Experimenting with Instant Services Using NFC Technology

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***Abstract*—In the NFC City project Near Field Communication (NFC) technology is used to demonstrate instant services. NFC makes it possible to connect electronic devices and initiate services with simply touching a tag (or a device) with a phone. In the NFC City project this is utilized in several experimental applications. A presenter application use this to set up a presentation (on a projector or screen) without having to connect cables or transfer files manually using USB memory sticks or similar. A chat application sets up a chat simply but touching two NFC enabled mobile phones. A party application transfers images and modifies the music play list by touching an NFC tag with the phone. A guide application provides information and suggest next sightseeing spot in the same way. The usage of NFC in these and a few other applications is presented and discussed, and shows how NFC can be used to provide instant services.**

***Keywords*-Mobile computing, Pervasive computing, Context-aware services, RFID tags**

I. INTRODUCTION

NFC (Near Field Communication) is a short-range wireless technology that tries to harmonize today's diverse contactless technologies, enabling current and future solutions like access control, ticketing, payment, loyalty programs, discount coupons, information collection and exchange. NFC is an extension of Radio Frequency Identification (RFID) technology. One way it differs from RFID is that it limits the range of communication to within 4 centimeters.

The use of NFC makes it possible to connect electronic devices and initiate services with a simple touch. It is believed that NFC will make people's lives easier and more convenient by enabling more intuitive access to new media and content services. It will for example be easier to pay for things; easier to discover, synchronize and share information; and easier to use transport and other public services.

This paper reports on the development and testing of a number of NFC-based applications [1]. In a previous short papert and poster we focused on social networking and context sensitivity [2]. In this paper we examine how various services can be made instantly available, in a simple manner, through the use of NFC-technology. We evaluate both the experience of implementing the NFC-based applications, and the experienced simplicity of using these applications.

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Our applications vary widely, from "NfcPresenter", which uses NFC to simplify the process of starting presentations from your mobile device, to "NfcSafari", which uses the user's location to identify the closest sightseeing spot, and from there on takes him on a city safari. The applications "PartyShare", "Game Collector" and "Are You the One?" explores how powerful NFC can be in social settings. All applications, including "BluetoothChat", demonstrates how instant service can be achieved with NFC.

This work is part of an NFC City project, where the objective is to promote the development and use of NFC-based services. This objective will be achieved through the establishment of an NFC ecosystem including network infrastructure, trusted service manager (TSM) functionality, NFC services and user handsets. The project is also developing a tool set for the development of NFC services.

In the next two sections, related work and NFC technology is discussed. In Section IV, the tool set and the application experiments will be presented. In Section V, the presented work is discussed and evaluated, and finally, in Section VI, the paper is summarized and future work is discussed.

II. RELATED WORK

Many related projects developing and disseminating NFC-based applications exists. A multitude of NFC activities are reported in the NFC Forum [3]. Field trials with NFC based systems have been conducted in a number of cities over the world [4], including Nice (France), Madrid (Spain) and London (UK), and are spreading to more cities. In these cities different types of NFC applications are tested. Examples include ticketing, payment and information delivery applications.

NFC Forum has defined three different NFC operation modes; Card Emulation, Reader/Writer and Peer-to-Peer. In card emulation mode, the NFC device acts as (and eliminates the needs for) a physical object, such as a credit card, key, ticket or coupon. In reader/writer mode, NFC devices can read and write data from/to NFC tags, while in peer-to-peer mode, data can be transferred between two NFC devices. In [5], a number of applications have been examined and classified according to the three operation modes.

The card emulation applications include payment [6], ticketing [7], mobile coupons [8], and loyalty applications [9]. Some

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typical reader/writer applications are designed for delivering information about tourist attractions [10], [11], providing users with location-based information and helping them finding points of interest. In [12], NFC technology supports personalized advertising that combines user profiles on mobil devices and direct interaction displays, and in [13] NFC is used for exchanging pictures between mobile device and computer.

Applications supporting social networking are described in [14], [15]. In [14], NFC technology is used to ease the update of presence information on social networks, while in [15] a peer-to-peer mode application allows users to make friends by exchanging personal information between devices. The peer-to-peer mode is also used in [16], where NFC is used to build ubiquitous games.

III. NFC TECHNOLOGY

NFC-Forum defines the technology as follows: *Near Field Communication (NFC) technology makes life easier and more convenient for consumers around the world by making it simpler to make transactions, exchange digital content, and connect electronic devices with a touch.*

NFC can be implemented in all types of devices, including your smart phone, your tablet, your computer and your car. However, the number of NFC-enabled devices today are quite limited. There has been a deadlock situation where handset vendors, service providers and users are waiting for the others to make a move. The lack of NFC handsets has hindered service development and lack of services has not been good incitement for developing new handsets. However, in current releases of mobile handset models we see a significant increase in NFC enabled devices.

In short, NFC is a set of short-range wireless technologies. Where Bluetooth and RFID may work within a range of up to 100 meters, NFC is limited to only work within distances as short as 4 cm. Also, where Bluetooth has a maximum bandwidth of 2.1 Mbit/s, NFC uses a bandwidth ranging from 106 kbit/s to 424 kbit/s. NFC operates at 13.56 MHz on the ISO/IEC 18000-3 air interface.

NFC always involves an initiator and a target; the initiator actively generates an RF field that can power a passive target. This enables NFC targets to take very simple form factors such as tags, stickers, key fobs, or cards that do not require batteries. NFC peer-to-peer communication, where both devices are powered, is also possible. However, the limited bandwidth makes it inferior to Bluetooth for big data transfers.

NFC tags contain data, and may be configured to be both read-only and rewritable. They can be custom-encoded by their manufacturers or use the specifications provided by the NFC Forum, including the Type 2 Tag format [17] for the tag header and the NDEF data format [18] for the payload. The tags can securely store personal data [19] such as debit and credit card information, loyalty program data, PINs and networking contacts, among other information. The NFC Forum defines four types of tags, which provide different communication speeds and capabilities in terms of configurability, memory, security, data retention and write endurance.

The NFC Data Exchange Format (NDEF) specification [18] defines a message encapsulation format to exchange information between NFC Forum Devices and NFC Forum Tags. In the specification it is described as follows: *NDEF is a lightweight, binary message format that can be used to encapsulate one or more application-defined payloads of arbitrary type and size into a single message construct. Each payload is described by a type, a length, and an optional identifier.* The type identifiers may be URIs, MIME media types, or NFC-specific types.

IV. THE EXPERIMENTS

All Android applications have been developed using Android SDK Tools, Revision 11, which includes the Android SDK and the Android Development Tools (ADT). NFC functionality is implemented using the Android API package *android.nfc*. All applications developed on the Android platform have been tested on a Samsung Nexus S with Android version 2.3.4.

The NFC cards and stickers used are 64 bytes MiFare Ultralight tags. These fulfill the NFC Forum type 2 tag specification with a total payload size of 48 bytes. The desktop NFC development has been on a SCM Microsystems SCL3711. This is a USB device with a PN532 chip, which supports emulation of all NFC Forum type tags and many other non-standard tags. It also supports read/write communication with the most common tag types. We have used Libnfc [20] development branch Revision 1120 for this development. Libnfc is an open source SDK and programmers API for working with NFC on traditional desktop computers.

A. EasyNfc Tool Set

As Libnfc is a low level API, our focus has been on developing higher level APIs for use in future application development processes. We have developed EasyNfc, which is a library that simplifies the process of developing NFC applications on the Android platform. The library contains extendible Activity classes for reading and writing to tags, P2P, and Bluetooth pairing of Android devices. It elegantly reduces the code required when creating NFC applications by hiding much of the boiler plate code from the application developer. This is done by creating EasyNfc as an extension of the original Activity-class. The application developer can simply extend one of the EasyNfc classes to gain access to a powerful set of NFC tools.

Our APIs include functionality for emulating and reading Type 2 Mifare Ultralight tags. It also simplifies the process of creating and parsing NDEF messages. The implementation of these APIs are done in C, but we have implemented a Python wrapper to make it even easier to integrate with our services in future projects. The advantage of emulating an NFC tag with a USB device compared to using a static tag is the possibility for varying responses. As the tag is emulated in software the application can give different responses dependent on context. The tag data may vary over several parameters, like what time of the day it is or what user is reading it. This may prove

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useful in many areas, including context sensitive functionality, permission control and security.

We have also included an Android application, called "Tagger", in the tool set. Tagger is a standard NFC tag reader and writer. The application utilizes the NFC capabilities of the mobile device to read Type 2 NDEF tags and display them in plain text to the user. The reader is capable of reading tags with Plain Text [21] and URI [22] payload records. Tagger can also write to tags, but this is limited to Plain Text records. As Tagger is implemented complying to the Type 2 and NDEF standards, the tags written with the application can be read by all standard compliant readers. The work done on Tagger provides the foundation for the other Android applications that have been build.

B. NfcPresenter

NfcPresenter is an Android application that simplifies the user-computer interaction by creating a more intuitive way to present slide-show presentations. Traditionally, starting a presentation is a cumbersome process. The person doing the presentation usually has two alternatives; either connecting his own laptop to the projector, or transfer the presentation with a USB memory stick to a local computer, which is already connected. Both routines are unnecessary tedious.

In the first case, inability to establish connection between laptop and projector and not being able to display the presentation correctly, are two common and often time-consuming problems. The alternative, transferring the presentation to a USB memory stick, connecting the USB device to the local computer, navigating to the relevant file, opening it, and starting the presentation, is not any more tempting.

With NfcPresenter we aim to create a smooth and painless presentation experience by utilizing NFC technology. Starting a presentation can be done by selecting the appropriate presentation file on the mobile device and touching it to an NFC tag present at the presentation location. Simple as that. When the presentation has started, the Android device serves as a remote control. With a swipe you can show the next or previous slide. In addition each slide is shown on the screen of the mobile device for better control.

NfcPresenter also lets a user download the currently active presentation to a mobile device. In other words, a spectator of the presentation can use the application to download the presentation to his own device by scanning a tag. This is a useful feature for distributing presentation material.

As explained, NfcPresenter utilizes NFC to collect the URL from a tag present at presentation location. The URL directs to a server running on the local presentation computer, which is already connected to the projector. The application uses the recently acquired URL to upload the presentation file to the server. The server starts the presentation and can now answer to other commands to control it remotely.

We predict that the way presenting is handled in NfcPresenter is the future for a presentation setup. To include NfcPresenter-like server functionality into popular end-user products like Microsoft Powerpoint or Apple Keynote would be a simple and efficient way to distribute this kind of features. It could be a great enhancement to the current presenting experience.

(a) NfcPresenter (b) PartyShare

Fig. 1. NFC-based applications

C. BluetoothChat

BluetoothChat demonstrates instant setup with NFC. It is a simple chat client where the user use the NFC features of their mobile phone to set up a bluetooth chat between the handsets. No other configuration is needed. The users open the chat program and then touch the other user's phone. NFC is then used to exchange the information needed to set up the bluetooth communication between the two phones. The communication is the set up without any user involvement, and the chat can start immediately. The advantage of this approach is not only a simplified setup, but also that the two users can be sure that they are actually communicating with the right person. The physical presence (at setup) and the short range of NFC ensure this.

This application can be easily extended to set up chat or other forms of communication using other network technology than the relative short range bluetooth network. In such a context the setup can be done once (when the users meet physically) and used later again and again remotely.

D. PartyShare

The goal of PartyShare is to bring multimedia from handheld devices to stationary devices in a seamless manner. It consists of a client running on an NFC enabled Android device, and a server running on a computer. The application allows you to share music or images from the Android device to the computer in real-time. The transfer is done simply by touching the Android device to the stationary device. As a result, the images are viewed and the music is played immediately.

In principle, PartyShare uses the HTTP protocol to transfer the multimedia from the Android device to the computer. This

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implies that the application could have been built without NFC technology. However, configuring such an application would be tedious. For instance, moving from one location to another would require the user to enter a new IP-address in order to interact with the current stationary device.

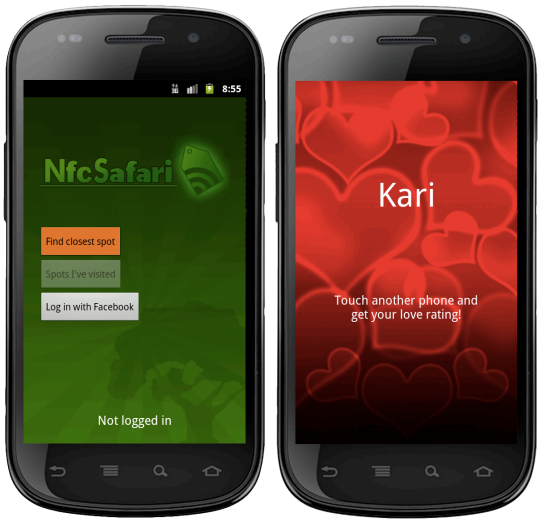
Entering a URL on a handheld device is both time consuming and cumbersome. By taking advantage of NFC technology we can remove the configuration step completely, and as a result get a smart and intuitive sharing application. The trick is to store the relevant URL in the NFC tag. This way the Android application can read the required information directly from the relevant device, and get immediate feedback as his image is viewed, or the track is played.

The server is implemented in Python, using a share of open source python modules. The ImageViewer, which displays the latest image is created using Pygame, and the music sharing is implemented using a self made libspotify-wrapper (spotipy). The web server responds to HTTP post requests on the URIs `/upload/image` and `/upload/track`.

On the client side we use internal Android activities to handle the camera and the gallery to choose image, and the Spotify meta data API to choose music. The music sharing works by transferring a Spotify URI, which is then used by spotipy to play the song.

E. NfcSafari

NfcSafari is a tour guide application that aims to help people discover, experience and remember interesting locations and spots. The general application area is giving tourists visiting cities and locations for the first time a helping hand by guiding them to interesting sightseeing spots. The overall goal of creating the application is to explore how NFC can be utilized in pervasive applications.



(a) NfcSafari (b) Are You The One?

Fig. 2. NFC-based applications

The application initiates the tour by using the current location of the user to find nearby spots. The user is given a choice between the three closest spots, and the user will start the Safari by choosing one of them. The next screen shows a map, guiding the user from his current location to the spot he chose.

When the user finds a spot, he needs to touch the nearby NFC tag to register his presence. By reading the ID of the spot, the application knows what web service to contact to download a description of the spot. If the user is logged in, we can now choose to share information about the spot through Facebook. It is also possible to give the spot a rating from 1 to 5 stars. When the user is happy with the experience he can continue the tour. The next spot is shown on the map, and the process starts from the top. All visited spots are stored in a local database.

In NfcSafari all sightseeing spots are predefined and grouped on the server. The idea is to let spots in close vicinity to each other, or spots with the same theme, to be placed in the same tour. All tours are defined in XML files, where each file describes a single Safari.

Each Safari has an ID and a name, in addition to having a list of spots with names, IDs and location. When the server starts, it parses all the Safari XMLs for spots and locations, which in turn is used when the Android application requests the closest spot. When this happens, the server computes the distance from the user to all active spots (from all Safaris) and returns a list of the three closest of them. When the user chooses one of them, the Safari it belongs to is chosen as the active tour and the corresponding XML is downloaded. When the user is done with the current spot, the next spot in the current Safari is chosen. Communication between the server and the Android client is done over HTTP, and the server is implemented using web.py.

F. GameCollector

Game collector is a prototype of a concept that can increase social interaction between mobile gamers. The idea is to make games, that are generally not made for social interaction, social.

In the prototyped example, the setting is a Pokemon like game, where the goal is to collect many collectables and use them in you game. With NFC, these collectables can be shared among friends giving a social experience to an otherwise not social game.

G. Are You The One?

“Are You The One?” is a quirky “love tester” that calculates the compatibility between two persons. The goal of the application is to illustrate how NFC can be used in social scenarios. The application works by having the user enters his or her name, and then touch another handset with the same application. As a result their “love match”, or compatibility, is visualized on screen as a percentage.

The compatibility is calculated deterministically using their names, and obviously has no basis in reality. Nevertheless, it is a fun example of a small application that delivers something new by incorporating NFC as a vital component.

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V. Discussion

NFC is a relatively new technology, and does not have the infrastructure of other older technologies. Because of this, there is less support available for development of NFC services and applications.

Developing NFC application on Android is not complex, but current Android NFC implementations can be unstable during testing. This is both due to the immature NFC support in Android and the existing tool set. This is continuously improving and a thorough implementation and documentation of both new and legacy NFC standards has been made available.

Developing with Libnfc is challenging. Not only because its a low level API, but also because the documentation is a bit weak, and unforgiving to newcomers. To be able to use Libnfc, and to fully understand it, you will have to do a lot of research and understand a range of technical specifications. With few other alternatives, this is a challenge for NFC development on desktop/server computers.

The MiFare Ultralight tags used in this project had some limitations worth noting. The mobile device was unable to read the tags if they were too close to metal. This is definitely worth remembering when placing tag stickers.

A. Evaluation

NFC is useful in many areas, such as payment, information sharing [12], [23], security [19], [24], configuration, and social interaction [14]. It acts as a link between the physical and virtual world, giving us a simpler and more intuitive way of sharing information [25]. One of the properties of NFC is that context is implicit defined. This stems from the very short range of the tags. This can simplify many aspects of development, including security and configuration. Context wise NFC provides both location (location of tag), interest (selection of tag), time (when NFC device is used), and identity (owner/user of NFC device).

Apart from payment and ticketing, we believe that NFC for mobile devices are most useful where it can simplify the user-interactions of services or applications. The best example is setting up connections for WI-FI or Bluetooth, as exemplified in BluetoothChat. A task that can be tedious is replaced by an intuitive gesture that connects touching devices. We think that NFC is not introducing something entirely new in this context, but it can certainly create more convenience to already established applications and services. In some cases it can also improve the accuracy, for instance in the case of many points-of-interest at geographical location an NFC tag can be used to clarify where the current focus is.

A good example of this is NfcSafari, which does not accomplish something we could not have done using GPS more extensively. However, the GPS would limit us to outdoor spots and might not provide the necessary accuracy. QR codes are also an alternative to NFC in this setting, however, scanning QR codes is slightly less convenient as it takes more time and can be hard in the dark. If this application was to be launched in todays market it would have been wise to incorporate both QR codes and NFC. This is due to the still limited use of NFC enabled devices.

NfcPresenter underlines the convenience of NFC enabled applications. To configure the upload and download URL by a physical touch instead of entering it manually makes a mobile presentation application go from something a few people will use to something everyone will want to have.

BluetoothChat both removes the inconvenience of the setup process and ensures that the chat is with the person you have met physically (and have touched phones with). It is easy to see this used in many other applications where interaction between people is included. If the initial NFC connection is used to agree upon encryption keys it can be used to set up a secure channel between the devices.

PartyShare illustrates how NFC can enhance a social event by giving everyone the ability to participate. This type of crowd sourcing has been possible before NFC, but the threshold to join the fun can now be significantly lowered by making the act of sharing something come down to a simple touch.

Applications like “Are You The One?” illustrates how an apparently exhausted concept gets a fresh feel by incorporating NFC. The act of touching two devices to get a love match (instead of typing in the names on one device) give a greater connection between the two participants. The application illustrates the easy exchange of information between two mobile devices, and the concept obviously opens up for exchanging personal information already available on the devices.

VI. Summary and Future work

These initial NFC experiments of the NFC City project have explored NFC technology both in design of new services and in the development of actual applications. Our experience with implementation and use of these applications indicate that NFC has a role to play in a wide range of future applications. In these experiments we have demonstrated NFC used to establish instant services.

In general, there is a lot more to explore regarding NFC technology. While we have investigated possible application and service areas, traditional NFC research areas, such as mobile payment, security and authentication, has been left untouched. This was done consciously, as other NFC City partners are currently exploring these fields to great extent. The result of this ongoing work will later be incorporated into our NFC activities.

While we have implemented a number of prototype applications utilizing NFC technology on mobile platforms, we have not developed any desktop prototypes using the USB devices. An advantage of the USB device is the possibility to create tags dependent on context. Although this is achievable by utilizing static tags combined with URLs and web access, USB may be a better option as it delivers the same context dependent experience without relying on a WI-FI or 3G/EDGE connection for the mobile device.

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REFERENCES

[1] Ø. Holmstad and T. Kreutzer, "NFC prototype bonanza," Department of Computer Science, Faculty of Science and Technology, University of Tromsø, Norway, Tech. Rep., Jul. 2011.

[2] A. Andersen, Ø. Holmstad, R. Karlsen, and T. Kreutzer, "NFC city context sensitive and social networking experiments," in *PDT'11, Proceedings of the Workshop on Posters and Demos Track at Middleware 2011*. Lisbon, Portugal: ACM, Dec. 2011.

[3] "The near field communication forum," [retrieved: March, 2012]. [Online]. Available: http://www.nfc-forum.org/

[4] "The contactless & NFC city league," [retrieved: March, 2012]. [Online]. Available: http://contactlesscities.wordpress.com/

[5] K. Ok, V. Coskun, M. Aydin, and B. Ozdenizci, "Current benefits and future directions of NFC services," in *Education and Management Technology (ICEMT), 2010 International Conference on*, Nov. 2010, pp. 334–338.

[6] M. Pasquet, J. Reynaud, and C. Rosenberger, "Secure payment with NFC mobile phone in the SmartTouch project," in *International Symposium on Collaborative Technologies and Systems (CTS 2008)*, May 2008, pp. 121–126.

[7] S. Ghiron, S. Sposato, C. Medaglia, and A. Moroni, "NFC ticketing: A prototype and usability test of an NFC-based virtual ticketing application," in *NFC'09, First International Workshop on Near Field Communication*, Feb. 2009, pp. 45–50.

[8] S. Dominikus and M. Aigner, "mCoupons: An application for near field communication (NFC)," in *21st International Conference on Advanced Information Networking and Applications Workshops (AINAW'07)*, vol. 2, May 2007, pp. 421–428.

[9] B. Ozdenizci, V. Coskun, M. Aydin, and O. Kerem, "NFC loyal: A beneficial model to promote loyalty on smart cards of mobile devices," in *International Conference for Internet Technology and Secured Transactions (ICITST)*, Nov. 2010, pp. 1–6.

[10] E. Siira, T. Tuikka, and V. Törmänen, "Location-based mobile wiki using NFC tag infrastructure," in *First International Workshop on Near Field Communication (NFC'09)*, Feb. 2009, pp. 56–60.

[11] F. Borrego-Jaraba, I. Luque Ruiz, and M. Á. Gómez-Nieto, "A NFC-based pervasive solution for city touristic surfing," *Personal and Ubiquitous Computing*, vol. 15, pp. 731–742, Oct. 2011.

[12] S. B. Paul Holleis, Gregor Broll, "Advertising with NFC," in *Workshop on Pervasive Advertising and Shopping, in conjunction with the 8th International Conference on Pervasive Computing (Pervasive 2010)*, Helsinki, Finland, May 2010.

[13] K. Seewoonauth, E. Rukzio, R. Hardy, and P. Holleis, "Two NFC interaction techniques for quickly exchanging pictures between a mobile phone and a computer," in *Proceedings of the 11th International Conference on Human-Computer Interaction with Mobile Devices and Services*, ser. MobileHCI'09. New York, NY, USA: ACM, 2009, pp. 39:1–39:4.

[14] A. Fressancourt, C. Hérault, and E. Ptak, "NFCSocial: social networking in mobility through IMS and NFC," in *First International Workshop on Near Field Communication*, Feb. 2009, pp. 24–29.

[15] E. Siira and V. Törmänen, "The impact of NFC on multimodal social media application," in *Second International Workshop on Near Field Communication (NFC'10)*, Apr. 2010, pp. 51–56.

[16] P. Garrido, G. Miraz, I. Ruiz, and M. Gomez-Nieto, "Near field communication in the development of ubiquitous games," in *International Conference for Internet Technology and Secured Transactions (ICITST 2010)*, Nov. 2010, pp. 1–7.

[17] NFC Forum, "NFC type 2 tag operation specification," NFC Forum, Technical Specification T2TOP 1.1, May 2006, [retrieved: March, 2012]. [Online]. Available: http://www.nfc-forum.org/

[18] ——, "NFC data exchange format (NDEF)," NFC Forum, Technical Specification NDEF 1.0, Jul. 2006, [retrieved: March, 2012]. [Online]. Available: http://www.nfc-forum.org/

[19] E. Haselsteiner and K. Breitfuß, "Security in near field communication (NFC)," in *Workshop on RFID Security*, Malaga, Spain, Jul. 2006.

[20] "Public platform independent near field communication (NFC) library," [retrieved: March, 2012]. [Online]. Available: http://www.libnfc.org/

[21] NFC Forum, "NFC text record type definition," NFC Forum, Technical Specification RTD-Text 1.0, Jul. 2006, [retrieved: March, 2012]. [Online]. Available: http://www.nfc-forum.org/

[22] ——, "NFC URI record type definition," NFC Forum, Technical Specification RTD-URI 1.0, Jul. 2006, [retrieved: March, 2012]. [Online]. Available: http://www.nfc-forum.org/

[23] M. Isomursu, P. Isomursu, and M. Komulainen-Horneman, "Touch to access the mobile internet," in *OZCHI 2008 Proceedings*, Cairns, QLD, Australia., Dec. 2008, pp. 17–24.

[24] M. Hutter and R. Togl, "Touch'n trust: An NFC-enabled trusted platform module," *IARIA International Journal On Advances in Security*, vol. 4, no. 1 & 2, pp. 131–141, 2011.

[25] G. Broll, W. Reithmeier, P. Holleis, and M. Wagner, "Design and evaluation of techniques for mobile interaction with dynamic NFC-displays," in *TEI'11 Proceedings*, ACM. Funchal, Portugal: ACM, Jan. 2011, pp. 205–212.

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