Universitet i Oslo
Institutt for Informatikk

Project report
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Utvikling av mobile informasjons -systemer

Topic:
RFID
(RADIO FREQUENCY IDENTIFICATION)

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INTRODUCTION

When you're talking about data collection, two technologies come to mind: bar code scanning and RFID (radio frequency identification). The bare code has been a staple in data collection for more than 30 years. RFID is a technology that while in some ways is relatively 'old' (appearing in more primitive form in the late 1960's). However, it wasn't until recently that the AIDC (automatic identification and data collection) industry took notice. Particularly the last year, RFID has been 'on the move' as far as technological advancements and practical possibilities for it's use are concerned. RFID is similar to the concept of bar coding, but it uses different technology to collect data. To make it simply: Bar code technology uses labels that are attached to items, and readers to scan the labels. RFID uses RFID tags to transmit data and readers to collect data via radio frequencies.
Handheld bar code scanners can be separated into two main groups: laser and linear imagers. Continual advancements and improvements have given linear technology a competitive edge over laser in an evolving market. RFID offers advantages in data collection that bar code scanners cannot. However, the price associated with RFID has played a role in the technology's slow adoption in AIDC, but that doesn't mean its potential should be underestimated. In the exploration of data collection, looking at RFID technology is just as imperative as looking at laser and linear technology. Scan speed, read range, and environment all play a role in determining which technology is best suited for your needs.

The subject of the project is the use of RFID. The possible impending widespread use of the technology has many implications on both the business and social arenas. The aim of our project is to examine the nature of RFID, and look at the issues and consequences involved in it's use in a general context (Part 1), and thereafter focus on a particular application field (Part2), and finally a discussion (Part3).

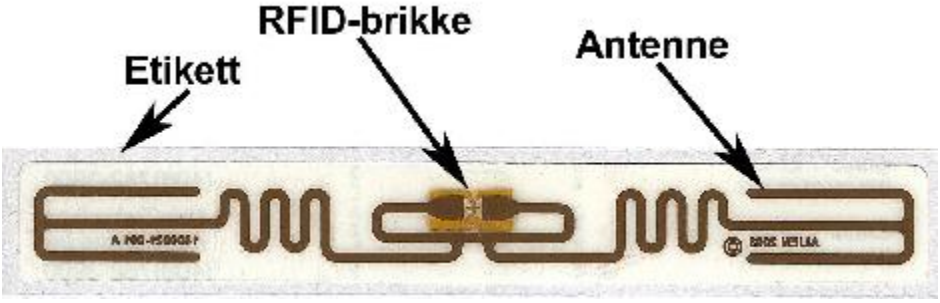
PART 1 – GENERAL BACKROUND

WHAT IS RFID?

RFID is one of many technologies that fall under the description 'auto identification', whereby machines can identify objects, for example through atomised data capture techniques. Other 'auto identification' technologies include bar codes, smart cards, some biometric technologies (eg retinal scans), and optical character recognition, to name a few.

RFID is a generic term, encompassing technologies that make use of radio waves to automatically identify individual items. The most common method used in RFID is to store a serial number (often referred to as an EPC ..Electronic Product Code..) and possibly other additional information on a microchip that has an antenna attached (together they are referred to as a 'transponder' or 'tag'). A RFID system comprises these tags, and 'readers', which transmit a radio signal that is picked up by the tag(s), and in response a signal carrying the stored data is sent back to the reader.

An RFID tag



WHY USE RFID?

The technology has a myriad of potential uses, and also perceived 'benefits' in terms of cost reductions, data collection, monitoring etc. ('benefits' is quoted since whether they are perceived as benefits depends on the point of view of those involved in, or affected by, it's use).

Through the use of RFID to auto identify objects, data concerning the monitoring and management of the movement (and/or interaction) of items (and/or people) has the potential to be available much faster, and in more accurate and precise form. This

principle can be used in a vast number of application fields, as mentioned. Some of these are discussed later.

RFID can be seen to have some advantages over other auto identification technologies, in that it is not line-of-sight dependant, is a 'contactless' technology, and there can be increased distance between the items being identified and the device doing the 'reading' (depending on the type of RFID system used). Radio waves can travel through most non-matallic materials, and as such tags can be placed in protective coatings and even inserted within material/organic structures, allowing for greater durability, reliability and flexibility with regard to potentially destructive environments. The amount of data that can be stored using tags can be significantly higher than other technologies, for example bar codes.

Until recently, any perceived benefits for those considering implementing RFID were often countered by the cost of implementation, and also the technical limitations of the physically available technology. Recent advances in design have meant decreased tag sizes, increased 'performance' (in terms of data throughput and storage capability), and decreasing tag prices (both production costs and retail prices), and have meant that implementation of the technology has become both more commercially viable and practically viable. For example, passive (see below) tag prices have dropped from over US$1 per tag to around 20 to 30 cents per tag, and prices are expected to drop even further as the production and demand cycle for tags and associated technology begins to gain momentum. Many analysts predict prices around 3 - 5 cents within the next five years or so[1] . Active tags (see below) are much more expensive, typically US$50+.

The picture below shows a tag of a pinhead size

HOW IS RFID IMPLEMENTED?

There are 3 main categories of tags - 'passive' tags, 'active' tags, and 'semi-passive' tags. Passive tags have no battery, and to transmit their data, they use an electrical current that

is induced in their antenna by the radio waves sent from the reader. Active tags have a battery as power source, and this allows the tags to transmit their data over much greater distances. Semi-passive tags are a hybrid form, using a battery to power the chips' circuitry, and the induced power from the radio waves to transmit the data.

Tags typically use a particular radio wave frequency - low frequency (eg.13.56Mhz), high frequency, or ultra high frequency (UHF - typically 868Mhz or 915MHz). The frequency for the tag will also affect it's 'read range' (ie the distance form which it can be read) - the higher the frequency the higher the read range. The read ranges for low-frequency tags are typically around 0 - 30 cm, high-frequency around 0 - 90cm, and UHF around 4 meters (active tags can have a higher range because of the battery boosting - perhaps to around 100m) [2] . The size of the chip (and it's antenna) will also affect range. For example, a "Mu chip" from 2001 (0 .3 mm x 0.3 mm, with antenna 5 -7 cm) has a range <30cm, while a recent antenna -on -chip version (0.3mm x 0.3mm, antenna included) has a range <4mm [3]. Higher frequencies generally mean higher data throughput (for example, reading large volumes of tags close together) than with lower frequencies, but new technology has reportedly [3] started to overcome this problem. Tags have a data storage capacity which can range up to around 8KB, depending on the tag type, but typically they carry about 2KB of data, which is enough to store a serial number and some basic information about the object to which it is attached.

Tags can be read-only, or read-write, but read-write tags are generally too expensive for use on low-value items. Some read-only tags can have been 'pre-programmed' with some non-erasable information during their manufacture, and can never be overwritten, while another type of read-only tag actually does allow for overwrite (once only). The latter are called EEPROM tags (electrically erasable programmable read-only memory).

Readers come in many shapes and forms (both stationary and portable), and are often capable of reading at multiple frequencies. Many reader / tag systems are currently proprietary systems and intercompatibility is a big problem. Standards are slowly being proposed (some exist already for very specific applications) but will probably not be widely adopted for some time.

WHO USES RFID?

The technology is already in use (to different degrees) by businesses, government agencies, armed forces, and the general public (for example automatic toll-station passing with Autopass [18]).

WHERE IS RFID USED?

The list of potential application fields is endless. Major fields include tracking of items in the transport and logistics industry, and monitoring of supply chains from manufacturing to distribution to sale point, but there are many more. A (non-exhaustive) list of example applications, to give an idea of the breadth of existing and possible use, is:

- car immobilizer systems (reader in key)
- theft reduction (in retailing/workplace)
- supply planning / preventing out-of-stock situations
- document management (tags placed in business documents to automate logistics systems/processes)
- recovery and identification of stolen items (enabling police to identify items that were stolen from a particular place)
- library operations
- elimination of labor-intensive stock takes
- tracking animals
- product handshaking e.g. incompatible items that should not be connected together
- identification/tracking of items/tools (and the item-carriers) under industrial processes (e.g. painting, assembly of cars etc)
- tags carry information necessary for an items assembly in composite products - read by robots etc
- payment systems e.g. Sony and Phillips are developing an RFID system called Near Field Communication (NFC), which will enable RFID communication between PCs, handheld computers, and other electronic devices. Consumers will log on to their personal online portal by using their smart card, embedded with a RFID tag, which will be read by a RFID reader plugged into the USB port on the computer. Consumers can then purchase online, for example a ticket, the information will then be transmitted to an RFID tag in their mobile phone, which they can wave near a reader at the event for automatic admission . Visa and Mastercard are also combining smart cards/prepaid cards with RFID chips, allowing contactless transactions, and to help prevent forged cards. [3][4]
- vehicle and terminal management (e.g. buses and trucks at depots, bus priotory systems to reduce delays for public transport, automatic toll stations etc)
- tags in clothing, for easier tracking in supply chains/sales outlets (e.g. washable RFID tags designed to be sewn into clothing. [5]
- counterfeit prevention (eg medications, valuable documents, passports etc. The European central bank has been reported to be considering embedding RFID tags into banknotes, as a means of preventing money-laundering, black-market transactions, and assist automated counting procedures [5])
- automatic transaction recording at waste disposal sites, mines, recycling plants etc
- tracking of people (e.g. Alexandra Hospital in Singapore recently

implemented a tracking system in its accident and emergency department as a result of SARS. All patients, visitors, and staff entering the hospital were issued a card embedded with an RFID chip, which could be read by sensors installed in the ceiling, to record the person's movements (spatially and temporally) in the department. The information is stored for 21 days. The principal aim of the system is that if anyone is later diagnosed with SARS, a record of all other individuals with whom that person has been in contact can be immediately determined. [6] Similarly, tags can be used for additional security for personnel working in high risk areas in case of an emergency evacuation.

- reduction of medication errors and patient safety (e.g. tags on special syringes, specifying it's specific type, so that computerised infusion pumps can check the administration rate and strength. Such use implies that 100% reliability is required.) [1]
- ticketing, using embedded tags (e.g. 2006 FIFA World Cup Germany, EXPO Japan, London Transport)
- combining RFID tags with sensors (e.g. tags used to track items can also alert if the item has experienced undesirable changes/conditions, for example temperature or contamination)
- security control (e.g. controlling access to buildings etc, using tags in ID cards)
- time/attendance controls (e.g. replacing 'punch cards')

RFID used in passports.

PRIVACY

The issue of personal privacy is perhaps the most prevalent issue related to the use of RFID. The technology allows (perhaps embedded) tags on items to be detected automatically from varying distances, and the prospect of people and their movements, behaviour and activities being monitored (directly or indirectly) through their possession of tagged items leads to a number of concerns over

potential impingements on personal privacy (both in the legal and ethical sense).

As the recent advances in the technology have made it's use more prevalent and widespread, it's impact with regard to privacy concerns has also grown. A number of interest groups have been formed as a result, focusing their efforts on the protection personal privacy. Issues raised include scenarios such as the possibility of being tracked or profiled at, and after leaving, the site of purchase. For example,"Currently, some RFID readers have the capacity to read data transmitted by many different RFID tags. This means that if a person enters a store carrying several RFID tags, for example in articles of clothing or cards carried in a wallet, one RFID reader can read the data emitted by all of the tags, and not simply the signal relayed by in-store products. This capacity enables retailers with RFID readers to compile a more complete profile of shoppers than would be possible by simply scanning the bar codes of products a consumer purchases." [6] Such profiles, possibly linked directly to a customer identity could conceivably also be sold to other organizations, and/or the data used for another purpose than that for which it was originally obtained.

In most countries a court order or similar is required to access/use private data such as phone records, bank/credit card records etc, and the data can only be used in a strictly defined way. Some concerned with privacy have advocated that the legal status of data obtained using RFID should be similar [7][12], although it is conceivable that the misuse of data, both ethically and legally, is still a potential problem.

Other scenarios include criminal use / detection of tags (for example thieves 'scanning' people or locations to determine potential targets/items for theft), and the possibility of surveillance by other parties, for example government agencies.

Another concern is the general loss of anonymity with regard to movements and transactions. The psychological aspect of the ever-present possibility of one's activities and movements possibly being recorded or monitored (in an Orwellian 'Big Brother' sense) is perhaps significant, although such an aspect would likely vary according to an individual's background and the society itself. Delegates to a recent Communist Party Congress in China were required to wear an RFID ID-card at all times so that their movements could be tracked and recorded [8] - such monitoring can of course have it's advantages, but it can also have it's 'darker' sides, and may or may not be acceptable in other societies or situations. Recently, Marks and Spencer, Tesco and Benetton reportedly trailed (unknown to the customers) the use of RFID technology in some of their stores, but cancelled the trials after their existence became known and the stores experienced protests and opposition from interest groups, the public and media. Perhaps in contrast, a

survey has reportedly indicated that many US consumers would not be averse to monitored to a certain extent (using RFID in-store) if it meant they could save money and time. [9]

The possibility of bank notes being tagged could be another instance whereby the feeling of anonymity could be eroded - cash transactions would no longer necessarily be anonymous. Similarly, as exemplified in the film 'Minority Report', your private data could 'follow' you around and perhaps be used in a public arena, for example advertisements flashing up on screens, based on your spending patterns and 'profile'.

To help deal with the prospect of monitoring via an item's RFID after leaving the site of purchase, the concept of a 'kill' mechanism built into tags has been proposed, whereby the tag can be permanently disabled. Such disablement could occur at the point of sale, but whether this is to be done by default, or only if the customer requests it, is an open question, and the policy of each retailer would likely be individual. A potential problem with this approach is the scenario whereby the tagged items will purposely have their tags 'read' after the purchase. For example, a washing machine might automatically adjust it's behaviour or give a message depending on the tags on the clothes within it. Similarly, the much-touted 'intelligent refrigerator' (knowing it's own contents etc) would be rather 'stupid' if the tags on it's contents had already been deactivated. Tags might also be useful for categorization for recycling purposes.

Another possible approach is the use of so-called 'blocker' tags, which are passive RFID tags that 'block' readers by simulating vast numbers of, or alternatively particular subsets of, possible ID-codes. For example those codes used by a particular manufacturer, or the codes in a dedicated range (i.e. a so-called 'privacy zone'[10]).

Voluntary self-regulatory frameworks have been proposed by interest groups on both sides of the RFID fence (both proponents and privacy groups), and are basically as follows [11]:

1. The right of the consumer to know what items possess RFID tags
2. The right to have tags removed or deactivated upon purchase of these items
3. The right of the consumer to access of the data associated with an RFID tag
4. The right to access of services without mandatory use of RFID tags and
5. The right to know to when, where, and why the data in RFID tags is accessed.

On a technical note, privacy and monitoring would of course also be affected by the nature of the data stored on tags and whether such data is in any way 'meaningful' or not (for example, it may be encrypted, or the data may only be meaningful/intelligible to a very limited group e.g. the item supplier). Thus the possibilities for interpretation and misuse of data would be more limited.
Similarly, the read range of the tags would also play a role, with privacy fears perhaps being reduced if the tags can only be read from a very short distance. As far as eavesdropping is concerned, the "risks can be reduced through the design of appropriate over-the-air protocols and data encryption methods. In addition, the reader changes frequency rapidly and the eavesdropping reader must follow the main reader exactly. This is very difficult since the hopping sequence is random." [12]

Privacy concerns are of course well founded, and need to be addressed. RFID as a technology has a principal objective, and that is to identify and possibly trace entities. As Rhodes [13] says while discussing ubiquitous computing, "sometimes privacy leaks are inherent in the application itself. For example, an application that shows where a person is on a map has no choice but to reveal that information; that's its job. Our goal is not to maintain total privacy, but rather to design a system whereby personal data is distributed on a need-to-know basis."
Technological implementations and societal changes occur, and what people and societies in general are willing to accept (or adapt to), whether consciously or not, is difficult to predict.

PART 2 - SPECIFIC APPLICATION FIELD

AN EXAMPLE OF RFID APPLIED IN THE FIELD OF PUBLIC TRANSPORT.

"Oslo Sporveier is a service company responsible for managing and operating Oslo's public transportation system, as well as some lines that extend beyond the city limits. It's metro-trains, trams and buses convey about 85 percent of public passenger traffic. Local private bus and ferry operators work under cost-based contracts with Oslo Sporveier, which is responsible for traffic services and revenues for these lines. An agreement with Stor-Oslo Lokaltrafikk AS (SL) and Norwegian State Railways (NSB) allows their customers transfer and compensation benefits when travelling with AS Oslo Sporveier." [AS Oslo Sporveier, Facts 2003]

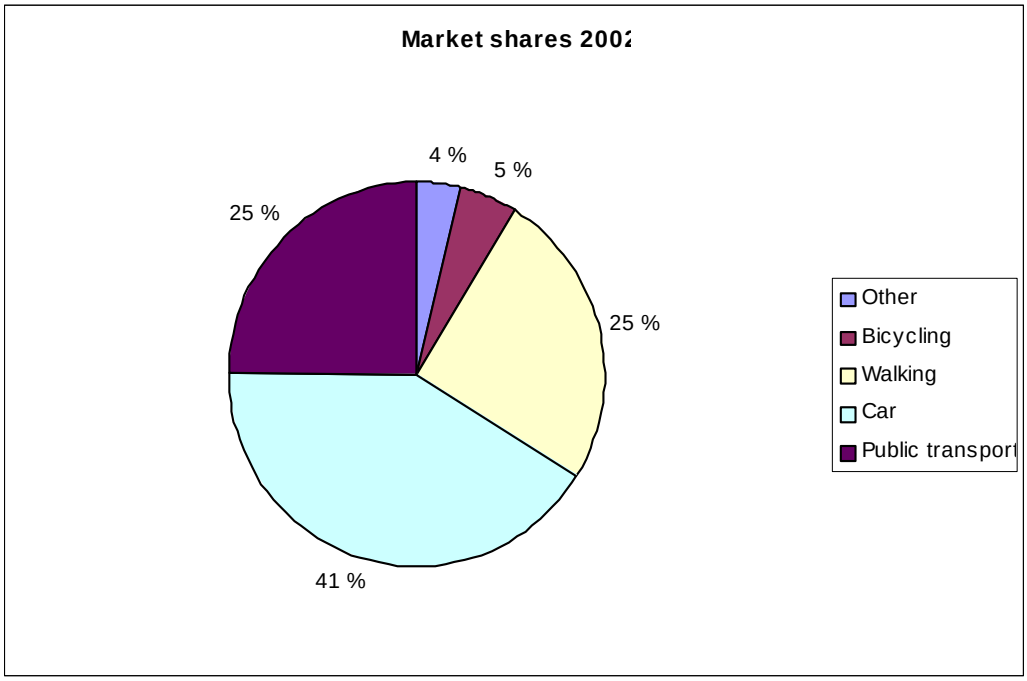
THE SITUATION TODAY

Oslo Sporveier currently uses a paper-based ticketing system whereby passengers' tickets are only checked on random occasions. Otherwise, passengers are free to enter and use stations and public transport. Different many types of tickets are available (single trip, day card, week card, month cards, 3month cards etc). A large problem with the current system is that of 'sneaking', where passengers travel without a valid ticket. Oslo Sporveier loses about 60 – 80 million kroner of potential ticketing-income annually as a result.

Recently the problem has been exacerbated by new 'services', provided by private companies that encourage passengers to sneak. For example, 'www.nettstedet.no' offers a pay-per-message SMS service which gives the location of known ticket-inspection teams, so that those sneaking can try to avoid them. Dagbladet performed a survey in august 2003, asking readers if they would use such a service. Of 876 responses, 56.1% were positive. Another type of service is that where travellers can pay a premium to the service provider (e.g. planka.com) and 'insure' themselves against the possibility of being caught and fined during a ticket-inspection. These passengers are encouraged to sneak, and if they are caught and have paid the premium, they can send the bill to the company.

Another drawback of the paper-based ticketing system is that of forgery. Many month cards and the like have been copied/forged, and with advances in copying and printing technology it is quite difficult to detect the forgeries. An extensive forgery operation was uncovered recently in Oslo.[Aftenposten 9.1.2004]

A problem for Oslo Sporveier during the last few years is that of falling passenger numbers. In 2002, Oslo Sporveier sold 3 million fewer journeys than in 2001. About 25% of travellers used public transport (see figure below). This was the first time for over a decade that passenger numbers fell, and the numbers for 2003 also showed a negative trend.



Sneaking and forgery of tickets, likely play a role in this trend. Another factor could be that of a relative lack of investment in maintenance and infrastructure, resulting in lower quality-of-service for passengers, in the form of delays, breakdowns, cancellations, aging carriages/buses etc. Consequently, fewer choose public transport. At the same time ticket prices have increased. In 2002 prices increased by 4.7% and in 2004 by more than 3%. Surveys indicate [17] that such price increases can have a significant effect on passenger numbers if passengers feel they don't receive value-for-money. Oslo Sporveier seems to be experiencing a negative spiral whereby they have to increase ticket prices to compensate for falling passenger numbers, which in turn leads to further falls in passenger numbers. Ironically enough, perhaps even more travellers sneak as a result of the price increases.

A possible help in this regard is to introduce ticketing systems, for example RFID based, that reduce the possibility for sneaking and forgery, and perhaps also give synergy effects in terms of more 'integrated' transport systems from the users viewpoint, and some other logistical benefits for the transport operator. RFID technology seems to have some

benefits over barcode technology in this regard, in that it is not line-of-sight. The use of barcodes would not necessarily be so practical in that it would tend to cause congestion and queues at entry/exit points to stations/transport. In order for the reader to scan the barcode, the ticket would have to be removed from the traveller's wallet and placed in the correct position in relation to the reader. The few seconds required to do this would cause congestion if there are many passengers. Another advantage of RFID cards is durability and ease of 'recharging'.

THE NBB PROJECT (NYTTBILLETT- OG BETALINGSSYSTEM)

This is a cooperative project involving SL, NSB and Oslo Sporveier, and aims to introduce a ticketing system based on RFID cards for public transport in the Oslo-Akershus region. Early in the 1990's 129 million kroner was spent on a similar project, but that project floundered due to supplier problems and lack of cooperation between the stakeholders. In the current NBB project, the idea is that the different companies can develop their own systems independent of each other, but these systems will also be able to work and communicate together using a shared database and a common RFID technology. The different systems should be able to recognise and understand the nature of the data and product associated with a card. The principle of apparently 'seamless' travel for passengers is important, and the intercompatability of systems necessary to achieve it.

The Oslo-Akershus region has one million inhabitants, and these account for around 60 % of all travel by public transport in Norway. As such, the proposed system will hopefully function satisfactorily and, if successful, perhaps be extended to other regions or cities. The introduction of the system is budgeted to cost around 200 million kroner. Assuming that sneaking and forgery are significantly reduced as a result of the system, the initial investment could be returned after perhaps 4-5 years, and after that the income gained through the reduction in sneaking could be used in other ways by Sporveier. Other aims of the project are to make routines and processes involved in ticketing and payment more cost effective, and to ease the collection of data for management, logistics, and income purposes.

For the metro system, NBB involves the use of RFID enabled 'gates' forming barriers at the entry and exit of central selected stations which have greatest passenger flow. To be able to leave the station, passengers must have a valid card/ticket. These gates have a capacity of one person per second, and studies done in other cities with the same system indicate that delays/queues are not a significant problem. The outer/smaller stations will not have such barriers, but instead will have readers (validators) at the platform so passengers can 'activate' their journeys there if necessary.

This is how Oslo Sporveier thinks Nasjonaltheater metro station will look like.

On buses, trams and boats there will also be validators that check tickets on entry, and the drivers will also have a special console for sales and validation.

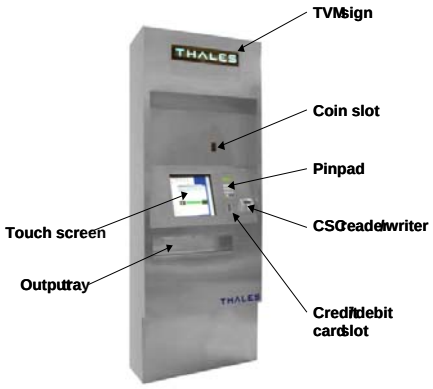
(buses / trams / boats validators)

drivers validator /sales console

(Validators for 'open' metrostations)

Automatic ticket-vending machines will be placed at a number of locations, and passengers can also purchase/'recharge' cards through comissionaries/agents, and via internet. New products can be sold using existing cards. Occasional manual ticket-inspections can still occur, but much less frequently, and will make use of portable validator units.

vending machine



portable unit for inspectors

sales console for agents

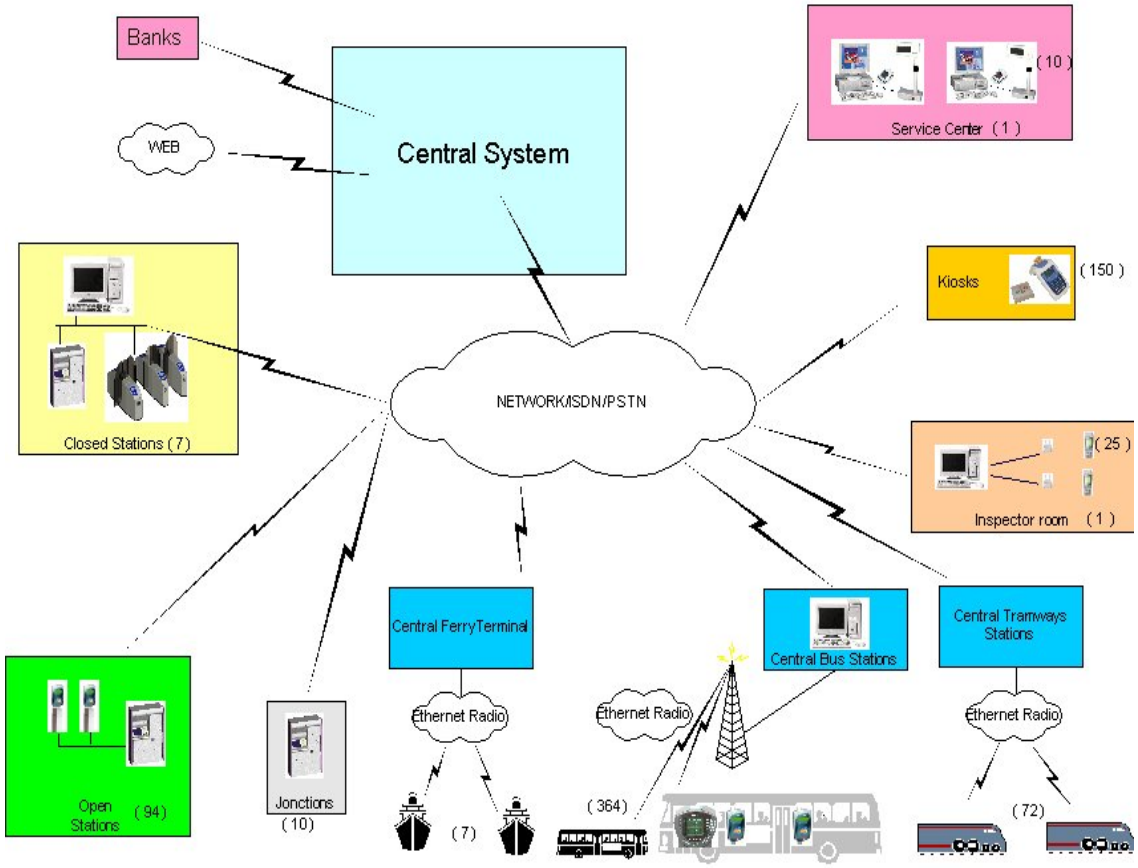
The system architecture revolves around network components which coordinates communication between the different entities around it, thus binding them together and allow the systems to speak to each other.

In order to choose which RFID card to use, the different transport companies agreed on several choice criteria for the card type:

- microprocessor based, with OS suitable for transport applications
- scalability (i.e. able to use other cards in the same 'family' without having to change significantly the applications in the readers

The initial choice fell on a card based on ISO 1443 type B, but Sporveier later decided that use of that card created some implementation problems for one of the system suppliers with regard to licensing and economical considerations. The Mifare cards from Phillips (see appendix) also satisfied the criteria and were subsequently chosen, although since the project's technology choice would probably become a defector national standard, the use of a proprietary technology from a particular company was a subject of discussion. The possibility of reduced costs and a more effective system through use of the Mifare cards proved to be the deciding factor.

NBB system architecture



SURVEY OF THE PUBLIC

As part of our research we decided it was important to try to gather some impressions of the application of RFID in the public transportation system. The survey consisted of 5 questions which where placed online, where the person answered one at a time. The questions were of a general nature, trying not to induce specific answers. Most of the people who took part in the survey were students in Oslo. After this we had general informal interviews with around 5 people who had participated in the survey, to try to obtain clear perspectives on the possible answers received.

The first question asked if they new anything about RFID, and was answered by about 99 people. The second question however had a longer case description important to give background to the future questions. This constituted for some a boring process and around 75% of the people stopped here. Others thought it was just one question and closed their browser after the first question. We did try to fix question #2 by reducing the text, but it still was important that they new the purpose of our project.

It also came to our attention some points of what people think of the current controls compared to new barrier orientated controls. The first question points out that many people don't know much about RFID, however after the personal interviews with some of the interviewed, they did know the other terms or words used more commonly for RFID technology, like intelligent cards, smart cards, electronic cards etc.
The survey results are going to be used and referred in the discussion through the dimensions of mobility. They can be helpful to observe hidden issues in the mobility concept of this implementation.

SURVEY RESULTS

You will find the results of the public survey in appendix A.

PART 3 - DISCUSSION

LOOKING AT RFID FROM THE EXPANDED MOBILITY CONCEPT

The article “Expanding the Mobility Concept” [15] discusses some important issues about mobility which can help us make a kind of different analysis not so orientated on the technology but more on the dimensions mentioned by this author. These theories are not the absolute truth but can indeed help analyze and point to parts of a system that we had not considered. We proceed based on the three dimensions: spatial, temporal and contextual.

SPATIAL DIMENSION

MOBILITY OF OBJECTS

Looking at the mobility of objects, we have the smartcard itself that would be used for validating your travel. The card which is proposed for usage will come in two varieties: one a rewritable model for use with monthly / weekly cards, and the other for day tickets. The mobility of this object can be important to understand. When dealing with this implementation we have to analyze how the system is going to work. As suggested by Sporveier, they are going to use 10 cm scanners, meaning that you have to take the card out and pass it through a validation/activation panel. This will be faster than having to introduce the card into a slot, but it is slower than not having to show it at all, which is the current situation in many circumstances.

The idea of the smartcard still helps fix some of the issues discussed in the article by Rhodes, Minar & Weaver [14], the wearable computing perspective where the sensors are located in the user. This is in part similar to the NBB technology proposal. Although the cards themselves are passive so the don’t emit signals alone, they still are in charged of holding the basic information, like an identification code, and possibly a valid 'start' date. It is then combined with ubiquitous computing, using scanners get the info on these cards to allow entrance or to record a 'start' time.
The system still suffers some of the problems mentioned by Rhodes, whereby, with ubiquitous computing, a card for example enters a station, the information might have to go to a central server that validates if it was paid and related to a number that could be the personal Norwegian number. This can cause problems with the amount of transactions processed and how long it would take for the barrier to actually process and let you in or out from the station. It will ultimately be a mixture of ubiquity and wear ability where the

solution lies. The smartcards can have some information that can be linked to a central server, and other information that simply helps it for fast validation. The central machines still exist but their connection with the card can be done at specific locations, like when it is refilled, or checked by human ticket inspectors with scanners.

The mobility of the card can also have some problems depending on the people using it. Since in Norway it's very popular that young people use metallic card holders as their wallets, the holders might block the signal emitted by the RFID. This would actually mean an extra step when validating, that is, taking the card out of the card holder. These steps represent time which is another dimension in the mobility concept, but have also been of concern for the NBB project. The following graphs illustrate the current procedure for a normal student with a valid month card in his cardholder and the new procedure assuming RFID is implemented.

Current process graph

New process graph for students

MOBILITY OF SYMBOLS

If we look now at the mobility of symbols, how many symbols can a transportation system have? How mobile do we need them to be? From a simple perspective one can argue that even though the technology is so 'advanced ' and not requiring people to introduce a card to a machine, it still requires some kind of orientation on how to use it. It is not very obvious when you come to one of these terminals that have no slot for a card that you have to just wave it over the terminal. Dealing with this problem, Oslo Sporveier takes the same perspective followed in other countries where the technology has been put to work. It is simply designing a sticker with arrows (or something that they will keep standard) in all places where the smartcard (RFID) should be used (see image). With this in mind you will know how to activate your card once you are in a tram, bus, or metro station. The mobility of these symbols then plays a great role in how easily the new

system will work. This might not be that important at low traffic times, but can be really decisive at rush hours when hundreds of passengers go to work. The symbol then has to be widely spread and easily recognizable.

This is the proposed symbol that Oslo Sporveier shared with us. The arrows point 2 directions for valid reading of the card, although the scanner will also be able to read horizontally. These symbols are of great importance so as to reduce possibility of confusion for the user.

MOBILITY OF SPACE

Space mobility can be related or analyzed in terms of how the stations are going to be redesigned for the RFID technology. Even if the scanning is fast enough, during rush hours we might encounter several problems that one must try to address. How many scanners are optimal and for which stations. How will the system then be applied to buses so that they make the system efficient. It is all those sort of situations that come up in the space created by this new technology.

Another important aspect in the mobility of space, that we had not consider was the need of cooperation between the Oslo Sporveier and SL and NSB. Oslo Sporveier pointed out that even if they are independent entities the RFID system must also be compatible. Because of their special agreements for people that live outside and come to work or study, it has been of great importance that the system can be easily used by all travellers.

TEMPORAL DIMENSION

Norway is a rich, developed country and is expected to conform to expectations and norms of functionality, for example with regard to punctuality and reliability in it's transport systems. The proposed NBB implementation will have to take in mind this dimension.

Looking at the temporal order, structurally we will continue to have timetables. However, interpretatively, human interaction with the new system can have temporal implications.

For example delays caused by people not being familiar with the technology. Eventually, the new system could be faster than the current paper-ticket stamping system on buses, which is recognized by Oslo Sporveier to cause delays. For example Oslo Sporveier pointed out that buses sometime suffer delays because of the driver's additional task of selling and checking for the tickets.

The idea with the RFID is to filter the ones that already have a ticket coming through one door, and those that need a ticket through another door, close to the driver. At first glance these delays are merely seconds, but if you multiply this by number of passengers and number of stations, those delays becomes in minutes, and if it adds up to more than 15 minutes then the timetable system is useless, the structure would have no sense. The public transportation system has then to establish if its going to follow the monochronical idea of time, specific slots of time assigned for tasks. Essentially, to maintain the timetables, or if they will transform to a more polychronical time order.
In some countries like in Colombia this was a change that the new bus system had to undergo. It was to hard to continue following specific time slots because of delays in the routes, or because the intervals were so small that was not worth having specific timetables (http://www.transmilenio.gov.co/Transmilenio.htm). As a result, time tables are replaced by a simple message that a bus will come every 3 or 5 minutes. Some of our interviews added the comment that delays related to some specific metro and tram lines should also be important for Oslo Sporveier to address.

The temporal aspect can also be translated to the time people will require in the new system to validate their tickets compared to the current stations without physical controls. It would not be much of a conflict when 10 persons come in a station, but it might produce a bottleneck effect at rush hours when people are going to work or coming from work. These studies of time will have to consider the echnological capacity of the system to validate against it's central database the information on the ticket/card, if the choice goes more to the ubiquitous than the wearable alternative.

CONTEXTUAL DIMENSION

The contextual dimension is probably where less research has been done and where it could still have some important aspects. It's the context of the situation which will ultimately measure the success of the technology. Many mistakes of technological implementation could have avoided by a detailed study of the contextual situation. For example the project of a geographical information system in India could have avoided many of the rejections it suffered if it took into account the cultural disengagement between people and maps. India is not a map-represented culture. Maps are usually not a common tool where this project took place, so it was to hard to later convince the same people to use something related to maps. The people would usually refer to locations by simple relations to other humans or landmarks. Next to the X family house etc. This can

be studied deeper in the case study by Sahay and Walsham [16].

The idea is that in our lives it is important to look at the contextual dimension of mobility. Mobility context dimension as discussed by Kakihara & Soerensen , states that “human action takes place in a particular context that frames or is framed by his/her performance of the action recursively”. It tries to answer to the questions: “In what way”, “in what particular circumstances” and”towards which actors”. This dimension is probably the one that relates more to the sociological implications of mobile technology and can create stronger conflicts with the implementation.

In our initial investigation for RFID as a suggesting technology for the public transportation in Oslo we had some thoughts on things that would be important to consider in the implementation. Some of them were submitted to questioning in the survey. For example the question “Do you prefer physical controls than human controls” we got responses where people prefer physical barriers by 64%, against 34% manual for ticket-inspection. Although the number of people interviewed provides only an initial view of the situation, the personal interviews revealed that preventive barriers could be less stressful than 40 ticket-inspectors closing off whole station and checking everybody for valid tickets. Some others just prefer to be suddenly checked once a month than having steady barriers at stations. These contexts aspects are not easy to observe and still with this survey do not point in a certain direction.

Soerensen also uses the two dimensions of interaction from Schmidt and Simone.

- Unobtrusive v/s obtrusive
- Ephemeral v/s persistent

If we now take the RFID Smartcard that would be implemented and try to fit it into the interaction dimensions it has, it can be 'unobtrusive' and 'persistent'. Unobtrusive in the sense that it might not alter your normal daily activities, but still keep record of enough information to validate that you have a valid ticket or not. As discussed with Oslo Sporveier the smart card will have a number stored, relating it to a payment and usage. This number could be the Norwegian personal number, and in this case maybe some people could complain of an 'obtrusive' interaction, since they could eventually trace which kind of transportation you have taken and where. It also then ends up with the decision of what orientation the smartcards will take, ubiquitous or not. Oslo Sporveier's decision is not yet final but it has been proposed to use this number, but that it would not be connected to other entities. Sporveier also mentions they could just use a regular registration number.

At the same time the location of physical barriers can construct an 'obtrusive' type of interaction because they limit the current freedom of movement in and out of stations.
In the question 'if the transportation system had a lower pricing will they be willing to accept having physical barriers it shows that people still have an perception of the

transportation system as 'erpensive'. It could be alleged that the system is not that expensive considering that with any kind of card you can use all buses, metro or tram services within 1 hour, which is not the case in some cities, like London.

Still with the 26 people who answered this question, 38% still do not agree to having physical barriers. When discussing the questions we got arguments like the time-consumption involved with physical barriers, plus the loss of the free and 'open' style of metro station. An interesting question was about people sneaking in the transportation system. With a grade of 3.7 over 5, 27 people mostly agree that the prices on the public system are mainly due to the number of people that sneak. Oslo Sporveier commented that they have an estimate 8% of sneakers, which is comparably low to our perception. Although we did not include a question about if the transportation system was expensive in Oslo, it can be seen that people do have a certain concern. A further survey with established focus groups could shed more light onto the topic of price perception. Oslo Sporveier does not seem concerned about the pricing, because it’s the amount needed to sustain the operation. Especially if they plan to extend the metro service to new locations, and at the same time reduce tram coverage.

CONCLUSION

We have now talked about RFID and different uses of it. RFID seems to be a promising technology. Especially in the logistic field it will cause a huge benefit. This technology has been known for decades, but now, the time has come for implementing it in the society even in more and more different relations. In some fields it may be difficult for people to accept it. For example in a supermarket in Rheinberg in Germany they had to remove the RFID tags, which they were using to track which products they were selling, and it could also be used for following shoplifters[19]. They had to remove it because protest and demonstration by group called FoeBUD (Verein zur Förderung des öffentlichen bewegten und unbewegten Datenverkehrs) [20]. Their vision is that this technology is a spy chip which will take away their privacy. Like Arnhold M. [21] writes about in his article it will always be a “Janus effect” with new technology, an effect which goes in the apposite direction than aspected and wished. It can be hard to see, but if we are aware of it, then we can try to balance it. A research in this field needs to be done to map what can be done to get people’s acceptance. We may also need to implement this technology in a different “accepted” way. Of course we always have to adjust it for different use.
But at last this technology is a revolution in data gathering.

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Appendix:

Results of public survey: Appendix A
Mifare cards specifications: Appendix B and C