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Mobile Services for Near Field Communication

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Abstract

Mobile phones are currently arguably the most widespread mobile computing devices and have found their way into our social and emotional life. Using physical objects as entry points to data and services can ease mobile information access. A new technology called *Near Field Communication* (NFC), which is an extension of *Radio Frequency Identification* (RFID) technology, has the potential to bring mobile devices and physical objects together. NFC promises to eliminate problems like difficult configuration, long duration of connection establishment and high power consumption. In addition, it is designed to enable users to interact with augmented objects or other devices intuitively. This article assesses the capabilities NFC technology offers. We report on a study that we have implemented and tested with users which demonstrates the new possibilities for physical mobile interactions. We conclude the paper with lessons learned from our experience in the development of prototypes and evaluation.

Motivation

Mobile phones have become ubiquitous companions in our life, enabling communication nearly always and everywhere. Additionally they facilitate information access to mobile services and the internet. Besides these communication functions, mobile phones have become multimedia computing platforms with integrated digital cameras for taking pictures and videos, and high-resolution color displays. People use phones to play music, record conversations and to organize their appointments. In summary we can observe that these modern mobile phones bring capabilities from the desktop computers and home entertainment into the world and hence into many different contexts.

Usage in context, while being mobile in the real world, creates information and communication needs. Applications such as buying tickets, way finding, comparing products in a shop to internet offers, or controlling appliances are inherently tied to being in a certain situation. Taking real world environments and objects from these different contexts into account can help to design attractive mobile services. To allow easy ways for interaction with the things in the real world, the things have to cooperate and this is achieved by equipping them with technology. It can be observed that modern environments are evolving towards Mark Weiser's vision of Ubiquitous Computing, where all objects are computerized and networked [1]. There are several options for enhancing objects to enable them to play a role in computational processes; this can be achieved by embedding full-scale computing devices into objects or by simply identifying objects with a barcode that is easy to recognize by machines. Radio frequency

(RFID) and Near Field Communication (NFC) tags are regarded as somewhere in between; they offer easy ways to identify tagged objects and to store a limited amount of data.

In our research we look at new ways and technologies that make interaction in such environments and with augmented objects possible. In particular the use of mobile phones to interact with these environments is a challenge but offers great opportunities. In our previous research [2] we found that finding services in a given context is one of the central issues that has to be addressed in order to create useful mobile services. Once the user has reached the service (e.g. is on a web page or in the dialog of an application) operating the application is often easy as the applications providing mobile services are in many cases simple.

The augmentation of the environment enables *physical mobile interactions*, which involve a user, his mobile device, and a physical object. The object is augmented with some kind of technology and subsequently stores information. This information is associated with a mobile service that might be triggered through interaction with the physical object. Physical mobile interactions make it possible to bridge the gap between the physical and virtual world in an intuitive way. Users benefit from this connection, because users' activities mostly concern physical objects [3]. In order to support communication between the mobile device and the augmented object, communication technologies are required.

Different short-range communication technologies have been integrated into mobile phones in the recent years. This process began with infrared transceivers for synchronizing applications with the desktop computer or to transmit personal business cards. Bluetooth technology evolved and overcame some of the problems experienced with infrared. However, Bluetooth has some major disadvantages when it comes to connecting two devices to make them communicate. The communication set-up between devices is lengthy and in most devices not user-friendly.

Recently, hardware manufacturers have begun working on integrating *Radio Frequency Identification* (RFID) technology into mobile phones. RFID works with active communication devices and passive non-powered tags. These tags can store information, are small and inexpensive. This makes them suitable for augmenting physical objects unobtrusively. An introduction as well as a range of applications to the RFID technology can be found in a recent issue of IEEE Pervasive Computing [4]. The next step is *Near Field Communication* (NFC), a standard that supports multiple RFID-standards and that creates many new opportunities [5][6].

Those devices can read and write tags but additionally are able to **emulate contactless smartcards**, and offer the means to **establish peer-to-peer connections**. The main advantages are the simple and quick way of using it and the speed of connection establishment. In addition, compatible infrastructure already exists around the world, e.g. installed ticketing systems for mass transportation. NFC combines the advantages of RFID and the advantage of having two-way communication.

Hence, NFC might offer a solution to easily interact with augmented objects and invoke services. The simplicity of interacting with computational entities could accelerate the acceptance of existing services. In addition, a plethora of new services that are very easy to use could be realized with NFC.

NFC Technology Overview

NFC technology is based on Radio Frequency Identification (RFID). RFID is a technology that was developed for automatic identification systems. RFID systems consist of two components, the

transponder, also called contactless target or simply tag and the transceiver also called read-write-device or simply reader or writer, depending on its functionality.

The transponder is attached to objects that are to be identified and contains information like an identification number, a product price, or a date. The transceiver is either only able to read the tag's information or also to alter it, assuming the tag is re-writable. The transceiver emits an electromagnetic signal that activates the tag and enables to read from and possibly write to the tag. Usually the reader is attached to a computer on to which the data is passed. RFID readers are small enough to integrate them into mobile phones, PDAs or tablet computers easily, eliminating the need for a standalone reader-device. In the recent years, efforts were made to integrate RFID technology into mobile phones. In 2005, Nokia brought the first commercially available mobile phone onto the market that is equipped with a built-in RFID reader [7].

From RFID to Near Field Communication (NFC)

NFC is based on RFID technology and uses the same working principles. The NFC standard [5] was issued in 2003 and is an interface technology for short-range data communication working in the frequency band of 13.56 MHz. NFC is standardized in ISO/IEC 18092 and is compatible to ISO/IEC standards 14443 (proximity cards) and 15693 (vicinity cards) and to Sony's FeliCa contactless smart card system. Thus, NFC can be used with existing infrastructures based on the standards mentioned, eliminating the need for a separate NFC infrastructure.

The key feature of NFC devices is that they can read out RFID transponders and emulate them. Furthermore, peer-to-peer communication is possible when two NFC devices are brought together. These communication modes are depicted in Figure 1. By contrast, classical RFID systems are designed with only a read-write device attached to a computer. NFC was designed to enable intuitive communication with other entities and to offer an intuitive way of sharing data between electronic devices. NFC technology combines two paradigms, the communication between devices that both have active power supply and computing capabilities, and the communication between powered devices and passive tags.

The supported range of NFC systems is approximately up to ten centimeters. NFC is designed to make communication between two devices very intuitive. Users wanting two devices to communicate simply bring them close together. Then, a protocol will automatically be initiated enabling communication in a peer-to-peer fashion. The required close distance between two NFC devices aggravates overhearing information exchange from outside and adds perceived security to data communication. NFC is expected to support a variety of applications in the future. Mobile payment, ticketing and peer-to-peer data exchange are expected to be realized using NFC devices.

NFC suits the requirements for physical mobile interactions very well. Objects can be augmented with passive RFID tags and mobile devices can be equipped with NFC chips. This enables interaction between mobile devices and objects, and between two NFC devices.

NFC is specified in two ECMA standards. Each of the standards defines a protocol that must be implemented by NFC devices. These protocols will be introduced in the following.

Near Field Communication Interface Protocol-1

The Near Field Communication Interface Protocol 1 (NFCIP-1) is defined in ECMA-340 and in ISO/IEC 18092. The standards define the modulation and bit encoding schemes and the frame architecture for the

supported data rates of 106, 212, and 424 kbit/s. In addition, the communication signal interface and the general protocol flow are standardized.

In NFC systems, at most two devices can communicate concurrently. They exchange data using inductive coupling and radio signals. One of the communication partners is called initiator and has an active role, whereas the passive part is called target. Both roles are always assigned, even if two battery-powered NFC devices communicate.

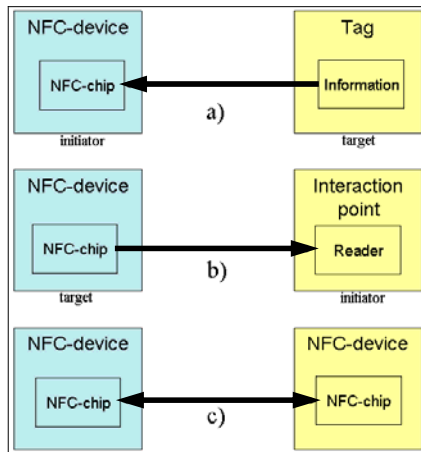


Figure 1: Types of interaction supported by NFC

Figure 1 shows the different physical mobile interactions that are possible using NFC technology. The NFC chip that is integrated into the mobile device can read out a tag's information (Figure 1a), emulate a smart card so that a reader can access its data (Figure 1b), or communicate directly with another NFC device (Figure 1c).

NFCIP-1 defines the active and passive communication modes. In active mode, both the initiator and the target generate a radio frequency field. The initiator starts the communication using the NFCIP-1 protocol. Once the initial handshake and configuration are completed, the data transfer starts. In passive mode, only the initiator generates the radio frequency field. The target is powered by inductive coupling and is able to send or receive data. This mode achieves significant power savings. Furthermore, NFCIP-1 defines the transport protocol, anti-collision methods for the active mode and target selection and initialization for the passive mode.

Near Field Communication Interface Protocol-2

The Near Field Communication Interface Protocol 2 (NFCIP-2) is defined in ECMA-352 [8]. The standard specifies a method for choosing one out of the three possible communication modes defined in ECMA-340 (i.e. NFCIP-1), ISO/IEC 14443 (e.g. Philips MIFARE) and ISO/IEC 15693 (e.g. RFID tags). As a result, NFCIP-2 provides a gateway between existing interface standards.

Devices that implement NFCIP-2 need to implement the functions *proximity coupling device* (ISO/IEC 14443), *vicinity coupling device* (ISO/IEC 15693) and the *initiator* and *target* functions defined in ECMA-340. This makes NFC devices compatible to existing FeliCa and MIFARE systems, and many more. However, compatibility is not achieved on the smart card emulation side for the standards ISO/IEC 14443B and ISO/IEC 15936, although read-out and editing is possible. Another aim of the protocol is not to disturb any ongoing communication on the operating frequency of 13.56 MHz. This is achieved using carrier sense multiple access (CSMA), hence an NFCIP-2 device will not activate its radio frequency field when it detects an external radio field that exceeds a certain threshold.

Enhanced Near Field Communication

INSIDE Contactless [9] has developed a standard called *Enhanced Near Field Communication* (eNFC) that has slightly more capabilities regarding compatibility with existing systems. In contrast to the original NFC standard, eNFC additionally supports the standards ISO/IEC 14443B (e.g. Philips MIFARE) and ISO/IEC 15936 (RFID tags) on the smart card emulation side. The main advantage of ISO/IEC 14443B is that it makes card emulation possible even when the mobile device's battery is empty or the device is turned off. This feature is very useful in ticketing applications. Without the feature, passengers could not present their ticket if their mobile phone is discharged.

Secure NFC

Secure NFC is currently being developed by Philips and combines NFC with smart-card technology to enable the storage of personal data securely [10]. Using Secure NFC ensures that confidential data is stored in a secure memory and remains there. Authentication is supported by the NFC device and transmitted data can be encrypted with a private key that is stored in the secure memory of the device. Secure NFC could be realized using either an additional secure integrated circuit or a SIM-card.

The connection of a secure storage to a NFC device is essential for many NFC applications. The secure storage is required for storing electronic money, personal data, tickets, keys and many more.

Near Field Communication Hardware

Nokia was the first hardware manufacturer to bring an NFC enabled phone shell for the Nokia 3220 mobile phone to market in 2005 [11]. BenQ Mobile has developed a prototype based on the Siemens CX70-Emoty mobile phone (see Figure 2 middle). This phone is equipped with an NFC chip from Philips that is fully NFC compatible. However, so far the phone's software only supports the read-out of Philips MIFARE smartcards and no other NFC features.



Figure 2: RFID (Nokia 5140 with NFC shell) and NFC enabled phones (Siemens CX70, Nokia 3220 with NFC shell)

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Nokia and Siemens/BenQ provide a proprietary Java 2 Micro Edition (J2ME) API for developing mobile applications that make use of the NFC capabilities. The NFC enabled Siemens CX70 provides the NFC Service Platform [i1] and the NFC enabled Nokia 3220 provides the Nokia NFC & RFID API [i2] to allow the development of such applications. Currently many mobile phone vendors support the development of the Java Specification Request (JSR) 257 *Contactless Communication API* [i3] to define a standard API for the contactless communications with RFID/NFC tags or bar codes.

The following source code example shows how a J2ME application could use the NFC capabilities when using JSR 257. The class `NFCExample` implements the interface `TargetListener` (Line 01) through which this class can find out about the connection to an NFC tag via the method `targetDetected` (Line 11). Through the usage of an instance of the `DiscoveryManager` (Line 02 and 06) the application registers itself (Line 08) to receive information about NFC tags scanned by the device. The method `targetDetected` (Line 11) is called when a NFC tag is scanned. The information stored on the tag can then be processed (Line 15-17).

```

01 public class NFCExample implements TargetListener {
02     private DiscoveryManager dm;
03     private ContactlessConnection conn = null;
04
05     public NFCExample() {
06         dm = DiscoveryManager.getInstance();
07         ...
08         dm.addTargetListener(this, TargetType.NFC_TAG);
09         ...
10     }
11     public void targetDetected(TargetProperties[] prop) {

```

```

12     ...
13     TargetProperties target = prop[0];
14     ...
15     conn = (ContactlessConnection)Connector.open(target.getUrl());
16     NFCContainer container = conn.read(false);
17     ServiceRecord[] records = container.getRecords();
18     ...
19 }
20 }

```

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Applications

Most companies see the greatest potential of NFC in applications for ticketing, mobile payment and authentication. This is reflected by the conducted field trials and visions of the companies working on NFC technology. These field trials and existing NFC products will be introduced in the following.

Mobile phone manufacturer Nokia offers an NFC shell for the 3220 phone, and the 5140 and 5140i mobile phones with integrated RFID reader shells for sale. In addition, Nokia has also conducted field trials to test the reliability of their RFID and NFC products. Nokia has equipped the British waste management company Biffa with RFID technology. In order to prove regular inspections of waste containers, these containers carry RFID tags. The inspectors are equipped with RFID-phones and can prove their inspection by scanning the RFID tag. In addition, identification of waste containers is unambiguously possible with this system [a1].

Another field trial Nokia conducted is with the Finnish advertising company JCDecaux Finland Oy. This company uses Nokia's RFID technology in its warehouses to manage stock efficiently. JCDecaux's warehouse personnel reports articles withdrawn or added by scanning an RFID tag next to the articles shelf. The quantity and the work order number are entered via the mobile phone's keypad and transferred to a back-end system via a wireless real-time connection [a2].

In 2006, customers will be able to use the Paris Metro System using NFC-enabled mobile telephones to access public transport [a3]. A similar project using the official NFC standard is at *Rhein-Main Verkehrsverbund* in Germany, where mobile phones are used for ticketing in public transport [a4].

Another field trial involving NFC technology and multiple services for interaction is the French city of Caen [a5]. Participants have the possibility to use their phones for payment and information retrieval. The mobile phones provided by Samsung contain NFC chips from Philips Semiconductors.

Japan's mobile operator NTT DoCoMo sells mobile phones that have a built-in IC chip. This built-in chip is able to emulate FeliCa contactless smart cards. These so-called wallet phones have a built-in prepaid wallet that can be used for mobile payment. Users interact with readers at point of sale, cash machines to recharge the wallet, and access control systems at train stations and airports using their wallet phone. NTT DoCoMo's suggested services include mobile payment, ticketing, check-in airports and train stations, authentication at doors and payment for online shopping. NTT DoCoMo does not use the official NFC standard because at time of installation, the NFC specification had not existed yet. However, FeliCa systems are fully compliant with the NFC standard [a6].

In addition to all kinds of obvious applications that the direct connection of two mobile devices offer, NFC also provides a possibility to enhance the use of high-bandwidth connections like Bluetooth or WiFi. The necessary negotiations between two devices can take place via the NFC technology removing the need for time consuming and potentially more security vulnerable configuration steps needed by, e.g., Bluetooth.

NFC has raised high expectations because chip prices are likely to fall and the range of applications is so vast. In addition, interoperability with existing smartcard systems removes some obstacles other new technologies face when entering the market. NFC could even become a success if only the existing infrastructures were used, because mass-transport systems around the world already have the required hardware installed.

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Case Study

NFC technology offers new possibilities for the creation of mobile applications. Physical objects can easily be augmented with passive tags in order to provide digital information. However, what can this information be used for? Moreover, what kinds of use cases are promising to disseminate this technology? In order to discuss these questions, we adopted, extended and implemented a scenario part of which has occasionally been used to explain the use of tags or markers. It involves four interactions.

A person walks along the street and notices a movie poster that attracts his attention. The person scans the NFC logo on the poster with his mobile phone to retrieve additional information about the movie and the actors. Finally, the user decides to buy a ticket for the movie with his mobile phone, paying with his phone bill. Later, the user enters the cinema by waving his mobile phone in front of the cinema's turnstile. Before he enters the theatre, the user buys a drink at a beverage machine, paying again with his mobile phone. After the show, the user notices an advertisement from a taxi company. He scans the poster's NFC logo and calls a taxi to the cinema by confirming a message on the phone's display.

We chose this scenario since it provides realistic benefits for the user, appears frequently enough in every-day life, is currently possible to be deployed and quick to explain and understand. Several steps of the interaction chain are only possible or easier or less costly to implement with the NFC technology. Money can directly be stored on the phone and authentication as well as transactions can directly be made between the phone and the appliance. After buying the ticket, the data about the transaction is stored in the NFC phone and directly be used in the communication between the phone and the turnstile.

We implemented all parts of the scenario using a NFC phone prototype from BenQ Mobile (see Figure 2 centre) and Philip's MIFARE smartcards.

The implementation on the handset's side is based on Java 2 Micro Edition (J2ME), using an API that is capable of addressing the phone's NFC functionality. This API is closely related to JSR-257 [12], the designated Contactless Communication API for J2ME. The required back-end system is based on web services and is implemented using Java 2 Standard Edition, Apache AXIS and the Tomcat web server. These user interfaces will appear when one of the four physical mobile interactions of the described scenario takes place. When the movie poster is scanned, the user is offered the choice of viewing further movie details, downloading the movie's trailer, calling a cinema that shows the movie, open the movie's web page or purchase tickets for the movie at a cinema. The scanning interaction with the cinema's turnstile will automatically initiate the checking of the cinema's reservation database. If tickets have been bought for the phone's owner, the user is granted access to the cinema. When the beverage machine is scanned, the price of the merchandise is transferred to the mobile phone and the user is asked to choose one of the available payment methods. If payment is successful, the machine will release the desired article. Finally, the scanning of the taxi advertisement will ask the user if he wants to call a cab to the current location. If the user confirms the message, a message is sent to the taxi company including information on the poster's location. These interactions do not necessarily need to take place in the given order. For example, it is also possible to use the purchase function for the beverage machine only or to purchase cinema tickets in multiple transactions before going to the cinema.

To examine the reactions of people confronted with NFC technology and its possibilities, we performed a user study involving 20 users. The users' opinions regarding security issues and the usage of mobile services were recorded using a questionnaire that was distributed to the participants of the user study. We

recorded personal data, frequency and patterns of mobile phone usage and what previous knowledge people had about RFID and NFC.

Four posters have been designed to visualize the interaction steps of the scenario. Each poster is augmented with an NFC logo. The MIFARE contactless smart cards are attached exactly behind these logos. Although the experiment took place in an in-door laboratory setting and two aspects of the scenario were simulated (a virtual turnstile and a Wizard of Oz vending machine), we paid attention to keep the setting as realistic as possible. We observed the interactions from a distance and only provided introductory assistance. The posters were placed in a way that could easily be found in the surroundings of a cinema. The setting was not isolated. Thus people were sometimes passing by providing distractions. Often, people did not have much time to spend in the user study. This also helped to create a realistic situation where people do not want to waste much time during interactions. In informal discussions with the people involved in the study, we could verify our presumptions that the lab setting did not deter people and most did not see reasons why they should feel or behave differently “in real life”.

The group of 20 participants included 12 men and 8 women. The average age of the volunteers was 25.7 years. The volunteers were asked to carry out tasks specified in the given scenario: they should read the movie poster and buy tickets for a certain screening. After buying the ticket, they should proceed into the cinema by scanning the poster that represents access control. Subsequently, they would use the poster with the vending machine, in order to buy a drink or snack. Finally, the volunteers should scan the taxi poster and order a cab to the cinema.

We conducted the user study with only one person at a time in order to prevent observation of the handling of the NFC enabled mobile phone and the scanning procedures. After completing the tasks, the volunteers were asked questions about their opinion of NFC technology and their security requirements.

Lessons Learned

Although the proposed scenario and the implemented application seem to be very simple and intuitive, users need to make several decisions and need background knowledge in order to benefit from NFC. In the following we list some of the important findings derived from discussions and the evaluation of the questionnaires.

- *Good usability.* The usability of the handset prototype and the implemented application was found to be very good after a short introductory session. The participants had no problems navigating the application’s menus and to understand what action lies behind each item in a menu.
- *No security concerns.* 90% of the group said they had no security concerns using their mobile phone in public to scan a contactless target, even though this might provide criminals with a clue as to their actions and phone models. They said it was not different from using the mobile phone to make calls in public.
- *Manual control necessary.* 80% wished to be able to manually switch the scanning functionality on and off. The reasons were security concerns and unwanted battery drain. Some participants proposed an extra hardware button on the mobile phone’s side that must be permanently pressed while scanning a target or emulating cards (as is already used by some phones like the Samsung SGH-E760 to indicate a gesture-recognition mode).
- *Appealing and beneficial interaction.* Generally, the idea of using the mobile phone for everyday activities was very appealing to the participants of the user study. Most volunteers would be glad to get

rid of some of the contents of their conventional purses and key rings. We also implemented an additional way of interacting with posters by using a common web browser on the phone. As we presented the participants with that second possibility, all of them readily assured that they would prefer the scanning procedure to the manual browsing and typing of URLs.

However, we also discovered several issues occurring with NFC interactions. Some of them will be occur less frequently or less crucially when people have become more acquainted with the technology.

- *Service association difficult.* Despite the high usability for people who are used to this interaction technique, it is not (yet) evident that the NFC logo is associated with some kind of service that can be invoked with an NFC phone. In addition, there must be some way to indicate to the user the type of service that will be invoked.
- *Privacy issues arise.* 95% of the participants explicitly want to confirm readings of sensitive personal data like credit card information, whereas the group's opinion is split when only non-confidential data like for example ID-numbers, are read. This leads to the general question of how the user can control when and what kind of data is read, written or submitted in such interactions.
- *Security concerns.* General security concerns were expressed by many participants of the user study. The concerns range from lack of trust in the wireless connection for mobile payment to the fear of having attacks on the electronic wallet by other persons with NFC devices.
- *Difficulties during scanning.* The scanning procedure itself is not as self explanatory and easy to use as the inventors of NFC have hoped. The left part of Figure 3 shows the number of attempts the participants needed to scan each of the four posters successfully.

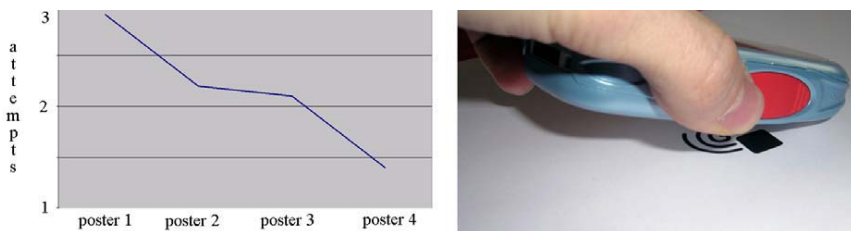


Figure 3: Scanning observations

One can clearly see that scan success improved drastically over time. On average, it took the participants 2.85 attempts to successfully scan the first poster. The second poster was successfully scanned after 2.2 attempts, the third after 2.05 attempts, and the last poster after 1.35 attempts.

- *Larger expected scanning range.* In general, the scanning range of approximately two centimetres was over-estimated. However, this only affected the first few scan attempts. After having become aware of the range after the first successful scan, most users touched the posters with the mobile phone to scan them. The observations made indicate that scan behaviour will improve with practise so that after a short period of training a target can be scanned successfully at the first attempt.

- *Shorter expected system response time.* In addition, scanning duration was under-estimated in the beginning. It took the hardware roughly one second to recognise and read out a smart card. Target recognition as well as the end of a scan were indicated by a sound. Most participants thought scanning was completed at the first sound and pulled the phone away from the smart card too early. This also only affected the first few scanning attempts. Once the user knew the scanning time and that he needed to wait for the second beep, no further problems could be observed.
- *Missing scanner mark.* The handset's NFC chip is integrated into the phone's back cover. Most participants expected the scan-sensible area to be at the front of the phone and hence held the phone towards the NFC logo as depicted in the right part of Figure 3. This resulted in failure, as the scanning range was missed. Clearer indication is required of where the handset is able to scan.

Conclusion

Our experiences in implementing and testing the example scenario above showed that NFC technology included into mobile devices and particular phones has a great potential. Even though people may have to learn how to use NFC based physical interaction, it still offers possibilities to be much simpler and quicker than classical screen-based user interfaces on mobile devices. Interesting options for physical and tangible interaction arise from this technology, especially when more than one tag is used in a single physical object. Associating a single tag with a specific action (e.g. opening a web page or initiating a call) is only a starting point but not sufficient to support more complex interactions.

It can be expected that data capacity of tags will further increase and offer the possibility to store whole services on a tag (e.g. a bus schedule at a bus stop). Hence, users could scan tags without the need for network connections and explore the offered services at no additional cost. This would eliminate negative effects of network connections like costs and time delay. In such scenarios the phone's remote network connection is required and invoked only if the user decides to make a transaction. However, the general advantages, characteristics and issues mentioned in this paper will remain pretty much the same even with future improvements like that.

An unsolved problem is how to unobtrusively augment objects. Potential users need to know that an object is augmented with a service and where the point of action exactly is. As suggested by the results of our study, advertisement posters can easily have a printed logo at the area of the tag. User interfaces that appear after scanning a target must also be intuitive to avoid long descriptions next to the poster's logo.

The potential and acceptance for NFC services is certainly evident from our research. It is now up to hardware manufacturers and service providers to create compelling products. The former need to develop devices that implement secure storage for sensitive data and that are easy configurable. The latter need to develop and rollout attractive services like those seen in the proposed scenario. Services must offer a real benefit to persuade people to use them. Privacy and security are central issues in the perception of the users when it comes to using services.

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