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Tags and the City

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ABSTRACT

This paper analyzes the findings of a set of field studies that explored the use of near field communication (NFC) tags in a mixed reality environment for providing access to digital services by touching a tag with a mobile phone. The field studies provide insight into user experience, usability, user acceptance and technical implementation issues that need to be considered when designing tag-based services. The paper proposes that if NFC technology becomes common, there is a compelling need for methods and practices for tag management. If such practices are not used and available, tags can form “tag litter” that ruins the user experience by corrupting the trust towards tags and tag-based services.

Keywords: *mixed reality, NFC, tags, physical browsing.*

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1. Introduction

The near-field communication (NFC) and RFID (radio frequency identification) technologies are finding their way into our everyday lives, for example, in ticketing applications (Card Technology Today, 2005) and payment solutions (Ondrus & Pigneur, 2007). The offerings of NFC-enabled devices are expected to increase slowly but steadily during upcoming years. For example, ABI research (ABI research, 2007) estimates that over 20% of all handsets sold globally will be NFC compatible by 2012. The first NFC standards were released by ISO/IEC in 2003, and there are several ongoing standardization efforts for tackling the issues related to wider adoption of NFC into versatile domain areas.

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The research presented here has been done within the context of the SmartTouch project (http://www.smarttouch.org). The project explores the possibilities of touch-based user interaction enabled by NFC technology (see Figure 1) through experimental field studies.

Figure 1. With NFC tags, users can access mobile services and content just by touching a tag placed in a physical space with their mobile phone.

In this paper, the findings of the field studies are analysed from the viewpoint of how to manage a large amount of tags that are distributed in an urban space. Without tag management, there is a danger that tags will create the problem of "tag litter" that only increases the complexity and information overflow in our everyday environment instead of supporting our lives with a simple interaction mechanism.

Tags can provide support in our everyday life activities by establishing a bridge between the physical and the digital worlds when they are ubiquitous in the everyday environments of users. This requires a large amount of tags distributed in different types of spaces – public and private, outside and inside, urban and rural, etc. The tags become an integral part of physical space, altering the way humans perceive and behave in it. Tags are also components of digital space and act as components of larger service systems that need to be maintained and monitored. As tags can be numerous and distributed into a geographically wide and versatile area, and as parts of complex networks of services, their management is challenging. Tag management requires digital tools that can be implemented as part of tag management platforms.

This paper discusses the requirements and problems of tag management that have arisen in the field trials undertaken in the SmartTouch project.

2. Bridging the Physical with the Digital

Digital services provide us with support and enrich our everyday lives. Access to digital services and applications can be provided by embedding technology into our everyday surroundings so that we can reach the digital world and its services whenever needed. This paper examines how tags can provide service and content access points for a mobile user in versatile environments to access and interact with the digital world.

2.1 Physical Browsing

Physical browsing (Ailisto et al., 2006) allows connecting the physical world with the digital world via tags. Tags can be used for direct access to the services and information without the need for browsing menus, typing addresses or using search engines. The physical browsing paradigm eliminates the need to type URLs or keywords for accessing services. This is especially beneficial in mobile contexts, as the effort needed to enter a word on a cell phone keypad is more than double the effort required to enter the same word on a full QWERTY keyboard (Kamvar & Baluja, 2006). NFC technology realises physical browsing with touch-based interaction (Rukzio et al., 2006). Initiating action with an NFC tag requires a close range contact with the tag and the reader (approximately 5 centimeters). By integrating the NFC reader with a mobile phone or other mobile device, NFC technology enables a touch-based user interface for ubiquitous access to mobile internet. The tag can be embedded, for example, in a sticker, that can be attached into objects or surfaces – virtually anywhere. The tag contains the information that is required to access the digital service, for example, the URL that is accessed when the user touches the tag with her mobile phone. The location and context of the tag should provide all necessary information that helps the user understand what services the tag offers.

Physical browsing provides a promising intuitive user interface solution to the problem of identifying and activating digital services in a space (problems are described, for example, in Lindenberg, Pasman, Kranenborg, Stegeman, & Neerinex, 2007). Touch-based interaction is fast to use, and it is easy to integrate into physical objects and structures. Tags are cheap and they are easy and fast to program. NFC tags can be programmed with a normal mobile phone with NFC functionality. All this provide possibilities for end users, communities, and commercial service providers to adopt the technology and contribute to the creation of a ubiquitous network of tags that can be used for accessing mobile internet and related services with a touch.

2.2 NFC Technology

NFC is a short-range wireless technology that allows electronic devices to exchange data upon touching. NFC combines both read and write modes into the same device. It is also capable of receiving and transmitting data at the same time. NFC standards have been built over existing radio frequency communication standards (e.g. RFID and smart card standards). It is also designed to be compatible with the old standards and infrastructures, which makes it versatile. (NFC forum, 2008)

NFC can be used for emulating smartcard functionality. In smartcard mode, NFC should be able to transmit an ID of the device or tag to any compatible reader. However, perhaps a more lucrative scenario is to use an NFC-capable device as an active reader device, which receives data from a passive tag. In addition, NFC enables peer-to-peer communication, where two active NFC devices communicate by transmitting and receiving data from each other upon touch.

In the research settings described here, the hypothesis is that the NFC reader capabilities will be widely integrated into mobile devices, such as mobile phones, in the future. Therefore, the data management requirements discussed here are based on an assumption that the users would use their mobile phone (or mobile computer) for accessing NFC-based services. In the experimental settings described here, the NFC-enabled mobile device is a mobile phone, but the users participating in experimental pilots used the mobile phone usually solely for accessing NFC-based services and chose additionally to carry their personal mobile phone with them. Another assumption made for research purposes is that as the NFC-based mobile devices become common, the amount, variety and visibility of tags in our physical environment and surroundings will also grow. In the experimental settings described here, the amount and variability of tags was restricted to those that were designed and distributed by this one research project, as tags are not yet visible and widely used in our everyday environment.

3. Research Setting

In the SmartTouch project, NFC-based applications have been implemented and piloted within several application domains in field settings. The goal has been to evaluate new technological solutions based on NFC with real users in a realistic use environment. The hypothesis was that this can provide information about problems and issues that can be expected with large-scale use in the real-world usage setting. The trials aimed at exposing the technology to real use under circumstances that can be observed and followed. Our trials aimed at making the effects of adopting new technology visible by creating realistic use situations where real-life user experience can happen, and where opportunities and problems related to realistic usage and behavior can be observed. Arranging a trial in a field setting requires that the technology under evaluation is mature enough that it can be used by real users in real usage environments, which was the case with the NFC technology, as all technical components were available on the market as commercial products. However, due to the novelty of the technology, the service concepts are not yet common and there is not much knowledge about user acceptance, usability and user experience related to NFC-based services. This paper contributes to existing knowledge by exploring how tag management affects service design and user experience.

Even though the components needed for building the NFC-based service system are commercially available, the service where the technology is integrated can be part of an infrastructure or process that does not exist yet. The non-existing parts can be simulated during the trial. These can be, for example, payment systems or legislation. Simulating crucial parts of the service creates challenges for interpreting and analysing the results. They must be tackled case-by-case by careful research planning. For example, the absence of real payment action can have a profound effect on how users trust the service and what their expectations are for security and reliability, etc.

The next subchapters briefly describe the trials used to derive the results of this paper. The first two field trials represent applications that use NFC technology for providing service access points in the everyday physical environment for accessing digital services. In these cases, the NFC tags are integral parts of service concepts. The last field trial represents a case where the tag provides fully autonomous functionality for accessing the content of mobile internet. In this case, the tag is not a component of a larger service system, but can operate in stand-alone mode.

3.1 Meal Ordering Application

The first field study evaluated an NFC-based application for enhancing a meal-ordering service provided by the city of Oulu. It was for elderly users who were not able to prepare balanced meals by themselves because of various health conditions. This study represents a ubiquitous computing application in a private space in an urban environment. The application enhanced an existing meal delivery service by providing the elderly home-care clients with the opportunity to choose which meal they would receive the following day (more details in Häikiö et al., 2007). Without the application, the elderly homecare clients did not have the possibility to express their preferences and the same food was delivered to all clients. The goal of the enhanced service was to increase the quality of life of meal delivery service clients by:

- empowering them by providing more control of their lives by allowing them to choose their meals, and
- ensuring the satisfaction of meals, which decreases the risk of malnutrition that has been found to be surprisingly common with the elderly (Pirlich & Lochs, 2001).

The user interface consisted of a meal menu that embedded NFC tags, and a mobile phone that was used for touching the tags to make meal selections (see Figure 2.). The meal selection was then delivered to the meal service providers. This application is an example of tags that are embedded inside the home of the user, therefore part of a private environment, but offering access to the digital services provided by external service providers.

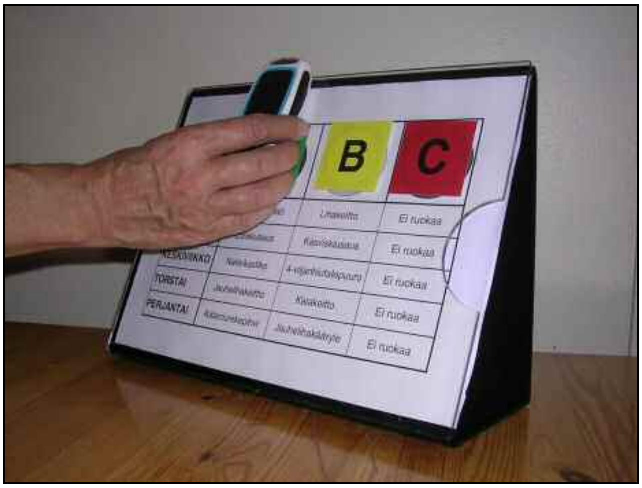

Figure 2. Meal ordering application in use. Options A and B are alternative meal options, and C is used for cancelling meal delivery for the following day.

The trial with the meal-ordering application was made with nine users for a period of eight weeks. Special research emphasis was directed towards analysing and ensuring the ethical consequences related to the pilot and the service (see Schulz & Hanusa, 1978 for reference).

3.2 Parking Payment

Tags in public spaces can provide access to public services. A trial was done in the city center of Oulu for enabling mobile payments of parking fees. The parking payment could be processed by touching tags that were attached to lamp posts and parking meters available at designated parking areas. The user was then able to pay the parking fee by touching on arrival the tag attached to the car for identifying the car to be parked, then touching a tag nearby to start measuring parking time (shown in Figure 3.). When leaving a parking slot, only the tag in the car needs to be touched to end the parking time. In a parking house, the tags were placed at the arrival and departure gates. Parking payment started rolling upon entry and was stopped when the car exited the parking house. Traffic wardens also used an NFC-capable mobile phone to check that the car had been correctly tagged for parking. They simply touched the tag in the car to check that parking was correctly reported.

Figure 3. Parking payment is initiated by first touching a tag in a car, and then touching a tag on a parking meter. When leaving the parking place, the user touches the tag on the car to mark the end of parking time.

The parking pilot was used by approximately 50 users and four traffic wardens for a period of two months. In this setting, the payment action was simulated, i.e. the money transfer from the customer to the service provider did not actually happen. This had to be taken into account in interpreting and analysing the results.

3.3 Information Tags

In the city of Oulu, NFC tags have been distributed throughout the urban area as "information tags", which means that they are visible in public places, and can be used for accessing predefined mobile services. For example, touching one of the tags initiates a phone call to a taxi. Another information tag initiates access to mobile internet, and displays a view to local news through the local newspaper. An example of a banner that includes several grouped information tags is presented in Figure 4.

Information tags have also been placed in specific places to provide information relevant particular to that place thus enabling access to location-based services and content. Examples include:

- a pub where clients can use information tags for browsing information about the selection of beer available
- at the theatre for accessing information about play performances and their cast and background information
- at the bus stop for accessing bus timetables and real-time information about arriving buses

Figure 4. Example of a banner displaying information tags. The blue icons indicate the area to be touched, and the text and icons explain the service accessed through the tag. The back of the banner is sticky, so it can be attached virtually anywhere.

Hundreds of users were able to use the information tags through a period of half a year. The amount of users and tags, as well as the selection of tags available at different times, varied throughout the experiment as information tags were usually a part of other trials.

4. Research Methods

The research results presented here are based on the findings of field trials that used new NFC-based applications and services in settings that aim at as high an experimental reality (Aronson, 2004) as possible. This means, that the research conditions of the field trial are arranged so that all actors and practices of the application and the service chain would be as close to real as possible.

As trials are done in a real world setting, the research setting is uncontrolled. However, the users are selected and recruited based on predefined criteria, and the duration of the experiment is restricted. Also, the users are committed to use the technology under evaluation during trial period, which means that there are constraints in choosing competitive technology alternatives.

The limited duration of the trial had effects on the constructs developed. As the expected life time of the applications, services and special technology developed for the purpose of the experiments was relatively short, compromises were made, for example, on how the new technology was integrated with existing systems.

The experiences related to the applications and services used in the experiments were collected from people experiencing the new technology in different roles. For example, in the elderly meal care experiment, experiences were collected and analysed from elderly users, meal delivery personnel and home care personnel (more details on methods in Häikiö et al., 2007). Different data collection methods were used in different cases, including interviews, questionnaires, web surveys and feedback, observations, diaries, etc. For each case, several different methods were used in different phases of the experiment (see summary in Table 1). The goal was to adopt data collection methods that would disturb the use of the technology as little as possible, but that would be able to capture user experiences when they occurred. This was very challenging as the technology and services were tightly integrated into the everyday lives of their users (Isomursu, 2008).

In addition to the experiences of people directly using the piloted applications, an important data source for the requirements analyzed here was the constructive research made to implement the applications and services used in the experiments. They were designed and implemented by the research group consisting of professionals from different disciplines and presenting different actors in the service chain, such as mobile network operator, technology providers (tags, mobile devices with NFC readers, software platforms, etc.) and service providers.

Trial	**n**	**Data collection**	
Meal ordering	9	before use	• face-to face interviews • observation of training
		during use	• diaries • observation: logs and support visits
		after use	• face-to-face interviews
		follow-up study	• face-to-face interviews
Parking payment	55	before use	• paper questionnaires
		during use	• logs • web feedback forms
		after use	• paper questionnaires • face-to-face interviews
Information tags	238	before use	• paper questionnaires
		during use	• logs • web feedback form • contextual observation
		after use	• paper questionnaires • web questionnaire • face-to-face interviews

Table 1. Summary of data collection methods used in each trial. “n” indicates the number of trial users, and data collection methods list all methods used in a trial (some methods were used only for selected user groups).

In all trials, the trial users were voluntary users that represented the expected user group of the service. The users were requested to sign a written agreement to (1) use the trial services for the trial period, and (2) give feedback about their experiences through methods specified for each study. In addition, for the elderly meal care pilot, a research permission was sought from the management of the social services of the city of Oulu, who also participated in the field study planning by ensuring that the users were informed well enough about the practical details related to the research, and that the trial users were physically and mentally able to participate and understand the research context. In the elderly meal care study, special attention was given to ensuring that the trial did not cause negative effects in the trial participants. This was done, for example, by providing non-stop support and monitoring by researchers who had experience both with the technology and elderly care, ensuring that system failures would not leave users without meals, and with a follow-up study performed a year after the trial period. In other trials, the privacy of the participants was protected by making the collected data anonymous in a very early phase, which made it impossible to later identify the individuals behind tracked activities.

5. Requirements for Tag Management

Using tags as access points to various services and applications usually means distributing tags into an environment that cannot be strictly controlled. There can be a high number of tags. The tags must resist weather, wear-and-tear and vandalism. As the tags are components of both the physical and digital realm, they need to evolve as the physical and digital environments change. In this paper, various requirements and design considerations that need to be taken into account in managing tags in such environments are analysed. The requirements presented here may be solved at different levels of the service platform architecture: they may need tools for the personal device of the user, for the mobile network operator or for the back-end system of the service provider.

As a result of analysing the pilots from the tag management viewpoint, a set of functional requirements was derived. In this paper, these requirements are described both by explaining the issues tackled and the problems faced during the experiment (i.e. the findings that led to deriving requirements for the specific functionality) and then by generalizing the requirements into more general requirements that are not specific to any individual use case and that aim to address generic problems.

5.1 Logs

In every trial, the tag providers wanted to have visibility on the usage of the tags. Logs can be used for monitoring which tags are used most frequently, at what times of day or year, and sometimes even by whom (depending on the service).

During the experiments, logs were used for research purposes for monitoring and analysing tag use. In real service environments, the tag providers would probably want to exploit logs for evaluating the operation of tags as a part of the service system. Log information can then be used, for example, for deciding where to optimally place the tags. Tag placement was found to be one of the most important factors affecting to the user experience of tags. Especially in public spaces the placement of tags can have an effect on how people locate themselves in the space, and even on how they interact with each other. In the information tag pilot, some of the tags were placed on the walls of a theatre waiting hall. Our observations indicate that placing tags on the posters on the walls had an effect on how people placed themselves in the space. Normally, people gathered around the centre of the space, where the lighting was brightest and where most of the furniture was located. The space near the walls of the room was more dimly illuminated, and there was no furniture. Some users reported that they had to leave the group they were socializing with in the centre of the room to use the tags that were located on the posters on the walls.

As tags can initiate different types of actions, one kind of log system does not fit all purposes. In the pilots, the needs for following kinds of logging tools arose:

- logging tag use in a mobile terminal
- logs generated by mobile network operators
- logs generated by the back-end service system

Logging Tag Use in a Mobile Terminal. Tags can initiate local action that only takes place between the tag and the tag reader, e.g. a mobile phone. For example, a tag can provide a predefined piece of information stored in the tag that is presented to the user via the user interface of a mobile phone, or the tag can request the phone to make a phone call to a predefined place. In these cases, the only way for generating automated logs about tag usage is to do it in a mobile terminal, as there is no connection to a back-end system or network during the transaction.

As the vision of large-scale use of NFC assumes that people use their own mobile devices to interact with the tags, the service and application providers would probably not have access to logs stored into the memory of a personal device of the user. However, logs that would be generated in a mobile device and stored locally could be used for other purposes, such as for the end-users to track their own interactions, for example with a ticketing service, using a tag-based user interface. In the case of problem or error situations, the user may be willing to share the logs generated and stored in a personal mobile device with a service provider. For example, in the parking ticketing application the log stored in the mobile terminal could be used to prove that the user had touched a tag to start the parking period, if the system failure had caused problems in managing the transaction in later phases.

Logs Generated by Mobile Network Operators. When a tag initiates an action that is processed through a network operated by a network operator, activity logs can be automatically compiled by the operator monitoring the network traffic. The network activity initiated by tags can be monitored and logs can be compiled. Typical data items to be included in logs are the identification code of the tag, identification of the reader device and the time of activity. The user who initiated activity can be identified through the device used for reading the tag, e.g. a mobile phone. For example, cellular operators can compile logs that indicate which mobile phones have initiated actions in monitored tags. However, if the mobile terminals are connected with services through peer-to-peer networks or other networks that do not have centrally organised operators, compiling log data can become more difficult.

When network operators compile logs about the use of tags, privacy issues may arise. As tags are always physically located in some specific place, using a tag does not only give information about the services used, but also reveals the location of the user. By combining the identification of the user with the location data provided by the tags and the observed service traffic, the network operators are able to generate personalised location-aware service profiles for users. However, all this information is available for the mobile network operators even without the logs related to tags. This problem becomes more serious if the networks operators provide logs and monitoring services for tag-based service providers. For example, the service provider (e.g. news providers) who provide mobile services through information tags could get information about when and where specific users accessed their services.

Logs Generated by the Back-End Service System. The third possibility is to monitor and log tag-generated actions in the service system that receives and processes the initiated action requests. These tools and systems can be specified, implemented and controlled by the service providers, so they can be tailored to their specific requirements. However, two challenges were identified in the pilots.

First, it may be difficult to track error situations when the logs are generated only for the action requests that are received by the service provider. If the error in the tag-initiated activity has taken place already in the tag-reading activity, or when the action request is processed through the network, the request may never reach the service provider in the first place. This means, that no logs can be generated by the service provider. This problem was faced in the elderly meal care pilot. Some meal orders were not received by the back-end system at all, and as the logs were created only by the back-end system, it was impossible to know where the error had occurred. With elderly meal-care service, the problem was especially severe, as failures in processing meal orders might, in worst cases, result in users not receiving their meals. However, in the service discussed here, this was handled by monitoring the meal orders. If no meal order or cancellation was received, the user was called by telephone, and if not reached, meal option one was delivered as the default option. However, this is possible only with services that have regular customer relationships and default service behavior. With sporadic service usage this would be more difficult.

Second, the service provider often has restricted access to the information they receive from the activity. For example, if the tag initiates an activity that opens a mobile internet site in a browser of the mobile phone, the service provider is unable to see who initiated the action. This adds to the privacy of the action, but decreases the service provider's ability to generate logs. The information tag pilot used this mode of action. The action request processed via the tag can be programmed to include the identification of the tag, but not identification of the mobile terminal requesting the web page. This information is available only for the network operator. However, if the service is accessed through a service specific application that the user is required to use to access the service, the application can be programmed to send user or mobile device identification with the action request to the service provider. This procedure was used in the elderly meal care case. In these cases, the service provider can track tag-initiated activities of individual users.

5.2 Tracking Tag Placement

Distributing tags is very easy. Tags are relatively cheap, and programming a tag is a fast and simple procedure. A tag in a sticker can be attached to almost any surface. Therefore, the effort and cost related to distribute large amounts of tags into the environment is relatively low. However, when tags are used as a part of a digital service system, it becomes crucial to keep track of the location of the tags. This requires some kind of register of tags and their placement.

The tag management platform should be able to manage and store the tag placement register. The simplest method for registering tag placement is to indicate the location of the tag with a street address or with GPS coordinates. However, as tags are very small, this level of granularity might not be detailed enough for specific maintenance purposes. For example, for locating a specific tag in a meal menu illustrated in Figure 2, a street address or a GPS coordinate obviously does not provide enough information for identifying an individual tag. In addition, tags are often placed inside buildings, so receiving a GPS signal for locating a tag cannot be trusted. To make things even more complicated, tags can be completely invisible as they can be hidden into objects or structures. The street address is, in many cases, not descriptive enough for indicating the location of a hidden invisible tag.

Moreover, tags can be placed in moving objects, which makes it even more difficult to keep track about their locations. For example, information tags (described in chapter 3.3) can be attached in public transportation vehicles such as busses (as in Figure 1) and trains. In these cases, the exact location of the tag cannot be tracked unless the object where the tag is attached can be tracked. Therefore, the most feasible way to indicate tag location can be to store information about the object where the tag is attached or placed, and instructions for how to locate and recognize the particular object in a physical space.

Keeping track of tag locations is crucial from several viewpoints. Knowing the location of tags enables several advanced application possibilities, such as location-based services and payment schemes.

The information tag field trial revealed that users expected the content and services accessed through tags to be very location-specific. They were very annoyed, if the tag provided access to a generic information service which required browsing or searching to access location-specific information. For example, one of the tags used in the information tag trial provided access to a generic event service. The service used the capital of Finland, Helsinki, as a default value; therefore displaying the events currently ongoing in Helsinki. In order to access event information in other cities, the users had to change the city from a pull-down menu. The users were very annoyed and surprised to access event information in Helsinki when they were 600 km away in Oulu. As tags are always located in some specific place, the location information should be used by the service for providing direct access to location-specific services and content for optimal user experience.

The owners of places and items where the tags are located can usually decide where tags can be placed, and on what conditions. Walls in a city are always owned by someone who most likely wants to control what is attached to the walls (or other surfaces). As the tag is connected with the digital world, usage-based payment schemes can be introduced for optimizing the income and monetary efficiency of tag placement. The space owner may receive a certain amount of money from each interaction initiated by touching the tag. This would result in higher income in places where tags can be easily used and accessed by their potential users.

Tag locations are also crucial for maintenance purposes. It is impossible to collect old and invalid tags from the environment if the tag locations are not known. Eventually, all applications become obsolete and at this point the tags need to be removed or reprogrammed. As NFC tags can be operated only from a close distance by physically touching them, all tags need to be visited. If obsolete, non-operating tags are not removed or re-programmed, they become “tag litter” that was found to evoke a negative user experience. Even when our trial users were exposed to very small amounts of tags, our experiences from the trials clearly show that broken or outdated tags corrupt the trust towards tags, and make users less willing to use tag-based service access. This problem would probably multiply, if tags would be more common and distributed by a wide range of service providers and actors. When the users touch tags that do not respond, or that include outdated information, they get annoyed and are less willing to use tags.

Also, if the tags become ubiquitous and could be distributed into our everyday environment by virtually anyone, owners and maintainers of physical spaces and surfaces need to know which tags are allowed and needed in a certain place, and which tags are unwanted and need to be removed. As with graffiti, it is probable that property owners would want to remove unauthorized tags from the surfaces and objects they own. Information about the placement of tags is needed by maintenance personnel in order to know which tags to remove. Solutions for communicating this to the maintenance personnel are also needed. In the information tag trial (described in chapter 3.3), one of the most serious problems faced during the trial was that the bus stop maintenance personnel removed the tags that were placed at bus stops. Even when the maintenance company had given permission to attach tags to the bus stop for the duration of the trial, this information had not reached each and every maintenance person. It is easy to imagine how complicated this can get, if the amount of tags would be high and different kinds of tags are allowed in different spaces.

Avoiding a bad user experience caused by tag litter requires that the people distributing tags actually care to maintain the tag-based services by keeping the content up-to-date, and by removing broken or obsolete tags from the environment. Of course, this might not always be the case. As tags are very cheap, easy to program and can be attached virtually anywhere, it might be easier and cheaper for the service or content provider to just distribute the tags and forget them.

5.3 Detecting Faulty Tags

The NFC tags are able to communicate with the digital world only when they are activated by an NFC tag reader device. This means, that it is impossible to see in real-time, if a tag is faulty. If the tag is faulty, the tag reader is unable to perform any actions, and therefore no trace of a malfunction can be stored in logs or background systems.

Testing and detecting malfunctioning tags manually is time consuming. This requires that all tags distributed are visited for testing their functional operability. Based on the pilot findings, the reliability of the tags is high. The durations of the pilots were some months, and no problems involving faulty tags were identified. However, in pilot planning some precautions related to faulty tags were taken. Two main approaches for detecting faulty tags were adopted: the first requested the users to report faulty tags, and the second was based on monitoring logs to identify tags that were not generating activity even if they were supposed to do so. Both approaches assume that the service provider distributing the tags is responsible and motivated to maintaining the tag infrastructure, and wants to identify and remove broken tags from the environment. However, as discussed in the previous chapter, this might not always be the case. For removing broken or obsolete tags that have been abandoned by their original owners, there might be a need for public “tag removal troops” who would clean public places of tag litter. However, this problem was not explored or addressed in our trials.

User Generated Error Notifications. In all pilot setups, the users were able to directly contact research coordinators for reporting problems with tags and the service. In some cases, the reporting channel was telephone (e.g. the elderly meal care) and in some, a web-based feedback application (e.g. parking pilot) was used. As the pilot applications were limited in scope and the users were recruited specifically for the trial, it was easy to establish procedures for reporting faulty tags. However, this would be considerably more difficult, if the users would use tags related to wider variety of services, and the users of tags would be random users with no special attachment with the service provider.

For large scale use, the procedures for reporting faulty tags must be made more transparent and easy for the user. For example, each tag could include instructions for the user when experiencing problems with a tag. This can be, for example, calling a service number. However, as reporting faulty tags probably will require extra effort and even monetary contribution from the user (cost of a phone call, for example), the users could be rewarded for reporting faulty tags. Service numbers could even be shared by different service providers through tag management service providers. This would make it possible to establish commonly known tag service customer touch points. However, our experience with tags in public spaces show, that the users are usually very mobile and busy, and are not too willing to contribute very much time and effort. User generated error notifications would probably work best for tags that are placed inside homes or other private spaces where the users would feel motivated to maintain service infrastructure, and would have a regular usage relationship with the services provided through tag infrastructure.

Monitoring Activity Generated by Tags. When the service provider monitors the use of tags, the tag logs can be analysed for identifying possible problem situations. In practice, this means that if the activity patterns generated by specific tags change radically, faulty tags may be a reason for the change. For example, in the elderly meal care pilot, if no meal selection was received by the service system, the elderly user was called to check why they had not placed an order for the following day.

By monitoring tag-generated activity patterns, the abrupt absence of activities received from a tag that normally generated activities can be interpreted as a sign of a faulty tag. However, at this point the tag already has disappointed several users as their service requests have not been successfully processed.

5.4 Visual Design

The demonstrations and applications utilising physical browsing propose two different visions of the future with tags. The first vision uses tags as a technique for adding digital nature into physical objects that already exist in an environment. In this vision, our physical world would still look exactly the same, only with added functionality. The tags would be attached to existing objects and they could be even invisible or hidden. The other vision brings digital services and content as an addition to the existing reality. In this vision, links and access points to digital content and services do not directly relate to a specific object that is already present in the environment. Rather, they bring new objects into our environment that relate to a service need that the users may have in the context of the given location. This vision brings new offerings and affordances into our everyday environment and at the same time, changes our environment not only on the functionality offered, but also by adding new objects and visual components into our everyday environment.

If tags are numerous and visible in the environment, they all compete with each other about the visual attention of the user. Public spaces are already loaded with visual information, so designing tags that can be found and recognized with ease is challenging. Standardisation efforts may help in creating widely recognized standardised icons and symbols that can be used for indicating a tag (Mäkelä, Belt, Greenblatt, & Häkkilä, 2007). Currently, the size of NFC tags is around four (4) centimeters. Both round and square tags are available. Our experience indicates that this size is well-suited for tags that are identified and used from a close proximity, e.g. when they are placed on a stand on a table and the user sits by the table. However, when tags placed on objects that are far from the user, such as posters hung on the walls of theatre waiting hall, the users reported that they had more difficulties to see and identify the tags, as they were viewed from a distance. In cases like this, it might be convenient to have tags that would have large touch areas, and therefore could be better seen from a distance. Of course, the visual marker of the tag can be larger than the actual touch area of the tag. However, then the user would need to locate the touch area within the visual marker.

Tags can be placed behind surfaces or they can be visually designed to blend into the environment to the degree that the tag is invisible for the user. Hidden tags can provide a strong feeling of magic (Isomursu, Hinman, Isomursu, & Spacojevic, 2007), as the user is able to initiate action without actually seeing the technology behind the action. For example, touching a picture frame holding a photograph of a grandson with a mobile phone can be used to initiate a call to the grandson. The picture frame would look just like any picture frame as the tag can be placed behind or inside the frame.

If the tag is invisible, the user may face problems in finding it and knowing which objects provide digital functionality. NFC tags need to be touched, so the user needs to know where the tag is. Therefore, a more common scenario is that the tags are visible.

Standardized NFC-Specific Icons. In parking and information tag pilots, the visual logos designed by the NFC forum were used to visualize tags (see blue icon in Figure 4). Generic icons for indicating tags can help users to identify where tags are available, and where the touch area is located. However, a generic tag indicating the location of the NFC tag does not give the user any information about the service provided through the tag. In order to provide the user this information, additional visual cues and/or textual information is needed. Some researchers (e.g. Välkkynen, Tuomisto, &

Korhonen, 2006) have proposed sets of tag visualizations that would give the user information about the service provided.

Accessibility Issues. In the elderly meal-care pilot, the visual language of tags was designed to be readable and usable for elderly users who have poor visual sight and trembling hands. As the tags were used for limited purposes in a controlled environment in the user's home, the users learned to find and recognize the tags quickly. In this pilot, the fixed size and form of the tag forced the UI design to follow a cognitively challenging table form (see menu illustrated in Figure 2), as the tag could not be placed directly behind the text indicating the meal selection. The possibility to specify the form and size of the area to be touched would give more powerful tools for user interface design.

For the visually impaired, finding a tag can cause problems. A tag can be difficult, or even impossible, to find without visual clues. However, for visually impaired users, the tag could be marked with the Braille system that would both indicate the place to touch and provide a visually impaired user with information about the service the tag offers.

Visual Design as a Tool for Creating Trust. The visual design of the tag and its surroundings needs to give the user information about the purpose and actions that are initiated by the tag. As the touching action itself does not define which action will be initiated, the visual cues of the tag and the surrounding environment need to give the user all the information that is needed for understanding what the tag is supposed to do.

Visual design is one tool for creating the sense of trust and security in the user. Using visual language, such as logos and colors that are well known and easily associated with reputable and well-known services and organizations can be used to create a feeling of trust. Existing product and company logos and visual look and standardised icons for services can be used.

5.5 Security

As programming and distributing tags is very easy and, at least for now, non-regulated, it can be assumed that if they become common, tags will be used for quite a variety of purposes. Some of these purposes may be unwanted or even harmful for end users.

Tags embedded into our environment may lure unsuspecting browsers to access content or services they do not wish to enter, causing financial or emotional worries. Especially, if the tag can initiate payment or billing actions, there always is a risk that the users are lured into paying on the basis of false information. For example, in the parking payment pilot the pilot system covered the parking areas maintained by the city of Oulu. Tags with similar outlook and functionality, only directing the payment to a private bank account, could be added by some entrepreneurial persons to areas that do not have parking fees, and a private non-legal parking business could be quickly established.

Walled Gardens. One solution is to allow only tags provisioned by a trusted service provider to initiate action. However, this would set up “walled gardens” [10] and limit the freedom of the user. Humans tend to prefer free, unlimited choice, even if they would be happier with limited or fixed choice (Brown, Read, & Summers, 2003).

Management of trusted service accounts can be done by a tag management layer in the NFC reader device. Security tools could keep track of trusted service providers, and the tools could warn the user if non-trusted parties are involved in the service request initiated by the tag. NFC forum has been active in creating security enhancing procedures such as signatures for secure identification of trusted service providers. Signatures can be used for identifying the issuer of a tag.

Confirmation of Tag-Initiated Activity. It is common that users express security concerns related to RFID technology because tags are viewed as “active” and therefore users are concerned that they would initiate actions without even noticing (Mäkelä et al., 2007), or that the expectations of tag-initiated behavior would not equal the service received. Therefore, in most of the experiments, a confirmation was requested before an action was processed. For example, when the user touched a tag where the text “Call a taxi” was displayed (one of the tags in the information tag bar described in chapter 3.3), the phone number of the taxi to be called was displayed on the screen of the phone, and the user was requested to confirm that the phone call would be made.

However, in some cases it was more convenient for the user to proceed with the tag-initiated activities without confirmation requests. These cases included, for example, meal ordering for elderly people. In this application, the users were able to fully trust the tags as they used them daily over a long period of time, and the tags were located inside their own homes. Moreover, as the users had memory problems and weakened eyesight and motor skills, reading text from the phone display, procedural activities and pressing small buttons were avoided.

6. Limitations and Validity

Even though the goal of the field trials was to aim for as high an experimental reality (Aronson, 2004) as possible, there are issues in the trial settings that probably have effects on the results.

Perhaps the most severe limitation of our research setting was the availability, selection and content of the services and content accessible through the tags. Tags are not widely used and common, so the trial users were exposed only to tags provided by the research group. As the tags were evaluated in the research project, there were no actual business goals or goals for the public good for providing the users access to mobile content. Tag placement, design and accessed information content were not rigorously designed to meet any specific goals, such as optimal coverage of a certain user group.

The content provided through tags was selected in a brainstorming session of the researchers, and the selection criteria used were probably very different from those that would be used if the tags were used for commercial, or for any purpose other than research. As a result, some tag content was obviously very poorly suited for the specific place it was offered in. For example, many users commented that a tag that helps you call a taxi when you are paying a parking fee was pretty useless.

On the other hand, if in the future the tags become commonly used and ubiquitous, poorly chosen and placed tags will probably be rather common, too, as some tag providers might find it faster, cheaper and easier to attach tags randomly than to do a proper analysis for the optimal locations for tags.

Also, as the tags were evaluated in one single research project, the availability, selection and variety of tags was very limited. If tags become popular Mobile Internet access points, there will be more variety in selection, and tags will be more numerous and available.

Another issue that may have an effect on the results is that none of the users could use their own mobile phone to access Mobile Internet through tags, but had to use a special NFC-enabled trial phone. This means that users usually carried two mobile phones with them, and used their own mobile as a phone, and the trial phone only for NFC-enabled features. This might have an effect on the usage frequency, perceived accessibility and ease-of-use, as the users suggested that they were more familiar with their own phones, and used them more frequently than the trial phone.

The fact that the user experiences were collected in a trial setting probably has an effect on the motivation of the users. The users were recruited as trial users, so they were committed to try out the provided services. Therefore, the first usage was probably initiated by this commitment, and not purely because of interest or curiosity towards the services provided. The trial users also knew that the services would be available only for the duration of the trial. As users are aware that the evaluated technology is part of their lives only for a limited period of time, their commitment to adopt the technology as an integral part of their lives may be weak. If users would think that they are stuck with the technology (e.g. if they had invested a significant amount of their own money for buying the technology), they would need to create strategies to successfully integrate it into their everyday life. If problems would arise, knowing that they would need to use the technology in spite of problems, would trigger a process for reducing cognitive dissonance (Festinger, 1957) which might make them feel and behave differently than in an experimental pilot. Irrevocability of decision has been shown to be an important contributor to user experience (Frenkel & Doob, 1976).

7. Discussion

Only time will tell how quickly NFC technology will penetrate markets and become ubiquitously accessible for all mobile users, or if it will make it at all. The first mobile devices with NFC capabilities have been on the market already for some time, but the low quantities still hinder application development. Adoption of NFC technology is in the typical egg-and-hen situation, where the device manufacturers are waiting for signals from application providers and users for a need to integrate NFC technology into devices, and the application providers and end users are waiting for the technology to become more common, allowing more uses and thus economies of scale. The findings presented in this paper are derived from the constraints and possibilities of NFC technology, but many remain valid also with other tag technologies, such as visual tags that rely on the use of a camera (López de Ipiña, Mendonça, & Hopper, 2002), or other tag technologies based on the use of radio frequency.

The importance and applicability of the requirements presented in this paper varies in different settings and between services. For example, the required durability and expected use time of the tag may vary from a very short time, even single usage to permanent infrastructures that are expected to serve users without a specific ending time. Examples of tags that do not have a long life span are tags attached to brochures or other printed material that are used once and then discarded. The differences with the expected life span of the tag affect the requirements for the management of tags during their expected time of use.

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