Networked Visibility: The case of smart card ticket information

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***Abstract*—This paper concerns the replacement of paper tickets with smart card tickets for public transportation. By contrasting the visibility of ticket information to users of paper tickets and smart card tickets, this paper describes the move from local information on paper tickets to distributed information on smart cards. Using the concept of 'networked visibility', this paper argues that this move has resulted in less informed travelers and more informed providers. In order to restore the accessibility of ticket information to users, we present one possible solution, ARTick, a mobile phone smart card reader app. ARTick shows that smart cards can make complete ticket information visible to the user, whenever and wherever this information is needed.**

Keywords*—*Information Visibility; Networked Visibility, Smart Cards; Ticket Information; Mobile Phones

I. INTRODUCTION

A major research and development area for human-computer interaction (HCI) over the last years has been to explore ways of interaction that emerge by embedding computing and networking technology in the everyday physical world in which we live. This development goes by many names such as tangible interaction [6], ubiquitous computing [5] and embodied interaction [3]. Examples of this development are pen and paper with embedded computing technologies and transportation tickets with embedded computer chips with networking capabilities.

When computing and network technologies are embedded in everyday objects, there are many ways *"to capitalize on our familiarity, skill and experience in dealing with the everyday world around us"* writes Dourish [2]. New values, new possibilities, but also new concerns may emerge from interaction between these familiar objects with and without embedded technology.

This paper reports from a case in which paper-based tickets for public transportation are replaced by so-called *contactless smart cards*. A smart card is a credit card size plastic card containing a microchip with antenna for contactless communication with a card reader; see Fig. 1 for the card and Fig. 2 for readers. The computerized and networked smart card can hold different kinds of information: ticket information, monetary information (the amount of money put on the card), but also other information such as the ticket for a football match or the annual subscription to a museum.

Our focus is on the visibility of information that is needed to use the smart card as a valid transportation ticket.

Figure 1. A smart card used in public transportation in Norway.

Figure 2. Smart card readers.

We identified three basic ticket information needs of public transportation users: the type of the ticket, the value of the ticket, and the duration of the ticket. There are other ticket information needs, such as the price of one trip, an overview or log of implemented trips, an overview of past travel expenses, etc., but they don't add significantly to our argument.

In design of information systems and usability studies, the visibility of information is related to the visibility of a system's status. Being informed about a system's status is one of the ways in which users receive feedback on a system's use or performance. Studies of the visibility of information on smart cards have been implemented in several sectors, such as supply chain management, the automotive industry, and the healthcare sector [1, 10, 11, 12]. We are not aware of visibility studies of ticketing systems in the public transportation sector although some other interesting and related issues have been reported in [7, 8, 9]. Morgner *et al.'s* proposal [9] is of particular interest to

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us, as the authors propose similar technologies in their design solution.

The rest of this paper is organized as follows: in the next section we present our case, the move from a paper-based ticket to a computerized ticket. In Section III we report on a small explorative study among randomly selected inhabitants of Oslo, conducted in order to get an indication if the visibility of smart card information influences users experience with the new system. In Section IV, we will use the concept of networked visibility, first introduced by Stalder [14], to discuss horizontal and vertical visibility of ticket information. In Section V we present ARTick as one possible solution for the visualization of smart card-based ticket information. In the last section, we present our conclusions and future work.

II. FROM PAPER TICKETS TO SMART CARD TICKETS

Moving from paper-based practices [13] or desktop-based practices to practices where computing and communications technologies are embedded into everyday objects poses many challenges. Dourish [2] states: "*In this world, our primary experience of computation is not with a traditional desktop computer, but rather with a range of computationally-enhanced devices, pieces of paper, pens, walls, books, hammers etc*." Rust and Kannan [12] consider this ubiquitous computation to be a fantastic opportunity to enhance customer experiences. In the case of smart cards, all sort of information may be stored and used by service provider(s) in order to offer better one-to-one services. We discuss how such embedded technology often offers much wider opportunities to providers than to customers.

A. The visibility of information

In our study of the smart card we focus on the visibility of public transportation ticket information. Our case is the 'Reisekortet', the smart card ticket used in the public transportation system in Oslo, Norway. The system was first introduced in 2009, replacing the paper ticketing entirely.

We are interested in the following questions: How are users of paper tickets able to find answers to their three basic ticket information needs: type of the ticket, value of the ticket and duration of the ticket (see Table 1) and how has this changed with the introduction of the smart card ticket?

We will answer this question by looking into three actions the users engage in: purchasing the new ticket, using a valid ticket and having an expired ticket.

B. Purchasing a ticket

When a ticket is purchased, the three pieces of basic information (type of the ticket, value of the ticket and duration of the ticket) are given by the user to a sales person or are selected by the user on a vending machine or on the public transportation website. In addition, public transportation users have also the choice between a registered and an unregistered ticket. 'Registered' means that the name and date of birth of the user is registered with the public transportation provider. 'Unregistered' means that the user is anonymous and that the age of the user is unknown. All information given/selected by the user is registered on the ticket.

TABLE I. BASIC TICKET INFORMATION NEEDS USERS OF PUBLIC TRANSPORTATION HAVE

Type of ticket The type of the ticket refers to the different kinds of tickets available. We can differentiate between types of tickets based on the number of trips and types of tickets based on the particular period they cover independent of the number of trips (day, week, month, and year). Other types are registered or unregistered (anonymous) tickets, and regular and discount tickets. • A popular paper ticket was the unregistered 8 trip-ticket, the so-called *flexi card*, which was available as a regular ticket and a discount ticket. The flexi card could be used by more than one traveler at the same time. There is no smart card variation of this ticket. • A popular smart card ticket is the prepaid card, which can be topped up when needed. This ticket can only be used by one traveler at the time. There is no paper variation of this ticket.
Value of ticket The type of ticket decides the monetary value of the ticket. In the case of the pre-paid fill-up ticket, the value of the ticket depends on how much money the user has put on the ticket. The monetary value of all tickets diminishes with use. A ticket has zero value when the duration of the ticket has expired or when the monetary value is below the price of a ticket. In the case of prepaid cards, any amount less than the value of a single ticket may be left on the card. Paper tickets did not have this characteristic.
Duration of ticket The duration of the ticket is decided by the date and time stamp of a ticket and varies for the different ticket types. Registered monthly paper tickets were sent automatically by mail to the user before the monthly ticket expired. Registered smart cards can be automatically topped up (in case of a prepaid card) or extended (in case of the 30 days card).

All this information is at all times visible on the paper ticket in the form of printed text (type, value, duration), the size of the ticket (type), the color of the ticket (type), and the shape of the ticket (type). For example, the 8-trip ticket (see Fig. 3) was the only folded paper ticket. It had a pre-printed

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text to indicate the value of the ticket (kr.180) and the word 'voksne' (adults) to indicate that it was a regular ticket. The fact that it was a regular ticket was also indicated by its color combination.

The printed text on a strip is a timestamp, indicating the time when the one-hour validity of the ticket ends. This timestamp is added to the ticket when a traveler enters a metro platform or a bus or tram and inserts the card in a ticket stamp machine (see Fig. 3).

Figure 3. A paper ticket (left) and a ticket stamp machine (right).

The crucial difference between the paper ticket and the smart card ticket is that on the smart card ticket, information is distributed across several devices and places, but it is never visible on the ticket itself. The information can *become* visible in four different ways: via stationary ticket readers positioned at the entrances of stations and platforms of the metro and inside busses and trams, scanners handheld by human ticket controllers, smart card terminals at the point of purchase, and the Internet (only for registered smart card holders, Fig. 4).

C. Using a Ticket

When one is travelling, the value and duration of the ticket change. On the paper ticket this information is at all times visible, while travelers with a smart card need to use ticket readers to access this information on their card. The stationary readers are also used to validate a ticket and give information about the type of card, expiration date or remaining value of the card, and expiration time. This information is visible for two seconds at the time of validation. This is often too short. The user can wait 2 minutes after validation to display the information again. The fact that the type of ticket is not visible without scanning it, presents the risk of traveling with a wrong card, e.g. a parent can use a child ticket without knowing it.

When a traveler validates a ticket, the reader can provide the wrong information. For example, an 11-year-old girl, who travels alone on a tram to her dance school, uses her prepaid smart card twice a week. Incidentally, her mother accompanies her one-day and notices that the child pays the adult fee instead of the discounted fee for children. The child's birthday was recorded at the time of the purchase of the smart card ticket and the card has been working well over a long period of time. The mother and the daughter walk into the public transportation service centre. The customer representative scans the card. All the trips, and the fees paid for them, appear on the screen. It becomes apparent that somehow the discount child's smart card was read as a regular card. The customer representative counts the number of wrongly charged trips, fills a paper based refund form, and issues the overcharged amount of fees in cash.

D. The Expired Ticket

A paper ticket is expired when the timestamp on a ticket has expired. The user of a smart card will not be able to see if the ticket is still valid. The ticket has to be read (see above). If the ticket is a registered smart card, the validity of the ticket can also be checked by logging onto the public transportation system's website.

At the moment, travelers have no way of checking the validity of their smart card ticket when they leave their home or office unless they have a registered card and Internet access.

Figure 4. Accessing on the internet the information from the smart card.

Smart card users taking the bus or tram find out if their ticket has expired or not by using a card reading located inside the bus or tram. Our observations with smart card readers located with the bus driver made clear that many travelers are surprised to find out that they have not enough funds on their card and that they were attempting to travel with an expired card (see Fig. 5).

In those cases the travelers need to buy an expensive one-time paper ticket from the bus driver or they have to leave the bus.

Figure 5. Validating a smart card ticket on the bus.

III. WHAT SMART CARD TICKET USERS SAY

As users of the public transportation system in Oslo, the authors are familiar with the change in the visibility of ticket information since the introduction of the ticket smart card. We decided to ask other users what their experiences with the new smart card ticket were. We selected at random 20

people in Oslo to conduct quick, semi-structured interviews about their awareness of the information stored on their smart card ticket. Eight of the twenty people interviewed were interviewed at the public places, but away from transportation points, in order to get a feeling if they would remember how much money they had or when they used their smart ticket last. Three persons were monthly ticket users and knew the expiration date of their card precisely. They also knew when they used the transportation last, though this piece of information was not important for them. Two were using a prepaid card, which can be used for multiple trips as long as there are enough funds on it. They also felt that they had no problems keeping track of the amount of money left on their respective cards. A young student, using the same type of prepaid card said: "*I never know, getting on the tram, if I actually have any money on the ticket. It is always a game of chance"*. One person in this group was an out of town visitor who always buys a day ticket because *"everything else is too complicated for me."* She continued to explain that it is hard to keep track of when she last used the transportation (tickets have 1 hour validity). As she was not in Oslo very often, she always had multiple tasks at different points of the city to accomplish. The day ticket then was the best option, also because the ticket could then be discarded, instead of taken care of for the future use. The last person we approached said that he has never used public transportation in Oslo.

The remaining twelve persons were interviewed at a bus stop (four) and at a metro station (eight). Ten of them are monthly ticket users. Three persons from this group said that they remember with certainty when their ticket expires. One of them remarked that although she does remember, she wishes that she did not have to. Three said that they remember approximate expiration date. They scan the card when it comes close to the day they think the ticket will expire. Three said that they do not remember expiration date and have to check their ticket frequently. One older person said that she keeps the receipt from the sale of the card in her valet and looks at it occasionally, as the date of the purchase is printed on it. Two persons with prepaid cards said that they have problems remembering how much money they still have on their card. One of them in particular had difficulties as he is only an occasional user of the public transportation system and forgets how much money is left on the card between the trips.

Thus, only about half of the people we talked to were entirely comfortable with the visibility aspect of the smart ticketing system. This number increases if those who do not mind scanning their card occasionally are included in the group that feels comfortable. However, 1/5 of this sample felt clearly uncomfortable with smart card information visibility.

Although only 20 persons were interviewed, the results give an indication that information visibility of a smart card is a real issue. The user satisfaction with the smart card ticketing solution may be improved by offering a better visibility of ticketing information.

IV. THE NETWORKED VISIBILITY OF TICKET INFORMATION

The answer to a simple question "*how much money is left on my smart card?"* involves a variety of devices and places. Ticket information, once located on a piece of paper in the hand of the user, is now distributed and networked. Stalder [14] calls this *networked visibility*, which is "created by the capacity to record, store, transmit, access communication, action, and states generated through digital networks". Stalder studies Web 2.0 and presents two types of visibility: *horizontal visibility* pertaining to information becoming visible to users and *vertical visibility* pertaining to what information the service providers can see. While users can manage their horizontal visibility, i.e. what information about themselves becomes visible to others, they have no control over the vertical visibility of their information. Service providers have access to the information of all users, but this visibility is one way, it is invisible to the users.

Similar to Stalder, we can differentiate between the horizontal and vertical visibility of ticket information. We understand *horizontal visibility* as the visibility of ticket information to the user of the public transportation system. The paper ticket user has immediate horizontal visibility, at all times and places. The ticket information is directly visible on the paper ticket – when the ticket is in use, not in use, or expired. The smart card user's horizontal visibility is limited to particular places: when the ticket is purchased, when it is read or scanned, or when it is checked on the web (only for registered cards). As we saw in the previous section, many travelers are insecure about the status of their smart card: they are not sure if the card is (still) valid.

We understand *vertical visibility* as the visibility of the ticket information to the provider of the public transportation system. The provider has other ticket information needs than the user. The provider is interested in *use information*, such as the users' frequency, time, and destination of travel, and what type of ticket they use. This information is the basis for organizing public transportation schedules, the frequency of departures, and the number of routes. The provider had only limited vertical visibility when the paper tickets were in use and therefore had to implement user surveys to get this information. With the introduction of the smart card, the provider has full access to ticket information.

In our case, the networked visibility created by embedding computing and networking capabilities to a transportation ticket has decreased the horizontal visibility of the users and significantly increased the vertical visibility of the provider. The loss of horizontal visibility negatively affects a large number of travelers who are uncomfortable using their smart card. They can't transfer their familiarity, skill, and experience in using the paper ticket to the smart card.

The increase of the vertical visibility of the provider creates new concerns in terms of privacy as the

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whereabouts of registered smart card users is recorded, stored, and transmitted. These data can be accessed or aggregated for uses not directly related to the public transportation system. As we saw above, an employee at a service point could access such data. On the other hand, the availability of these data made it possible for the mother to get a refund. This would have been impossible with a paper ticket.

V. ARTICK: AUGMENTING THE SMART TICKET

The design of the smart card ticket builds forth on some of the characteristics of the paper ticket: tickets need to be validated before use and the points of validation are at the same locations as the paper ticket. The main difference is the visibility of ticket information. On paper tickets, information was visible at all times and places because it was *local information*, it was locally stored on the paper ticket. Can we make this characteristic of the paper ticket available on the smart card ticket?

In order to improve the user experience with smart tickets and offer local visibility of the ticketing information, we made a simple prototype: ARTick (Augmented Reality Ticket). ARTick turns any smart phone into a mobile smart card reader using NFC (Near Field Communication) standards, see also [9]. NFC is a short-range wireless technology, enabling one-way and two-way communication between smart phones or between smart phones and other wireless devices, in our case the contactless smart card [4].

On NFC-enabled mobile phones, the ARTick application uses NFC to read the information off the card. The application enables the user to check the type of ticket, the value and duration of the ticket, as well as the latest transactions. ARTick enables ticket information to be read in 2D and 3D, augmented using the camera as shown in Fig. 6, as well as audio for the visual impaired.

Non-NFC-enabled smart phones use the camera to take an image of the card number on the back of the ticket smart card and use Optical Character Recognition (OCR). This card number corresponds with ticket information stored on the website of the public transportation provider. The same ticket information will now be available on NFC-enabled smart phone. The addition of audio is in particular interesting for users who have issues with their vision, whether it is related to sight challenges or various forms of dyslexia. ARTick follows universal design principles [15]. ARTick enables the user to leave home with a valid smart card ticket; this may result in more confident and informed users of the public transportation system.

VI. CONCLUSION AND FUTURE WORK

New concerns emerged after the move from paper tickets to smart card tickets. Users couldn't use their familiarity with the paper ticket in their use of the smart card ticket, because this familiarity was based on their immediate and continuous access to ticket information, type of ticket, value of ticket, and duration. The smart card ticket didn't provide this type of access to the user. At the same time, the provider gained access to user and use information, creating new concerns about privacy.

We have used the concepts of networked visibility and horizontal and vertical visibility to discuss the emergence of new concerns when computing and networking technology is embedded in a transportation ticket. These concepts were also used to explore solutions, such as how to restore the horizontal visibility of ticket information, the immediate and continuous ticket information to the users. ARTick, an app that turns a smart phone into a smart card reader, provides one possible solution to the problem.

As to future work, we plan to study the effect of ARTick on user satisfaction with a smart card transportation system. Further, we wish to use the concept of networked visibility to study information accessibility in other systems using solutions similar to the smart card.

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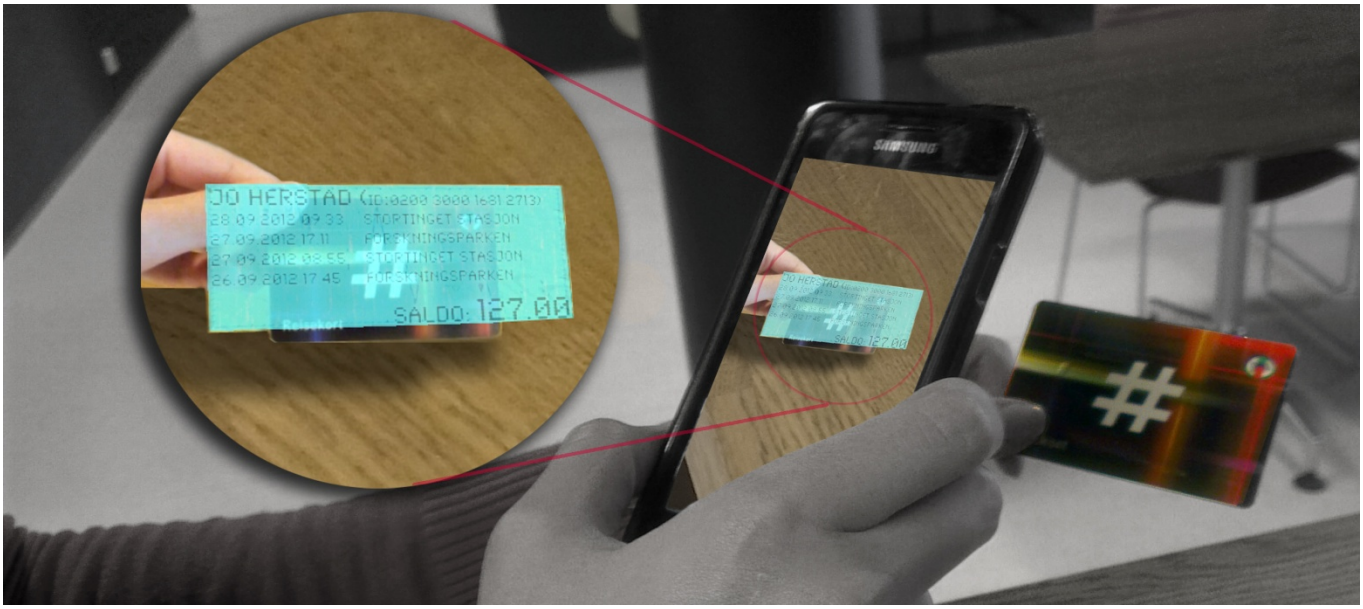

Figure 6. A 3D rendering of smart card ticket information using a NFC-enabled smart phone with ARTick.