Making the Invisible Visible

Increasing travellers' trust in electronic ticketing for public transport by making ticket information visible during the journey

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OV-chipkaart Graduation Lab

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Challenge the future

Delft University of Technology
This report is part of the OV-chipkaart Graduation Lab.

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List of Definitions

Certainty is the "firm conviction that something is the case" (Oxford Dictionary).

Comfort refers to a sense of physical or psychological ease. Discomfort means the opposite of comfort: a sense of physical or psychological hardship.

Concession refers to a region wherein one operator has the time-limited monopoly on providing a certain transport service. Granted by an OV-authority (regional government) and usually acquired through a public tendering process.

Interaction means the "bi-directional information exchange between users and equipment" (ISO, 2008b).

A *journey* takes a traveller from their place of departure to their destination and often includes various modalities. This report is concerned with what the traveller sees as a journey, regardless of what part is facilitated by public transport. A *trip* is any separate leg of the journey traversed in a single vehicle, or multiple national rail vehicles. Each trip requires a separate ticket.

Modality refers to the mode of transport (Oxford Dictionary), of which the most common in this report are: train, light rail, metro, tram, bus, ferry, bike, car and walking.

OV-chipkaart system refers to the infrastructure needed to support electronic ticketing in the Netherlands: from mechanical, to digital and human support. It encompasses all ticketing aspects the traveller has to deal with to get to their destination.

Public transport provides a shared passenger transportation service with set fares on a fixed route that is available to the general public (Oxford Dictionary).

Public transport operator manages a public transport service.

A *season ticket* is bought in advance of travelling and pays for (part of) future journeys taking place in a particular timeframe. Often used by frequent travellers to enjoy discounts.

Ticket information is the collection of data regarding validity of the ticket (operator, modality, route, date, time, amount of people, comfort class, supplements) and the fare (price, discount).

Trust is the "firm belief in the reliability, truth, or ability of something" (Oxford Dictionary).

Usability refers to "the extent to which a product can be used by specified users to achieve specified goals, with effectiveness, efficiency and satisfaction, in a specified context of use" (ISO, 2008a).

User-centred design is a process in which the needs, wants, and limitations of end users of a product are given extensive attention at each stage (ISO, 2010b).

User experience is "a person's perceptions and responses that result from the use or anticipated use of a product, system or service" (ISO, 2010a).

Summary

This thesis is part of my Master of Science graduation project at the OV-chipkaart Graduation Lab of the Faculty of Industrial Design Engineering at the Delft University of Technology. The aim of the Graduation Lab is to improve electronic ticketing for travellers using Dutch public transport in a 3 to 10 year time-span. This work is supported by the Ministry of Infrastructure and the Environment, provinces (IPO), city regions (SkVV), Dutch Railways (NS), Rotterdam public transport (RET), and consumer organisation Rover.

Electronic ticketing

The OV-chipkaart electronic ticketing system for Dutch public transport achieves its goals and fulfils its purpose as is (Niemantsverdriet, 2011). It is a reliable payment system that allows for exact revenue distribution and securing stations by limiting entrance to people with tickets. While these business goals have been achieved, a holistic and integrated travel experience has not been a top priority.

Problem

Groups of travellers have experienced system related problems that could have been solved beforehand, such as inconsistent and confusing human-machine interfaces, hard to understand system rules, and a lack of system transparency. Wayfinding, smartcard acquisition, problem solving and lack of transparency were the four main usability problems found in Joppien, Niermeijer & Niks (2013). The lack of transparency caused by the ticket information invisibility is a usability problem with low impact, high frequency and high persistency. Solving this usability problem will improve the customer satisfaction of a large group of people on many occasions.

Product proposals

To make ticket information visible, I studied the available technologies and analysed several solutions: portable smartcard reader, a smartcard with integrated display, local NFC smartcard communication and backend information communication. I evaluated these proposals with medium-fidelity prototypes with 16 travellers and 15 experts. I concluded that they see limited usefulness for a portable reader and are enthusiastic

about the display card, but have strong preference for a smartphone solution. Participants would preferably use a smartphone that allows fare payment instead of just local NFC or backend ticket information visualisation.

Recommended proposal

With this user input, I designed a smartphone solution that allows travellers to pay for public transport and fits the existing OV-chipkaart infrastructure. I compared the viability of using GPS, NFC, BLE, tracking and QR codes for this purpose and concluded that QR codes best fit the requirements for the foreseeable future. QR code tickets are able to use scanners that are already being developed for international travellers and post-pay services for business travellers. Some of the other technologies do not have enough market penetration or have technical limitations.

The proposed design for fare payment with smartphones is an app that generates a QR code and displays it on screen. This QR code is scanned at check-in and check-out points by a new type of validator, ensuring reliable fare collection. The QR code communicates the ticket information to the OV-chipkaart system while the app can display the same information in a human readable format to travellers. Conductors are able to validate tickets by scanning a similar QR code generated by the app. The app can also show travel history, as well as purchased and available season tickets, and current travel information based on GPS location information and online route information services. A user of this app is logged in to his public transport account, which links the smartphone to a bank account.

I evaluated this smartphone fare payment proposal with a high-fidelity prototype with 10 participants and the results were positive. Participants preferred the use of a contactless technology that would not require line of sight (i.e., NFC, BLE or similar), but indicated that a solution that uses QR codes would both solve their ticket information visibility problem and be preferable in use to the current smartcard.

While a growing majority of people has smartphones, there will probably always remain a group of people who either do not have one or do not want to use one for fare payment. To also improve the travel experience for these people, I also re-evaluated the display card. Participants without smartphones prefer the display card to paper tickets, the current smartcard and a smartphone solution. A major concern remains the development and production costs: travellers are probably unwilling to pay more for a required purchase. Selling the display card for a higher price besides a regular smartcard will probably result in a relatively low volume of sales, increasing the per unit production costs in a vicious circle. Especially infrequent travellers and low-income

earners could benefit from greater insight into their credit balance and travel expenses, but would probably be reluctant to purchase a higher price display card.

Conclusion

I recommend developing both the display card and smartphone fare payment app, in order to improve the travel experience for all people. The display card should replace the existing smartcard. The smartphone app should start with QR codes for device-system communication and other technologies should be followed closely.

1

1 Introduction

This design project took a user-centred approach to advance the usability of the electronic ticketing in use by the Dutch public transport for travellers in the coming 10 years. The focus was on improving the interaction between system and traveller. To improve the understanding and approach travellers have towards the ticketing system.

Earlier research (Joppien, Niermeijer & Niks, 2013) concluded that one of the areas that could be improved is the visibility of ticket information. This report describes usability problems with electronic tickets in Dutch public transport. It lists causes of these problems, and explains the usage and system context. It describes possible solutions that improve electronic ticket information visibility and recommended solutions.

This report is part of the graduation requirements for the Master of Science in Design for Interaction at the Faculty of Industrial Design Engineering at the Delft University of Technology in the Netherlands.

1.1 Problem statement

Public transport in the Netherlands used paper tickets for a long time to provide travellers with a receipt of their fare payment. These paper tickets provided a way for the operators to efficiently check whether someone paid for his trip and gave travellers the assurance that they were allowed to use public transport. These analogue receipts (see Figure 1) conveyed information about the validity of the ticket (operator, modality, route, date, time, amount of people, comfort class, supplements) and the fare (price, discount). Having this information at hand provided peace of mind for travellers by eliminating fears of being removed from the vehicle or fined for fare dodging.

Figure 1: Paper ticket for a NS train from Delft to Rotterdam

Electronic tickets for public transport have been introduced in the Netherlands to solve revenue distribution, fare evasion and security problems operators experienced. This is electronic ticketing system is called the OV-chipkaart and works with contactless smartcards. Once a traveller has such a smartcard and configures it accordingly, it also reduces the ticket buying process time.

Besides the problems the OV-chipkaart solves, it also changed the way ticket information is stored, transferred and checked. The validity and fare information is now stored electronically on the smartcard by the various ticket validators, a process that reduces the visibility of the information to the traveller compared with how the paper tickets worked. Travellers are no longer able to check at all times during their journey whether they bought the correct ticket. This has increased uncertainty among travellers about their actions and decreased comfort and trust. This reduces customer satisfaction, which in turn aversely affects the goal of increasing the use of public transport (CPB & KiM, 2009), especially among infrequent travellers.

The problem statement (formulated according to Roozenburg & Eekels, 1998) is thus:

> A group of travellers lacks trust in electronic tickets for public transport in the Netherlands because the ticket information is invisible during use. This lack of transparency increases uncertainty, which causes discomfort.
>
> The design proposal should increase trust by increasing certainty and comfort, which is achieved by providing improved insight into ticket information. This should occur without excluding people from using public transport and while taking into account the context and all stakeholders' interests. The goal is to provide design solutions for over 3, 5 and 10 years.

An example of invisible ticket information that can cause discomfort for travellers is that one has to remember how much credit is left on the OV-chipkaart, because the smartcard is not able to tell by itself. If one does not have enough credit, the validator will reject any attempt to check-in.

1.2 Design process

The design process started with an analysis of public transport usage through observations and interviews with travellers and experts, and reading of documentation. Part of the information necessary for the analysis was gathered during earlier research (Joppien, Niermeijer & Niks, 2013; represented in Figure 2t by the grey area).

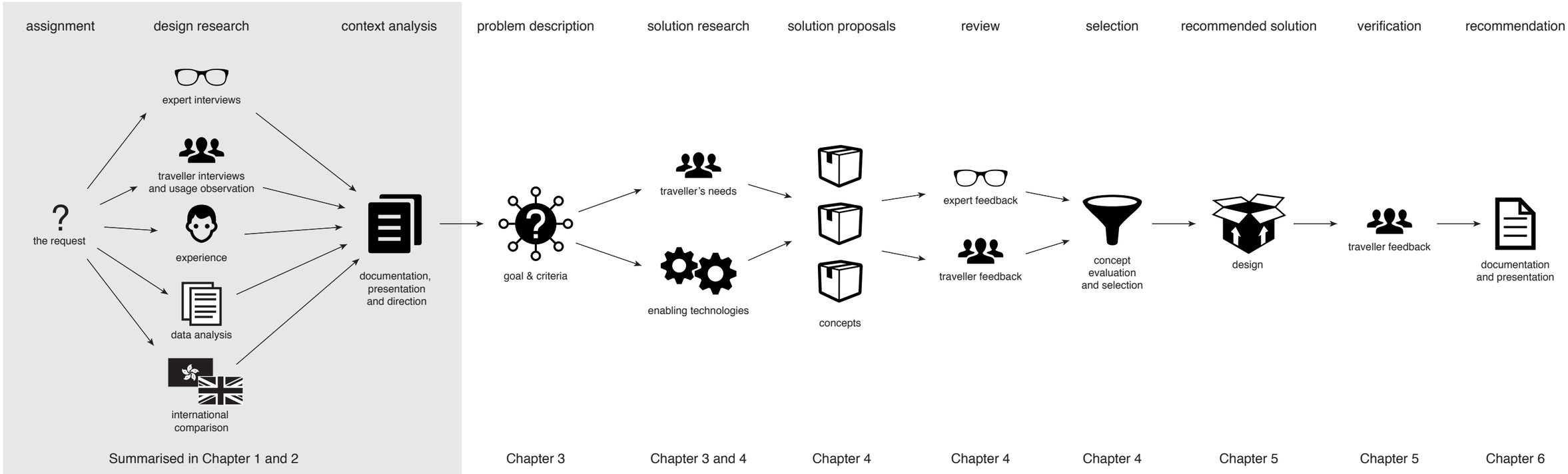

Figure 2: Process visualisation

Simultaneously, available and developing technologies were studied to obtain an overview of the possibilities. The results informed the design requirements and yielded design concepts in different directions.

These concepts were evaluated with users and stakeholders and compared to the requirements. The most promising concepts were developed in more detail and again tested with users.

Based on the research and design, recommendations were formulated for future development and implementation.

1.3 Research questions

In order to improve the travel experience, one has to understand the context and usage of the existing situation. To determine the current context of the electronic ticketing system for public transport in the Netherlands, the following research questions were formulated:

- How do travellers use public transport?
- What is their experience?
- How do they make decisions?
- Why do they use public transport?
- What interaction problems do travellers experience?
- Where do they experience these problems?
- What are the causes for these interaction problems?
- How do travellers mitigate these problems?
- How could these interaction problems be addressed?
- What needs to be changed to accommodate improvements?
- How much does it cost to address these problems?
- What impact do these changes have on the stakeholders?

1.4 OV-chipkaart Graduation Lab

This work is part of the OV-chipkaart Graduation Lab of the Faculty of Industrial Design Engineering at the Delft University of Technology.

1.4.1 Goal

The goal of the OV-Chipkaart Graduation Lab is to improve the usability of Dutch public transport electronic ticketing for travellers in the coming decade. For implementation of the results of this Lab, we focused on providing a three year short-term, five year medium-term and ten year long-term trajectory.

1.4.2 Mission

The mission of the Lab is to improve Dutch electronic ticketing to such an extent that travellers will boast about it to people abroad. Electronic ticketing for public transport should be something that people think is a reliable implementation and smart solution for a mundane administrative action.

1.4.3 Approach

The Lab works with a user-centred approach: the user is taken into account and consulted at all stages of the research and design process. The work centres on the traveller and his desires.

While working, we approach a problem from three sides: human desires, technological viability and business considerations. As seen in Figure 3, the circles overlap and good products balance all three factors. We also take into account the existing infrastructure, stakeholder interests, political viability, technological progress, financial impact and social acceptance.

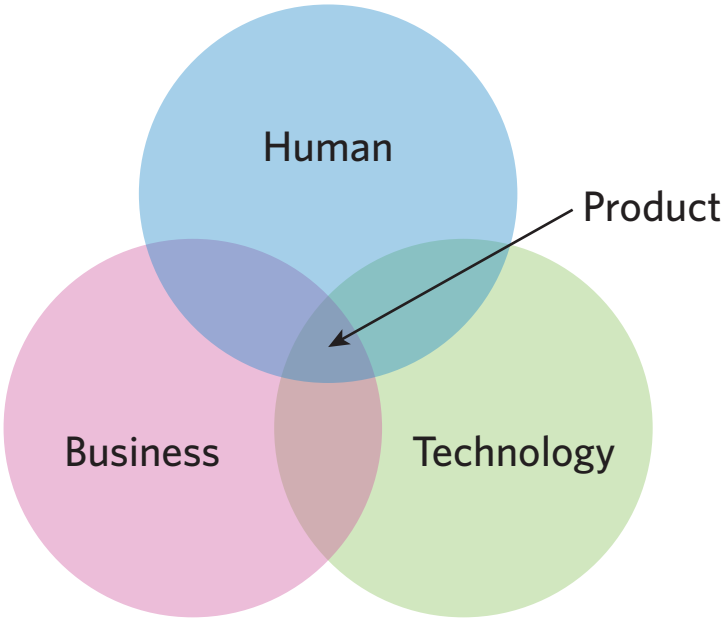

Figure 3: Human, business and technology, as visualised by IDEO (2009)

1.4.4 Reports

The work in this report is a follow-up to earlier research, documented in Exploring New Possibilities For User-Centred E-Ticketing (Joppien, Niermeijer & Niks, 2013). Complementary work was conducted by Joppien (2013) in the area of improving system adoption and by Niermeijer (2013) in the area of improving the check-in and check-out procedure.

1.4.5 Delft University of Technology

The Delft University of Technology is a natural partner for the OV-chipkaart system, because it has expertise in large (infrastructural) projects. Its 17.500 students and 2.500 researchers work on a wide range of complex engineering problems and their impact on society. From green energy production to new surgical tools, the university uses its knowledge and facilities to advance people's welfare in the Netherlands and across the globe since 1842.

The Faculty of Industrial Design Engineering specifically studies the development and improvement of products and services. Whether it is to make safer cars or easier to use software, the faculty studies the innovation process and educates new designers. Increasingly this means exploring multi-stakeholder product-service systems. Often in close collaboration with companies, organisations and governments. This results in a deeper understanding of the design process, better production methods and improved design methodologies.

The Faculty's Design for Interaction program focuses on human-system interaction. It takes the fields of ergonomics, aesthetics, interaction design, psychology and sociology, and applies them to product design and development. The goal is to teach people in making products that fit users' needs.

1.4.6 Sponsors

Substantial financial and organisational support for the OV-chipkaart Graduation Lab and this report was provided by the Ministry of Infrastructure and the Environment, Permanent Structure in formation, provinces (IPO), city regions (SkVV), Dutch Railways (NS), Rotterdam Public Transport (RET) and consumer organisation Rover. These organisations were consulted on the content of this report throughout the project, but they do not necessarily endorse all conclusions.

1.5 Reading guide

The next chapter introduces the OV-chipkaart system to better understand it. Chapter 3 explains the ticket information visibility problems travellers experience. Chapter 4 describes the synthesis of the technologies in product proposals and the results from the user evaluation. Chapter 5 shows the adapted and detailed design proposals, and the results from the second user evaluation. Chapter 6 lists recommendations and conclusions. References are listed at the end of the report. Appendices can be found in a separate publication.

2

2 Electronic ticketing in Dutch public transport

2.1 Introduction

Dutch public transport has gone through many phases in the past century: from fully private endeavours to public companies and now to a regulated private market again. The changing governance structures, shifting revenue models and technological progress have had considerable impact on the operational approach. Some of the largest changes have occurred in the past decade: decentralisation, liberalisation and digitisation. These have brought changes to the payment method and tariff system for travellers.

In order to understand the impact this all has on system development, this chapter explains the history, describes the stakeholders, lays-out the technology and discusses trends. The information is sourced from government publications, business reports, news publications and off-the-record expert interviews.

2.2 Historical perspective

Public transport started out in the Netherlands as a private activity in the 19th century. After World War I, the largest rail companies almost went bankrupt and the government nationalised and merged them into Dutch Railways (NRC Handelsblad, 2001). At the same time buses became more popular and government organised concessions in the 1920s. With the arrival of the personal car, bus companies became less profitable and started making losses. To guarantee the level of public transport service, national government started to subsidise buses as well in the 1960s (Minister of Transport, 1979; KpVV, 2010). In return for the subsidies, the government demanded a say in the level of service and acquired price setting authority (Minister of Transport, 1979). This led to ticket harmonization in the 1980s: a national tariff system for bus, tram and metro was introduced (Minister of Transport, 1979). This consisted of a national zoning system and a national paper ticket ("Strippenkaart").

Since public transport tickets could now be bought at one side of the country and used to travel with a public transport company at the other side of the country, a revenue distribution system was set-up. Government tasked an agency to distribute the national ticket revenue based on sales and usage surveys. The methodology and results of

these surveys led to disagreement among public transport operators, which demanded a fairer system (Meijdam, 2011). In order to have a more detailed overview of travel behaviour, several new fare payment systems were tested in pilot studies (magnetic stripe, "Tripperpas"). However, these were scrapped, because they had a number of drawbacks, including unacceptably long boarding times (Leeuwarder Courant, 1989).

Simultaneously, Dutch Railways (NS) was looking for ways to close stations to non-ticket holders in order to increase security and decrease fare dodging (Zwan, 2011). Hong Kong introduced a contactless electronic ticket for public transport in 1997 and the NS started to investigate this technology (Zwan, 2011). The Minister of Transport agreed to support the development of a contactless electronic ticketing system, under the condition that it would take over the role of the existing national paper ticket (Minister of Transport, 2006). The five largest Dutch public transport operators formed a joint venture called Trans Link Systems in 2001 to develop this new electronic ticket (TLS, n.d.), which resulted in the OV-chipkaart. Testing started in 2004 and it fully replaced the Strippenkaart national paper ticket in 2011. Travellers are now required to either use the OV-chipkaart or buy (usually more expensive and harder to obtain) single journey paper tickets.

2.3 Electronic ticketing process

Travellers can buy disposable single journey tickets, credit and/or season tickets. Disposable tickets are valid for a certain route or time. Credit balance can be stored on an anonymous or personal card (see Figure 4) and season tickets can only be stored on a personal card. OV-chipkaart smartcards are reusable and valid for five years. Most fares are now collected with the OV-chipkaart electronic ticketing (e-ticketing) system.

Figure 4: Anonymous (blue windmill, left) and personal (yellow cow, right) OV-chipkaart

The smartcard contains a passive radio-frequency identification (RFID) chip that stores the ticket related data. This is called the 'transponder', or 'tag'. It is powered by energy wirelessly transmitted by the operator hardware. This operator hardware also contains a 'reader' to access the data on the smartcard and a 'transmitter' to send data to the smartcard.

People use the smartcard to pay for each trip by registering at the beginning and end. This is either when entering and exiting a station, when transferring at a station from one operator to another, or when boarding and disembarking a vehicle.

An anonymous smartcard stores the credit balance, 10 latest check-in or check-outs, 2 latest credit transactions, internal chip number, card issuer, card manufacturer and expiration date (TLS, 2013; PC-Active, 2011). A personal card also stores season tickets, the owner's gender and birthdate, and for what amount of credit the card is activated to top-up automatically (TLS, 2013).

The RFID chip in the smartcard that stores and transmits this data was originally a Mifare-family one. Researchers cracked the chip's security measures in 2007 (Nohl & Plötz), forcing the companies to migrate to more secure chips. These had to be compatible with the existing hardware that was placed throughout the country. The new RFID chip therefore emulates the Mifare protocol that the machines expect, while still providing a higher level of security by means of added intelligence.

Each registration thus leaves a transaction on both the smartcard and the system endpoint (validator, see Figure 5). This transaction represents a financial claim and is digitally signed at the validator to ensure authenticity. Signing is done with temporary keys provided to the equipment at intervals, in order to reduce the impact if a malicious person obtains keys. See Figure 6 for the different system levels involved in transferring the transactions from the validator via the station or depot to the operator and finally onto the Central Back Office (see Paragraph 4.4) and traveller facing web services.

At check-in, the system takes a deposit if the person is travelling on credit in order to motivate travellers to check-out. During check-out, the system calculates the fare. If the fare is more than the deposit, extra credit is taken from the card. If the fare is less, credit is returned to the card. The operator will keep the deposit and the check-in will expire if one does not check-out within a set interval.

Transactions are relayed upstream to the central database of the operator and, except for the disposable e-tickets, the central back office maintained by Trans Link Systems. It takes 5 minutes to 24 hours for a transaction to arrive at Trans Link, due to the offline

nature of the system. A check-in on a bus in the morning will be transferred to the depot server at night, move to the operator's database in due course and is then transferred to the Trans Link database. Some trams relay their transactions each time they reach the end of their line and most fixed-position endpoints relay their transactions in batches throughout the day. Sometimes, the transaction propagation fails and operators have 60 days to fix issues before the central back office will not accept them anymore. Transactions that miss this window represent lost revenue.

This offline and decentralised approach has the benefit that most of the electronic ticketing system keeps working regardless of the state of the network or other parts of the system.

Figure 5: Traveller checks-out with his smartcard at an Arriva validator (left) before checking-in at the NS validator (right) to transfer from one train operator to another.

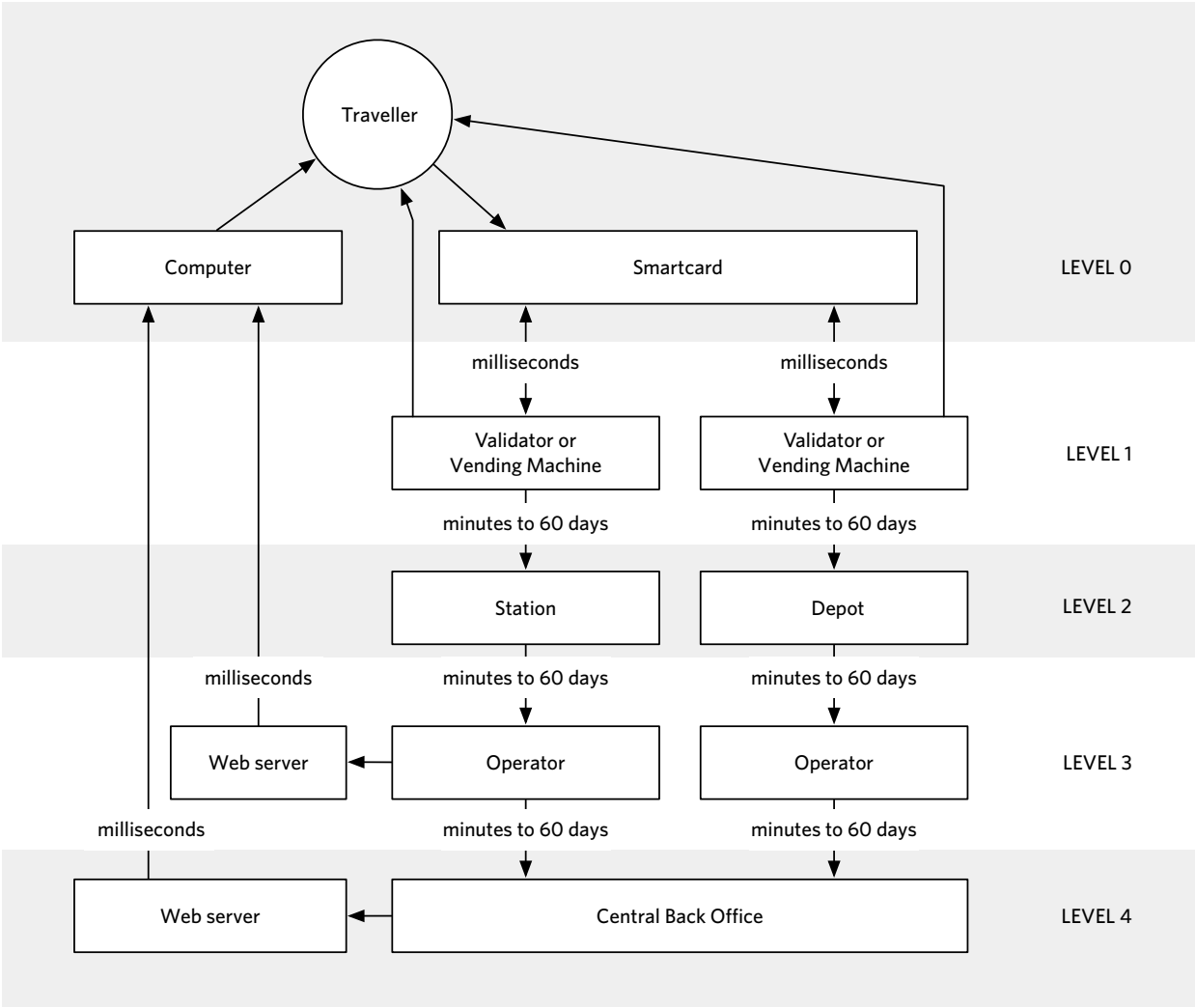

Figure 6: Infrastructure levels and transaction propagation time (best and worst case)

2.4 Public transport stakeholders

There are many stakeholders in the Dutch public transport sector, as visualised in Figure 7.

First and foremost the travellers, without whom there would be no demand for the service. Travellers, however, have little formalised influence in the governance of public transport. Their interests are represented by consumer organisations, which inform public transport operators and governments.

Operators provide the public transport services for which they acquire regional concessions from the national or regional government. These concessions last for several years and dictate the operational and financial terms of the service and vary from region to region.

All public transport operators use the OV-chipkaart electronic ticketing system and are connected to a central clearing house run by Trans Link Systems. Technology and service suppliers provide the equipment for fare collection. System capabilities are influenced by concession requirements from the government, operator investment, Trans Link policies and supplier efforts.

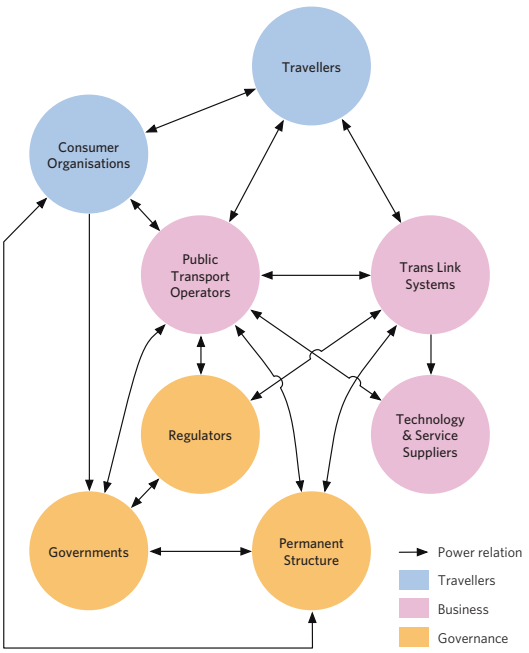

Figure 7: Stakeholder map

Regulators make sure that organisations respect the laws concerned with, for example, privacy and financial regulation.

The Permanent Structure was proposed to solve inter-concession problems by bringing together governments, operators and consumer organisations under a board with the mandate to take decisions. Mr Meijdam was tasked with setting up this organisation, but he stepped down on May 30, 2013, because he concluded there is "a lack of support throughout the governance structure for an empowered organisation" (Meijdam, 2013). The Minister has decided that inter-concession problems will be dealt with on a

consensus basis between governments and transport operators (Secretary of State for Infrastructure, 2013).

2.5 Public transport customer journeys

A customer journey describes and visualises the different situations users encounter and the problems they might face during their use of a product (Stickdorn & Schneider, 2010, p. 158). A customer journey is a structured overview of key insights into usage that makes it possible to highlight fields of interest to product developers.

Joppien, Niermeijer & Niks (2013) found that the generic public transport customer journey consists of a purchase, pre-travel, travel and post-travel phase. Purchase is split in two steps: orientation ("what ticket should I get?") and purchase ("where do I get it?"). Pre-travel consists of: activation ("how do I activate my ticket?"), loading ("how do I load credit and season tickets?") and preparation ("how will I travel?"). Travel is made up of: check-in, station (waiting), traveling, interchange and check-out. Post-travel consists of: evaluation ("how did it go?"). See Figure 8 for a visualisation.

Figure 8: Public transport customer journey phases (Joppien, Niermeijer & Niks, 2013)

The orientation, purchase, product activation and product loading steps occur at the beginning of the OV-chipkaart use and are no longer necessary once the traveller has configured its smartcard. Preparation, check-in, station, travelling, interchange, check-

out and evaluation are steps that occur during (almost) every journey. And while evaluation is visualised as a final step, the process itself will occur throughout the journey.

The situations a traveller encounters largely depend on the complexity of the journey. Examples of the three most common journeys are presented here.

2.5.1 Single vehicle, single operator

A journey with a single vehicle (see Figure 9) starts with the preparation: determine journey schedule, share schedule with others and pack things to bring. The departure includes the goodbyes, locking the doors behind you, etc.

Pre-public transport is the transportation between departure location and public transport station: from home to the train station, or from work to the bus stop, etc. This could be by foot, cycling, car, drop-off by a friend, taxicab, etc.

Check-in encompasses the arrival at the station, adding credit to the OV-chipkaart balance, registering the OV-chipkaart smartcard with a validator, finding the exact location of the vehicle and waiting for it to arrive.

Public transport includes the boarding of the vehicle, travelling, ticket validation by the conductor and disembarking of the vehicle.

Check-out is the process of locating a validator to register the smartcard to close the trip and of finding the station exit.

Post-public transport takes the traveller from the station to his destination, by way of walking, cycling, driving or any other private modality.

Arrival includes reaching the destination, accessing it and putting away your things.

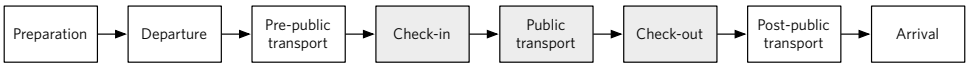

Figure 9: Customer journey map with a single public transport vehicle (for example, a RET bus trip). Grey coloured blocks are official OV-chipkaart domain.

2.6 Multiple vehicles, modalities and/or operators

The customer journey changes if a journey becomes more complex. Changing trains or metros adds an interchange step to the chain (see Figure 9). The traveller has to disembark vehicle 1, locate vehicle 2 and board, provided that the second vehicle is by the same operator, same modality and in the same station.

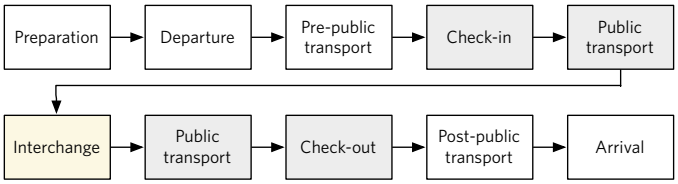

Figure 10: Customer journey map with multiple public rail transport vehicles provided by one operator (for example, NS train to NS train transfer). Yellow coloured block indicates extra step.

The interchange process gets more complicated as soon as a traveller has to transfer to another operator, another modality or to a non-rail vehicle (see Figure 11). Electronic tickets are currently valid for one tariff and transfer in these cases means that the traveller has to finish the trip on the current tariff and start a new trip on the next tariff. The traveller thus has to check-out and disembark the vehicle (in case of a bus, tram, ferry or light rail) or disembark the vehicle and check-out (in case of national rail, regional rail and metro), find the next validator (either on the station or vehicle) and check-in.

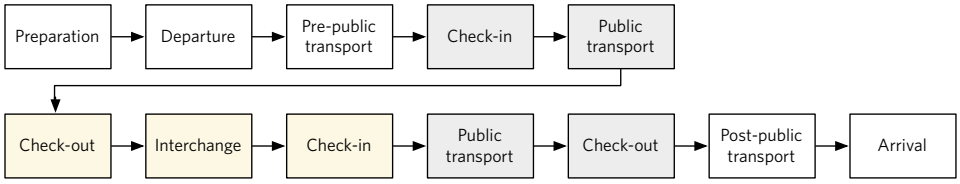

Figure 11: Customer journey map with multiple transport vehicles, either with multiple operators (for example, NS train to Arriva train transfer) and/or multiple modalities (for example, NS train to Connexxion bus transfer) or same modality and same operator (for example, Connexxion bus to Connexxion bus transfer). Yellow coloured blocks indicate extra steps.

2.6.1 Public and private modalities

The pre- and post-public transport modes are private: from walking to driving to being driven. Currently, the OV-chipkaart only officially supports transport services that are part of a concession: the buses, trains, trams, metros and ferries.

Some private services decided to piggyback on the OV-chipkaart market penetration and use it to identify users. Services, such as the OV-fiets (rent-a-bicycle) or Greenwheels (rent-a-car), use the OV-chipkaart card number for identification and send post-paid invoices based on usage. These services are part of the customer journey and their limited integration with the OV-chipkaart is undiscoverable to travellers.

2.6.2 Conclusion

Customers travel from their departure location to their destination and expect to be able to take any modality that suits them. Travellers have little regard for the intricacies of how the ticket payment process works (Van Brienen, 2011). For example, whether services are officially part of the OV-chipkaart or not is irrelevant to their desire to get from A to B. Or determining whether a train interchange requires checking-out and checking-in, is something many travellers have difficulty with (Van Brienen, 2011), which is unsurprising considering the artificial differences between one customer journey and another.

2.7 Traveller segmentation

While designing a product, it helps to have an understanding of the user group. Since public transport has a very broad user group, the travel frequency, technology understanding and use of one or multiple operators are more accurate indicators of problems (Joppien et al, 2013). This is visualised in Figure 12.

People who have little technology understanding, travel infrequently and use multiple operators are the most likely to encounter problems and thus form the largest triangle in the model. On the other hand, people who have a lot of technology understanding, travel frequently and with one operator are predicted to have the fewest problems in general.

This segmentation helps to understand which group of people might be best served by the solutions I develop.

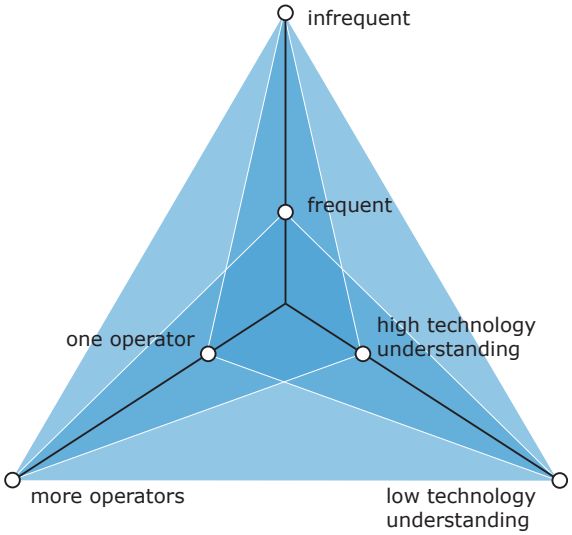

Figure 12: User group segmentation visualisation. The larger the area between the predictor points, the more likely it is a traveller will encounter usability problems (Joppien, Niermeijer & Niks, 2013).

2.8 Trends

The design of the OV-chipkaart system started over 15 years ago and many technology, business and social constraints from those days are embedded in the system. Since it took more effort and longer than expected to get the OV-chipkaart operational, some of these constraints have disappeared because of changes in society. However, they are still taken into account in of the OV-chipkaart system and are preventing the system from taking full advantage of the possibilities electronic ticketing provides. In the coming years, the OV-chipkaart and its infrastructure will improve in many areas.

2.8.1 Real-time data processing

One of these improvements will concern the speed of upstream propagation of transactions. While 15 years ago it was too costly to bring all system endpoints online, the progress in wireless networking has since been tremendous. People transmitted a combined amount of less than 1 petabyte of mobile data in the Netherlands in 2007 (OPTA, 2010). In 2012, this was about 22.6 petabyte (ACM, 2013a) and the first quarter in 2013 showed a 58 per cent year-on-year growth (ACM, 2013b). See Figure 13 for a visualisation of data usage from 2007 to the expected 2013 level.

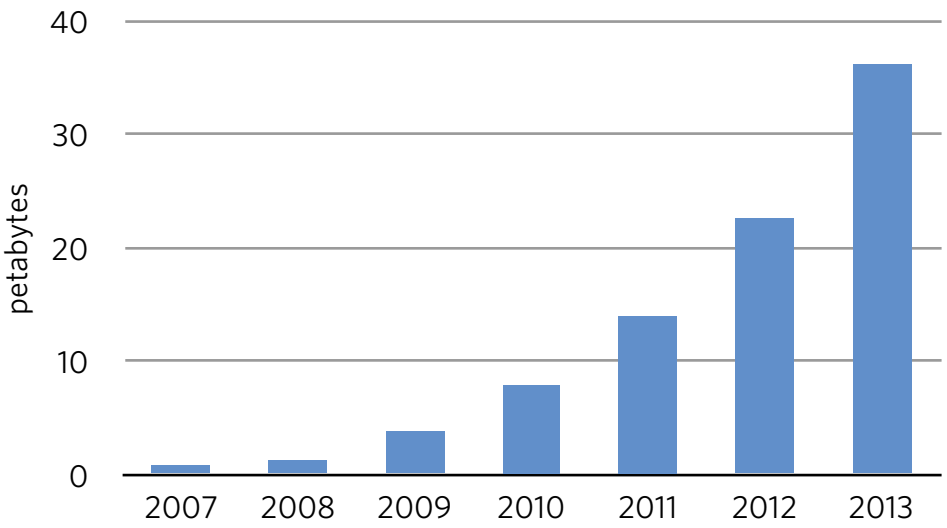

Figure 13: Mobile data usage in the Netherlands, 2007-2012 (OPTA, ACM). Extrapolated expected usage 2013. 1 petabyte is 1,000,000,000 megabytes, or the equivalent 250,000 full high-definition movies. Expected mobile usage in 2013 is comparable to the data needed for 2000 years of non-stop movie watching.

With a much improved and growing mobile data network, it is possible to propagate more transactions faster than ever before. A near real-time up-to-date central transaction database on top of which near real-time analysis can be performed, is now viable. This was unforeseen 10 years ago, during the development of the OV-chipkaart. Besides being able to offer direct access for travellers to their transactions, this business data could also be used for better-informed fleet operation.

2.8.2 Antiquated tariffs

Another constraint that is likely to fade away over the years is the remains of the national tariff system. New season tickets based on a new tariff system will replace season tickets based on the previous tariff system. While many governments required equivalents for these old tariffs in the new system to please existing traveller groups, it is likely that these will be overtaken by new commercial offers. Depending on the course taken, this transition could be used to simplify the product offering and improve the fare predictability or can turn a complicated product portfolio in a bewildering one.

2.8.3 Liberalisation

Besides overcoming some of the constraints, the system will also need to adapt to a number of other developments. In the last decades, many public transport organisations have been privatised and large parts of the market have been liberalised. While this has slowed down in recent years, there is no reason to expect this is the end of the trend. It is plausible that the (partial) liberalisation of the remaining privately awarded concessions will take place in the coming decades and new operators might enter previously closed markets or replace incumbents (Accardo, 2013). This could, for example, result in even more complex rail ticketing situations, if more operators are using more stations. Single check-in/check-out initiatives (Meijdam, 2011) could allow further liberalisation in the rail domain without burdening the traveller.

2.8.4 Technology expectations

It is also likely that people will keep expecting more and more from technology. As the results of progression in other fields take shape and become mainstream, the OV-chipkaart will need to live up to changing expectations. An increased level of personalisation and service could be expected. And as technology-based self-service and proactive systems take on larger roles in society, so will the acceptance of such systems.

2.9 Conclusion

There were strong market incentives to transition from paper tickets to electronic tickets. And while this was mostly a private initiative, the government has had a large influence in the implementation through concession contracts, regulation and subsidies. The development of the OV-chipkaart system took many years and technological innovations surpassed the current implementation. Previous constraints no longer exist and people's expectations have changed. There is now room for the OV-chipkaart to improve and take full advantage of the long-term trends.

3

3 Information deficit and user requirements

3.1 Introduction

The previous chapter explained how the OV-chipkaart came to be and this chapter will describe the usage. Understanding how the OV-chipkaart is used is necessary to determine how it performs and what could be improved.

Travellers indicate in surveys that they are generally satisfied with the OV-chipkaart. Several studies have shown that most travellers rate the OV-chipkaart between 6 and 8 on a scale of 1 (worst) to 10 (best) and the rating has improved over the last few years (NS, 2013; KpVV, 2013; Lubbe & Larsen, 2007; Broek & Radewalt, 2009; Stadregio Rotterdam, 2010).

Overall satisfaction, however important, does not guarantee that all travellers are able to reach all their goals in all contexts with effectiveness, efficiency and satisfaction. And while it would be desirable to achieve that for all travellers, universal design research has shown that you can only serve "all people, to the greatest extent possible" (CUD, 2008; Bringolf, 2008). The key in improving the OV-chipkaart thus lies in making sure that as many travellers as possible are able to reach as many goals as possible in as many contexts as possible with effectiveness, efficiency and satisfaction.

During our previous research (Joppien, Niermeijer & Niks, 2013), we found several areas that proved to be sources of usability problems for travellers. These included cumbersome smartcard and season tickets acquisition, too few incentives and too many barriers to entry, hard to develop mental model (how people think it works), too many partial information sources, many helpdesks with limited power, technology-based self-service systems without escape and a lack of ticket information visibility.

Since there are not enough resources to address all usability problems during this project, the focus is on the transparency problem: the lack of ticket information visibility to travellers during their journey. This area was identified as the most promising one to improve: relative to other areas, ticket information invisibility affects more travellers in more contexts.

Indeed, electronic tickets, travellers cannot access the information stored on their smartcard without the presence of an operator-provided machine, either a validator or vending machine. Because of this, questions travellers now have include "do I have enough credit to take the bus?", "did I really check-in?" and "how much did that last trip cost?".

To get insight into the travellers' situation, this chapter presents customer journey maps, explains the traveller segmentation used in this report, describes the ticket information transparency deficit and summarises the results in a user requirement list for product development.

3.1.1 Research questions

The following research questions form the basis for this chapter:

- How do travellers use public transport?
- What problems do they encounter?
- What is the ticket information transparency deficit?
- What influence do these problems have on usage?
- What types of travellers use public transport?
- What user requirements for product development exist?

3.1.2 Method

The information in this chapter is based on observations of travellers, interviews with travellers and experts, traveller complaints collected by OV Loket and research reports commissioned by operators, governments and related organisations.

In total, Joppien, Niermeijer & Niks interviewed 45 people for the analysis report (2013) and for this report an additional 20 people were interviewed during their journey, 18 people at home and 22 people at a train station (see Appendix B & E). The interviews were conducted with a semi-structured method: the interviewer used a script of questions and topics to be covered (see Appendix C) and had the opportunity to ask follow-up questions in order to "delve deeply into a topic and to understand thoroughly the answers provided" (Harrell & Bradley, 2009; Drever, 2003). Interviews help in collecting beliefs and opinions (Kvale, 1983), and in understanding phenomena (Sleeswijk Visser, 2005). The interviews were videotaped and analysed.

bruna

Joppien, Niermeijer & Niks (2013) videotaped 52 traveller interactions with the electronic ticketing system in 10 different Dutch cities. This covered the use of train, metro, tram, bus, light rail and ferry. These covert observations of natural behaviour (Malterud, 2001) helped gather information about the usage without influencing the participants' actions.

Joppien, Niermeijer & Niks (2013) also conducted interviews with 13 experts from government organisations, operators, consumer organisations and technology suppliers, and additional interviews were conducted with 15 experts for this report (see Appendix B). These were also conducted with a semi-structured method and the interviewers took notes during the conversation.

The OV Loket is a non-profit that collects public transport user complaints. I had access to 600 complaints about the OV-chipkaart, dated from 1st of July 2012 till the 1st of November 2012. These provided insight into often complex problems travellers encountered and were not able to solve by themselves.

Several public transport related organisations have commissioned reports in the past years: from the Meijdam commission (Meijdam, 2011; NEA, 2011; Van Brienen, 2011) to operators (NS, 2013), research institutes (KpVV, 2013) and governments (Lubbe & Larsen, 2007; Broek & Radewalt, 2009; Stadregio Rotterdam, 2010). These reports focused more on quantitative instead of qualitative data and were used to put the insights from the interviews and complaints into perspective.

3.2 Ticket information transparency deficit

The OV-chipkaart electronic ticketing system is used by many travellers and requires different interactions than the previous paper-based ticketing system. Requiring such a large and diverse group of users to migrate from an entrenched system to a new system is likely to cause problems for, and resentment among, part of the group (Davis et al., 1989; Reinders et al., 2008; Venkatesh & Bala, 2008). This has indeed been the case, as reported on by the media (Berkhout, 2005; Heide, 2005; Parool, 2005; Trouw, 2005) and discussed in the Dutch House of Representatives (2013). While the system functions mostly as intended (Niemantsverdriet, 2011), there are usability problems that impede travellers (Joppien, Niermeijer & Niks, 2013).

Four customer journey steps and three customer dimensions define most usability problems (see Table 1).

The steps are:

1. Acquiring a smartcard
2. Determining the status of the smartcard
3. Finding your way through the physical public transport domain
4. Evaluation and problem solving

The customer dimensions are:

1. Infrequent travellers
2. Limited technology understanding
3. Use of multiple operators

	Frequent travellers	Infrequent travellers	Technology uderstanding	No technology understanding	One operator	Multiple operators
1 Orientation online				■		■
2 Online payment				■		
2 Offline payment		■		■		
2 Wating new/first card	■	■	■	■	■	■
3 Activation		■		■		
4 Loading		■		■		
5 Preparation				■		■
6 Check-in		■				
6 Status of the card	■	■	■	■	■	■
7 Station: way finding		■		■		■
8 Travelling						
9 Change: recognition		■		■		■
9 Change: way finding	■	■	■	■		■
10 Check-out		■		■		■
11 Evaluation	■	■	■	■	■	■

Table 1: Overview of the problems encountered per dimension.

Since not all usability problems could be addressed within the scope and resources available to this project, this report aims find a solution to one particular problem. To determine the severity of a usability problem, one has to assess (Nielsen, 1995):

1. Impact: is the problem easy or difficult to overcome for the user?
2. Frequency: is the problem a common or rare occurrence among users?
3. Persistency: is the problem a one-time or repeated problem for a user?

Acquiring an OV-chipkaart smartcard and configuring it with the correct travel products can be a considerable hurdle for some, but these problems fade away once you figured it out. Difficulties with wayfinding ("where is the validator?") have a relatively small impact, but a medium occurrence frequency, especially for irregular trips, and a medium persistency. Solving problems and reaching the right customer service can be hard, but should not occur too often once your smartcard is configured correctly and it has a low persistency. Being unable to determine the status of the smartcard has a relatively small impact, but it is a situation that happens frequently and persistently. See Table 2.

	Low frequency	*Medium frequency*	*High frequency*
Low impact		Wayfinding	Card status
Medium impact	Smartcard acquisition and configuration		
High impact	Problem solving		

Table 2: Usability area severity assessment: impact (left) vs frequency (top). Colour-coded persistency level: high (red), medium (orange), low (yellow).

Solving a high frequency, low impact, high persistency usability problem makes the overall travelling experience smoother for many people. This thesis therefore aims at solving the card status problem.

3.2.1 Method

To determine what the card status problem is, several methods were used. Key to understanding usability problems is to observe and listen carefully to users (Kanis, 1999). Travellers will not come and complain about these low impact problems by themselves, because they often already accepted the situation and consequences as-is (Mauro, 2005, p. 287).

To gather the insights into which consequences this problem has, 20 people were interviewed during their journey, and 18 people at home, with a semi-structured interview method. This was in addition to the 52 video observations by Joppien, Niermeijer & Niks (2013).

The qualitative research was compared to the available quantitative research on this topic, as published by Van Brienen (2011).

3.2.2 Results

The transparency deficit is caused by the invisibility of the electronic ticket information to the user. Travellers cannot see the current ticket information without using a machine provided by the operator at fixed locations for general use (see Figure 14). If there is no machine nearby, users are unable to determine the status of their smartcard. Which is the case for large parts of the customer journey.

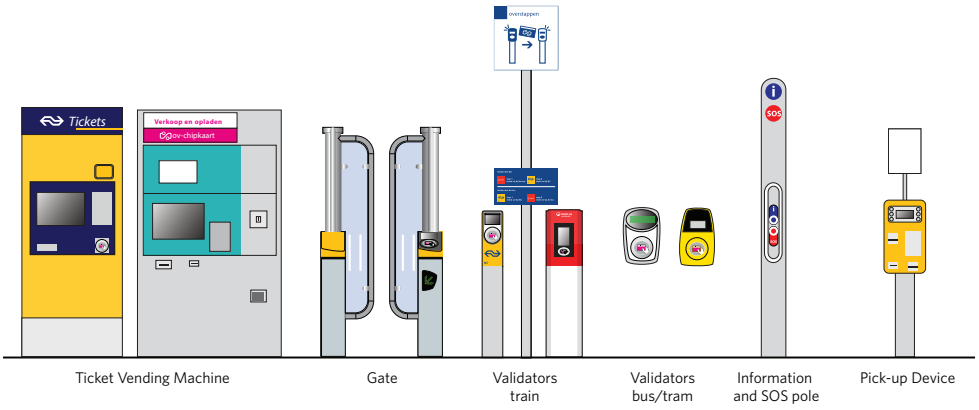

Figure 14: Self-service OV-chipkaart touchpoints

If a traveller presents his smartcard to a validator for a check-in or -out action, the validator will act upon the user's input, process the transaction and give auditory and visual feedback to the traveller. Operators also provide ticket vending and add-value machines which are able to display the current status of the card. These machines read the data that is stored on the card and use display to present it to the user (see Figure 15).

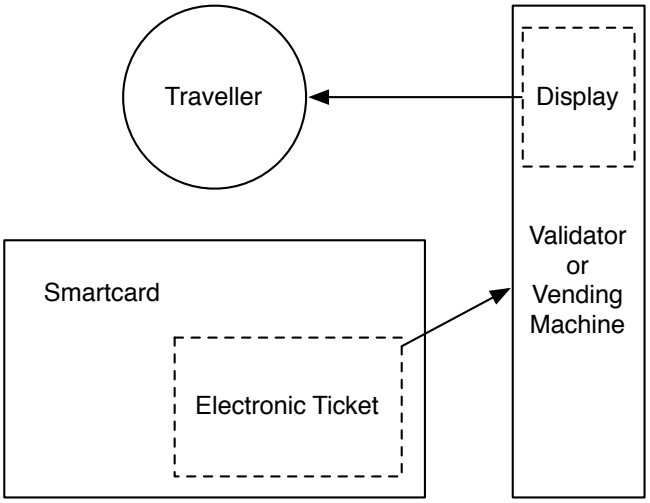

Figure 15: Using an operator-provided machine is the only method available to the traveller to determine the current state of his smartcard. Arrows indicate information flow.

The data that is stored on the card and relevant to the traveller includes:

- Current check-in or check-out status
- Most recent check-in or check-out location
- Most recent operator check-in or check-out
- Most recent check-in or check-out date and time
- Fares of previous trips
- Departure and arrival stations of previous trips
- Season tickets
- Credit balance transactions
- Current credit balance

If a traveller presents his card to a validator, pieces of this information change and a record is stored on both the card and the validator. The validator then sends that up through the OV-chipkaart information infrastructure where it will eventually reach the Central Back Office (CBO). Once the CBO has all transactions, it is able to provide the traveller with a receipt of his tickets through, for example, a web service. This can take up to 60 days. A quicker way for the traveller to get a receipt for a recent trip is to walk over to a ticket vending machine and ask it to print the transactions that are still stored on the smartcard (maximum: 10 most recent check-ins and -outs; 5 trips).

Working memory

A traveller is interested in the ticket information, because it proves that he paid for the trip. The ticket is his fare receipt that protects against negative experiences, such as receiving a fine for fare dodging and/or being removed from a vehicle. With the OV-chipkaart, the only confirmation of payment a traveller receives is the temporary feedback validators provide. This requires the traveller to pay close attention to the feedback and memorize it while he is already paying attention to many other things, such as "is this the right vehicle?", "which platform should I go to?", "is there a seat I can take?", "what is the connecting service?", etc.

The working memory capacity of people is limited (Miller, 1956) and upcoming tasks receive more attention than recently performed tasks, resulting in people forgetting the result from their check-in or -out action (Van Brienen, 2011). Travellers have trouble understanding the validator feedback and remembering whether they did check-in or -out and other ticket information.

Van Brienen (2011) conducted a survey among 1044 participants and one of the questions was: "Do you expect problems regarding the validity of your train ticket if the conductor checks it?" With paper tickets, 8 to 15 per cent of the participants expect problems at least sometimes while 80 to 89 per cent of the participants never expect problems. With the OV-chipkaart, 22 to 44 per cent expect problems at least sometimes while 25 to 64 per cent never expects problems. The amount of OV-chipkaart travellers who expect to often encounter ticket validity problems quadrupled. See Figure 16.

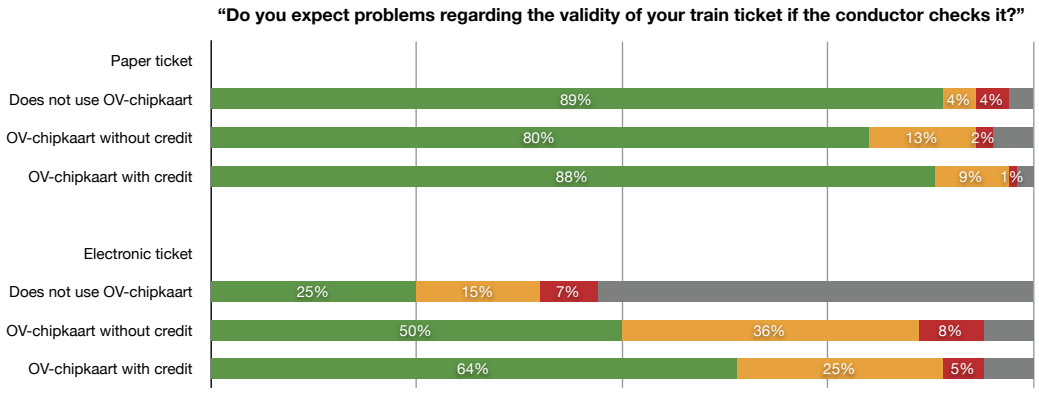

Figure 16: Van Brienen (2011) survey, n=1044. OV-chipkaart users without credit are, for example, student season ticket holders.

“Ik heb het nu weleens dat ik denk van — en ook als ik in de tram stap — dan ga ik zitten, vooral als ik een hoop bagage bij me heb, dan heb ik zoiets van ‘shit, heb ik nou wel of niet ingecheckt?’. En dan doe ik het altijd toch nog maar een keertje extra. Dan zie ik het vanzelf wel. Soms heb ik inderdaad wel van “oh, ik heb inderdaad niet ingecheckt”.

En ik heb het inderdaad ook een paar keer meegemaakt dat ik vergeten ben uit te checken. Vooral als ik na mijn avonddienst—ik werk in het ziekenhuis—met de bus naar huis ga. Of als ik uit de nachtdienst komt. Dan ben je zo slaperig, dan vergeet je het ook nog weleens.”

Female, 30-39 year old, Rotterdam

Hoe houd je in de gaten hoeveel het reizen kost?

> “Als ik uitcheck kijk ik nog even hoeveel erop staat en hoeveel hij eraf haalt.”

Is het ook weleens voorgekomen dat je dat niet kon zien of dat je vergeten was uit te checken?

> “Ik vergeet weleens te kijken überhaupt. Dus ik weet niet altijd hoeveel erop staat.”

Female, 20-29 year old, Rotterdam

Situations

Of the 38 participants I interviewed, 31 indicated that they (sometimes) have forgotten check-in or check-out actions. Common responses were that they did not remember the feedback or were not able to understand the feedback. Not remembering the feedback seemed more prevalent in the train domain than other forms of public transport, probably because the check-in occurs before boarding and often even before determining which vehicle to take.

Not being able to process the validator feedback seemed to a bigger problem with buses and trams, where especially the check-out action is complicated by social pressure (other passengers queuing behind you, the bus driver waiting for you to get off) and an often complicated disembarking process (stairs, noise, unpredictable station lay-out).

The consequences of not being able to recall the status of your smartcard is that one starts to doubt whether it is safe to travel with public transport.

For example, if a traveller is unaware of the amount of credit that is left on his smartcard. There might not be a self-service point around to check and without credit and cash, the bus will not allow her to board. The anxiety of possibly not being able to travel makes for an uncomfortable time between deciding to take public transport and checking-in. It takes risk on his part to wait for a bus he might not be able to pay for with the OV-chipkaart system.

Or if someone exits the tram and thought he checked-out, but is not sure anymore because the audio feedback could have been for the card of the person behind him and the low-quality display was positioned to low to be able to read it. Maybe he just lost his deposit, maybe he did not. And how much did that trip cost anyway? There is no quick way to check the status of the card, since tapping the validator has a 50/50 chance of checking-in.

Or a person enters the train station, checks-in, buys something in the supermarket, checks the train schedule and waits at the platform. All these intermediate steps took mental effort and he now doubts whether he did really check-in. Going over to a machine to check could solve the problem, but the train is rolling in and he does not want to take the risk of missing it.

Heb je weleens op het perron gestaan en dat je denkt “oh ja, heb ik nou ingecheckt of niet”?

> “Ja, heel veel keren. Soms had ik ook echt vergeten om in te checken.”

Wat doe je dan als je dat bedenkt?

> “Ik blijf gewoon bij die twijfel. Ik doe helemaal niks. Ik blijf gewoon bij die twijfel.”

Dus dan ga je in de trein zitten en dan hoop je dat het goed komt?

> “Ja, ik hoop het. Ik ga gewoon in de trein zitten. Ik hoop het gewoon dat ik heb ingecheckt.”

Weleens voorgekomen dat je niet ingecheckt had en dat er een conducteur kwam?

> “Ja, twee keer zelfs. Had bijna een boete gekregen. Bijna.”

Male, 20-29 year old, The Hage

U zei “ik kijk weleens online om te zien of ik niet vergeten ben om uit te checken”. Waardoor komt die twijfel?

> “Soms hoor je de piep niet. Als het druk is en mensen gaan achter elkaar, dan denk je ‘was het mijn piep of van de vorige persoon?’”

Female, 40-49 year old, Rotterdam

Als het druk is kan het lastig zijn om te zien hoeveel saldo ik over heb. Als mensen onmiddellijk na je komen. Maar bij de trein valt het wel mee, in bussen is het vaak niet te zien. Je hebt nooit de tijd daar. Je moet uitstappen, er staan mensen achter je. Het gaat eigenlijk te snel om het goed te volgen.

Male, 40-49 year old, Rotterdam

Waar reist u allemaal mee met de OV-chipkaart?

> "Hoofdzakelijk met de metro naar de stad. En als ik dus met de trein ergens heen moet. Met de bus vind ik een ramp."

En waarom is de bus een ramp?

> "Dat is voor mij een ramp, omdat het nogal gehaast gaat dat uitchecken. Dus dan doet ie het niet goed en dan probeer je het nog een keer, maar dan heb je in wezen alweer ingecheckt. Dus de bus is een ramp. Ook omdat er mensen achter je staan, dus het is gehaast. Je kan het door de herrie niet horen. Dan twijfel ik dus of het wel gewerkt heeft wat ik heb gedaan heb. Dat is dus met de trein en de metro absoluut geen probleem."

Als u dan toch met de bus moet, hoe lost u dat dan op?

> "Toch met de bus gaan, maar dat is niet leuk dus."

Male, 60-69 year old, Rotterdam

Or someone is sitting in the train and sees the conductor approaching (see Figure 17). Usually he would get his paper ticket out and double check the validity, but now the only option is to wait till the conductor approves the invisible ticket by scanning it with a handheld validator.

Figure 17: Conductor anxiety. Source: Tom Klaver & Ionica Smeets on Twitter

Or a person exits the train station, bikes home and discovers his OV-chipkaart is still in his pocket. Did he put it back there after checking-out or did he forget to check-out? By the time the information is online, a forgotten check-out is already expired. So should he bike back to the station to make sure he checked-out?

3.2.3 Conclusion

With paper tickets it is clear whether you have a valid ticket: it shows the departure and arrival station, date, price and discount. Travellers can check this information at any point after purchase to verify the validity. The OV-chipkaart, on the other hand, is an electronic ticket that stores its information invisibly on a chip.

Status change happens at system endpoints, which usually provide visual feedback, but travellers have to interpret this in a set timeframe and memorize it for the duration of the use of the ticket.

With the shift from paper to electronic tickets, the burden of information storage for the purpose of reassurance has shifted from the object to the user. The lack of transparency of ticket information causes travellers to second-guess their actions: did I really check-in correctly? This uncertainty decrease the traveller's comfort level and trust.

3.3 User requirements

The solutions I develop will have to fulfil certain criteria. These requirements are based on the research presented in this report.

- The solution should give travellers insight into: whether they have a valid ticket while travelling; what they paid for their most recent trip; whether they are receiving the discount their season ticket offers; and preferably what their travelling history is.
- The solution should make ticket information more transparent for at least 50% of the travellers, because improvements will only be meaningful if a large group of people can use it.
- The solution should make ticket information more transparent for infrequent travellers, because these people have the least experience and the most trouble with remembering the status of their electronic ticket.
- The solution should be affordable, because public transport needs to be accessible to people of all means.
- The solution should be accessible throughout the journey, because ticket information questions arise at all points of the journey.
- The solution should fit the existing OV-chipkaart infrastructure (see Figure 5) as much as possible, because adaption is costly and thus less likely to be implemented.
- The solution should offer a solution that is 10 years away from existing and propose intermediate versions for the 5 year and 3 year horizon.
- The solution should be reliable and secure for travellers and operators.
- The solution should be careful in changing the ticket buying interaction, because that would require travellers to learn again how things work.

3.4 Conclusion

A journey is a lot longer for a traveller than just the part provided by public transport and a traveller has the need to verify their public transport ticket at more places than the OV-chipkaart now supports. The lack of transparency makes that travellers with electronic tickets are more uncertain about the ticket they have than travellers with a paper ticket, which decreases the comfort level and the trust in the electronic ticket. A solution to this low impact, high frequency, high persistency problem has the potential to make travelling with public transport smoother for many people.

4

4 Product proposals for electronic ticket information access

4.1 Introduction

The previous chapter described the usability problem of ticket information visibility. This part of the report describes the process of product development to address that problem and the user and expert evaluation of the developed products.

4.2 Self-service electronic ticketing

A self-service electronic ticketing system, such as the OV-chipkaart, needs to be able to identify and authenticate unique personas to ensure fare payment is handled correctly. The transaction data generated by travellers needs to be transferred from a system endpoint to other parts in order to fulfil payment, and with the OV-chipkaart system it is also required to transfer it to the smartcard. Making this data visible to the traveller requires a visualisation technology and providing input might be useful in certain circumstances. And all these parts need to be powered. See Figure 18 for an abstract overview.

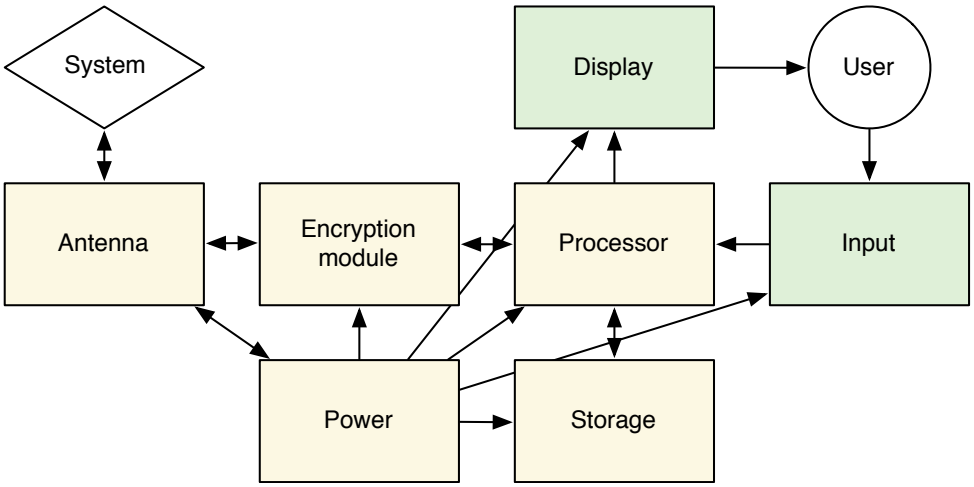

Figure 18: Abstract overview of the parts that make up a user token. Yellow coloured items are part of the current smartcard; green coloured items would be provided by new technology.

4.3 Product proposals

Four distinct product proposals are outlined here, based on the expected technological and social developments of the coming 5 to 10 years (see Appendix A). The proposed portable reader, display card and smartphone app all show ticket information, whereas the biometric proposal is a consequence of technological development and disappearing physical/digital tokens.

4.3.1 Private portable smartcard reader

Current situation

Currently, a traveller can only read the information on his smartcard with the help of public validators provided by operators. This does not cover the other parts of the customer journey. A portable, private smartcard reader would allow a traveller to access the information on his smartcard at all steps of his journey.

Proposed changes

The existing OV-chipkaart smartcards store information and are able to communicate over RFID. Increasing transparency at every moment during the customer journey would at least require a tool to communicate with the smartcard and display the information.

Design

This portable reader would preferably be as small as possible, in order to be able to bring it everywhere. Figure 20 shows a prototype of a possible implementation of a personal portable reader as a key fob that includes a battery, display, antenna and processing unit.

The screen could be LCD (cheap) or e-paper (energy efficient) and holding it near a smartcard activates the display. It has three states (see Figure 19):

1. Off (only LCD): no information.
2. Standby (default e-paper): usage instruction.
3. On (LCD and e-paper): shows ticket information.

Figure 19: Screen states. Left: Standby. Middle: checked-in. Right: Checked-out.

Figure 20: Low-fidelity portable reader as key fob implementation prototype

If necessary, an on/off switch could be used to eliminate even the limited standby power usage.

The size of the reader would allow it to be used as a key fob, though this is optional. Other implementations could, for example, take the shape of a watch or cardholder.

Information the reader could display includes credit balance, credit balance top-up transactions, last check-in, and previous trips. Earlier research determined that credit balance and last check-in are the most important information needed to feel at ease during card use. The fare of the last trip is important to know during the final leg of the customer journey. Recent credit balance transactions and previous trips have limited impact on the current trip.

The graphical user interface would show the credit balance, check-in status and costs of the last trip. For clarity, these items will be displayed in text. The reader would be able to support multiple languages, in order to support foreign travellers as well.

Required technology

Besides the display, the portable reader would need other key technology components.

Security

Card reading operations are secured on multiple levels: both the storage and communication are encrypted. This is to prevent unauthorized parties from intruding on the

privacy of travellers by reading personal information on the card or from eavesdropping on the card-reader communication.

In order to perform a reading operation, the reader needs to possess the card's encryption keys. Operator's validators receive these disposable keys from the Central Back Office. Each key is limited to a predetermined amount of operations, in order to limit the impact of a security breach. Any key that ends up in the wrong hands will have limited usefulness, decreasing the incentive for (forcefully) acquiring one.

Any personal portable reader would need to possess (derivative) keys to be able to read the ticket information on the smartcards. Since the device will be distributed widely and reside in the possession of unknown third parties, it is important to use a system that is able to withstand direct attacks.

Distributing operation-limited keys during the reader's lifetime increases the security of the system, but would require a secure network connection with the Central Back Office. Devices suspected of being used for malicious purposes could then be prevented from receiving new keys and the damage would be contained.

Another way of limiting the impact of a security breach is limiting the versatility of the security keys. Instead of providing the personal reader with keys that allow it to read any card, the reader could also receive derivative keys that only allow it to work with a subset of the cards. This would eliminate the need for remote key distribution during the lifetime of the reader, but would also limit its usefulness for travellers. This limited key could be placed on the portable reader during the production process.

Using card specific keys on personal readers would require a personalised production and distribution process where the smartcards need to be known in order to provide the reader with the limited keys. This would prevent indiscriminate distribution and increase barriers and costs.

Power

The portable reader would draw its power from a battery that could be removable, depending on the preferred lifespan and serviceability of the device. Standard IEC R03 (AAA) or CR2450 (coin) battery would provide enough power to operate the reader daily for a reasonable period of time.

Potential limitations

The distribution of these readers would need to be personalised, because of the security requirements. This means the portable reader will be harder to obtain and more expensive to distribute.

4.3.2 Display card

Current situation

Currently, the smartcard is a piece of coloured plastic to protect an antenna and a chip. It communicates wirelessly with other system components, but has no ability to communicate directly with the user.

Proposed changes

Instead of using a separate tool to give the traveller insight into his ticket information, the OV-chipkaart smartcard could be enhanced with a display to communicate directly with the user.

Design

LCD displays have become smaller and more energy efficient over the years. Several manufacturers currently make ISO/IEC 7810 ID-1 compliant cards with embedded displays (see Figure 21). These new smartcards have the same physical dimensions as existing OV-chipkaart smartcards and adhere to the durability standards for bending, flame, chemicals, temperature and humidity. Versions with e-paper displays are currently under development (see Figure 22).

Figure 21: Nagra ID Codesure creditcard with LCD pixel display and keypad

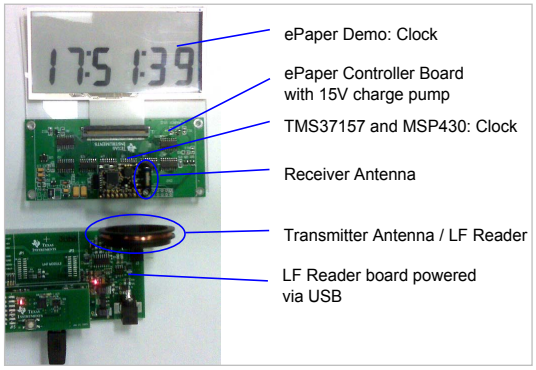

Figure 22: E-paper display for RFID tag (development prototype of Texas Instruments)

Required technology

Display

These smartcards with embedded displays come in segmented or pixel based displays. Segmented displays are able to highlight pre-drawn elements that together form a limited set symbols, often the Roman alphabet and Arabic numerals (see Figure 23). Pixel displays use a matrix of dots to form an unlimited set of symbols (see Figure 21). While

Figure 23: Creditcard with segmented display

the size of commercially available displays is limited currently limited to 100 square millimetres with the current state of technology, it is likely that these limitations will disappear with the progress of production methods.

Power

Either an embedded battery in the card, or induction during system interaction, provides the energy to power the display and its processing unit. Embedded batteries currently last an average of 3 years with daily use and this technology is expected to improve in the coming years. Induction provides small amounts of power but could work for cards that are used often; it would be a disadvantage for infrequent travellers. Whereas LCD requires constant energy to display an image, e-paper technology only requires energy to change the image and thus offers a superior functionality with the potential for superior energy efficiency.

Security

The display is embedded in the card and only needs to be able to present data from that particular card. Accessing the card storage requires read keys and these can be programmed during production. The risk of malicious use is limited.

Graphical user interface

The graphical user interface consists of an electronic display, possibly turned on and off by the user with a button and augmented by printed instructions and labels. The on button (see Figure 24) is only required for LCD displays and not e-paper displays, because of the power usage. Printed instructions support the understanding of the card and using printed labels (see Figure 24 and Figure 25) saves precious display space. Pre-printed labels will not be necessary as soon as the displays are large enough to accommodate all required information (see Figure 26). The language of the text on the display, instructions and labels can be determined during the production process.

Figure 24: OV-chipkaart with LCD pixel display, on button (lower right) and printed labels to save display space

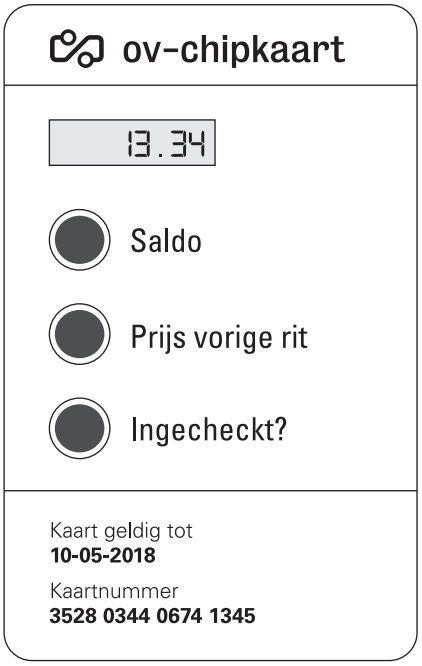

Figure 25: OV-chipkaart with LCD segmented display and single function buttons

Figure 26: OV-chipkaart with full-size e-paper display

Potential limitations

While these smartcards with displays adhere to all durability standards, it does have more components than the current smartcard. Any extra components slightly increase the risk of something breaking. A display card should first and foremost be able to complete electronic ticket transactions and continue to work, even if the display and related components break down.

4.3.3 Smartphone: local NFC information

Current situation

Many people own a smartphone and take it with them during travelling. Statistics Netherlands (CBS) reported that over 60 per cent of the population regularly used mobile internet in 2012 (see Figure 27). Based on the 2010-2012 statistics, the trend seems to be that usage will grow to close to 70 per cent in 2013. Penetration is particularly high market among 12 to 55 years old.

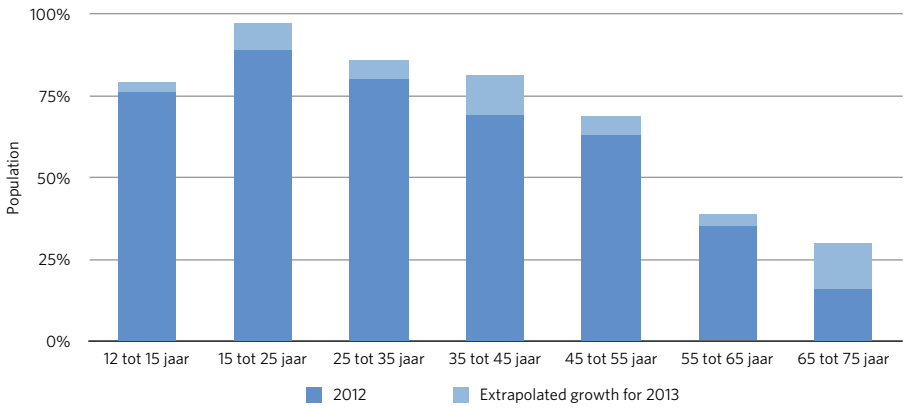

Figure 27: Mobile internet usage in the Netherlands in 2012 (blue) and extrapolated 2013 growth prediction (light blue).

Transport operators see an even higher penetration of smartphone usage among travellers, including the group of people over 55 years old. One possible explanation for this is that people who participate in social life are both more likely to use public transport and use newer communication technologies.

Smartphones are currently unable to show ticket information, unless it has reached level 4 (see Figure 6 on page 15).

Proposed changes

Provide ticket information on the smartphone, instead of providing a new device or changing the existing smartcard. Ticket information resides on the smartcard and can be read by smartphones by using NFC technology.

Figure 28: NFC enabled smartphone reads data from an OV-chpkaart smartcard (photo is staged)

A traveller would open the OV-chipkaart app on his smartphone and hold his OV-chipkaart near the device (see Figure 28). The smartphone would read the information that is stored on the smartcard and display it on the screen. This includes credit balance, check-in status, most recent trips and credit balance transactions. If an internet connection is available, the recent but limited dataset stored on the card can be expanded with the historical data retrieved from the backend.

Design

The app would run on smartphones. Figure 29 shows an example of how such an app could look. It displays check-in location, current credit balance, deposit and which season ticket is used. It also offers to top-up the credit balance and view travel history.

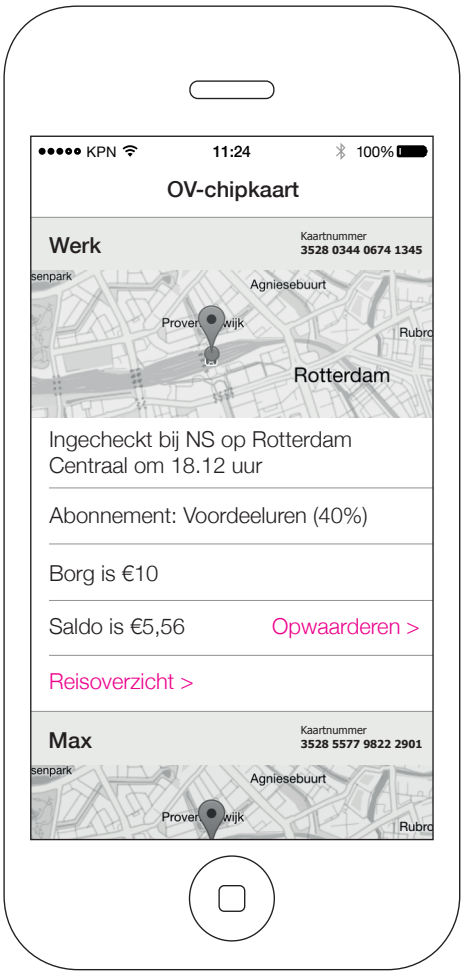

Figure 29: Wireframe design of information display app

Required technology

If the smartphone has near-field communication (NFC) capabilities, it has the right hardware to be able to read information from the smartcard (see Appendix A). Additionally, the smartphone would need to have the keys to read the encrypted information and the software to present that information to the user.

Security

In order to securely communicate with the smartcard, the smartphone needs to receive decryption and encryption keys. This could be one-time-use keys distributed over the internet when required. These limited keys are secure, but the downside is that an internet connection is required.

The alternative is to store multiple-use keys in the secure element of the smartphone. Putting the more versatile key in this secure element increases the protection against a malicious attack to an acceptable degree, whereas the other hardware and software parts of the smartphone are too easy to break into. This would allow the smartphone to perform operations without an internet connection. However, this level of protection requires access to that secure storage, which is guarded by either the phone manufacturer or telecom provider. Acquiring access to this limited secure storage will require negotiations with many powerful organisations that will probably want something in return.

Another option is that the smartcard itself is upgraded to a more capable self-executing card. The smartphone would then function as a conduit, providing network services to the smartcard that connects to the backend over the internet. The backend in turn sends the ticket information to the smartphone, allowing it to display it. In this scenario, the sensitive keys are only used on systems controlled by the operators (card & back-end), leaving less room for break-ins. This secure environment would not only allow for information reading operations, but could also accommodate information writing operations. A NFC enabled smartphone could be turned into a full Ticket Vending Machine, replacing the need for travellers to ever stop for credit top-up or product loading. In this scenario a constant internet connection is required.

Possible limitations

Technology

The OV-chipkaart started out on Mifare RFID chips and used the Mifare communication protocol. It turned out that these chips were insecure and the smartcards have since moved onto newer, more secure chips. The hardware in the field, however, has a lifespan of at least a decade and still expects Mifare communication. The newer chips are therefore specifically designed to emulate the old responses.

Smartphones with NFC will need to be able to communicate with a Mifare chip in order to retrieve the information. Mifare has been around for a long time and has been superseded by other chip architectures and protocols. Recently released smartphones, like the Samsung Galaxy S4 and Google Nexus 4, do not support Mifare anymore (Klug, 2012 & 2013).

Travellers will thus need to possess a yet to be released OV-chipkaart with newer chips that are compatible with both the existing system hardware, existing smartphones and as-of-yet unreleased smartphones. There are plans to bring new OV-chipkaart smartcards into circulation that works with newer smartphones.

A complication is the out-of-sync replacement cycles: smartphones are usually replaced every 3 years, smartcards are replaced every 5 years and system hardware is replaced about every 10 years. Three generations of technologies will have blossomed and died in the smartphone sector during the lifespan of one system hardware generation.

Market penetration

NFC-equipped phones have been available since February 2006, when Nokia launched the 6131. Since then, a limited amount of phones has included NFC. As of January 2013,

12.17 per cent of all worldwide mobile device web traffic came from devices that are NFC-enabled, with an average monthly growth rate of 0.65 per cent during 2012 (Davine, 2013). This low current market penetration and growth rate, combined with the protocol diversity, seems to indicate that NFC-based products will only work for a limited group of users.

Power

This solution only works if the smartphone has enough battery. Since this is an augmentation of the core functionality of the OV-chipkaart, it will not be a major problem for travellers if their phone is empty. Furthermore, battery technology will improve, which should allow for smartphones with longer battery lives in the coming years.

4.3.4 Smartphone: smartcard with backend information

Current situation

Instead of changing the OV-chipkaart system or smartcard, ticket information could also be displayed to travellers on their smartphones. A majority of people actively uses one.

Proposed changes

Besides directly accessing the ticket information on the smartcard, there is also the option of retrieving the same ticket information from the OV-chipkaart backend. All transactions are both logged on the card and by the system.

A traveller would open the OV-chipkaart app on his smartphone, which retrieves the latest ticket information from the OV-chipkaart backend and displays it. The traveller may top-up his credit or buy season tickets, but these will need to be loaded onto the card separately by operator-controlled validators. The app can cache historical information, but an internet connection is required to receive up-to-date information.

Design

The design of this app would be similar to the NFC proposal (see Figure 30). The difference is not the kind of information being displayed, but the source of the information.

Required technology

Security

All actions can be securely performed, since the app talks directly to the backend. Malicious users can also be blocked instantaneously.

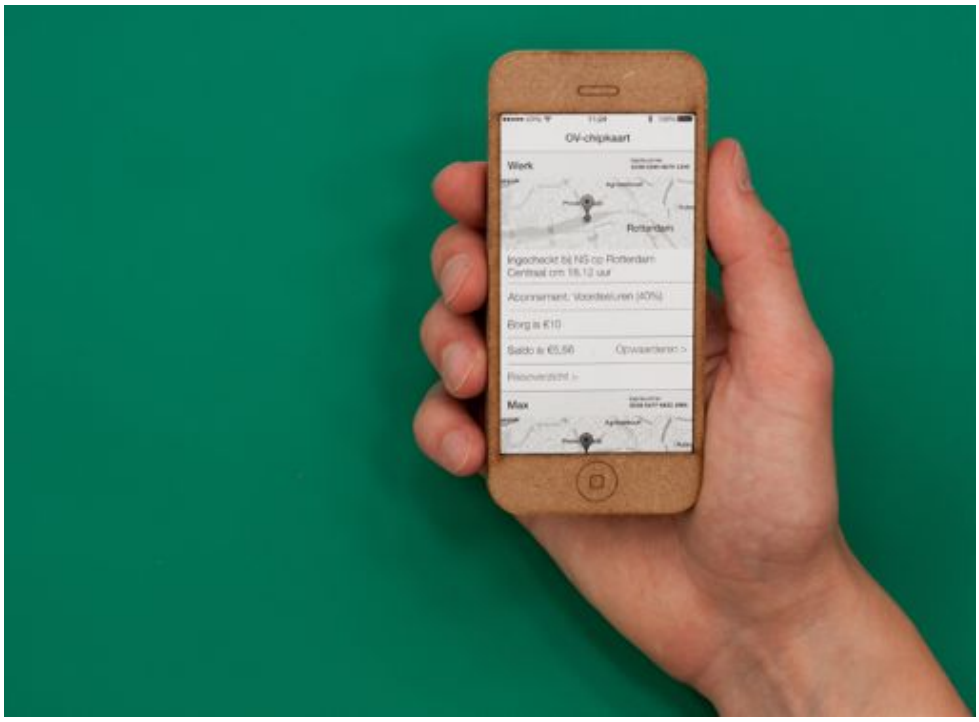

Figure 30: App linked to smartcard via low-latency backend

Technology

The app and information source (level 4) are proven technology and relatively easy to implement. Important for functionality of the app is the accurate reflection of reality by the information, which relies on low system latency to always show the latest status. Transactions thus need to be transferred from level 1 up to level 4 within 30 seconds, requiring a software and hardware upgrade on level 1, 2 and 3. Currently, transactions take 15 minutes (Dutch Railways) to 24 hours (bus operators) to reach level 4. The general direction of system development is towards lower latency, which would enable this proposal

Potential limitations

Mobile internet

Mobile internet is required for up-to-date information. Connections have been unreliable around public transport stations, tunnels, railway lines and underground metro lines in the past years for various reasons. For one, railway infrastructure monopolist ProRail has been reluctant to allow telecom providers to increase capacity in fear of interference with the mobile communication network of the train safety system (Hei-

jne, 2012). Together with rush hour at stations and high speed trains, the mobile data networks are often not able to keep up with demand.

Backend upgrade

This solution only works well if all operators upgrade their backend to increase the speed of transaction propagation. Otherwise, travellers will experience different reliability and quality of service in different regions and modalities, making the system unpredictable and not user friendly.

Power

As with any smartphone solution, the battery it has determines whether it can be used. With the development of battery technology, it is expected that future devices will have an increased battery life.

4.3.5 Smartphone: biometric recognition with backend information

Current situation

Currently, some operators use biometric recognition to identify people with a restraining order if they board a vehicle or enter a station. The system allows for automated notification and direct response.

Proposed changes

Instead of carrying around a physical smartcard to pay for public transport, the operators could use biometric recognition technology to identify travellers and send them invoices afterwards.

Travellers use public transport and cameras would register which route they take at what time and with which modality. The system would notify the traveller of registered check-ins via text message to his (smart)phone and it calculates the fare afterwards. Only registered travellers will be able to use this payment method. A smartphone app would be able to display additional information linked the person's public transport account, such as travel history and purchased or available season tickets.

The major reason to move to a biometric recognition system is ease-of-use for travellers. The ability to just take any transportation and not worry about purchasing a ticket removes a large barrier to use.

Design

One of the key design features from the traveller's point of view is the invisibility of the system. The biometric recogniction would happen from a distance and the traveller

would be able to see feedback on their smartphone similar to the other proposals, see Figure 29.

Required technology

Cameras for combined face, body and movement recognition most likely have the highest rate of success. Possibly augmented with phone tracking. These cameras would need to be installed in all vehicles and/or stations. To be able to still close off stations to increase safety, cameras would have to be installed on each gate.

Potential limitations

Privacy & acceptance

A potential limitation is the privacy aspects of automatically recognising people and following their movements. The current smartcard is able to tell check-in and check-out location and many vehicles and stations already have (automated) security camera systems, but this would be a next level system that could trigger protests.

Its capabilities would be similar to the location tracking of mobile phones, which already happens. With mobile phones, one at least has the option of not using them, while a biometric recognition system would need to analyse everyone, all the time.

It is unlikely that society has enough trust in private companies to set-up a system like this, but social acceptance of technology will change in the future and biometric recognition is something operators need to keep an eye on.

Error rate

The system is completely in the hands of the transport operators, but its effectiveness depends on the identification success rate. If the error rate or false positive rate is too high, too much revenue will be missed. It would not be fair to fine travellers in cases of system error, because the traveller has no active role anymore.

Power

The feedback of the system would be presented to the user via their personal devices or through operator-controlled systems at gates. If the phone or smartphone of the traveller has no battery, the system will still be able to follow the person and complete the transactions, but the traveller will have no ability to see his ticket information.

Conductor

It will be more difficult for conductors to check for ticket validity, because they will not easily know who is using the biometric ticketing system and who is not. Unless they

carry a device that augments their field of vision, for example a Google Glass type of device with a head-up display.

Social control

Other travellers will not be able to see whether you pay for your trip, decreasing social control in situations where the public feedback enforces it now (busses, trams). This could result in an increase in fare dodging, unless there is a public feedback system.

4.4 Proposal evaluation

4.4.1 Aim

The aim of the proposal evaluation was to discover the strength, weaknesses and potential of these design concepts and to get feedback on the human, technology and business sides. I presented prototypes to a mixed group of travellers and to the stakeholders.

4.4.2 Research questions

The evaluation should provide answers to the following research questions:

- What are the strengths and weaknesses of the proposals?
- What are the business interests?
- What is the technological feasibility?
- How do the proposals fit into the current OV-chipkaart development planning?
- Which organisation would or should put its support behind these proposals?
- How do travellers assess the functionality?
- How do travellers assess the interaction?
- How do travellers assess the Design?
- Which proposal would travellers prefer to use?
- Would travellers use such a product?
- Would the product solve a problem for travellers?
- What would travellers like to change about the proposals?

4.4.3 Prototypes

Each design concept was developed into a medium-fidelity prototype. These showed both the physical dimensions and simulated the interface, but lacked the detailing and interactive qualities of the final product. It allowed the test participants to imagine the use of each concept and the lack of details showed that it was work in progress that could be criticized (Bowles & Box, 2011).

The prototypes were made from cardboard and wood to the dimensions of the proposed designs. Different stages of the interaction were made visible by different versions of the prototype, which were given to the test participants when they initiated a state change. Care was taken to use similar materials and similar level of detailing in each prototype, to ensure that this did not influence the evaluation process. To that end, it was decided that the app for NFC, backend and biometric tracking would be presented on paper in a smartphone model of wood (see Figure 32). The personal reader was presented as a key fob shaped piece of wood with paper display (see Figure 31). And the card with display was made from cardboard (see Figure 33).

Figure 31: Low-fidelity prototype of personal reader

Figure 33: Low-fidelity prototypes of the display card.
Top: segmented LCD display. Middle: pixel LCD display. Bottom: full-size e-paper display.

Figure 32: Low-fidelity prototype of smartphone app

4.4.4 Method & participants

Human desire

To collect data about the desirability of each design concept, I asked 15 travellers to evaluate and compare all five:

1. Personal reader;
2. Display card;
3. Smartphone with NFC;
4. Smartphone with smartcard backend;
5. Smartphone with biometric backend.

I invited these people separately and asked them to bring their own OV-chipkaart smartcard, key ring and, if applicable, smartphone.

Earlier during this project, I established that there are three factors that are predictive on the amount of problems a traveller can encounter: technology understanding, travel frequency and operator diversity. For each of these factors, I selected at least two participants who sat on opposite sides of the scale: for example, someone with a lot of technology understanding and someone with little technology understanding.

While age did not prove to be a predictor of OV-chipkaart problems, it is a factor in physical capabilities. Since all three concepts rely on a display to communicate the information, I selected a minimum of three participants with worse-than-average eyesight.

Furthermore, gender is not a predictor of OV-chipkaart problems either, but does influence how people carry and use products. Therefore, this was included as a criterion as well.

These participant selection criteria were not deemed to be mutually exclusive. Participants were categorized based on their answers to a questionnaire (see Appendix D).

Each participant was invited to a room and seated at a table. It was explained to them that the study had the aim of improving the OV-chipkaart and that they would be shown design concepts under development. Participants filled out the questionnaire at the beginning of the study and signed for the usage of their information (see Appendix D). Each session was videotaped and the researcher took notes. After filling out the questionnaire, participants were asked to lay their OV-chipkaart, key ring and smartphone on the table and the researcher asked several questions to understand their experience

with the OV-chipkaart so far (see Appendix C & D). They were asked to rate the OV-chipkaart on a good/moderate/bad scale.

Participants were then presented with a potentially problematic OV-chipkaart situation they could find themselves in (see Appendix C) and asked how they would assess and resolve it. Following their explanation, they were presented with one of the design concepts and asked to tell what they thought this product would do. If a participant was not able to figure out the use, the researcher would explain it. Participants were then asked how this design concept would fit in the situation they had to solve earlier. At the end, participants were asked to explain what they thought was good and bad about the design concept, and what they would change to improve it. They were then asked to rate the design concept on the same good/moderate/bad scale as the existing OV-chipkaart. This process was repeated with all three design concepts, which were presented in different order to each participant (see Appendix C).

At the end of the session, participants were asked which concept had their preference and why, and if there was anything they wished to elaborate on. Afterwards, each participant received a present for his or her time and effort. See Table 3 for a time schedule.

The set-up was tested in a pilot study with two participants. This showed that the overall schedule and set-up worked, but that some aspects of the prototype models were confusing. Based on these results, a thinner variant of the card model was made, because the pilot participants focussed on thickness ("too thick for my wallet") instead of the suggested interactions. Furthermore, the card model was made to look more like an existing OV-chipkaart and the language of several instructions was changed. For example, from "scan card" to "hold close to card" and "last journey" to "previous journey".

Time (minutes)	*Item*
0-2	Welcome
3-5	Fill out questionnaire
6-10	Experience questions
11-13	Present situation and ask for solution
14-17	Present concept 1 and ask for use
18-21	Present concept 2 and ask for use
22-25	Present concept 3 and ask for use
26-29	Compare concepts
30	Thank for participation

Table 3: Evaluation study timetable

Technology capabilities & Business objectives

The technology capabilities and business objectives were evaluated with 15 experts from transport operators, government, suppliers and consumer organisations. The interviews were semi-structured. Each design concept was presented and accompanied by the results from the user evaluation. The experts were asked a set of questions (see Appendix C) about how each design concept would integrate with the goals of their organisation, how it would fit in with current developments, how it would fit the capabilities of their technology platform and how they assessed the viability and feasibility.

4.4.5 Results

The in-depth user and expert interviews generated qualitative information, which is categorised below by human desire, technology capabilities and business objectives (IDEO, 2009).

Human desire

12 out of 16 participants had a smartphone and 13 out of 16 participants indicated that they would prefer using a smartphone to a display card to see ticketing information. 15 of the 16 participants preferred the display card to the portable reader. All participants preferred the display card to the current smartcard. 10 out of 16 participants would like to be able to use a portable reader, but predicted that they would not carry it with them during travelling.

Participants said that they expect a smartphone to provide insight into travel history, current credit balance, current check-in or -out status, and an overview of their season ticket validity.

The people without automatic top-up saw being able to top-up the credit balance from a smartphone at any time at any location as a big advantage.

4 participants voiced concern about the need for a smartphone to use these features and some doubted whether they would use it if it has an information-only feature set. 9 out of 16 participants explained on their own account that they want to use the smartphone for ticketing as well, and 5 of the other 7 participants agreed when asked. The most mentioned reasons for this request were “I always carry my smartphone”, “it saves me from carrying an extra card” and “I expect it to inform me better”.

Participants said that the display card would be “very useful”, but voiced concerns about battery life, durability and cost. 5 participants indicated that they keep their smartcard in their wallet at all times and doubted whether they would look at the display regularly.

14 participants had trouble understanding the "instaptarief" and considered it irrelevant to them after explanation. All participants appreciated the check-in/-out status indication, all manual top-up users indicated that the credit balance display is useful, and all automatic top-up users indicated that they have no use for the credit balance display. The fare of the last trip confused some participants: it was unclear which trip this fare related to and some participants had no interest in this information.

The portable reader provided the essential data according to most participants, but 13 out of 16 objected to carrying an extra device. Especially a key fob was considered unattractive, since most participants tried to keep only essential (keys) or decorative (fobs) items on their key ring: the portable reader is neither, they concluded.

Technology capabilities & Business objectives

The 15 experts assessed all three proposals. The general conclusion was that the display card would have the least impact on the existing infrastructure, but would require a new card production process. The portable reader also does not influence the existing infrastructure, but requires a new distribution process that has to be linked to the existing one. The smartphone proposal hooks up to the existing infrastructure and requires some structural changes to connect these mobile devices to level 4, but the bigger change is the required information latency reduction between level 1 and level 4.

Most public transport operator experts have the view that the information latency reduction will be achieved in the coming years, because hardware and software will improve and it will be helpful in achieving other operational goals. They do not, however, expect that a smartphone app will be enough reason to fund this "multi-million euro expense". Both the operators and government experts expect that the smartphone will take on a more extensive role in the coming years, including payment. Operators' experts believe the smartphone will help make public transport more predictable and a "better fit for people's lives".

The display card was considered "an interesting solution", but the main concern was who would pay for the associated development and production costs. Operators gain a reduction in customer service requests and an increase in customer loyalty, but these effects are hard to quantify. The costs, on the other hand, are immediate and considerable. Operators see limited opportunity to carry these costs, government experts considered it an operator issue, and consumer organisations considered it an issue for both the operator and governments. Increasing the price of the smartcard for travellers was considered the most likely scenario, but the display card would need to be optional. Operators and consumer organisations expect a small group of people to purchase

this costlier card, which would in turn reduce production volume and increase per unit costs. The technology was not considered a problem.

The portable reader would most likely be needed to be linked to specific smartcards, in order to prevent privacy related problems with people being able to read other people's cards. Linking portable readers to smartcards would require an additional distribution channel that is coordinated with the existing one. The experts expect that the product would be helpful for certain groups of people (elderly, people with a disability), but doubt whether it would find widespread adoption because of the limited functionality, costs and distribution challenge. They do think it is the easiest of the three proposals to implement.

4.4.6 Discussion

The most remarkable result was the enthusiasm the participants had towards the idea of using their smartphone to pay for public transport. A majority initiated the topic and almost all were in favour. There still is a large gap between participants saying they want to pay for public transport with their smartphone and those who would actually do it. The evaluation provided a medium fidelity prototype of a smartphone app that provides information, but did not present any solution for payment. It is impossible to say whether the participants would be as enthusiastic about a real smartphone payment method when it operates within the boundaries of technology and business requirements as they are about the one they envision.

It is clear from the evaluation, however, that the participants are not enthusiastic about a portable reader. They find it objectionable to carry an extra object that does not provide enough value. Even though this proposal seems the easiest to manufacturer, it probably will not reach enough people and probably will not be used enough to improve the overall travel experience.

The display card was received well by both participants and experts, but the main concern is the costs. And both the participants and experts were keener on a smartphone variant.

4.5 Conclusion

The portable reader seems unlikely to make enough of an impact and I will not pursue it any further. The display card was received well, but seen as less interesting than a smartphone solution. Most participants, however, were experienced smartphone users, so additional research among non-smartphone users is required to properly evaluate the display card use. A smartphone solution is seen as the way forward by most participant, but preferably one that allows you to pay besides providing just information. I will develop this design concept further.

5

5 Recommended products for improved electronic ticketing

5.1 Introduction

The portable reader, display card and smartphone app were presented in the previous chapter. Based on the evaluation with travellers and experts, I decided to further develop the smartphone and display card concept. The conclusion based on the evaluation was that the portable reader does not provide enough value to pursue.

This chapter describes the changes to the smartphone and display card proposals based on the evaluation. These new designs were evaluated again with travellers and the results were used for the final round of changes.

5.2 Detailing: display card

Participants and experts agreed that the display card needs few changes. The short-term version (2-5 years) design consists of two variants: one with a segmented display (see Figure 34) and one with a pixel display (see Figure 35). The differences between the two are listed in Table 4. The biggest difference is whether there is one button for all information, or separate buttons for separate pieces of information. Participants had no strong preference for either. Furthermore, the pixel display allows showing other types of information, such as a warning in case the validity end date is approaching.

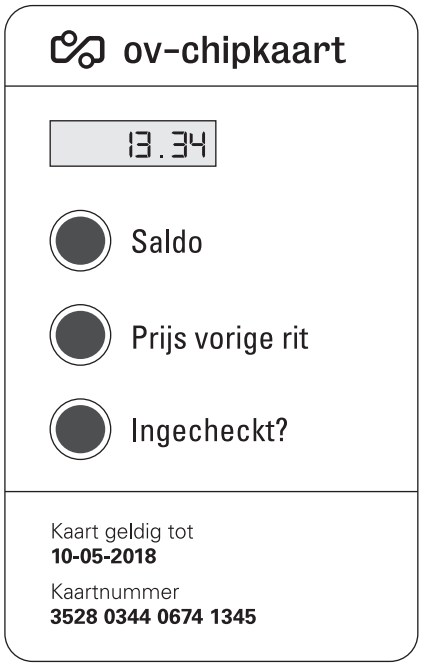

Figure 34: OV-chipkaart with LCD segmented display and single function buttons

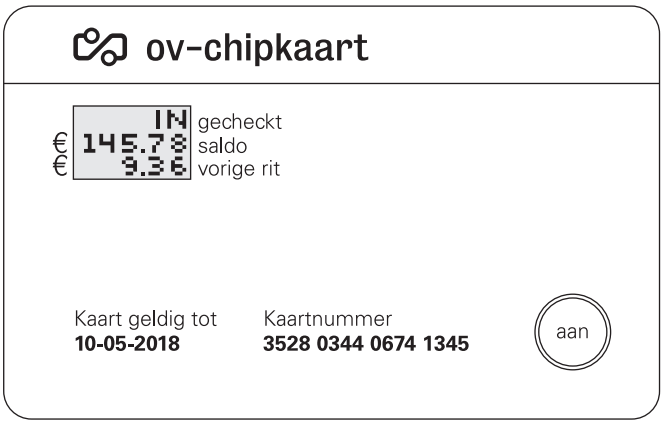

Figure 35: OV-chipkaart with LCD pixel display and on button

Display	Pixel	Segmented
Cost	Costlier	Cheaper
Action to info ratio	1 button, all information	3 buttons, 3 pieces of information
Display graphic flexibility	Flexible	Semi-flexible

Table 4: Differences between the short-term display card variants

The long-term version (10 years, see Figure 36) was considered more desirable by the participants, but requires display and battery technology advancements. The large display is able to show more information in a flexible, but structured, manner. However, larger displays usually require more energy. A promising display technology that requires less energy and has great contrast is e-paper. These e-paper displays are not yet thin and cheap enough to use in a display card.

While most participants and experts would like to have a display card, the most prominent concern is costs. According to one of the manufacturers, a card similar to the short-term proposal costs about 7 to 10 times as much as the current OV-chipkaart to produce at scale. See Table 5 for a comparison. Per unit costs will rise if production is limited, likely going up to 20 euro.

	Current OV-chipkaart	*Long-term*
Production	1 euro	7-10 euro
Handling and distribution	2.5 euro	2.5 euro
Transport credit	4 euro	4 euro
Total cost	7.5 euro	13.5-16.5 euro

Table 5: Differences between the short-term display card variants

It is impossible to estimate the production cost for the long-term, full size e-paper display card, because the technology is still being developed.

The usage of the display card would be similar to the current OV-chipkaart smartcard, with the added benefit of being able to see credit balance, check-in status and fares. See Figure 37 for a scenario example.

Figure 36: OV-chipkaart with full-size e-paper display. Top: traveller is checked-in. Middle: Traveller is checked-out. Bottom: Card shows expiration warning.

Figure 37: Usage scenario display card during a bus trip

5.3 Detailing: smartphone

The previous iteration of the smartphone proposal only showed ticket information. During the evaluation, participants indicated that they would like to use their smartphone for more actions and especially for ticket payment. Participants envisioned the upsides of having one fewer smartcard that they can lose and considered that they would be able to look up more ticket information on their phone.

This process of doing more functional things with ever less weight, time and energy was called "ephemeralisation" by Buckminster Fuller (1938) and the smartphone is the prime example of this. In recent years, the smartphone has become, for example, the most popular camera (Flickr, 2013). It also replaces for many people their satellite navigation system, physical maps, wrist watch, alarm clock, landline phone, voice recorder, camcorder, game console, agenda, address book, calculator, dictionary, portable music player and other things (see Figure 23). The smartphone integrates the functionality previously found in dedicated equipment, delivering more convenience at sometimes a loss in quality.

Figure 38: Ephemeralisation—one device to rule them all. Top: PDA, video camera, laptop, mobile phone, photo camera, tape cassette player, pager, watch. Bottom: smartphone. Photographer: unknown.

5.3.1 Requirements

Important for transport operators is that travellers pay for the distance they traverse and transport level they use. This requires reliable departure and arrival location and time, combined with payment security and ticket verifiability. Besides payment, electronic ticketing also allows operators to close-off stations, it increases social pressure to pay for transport by giving public feedback, and increases throughput speed.

The OV-chipkaart achieves these objectives by: registering at check-in and -out points with auditory feedback and controlled by operators; prepaid credit, automatic bank transfers or trustworthy contracts; and conductors with validators.

A smartphone solution needs to be able to reach the same goals of reliability, security, social pressure, throughput, affordability, and opening gates.

5.3.2 Technologies

There are several technologies that would allow a smartphone to be used for electronic ticket payments.

GPS

Travellers could use a smartphone app that determines, based on location and time, what vehicle one takes. Users would open the app, select to confirm their vehicle and the app would determine arrival location and cost (see Figure 39). This is credited to their public transport account, which is linked to their bank account.

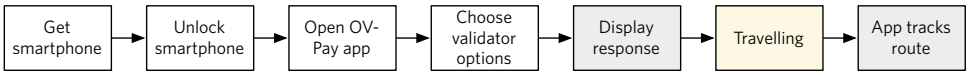

Figure 39: GPS ticketing flow

For this to work, the smartphone will need a reliable internet connection. One of the problems is that it undermines social control, because the bus drivers and other passengers cannot tell whether you actually are paying.

Near-field communication

Near-field communication, or NFC, allows devices to communicate to each other over short distance (centimetres). Travellers could open an app that would talk to validators over NFC (see Figure 40).

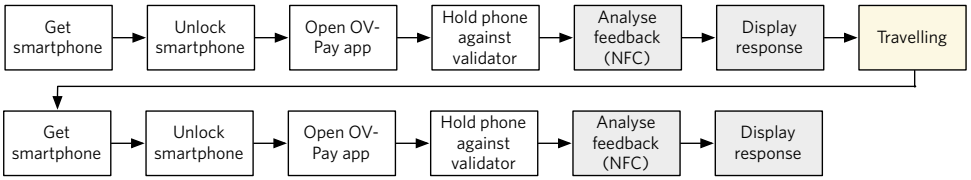

Figure 40: NFC app ticketing flow

It would be even better if smartphone would support NFC communication on the operating system level, allowing travellers to check-in without opening the app. Preferably even if the phone is locked and in standby (see Figure 41).

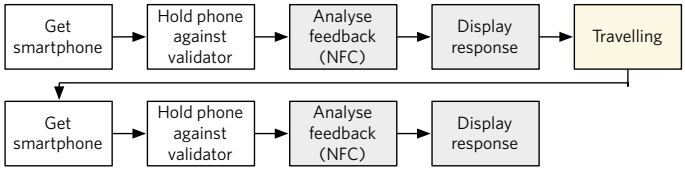

Figure 41: NFC operating system ticketing flow

As discussed on earlier, NFC is not standardised yet and does not have enough market penetration yet. Mobile operating systems do not allow for secure NFC communication on their level yet and there is no common standard for NFC payments yet.

Bluetooth Low Energy

Bluetooth Low Energy (BLE) allows several devices to connect to each other and exchange information over several metres. It is supported by all major smartphones (Apple, Samsung, Nokia, Blackberry). For certain situations, such as location beaming, pairing between devices is not necessary.

BLE would allow smartphones to receive the location information, necessary for departure and arrival registration, from operator validators (see Figure 42).

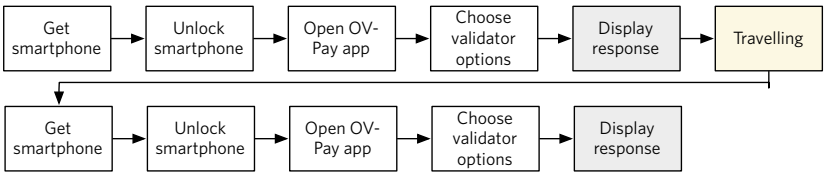

Figure 42: BLE ticketing flow

Using this wireless technology, however, makes it difficult for bus drivers and other passengers to see who pays for public transport and who does not. It is also more difficult to open gates with BLE, since the traveller's location is uncertain.

Tracking

Mobile phones connect wirelessly to base stations and identify themselves. By tracking, for example, the wifi signal of smartphones (Clifford & Hardy, 2013), one can establish travel routes. If transport operators would know which person carries which phone, one could send the bill afterwards (see Figure 43).

Figure 43: BLE ticketing flow

The downside is that there is again no public feedback that someone is paying for public transport, making it hard for the social surroundings to know who pays and who does not. There are also related fraud concerns with people who switch their phone on and off and privacy concerns related to this detailed tracking.

QR codes

Quick Response (QR) barcodes are two-dimensional and allow for optical information transmission. Almost all smartphones have a relatively large screen (>3 inch diagonally) capable of displaying QR codes that could be scanned by operator validators (see Figure 44).

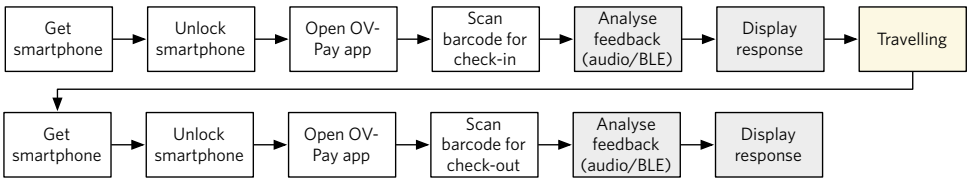

Figure 44: QR ticketing flow

Currently, only the validators of NS conductors are able to scan QR codes, but the NS is already planning on outfitting all gate lines with at least one scanner for international travellers.

An app could dynamically generate these QR codes, allowing for sending specific parameters to the validator. This way, the smartphone could convey, for example, what comfort class a travellers wishes to sit in. Or whether the traveller is bringing a bicycle.

Conclusion

Of the available technologies, the one that fits the best with the existing infrastructure and requirements is QR. The other technologies either require too much new infrastructure (NFC, tracking), do not have the required market penetration (NFC), are not able to open gates (GPS, BLE, tracking) or undermine the social control of paying for public transport (GPS, BLE, tracking). See also Table 6 for a comparison.

	GPS	*NFC*	*BLE*	*Tracking*	*QR*
Infrastructure	Backend changes needed	All validators need costly upgrading	All validators need affordable upgrading	All vehicles need extra equipment	Regional transport needs extra equipment. Train stations get hardware in near future.
Market penetration	High	Low	High	High	High
Opens gates	No	Yes	No	No	Yes
Social control	No	Yes	No	No	Yes
Security	Limited	Good	Good	Limited	Good

Table 6: Smartphone ticketing technology comparison

5.3.3 Design proposal

Paying for public transport with a smartphone can be achieved by displaying a QR code that is scanned by operator validators. The QR code contains unique information, allowing the validator to link the check-in or -out to the traveller's account. This account is linked to a bank account, securing fare payment for operators and circumventing the need to 'store' money on the mobile phone itself. A traveller is logged into the app with this account. The name of this design concept is: OV-Pay.

Ticket

Check-in throughput depends on the speed of the optical recognition sensor the validators will use. If the check-in is successful (i.e., the QR is valid), the gate opens and/or the validator will give regular auditory and visual feedback. The validator will also send

failure/success feedback to the smartphone, either through, for humans, inaudible differences in the auditory feedback or over BLE. This allows the app to change state and display ticket information (see Figure 29). The same happens for check-outs, which are needed upon arrival. Conductors are able to check the validity of the ticket by also scanning a QR code displayed on the smartphone.

Additional information

In addition to allowing travellers to check-in and -out, the app can also show extra information if it is connected to the internet and receives satellite positioning signals. It can, for example, display travel history (combination of local data & download from level 4), current travel information (GPS location & fleet operation data determine vehicle), account status (downloaded from level 4), and available season tickets (downloaded from level 4).

See Figure 45 for a usage scenario. A functional flow block diagram can be seen in Appendix F.

Fare payment

Currently, a deposit is taken from the smartcard credit balance at check-in to incentivise checking-out in order to ensure fare payment. Since there is no actual credit on the smartphone, but only an account linked to the smartphone, the banking fees for taking a deposit at check-in are costly. To mitigate this, the maximum fare will be deducted if smartphone users do not check-out. This can be more money than the current 4 to 20 euros. The maximum far for a single journey with Dutch Railways, for example, is 24.60 euros in second class. The user's benefit of using the smartphone app, is that it can allow you to correct a forgotten check-out, because the GPS tracking of your journey gives reasonable confidence about your arrival station to transport operators. Getting your money back after a forgotten check-out is thus a lot easier if you use a smartphone instead of a smartcard. Fraud prevention might require limiting the amount of times a year a user can use this feature.

Power

Using a smartphone for fare payment is impossible if its battery is empty. This problem could occur at two different stages: before entering public transport and during the trip. If your battery is empty before entering public transport, the situation is akin to forgetting your current smartcard. The solution is to buy a single journey ticket. If the battery drains during the trip, there are two possible situations:

Figure 45: Usage scenario smartphone app. The validator will vary, depending on the technology used.

1. If there are gates, a traveller can use the information button to request a check-out. The service desk will be able to see you checked in with your phone by looking up your account in the system.
2. If there are no gates, a traveller is able to go home and charge his phone. He will be able to open the app and request fare correction.

Internet

The QR code is generated by the app based on cached account parameters, such as ticket options, date, time, and account identification number. The app does not have to be connected to the internet to perform the core functions related to ticket purchase. Internet connection is required for additional functionality, such as viewing arrival information and reviewing and purchasing season tickets.

5.4 Evaluation

5.4.1 Aim

The purpose of the evaluation is to determine the products' usability, interaction and desirability.

During the previous evaluation study of the display card, much information was already gathered about especially the usability and interaction. During this study, the focus was on the attitude towards the card and specifically in relation to the pricing strategy.

One of the conclusions of the previous study was that participants who owned smartphones preferred a solution that uses said phone. The results also indicated that participants without smartphones had a stronger preference for a display card than for other presented solutions. This second evaluation thus focused on the attitude towards the display card of travellers without a smartphone.

The smartphone app offered a yet untested usability and interaction, thus the evaluation needed to cover more items than the display card's evaluation. The focus was on determining if people understand the app and how people experience using the app.

5.4.2 Research questions

Display card

The evaluation of the display card focused on the following research questions:

- What are the strengths and weaknesses of the display card?

- How do travellers assess the functionality of the display card?
- How do travellers assess the envisioned interaction of the display card?
- Would travellers use a display card?
- What would travellers be willing to pay for a display card?
- Would the display card solve a problem for travellers?

Smartphone

The evaluation of the smartphone app focused on the following research questions:

- What are the strengths and weaknesses of the smartphone app?
- How do travellers assess the functionality of the smartphone app?
- How do travellers assess the actual interaction of the smartphone app?
- Would travellers use such a product?
- Would the product solve a problem for travellers?
- What would travellers like to change about the app?

5.4.3 Method & participants

While the research questions for each product are similar, the aim and available resources led to the decision to use two different methods. The testing of the display card therefore focused on the aspects that were not evaluated yet (price, design iteration), while the smartphone app evaluation included more usability and interaction items.

Display card

The goal was to evaluate the desirability of the display card with a group of travellers whom were underrepresented in the previous study: people who do not own a smartphone, but do use public transport. The test also aimed to find out how this group of users assess the display card and what they would be willing to pay for it.

To gather this data, an interview script was determined:

- Select person
- Ask for participation & permission for video documentation
- Introduce display card, show prototype, explain functionality and operation

- Ask (follow-up) questions about the participant's opinion of the display card
- Thank for participation

At the end of the questionnaire, the participants were introduced to the smartphone app prototype and asked how they would assess it and if it would be a reason to purchase a smartphone.

The intention was to keep the interviews under 5 minutes, in order to be able to go out and ask people on the street during their journey.

For the purpose of gathering indicative data, 12 people were interviewed: 6 males and 6 females. From the CBS data we know that smartphone market penetration in the age group 12-55 years is over 50 per cent and from operator's market data we know that the public transport user is more likely to have a smartphone than the average Dutch person. It was thus expected that the age of the participants would skew towards over 55 years. Participants were approached at random at train stations in The Hague and Rotterdam, disregarding those travellers who held a smartphone in their hand.

Smartphone

To evaluate the smartphone app, a more in-depth method was required to collect the qualitative data and insights about the travellers' concerns. In order to mimic a real-life situation, 10 participants were given a high-fidelity prototype of the product.

Participants were asked about their travel experience with the OV-chipkaart and how they would envision smartphone fare payment. They were then given the prototype. Participants were asked whether they had any idea how travelling with this new app would work. If they were not able to deduce it, the researcher would explain the check-in and check-out procedure.

The prototype was introduced as a "genuine public transport ticket" and participants were asked to use it to check-in at an existing validator at a train station. The participant would try to scan the barcode that was displayed on the smartphone screen and the research would remotely trigger the system response.

At the end of the study, the participants were asked several closing questions about their experience, opinion and what they would change if they could. They were also introduced to the display card prototype and asked how they would assess it compared to the app the just used.

5.4.4 Prototypes

Prototypes were developed to let travellers see and try the products without having to invest in building full versions. Since participants would only see one of the two products (see Paragraph 7.4.3), there was no need to keep them on the same fidelity-level (Bowles & Box, 2011).

Display card

The display card prototype was build at a medium-fidelity level, because building a high-fidelity version that showed both the product's physical dimensions and interactive qualities was too expensive. The prototype consisted out of static screens printed on paper glued to cardboard. This showed the intended information, lay-out and physical size for travellers to evaluate (see Figure 46).

Figure 46: Display card low-fidelity prototype

Smartphone

The product evaluation depended less on physical dimensions and price, and more on interaction and speed of operation. This required a prototype that would perform closer to the real product than a paper prototype could.

The smartphone app was build at a high-fidelity level. The product was build as an app, though without the backend integration a production version would need. All elements, from start-up time to animation and responsiveness, were performing as a real product would. The data was, however, predetermined. Stations, travel history, account details, etc, were based on sample data and personalised per participant. See Figure 47.

Figure 47: High-fidelity prototype of OV-Pay app. Top left: QR barcode for checking-in. Top right: Ticket options. Bottom left: Travel information. Bottom right: Travel history.

5.4.5 Results

Display card

7 out of 12 participants said they have been in a situation where they did not know whether their OV-chipkaart was checked-in or -out. 9 out of 12 participants said they have been in situations where they did not know whether their current credit balance would allow them to travel.

When asked how much participants thought a display card would cost, the average response was 30 euro. When asked how much they thought it should cost, the average response was 20 euro. When asked whether they would pay 15 euro for it, only 2 out of 12 agreed. 2 participants said they would buy it under 10 euro and 8 out of 12 participants thought it should not cost more than a regular OV-chipkaart.

When asked if they would prefer a display card or smartphone app, 11 out of 12 preferred the display card. Most participants answered that they "do not want a smartphone" or that "a smartphone is too expensive". One participant said that they expect to buy a smartphone in the future and an OV-chipkaart app would be "useful".

Smartphone

7 out of 10 participants thought they would use a QR smartphone app to pay for public transport if it was available. All of these 7 people would prefer a version with NFC support on operating system level, allowing them to check-in without having to unlock their phone.

The other 3 participants considered the current smartcard either "easier" or "more secure and safe". Security both in terms of pickpockets during check-in and linking a bank account to their smartphone, even if only for public transport. And safety in the sense that using a smartphone during rush hours in close proximity to others to check-in might increase the risk of dropping it. These 3 participants also preferred the display card, though only 1 of them would be inclined to pay a premium for it.

8 participants did prefer direct debit transactions for travel expenses to a prepaid credit balance. One participant remarked that she would "feel safer with a password option for opening the app".

4 out of 10 people said that the "NS meereiskorting" was more complicated now than it used to be with paper tickets and that they would expect the smartphone variant to support it in an easier way.

The prototype allowed participants to force a check-out: instead of going back to the station, one could check-out at any time, anywhere. The concept and consequences were difficult to understand for most participants.

Being able to change ticket options (comfort class, bicycle, high speed train) right from within the app was seen as a big upside by all participants. Travelling with multiple people on one account raised questions about payment ("could be useful for a family, but not with friends") and social control ("how does the bus driver know how many people you pay for?").

4 out of 10 participants worried about the time it would take them to find their smartphone, open the app and scan the barcode. Other participants remarked that they would take out their phone while walking towards the station or vehicle, something they "already do now for checking departure times".

One participant worried about his smartphone running out of battery and said that he would expect to be able to charge his phone on the train to alleviate this possible problem.

3 participants did not immediately understand what the purpose of the barcode was, 2 of whom thought they had to use the smartphone camera to take a photo of a barcode and that the app was showing an example of what to look for.

All participants appreciated the travel history overview, though some said they would rarely use it.

5.4.6 Discussion

Display card

As expected, non-smartphone owning participants are more enthusiastic about the display card than smartphone owning ones. Participants also found it hard to put a price on it and tended to overestimate. This, however, does not seem to increase their willingness to buy. The cost and business case remain the main items that are likely to influence the success of the product.

Almost all participants were over 45 years old. Smartphone adoption is lower among older people, which explains the average age of the participants.

Smartphone

While the participants preferred payment options that require less steps and attention (NFC over QR), they still prefer any smartphone solution to the existing smartcard or display card.

The concerns of safety and security by some participants regarding the use of a smartphone in a public, and possibly busy, setting are hard to alleviate. For most people, the use of a smartphone for these purposes will be subject to a risk/benefit assessment. The smartphone is taking on more and more public roles, suggesting an acceptance of risk by many people.

Automatic fare payment by withdrawing money from a bank account linked to a user account works well conceptually for participant. Whether it would work in reality depends on transaction costs. It also puts this service out of reach for people without a bank account, about 1 per cent of people in the Netherlands (AAPIM, 2013).

Besides using the smartphone for public transport to be able to do more with less (ephemeralisation), participants were also positive about being able to easily change their ticket preferences. One of the big advantages of working with smartphones and electronic tickets is the flexibility and speed: there is no need to send around plastic smartcards via the mail anymore and no need for "activating products". Season tickets can work instantly. Download the app and you are ready to enter public transport.

Putting more functionality in fewer devices makes you also more dependent upon those devices. A smartphone without a battery charge is no good as a payment method if you have to take public transport. Alternatives to paying with your smartphone will need to continue to exist, similar to the need for alternatives to the current smartcard. With the advancement of technology, smartphone batteries should increase in capacity and allow travellers to use them without worries.

An uncertainty still is the throughput speed of people using (QR) smartphone tickets. This depends on both the hardware quality operators will use and the dexterity of users. This evaluation did not give any conclusive insight into the latter.

Almost all participants were between 20 and 35 years old and enjoyed tertiary education, which could have influenced the results. Many of these participants have used public transport at no cost for a long time, because they received a student season ticket. Their use of public transport is thus framed by the experience of easy, all-access usage for years. They have not, in general, used paper tickets extensively and have used the OV-chipkaart for several years.

5.5 Conclusion

Display card

Based on the results from the evaluation, the display card seems to provide the group of travellers without a smartphone access to their ticket information in a desired way. The price of the display card will determine its success.

Smartphone

The new smartphone app design is much closer aligned to what participants want from such a product.

Paying for public transport with a smartphone is highly desired by a large group of people, even if it would work with QR codes instead of faster communication protocols such as NFC.

Smartphone payment offers the advantage of carrying one device for multiple functions and greatly reduces the barriers to entry by making it as easy as downloading an app.

The limited scale and scope of this evaluation provides answers to the specific questions of technology preference (NFC), QR code acceptance (yes) and usability concerns (forgotten check-outs, etc.), but is not definitive. The basics of the technology and interaction of the smartphone app have been evaluated and further studies will need to refine this.

6

6 Recommendations & conclusion

6.1 Recommendations

I recommend implementing both the display card and smartphone app, because they solve the ticket information visibility problem for different user groups.

6.1.1 Display card

To make ticket information visible to travellers without smartphones, I recommend replacing all smartcards with segmented display cards. Contracts, development and setting up manufacturing processes will take 2-3 years according to experts, allowing for introduction soon afterwards.

For the longer term, I expect the smartcard to still be used by a certain group of travellers. Investing in the development of better display technology would allow moving to a full display card based on e-paper in 7 to 10 years. This would make the interaction even more seamless, by removing the need for buttons.

The sales price of segmented display cards is currently about double the price of regular smartcards. It is expected that the production cost will drop in the coming years due to improved manufacturing processes. The time it takes to set-up the distribution process thus likely results in a lower sales price, addressing the main concern regarding this design.

Extra market research will need to settle the question of how the production cost will need to be covered. There are several options:

- The traveller will bear the extra costs at point of purchase. The evaluation study points at likely resistance among travellers.
- Travellers will not buy the card, but pay a deposit for it. This could take away travellers' concern of the increased price, but production cost would need to be covered through other means. This would most likely happen with a fare increase, which could result in initial resistance and would need the approval of all regional governments and/or operators.

- The transport operators will bear the extra costs. While operators receive certain benefits from this new card (increased customer satisfaction, decreased customer service cost), it is unlikely they will voluntarily agree to this.
- The governments will bear the extra costs. While the governments will receive little direct benefit, it would likely increase public transport satisfaction.
- A combination of the above.

I advice against introducing the display card along side the existing card. Many travellers will only discover the benefit of ticket information visibility after extensive use. Side-by-side sales will likely steer the groups of people that would greatly benefit from better insight into their credit balance and spending patterns, such as infrequent travellers and low-income earners, to purchase the cheaper existing smartcard without a display. The same situation will occur if the display card would only be available (at reduced cost) to season ticket holders. Limited distribution will bring the per unit production cost up, increasing the purchase barrier for more people in a vicious circle.

6.1.2 Smartphone

Participants who owned a smartphone prefer using a smartphone to pay for public transport and view ticket information to paper tickets or smartcards. Enabling smartphone payments will likely increase customer satisfaction and reduce costs related to smartcard distribution. I recommend enabling QR code payment within 3 years and working towards a wireless solution in 8 years. It is important to do additional user testing of concepts. Building a functional proof of concept and setting-up a small scale real-life user test will help in determining the final implementation.

Implementing smartphone fare payment will require incredible efforts of all operators and suppliers. Developing the app itself for the different platforms is easy compared to adding the necessary optical recognition technology to all vehicles of regional operators. The fact that NS is planning to place these validators at gate lines already, helps in tipping this technology, but there are many more vehicles in the country than stations.

Besides upgrading the validators, the payment infrastructure needs to be updated as well. Luckily, here as well the NS is leading the way in post-paid accounts. The smartphone solution is thus likely to be able to use the infrastructure that exists or is currently under development for other purposes.

6.2 Conclusion

Replacing paper tickets with electronic tickets solved the revenue distribution problem and allowed for controlled access to stations. In the process, ticket information moved from being visible to being invisible to travellers.

Introducing both the display card and smartphone fare payment app would make ticket information visible again and improve the transparency of the OV-chipkaart system for travellers.

Based on the results from the studies, it is expected that removing this low impact, high persistency, high frequency usability problem of invisible ticket information will increase customer satisfaction.

It is expected that the smartphone app would need lower operational expenditure than the current smartcard, while the display card requires higher capital and operational expenditure compared to the current smartcard. Both products are necessary, though, because there will continue be a group of travellers that will not have a smartphone or does not want to use a smartphone for fare payment.

The display card can be introduced in the coming 3 years and the smartphone app could arrive sooner for trains and in 3 to 5 years for busses and other regional transport.

Both the display card and smartphone app shoud be developed in stages. The first version (LCD display card; QR barcode app) should be easier to implement in the current production, distribution and infrastructural processes. The second version (e-paper display card; wireless app) should use newer technologies to improve usability.

The development cost for both products will be considerable and have to be covered by a profit margin reduction, government subsidy, fare increase, higher purchase price, cost reduction elsewhere or combination of these. It is too early to tell which is the best.

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Appendices

Making the Invisible Visible

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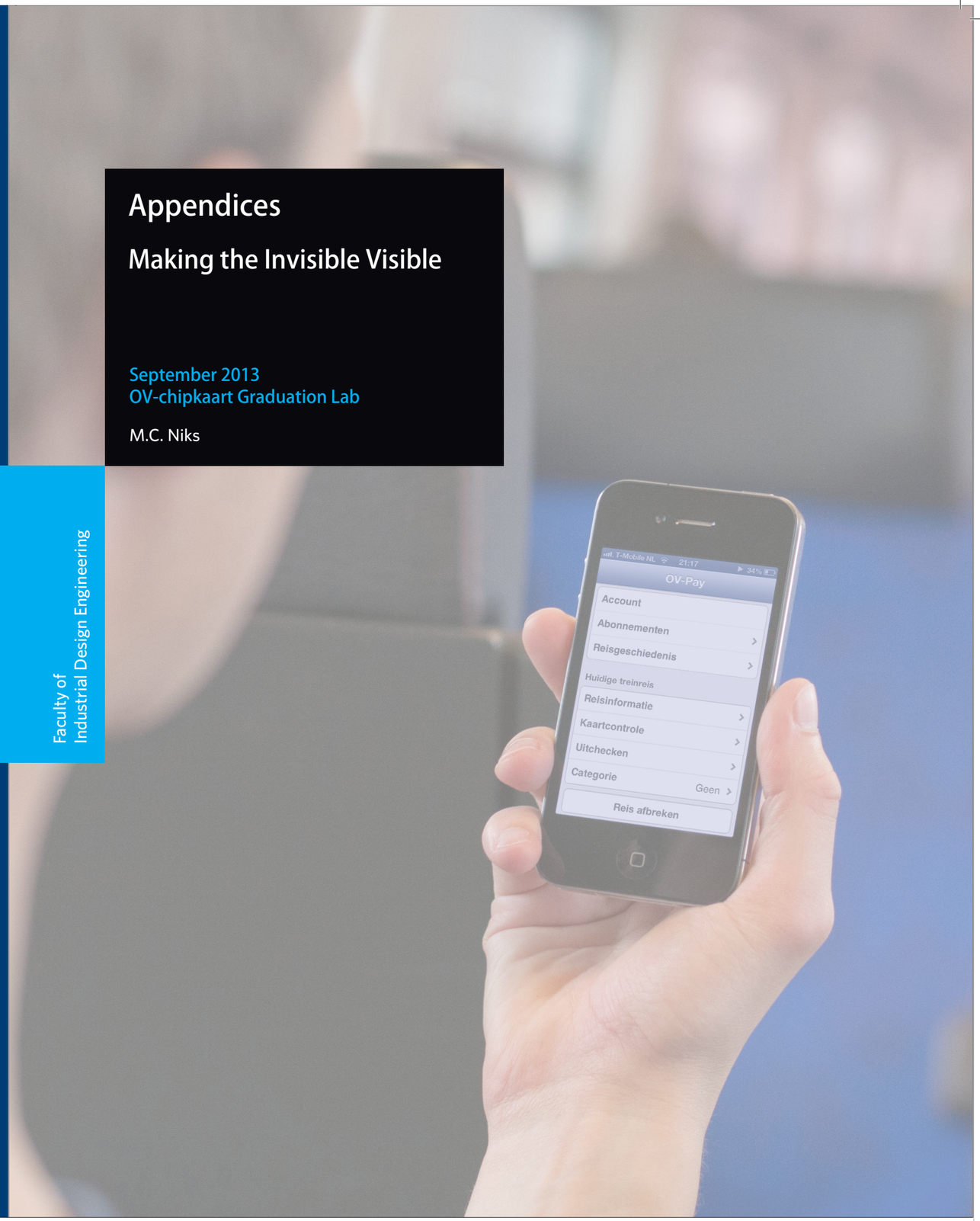

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These appendices belong to a report that is part of the OV-chipkaart Graduation Lab.

Report title: Making the Invisible Visible — Increasing travellers' trust in electronic ticketing for public transport by making ticket information visible during the journey

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Appendix A Available technologies

Available technologies

14.1 Introduction

The previous chapter described lack of transparency user of the OV-chipkaart experience. Different technologies could be used to give the traveller access to the electronic ticket information in order to improve the usability. This chapter describes several technologies that might be used to build a solution and explains why some are in use already, why others could be used in the future and why some are not viable.

A self-service electronic ticketing system needs to be able to identify and authenticate unique personas to ensure fare payment is handled correctly. Different ways to enable this are described in paragraph 3.2. The transaction data generated by travellers needs to be transferred from a system endpoint to other parts in order to fulfil payment, and with the OV-chipkaart system it is also required to transfer it to the smartcard. Technologies that enable this data transfer are described in paragraph 3.3. Making this data visible to the traveller requires a visualisation technology, which are described in paragraph 3.4. Providing input might be ––useful in certain circumstances, and technologies to enable that are described in paragraph 3.5. And all these parts need to be powered, for which possible sources are described in paragraph 3.6. [image]

14.2 Identification & authentication of personas

Fare payment requires the transfer of money from the traveller to the public transport operator. In order to accomplish this with an electronic ticketing system, a computer needs to be able to identify travellers and authenticate their right to ride. With Dutch public transport, this happens either by verifying a season ticket or by accepting the stored credit. The OV-chipkaart system requires travellers to check-in at the beginning of their journey and check-out at the end of their journey. These two actions allow a computer controlled by the public transport operator to update the credit on a smartcard or link usage to an account or person.

Identifying personas, authenticating their credit and verifying their use requires technology to track these aspects. Currently, distributing electronic tokens to individual

travellers enables this. In the future, technology will advance to the point where a token is not necessary anymore to enable reliable identification.

If the fare payment system would move from the current offline to a future online state, the identification method could be changed. In an online situation, it is not longer necessary to have the traveller move around his ticket information from system endpoint to system endpoint to guarantee correct fare payment, but the system could move this data around for the traveller. The need to store ticket information on level 0 of the OV-chipkaart system would thus be removed, allowing for a system that relies on identifying persons.

Biometric recognition is based on matching a feature scan to a previously stored profile. Using a multimodal approach increases the success rate. A concern of travellers is the ability to make use of public transport anonymously. Since biometric characteristics are unique to a person, the anonymity relies on the implementation instead of the use. The technology acceptance would thus require a high level of trust in the system owners.

This paragraph explains the use of the existing electronic token and promising biometric technologies.

14.2.1 Electronic storage

Travellers currently possess a smartcard that contains an electronic chip that stores data. This data is read and updated by the OV-chipkaart system during each interaction.

Information stored on the current cards includes: unique card serial number, serial verification number, manufacturer, distributor, card expiration date, card type (anonymous or personal), encryption keys, birthday (in case of a personal card), automatic top-up information, season tickets, credit balance, last 11 transactions, last 13 check-in and check-out actions, and the last 3 top-up transactions.

Storing all this data on the smartcard allows the fare payment system to work decentralised and offline. Fare payment transactions can take place at a local level solely based on the information the smartcard provides and these transactions are later send to a central point to allow for revenue distribution among operators.

14.2.2 Visual storage

Cameras can photograph barcodes and these images can be analysed by computers to determine the embedded information. This allows for cheap information storage that

can only be retrieved. Information encoded in barcodes could be just a token that links it to more information in a backend system, or it could be a self-contained information package. Since barcodes can be easily reproduced, their security usually relies on one-time use and information encryption.

14.2.3 Fingerprint or hand recognition

Fingerprints of people are relatively unique, which allows for identification of a person with a relatively high probability. If the fare payment system would be online and takes care of the ticket information distribution, identifying unique travellers would be enough to authorize payments.

The most common approach to fingerprint recognition is to have the person put a finger on a glass plate and have one or more cameras detect the friction ridges that form a unique pattern. Using current technology would, however, increase the check-in and check-out transaction times in comparison with the existing smartcards. There are also security concerns around fingerprint duplication, which could lead to identity theft. It is possible to do full hand recognition to increase the success rate.

There is a small group of people who are not able to present a fingerprint for scanning, which would require the operation of a secondary system to support their fare payment.

14.2.4 Eye scan: iris and retina

The human body has more biometric traits that allow for identification. Besides fingerprints, one could also use the irises or retina to recognize a person. This is, for example, already in use for some high-level security clearances, self-service border crossings at airports or by the United States Army.

Both the iris and the retina of an eye can be used for biometric identification. The iris is the coloured section around the pupil, whereas the retina is the light receptive area in the back of the eye. An iris scan takes less time, effort and detail than a retina scan, but also has a higher error rate.

Eye scanning currently requires people to keep their eye 5 centimetre (retina) to 50 centimetre (iris) in front of a camera. This transaction takes more time than the current smartcards, but an advance in technology could bring both the transaction time and required user attention down. There are already research projects that allow for medium-distance iris scanning.

Again, a small group of people is not able to participate in an eye scan.

14.2.5 Physical appearance

Another option is identifying people based on their physical appearance. Both facial recognition and general body recognition by cameras are possible at relatively large distances and have a relatively high throughput. The effectiveness of the recognition is influenced by the way people dress and age.

Facial recognition is already in use for identifying people with an outstanding restrain order in Rotterdam. Instead of using it to keep people out, it could be used to allow people in.

14.2.6 Behavioural recognition

People can also be identified by the way they move and behave. Measuring a person's gait by observing step length, step width, walking speed, cycle time, joint rotation, joint angles and limb angles generates a unique profile. This can be performed from large distances, but becomes harder in tight groups.

14.3 Data communication channels

Data transmission is required in a networked system to inform the separate parts of actions and this includes communication with the smartcard in the current implementation of the OV-chipkaart.

Data transmission media are classified in guided (solid medium; wires) and unguided (liquid medium; wireless). In general, guided media require less energy, have a higher bandwidth, a lower latency and a lower noise rate compared to unguided media. Unguided media offers flexibility in device location and requires less user action. Wired communication proved to require too much user attention in previous tests with fare payment systems and wireless communication improved to the point where it became feasible to complete the transactions within a reasonable time frame.

Currently, there are several wireless communication standards available: RFID, NFC, Bluetooth, Wi-Fi and various cellular ones. This paragraph describes the capabilities and applications of each.

14.3.1 RFID: Radio-frequency identification

RFID is used to perform low-energy low-bandwidth wireless data transfer over usually short distances without a required line of sight between the tag and reader. RFID communication can occur on low (125 or 134 Khz), high (13.56 Mhz) and ultra-high (865 to 915 Mhz) radio frequencies. With RFID, readers have significantly more computa-

tional and communication capacities than tags, making it possible to have cheaper and smaller tags.

Tags store data electronically, have an antenna and either use electromagnetic induction to operate (effective up to 30 centimetres) or run on batteries or other power sources (effective up to 100 meters). Tags are either activated and powered by reader inquiry (passive), activated by reader inquiry and powered by a connected source (assisted passive) or send information at will and powered by connected source (active). Tags data storage can be read-only or read-and-write. Information stored on tags can be encrypted to prevent access by unauthorised systems and tags can contain transmission encryption modules to prevent reader-tag communication interception.

The current OV-chipkaart smartcards contain a partially encrypted passive read-and-partial-write high frequency RFID tag, omitting the need for a connected power source and allowing for data exchange.

14.3.2 NFC: Near field communication

NFC is based on high frequency RFID with the purpose of short-distance (few centimetres) low-energy low-bandwidth automatic-pairing wireless two-way information exchange between systems, instead of data storage and retrieval. Since NFC is based on RFID, most NFC readers have the ability to read and write to high frequency RFID tags, provided the necessary access information is available.

In recent years, some manufactures of mobile consumer electronics have included NFC in their devices to enable easy set-up short-distance communication. Devices equipped with NFC can sense each other's presence, if close enough, and use that communication channel to set-up a higher bandwidth channel such as Bluetooth. NFC enabled smartphones could theoretically read and write to the existing OV-chipkaart smartcards, provided that the required access keys are available.

14.3.3 Bluetooth

Bluetooth is a medium-distance medium-energy medium-bandwidth manual-pairing wireless data communication standard. It can be used to set-up secure personal area networks in order to communicate among a group of devices. The protocol defines a master-slave structure, in which one device at a time is the master and determines the transmission and up-to seven other devices are the slaves and listens. Listening to multiple other devices requires more energy. Upon mutual agreement, the master-slave roles can reverse.

The power requirements and manual connection configuration make Bluetooth uninteresting for application in the ad-hoc many-devices low-power low-bandwidth context of electronic tickets.

14.3.4 Wi-Fi: Wireless Fidelity

Wi-Fi is a medium-distance high-energy high-bandwidth manual-pairing wireless data communication standard. It was developed to replace wired local area networks and often provides access to the internet. The power consumption of Wi-Fi equipment is large compared to Bluetooth and RFID, limiting its use in electronic ticketing use cases.

14.3.5 Cellular data

Cellular data is provided by several similarly operating communication standards between high-powered radio stations and medium-powered devices. Widespread examples of cellular data standards are GPRS (2.5G), EDGE (2.75G), UMTS (3G), CDMA (3G), HSPA (3.5G), and LTE (4G). These are high-bandwidth, large-distance and automatic-pairing and each provides progressively more bandwidth. While RFID, Bluetooth and Wi-Fi are often operated as auxiliary services, dedicated network operators often provide cellular data because it requires large capital investment in radio towers and cable networks.

14.3.6 Guided

Wired connections provide low-energy low-latency high-bandwidth communication for fixed-position equipment. Building wired networks requires more capital investment than wireless networks, but generally functions more reliably and predictably.

14.4 Information visualisation technologies

14.4.1 LCD: Liquid-crystal display

LCDs consist of liquid-crystals placed in formations with polarised light filters on both sides and optional colour filters on one side. The liquid-crystals are backlit and only allow these rays to pass through if the crystals align, which they do if an electric field is applied. The smaller the liquid-crystal formations, the more detailed the picture is the display can show. A combination of formations (‘pixels’) with red, green and blue colour filters allow a display to show millions of colours.

The liquid layer, light filters and backlight source can all be very thin, which allows for various product applications. Most televisions and computer displays use LCD technology nowadays.

14.4.2 E-paper: Electronic paper

Electronic paper uses either light reflective particles in a non-reflective oil, with electrodes on either side. Charging certain parts of the display with electricity attracts the particles and creates a light-reflecting area. Surrounding light will reflect on these particles in the display and this makes the image visible to the viewer. Because of the lack of backlight and the stationary behaviour of the particles, e-paper displays consume little energy and only require power to change the image. Once an image is displayed, it will stay visible till the particles are rearranged by applying electricity.

14.4.3 Head-up display

Most head-up displays use a liquid-crystal layer to form images. The backlight rays are reflected on a transparent medium in order to overlay this projected image on the field of vision of a person. Since the image is reflected and overlaid, it often needs to be high-contrast. The augmentation of the existing field of vision allows a person to take-in information from multiple sources at once.

14.5 Input

People operate computers by providing input. The input controls support the translation of human desires to computer commands: input ambiguity increases computer interpretation error rates. There are four main human-controlled input methods: hardware, speech recognition and visual recognition.

14.5.1 Hardware

By manipulating hardware, people can give highly specific commands. The most common form are mechanical-electric switches, but also RFID tags or touchscreens. The latter is often a combination between input and output device, allowing for a flexible and context specific control layout.

14.5.2 Speech

Spoken commands can be interpreted by a computer and mapped to known commands. This technology is under active development and has made great progress in recent years, but the interpretation ambiguity still results in high error rates or a fixed command set that needs to be memorised by the user. Speech commands are also indiscrete and can be an annoyance if other people are around.

14.5.3 Visual signals

Computers are also able to interpret visual images and analyse for signals. An example of inflexible visual signals are barcodes and an example of flexible visual signal interpretation is the Microsoft Kinect. As with speech interpretation, the ambiguity of visual signals still results in high error rates, though great progress has been made in recent years.

14.6 Energy

Electronic components need electricity to function and this can be provided by different sources. The main options are network linked, battery storage, induction and kinetic generation.

14.6.1 Network

Electronic equipment can be linked to an energy network that provides a constant and predictable flow of energy. This is the most reliable and predictable source of electricity for fixed-position equipment, but requires capital investment for building and maintaining the network.

14.6.2 Battery

Mobile equipment often relies on batteries to store electricity. These are electrochemical cells, which can be charged and discharged over time. Batteries come in almost all sizes and capacities. Some are one-time use, while others can be recharged. Their performance decays over time.

14.6.3 Induction

Inductive charging relies on an antenna picking up an electromagnetic field to generate an electric current. It is the basis for technologies such as radio-frequency identification. The transmission efficiency is low. The receiving hardware, however, can be miniaturised.

14.6.4 Kinetic

Motion energy can be converted to electric energy, though the efficiency is low and the hardware is currently too big. This combined makes that it has not been applied on a large scale in mobile devices yet. Electric cars, on the other hand, generate power from braking and this has proved moderately efficient.

Appendix B Participants concept evaluation study

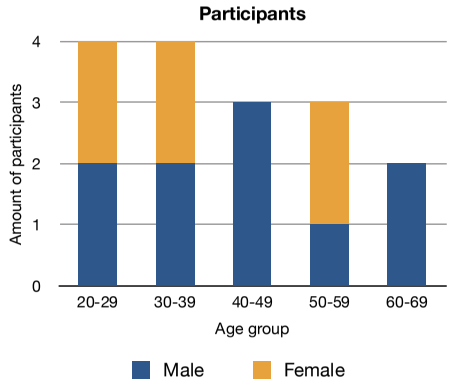
Participant selection criterion overview.

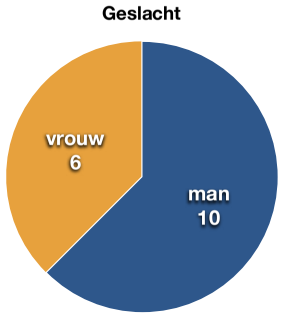
Criterion	Minimum number of participants
Extensive technology understanding	3
Limited technology understanding	3
Travels frequently	3
Travels infrequently	3
Uses one transport operator	3
Uses multiple transport operators	3
Good eyesight	3
Worsening eyesight	3
Male	3
Female	3
Under 35 years old	3
Over 50 years old	3

Participant	Video	Opnameduur	Geslacht	Woonplaats	Leeftijdcohort	Beroep	OV frequentie	OV-chipkaart sinds	Auto opwaarderen	Huidige OV-chipkaart	OV-betaling	OV modaliteit	Chipkaart gebruik	Leesbril	Tech affiniteit
1	MVI_3410	27:44	man	Rotterdam	30-39	Online strateeg	week	2 jaar	Ja	persoonlijk	Voordeeluren & saldo	trein, metro, tram, bus	prettig	niet	zelf
2	MVI_3411	37:26	man	Gouda	60-69	Gepensioneerd	week		Ja	persoonlijk	saldo	trein, metro, tram, bus	prettig	wel	zelf
3	MVI_3412	30:45	vrouw	Gouda	50-59	geen	maand		Nee	persoonlijk	saldo	trein, metro, tram, bus	prettig	niet	zelf + hulp
4	MVI_3413	43:25	man	Gouda	50-59	Directeur	dag			persoonlijk	abonnement	trein, metro, tram, bus	prettig	wel	zelf + hulp
5	MVI_3414	26:44	vrouw	Gouda	50-59	ZZP'er	week			persoonlijk	Voordeeluren & saldo	trein, metro, tram, bus	neutraal	wel	hulp
6	MVI_3415	29:12	man	Gouda	60-69	Gepensioneerd	week	3 jaar		persoonlijk	saldo	trein, metro, tram, bus	prettig	wel	zelf
7	MVI_3416	49:10	man	Delft	40-49	Social media consultant	week	In het begin voor €1		persoonlijk	saldo	trein, metro, tram, bus	prettig	niet	zelf
8	MVI_3417	37:13	vrouw	Amsterdam	30-39	Online strateeg	maand	2 jaar		anoniem & persoonlijk	Voordeeluren & saldo	trein	neutraal	niet	zelf + hulp
9	MVI_3418	31:07	man	Amsterdam	40-49	Communicatie adviseur	maand	2.5 jaar	Nee	persoonlijk	Voordeeluren & saldo	trein, metro, tram	prettig	niet	zelf
10	MVI_3419	35:11	vrouw	Haarlem	30-39	Online strateeg	dag			persoonlijk	saldo	metro, tram, bus, fiets	onprettig	niet	zelf
11	MVI_3420	29:41	man	Utrecht	20-29	Online strateeg	dag			persoonlijk	Voordeeluren & saldo	trein, bus	prettig	niet	zelf
12	MVI_3421	30:06	man	Amsterdam	30-39	Ondernemer	week	2 jaar	Nee	persoonlijk	Voordeeluren & saldo	trein, metro, tram, bus	neutraal tot prettig	niet	zelf + hulp
13	MVI_3422	45:31	vrouw	Den Haag	20-29	Ontwerper	week			persoonlijk	saldo	trein, tram, bus	prettig	niet	zelf
14	MVI_3423	32:57	vrouw	Den Haag	20-29	Ambtenaar	week			persoonlijk	abonnement	trein, metro, tram, bus	prettig	niet	zelf + hulp
15	MVI_3424	20:00	man	Delft	20-29	Rechten student	maand			persoonlijk	abonnement & saldo	trein, tram, bus	neutraal	niet	zelf
16	MVI_3425/6	29:19	man	Delft	40-49	Voorlichter	maand			niet	nvt	niet	neutraal	niet	zelf

Cohort	Man	Vrouw
20-29	2	2
30-39	2	2
40-49	3	0
50-59	1	2
60-69	2	0

Geslacht	Aantal
man	10
vrouw	6





Overview of interviewed experts (off the record).

Type of organisation	Number of interviewed experts	Province
Operator	3	Noord-Holland
Operator	2	Utrecht
Government	2	Zuid-Holland
Operator	2	Zuid-Holland
Consumer organisation	3	Utrecht
Technology supplier	3	Utrecht

Appendix C Script concept evaluation study

Device rotating order to mitigate learning effect.

Participant	Concept 1	Concept 2	Concept 3
1	Smartphone	Card 3	Key fob
2	Smartphone	Key fob	Card 10
3	Card 3	Smartphone	Key fob
4	Card 10	Key fob	Smartphone
5	Key fob	Smartphone	Card 3
6	Key fob	Card 10	Smartphone
7	Smartphone	Card 3	Key fob
8	Smartphone	Key fob	Card 10
9	Card 3	Smartphone	Key fob
10	Card 10	Key fob	Smartphone
11	Key fob	Smartphone	Card 3
12	Key fob	Card 10	Smartphone
13	Smartphone	Card 3	Key fob
14	Smartphone	Key fob	Card 10
15	Card 3	Smartphone	Key fob

Experience questions

- Since when do you have and use an OV-chipkaart?
- Do you pay with credit balance and/or use season tickets?
- How has your experience been so far?
- Have you experienced any problems?

Situations

- You just exited a bus and are not sure how much you paid for the trip. How do you solve this problem?

- You just exited a tram and are not sure whether you really checked-out. How do you solve this problem?
- You are waiting for the train on a platform and doubt whether you checked-in. How do you solve this problem?

Expert questions

- What would be the technology impact of a real time backend for your organisation? What would that cost? Is that something you are planning to build? How long would it take to implement that?
- What would be the technology impact of transferring more data from the validators to the card? What would that cost? Is that something you are planning to build? How long would it take to implement that?
- What would be the organisational impact of distributing keyring readers to people? How much would that cost? Is it something you would combine with other services and/or products?

Appendix D Questionnaire evaluation study

Productevaluatie

Mijn doel is om de OV-chipkaart te verbeteren voor reizigers en uw deelname aan deze productevaluatie draagt daaraan bij.

Enquête

Naam:

Geslacht: *man/vrouw*

Woonplaats:

Geboortejaar:

Beroep:

Ik gebruik het openbaar vervoer elke: *week/maand/halfjaar/jaar/nooit*.

Mijn OV-chipkaart is *anoniem/persoonlijk/heb ik niet.*

Met mijn een OV-chipkaart gebruik ik *reizen op saldo/abonnement*.

Mijn OV-chipkaart gebruik ik voor de *trein/metro/tram/bus/niet/*_____

Het gebruik van de OV-chipkaart vind ik *prettig/neutraal/onprettig*.

Een leesbril heb ik *wel/niet*.

Ik heb een *smartphone/gewone mobiele telefoon/geen mobiele telefoon.*

Nieuwe software of gadgets:

- *laat ik door iemand anders uitzoeken en uitleggen;*
- *probeer ik zelf uit te zoeken, maar ik haal vaak iemand met kennis erbij;*
- *zoek ik zelf uit*.

Toestemming gebruik beeld- en geluidsopname

Ik geef toestemming om van dit onderzoek beeld- en geluidsopname te maken ten bate van de analyse en presentatie van de resultaten aan derden.

Vrijwillige deelname

Ik begrijp dat deelname aan dit onderzoek vrijwillig is en ik op elk moment, zonder consequenties, kan besluiten om te pauzeren of stoppen.

Datum:

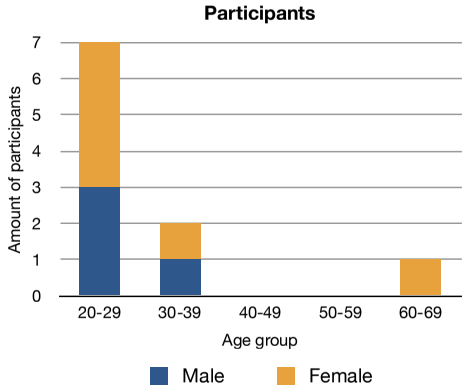
Handtekening:

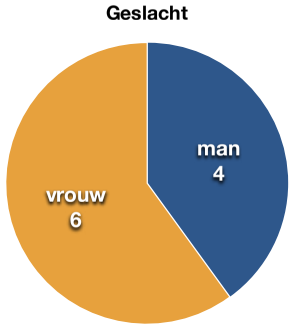
Appendix E Participants detail evaluation study

Participant	Video	Opnameduur	Geslacht	Woonplaats	Leeftijdcohort	Beroep	OV frequentie	Auto opwaarderen	Huidige OV-chipkaart	OV-betaling	OV modaliteit	Chipkaart gebruik	Leesbril	Tech affiniteit
1	MVI_3474	28:17	vrouw	Delft	20-29	Student	maand	ja	persoonlijk	saldo	trein, tram, bus	prettig	nee	zelf
2	MVI_3494	24:59	vrouw	Gouda	20-29	Pedagogisch medewerker	halfjaar	nee	persoonlijk	saldo	trein, metro, tram, bus	neutraal	nee	zelf
3	MVI_3495/6	21:33	vrouw	Nijmegen	20-29	Ergotherapeut	week	nee	persoonlijk	saldo + abonnement	trein, bus	prettig	nee	zelf + hulp
4	MVI_3497	27:09	man	Gouda	20-29	Programmeur	halfjaar	nee	persoonlijk	saldo	trein, bus	prettig	nee	zelf
5	MVI_3498	26:33	man	Leiden	20-29	Projectmedewerker	week	nee	anoniem + persoonlijk	abonnement	trein, tram, bus	prettig	nee	zelf + hulp
6	MVI_3499/3500	23:14	man	Delft	20-29	Student	week	nee	persoonlijk	saldo + abonnement	trein, tram, bus	neutraal	nee	hulp
7	MVI_3501/2	36:48	vrouw	Delft	60-69	Procesarchitect	maand	ja	persoonlijk	saldo + abonnement	trein, metro, tram, bus	neutraal	ja	zelf
8	MVI_3503	26:20	vrouw	Amsterdam	20-29	Ondernemer	week	nee	persoonlijk	saldo	trein, metro, tram, bus	neutraal	nee	zelf + hulp
9	MVI_3504/5	36:34	vrouw	Amsterdam	30-39	Ondernemer	maand	nee	anoniem	saldo	trein, metro, tram	prettig	nee	zelf
10	MVI_3506	20:01	man	Amsterdam	30-39	Journalist	maand	nee	persoonlijk	saldo	trein, metro, tram, bus	prettig	nee	zelf + hulp

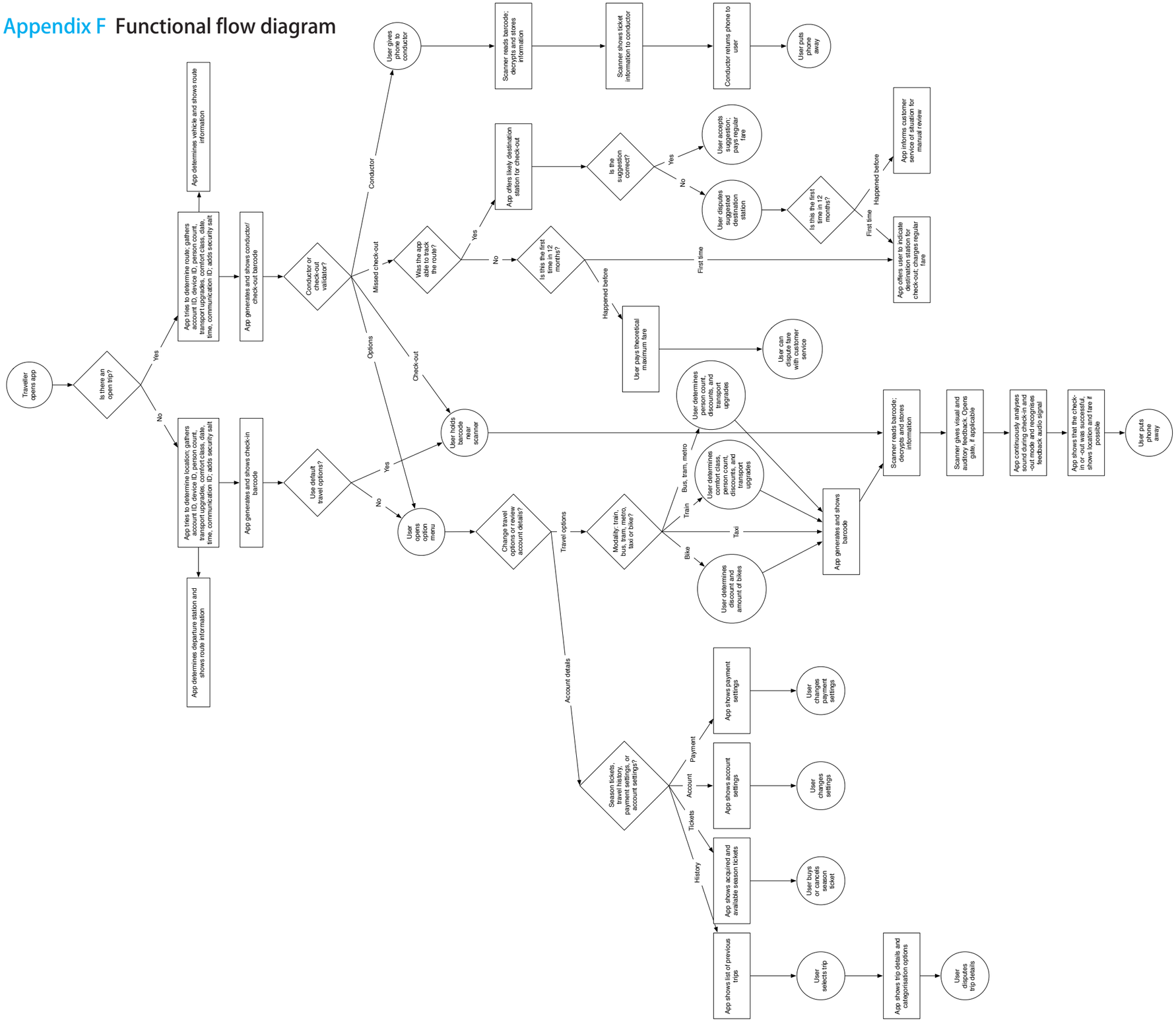
Cohort	Man	Vrouw
20-29	3	4
30-39	1	1
40-49	0	0
50-59	0	0
60-69	0	1

Geslacht	Aantal
man	4
vrouw	6





Appendix F Functional flow diagram



Appendix G Partial transcripts concept evaluations

Transcript 1

#00:04:48-9# Ik heb een aantal keren een losse gekocht omdat ik mijn kaart was vergeten. Dan koop ik een anonieme OV-chipkaart, ook omdat ik die dan weer eens uit kan lenen.

#00:06:04-1# Het [reizen met de OV-chipkaart] is prettig, nu ik het geregeld heb.

#00:06:28-9# Ik heb een kortingsabonnement erop gehad waarvan ik dacht dat het doorliep, maar het bleek voor één maand te zijn waardoor ik gewoon het volle tarief betaalde terwijl ik dat niet door had.

#00:06:42-2# Het is mij altijd onduidelijk. Je ziet een paar cijfertjes op het moment dat je uitcheckt, maar dan gaat het altijd heel snel: korting of niet, etc. Dan is het alweer verdwenen. Ik moet ook altijd snel weg.

#00:06:59-9# Nu het eenmaal geregeld is, is het handig in gebruik. Maar daarvoor was het dus lastig. Met de dingen die je moet activeren, afhalen, accounts aanvragen.

#00:07:25-8# Dat ik dan toch een kaart bij NS moest aanvragen, niet bij OV-chipkaart.nl. Maar wel bij OV-chipkaart moet registreren. Het is voor mij één grote chaos van onduidelijkheid geweest, maar nu heb ik het volgens mij geregeld. Het saldo wordt automatisch ge-updatet en de korting blijft erop zitten.

#00:09:23-6# Ik heb vergelijkbaar meegemaakt: dat ik niet weet of ik ben ingecheckt of niet, maar niet per se bij het uitstappen. Ik heb heel erg vaak dat ik niet weet of ik ben ingecheckt bij de trein. Op een gegeven moment wordt het wel een automatisme, maar dan weet je ook niet meer bewust of je bent ingecheckt. Dan loop je terug en dan zegt de paal dat je al ingecheckt bent als het kort geleden is. Als het lang geleden is, wordt je weer uitgecheckt en moet je opnieuw inchecken en twee minuten wachten. Dat is wel een paar gebeurd.

#00:10:46-4# Ik wil feedback van de apparaten die ik gebruik over de huidige status: ben ik ingecheckt, wat kostte de afgelopen reis, ben ik uitgecheckt, dat soort dingen? Dat schermpje wat je te zien krijgt verdwijnt weer of je denkt er niet aan. Als ik een sys-

teemverbetering moet bedenken dan zou het gaan om dat ik op mijn voorwaarden, met iets dat ik heb, live feedback krijg over wat mijn status is.

#00:11:57-1# Dit is een iPhone met een OV-chipkaart app. Ik verwacht dat ik inzicht krijg in mijn reisgedrag. Ik verwacht dat als ik hem open dat ik kan zien of ik ingecheckt ben of niet, wat de laatste reizen zijn geweest, de kosten die ik maak en eventueel mijn gegevens kan wijzigen.

#00:12:23-1# Ik zie mijn huidige locatie en mijn kaartnummer. "Ingecheckt bij NS op Rotterdam Centraal om 18.12 uur." Ik verwacht dat dit de laatste actie is die ik heb verricht. Daaronder het abonnement voordeeluren, het type account dat ik heb en de instellingen daarvan. "Instaptarief is 10 euro." Dan vermoed ik dat het instaptarief is van mijn laatste incheck, maar de eerste mededeling over wat nu het geval is en de tweede mededeling gaat over een algemeen kenmerk. Dat zijn verschillende informatiesoorten en daardoor weet ik niet of het instaptarief hoort bij de kaart of reis. Saldo is wel kenmerk van mijn huidige account en dan denk ik gelijk "oh jee, moet die niet automatisch aangevuld worden". En ik kan opwaarderen en mijn reisoverzicht.

#00:15:00-1# Bij een incheckpaaltje heb je niet de gelegenheid om informatie te raadplegen, je verricht altijd een actie. Dus het is hoogdrempelig om die te gebruiken, want de kans dat er iets gebeurt dat je niet wilt is redelijk groot.

#00:15:41-3# Je hebt altijd informatieachterstand, want je niet weet wat je huidige status is en hoe het systeem werkt in alle opzichten. Dus je hebt heel veel onzekerheden.

#00:16:18-0# Dit is een OV-chipkaart. En ik zie een informatievakje en een aan-knop. Dus ik verwacht dat dit een intelligente pas is die niet alleen informatie overdraagt aan het systeem, maar die dus inderdaad feedback geeft.

#00:17:23-3# Hij werkt op batterijen en je zet de kaart alleen aan en hij gaat vanzelf uit.

#00:18:22-3# Door de context weet je wat "ingecheckt" of "uitgecheckt" betekent.

#00:18:22-9# Het instaptarief is iets wat onder de motorkap zit. Het instaptarief is 20 en je hebt uiteindelijk een treinreis van 4 en dan is uiteindelijk maar 4 afgegaan. Het is iets waar ik dan toch van ga twijfelen; want hoe werkt het nou ook alweer. Ik weet het opzich wel, maar het zou onder de motorkap moeten gebeuren. Het is te abstract. Als je te weinig saldo hebt om te reizen en dat moet de incheckpaal zeggen. Ik hoef niet te weten wat het instaptarief is. Je betaalt voor een reis wat het kost en dat is het. Het instaptarief is iets wat de organisatie heeft ingebouwd, maar het is een principe wat alleen voor de organisatie relevant is en nooit interessant voor mij.

#00:20:52-2# Vorige rit verwijst naar de laatste voltooide rit waar je bent ingecheckt en uitgecheckt. Je wilt vaak weten wat een reis gekost heeft. Al interesseert het mij niet. Reizen met openbaar vervoer kost iets en het gaat mij niet om een euro meer of minder. Ik zie het ook nooit meer, maar ik zou het wel willen weten. Maar de afweging om met het openbaar vervoer te gaan is voor mij niet ingegeven door de kosten.

#00:23:15-1# Ik verwacht dat het een RFID device is die ik tegen mijn bestaande OV-chipkaart kan aanhouden zodat je zelf kunt inchecken. En je kunt je incheckstatus, saldo en vorige ritprijs kunt zien.

#00:24:40-6# Ik heb mijn sleutelbos in mijn tas zitten en mijn OV-chipkaart in mijn broekzak.

#00:25:52-2# Als ik automatisch opwaarderen aan hebt staan, dan wil ik niet eens geconfronteerd worden met mijn saldo want dan moet ik nadenken of ik moet opladen of niet.

#00:27:37-1# Als ik kan kiezen, dan wil ik de app. Ik gebruik mijn telefoon altijd en dat is de toegangspoort voor mij om persoonlijke informatie te vinden.

Transcript 2

#00:04:22-3# Het verlengen van het abonnement is ontzettend moeilijk. Je moet opnieuw het saldo ophalen, je moet weer opnieuw je producten ophalen. Waar ik mee opgehouden ben is de OV-fiets. Om het nu weer erop te krijgen lukt voor geen meter. Dat is hopeloos. Dan zeggen ze dat je de klantenservice moet bellen, maar dat helpt niet want die sturen je weer door en daar sturen ze je ook door. Dus kijk ik op internet en daar lukt het weer niet. Het voor mekaar krijgen is zo moeilijk, daar begin ik niet meer aan. Klaar.

#00:06:44-5# Het reizen met de kaart met openbaar vervoer is fantastisch.

#00:07:09-2# Ik gebruikte de boot van Terneuzen naar Vlissingen. Ook daar kun je gelukkig met OV-chip reizen. Daar kun je inchecken, maar ik kon niet uitchecken. Men zegt dat het systeem het zelf regelt. Het lastige is als ik in situaties kom die niet gebruikelijk zijn.

#00:08:17-9# Als het niet goed gaat, dan hoor ik hem wel piepen. Daarom heb ik hem ook volledig automatisch op saldo. Daar vertrouw ik op.

#00:08:34-0# Zodra ik bij andere vervoerders kom, wordt het lastig. Dan kan ik niet zien wat een reis kost en wat er af geschreven wordt. Dat kun je niet nagaan. Ik vind

het prettig als je dat direct tijdens de reis kunt zien. Bij de NS hebben ze schermen op de palen, maar ik heb een leesbril en die zijn heel lastig om te bekijken. Het scherm zit te laag en ik moet door mijn knieën en dan omhoog kijken. In de bus idem dito. Daar staat hij wel op schouderniveau, maar dat gaat zo snel dat ik het alsnog niet kan lezen. En bij het uitstappen moet je snel door, want er staan mensen achter je. Je wordt wel uitgestapt door de mensen achter je. Dan staan ze in je rug te hijgen. Ik ga af op het geluid van de NS, maar bij de andere vervoerders is het uitchecksignaal hetzelfde als het incheckgeluid. Wat nou een zone in een stad kost met de bus, kan ik niet zien.

#00:17:20-4# Het is wel gebeurt dat ik thuis kwam en dat ik twijfelde of ik uitgecheckt had. Toen ben ik teruggegaan naar het station. En ik had inderdaad niet uitgecheckt.

#00:20:22-2# Dat je de informatie op de kaart zelf ziet, vind ik makkelijker. Omdat ik moet lezen, is het makkelijker op de kaart. Die kan ik op de juiste hoogte kan brengen. Als ik een app gebruik en ik moet inchecken, dan weet ik al: dat gaat nooit goed bij mij. Dat is gewoon te lastig, verwacht ik. Zo'n kaart is ontzettend makkelijk, want die heeft de snelheid.

#00:22:20-1# Als je op de app kunt zien wat je doet met de kaart, zou het goed zijn. Dat zou makkelijker zijn dan het zien op de kaart, want de kaart zit in mijn portemonnee.

#00:24:35-7# Aan mijn sleutelbos zit één sleutelhanger en dat is eigenlijk al veel. Liefst zo min mogelijk. Voor mij is dat allemaal ballast.

#00:26:31-3# Als je de informatie in de app op de telefoon kunt zien, zou dat geweldig zijn. Het scherm op de kaart hoeft niet zo zeer als het op de telefoon te zien is.

#00:28:08-8# Voor mij is het belangrijkste om te weten of ik in- of uitgecheckt ben.

Transcript 3

#00:05:50-2# Ik ben wel, sinds ik de OV-chipkaar gebruik, doodsbang dat ik niet uitcheck. Ik heb een gewoonte ontwikkelt: de kaart zit altijd in mijn portemonnee, behalve als ik hem gebruik. Als ik ga inchecken haal ik hem uit mijn portemonnee en daarna stop ik hem in mijn broekzak tijdens de reis: dat is voor mij het teken dat ik nog niet heb uitgecheckt. Tot nu toe gaat dat goed, maar ik blijf doodsbang dat ik niet uitcheck. Ik ben ook weleens teruggegaan naar het station, omdat hij nog in mijn zak zat. Toen was ik al bijna thuis. Bleek uiteindelijk dat ik wel had uitgecheckt, maar vergeten was om hem in mijn portemonnee op te bergen.

#00:10:03-4# Ik heb me wel heel erg vaak afgevraagd of het uitchecken heeft gewerkt. Ik ben ook zo'n iemand die dan naar het schermpje gaat kijken of daar "Bedankt" of "Tot ziens" staat, of iets dergelijks.

#00:10:31-8# Bij overstappen was mij niet helemaal duidelijk wat ik moest doen. Of ik gewoon uit moest stappen: niet uitchecken en in een andere tram stappen. Dat heb ik niet gedaan de eerste keer toen ik dat gevoel had. Ik heb uitgecheckt en weer ingecheckt en toen stond er "Overstap, dankjewel". Oké, dan weet ik nu hoe het moet. Misschien was het wel uitgelegd hoor, maar dat was niet blijven hangen bij mij.

#00:13:59-5# Het saldo zien vind ik wel prettig, ook als ik automatisch opwaarderen aan heb staan. Dat geeft mij een beetje inzicht in hoeveel geld ik uitgeef. Want dat is verdwenen. Met het weggaan van het kopen van een kaartje heb ik geen direct benul meer wat een reis kost. Bij het uitchecken staat het wel op het scherm, maar dat is kort zichtbaar en onoverzichtelijk.

#00:16:41-6# Oh, de bovenste regel laat zien of ik ingecheckt ben of niet. Dat zou supertof zijn. Dat ik gewoon op mijn kaart kan kijken of ik in betaalmodus ben of niet. Dat zou mij heel veel geruststelling geven. Als ik weet of ik ingecheckt ben of niet zonder dat ik naar een apparaat hoef dan zou dat een behoorlijke meerwaarde zijn. Ik wil weten of ik ingecheckt ben, of ik veilig ben op het moment dat de conducteur langskomt met dat scanapparaat. Dan weet ik of ik moet gaan rennen of dat ik gewoon betaald heb. "Heb ik ingecheckt" flitst altijd door je hoofd als de conducteur langskomt. Ik heb nog nooit niet ingecheckt, maar elke keer als de conducteur komt schiet die angst door mijn hoofd.

#00:19:33-3# De term "vorige rit" vind ik verwarrend, want dat kan ook de voorlaatste rit zijn. Stel ik reis van Delft naar Utrecht en dan van Utrecht naar Amsterdam, dan zou ik bij "vorige rit" de Delft naar Utrecht reis verwachten. En de meest recente rit is die van Utrecht naar Amsterdam. En ik twijfel nu welke rit die weergeeft als ik over de Dam in Amsterdam loop. "Vorige rit" verwijst voor mij dan nog steeds naar Delft-Utrecht.

#00:20:50-3# Ik zou ook willen browsen tussen ritten. Ik heb de neiging om meer saldo informatie te willen zien. In de trein heb je ook niet veel te doen, dus dan zou ik dat wel willen zien.

#00:22:17-2# Ik ben wel meteen in de war doordat je vroeg of ik de kaart wilde aanzetten, want dat heb ik al gedaan volgens mij. Anders staat er niks op dat kaartje. Ik vind eigenlijk dat ik de kaart niet aan hoef te doen. Als ik incheck moet hij aan gaan.

#00:24:43-7# Dan verwacht ik dat in de app dezelfde informatie staat als op de kaart.

#00:25:20-9# Ik vind de combinatie van de app en de kaart met scherm wel prettig. Ik zou ze anders gebruiken. In de app kun je ook andere dingen stoppen. Lean en mean, maar wel functionaliteit zoals “waar is het station” of “waar kan ik de dichtstbijzijnde halte vinden”.

#00:26:52-5# Locatiegebaseerde korting en aanbiedingen via de OV-chipkaart vind ik intrusive. Rot op. Ik vind niet altijd korting interessant. Dit is zo’n grens waarvan ik denk “nee, dat voelt niet oké”.

#00:27:38-1# Ik vraag me wel gelijk af waar het kaartschermpje zijn energie vandaan krijgt. Moet ik hem opladen? Ik zou hem niet willen opladen.

#00:29:36-5# Als het bijvoorbeeld dat ik niet kan inchecken als ik niet heb opgeladen, dan zou ik dat vervelend vinden. Ik verwacht niet dat het zo is, want ik hoef de huidige OV-chipkaart ook niet op te laden en daar kan ik ook altijd mee inchecken. Dus dat kost geen energie kennelijk.

#00:29:58-4# Ik vind de meerwaarde van dat schermpje wel de moeite waard.

#00:31:23-4# Het is een sleutelhanger, gezien het kettinkje.

#00:31:43-1# Ik moet hem tegen de OV-chipkaart aanhouden, want dat staat erop. En het heeft hetzelfde nummer als op mijn OV-chipkaart staat. Blijkbaar is het dus een persoonlijk ding en hebben we vier van die dingen in huis die ik kan kwijtraken. Daar ben ik goed in, dingen kwijtraken. Behalve als het in mijn portemonnee zit trouwens. Wie weet, als ik hem tegen de kaart houdt gaat het schermpje aan. Of misschien kan ik ermee inchecken. Soort self-incheckapparaat. En uitchecken. Ik zou het een onding vinden. Die sleutelbos is altijd te groot. Er zitten nu twee ringen aan mijn sleutelbos om werk en thuis te scheiden, maar zelfs dat vind ik irritant.

#00:33:47-9# Wat zou ik doen met een sleutelhanger? Kwijtraken. Ik ga hem niet aan mijn sleutelbos hangen, dat vind ik verschrikkelijk. Dat is een no-go. Ding kan ook kapot enzo. Ga ik niet doen. Hij zou in de la eindigen van het kastje waar dingen van belang in liggen, maar die kunnen daar ook jaren kunnen liggen zonder dat ze eruit komen.

#00:34:47-6# [Houdt kaart tegen sleutelhanger] *Bliep* Blijkbaar heb ik inderdaad ingecheckt.

#00:35:03-7# Eerst zegt de sleutelhanger “doe iets met mij” en daarna geeft hij een status weer. Verwarrende conversatie. Ik zou willen dat hij op dezelfde manier praat. Hier zegt dat ding “doe jij eens wat met mij” en hier zegt hij “ik ben ingecheckt”. Als je

het gelijk zou willen hebben, zou hier moeten staan “je hebt ingecheckt”. Dan spreekt het weer naar mij toe.

#00:36:37-9# Mag ik vragen wat het instaptarief is eigenlijk? Ik weet niet wat dat is. Dat is het bedrag dat ik kwijt ben als ik vergeet uit te checken? Het voelt als een boete. “Jij stomme meneer, je hebt vergeten uit te checken, maar je krijgt van ons een boete van 10 euro.” En hier staat “instaptarief” en dan denk ik “het instappen kost meteen 10 euro!”. Zo voelt dat. Als daar borg zou staan, zou ik het al een stuk beter snappen. Dat heeft een andere lading. Dat moet een positieve benadering krijgen.

#00:37:44-3# Stel dat ik naar Rotterdam reis vanaf Delft, dat kost geen 10 euro. En dan denk ik “Euh, waarom? Dat kost geen 10 euro”. Dat kost 3, 2, 1 euro. Ik heb geen idee, maar geen 10 euro. Dan denk ik “stelletje boeven!” Wat je wilt zeggen met instaptarief is: “Welkom in de trein, als borgstelling voor deze reis leggen we een claim op het saldo van de kaart van 10 euro voor het geval dat je eventueel misschien niet uit hebt gecheckt”. Dan snap ik de conversatie, maar ben ik het nog steeds niet mee eens dat we, dat ze, het doen. Dan zou ik liever een stukje privacy opgeven omdat er een GPS dingetje in zit die automatisch ziet dat ik in Rotterdam ben uitgestapt. Liever dat, dan dat ze geld afschrijven. Ik ben niet zo heel erg gesteld op die privacy. Zou voor mij de moeite waard zijn. Kijk maar gewoon waar ik op de trein stap; waar ik instap en waar ik uitstap. Ik zou het inchecken wel willen doen, maar het uitchecken niet. Bij het inchecken geef ik aan dat ik weet dat het geld gaat kosten en dat ik bewust in de trein stap. Maar als je instapt, stap je ook uit en dat weet je dan wel. Als je in de gaten houdt dat ik naar Groningen reis en dan de omgeving van het station verlaat, check dan maar voor mij. Als je het inchecken niet meer zelf aangeeft, dan krijg je het gevoel dat het ding zomaar je gaat inchecken als je in de buurt bent van het station. Of als je op bezoek bent om iemand uit te zwaaien. Dan ben ik bang dat het systeem een foute beslissing neemt die me geld kost.

#00:42:20-7# Ik moet nadenken bij “prijs vorige rit”. Het is wel de enige logische conclusie, maar dat moet ik beredeneren. Wat mij betreft staat er dat het om de reis van Delft naar Utrecht ging. Dat vind ik waardevollere informatie dan het instaptarief.

#00:43:27-3# Het instaptarief is niet relevant om te weten, want dat ding zou of zelf moeten uitchecken of mij moeten triggeren om uit te checken. Het uitchecken is niet mijn probleem, dat is hun probleem. Het instaptarief voelt als een dreigement en dat voelt als het verplaatsen van het probleem. Het voelt alsof de bedrijven te lui zijn om het technisch op te lossen en dat de reiziger daarvoor moet betalen.

#00:45:01-0# De sleutelhanger werkt niet voor mij. Ik vind een dialoogvenster op de OV-chipkaart enorm waardevol. Ik zie wel een combinatie tussen de dialoog op de kaart en de app, waarbij de kaart alleen de essentiële informatie weergeeft en de app meer.

#00:45:53-6# Ik verwacht op de app wel dat ik hetzelfde kan doen als op de website van Mijn OV-chipkaart. Ik zou liever een app hebben dan een website. Voor een website moet ik achter een computer kruipen en daar heb ik geen zin in. Ik wil gewoon alles op mijn mobiel kunnen doen. De website is ook altijd achteraf. Als ik bijvoorbeeld mijn declaraties ga doen, dan is dat één keer in de zoveel tijd. Als ik die app heb kan ik tijdens de reis al aangeven dat dit een reis is die ik voor die redenen doe. Categoriseer hem zo dat ik op het moment dat ik ga declareren alleen maar op een knopje hoef te drukken. Dan hoef ik maar beperkt achter die computer te kruipen. Dat zou ik prettig vinden als het gelijk in categorieën staat.

#00:47:25-0# Dus een combinatie wat mij betreft van de kaart met display en de app.

Transcript 4

#00:05:30-5# Ik kocht een anonieme kaart, omdat ik het uit wilde proberen. Toen ging ik van Amsterdam Centraal naar Amsterdam Arena en toen moest ik er gelijk 20 euro op zetten terwijl die rit 2 euro kost. Dat vond ik vervelend, want ik weet al dat ik die kaart ergens in stop en dan weer vergeet. Vooral door de manier waarop je hem gebruikt, want je kunt hem niet in je portemonnee laten zitten zoals met je bankpas. Als je dus door de poortjes gaat, moet je de kaart uit je portemonnee vissen. En als je op het station bent, wil je de portemonnee niet in je zak stoppen, dus die zit ergens helemaal onderin je tas. En je hebt al haast en het is al chaos. Dus de volgende keer stop ik de OV-chipkaart maar in m'n jaszak, maar dan neem ik later een andere jas mee en dan heb ik geen OV-chipkaart bij me. En daarom had ik er op een gegeven moment vijf.

#00:06:36-5# Ik stop de OV-chipkaart niet in mijn portemonnee, want die wil ik het liefst veilig opgeborgen hebben—mijn iPhone is al een keer gestolen op Amsterdam Centraal. De kaart wil je binnen handbereik hebben, maar het gevolg daarvan is dat je hem makkelijk laat zitten in kledingstukken.

#00:08:10-5# Je staat met tien man bij zo'n paaltje en die willen allemaal uitchecken, dus je hebt ook geen idee van hoeveel geld er is afgeschreven. Op zo'n moment mis je een duidelijk koppeling met de resultaten: wat het gekost heeft en of je wel bent uitgecheckt. Dat is verwarrend. Als je alleen bij zo'n paal staat is het helder, maar als je met meer mensen er langs loopt gaat het zo snel dat je niet kunt zien wat jij gedaan hebt.

#00:10:16-8# Ik zet altijd zelf saldo op mijn kaart. Ik heb daar een ambivalente houding tegenover. Aan de ene kant vind ik het heel handig dat je automatisch kunt opladen en vind ik het irritant dat als ik bij een paal sta en hij zegt dat ik moet gaan opladen. Voor mijn gevoel staat er altijd te weinig saldo op. Automatisch opwaarderen zou een oplossing zijn, maar dat vind ik niet prettig omdat je niet weet wat wanneer van je rekening wordt afgeschreven en daar houd ik het liefst wel controle over.

#00:11:30-6# Met kaartjes weet je gewoon precies hoeveel het gekost heeft, terwijl met zo'n OV-chipkaart heb ik nooit overzicht over hoeveel een treinkaartje kost. Als je instapt weet je dus niet hoeveel een treinrit kost en als je uitstapt ben je met andere dingen bezig. Als je een product of dienst koopt, bedenk je van tevoren hoeveel het kost en geef je dat uit. Terwijl het heel gek is om eerst te gaan en later af te rekenen. Als ik eenmaal aankom op het station ben ik veel meer bezig met waar ik vervolgens naartoe ga. Dan kijk je wel naar de uitcheckpaal en als het heel gek is zal het ook wel opvallen, maar op dat moment heb ik meer aandacht voor andere dingen. Ik heb ook geen zin om de hele tijd bezig te zijn met de OV-chipkaart. Het moet gewoon kloppen. Ik moet niet de hele tijd denken "oh, klopt het wel, klopt het niet?" Maar ik ga er niet standaard vanuit dat het klopt. Ik denk dat ik vaak vergeten ben uit te checken, dat het mis ging en dat er teveel afgeschreven werd. Dat baseer ik niet op objectieve observaties, maar meer dat ik ook weet dat ik chaotisch ben met "ben ik nu ingecheckt of uitgecheckt?" of "moest ik hier nou overstappen?" Dan haal ik hem nog maar een keer langs dat paaltje en ik zie wel wat er gebeurt. Als de conducteur dan komt, dan zeg ik gewoon "ik heb wel iets gedaan, maar of het klopt, dat weet ik niet". En meestal zijn zij ook wel aardig vergevingsgezind. Als ik niet goed heb ingecheckt, kom ik er wel mee weg.

#00:15:03-9# Vrij in het begin is het wel fout gegaan. Toen ik net was afgestudeerd kreeg ik een OV-chipkaart waarmee je een jaar lang met 40% korting kon reizen. Dat kreeg je, maar die moest je wel nog eerst activeren. Dat wist ik natuurlijk niet, ik heb de brief die daarbij zat natuurlijk niet gelezen. Toen zei de conducteur dat ik niet zo handig had gedaan, maar ik was al de tiende die hij tegenkwam. Na die reis heb ik hem wel geactiveerd.

#00:16:14-6# Ja, ik heb weleens gehad dat ik thuis kwam en niet zeker was of ik was uitgecheckt. Dan doe ik daar niks mee. Wat moet je op zo'n moment doen? Volgens mij kun je dan alleen iets doen als je een persoonlijke kaart hebt. Dat heb ik weleens gelezen, dan kun je dat uitzoeken. Maar ja, voor 5 euro ga ik dat niet uitzoeken.

#00:17:02-5# Ik kan me voorstellen dat als je regelmatig reist, dat het een automatisme is waarbij je weet hoeveel een treinreis kost en waar je elke dag dezelfde hande-

ling doet. Dan valt het ook precies op als iets anders is. Maar ik reis soms één keer in de week en soms een halfjaar niet met de trein en ik reis altijd naar andere bestemming, dus ik weet niet exact wat een kaartje naar Utrecht of Den Bosch of weet ik veel kost. En ik weet ook niet hoe het precies werkt. Ik moet ook altijd even zoeken naar hoe of wat. Als het echt iets is wat je dagelijks doet, dan denk ik dat je beter overzicht hebt.

#00:18:34-4# Ja, het is een model van de iPhone. En er zit een icoon van een app van de OV-chipkaart op. Super handig. Die wil ik ook. Ik hoop dat die gekoppeld is aan een kaart en dat ik dan gelijk kan zien hoeveel mijn treinreis gekost heeft.

#00:20:19-2# Ik denk dat ik deze sleutelhanger tegen mijn kaart moet houden en dan synchroniseert hij data die op mijn kaart staat. Misschien dat er een GPS dingetje in zit die aangeeft waar ik ben. Misschien is het de koppeling tussen de kaart en de smartphone app.

#00:22:22-1# Mijn eerste ingeving is dat het een digitale OV-chipkaart is die hetzelfde weergeeft als de sleutelhanger, maar ik denk niet dat ze die zomaar gaan uitgeven. Er komen wel steeds dunnere en flexibelere beeldschermen, dus het is wel vet als de kaart actueel wordt. Is natuurlijk wel veel te duur om aan al die reizigers te geven.

#00:24:20-3# Ik wil zeker de kaart met display hebben. Het formaat is handig. En de sleutelhanger maak ik vast stuk als die aan mijn sleutelbos zit. Sowieso zou ik een dunne kaart mooi vinden, maar het blijft wel dat je hem goed op moet bergen. Dat gedoe heb je niet met een sleutelhanger. Een sleutelhanger raak je minder snel kwijt en hoef je minder ver weg te stoppen. Maar ik vind de kaart met scherm mooier.

#00:27:08-2# Het liefst heb ik al deze kaart en sleutelhanger shit helemaal niet en wil ik gewoon dat alles op mijn telefoon gebeurt. Het liefst heb ik gewoon dat mijn telefoon weet waar ik ben en dat ik op mijn telefoon kan inchecken; dat ze via mijn GPS zien dat ik uit het openbaar vervoer ben en dat er dan zo wordt afgerekend. Dat alles in mijn telefoon staat. Want de kaarten en sleutelhangers zijn allemaal clutter. Die zijn leuk en aardig, maar ik zou toch denken dat je die op een gegeven moment allemaal niet meer nodig hebt. Het liefst heb ik dat ik gewoon de trein in- en uitstap en dat mijn telefoon automatisch afrekent. En als het niet anders kan, dan wil ik ook best zelf op mijn telefoon inchecken. Dat is één druk op de knop. Als ik op het station, ik open die app en ik zeg “check-in”. Dan heb je zelf ook controle. In eerste instantie denk ik “dat moet zo makkelijk mogelijk”, maar als ik erover nadenk vind ik het wel prettig als je zelf controle hebt over in- en uitchecken en aangeven waar je bent. Dan vind ik het wel prettig om een moment in te bouwen waarop je zegt “ik ben er nu”. Ik wil niet dat als ik op een willekeurige station loop dat de NS weet waar ik ben. Iedereen weet dat je voor de trein moet

betalen, dus dan heb je een moment om te zeggen “nu ga ik met trein”. Dat uitchecken hoeft dan voor mij niet per se. Het probleem is dat je uitchecken weer vergeet als er geen poortjes zijn. Er zijn niet voor niets die poortjes die *bam* voor je neus dichtgaan.

#00:31:17-4# In eerste instantie, als je kijkt wat je nu hebt: deze OV-chipkaart waarbij je geen idee hebt hoeveel ik per rit betaal, wat er afgeschreven wordt en wanneer ik moet opladen. Dat ik ook thuis niet kan zien “oh ja, er staat nog 5 euro op, ik moet hem even opwaarderen”. Op het moment dat ik nu op het station kom en in wil checken, denk ik “oh shit, staat er weer geen geld op, ik heb haast, moet de trein halen”. Dan moet ik weer naar de kaartmachine om hem op te laden. Dus als ik nou thuis in mijn app kan checken hoeveel saldo erop staat, als ik hem thuis alvast kan opwaarderen bijvoorbeeld. Dat lijkt me al heel handig, dan hoef ik dat op het station niet te doen. En ook een overzicht van mijn reizen en declareren via de applicatie. Dat lijkt mij heel handig. Dat lijkt me al een megavooruitgang die volgens mij ook niet heel ingewikkeld is. Nou ja, misschien voor vervoerders wel. Maar het zijn de functionaliteiten die ik eigenlijk verwacht, die ik eigenlijk nu al verwacht had. Dat zijn dingen die ik vind dat je moet aanbieden als je van mij vraagt om met een OV-chipkaart te reizen. En als je verder gaat naar een kaart met display of sleutelhanger, dan vind ik dat interessant, maar de app lijkt mij de eerste stap.

#00:36:08-0# Die techniek met transacties... Banken kunnen dat toch ook live? Als ik nu PIN, dan staat dat gelijk in mijn Rabobank app, dus dat kan wel. Het is niet dat het onmogelijk is, omdat de techniek nog niet zo ver is. Het is gewoon dat de techniek bij de vervoerders niet zo ver is, toch?

Transcript 5

#00:05:11-8# Na een keer of 2, 3 vergeten uit te checken, maak ik die fout ook niet meer. Bij de tram heb ik het uitchecken aangeleerd. Bij de trein loop je eerst door de hal en wil ik het nog weleens vergeten, maar dan kom je bij de poortjes en denk ik “oh ja”.

#00:06:52-4# Het is meerdere keren voorgekomen dat ik door de poortjes van de GVB ben gelopen in plaats van de NS of andersom op station Amsterdam Arena.

#00:07:05-1# Bestaat automatisch opwaarderen? Daar maak ik geen gebruik van. Ik zet er nu telkens zelf geld, een vast bedrag van 50 of 100 euro. Dat automatisch opwaarderen ga ik zeker doen, want nu zegt het apparaat dat ik onvoldoende saldo heb. Soms denk ik na 8 of 10 reizen “het zal zo stilaan wel nodig zijn” en dan ga ik uit mezelf. Je bent op reis dus je wilt de tijd niet verliezen, dus het moment dat het apparaat vertelt

dat je te weinig saldo hebt probeer je te voorkomen. Je probeert het voor te zijn. Je probeert er zelf aan te denken.

#00:08:40-5# Ja, het komt voor dat ik de tram uitstap en me dan afvraag of ik wel heb uitgecheckt. Omdat ik dan niet geregistreerd heb of het piepje nou van mij was of van een ander. Of dat ik niet bewust het tekstje "goede reis" heb gezien. En dan denk "shit, nu weet ik het niet zeker". En dan doe ik niks. Ik vraag dat geld ook niet terug. Ik houd mijn reizen ook niet bij.

#00:09:36-9# Ik heb een keer gehad op Schiphol dat ik al door de douane was en dacht "kut, daar gaat 10 euro". Toen kon ik niet meer terug. Een andere keer op Schiphol ben ik wel teruggegaan. Ik had nog tijd, maar daar had ik achteraf spijt van want het is een flink stuk lopen van de incheckbalie naar het perron. Schiphol heeft dus geen poortjes, maar alleen paaltjes die op het perron tussen allerlei andere dingen staan. En daar ben je ook veel minder bewust van het uitchecken.

#00:12:06-2# Dit is een OV-chipkaart met een display waarop ik kan zien of ik ingecheckt ben, wat mijn saldo is, welk abonnement ik heb en waar ik ben ingecheckt.

#00:13:41-3# Ik zie hier de incheck, maar daar heb ik niet zoveel aan, ik zou dan de afgelegde route willen zien.

#00:15:48-6# In de app staat ook nog het kaartnummer. Als gebruiker heb ik daar niks aan, dus dat is voor mij het signaal dat ik de app ook aan de conducteur kan laten zien.

#00:17:10-5# De sleutelhanger is ter vervanging van de OV-chipkaart, maar hoort denk ik wel bij de app.

#00:17:38-9# De app is sowieso een goed idee. Online check ik niet wat mijn reizen waar en ik vraag mijn geld niet terug als ik vergeet uit te checken, als dat in een app zit dan doe ik dat wel. Die telefoon gebruik ik de hele dag, terwijl voor die website moet ik achter mijn computer zitten en inloggen met een wachtwoord dat ik altijd vergeet. Allemaal handelingen die veel vanzelfsprekender zijn op de telefoon. Ik check m'n Twitter, check-in op Foursquare en ga gelijk even kijken hoe het met mijn OV-chip is. Je zou kunnen inchecken met de telefoon, maar de app kan ook prima alleen die informatie geven.

#00:19:38-7# Een kaartje met een display, dat is toch vet! Ik vind het tof. Sexy. Next level shit.

#00:19:51-2# De app moet sowieso. Ik wil op mijn telefoon bij mijn OV-chipkaart kunnen. Dat is een basisvoorwaarde. Heel logisch en wenselijk. Liefst ook zonder dat ik de

kaart uit mijn portemonnee hoef te halen en bij mijn telefoon moet te houden. Betalen met mijn telefoon hoeft niet per se, ik zou het wel tof vinden.

#00:20:14-0# Ik snap de toegevoegde waarde van de sleutelhanger niet goed. Als die aan kan lezen, dan doet het wat de app doet en dan heeft sowieso de telefoon mijn voorkeur. Eerst mijn kaart bij de incheckpaal houden en dan mijn kaart bij de sleutelhanger houden vind ik raar. Wanneer doe ik dat?

#00:21:03-2# De kaart met display vind ik beter dan de app, maar met alleen de app zou ik ook tevreden zijn. Dat lijkt me al fijn.

#00:21:20-3# Als ik zou kunnen inchecken met de sleutelhanger, zou ik dat fijn vinden. Dan zou ik hem aan mijn sleutelbos doen.

#00:22:34-9# Voor me zelf zou ik de telefoon fijner vinden dan de kaart met scherm. Mijn telefoon gebruik ik altijd, maar mijn kaart zit in mijn portemonnee. Die heb ik dan vaak in mijn tas zitten, want anders zit je in de trein op zo'n bult en dat wil ik niet. Dan moet ik de kaart uit mijn tas halen, portemonnee openen en de kaart eruit halen. Ik moet waarschijnlijk eerst mijn telefoon wegstoppen om mijn portemonnee te kunnen pakken, want die heb ik altijd vast. Mijn telefoon heb ik sowieso in de buurt en mijn portemonnee heb ik veilig opgeborgen.

#00:25:11-2# Ik kan me voorstellen dat je ook de dienstregeling op de kaart laat zien. En andere praktische informatie.

#00:25:25-7# Als de conducteur de coupé binnenkomt twijfel ik altijd of ik wel ingecheckt heb. Altijd de gedachte "het is gewoon goed, kan niet anders, toch?" Dan is er even spanning.

#00:27:10-4# De kaart voelt toch als een soort tussenvorm van papieren kaartje naar telefoon.

#00:28:41-1# Met bankierapps werkt het ook.

Transcript 6

#00:03:01-6# Ik heb een OV-chipkaart sinds die ingevoerd werd... 2 jaar geleden? Ik heb er inmiddels wel veel gehad al. Ik raak hem nog al eens kwijt. Ik heb nog steeds niet echt een goeie routine. Ik heb mezelf nog steeds niet aangeleerd dat nadat ik hem uit mijn portemonnee haal en bliep ook weer terug in mijn portemonnee stop. Ik vergeet het nogal eens en dan zwerft ie door mijn jas of broekzak en dan ben ik hem kwijt en verlies ik hem. Misschien wel vier of vijf keer. Ik probeer nu heel gedisciplineerd de

kaart elke keer terug in mijn portemonnee te doen. Ik probeerde eerst om hem in mijn portemonnee te laten, maar dan werkt ie niet om één of andere reden. Hij moet eruit. Dat is ook weer kut, want dan loop je met je portemonnee open op het station en daar heb ik helemaal geen zin in.

#00:04:33-8# Ik vind het op zich een makkelijk systeem, omdat je hoeft geen kaartje meer hoeft te kopen enzo. Dat kostte altijd tijd en is best wel irritant. Ik ben nogal van de klok, dus dat zijn meestal de minuten die ik net nodig heb om de trein te halen. Ik vind het wel bloedirritant als ik vergeet uit te checken, dat is dan mijn eigen schuld, dat vind ik gewoon zelf dom. Maar wat ik echt kut vind, is als ik op een station ben en de paaltjes op een heel onlogische plek staan en dat gebeurt me echt net iets te vaak. Dan moet ik echt zoeken naar waar ik moet uitchecken. Die logica zit er nog niet helemaal in.

#00:06:00-3# OV-chipkaart is een aardig systeem, maar tegelijkertijd denk ik ook: "kan dat niet handiger dan een kaartje, kan dat niet met een smartphone." Een kaartje is toch een beetje achterhaald.

#00:06:16-2# Nee, ik maak geen gebruik van automatisch opwaarderen. Dat is nog weleens irritant, want je komt er pas achter als je wilt inchecken. Dan staat er "saldo te laag, aub opladen" en dan moet je alsnog naar de automaat, maar ik vind het prettig om er controle over te houden en hoeveel ik daaraan uitgeef. Het voelt prettiger alsnog om eens in de zoveel tijd er geld op te zetten dan dat ik het automatisch laat doen. Dan ben ik bewust van wat ik uitgeef aan openbaar vervoer. Dat valt heel erg weg omdat je gewoon bliept, daar worden het anonieme bedragen van. Terwijl als ik een kaartje koop, dan voelt het als een directe transactie. Maar misschien moet ik gewoon maar eens proberen.

#00:07:28-1# Wat ik echt heel kut vind aan die OV-chipkaart, is hoe ingewikkeld het is om producten erop te laden. Variërend van OV-fiets tot voordeelurenkaart. En ik ben er nog steeds niet achter dat ik niet meer kan kiezen dat ik soms eerste klas kan reizen. Ik wil soms eerste klas zitten. Volgens mij moet je dan een toeslag kopen bij de kaartjesautomaat, maar ik heb het nog niet gevonden hoe dat precies werkt. Dat vind ik echt bloedirritant. Dus reis ik tweede klas. En het hele systeem van een product online bestellen en dan afhalen bij de kaartjesautomaat, dat is gewoon gedoe. Daar word ik altijd een beetje iebelig van. Dat is ook weleens fout gegaan. Het wordt helemaal klote op het moment dat je je OV-chipkaart verliest. Dan ben je namelijk ook al je producten weer kwijt. De laatste keer hebben ze volgens mij wel alles over kunnen zetten op mijn nieuwe kaart, behalve dan weer OV-fiets. Want die moet je dan weer koppelen aan het nummer van je kaart en daar moet je allerlei aparte handelingen voor verrichten. Dat

is gewoon gedoe en dat hoeft geen gedoe te zijn. Ik moet gewoon niet allerlei handelingen hoeven verrichten om het product waar ik voor betaald heb ook in werking te zien treden. Daar heb ik een hekel aan. Het hoeft volgens mij ook niet.

#00:09:23-2# Ik had verwacht dat het OV-fiets abonnement overgezet zou worden van mijn oude naar mijn nieuwe kaart, maar dat was niet gebeurt, dus kon ik geen fiets huren. Dat was best irritant, want toen moest ik alsnog met de bus en was ik bijna te laat bij een afspraak.

#00:10:09-1# Bij de tram twijfel ik niet of ik uitgecheckt hebt, omdat het apparaat bij de uitgang hangt en je wordt dus altijd geconfronteerd dat je daar iets mee moet. En tramritjes zijn meestal korter, dus dan blijf ik met mijn kaart in mijn hand zitten. Maar als ik het treinstation uitloop twijfel ik vaak wel of ik uitgecheckt heb. Dan moet ik goed nadenken of ik het wel gedaan heb. Het is ook voorgekomen dat ik dacht dat ik het niet had uitgecheckt, maar dat ik het wel had gedaan en toen checkte ik weer in toen ik terugging. Dan moet je weer een minuut wachten bij de paal voordat je mag uitchecken.

#00:11:20-8# Het is ook wel voorgekomen dat ik op het perron stond en dat ik twijfelde of ik ingecheckt was. Meestal weet ik dan wel gelijk dat ik het niet gedaan hebt en dan moet ik terug. Als ik mijn kaart niet uit mijn portemonnee gehaald heb, dan heb ik meestal niet ingecheckt.

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