in place a thief is not likely able to steel more than this amount before the owner can notify the bank or card issuer. The participants would like an option to personalize both the per day limit and the per transaction limit. The participants also mentioned that the default setting when the application is first installed should be with PIN-less payment turned completely off.

8.3.1 PIN-less confirmation

PIN-less confirmation, i.e. tap to confirm (tasks i) vs no confirmation (tasks ii), were tested for each PIN-less task. All participants agreed that tapping the phone to the terminal should be analogous to swiping a card through the reader. This is an action that are associated with the act of paying for a product. Using the same action to confirm the transaction was considered unsuitable, confusing and even repetitive. Several participants were concerned that the extra tap meant they had payed for the product twice, while others thought that they had done something wrong (i.e that "tap to confirm" was an error message).

Although the tapping action was deemed unsuitable for PIN-less confirmation, the concept of PIN-less confirmation was not rejected. One participant felt that PIN-less confirmation was unnecessary since the amount in question was not significant. However, most participants were positive to a PIN-less confirmation, but wanted to use the `OK`-button on the terminal instead of the tapping action.

8.4 Extra Features and Other Findings

Digital receipts to the phone was the most heavily suggested extra feature. Participants suggested an inbox for receipt, but did not agree on whether they wanted to be notified that the receipt was received. The participants also wanted the available balance displayed as well as card details (such as card number, expiry date etc). Access to an overview of the latest transactions for different credit cards was also suggested.

Chapter 9

Workshop No. 2

This chapter describes the second workshop which was conducted November 26th, 2008 at the usability lab at NSEP.

9.1 Focus and Goals

This workshop focused on

- The role of the payment application, whether it should be in the foreground or background.
- The relevance of the card selection options in an extended shopping scenario.
- The usability of the second iteration of the prototype, including the new features suggested in the first workshop.
- Identifying central themes trade-offs.

9.2 Methods

This workshop was conducted as described in chapter 5, with three group of two participants each. The first group was one woman and one man, both Ph.D students from NSEP in their late twenties. The second group also consisted of a man and a woman. These were researchers in their mid-thirties. The last group consisted of two male master students in their mid-twenties. During the role-playing session the participants were asked to go shopping for three products in three different "stores". The "stores" were identified by signs with the logo of the store. These signs were posted at the entrance of the store and at the counter. When the Customer had completed a transaction in one store he would leave the room. The facilitators would then change the signs before the Customer entered the room again. This is illustrated in the floor plan in fig. 9.1.

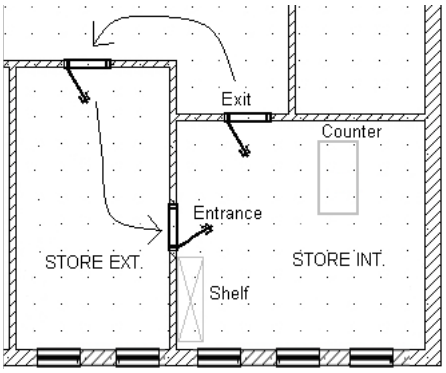

Figure 9.1: The floor plan of the simulated lab

The cards installed on the phone was introduced to the participants in the introduction. The cards were nicknamed according to their purpose. The nicknames is an example of possible custom names the people might give their cards if given the opportunity (During the post-test discussion, the participants were asked if they were positive to such a feature). The cards installed on the phone, their nicknames and purposes were as follows:

1. VISA ("current account card"), a debit card charged to private account
2. Master Card ("work card"), a credit card used for work related purchases. The bill is charged to the user.
3. American Express ("travel-card"), a credit card used on foreign travel.

9.3 Execution

The task in this workshop was to go shopping. Each of the three purchases incorporated a card selection usage scenarios from the first workshop (see subsection 6.3.1) as well as the PIN or PIN-less dimension. The shopping task was performed twice to test the final dimension of the role of the wallet application (see subsection 4.2.4).

9.3.1 The Shopping Task and Incorporated Aspects

The shopping task of this workshop incorporates several of the usage scenarios of subsection 6.3.1. After designating the VISA card as the default card, the participants were instructed to purchase the following products, first a blu-ray movie at "Platekompaniet", second a USB-adapter at "Clas Ohlson" and finally a bottle of soda at "7-Eleven". The USB-adapter was a work related purchase and the participants were told to charge it to their Master Card ("work card"). The other two purchases were private and the participants were told to use

their VISA card. When done shopping the participants were asked to fill out a reimbursement form for the USB-adapter.

Card Selection

Each purchase in the shopping errand corresponds to a usage scenario and design alternative. When buying the movie (1a), the Customer uses a pre-selected default card as based on card selection design alternative A. The USB-adapter (1b) is then bought with a different card than the default card. Again, this is a combination of alternatives A and B. There is a default card designated, but the Customer must select a different card at payment time. This serves as a test of design alternative B alone as well. With the prototype used for this workshop, the procedure for selecting a card at payment time when there is no default card, is identical to the procedure for selecting a different card than the pre-selected default card. The purchase of the soda (1c) with the default card at the end, serves to test that the participants understand and trust that the active card reverts back to the default card after the transaction with the temporary non-default card is completed.

PIN or PIN-less

The purchase of the soda is small enough to be PIN-less, while the first two purchases requires a PIN. The two design alternatives, PIN or PIN-less, is thus tested as well. Because of feedback in the previous workshop, the PIN-less purchases is now confirmed by simply pressing `OK` on the terminal, instead of the confusing tap to confirm.

Extra Features

On the reimbursement form the participants were asked to fill out their account number[1], and the price of the adapter. This information is available in the card details screen and receipt archive, respectively (see subsection 10.1.2 and figs. 10.3 and 10.5). Thus, the reimbursement form forces the participants to use these extra features which they may not otherwise have encountered. Other extra features encountered include the display of available balance (see subsection 10.1.1 and Figure 10.1). In addition personalized card names were given to the cards. Although there was no option in the prototype to edit these names, the feature was implied.

9.3.2 The Role of the Wallet Application

In order to explore the role of the wallet application the shopping task were given twice. The first time the wallet application were required to be opened, while it would run in the background the second time.

[1] That is the fictive account number associated with their primary card

9.3.3 Overview of the Tasks

1. Go Shopping and buy:
   (a) A movie at "Platekompaniet", using the VISA card. (PIN required)
   (b) A USB-adapter at "Clas Ohlson", using the MasterCard (PIN required)
   (c) A bottle of soda at "7-Eleven", using the VISA card (PIN-less)
2. Fill out reimbursement form.

Perform the tasks with the wallet application in the foreground, then repeat task 1 with the wallet application in the background.

Chapter 10

Prototype and Mockup Used in Workshop No.2

This chapter describes the prototype of the wallet application, and the payment terminal mockup that was used in the second workshop. Results and experience from the first workshop helped shape this second prototype. This prototype was developed as a smart device application using .NET Compact Framework and C#.

10.1 The Wallet Application

Results from the first workshop show that the users prefer to focus solely on the payment terminal during payment and avoid a distributed user dialog. For this reason the second prototype have no feedback or dialog on the phone after the phone is tapped. This prototype can be divided into to two parts, card selection and wallet administration.

10.1.1 Card Selection

The main screen of the application will be the card selection screen (fig.10.1). It shows which card is selected and optionally the available balance on the users account. The user can flip through the available cards with the D-pad[1]. This screen will correspond to holding a plastic card in your hand. The screen consists of a combo box [2] at the top which holds all available cards. Directly beneath the available balance of the currently selected card is displayed. There is also a check box that allows the user to toggle the visibility of the balance on or off. The rest of the screen is filled with a logo identifying the selected card. When

[1] D-pad = Directional pad

[2] The combo box component for a Windows Mobile 6 Standard (smartphone) application looks slightly different from a desktop combo box. It uses a horizontal spinner instead of the traditional drop-down list. This is due to the limited screen real-estate available

the user changes the selected card with the combo box, the logo and available balance is updated correspondingly. Finally the screen offers a `Close`-command and a `My Cards`-command, for the right and left soft button respectively. `Close`-command closes the wallet application and takes the user back to the phone menu, while the `My Cards`-command opens the wallet administration screen.

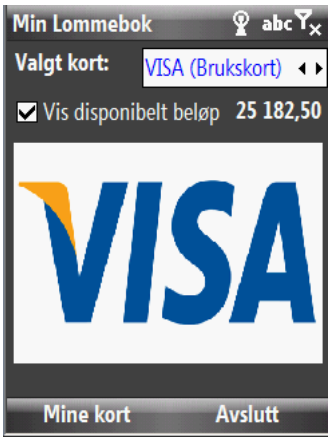

Figure 10.1: The card selection screen

10.1.2 Wallet Administration

From the main screen the users can select the `My Cards`-command to enter the administration screen (fig.10.2). In this screen the users can set a default card or view card details and receipts. Setting a default card is done in the same manner as selecting a card in the main screen, by using the combo box [2] . Below the default card combo box is a list of all the virtual cards on the phone and their corresponding available balance. Pressing the `Select`-command (left soft button) accesses the card details (such as card number, card type and associated account number[3]) of the highlighted card. A receipt archive is accessible with a link at the bottom of the wallet administration screen. The receipt archive resembles a message inbox. It shows a list of receipts with columns for received time and issuing store. The (electronic) receipt is displayed by selecting it from the list (using the left soft button).

10.2 Terminal

The mockup payment terminal used in workshop no. 2 was created as described in 5.3.1. The dialog was changed slightly to accommodate the scenarios. Fig. 10.6 shows the behavior of the terminal as used in Workshop no. 2.

[3] if applicable. Not all cards have an account associated with it

Figure 10.2: The wallet administration screen

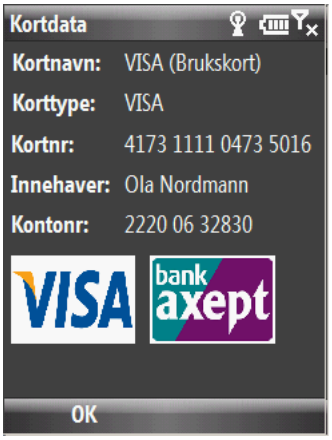

Figure 10.3: The card details screen

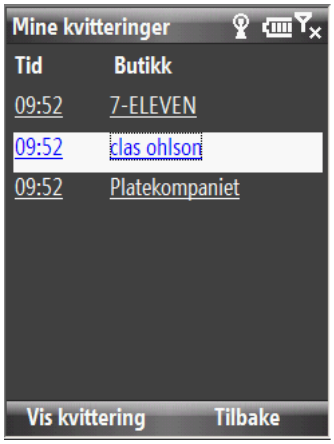

Figure 10.4: The receipt archive screen

Figure 10.5: The receipt screen

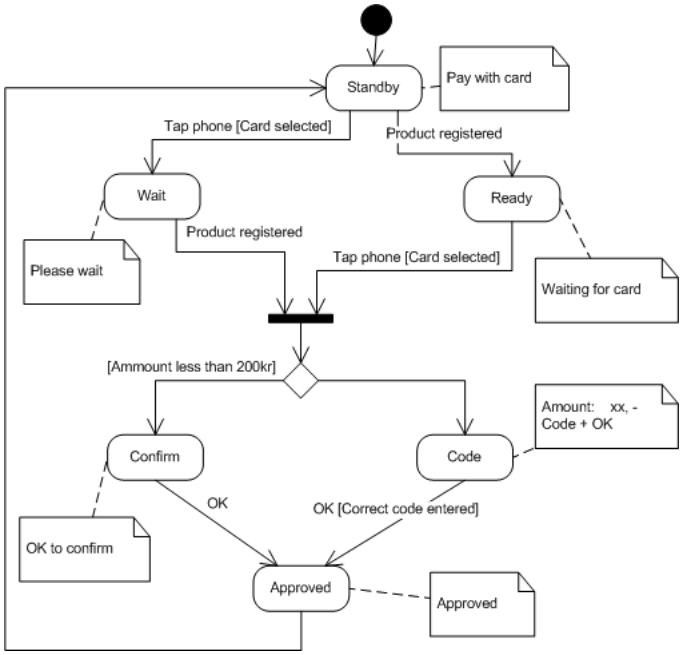

Figure 10.6: State diagram showing the behavior of the mockup used in Workshop no. 2

Chapter 11

Results from Workshop No. 2

This chapter describes the results from workshop no. 2. These results are the product of the various tasks and the following discussions.

11.1 The Role of the Phone

This dimension was not tested in the second workshop since the results from the first workshop was conclusive enough. Design alternative B (Inactive phone) was implemented and used in the second workshop. None of participant had any complaints to this solution which confirms the previous conclusion.

11.2 Card Selection

The participants confirmed that usage scenarios were relevant. Most of them had either one card that they used for all purchases or one for most purchases and a second for special purchases (examples were household purchases or gasoline). Although the second prototype improved on some of the usability issued associated with card selection, there were still some issues left. The participants had most problems understanding if a card was selected or not. Some did not fully understand the spinner component in the main card selection screen or that a card was selected when its logo was displayed in the same screen. Others strayed off to the administration screen and tried to select a card there (mostly by entering the card details screen).

11.3 PIN or PIN-less

Once again the participants were divided with regards to PIN-less payments. In all three groups at least one participant suggested a personal limit like those suggested in the first workshop. One participant preferred a PIN regardless

while most were open to PIN-less payments. The combination of PIN-less payment and running the wallet application in the background also raised some concerns (see section 11.4).

11.4 The Role of the Wallet Application

With regards to the wallet application running in the background, the participants expressed concerns about loosing control. Some became unsure as to which card was selected after using a non-default card (as in task 1c), however the main concern was the lack of conscious user actions required when PIN-less transactions are combined with a wallet application in the background. They feared that this might give criminals an opportunity to "pick their pockets" by simply standing next to them with a concealed reader. Most participants wanted the system to require some sort of conscious user action to enable contactless payment. Explicitly opening the wallet application is one example of a conscious action. Another suggested example was to activate the wallet just as bluetooth has to be activated. It was suggested that such activation could be achieved by pressing a button (or a combination of buttons) on the phone.

The participants were also asked whether they would accept a code or password to open the wallet application. The participants expressed that this kind of log in would make them feel more secure, however they also acknowledged that it does involve extra effort. While some stated that they would prefer the extra security despite of the effort, others commented that they would likely "sacrifice security for comfort". One participant suggested that there should be a setting for turning log in on or off.

11.5 Extra Features

All participants were very positive to the extra features that were implemented.

Available Balance None of the participants could think of any reasons why the available balance should not be displayed and though it might be very useful.

Digital Receipt The same applies to digital receipts. Paper receipts are rarely looked at and the participants said they may not need the digital receipts very often either, however provided there are no inconvenience receiving the receipt, the participants were positive. Therefore the participants preferred to receive the receipt silently (i.e. without a beep or message displayed).

Personalized Card Names Personalized card names were also perceived as useful. In fact several participants mentioned that they already used personalized card names on several web services. Others had experienced difficulties separating their existing plastic cards.

Other Features Other suggested features were access to latest transactions or even full online banking features. Other participants made it clear that they only wanted a minimum of extra features. The features already included were fine, but there were concerns that more features would clutter the interface.

Chapter 12

Analysis of the Results

In this chapter the results of the two workshops (see chapters 8 and 11) will be analyzed in order to answer the remaining research questions:

2. Which technological solutions and underlying metaphor do the users prefer?

3. What are the central themes and trade-offs that emerge from the users arguments?

12.1 Preferred Solutions and Underlying Metaphor

The main underlying metaphor is the card metaphor. Contactless mobile payment is meant to replace plastic cards and the card metaphor is therefore the obvious and natural choice. When using contactless mobile payment, the user will utilize virtual cards that have the same affiliations as the plastic cards. The workshops exposed that the card metaphor was deeply entrenched in the users mind. In fact the card metaphor extends well beyond the simple association of the cards and card selection. The card metaphor influences the role of the phone during the payment dialog as well.

As workshops clearly showed, the users prefer a solution where the payment dialog is confined to the payment terminal. An inactive phone is easy to accept and understand since it matches the card metaphor, while an active phone breaks with it. The participants of the workshops also indicated that all instructions and messages that are part of the payment dialog should be displayed on the device where input is expected. Since the PIN must be entered on the payment terminal (for legal and security reasons), all instructions and messages should be displayed there. Displaying parts of the payment dialog on the phone only causes confusion. This makes an inactive phone (design alternative B) the preferred solution with regards to the role of the phone.

The strong card metaphor also influenced the participants preference with regards to PIN-less confirmation. Although PIN-less payments and PIN-less

confirmation was new to the participants they indicated that tapping to confirm was an unsuitable solution. The participants equated the tapping action with the swiping action and associated these actions with payment. Thus, using the same action as a confirmation breaks with the card metaphor. Although the action used for PIN-less confirmation in the first workshop was disapproved, the concept was not. The participants of the first workshop suggested pressing the "OK"-button on the payment terminal as confirmation instead of the tapping action. This was implemented for the second workshop and accepted by the participants which makes it the preferred solution for PIN-less confirmation.

Designating a default card was seen as a valuable feature. All participants said they would use this feature. The option of selecting a non-default card was deemed a necessity for the default card feature to be relevant. There were several usability issues with both prototypes with regards to card selection. A preferred solution was thus not determined, however the participants had the most problems with determining whether a card was selected or not and how to select a card. A future solution should seek to answer these questions very clearly.

Electronic receipts as well as display of available balance and card details are the preferred extra features. These features were requested in the first workshop and received praise in the second. More features were also suggested while others wanted to keep the number of extra features to a minimum.

12.2 Central Themes and Trade-offs

A couple of themes dominated the post-test discussions. These recurring themes were the card metaphor, the users' routines for card usage, and the trade-offs between efficiency and confidence, and features and complexity.

The card metaphor was heavily referenced by the participants and clearly plays a major role in the users' minds. The card metaphor's effect on the users' preferences is detailed above.

When considering card selection options the users' routines for card usage were a central theme. The assumptions (from subsection 4.2.1 as well as subsection 6.3.1 and section 9.3) about card usage and people's habits and routines concerning card selection were confirmed. The participants had a private debit card used for most purchases and perhaps a secondary card. Depending on marital status, the secondary card is usually for household purchases. The participants also confirmed that card selection is dictated by the purpose of the purchases and that the users know which card should be selected before even entering the store.

12.2.1 Efficiency vs. Confidence

Efficiency refers to how quickly the users can perform a task (in this case purchase a product). The most efficient solution is a solution where a purchase can

be completed as fast and effortless as possible. This may be achieved by demanding very little action from the user. A simple tap and nothing more would be the most efficient solution. However, it would be a very insecure solution and the user is unlikely to have confidence in the solution. Efficiency vs Confidence is the usability equivalent to the classical trade-off between performance and security.

The participants were notably concerned with the security of contactless mobile payment. Several features and settings were suggested to increase their confidence in the system's security. Most of these suggestions involved added required actions at the expense of efficiency. The participants were divided with respects to how much efficiency they would sacrifice for increased confidence.

The influence of a PIN

There are mainly two dimensions (from section 4.2) that affects efficiency and confidence: PIN or PIN-less and The role of the wallet application. Obviously a solution that requires a PIN is less effective than a PIN-less solution. Entering a PIN is an added required action that takes some time and effort to complete, but also increases the security by validating the user. Telenor has determined that any transaction above 200 kroner must require a PIN. This is a likely minimum requirement from banks and card issuers. Transaction below 200 kroner could possible be PIN-less. However the participants were not entirely confident with PIN-less transactions without further restrictions. They were very concerned about the possible consequences of a stolen phone and did not trust a per transaction limit of 200 kroner alone. To increase their confidence in the system, the participants suggested that the per transaction limit should be personalized and that another personalized limit should be added. A spending limit for PIN-less transaction would restrict the total amount spent on PIN-less transactions per day, and would reduce the risks of getting one's account emptied in case of theft. These limits should be personalized because people value confidence and efficiency differently.

The influence of the wallet application's role

The second dimension to affect efficiency and confidence is the role of the wallet application. A wallet application that runs in the background does not require any action before the phone can be tapped and is thus more efficient and effortless than having to open the wallet application explicitly. Coupled with a PIN-less transaction, the tap-action is the only required action to complete a transaction. While this is very efficient, the participants were worried that criminals could take advantage of this in a form of electronic pickpocketing. To increase confidence the participants wanted the system to require some form of conscious action by the user. Opening the wallet application or entering a PIN are actions that alleviate these concerns. However, the participants stipulated that pressing "OK" on the terminal was not sufficient, because the pickpocket could be the one who presses the "OK"-button. Thus, the required action should

preferably be performed on the phone. Entering a PIN on the terminal only suffices because only the user can enter the correct PIN.

Overview

Entering a PIN or opening the wallet application are actions that increase confidence and decrease efficiency. Increasing confidence further can be achieved by requiring the user to log-in to the wallet application (using a password or PIN). How the combination of these dimensions affect efficiency and confidence is estimated in the following table and illustrated in Figure 12.1. The combinations that scored "Very Low" on either efficiency or confidence were rejected by the participants (this is illustrated by the red circles). As evident from the figure, efficiency vs confidence is a genuine trade-off. Efficiency must be sacrificed for confidence or vice versa, one cannot have both.

#	PIN	Open App.	Efficiency	Confidence
1	no	no	Very High	Very Low
2	no	yes	High	Low
3	no	log-in	Medium	Medium
4	yes	no	Medium	High
5	yes	yes	Low	High
6	yes	log-in	Very Low	Very High

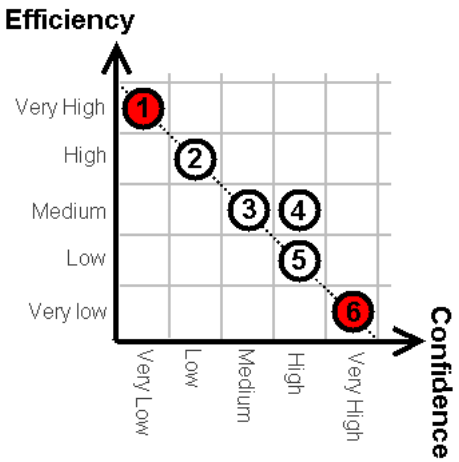

Figure 12.1: The trade-off between efficiency and confidence

The participants displayed some initial skepticism to the security of contactless mobile payment and its features that increase efficiency. This seems to indicate that most users is likely to prefer confidence over efficiency. However, the workshops did not fully simulate a stressful situation where the benefit of efficiency was evident. The participants had all the time in the world to purchase the products. They did not have a bus to catch, or anything else that

would increase their need for efficiency. Once the initial skepticism wears off and the users are subjected to stressful situation their preferences may change. Some participants knew with themselves that the would sacrifice confidence for efficiency, and it is possible that many users will forget or disregard the perceived threat and opt for efficiency over confidence, despite the initial need for increased confidence. However when dealing with people's money, the need for confidence should not be underestimated and it is not unlikely that many users will lean toward confidence over efficiency.

12.2.2 Feature vs. Complexity

The trade-off between feature and complexity is not as prominent at that between efficiency and confidence, yet it is relevant with regards to how much extra features a contactless mobile payment system should offer. The purpose of the extra features is to offer extra incentive for plastic card users to start using contactless mobile payment. Possible extra features include digital receipts, displaying available balance, and everything form a simple overview of the latest transaction to a full online banking service. Even though there are many possible features, more is not always better. More features will make the application more complex and the user interface more cluttered. Thus it is important not to stuff the application with features that are not needed or wanted.

Although there were some differences in the participants preferences, all participants welcomed the features that were implemented in the second prototype (digital receipts, personalized card names and display of available balance [1]). Other features such as various online banking services were suggested, but not presented as something of great importance. Maintaining simplicity was deemed more important to the participants. Online banking services is best left out of the wallet application, but could possible warrant its own separate application.

[1] Displaying the card details was also wanted but are not considered an extra feature since it is a "feature" offered by plastic cards already

Chapter 13

Conclusions

This chapter concludes the report by summarizing the results and suggesting further work.

13.1 Conclusion

Taking something physical and making it virtual, demands a lot of the user interface. Fancy application of new and advanced technology is useless unless the user is able to use it. The minimum requirement for the usability of the virtual representation is that it must be just as easy to use as the physical thing. People will not start using a new way of using bank cards if it is more tedious that the old way.

The first research question from section 1.2 was answered by analyzing the payment situation. To answer the two remaining questions, two iterations of a prototype were developed. Each iteration was used in a workshop where the participants simulated several payment scenarios using the prototype. After the simulated payments, the participants were asked to discuss their impression of contactless mobile payment and the prototype solutions.

13.1.1 Dimensions of the Design Space

The analysis of the payment situation revealed four important dimensions, each with two design alternatives. The first dimension is card selection. A card can be pre-selected or selected at payment time. Second is dimension is PIN or PIN-less. A purchase can require a PIN or they can be PIN-less. PIN-less purchases is only an option for small purchases (below 200 kroner). For PIN-less purchases there are two sub-alternatives concerning PIN-less confirmation. PIN-less purchases may or may not require confirmation. These sub-alternatives were discovered during prototyping

Then there is the role of the phone. The phone can participate actively in the payment dialog or it can be inactive. The final dimension is the role of the

wallet application. The system can require the wallet application to be explicitly opened and run in the foreground during transactions or it can be allowed to run in the background. When opening the wallet application the system may or may not require a log-in. These are the two sub-alternatives for a foreground wallet application and was discovered before the second workshop.

Dimensions	Design alternatives
Card selection	Pre-selected card
	Select at payment time
PIN or PIN-less	PIN required
	PIN-less purchase – confirmation (Tap or OK) – no confirmation
The role of the phone	Inactive phone
	Active phone
The role of the wallet application	Open in the foreground – log-in required – no log-in required
	Running in the background

Table 13.1: The dimensions of the design space and corresponding design alternatives

13.1.2 Preferred Solutions and Metaphor

The workshops revealed a clear preference for an inactive phone with the payment dialog confined to the payment terminal. For PIN-less purchases the workshop revealed a preference for using the "OK"-button on the terminal to confirm the transaction. Using the tap action as a confirmation was strongly disapproved. These preferences can be attributed to the strong underlying card metaphor. Solutions that break with this metaphor is likely to cause confusion among the users.

The workshops also showed that users are likely to designate a default card. Using a pre-selected default card will be the most common card usage scenario. Most users also have some kind of secondary card which makes selection of a different card than the default card, a relevant scenario. Considering than not all users may designate a default card, the card selection at payment time must also be considered.

13.1.3 The Trade-off Between Efficiency and Confidence

Efficiency vs. confidence was identified as a significant trade-off point. Users are likely to be concerned about the security of contactless mobile payment and the fear of loosing the control over their money might cause users to value

confidence over efficiency. The users are confident in the security of PINs and contactless mobile payments involving PINs are thus not the concern.

Although the participants in the workshops valued the increased efficiency of PIN-less transactions they called for a couple of measures to increase their confidence. Additional limits on PIN-less purchases were suggested. The participants wanted the option to personalize the transaction limit (in case they wanted a lower limit, and thus more confidence, than the standard 200 kroner limit) and an additional personalized spending limit per day on PIN-less purchases. These limits would alleviate the users' concerns about PIN-less transactions in case the phone is stolen.

The participants also wanted the system to require some sort of conscious user actions before a transaction could be completed. Entering a PIN is a qualified action, but for PIN-less transaction the system should require the user to open the wallet application or in some other way "activate" contactless payments. This would alleviate the users' concerns about electronic pickpocketing (where transactions are completed without the users awareness)

13.1.4 Extra Features and Features vs Complexity

Extra features such as electronic receipt, personalized card names and display of available balance are welcome. But further extra features should be limited to minimize complexity. The workshops indicated that the possibility of paying with one's phone and thus leaving the wallet and plastic card at home, along with the mentioned extra features, are all the incentives people need for starting to use contactless mobile payment.

13.2 Further Work

Telenor and their partners (among them banks and card companies) should evaluate the trade-off between efficiency and confidence further and determine which combinations they are comfortable with. Ultimately a system should be developed with setting that leave the final decisions and tweaking to the users. When the final user interface is designed how to select a card and how to determine which card is selected are issues that should be emphasized. Also the card metaphor and its effect on the users conceptual model must not be forgotten.

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