NFC – the intuitive contactless technology becomes reality

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Near Field Communication (NFC) is opening-up completely new perspectives for the mobile communication industry. It enables contactless peer-to-peer communication, reading/writing of contactless cards and, when combined with a smart card IC, emulation of a contactless card. NFC has taken major steps towards market acceptance: ISO standards are in place for the interface and communication protocols, many leading companies in the field are promoting it within the NFC Forum, and numerous field trials are being deployed around the world. Different architectures are being considered for NFC and security mobile phone architectures. The first Philips cellular system solution integrating NFC hardware and software illustrates a successful implementation of one of these architectures.

Keywords: **Near Field Communication; contactless; wireless; contactless systems; data exchange; smart cards; mobile telephone systems; NFC Forum**

Die intuitive kontaktlose NFC-Technologie wird Realität.

Die von Philips und Sony gemeinsam entwickelte Near Field Communication (NFC), eine kontaktlose Schnittstellentechnologie für den Datenaustausch über kurze Entfernungen bis zu 10 cm, eröffnet völlig neue Perspektiven für die Elektronikindustrie. Mit NFC ist es möglich, zwei beliebige Geräte drahtlos miteinander zu verbinden, um einfach und sicher Informationen auszutauschen oder Inhalte und Dienste abzurufen. NFC kann auch als virtuelle Verbindung für den raschen Aufbau von anderen Wireless-Systemen, wie Bluetooth oder 802.11, fungieren. Die NFC-Technologie ist darüber hinaus mit weithin verwendeter kontaktloser Smart Card-Infrastruktur kompatibel. NFC ist bereits heute gemäß den internationalen Normierungsbehörden nach ECMA und äquivalent nach ISO/IEC und ETSI standardisiert. Viele führende Unternehmen treiben im Rahmen des NFC Forums die Implementierung und Standardisierung von NFC voran, zahlreiche Pilotprojekte sind gegenwärtig weltweit im Laufen, und verschiedene Systemkonfigurationen werden für NFC und sichere Mobiltelefonie-Anwendungen entwickelt. Philips hat mit der Nexperia Sy.Sol 6100-Plattform eine erste komplette Mobiltelefon-Systemlösung mit NFC-Hard- und -Software konzipiert.

Schlüsselwörter: **Near Field Communication; kontaktlos; drahtlos; Kontaktlos-Systeme; Datenaustausch; Smart Cards; Mobiltelefonie-Systeme; NFC Forum**

1. Introduction to NFC

Jointly developed by Philips and Sony, Near Field Communication (NFC) is a combination of contactless identification and interconnection technologies that enables contactless short-range communication between mobile devices, consumer electronics, PCs and smart objects.

1.1 The NFC experience

Enabling rapid and easy communication, NFC is the perfect solution for exchanging data in our increasingly complex and connected world. Secure mobile payments and transactions, easy peer-to-peer communication and simple access to information on the move become possible with NFC. Its intuitive touch-based operation makes it particularly easy for consumers to use.

NFC related applications could be split into four basic categories:

- Touch and go: applications such as access control or transport/event ticketing, where the user only needs to bring the device storing the ticket or access code close to the reader.
- Touch and confirm: applications such as mobile payment, where the user has to confirm the interaction by entering a password or just accepting the transaction.
- Touch and connect: linking two NFC-enabled devices to enable peer-to-peer transfer of data such as music, pictures or synchronizing address books.
- Touch and explore: NFC devices may offer more than one possible function. The consumer will be able to explore a device's capabilities to find out which functions and services are offered.

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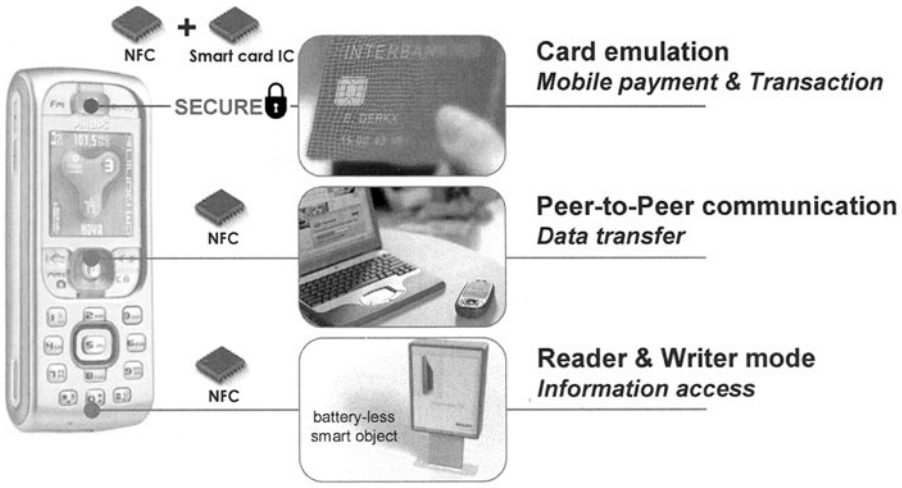

Fig. 1. Overview of possible NFC and security modes

As illustrated in Fig. 1 NFC devices enable these numerous applications because they can read and write contact-less cards, communicate with peer devices and, when combined with a smart card device, emulate contact-less card behaviour. NFC is backward compatible with the proximity contact-less interface standard ISO 14443 and can thus leverage the contact-less infrastructure being currently rollout by major players in the field (e.g., point of sales in banks, restaurants, gas stations, stadiums, public transport, etc.).

1.2 The NFC interface and communication protocol standards

The NFC interface and communication protocols have been standardized in ECMA and ISO/IEC.

ISO 18092 (derived from ECMA 340) defines communication modes for Near Field Communication (NFCIP-1). This international standard specifies modulation schemes, coding, transfer speeds, and frame format of the RF interface, as well as initialization schemes and conditions required for data collision control during initialization. Furthermore, it defines a transport protocol including protocol activation and data exchange methods.

The standard outlines an active and a passive communication mode. Figure 2 and 3 outline these different communication modes. In passive communication mode the Initiator generates the RF field, starts the communication and the target is answering using load modulation for the data transfer. The active communication mode shares the power between both initiator and target (allowing thus lower power consumption). The device that is sending data is also the device that is generating the RF field.

Passive and active modes should support three different communication speeds: 106, 212 and 424 kbit/s. The RF communication at 106 kbit/s and the initialization (single device detection) is compliant to the ISO/IEC 14443A / Philips' MIFARE® communication. The RF communication and initialization at 212 kbit/s is compliant to Sony's FeliCa™ communication scheme.

Furthermore, ISO 21481 (NFCIP-2, derived from ECMA 356) specifies the communication mode selection mechanism, designed not to disturb any ongoing communication at 13.56 MHhz for devices implementing ISO/IEC 18092 (see above), 14443 ("proximity" contact-less interface) and 15693 ("vicinity" contact-less interface).

1.3 The NFC Forum

The NFC Forum (*www.nfc-forum.org*) is a non-profit industry association launched in 2004 by Philips, Nokia and Sony. More than 50 organizations from around the world representing all relevant industry domains have joined the Forum to promote NFC technology (semiconductor companies, handset manufacturers, mobile phone operators, service providers, software companies, smartcard manufacturers, payment processing companies, etc.). MasterCard International, Matsushita Electronic Industrial Co, Ltd, (Panasonic), Microsoft, Motorola, NEC Corporation, Samsung, Texas Instruments and Visa International are Sponsor Members and sit on the Forum's board of directors. The NFC Forum promotes implementation and standardization of NFC technology to ensure interoperability between devices and services. The vision of the NFC Forum is to enable users to access content and services in an intuitive way by simply touching smart objects and connecting devices just by holding them next

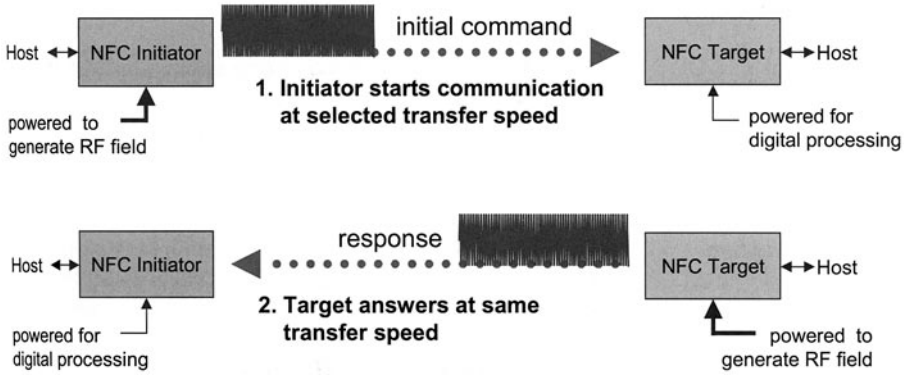

Fig. 2. Passive communication mode defined in ISO 18092

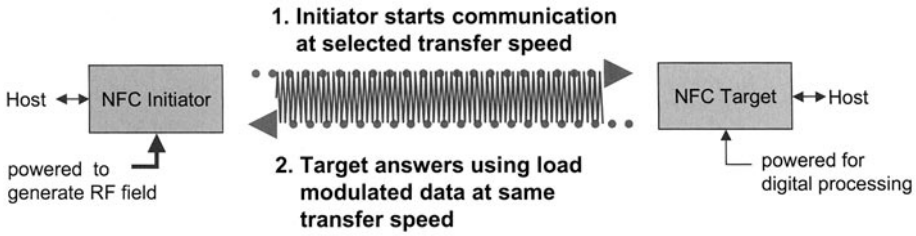

Fig. 3. Active communication mode defined in ISO 18092

to each other. The NFC forum specifies a standard way to code data, identify communication partners (polling) and services (registration and notification), manage various contact-less card/tag formats and a transparent protocol for peer-to-peer communication (NFC device to NFC device).

2. NFC integration in mobile phone platforms

2.1 Benefits of NFC integration in mobile phones

Mobile phones enabled with NFC are set to spur consumer usage and open up revenue opportunities for wireless operators, merchants and handset manufacturers (*Balaban, 2005*). Delivering an intuitive connected consumer experience NFC equipped phones will change the way information and services are distributed paid for and accessed. Enabling secure mobile payments and transaction they can also allow easy peer-to-peer communication and simple access to information on the move.

Mobile payment and transactions with NFC exploits two basic principles of modern society: everyone needs to pay for products and everyday services and just about everyone carries a phone. Results from worldwide implementations demonstrate that consumers everywhere like the convenience of mobile payment (*www.smartcardalliance.org*).

More and more consumers are using mobile phones to download paid content such as ring tones to their phones (currently, 10 to 15 % of mobile operators' revenues come from the downloading of ring tones or small Java-based games). NFC offers a standardized next generation connection that will enable consumers to access digital content (ring tone, song, game, web link, address, discount coupon, etc.) from items such as posters, magazines, kiosks and also enables device to device transfer among NFC equipped cellular phones. NFC offers pull versus push opportunities for location-based services that eliminates unnecessary spamming. The one to one marketing comes from consumer's ability to access content and information from trusted friends in a secure peer based environment.

With the majority of handsets equipped with Bluetooth today (and WiFi tomorrow), NFC can act as an enabler to facilitate data exchange transfer among phones. NFC could also enable multi-player gaming in more handsets. In today's market device interfaces are anything but intuitive and make it difficult to embrace the technology (e.g., scrolling through menu to select the specific Bluetooth device). NFC allows people to interact with their environment without needing to navigate complicated menus or perform complex set-up procedures.

2.2 Possible architectures for NFC and security in mobile phone platforms

Various architectures are being considered for NFC integration in mobile phones. These are a few examples of existing or ongoing implementations:

- The NFC device can be integrated in a phone functional cover. This corresponds for instance to the solution developed by Nokia for their phone model 3220 (*www.nokia.com/link?cid=EDITORIAL_2026*).
- The NFC device can be integrated on the phone main printed circuit board.
- The NFC device can be integrated in a Secure Digital (SD) card as recently announced by wireless dynamics (*Pilato, 2005*).

In order to enable secure applications (e.g. payment) the NFC device is coupled to a secure smart card device (smart card emulation mode described in the introduction). Here also different options are being considered by major players in the field (*Balaban, 2005*):

- NFC + security via the SIM (subscriber identifying module): One or more wires connect the SIM card to a contactless chip complying with NFC technology standards. In this case the SIM would host mobile commerce applications and security keys. The antenna connection is done directly to the NFC chip. NFC and smart card IC currently manufactured by Philips support a two wire digital interface. This interface (S^2C) between a NFC IC and Smart Card IC provides full compatibility with existing contactless standards and has been submitted to ECMA for standardization.
- Secure NFC bypassing the SIM: In this case a specific smart card device is mounted either in the phone functional cover, on the phone main PCB or even in the SD card. The payment/ticketing applications and related security keys are to be stored on the smart card IC. Area/cost attractive solutions combining both the NFC and smart card IC in a single package or chip are also possible candidates.
- Combinations of NFC and security through both the SIM card and a dedicated smart card IC might eventually also be considered.

Final choice of the actual NFC and security implementation will be affected by many factors. Ownership of the secured applications, business partnerships formed between the different players (mobile operators, financial service providers, handset manufacturers, etc.) and the actual personalization process of these secured applications will play an important role in the definition of the optimal implementation.

2.3 Examples of NFC enabled phone applications in the field

Many new NFC enabled contactless services are being tested in the field around the world. A few examples involving the use of NFC enabled mobile phones with Philips NFC technology are listed below:

- In Germany, the Rhein-Main Verkehrsbund (RMV), the public transport authority for Frankfurt is testing an NFC ticketing solution. The trial uses NFC enabled phones to gain access to the local bus network. The system will allow RMV's customers to use a Nokia 3220 phone equipped with a Nokia NFC shell to purchase, store and use electronic travel tickets (*Telecom news*).

- In the Netherlands a trial will be run during the forth coming football season. Supporters will use their phones (Nokia 3220 with the NFC functional shell) to access the ParkStad Limburg Stadium of the Roda JC club as well as to make purchases at food stands and in supporters shop.
- In France, Caen, multiple trials using NFC enabled phones from Samsung (D500) have been announced. These trials will involve car parking access/payment in the city, payment and fidelity applications using a private card in retail stores and finally audio guides for pedestrian visiting city monuments (*Caen trial was launched on October 18, 2005*).
- In Taiwan the Proximity Mobile Transaction Service Alliance (PMTSA) is demonstrating a prototype mobile phone capable of making secure payments using NFC phones developed by BenQ. Residents of Tapei can use NFC enabled phones to access the city's mass transit rail as well as other public transport in Taiwan. The network already has an existing contactless smart card infrastructure based on MIFARE technology, which is compatible with NFC (*www.semiconductors.philips.com/news/content/file_1115.html*).
- In the United States Motorola is conducting a field trial of mobile phones enabled with MasterCard® PayPass™, a new „contactless" payment option and Near Field Communication technology. Consumers will enjoy the benefits of simpler and faster transactions conducted with their mobile phones (*www.motorola.com/mediacenter/news/detail/0,,4762_4058_23,00.html*).

2.4 NFC integration in Philips mobile phone platforms

To become a leader in system solutions, Philips focused on creating compatible building blocks of multimedia and connectivity intellectual property. By extending system solutions in such a way it becomes easier for manufacturers to differentiate products and quickly incorporate new technologies into handsets that meet operators' changing needs. The latest addition is NFC. With this NFC-enabled system solution, secure connectivity now joins a long list of cell-phone feature options such as MMS, MP3, JAVA™, speech recognition, MPEG video and FM radio (see Fig. 4).

An illustration of how NFC and security can be embedded in a mobile phone platform is the first NFC-enabled Philips Nexperia Cellular System Solution for high-end cell phones (Nexperia Sy.Sol 6100).

NFC and security hardware functionality is realized by combining two devices: the PN531 NFC controller with embedded firmware and the SmartMX a High Security Smart Card IC.

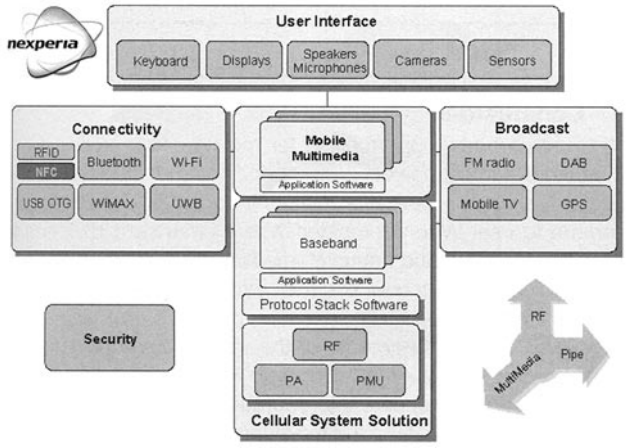

Fig. 4. Nexperia cellular system solutions – a total approach to integrating new features

The PN531 is a highly integrated transmission module for contactless communication at 13.56 MHz including controller functionality based on an 80C51 core. The embedded firmware supports all the RF communication layers, ISO 14443-A cards (Mifare, T = CL), Felica cards and the NFCIP-1 protocol.

The SmartMX is based on a secure MX51 CPU with Crypto Co-Processors (3DES, AES & PKI algorithms) and compliant to numerous international standards (EMV96&2000, EUROPAY CQM, ETSI TS 102 221, 3GPP TS 51.011, GSM 11.1x). This IC is already widely used for applications such as banking, ID cards, health card, citizen cards, access cards, smart passports, etc.

In the NFC and security implementation described in Fig. 5 the SmartMX is supplied and controlled by the PN531 via a 2-wire S²C interface. The PN531 is controlled by the baseband processor via the I²C-bus and two general purpose I/Os (GPIOs) for the handshaking mechanisms. The antenna circuitry is split into two parts: 1) the EMC filtering and the RX path, 2) the antenna tuning. This gives extra freedom in the choice of the RFID antenna location (e.g., in the battery pack). Another GPIO controls the dedicated LDO (low dropout linear regulator) for the NFC power supply.

In smart card emulation mode, the RF transceiver is under the control of the SmartMX and the PN531 is not aware of the data exchange. This guarantees the required security level for transport or payment applications. The SmartMX sends a signal when the transaction with the external reader is completed, and then PN531 can read the result (OK or not) in the SmartMX.

As illustrated in Fig. 6 specific software modules have also been integrated into the Nexperia system solution 6100. These modules have been developed to be compatible with the different use cases and thus data flows and also to fit the current Nexperia software stacks:

- the hardware abstraction layer (HAL) with its adaptation layers to the I²C driver and to the application,
- a specific module to manage the smart card IC,
- the Java™ device layer to interface with the J2ME stack and also to allow interactions with the SIM.

Operators may download over-the-air Java applications for supporting new use cases when they occur.

The Smart card IC, with its JCOP operating system (Java Card Open Platform) is initially delivered with the MIFARE™

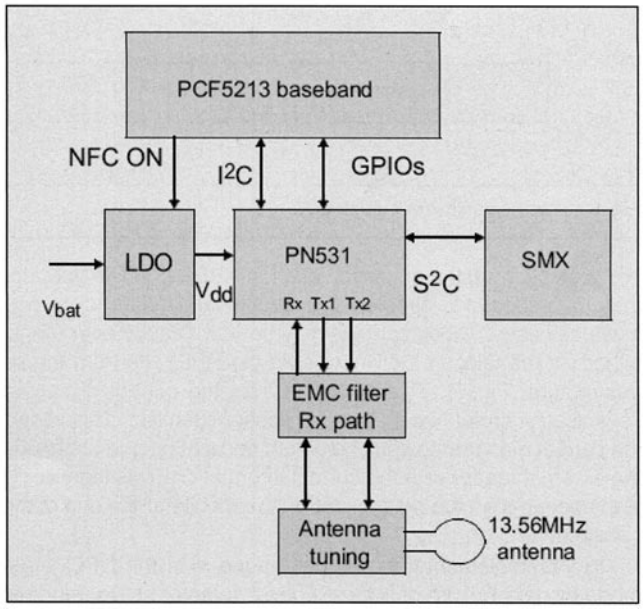

Fig. 5. NFC and security integration in Nexperia system solution 6100

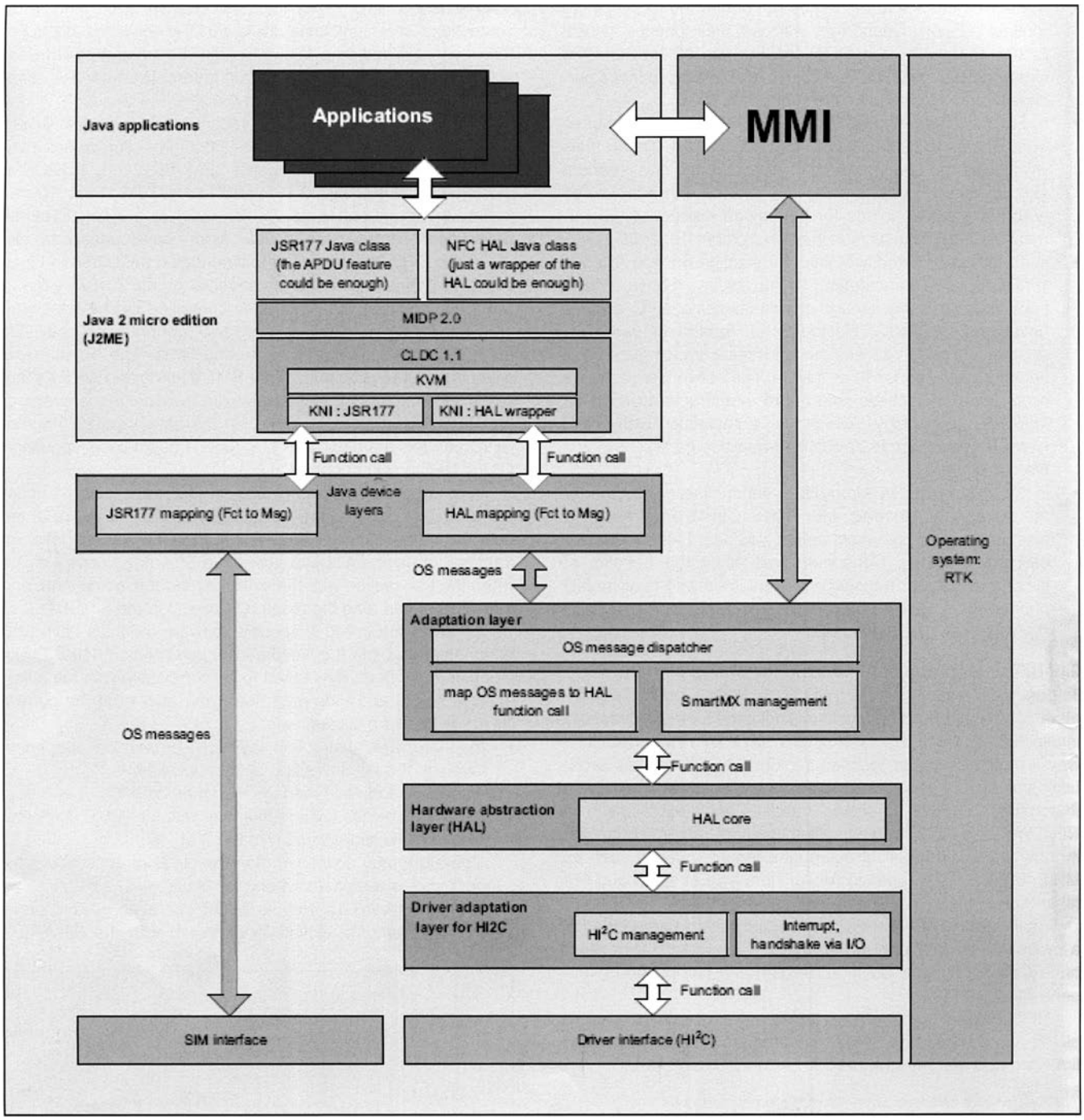

Fig. 6. Specific software modules

protocol, allowing the emulation of a MIFARE card. The operator may then choose to securely add additional cardlets to support new use cases. These cardlets may be downloaded over the air either via the telecom network or via the RFID link from the infrastructure (Fig. 7). This is done under the control of secure keys. Each cardlet has its own application identifier. This allows the cardlet manager to select the right application and to provide the external reader with the correct information. This identifier is also used to start the right midlet on the mobile at the end of the transaction.

In this implementation the cell phone is in the NFC target mode by default, with only the RF level detector active, ready to answer an external reader request. In this mode, the power consumption is very low. Other modes can be initiated by Java actions at any time.

3. Conclusions

NFC creates new opportunities for mobile commerce and has the potential to change consumer behavior and spending habits. Its unique intuitive operation makes it particularly easy for consumers to use. When combined with a smartcard IC it is also ideal for payment and financial applications. The interface and communication protocols of NFC have been standardized in ISO. A large non-profit organization (NFC Forum) with representatives from all segments of the mobile communication industry promotes implementation and further standardization of NFC technology to ensure interoperability between devices and services. The many field trials around the world with NFC enabled mobile phones are an essential step for bringing NFC into everyone's mobile phone. Depending on target applications and business partnerships different NFC and security implemen-

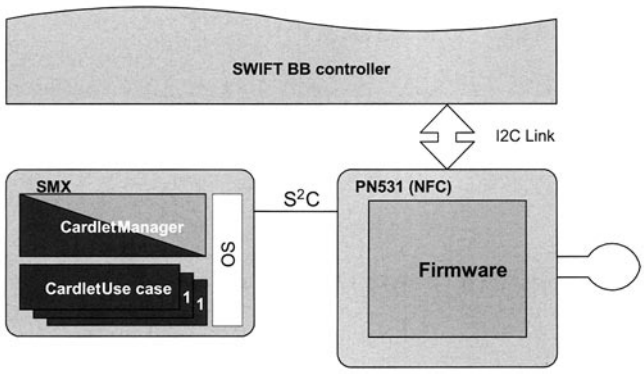

Fig. 7. Smart Card IC

tations could be adopted in mobile phones. Philips has developed the first NFC-enabled cellular system solution for high-end cell phones (Nexperia Sy.Sol 6100). This NFC solution allows to read and write contact-less cards, communicate with peer devices and, when combined with a smart card device, emulate contact-less card behavior.

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