# NFC Provided User Friendliness for Technologically Advanced Services

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**Abstract.** This paper will discuss how an NFC enabled university campus can provide a wide range of user-friendly advanced services for its students and staff. These services combine information sources related to teaching, room reservation, social networking, proximity sensing, information collection and exchange, calendar services, event notifications, ticketing, loyalty cards, payment and more. In the ongoing NFC City Campus trial the usage of NFC enabled mobile phones, SIM cards as secure elements, and an adaptive infrastructure supporting information integration, demonstrates how NFC can contribute to the development of user friendly advanced services.

## 1 Introduction

Near Field Communication (NFC) [17] differs from other existing communication technologies in a few but important manners. Most importantly is its short range. This limitation is intentional and it contributes to security and the accuracy of proximity sensing. NFC is also intuitive to use. NFC communication is initiated with a simple touch, and can enable the usage of other technologies. An example is the usage of NFC to setup a secure WiFi connection on your mobile phone by simply touching an NFC tag. NFC has also built-in capabilities to support security [10,4]. The encryption support in NFC can be used to set up a secure channel for the NFC communication [8].

These characteristics make NFC a promising technology to combine technological advanced services with user friendliness. A wide range of advanced services is traditionally considered inaccessible for people without a lot of knowledge or interest in such technology. Such services are slowly adapted outside the group of technological savvy people. The consequence is that it is difficult to find motivation in an organization to invest resources and time in developing, maintaining and further enhancing these services. And if the services are not developed, maintained and further enhanced, the quality and usefulness of the services will degrade. User friendliness for a large number of different users with different background and technological expertise can be a major success factor when introducing technological advanced services.

Why is it NFC can play a role in user-friendly advanced services? The common NFC enabled personal device is the mobile phone with a user that can be

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identified. The presence of the mobile phone indicates the presence of the user. A set of possible context related data that is implicitly or explicitly given by an NFC enabled device could be linked to the user. This can be used to reason about the user's intention, current interest, relevance of data, and so on. An example could be a user planning a trip on a bus stop. When the user uses the NFC enabled mobile phone to select the destination for the bus trip on a map (that is an NFC enabled smart-poster), both the current location and the selected destination are implicitly provided as context data to the travel-planning application on the phone. The application uses the context data to present the user with information about the next bus to the selected destination and, if necessary, where and when to change bus.

The paper will give examples of a number of advanced services and describe how NFC is used to enable user-friendly service interaction. The paper builds on experiences and preliminary results from an ongoing field trial where students at a university campus are exposed to a variety of NFC enabled services.

## 2 Background

### 2.1 NFC Technology

NFC Forum [12] has defined three different NFC operation modes; Card Emulation, Reader/Writer and Peer-to-Peer [17]. 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. All three operation modes have the potential of enabling user-friendly service interaction, and can make people's lives easier and more convenient by enabling more intuitive access to new media and content services. It can for example be easier to pay; easier to discover, synchronize and share information; and easier to use transport and other public services.

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 tag format for the tag header and the data format for the payload. The NFC Data Exchange Format (NDEF) specification [13] defines a message encapsulation format to exchange information (payload) between NFC Forum Devices and NFC Forum Tags [15]. 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.

The type identifier can be used by NFC enabled devices to perform the correct action when an NFC tag is touched. On an Android phone the correct

application matching the MIME media type of the tag can be opened to process the information on the tag. You can configure Android to open a given application based on this type information. This means that when you use the phone to touch a tag you do not have to open any application before you do that. Touch the tag and the correct application is opened automatically. This makes the usage of NFC more user friendly than for instance QR codes where you first have to open the QR code reading application, and then be forwarded to the correct application to process the information.

NFC technology becomes even more exciting when it interacts with the UICC (SIM card) on a phone. The UICC can act as a tamper-resistant secure element, securely hosting applications and their confidential data. The Single Wire Protocol (SWP) [6] enables direct communication between the UICC and the NFC chip on a phone. Applications on the UICC can then directly interact over NFC without involving any part of the Android system (even when the phone is turned off). This is important for applications like NFC locks and ticketing.

### 2.2 User Friendliness and NFC

The term "user-friendly" can be defined as "easy to learn, use, understand, or deal with"[1]. Closely related to user-friendliness is the term "usability" that in the ISO 9241 standard is defined as: "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use". In [18] the definition of usability is elaborated on, focusing on the terms "effective", "efficient", "engaging", "error tolerant" and "easy to learn".

Papers describing NFC communication and services, such as [16] and [14], point out the user-friendliness of the technology, and claim it to be easy to use and familiar to people since users do not need any knowledge about the technology. All a user has to do is to start communication by bringing two devices together [16].

Usability of touch interaction has been studied in [19,7,11]. According to [19], the user interface of an NFC application is mainly the tag, and the work of [19,7] investigated how people locate an NFC tag, and emphasize the need for a common visual language for locating NFC services. [19] also studied the simple usage pattern of touching a tag, and users' understanding of the actions triggered by the touch.

The work of [11] evaluated and compared interaction methods; pointing, scanning, touching and text search, in a user study regarding efficiency, utility and usability. They found that touching and scanning was evaluated as the fastest method, and also ranked first in user satisfaction.

A field trial where users used NFC enabled mobile phones to access mobile Internet content is reported in [9]. The findings indicate that the users found the touch-based mobile content access easy to use, but details such as placement of tags and static/dynamic nature of content, had an impact on the user

[1] `http://www.merriam-webster.com/`

behavior and perceived quality. Based on the findings, a set of design principles for developing NFC applications was suggested.

[3] focuses on spontaneous interaction of devices, and presents a categorization of factors that influence the usability of device association. The authors aim to provide a framework that informs on the considerations needed when designing or adopting an association technique.

In our work, we have studied user-friendliness from the perspective of how NFC technology can simplify communication setup and service initiation by providing efficient, automatic startup. We compare the touch with the alternative, which very often is a manual setup of communication or startup of services.

## 3 NFC Characteristics Supporting User-Friendliness

We find that the characteristics of the NFC technology that in particular contribute to user friendliness (through efficient and easy to learn startup of services and communication setup, effective information collection and in many cases engaging use of technology), are the close range communication and context awareness.

Through close range communication, services and resources are uniquely determined through a simple touch. A communication and/or service is started by touching an NFC tag with a mobile device. The tag is linked to a resource or a service, and the touch is handled as a specific request for the resource/service. There is little room for ambiguity, and more startup interaction from the user is normally not needed.

The touch of a tag can for instance display information about a point of interest, provide timetables or similar, while a touch of two NFC-enabled devices can setup a Bluetooth communication between them. In these cases, the user avoids manual setup of communication where several parameters must be known and explicitly provided by the user. The user is also relieved of the burden of knowing where information is located and explicitly requesting the information.

Many applications using NFC technology have been developed [16]. In its most basic usage, data is collected from an NFC tag and displayed on the screen of the mobile device, while in more advanced applications the receiving of information triggers additional processing or delivery of user provided information [16]. Examples of the latter include applications for electronic voting or ordering of goods.

Context-awareness is supported through the physical location of NFC tags, identification of touch time, the action or selection performed by the user when touching a tag, and the mobile device as a personal belonging. When the user is touching a tag, the time of touch and location of the user is explicitly determined, and time- and/or location-dependent services/information can be presented. Also, the NFC-enabled mobile device is in most cases a personal device containing personal information (for instance preferences, interests, health information, and more) that allow for delivery of personalized information/services. The context information allows for a whole range of advanced applications where the user, through a simple touch, can obtain services/information tailored to his/her specific needs or preferences.

## 4 Experiments

In the NFC City project we have experimented with a wide range of NFC enabled services and applications [1,2]. In the NFC City Campus trail many of these services and applications have been deployed and made available to a group of students. The participating students are given an NFC enabled Android phone, a set of programmable NFC tags, an UICC (SIM card) with pre-installed applications, and support [5]. The provided NFC enabled phones also support the Single Wire Protocol (SWP) [6].

Below we will explore some of the services and applications developed and deployed in the NFC City Campus trail. We will discuss how NFC technology contributes to the user-friendliness of these services and applications.

### 4.1 Training Guidance

At two student fitness centers we have created a full size smart-poster with the different muscle groups. When exercising, the user can select a muscle group by touching that part of the poster. On the NFC enabled phone a web page describing training tips for this muscle group is opened. The web page also includes training videos demonstrating some possible exercises. At the different exercise equipments NFC tags can be touched to display videos demonstrating how they are used.

This is a very convenient way of presenting instructions as combinations of media types, and at the same time allow users to choose instructions of specific interest and bring all the instructions with them for use also at home. Alternatives include traditional posters and/or pamphlets, which can not support the combination of media types, and larger screens that may display videos, but are not so easily personalized to the specific needs of a user and are certainly not mobile. Using a mobile device without NFC, requires the user to start the an application (browser or other) and actively locate or search for the instructions. This requires explicit knowledge of where the different instructions are to be found.


**Fig. 1.** Student using smart-poster at fitness center

### 4.2 Location Check-In

On campus the entrance of key locations, like cafés, lecture halls and meeting points, are tagged with NFC tags used to check-in to these locations. Friends

can then know that a given person just arrived and currently is at this location. Students use this to meet for coffee breaks without any cumbersome interaction by phone, email or SMS. By touching the NFC tag at the campus coffee bar your friends can discover that you currently are there. The service is based on Foursquare[2] and the NFC tags representing the location have an URL representing the check-in at this location.

Using NFC instead of other means of achieving this is a much simpler process for the user. No application has to be started and no web page has to be opened. The user just takes the phone and touches the tag. However, we expect some preparation from the user. The user has to be registered at Foursquare and provide some additional information. Once this is done the usage is straight forward. Touch a tag and you have checked in at the given location.

### 4.3 Coffee Card

The coffee card application is a combination of a prepaid service and loyalty card. Students can buy 11 cups of coffee for the price of 8 and the prepaid coffee cups are stored on the UICC. Since the UICC is a secure element, the users cannot alter its content. Each time a coffee is bought, the student touch the NFC reader connected to a tablet computer. The application on the tablet computer informs the barista that the user have prepaid for the coffee and it withdraw a single cup from the stored coffee cups on the UICC. The user can fill up the registered prepaid coffee with 11 more coffee cups using an accompanying Android application on the phone. The application will withdraw the given amount from the users bank account and then transfer the 11 coffee cups to the UICC.


**Fig. 2.** The coffee card Android application

The application combines in a single touch, paying for the coffee with use of the loyalty card. The user gets the benefit of the loyalty card without the hassle of taking care of (possibly a number of) paper cards. The single touch makes paying for the coffee very simple and fast. This is also the case for filling up the coffee card, which is also done through a single touch.

### 4.4 Ticketing

Public transportation is the recommended way of transportation to our local campus. The available public transportation is bus and to travel with the bus

[2] `https://foursquare.com/`

you need a bus card that you use when entering the bus. By touching the ticket machine with the bus card the tickets on the card is checked. A single card can have different tickets on it, and if a valid ticket for this ride is found, the trip is registered and the passenger is allowed to enter the bus.

In the NFC City Campus trail we have replaced the bus card with an Java Card application running on the UICC. This application emulates the bus card (NFC card emulation). Accompanying this Java Card application is an Android application where the user can see the current tickets on the bus card and buy new tickets. New tickets can then be transferred to the emulated bus card on the UICC or to another bus card using NFC. This makes it possible for you to buy tickets for family or friends that do not have an NFC-enabled phone. They can get the tickets transferred from your phone to the traditional plastic bus card. This application both replaces the bus card, and provide a very convenient way of buying tickets through the mobile phone.

### 4.5 The Presenter Application

The presenter application is meant for all situations where a presentation is to be presented on a screen. An Android application on the phone lists all your presentations available. If the presentation has meta-data related to when or where this presentation is planned, the application can list them in the order of relevance. Presentations planned close to the current location and/or time will be listed first. When ready to do the presentation, the correct presentation is selected and an NFC tag at or close to the screen is touched. The presentation will automatically appear on the screen and the user can use the Android application to control the presentation. This ensures no more hassle with connection cables to the projector or transferring the presentation from the USB memory stick to the computer at the lecture hall or meeting room.

The NFC tag touched contains an URL representing the screen in the room. The Android application uses this URL to connect to a web-service controlling the screen. It transfers the presentation to the server and uses a web-service API to control the presentation.

Other participants at the lecture or meeting can touch the same tag to download a copy of the presentation to their phones. In the current implementation the presentation will be downloaded to a pre-defined Dropbox folder of the user, but the application can be easily extended to download it to a wide range of storage services or locally on the phone. In the current implementation the presenter also use a pre-defined Dropbox folder as the means of transferring the presentations to the phone.

### 4.6 User Programable Tags

Each user are given a set of programable NFC tags and a short introduction of how to program them (using a pre-installed Android application on the phone). These tags can be used to access often used services on the phone just with a

touch. This is some examples of tasks performed by the phone when touching a tag programmed by the user:

- Send a predefined SMS message to a predefined phone number. Some users have installed such a tag in the car with the message "On my way home" sent to a family member. Then they can send this message just by touching the tag (no typing of text message and no searching for mobile phone number of the receiver).
- Set the alarm clock to a predefined time. Some users have installed a set of such tags beside their beds with different wake up times. When they go to bed they do not have to open the alarm clock application and set the time on their phone. They just touch the tag corresponding to the time they want to wake up the next day.
- Put the phone in silent mode. Such a tag is typically installed at a meeting room where the user does not have to open the setting application to perform this task. It can also be a reminder for the attendants to do this at the meeting.
- Connect the phone to a wireless network. The process of setting up and typing all the configuration data to connect your phone to a wireless network can be cumbersome and error-prone. Just by touching a tag to do this is the user friendly alternative. That means that access to the tag is equal to access to the network.

The information necessary for the phone to perform these tasks are found on the NFC tags, and are examples of tasks where the touch of a tag triggers some processing on the phone.

## 5 Conclusion

We have in this paper described how NFC technology can support user-friendly service interaction, and have in particular identified close range communication and context awareness as important NFC characteristics for providing convenience and user-friendliness for technologically advanced services.

NFC technology can simplify communication and service startup by providing efficient and user-friendly startup through just a touch of a tag. The paper give examples of a number of NFC-enabled services, developed as part of an NFC City project and currently part of an NFC City Campus trial. There we compare the touch with the alternative, which very often is a manual setup of communication or startup of services, requiring both technical skills and knowledge of how and where to find the required information or services.

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