Near field communication

Near field communication (**NFC**) is a set of standards for smartphones and similar devices to establish radio communication with each other by touching them together or bringing them into close proximity, usually no more than a few centimeters. Present and anticipated applications include contactless transactions, data exchange, and simplified setup of more complex communications such as Wi-Fi.[1] Communication is also possible between an NFC device and an unpowered NFC chip, called a "tag".[2]

An NFC-enabled mobile phone interacting with a SmartPoster

NFC standards cover communications protocols and data exchange formats, and are based on existing radio-frequency identification (RFID) standards including ISO/IEC 14443 and FeliCa.[3] The standards include ISO/IEC 18092[4] and those defined by the NFC Forum, which was founded in 2004 by Nokia, Philips and Sony, and now has more than 160 members. The Forum also promotes NFC and certifies device compliance.[5]

A ticket stamping machine of the Austrian Federal Railways that can be used to purchase mobile tickets ("Handy-Ticket").

Uses

NFC builds upon RFID systems by allowing two-way communication between endpoints, where earlier systems such as contactless smart cards were one-way only.[6] Since unpowered NFC "tags" can also be read by NFC devices,[2] it is also capable of replacing earlier one-way applications.

Commerce

NFC devices can be used in contactless payment systems, similar to those currently used in credit cards and electronic ticket smartcards, and allow mobile payment to replace or supplement these systems. For example, Google Wallet allows consumers to store credit card and store loyalty card information in a virtual wallet and then use an NFC-enabled device at terminals that also accept MasterCard PayPass transactions.[7] Germany,[8] Austria,[9] Finland,[10] New Zealand,[11] and Italy[12] have trialed NFC ticketing systems for public transport.

India is implementing NFC based transactions in box offices for ticketing purposes.[13]

Bluetooth and Wi-Fi connections

NFC offers a low-speed connection with extremely simple setup, and can be used to bootstrap more capable wireless connections.[14] For example, the Android Beam software uses NFC to complete the steps of enabling, pairing and establishing a Bluetooth connection when doing a file transfer.[15] Nokia and Sony have used NFC technology to pair Bluetooth headsets and speakers with one tap in its NFC-enabled devices. The same principle can be applied to the configuration of Wi-Fi networks.

Social networking

NFC can be used in social networking situations, such as sharing contacts, photos, videos or files,[16] and entering multiplayer mobile games.[17]

Identity and access tokens

The NFC Forum promotes the potential for NFC-enabled devices to act as electronic identity documents and keycards.[14] As NFC has a short range and supports encryption, it may be more suitable than earlier, less private RFID systems.

Smartphone automation and NFC tags

Smartphones equipped with NFC can be paired with NFC tags or stickers which can be programmed by NFC apps to automate tasks. These programs can allow for a change of phone settings, a text to be created and sent, an app to be launched, or any number of commands to be executed, limited only by the NFC app and other apps on the smartphone. These applications are perhaps the most practical current uses for NFC since it does not rely on a company or manufacturer but can be utilized immediately by anyone anywhere with an NFC equipped smartphone and an NFC tag.[18]

History

NFC traces its roots back to radio-frequency identification, or RFID. RFID allows a reader to send radio waves to a passive electronic tag for identification, authentication and tracking.

- 1983 The first patent to be associated with the abbreviation RFID was granted to Charles Walton.[19]
- 1995 wallet paying and receiving electronic, described in the report and annexes describing the invention of Gaston Schwabacher in 0017 patented protocol 24/01/1995 at INPI Brazil with the IP number 9500345
- 2004 Nokia, Philips and Sony established the Near Field Communication (NFC) Forum[20]
- 2006 Initial specifications for NFC Tags[21]
- 2006 Specification for "SmartPoster" records[22]
- 2006 Nokia 6131 was the first NFC phone[23]
- 2009 In January, NFC Forum released Peer-to-Peer standards to transfer contact, URL, initiate Bluetooth, etc.[24]
- 2010 Samsung Nexus S: First Android NFC phone shown[25][26]
- 2011 Google I/O "How to NFC" demonstrates NFC to initiate a game and to share a contact, URL, app, video, etc.[16]
- 2011 NFC support becomes part of the Symbian mobile operating system with the release of Symbian Anna version.[27]
- 2011 Research In Motion is the first company for its devices to be certified by MasterCard Worldwide, the functionality of PayPass[28]
- 2012 March. EAT, a well known UK restaurant chain and Everything Everywhere (Orange Mobile Network Operator) partner on the UK's first nationwide NFC enabled smartposter campaign. (lead by Rene' Batsford, Head of ICT for EAT, also known for deploying the UK's first nationwide contactless payment solution in 2008) A

specially created mobile phone app is triggered when the NFC enabled mobile phone comes into contact with the smartposter.[29]

- 2012 Sony introduces the "Smart Tags", which use NFC technology to change modes and profiles on a Sony smartphone at close range, included in the package of (and "perfectly paired" with) the Sony Xperia P Smartphone released the same year.[30]
- 2012 Samsung introduces TecTile;[31] a set of MIFARE NFC stickers and a companion application for Android to read and write the TecTile stickers, and design macros that can be triggered by them.

Essential specifications

NFC is a set of short-range wireless technologies, typically requiring a distance of 10 cm or less. NFC operates at 13.56 MHz on ISO/IEC 18000-3 air interface and at rates ranging from 106 kbit/s to 424 kbit/s. 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 is possible, provided both devices are powered.[6] A patent licensing program for NFC is currently under development by Via Licensing Corporation, an independent subsidiary of Dolby Laboratories. A public, platform-independent NFC library is released under the free GNU Lesser General Public License by the name libnfc.[32]

NFC tags contain data and are typically read-only, but may be rewriteable. They can be custom-encoded by their manufacturers or use the specifications provided by the NFC Forum, an industry association charged with promoting the technology and setting key standards. The tags can securely store personal data 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 that provide different communication speeds and capabilities in terms of configurability, memory, security, data retention and write endurance. Tags currently offer between 96 and 4,096 bytes of memory.

- As with proximity card technology, near-field communication uses magnetic induction between two loop antennas located within each other's near field, effectively forming an air-core transformer. It operates within the globally available and unlicensed radio frequency ISM band of 13.56 MHz. Most of the RF energy is concentrated in the allowed ±7 kHz bandwidth range, but the full spectral envelope may be as wide as 1.8 MHz when using ASK modulation.[33]
- Theoretical working distance with compact standard antennas: up to 20 cm (practical working distance of about 4 cm)
- Supported data rates: 106, 212 or 424 kbit/s (the bit rate 848 kbit/s is not compliant with the standard ISO/IEC 18092)
- There are two modes:
  - Passive communication mode: The initiator device provides a carrier field and the target device answers by modulating the existing field. In this mode, the target device may draw its operating power from the initiator-provided electromagnetic field, thus making the target device a transponder.
  - Active communication mode: Both initiator and target device communicate by alternately generating their own fields. A device deactivates its RF field while it is waiting for data. In this mode, both devices typically have power supplies.

Speed	Active device	passive device
424 kbit/s	Manchester, 10% ASK	Manchester, 10% ASK
212 kbit/s	Manchester, 10% ASK	Manchester, 10% ASK
106 kbit/s	Modified Miller, 100% ASK	Manchester, 10% ASK

- NFC employs two different codings to transfer data. If an active device transfers data at 106 kbit/s, a modified Miller coding with 100% modulation is used. In all other cases Manchester coding is used with a modulation ratio of 10%.
- NFC devices are able to receive and transmit data at the same time. Thus, they can check for potential collisions, if the received signal frequency does not match with the transmitted signal's frequency.

Comparison with Bluetooth

Aspect	NFC	Bluetooth	Bluetooth Low Energy
RFID compatible	ISO 18000-3	active	active
Standardisation body	ISO/IEC	Bluetooth SIG	Bluetooth SIG
Network Standard	ISO 13157 etc.	IEEE 802.15.1	IEEE 802.15.1
Network Type	Point-to-point	WPAN	WPAN
Cryptography	not with RFID	available	available
Range	< 0.2 m	~100 m (class 1)	~50 m
Frequency	13.56 MHz	2.4–2.5 GHz	2.4–2.5 GHz
Bit rate	424 kbit/s	2.1 Mbit/s	~1.0 Mbit/s
Set-up time	< 0.1 s	< 6 s	< 0.006 s
Power consumption	< 15mA (read)	varies with class	< 15 mA (transmit or receive)

NFC and Bluetooth are both short-range communication technologies that are integrated into mobile phones. As described in technical detail above, NFC operates at slower speeds than Bluetooth, but consumes far less power and doesn't require pairing.[34]

NFC sets up more quickly than standard Bluetooth, but has a lower transfer rate than Bluetooth low energy. With NFC, instead of performing manual configurations to identify devices, the connection between two NFC devices is automatically established quickly: in less than a tenth of a second. The maximum data transfer rate of NFC (424 kbit/s) is slower than that of Bluetooth V2.1 (2.1 Mbit/s). With a maximum working distance of less than 20 cm, NFC has a shorter range, which reduces the likelihood of unwanted interception. That makes NFC particularly suitable for crowded areas where correlating a signal with its transmitting physical device (and by extension, its user) becomes difficult.

In contrast to Bluetooth, NFC is compatible with existing passive RFID (13.56 MHz ISO/IEC 18000-3) infrastructures. NFC requires comparatively low power, similar to the Bluetooth V4.0 low energy protocol. When NFC works with an unpowered device (e.g., on a phone that may be turned off, a contactless smart credit card, a smart poster), however, the NFC power consumption is greater than that of Bluetooth V4.0 Low Energy, since illuminating the passive tag needs extra power.[34]

Standardization bodies and industry projects

Standards

NFC was approved as an ISO/IEC standard on December 8, 2003 and later as an ECMA standard.

NFC is an open platform technology standardized in ECMA-340 and ISO/IEC 18092. These standards specify the modulation schemes, coding, transfer speeds and frame format of the RF interface of NFC devices, as well as initialization schemes and conditions required for data collision-control during initialization for both passive and active NFC modes. Furthermore, they also define the transport protocol, including protocol activation and data-exchange methods. The air interface for NFC is standardized in:

ISO/IEC 18092 / ECMA-340

Near Field Communication Interface and Protocol-1 (NFCIP-1)[35]

ISO/IEC 21481 / ECMA-352

Near Field Communication Interface and Protocol-2 (NFCIP-2)[36]

NFC incorporates a variety of existing standards including ISO/IEC 14443 both Type A and Type B, and FeliCa. NFC enabled phones work basically, at least, with existing readers. Especially in "card emulation mode" a NFC device should transmit, at a minimum, a unique ID number to an existing reader.

In addition, the NFC Forum has defined a common data format called NFC Data Exchange Format (NDEF [37]), which can store and transport various kinds of items, ranging from any MIME-typed object to ultra-short RTD-documents,[38] such as URLs.

The NFC Forum added the Simple NDEF Exchange Protocol to the spec that allows sending and receiving messages between two NFC-enabled devices.[39]

GSMA

The GSM Association (GSMA) is the global trade association representing nearly 800 mobile phone operators and more than 200 product and service companies across 219 countries. Many of its members have led NFC trials around the World and are now preparing services for commercial launch.[40]

GSM is involved with several initiatives:

- Standard setting: GSMA is developing certification and testing standards to ensure the global interoperability of NFC services.[40]
- The **Pay-Buy-Mobile initiative** seeks to define a common global approach to using Near Field Communications (NFC) technology to link mobile devices with payment and contactless systems.[41][42]
- On November 17, 2010, after two years of discussions, AT&T, Verizon and T-Mobile launched a joint venture intended to develop a single platform on which technology based on the Near Field Communication (NFC) specifications can be used by their customers to make mobile payments. The new venture, known as ISIS [43], is designed to usher in the broad deployment of NFC technology, allowing NFC-enabled cell phones to function similarly to credit cards for the 200 million customers using cell phone service provided by any of the three carriers throughout the United States.

StoLPaN

StoLPaN ('Store Logistics and Payment with NFC') is a pan-European consortium supported by the European Commission's Information Society Technologies program. StoLPaN will examine the as yet untapped potential for the new kind of local wireless interface, NFC and mobile communication.

NFC Forum

The NFC Forum is a non-profit industry association formed on March 18, 2004, by NXP Semiconductors, Sony and Nokia to advance the use of NFC short-range wireless interaction in consumer electronics, mobile devices and PCs. The NFC Forum promotes implementation and standardization of NFC technology to ensure interoperability between devices and services. As of March 2011, the NFC Forum had 135 member companies.[44]

Alternative form factors

To realize the benefits of NFC in cellphones not yet equipped with built in NFC chips a new line of complementary devices were created. MicroSD and UICC SIM cards were developed to incorporate industry standard contactless smartcard chips with ISO14443 interface, with or without built-in antenna. The microSD and SIM form factors with built-in antenna have the great potential as bridge devices to shorten the time to market of contactless payment and couponing applications, while the built in NFC controllers gain enough market share.

Other standardization bodies

Other standardization bodies that are involved in NFC include:

- ETSI / SCP (Smart Card Platform) to specify the interface between the SIM card and the NFC chipset.
- GlobalPlatform to specify a multi-application architecture of the secure element.
- EMVCo for the impacts on the EMV payment applications

Security aspects

Although the communication range of NFC is limited to a few centimeters, NFC alone does not ensure secure communications. In 2006, Ernst Haselsteiner and Klemens Breitfuß described different possible types of attacks, and detail how to leverage NFC's resistance to man-in-the-middle attacks to establish a specific key.,[45] Unfortunately, as this technique is not part of the ISO standard, NFC offers no protection against eavesdropping and can be vulnerable to data modifications. Applications may use higher-layer cryptographic protocols (e.g., SSL) to establish a secure channel.

Eavesdropping

The RF signal for the wireless data transfer can be picked up with antennas. The distance from which an attacker is able to eavesdrop the RF signal depends on numerous parameters, but is typically a small number of metres.[46] Also, eavesdropping is highly affected by the communication mode. A passive device that doesn't generate its own RF field is much harder to eavesdrop on than an active device. An attacker can typically eavesdrop within 10m and 1m for active devices and passive devices, respectively.[45] With the use of a patch loop antenna it is possible to place a receiver close to the target and disguise it. This is much like ATM skimming in that it needs to be near the location however in this case no contact with the device or reader is required.

Data modification

It is easy to destroy data by using a jammer. There is no way currently to prevent such an attack. However, if NFC devices check the RF field while they are sending, it is possible to detect attacks.

It is much more difficult to modify data in such a way that it appears to be valid to users. To modify transmitted data, an intruder has to deal with the single bits of the RF signal. The feasibility of this attack, (i.e., if it is possible to change the value of a bit from 0 to 1 or the other way around), is amongst others subject to the strength of the amplitude modulation. If data is transferred with the modified Miller coding and a modulation of 100%, only certain bits can be modified. A modulation ratio of 100% makes it possible to eliminate a pause of the RF signal, but not to generate a pause where no pause has been. Thus, only a `1` that is followed by another `1` might be changed. Transmitting Manchester-encoded data with a modulation ratio of 10% permits a modification attack on all bits.

Relay attack

Because NFC devices usually include ISO/IEC 14443 protocols, the relay attacks described are also feasible on NFC.[47][48] For this attack the adversary has to forward the request of the reader to the victim and relay back its answer to the reader in real time, in order to carry out a task pretending to be the owner of the victim's smart card. This is similar to a man-in-the-middle attack. For more information see a survey of practical relay attack concepts.[49] One of libnfc [50] code examples demonstrates a relay attack [51] using only two stock commercial NFC devices. It has also been shown that this attack can be practically implemented using only two NFC-enabled mobile phones.[52]

Lost property

Losing the NFC RFID card or the mobile phone will open access to any finder and act as a single-factor authenticating entity. Mobile phones protected by a PIN code acts as a single authenticating factor. A way to defeat the lost-property threat requires an extended security concept that includes more than one physically independent authentication factor.

Walk-off

Lawfully opened access to a secure NFC function or data is protected by time-out closing after a period of inactivity. Attacks may happen despite provisions to shut down access to NFC after the bearer has become inactive. The known concepts described primarily do not address the geometric distance of a fraudulent attacker using a lost communication entity against lawful access from the actual location of the registered bearer. Additional features to cover such an attack scenario dynamically shall make use of a second wireless authentication factor that remains with the bearer in case of the lost NFC communicator. Relevant approaches are described as an electronic leash or its equivalent, a *wireless key.*

NFC-enabled handsets

In 2011, handset vendors released more than 40 NFC-enabled handsets. Notably absent among them was Apple with its iPhone; version 6 of its iOS mobile operating system does not support NFC. According to a *Wall Street Journal* article, today's Apple prefers not to be in a first mover position.[53] Google, on the other hand, includes NFC functionality in their Android mobile operating system and provides a NFC payment service, Google Wallet. BlackBerry devices have also supported NFC using BlackBerry Tag on a number of devices running BlackBerry OS 7.0 and greater.[54] Mastercard has added further NFC support for PayPass for the Android and BlackBerry platforms, enabling PayPass users to make payments using their Android or BlackBerry smartphones.[55] Microsoft added native NFC functionality in their mobile OS with Windows Phone 8, as well as the Windows 8 operating system. Microsoft provides the "Wallet hub" in Windows Phone 8 for NFC payment, and can integrate multiple NFC

payment services within a single application.[56]

Deployment

As of April 2011, several hundred NFC trials have been conducted. Some firms have moved to full-scale service deployments, spanning either a single country or multiple countries. Multi-country deployments include Orange's rollout of NFC technology to banks, retailers, transport, and service providers in multiple European countries,[57] and Airtel Africa and Oberthur Technologies deploying to 15 countries throughout Africa.[58]

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Further reading

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- Memory Capacity and Compatibility of Common NFC Chips (http://rapidnfc.com/which_nfc_chip)

External links

- A day at MIT with Near-Field Communication (http://vimeo.com/2028724/)
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