

NFC Technology for the Optimization of Business Processes

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Abstract - Near Field Communication (NFC) is a part of RFID Technology based on inductive coupling with a reading range of a few centimeters. NFC is used in particular with smart cards, electronic passports, loyalty and signature cards and mobile telephones that act like smart cards. In 2004 Nokia, Sony and Philips founded the NFC Forum (www.nfcforum.org). NFC provides better communication than Bluetooth and WLAN and enables simple, intuitive communication. Instead of using an elaborate pairing process with several distinct steps, the user simply holds a NFC enabled device close together for a short time. The devices identify each other without the usual bandwidth search, device selection, service selection or password transfer. NFC is expected to be used with smart cards, RFID tags, bank cards, credit cards, entertainment electronics, mobile phones, PCs and other smart objects. Leading financial companies have already issued NFC credit cards that accelerate wireless payment transactions and enhance their security.

I. INTRODUCTION

NFC is designed as a short-range standardized technology for providing contactless communications for mobile devices [1]. NFC is intended to be an intuitive method of establishing ad-hoc connections, simply requiring that two NFC-enabled devices are brought in close physical proximity to each other. NFC also allows for devices to interact with existing contactless/RFID (Radio Frequency Identification) systems. In ‘passive’ communication mode NFC allows devices to emulate passive contactless smart cards, while ‘active’ mode allows for devices to act as contactless smart card readers or to communicate with each other. The use of NFC-enabled devices in contactless systems has received much publicity.

II. TECHNOLOGY BACKGROUND

NFC technology allows for the integration of contactless technology into active devices, such as mobile phones. A NFC enabled device can act as both a “contactless card” and a “contactless reader”.

NFC devices, as specified in ISO-18092/ECMA-340 [1] and ISO-21481/ ECMA-352 [2], are compatible with existing contactless systems adhering to ISO 14443 [3], ISO 15693 [4] and FeliCa [5]. The NFC standards also define a communication mode for peer-to-peer (P2P) or ‘active’ communication, with the purpose of facilitating communication between two NFC-enabled devices.

At first sight, NFC is not an RFID system, but a wireless data interface between devices is similar to Infrared or the well-known Bluetooth. However, NFC has several characteristics that are of interest in relation to RFID systems. Data transmission between two NFC interfaces uses high-frequency magnetic alternating fields in the frequency range of 13.56 MHz. The maximum communication range typical for NFC data transmission is 20 cm because the respective communication counterpart is located in the near-field of the transmitter antenna; therefore the communication is called near-field communication.

Figure 1 illustrates the physical principle of data transmission between two NFC interfaces.

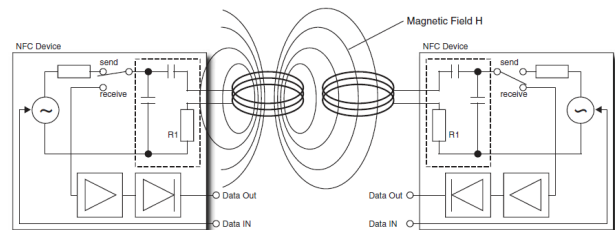


Figure 1. In active mode, the NFC interfaces alternately emit magnetic fields for data transmission [6]

For communication between two NFC interfaces, the individual NFC interface can take on different functions, i.e. that of an NFC initiator (master device) or an NFC target (slave device). Communication is always started by the NFC initiator. In addition, NFC communication distinguishes between two different operational modes, the active and the passive mode.

A. Active Mode

In order to transmit data between two NFC interfaces in active mode, at first one of the NFC interfaces activates its transmitter and thus works as the NFC initiator. The high-frequency current that flows in the antenna induces an alternating magnetic field which spreads around the antenna loop. Part of the induced magnetic field moves through the antenna loop of the other NFC interface which is located close by. Then a voltage is induced in the antenna loop and can be detected by the receiver of the other NFC interface. If the NFC interface receives signals and the corresponding commands of an NFC initiator, this NFC interface automatically adopts the roll of an NFC target. For data transmission between the NFC interfaces,

the amplitude of the emitted magnetic alternating field is modulated ('Amplitude-Shift Keying' - ASK modulation), similar to the data transmission between RFID reader and transponder. However, the difference between an NFC target in active mode and an RFID transponder consists in that the magnetic alternating field has to supply the transponder with power in order to operate the microchip. As opposed to this, the electronic device containing the NFC interface supplies the interface with power. The transmission direction is reversed in order to send data from the NFC target to the NFC initiator. This means that the NFC target activates the transmitter and the NFC initiator switches to receiving mode. Both NFC interfaces alternately induce magnetic fields where data is transmitted from transmitter to receiver only.

In 'active' NFC, the participants communicate in a "client-server" model. The device that starts the data exchange is known as the Initiator and the recipient is known as the Target. In 'active' mode, the Initiator and Target uses their own generated RF field to communicate with each other. First the Initiator transmits an RF carrier, which it uses to send data to the Target. Once an acknowledgment for the data sent has been received from Target (by modulating the existing field), the Initiator switches the carrier off. The original Target then reprises the role of Initiator, switching on its carrier, and transmits a response to the original Initiator. For the purposes of reader's clarity, we call the NFC enabled mobile phone configured as the Initiator to be in "writing" mode and the phone configured as the Target to be in "reading" mode.

On NFC-enabled mobile phones the Secure Element (SE) provides the security means to establish trust between service provider and the device. The SE also provides a secure environment for hosting sensitive applications and storing cryptographic keys. Currently there are three main architectures for NFC.

The first involves an SE that exists as an 'independent' embedded hardware module, i.e. a stand-alone IC (Integrated Chip) is built into the phone. In the second option, the SE is implemented within the UICC (Universal Integrated Circuit Card) [7]. The third option implements the SE on a removable memory component such as a Secure Multi-Media Card (Secure MMC) or Secure Digital card (Secure SD).

B. Passive Mode

In the passive mode, too, the NFC initiator induces a magnetic alternating field for transmitting data to the NFC target. The field's amplitude is modulated in line with the pulse of the data to be transmitted (ASK modulation). However, after having transmitted a data block, the field is not interrupted, but continues to be emitted in an unmodulated way. The NFC target now is able to transmit data to the NFC initiator by generating a load modulation. The load modulation method is also known from RFID systems.

Using this method for NFC interfaces provides a number of advantages and interesting options for practical operation. Thus the different roles of the two NFC interfaces within the NFC communication can be negotiated and changed, at any time. An NFC interface

with weak power supply, e.g. with a low-capacity battery, can negotiate and adopt the role of the NFC target in order to save power by transmitting data via load modulation.

The NFC interface that is the target is also able to establish, in addition to other NFC interfaces, the communication to compatible passive transponders (e.g. according to ISO/IEC 14443) that the NFC target supplies with power and that, via load modulation, can transmit data to the NFC interface. This option enables electronic devices equipped with NFC interfaces, such as NFC mobile phones, to read and write on different transponders such as smart labels or e-tickets. As the NFC interface in this case behaves similar to an RFID reader, this option is also called 'reader mode' or 'reader-emulation mode'.

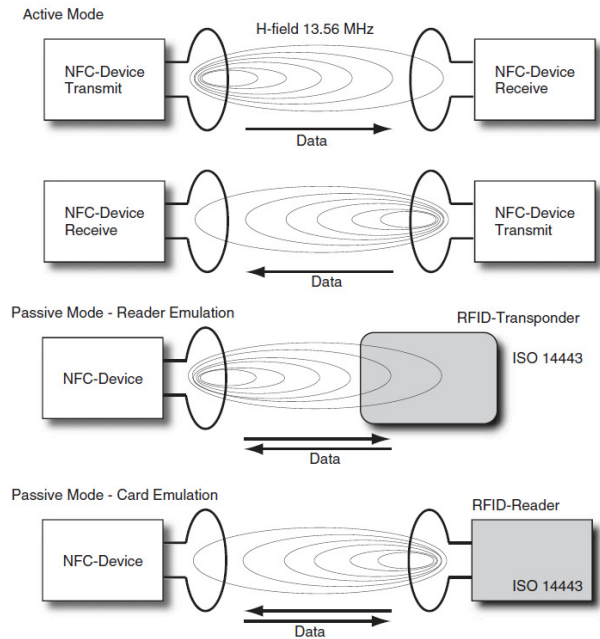


Figure 2. NFC distinguishes between three different operating modes: active mode (i); and passive mode in the operating modes reader emulation (ii); and card emulation (iii) [6]

If an NFC interface is located close to a compatible RFID reader (e.g. according to ISO/IEC 14443), the NFC reader is also able to communicate with a reader. Here, the NFC interface adopts the roll of an NFC target and can transmit data to the reader using load modulation. This option enables RFID readers to exchange data with an electronic device with NFC interface, such as NFC mobile phones. From the reader's perspective, the electronic device behaves like a contactless smart card; this option is also called 'card mode' or 'card-emulation mode' [6].

III. NFC APPLICATIONS

NFC provides a technology that makes it possible simply to add a very flexible RFID interface to electronic devices. In addition, NFC is compatible with MIFARE, a common NXP contactless smart card technology, and with FELICIA, Sony's contactless smart card system [8] as well as with all ISO/IEC 14443-A-specified transponders and readers. NFC application can be divided into different categories [9]:

- **Touch and Go:** in this category we find applications such as access control systems, logistics reporting systems or security technology as well as ticketing systems. Here the NFC device behaves like a contactless smart card that contains an access code or ticket and has only to move quickly past the reader.
- **Touch and Confirm:** applications such as mobile payment where the user has to confirm the interaction by pressing a button or entering a PIN into the NFC device.
- **Touch and Capture:** here, the NFC device is located close to the transponder (smart label) which for instance can be attached to a smart poster. The NFC device can read out transponders for information such as phone numbers or a URL for further information.
- **Touch and Link:** applications that require an online connection of the NFC device. Data read by the NFC interface are forwarded via an online connection (GPRS, UMTS) to a server. The server can process these data and send back information to the NFC device where it is shown on the display.
- **Touch and Connect:** a connection of two NFC devices for transmitting images, MP3 files or simply for matching phone directories of two NFC-enabled mobile phones.
- **Touch and Explore:** it is possible to randomly combine the above categories. Touch and Explore allows the user to intuitively 'find and explore' new applications.

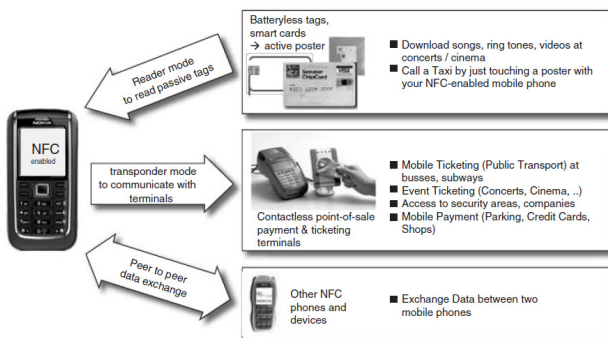


Figure 3. NFC provides three different operating modes with a variety of applications [6]

There are clear signs that in the future the mobile phone will be the personal NFC device. As most people carry their mobile phones on them all the time there is a valuable additional benefit if everyday services can be provided through an NFC-enabled mobile phone. Starting in 2005, throughout the world NFC applications are being introduced. NFC devices are most easily used in applications that already dispense with of a reader infrastructure. Therefore, contactless smart cards of a public transportation ticket application can be easily replaced by NFC-enabled mobile phones. The phone's NFC interface takes on the function of the contactless

smart card, with the ticket data sets being safely stored in a secure element. However, the special advantage of mobile phones is that, via the GSM interface, new additional functions and services can be offered that may lead to novel business models. OTA services (OTA = over the air) can administer data in the secure element of an NFC-enabled phone. OTA services make use of the mobile's option to transmit data via GPRS or UMTS. Using OTA services ensures secrecy of personalization data due to strong encryption and authentication [10]. This way it is possible for public transportation businesses to use OTA services to automatically send customers an electronic monthly season ticket at the beginning of the month which the customer can save in his or her NFC phone. Even a single ticket that was ordered with the Internet browser of a modern mobile phone could be directly transmitted to the secure element of the mobile after processing the order with OTA services; and it will be immediately available to the user.

IV. NFC APPLICATIONS FOR CONSUMERS

In April 2006, Royal Philips Electronics and Visa International published the results of a study on NFC technology for contactless payment, with the title 'How Would You Like to Pay for That? Cash, Card or Phone?'. According to the study, consumers rate the convenience, ease of use and 'coolness' of NFC mobile telephones very highly [10]. The study participants used NFC mobile telephones to make purchases in coffee shops, download films in DVD shops and buy concert tickets via smart posters, among other things. Further expansion of NFC technology is thus very probable.

A. Application scenarios for NFC mobile telephones

A smart poster has an RFID tag with a suitable marking. If an NFC telephone is held close to the tag, it can read the data stored in the tag. It can then call the ticket centre of a concert promoter or similar organization to reserve tickets immediately and pay for them. When the concertgoer arrives at the event location, he or she holds a mobile telephone next to the check-in terminal at the entrance and is immediately allowed to enter. For the concertgoer, standing in line to pick up a ticket is a thing of the past. It could hardly be faster or easier.

NFC-enabled mobile phones could even be used to implement applications that are problematic regarding the installation and networking of the readers (e.g. in vehicles) or that are too expensive (if the target is nationwide coverage, for instance). Here, the stationary reader and portable transponder simply switch their traditional roles. This was the case of the project Touch and Travel introduced in 2005 by Deutsche Bahn AG where NFC-enabled mobile phones used as tickets for long distance travel [6]. Railway stations that are part of the Touch and Travel network only need to be equipped with passive transponders (ISO/IEC 14443) that are located in eye-catching 'touchpoints'. To buy a valid ticket, the previously registered customer starts a specific application – the Touch and Travel applet – on an NFC-enabled mobile phone immediately prior to the journey and moves the phone into the reading range of the touchpoint transponder. The Touch and Travel applet now builds an

online connection via mobile phone to a data centre, transmits the data read out of the transponder to a server and writes some of the data received by the server into the mobile phone's secure element. This way the customer is booked into the system and the railway station where the touchpoint was read is entered as departure station of the forthcoming journey. The booking data set entered into the secure element now constitutes a valid ticket and can be easily verified by the conductor with a portable reader. At the end of the journey, the customer simply goes to the nearest touchpoint and repeats the reading procedure. This way, the customer checks out of the system, the journey is registered as ended and the corresponding price is calculated.

Even for payment transactions, the use of NFC phones



Figure 4. An NFC-enabled mobile phone with the corresponding payment application simulates a contactless credit or debit card [8]

opens up completely new opportunities. An NFC mobile phone that is used for payment simulates contactless credit or debit cards (card emulation mode). The POS terminal cannot distinguish whether the card holder uses a contactless card or an NFC phone with the corresponding payment application. The advantage is obvious: If the POS terminal includes a contactless reader NFC technology can be accepted for payment without any additional efforts. This does not affect the processing of the payment with NFC phones as the existing infrastructure can be used. Even if the battery is empty, NFC phones can still be used for paying as the POS terminal contactlessly provides the necessary power to the NFC chip.

Differences become obvious when the 'credit card in the phone' supports additional functions that traditional cards do not have. An NFC-enabled phone is, strictly speaking, a highly complex IT system and can store several card data sets in the secure element, i.e. also several credit and debit cards of different payment systems. During the payment process, the 'card holder' (i.e. the phone user) only has to select a preferred card or has the option to previously make this selection with a special menu entry in the NFC phone. Other possible functions include the temporary inactivation of the card; for instance, if owner lend the phone to somebody else who is not supposed to use the stored credit cards. OTA services can be used to personalize the secure element with personal credit card data and extend an existing expired card. If the owner of an NFC-enabled phone registers the phone as lost and wants to remotely

inactivate the card functions he or she can easily use OTA services to do so.

Some pilot projects and scenarios [10]:

- Philips Arena, Atlanta, USA. Sports fans can use NFC here to buy products or download mobile contents – such as ring tones, screen savers or video clips – by holding their mobile telephone next to a smart poster.
- City of Caen, France. During a six-month trial project, 200 residents of the city used Samsung NFC mobile telephones to make payments in shops and car parks and download video clips, bus schedules and information about interesting sites.
- Taiwan Proximity Mobile Service, Taiwan. Prototype BenQ NFC mobile telephones were used to test secure payment transactions for public transport in Taiwan.
- Ordering a taxi at a hotel. An out-of-town hotel guest needs to order a taxi. In the future, the guest can simply touch his or her mobile telephone to the tag of a taxi poster in order to be connected to the taxi dispatch centre. The dispatcher knows the customer's location right away without asking and thus knows where to send the taxi.
- Arriving in Paris by train. A traveller is looking for the schedule of trains returning to the airport. The traveller touches the tag on the schedule and enters the desired departure time, and suitable connections are downloaded to his or her mobile telephone.
- Paying parking fees and bus fares. To pay for a parking ticket in a controlled parking zone, you can hold your mobile telephone next to a parking ticket dispenser. You can pay for a bus fare by swiping a mobile telephone past a check-in unit.
- Access to ski areas. Smart cards are already widely used in large ski areas for contactless access to the slopes. In the future, you can use your mobile telephone and avoid queuing at the lift station for a smart card. This also puts an end to arriving back home and discovering that you forgot to return the smart card and collect your deposit.
- Calling a service hotline. If you have a malfunction with a home appliance or trouble using the appliance and you want to sort this out by calling a service hotline, you usually do not know the telephone number. In the future, you could simply hold your mobile telephone next to the nameplate of the appliance and the call would be placed for you automatically.

B. Industrial Uses of NFC

NFC mobile telephones also offer new possibilities for industrial uses, since they are an order of magnitude less expensive than current RFID readers. They are thus a logical choice to replace RFID readers. This naturally

assumes that employees who use the RFID readers already have mobile telephones. The 13.56 MHz NFC frequency is also widely used for RFID tags on individual objects (items), so the ROI in RFID methods can be accelerated considerably in trade and industrial applications. For example, Nokia offers a service product for security and maintenance organizations that require full-coverage communication with their technicians or contractual partners [10]. NFC mobile telephones can be used to manage and monitor the tasks of technicians and security personnel. For example, if the check points of a security round are fitted with RFID tags, the security guard only has to hold his or her mobile telephone next to the tags to document proper performance of the round in terms of locations and times. The same holds true for maintenance technicians if the equipment to be maintained is fitted with RFID tags. In this way, the necessary documentation of the work or the rounds can be generated automatically and concurrently with the activities.

V. CONCLUSION

The use of NFC Technology not only creates a great method for mobile payments and data communications but it also allows these experiences to be extended and create vision of future - technological ubiquity, one in which computing through dedicated devices will slowly disappear, while information processing capabilities will emerge throughout our surrounding environment. With the benefit of integrated information processing capacity, industrial products will take on smart capabilities. They may also take on electronic identities that can be queried remotely, or be equipped with sensors for detecting physical changes around them. Such developments will make the merely static objects of today dynamic ones - embedding intelligence in our environment and new business opportunities. The Internet of Things will enable forms of collaboration and communication between people and things, and between things themselves. With continuing developments in miniaturization and declining costs, it is becoming economically feasible to make everyday objects smarter, and to connect the world of people with the world of things.

One of the most important challenges is convincing users to adopt emerging technologies like RFID. Concerns over privacy and data protection are widespread, particularly as sensors and smart tags can track a user's movements, habits and preferences. But whatever the concern, one thing remains clear: scientific and technological advances in these fields continue to move ahead at breakneck speed. Further, the traditional phone interface is generally too bulky for anything beyond dialing numbers and the simple act of touching an object to gain access to information and services is both simple and intuitive for the majority of users.

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