Connecting the Mobile Phone with the Internet of Things–Benefits of EPC and NFC Compatibility

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Abstract
This paper describes the Electronic Product Code (EPC) and Near Field Communication (NFC) technologies. It lists the involved industry standards and elaborates on their commonalities and compatibility issues.
The paper discusses the combination of EPC and NFC as a means to unleash the Internet of Things into the hands of the consumer. The authors investigate the benefits of enabling individuals to read EPC tags with mobile phones and detail the steps necessary to achieve that goal.
If both technologies can be brought to work together in the future, it could positively influence consumers' perception of Radio Frequency Identification (RFID).

Introduction

Computers are no longer just placed on desktops in the form of stationary machines, they are also embedded into everyday objects. The seamless integration of computing capabilities into physical objects is the foundation for an *Internet of Things*, which interlinks the physical world of goods and items with the virtual world of services and data bases.
The most prominent and widely deployed medium for this *Internet of Things* is RFID, which enables the real-time linkage of physical artefacts with information systems. The development of the Electronic Product Code (EPC) has been a crucial step for the global adoption of RFID. The EPC specifies a global numbering scheme intended to unambiguously identify any article in the world, with the objective of linking information with the physical flow of goods. The related UHF EPC Class 1 Gen 2 specification, defining an interface for tag-reader communication, has been ratified as the ISO 18000-6C standard. Tags compliant to this standard have been used in several RFID roll-outs all over the world, by companies such as Wal-Mart and Metro. The expanding adoption of RFID technology – 1.3 billion passive RFID tags were sold in 2006 – prepares the ground for the control of logistic processes and supply-chain movements at item-level in real-time.
Simultaneously, the widespread adoption of mobile phones – 3 billion users in 2006 worldwide – provides evidence for the tremendous penetration of permanent connectivity into everyday life. The advent of Near Field Communication (NFC) technology, which enhances mobile phones with RFID capabilities such as acting as a smartcard or RFID tag, as well as reading smartcards and RFID tags, takes the permanent connectivity phenomenon an important step further: NFC enabled mobile phones connect a completely new group of users to everyday items and, as such, extend the role of mobile phones by new forms of communication between people and objects.
Whereas the driving forces of NFC have not fully comprehended the need for also networking RFID-enabled items as an Internet of Things, the developers of the EPC network currently have mainly industrial uses of such a network in mind.

Reading EPC tags with Mobile Phones

The applications driving NFC technology in the view of the *NFC Forum* are: (a) payment, (b) ticketing, and (c) more intuitive initiations of other wireless services, e.g., the pairing of devices to establish connectivity through Bluetooth or wireless LAN. Another prominent NFC showcase is the smart poster application, which features the download of movie trailers, ring tones, and other content when a smart poster is touched by an NFC device.
Assuring the compatibility of these NFC enabled mobile phones with EPC tags would further provide the possibility to access EPC based network services, thereby enhancing the use of physical items. As soon as EPC tagged consumer goods be-

come available in stores, retailers and producers could start offering product related services, such as additional product information, recipes, handling advice, or the download of user manuals or drivers. There would also be the possibility to use the EPC tags to access user-driven services, such as product-related user community forums, product voting and market forums, e.g. to help purchasing related accessories.
These services have the potential to change the way in which mobile phones are used and perceived by their users. They could evolve from devices that enable users to communicate with others to devices which enable users to communicate with objects.
The ability to ubiquitously read EPC tags with mobile phones could also promote the use of RFID in business environments. EPC compatible phones could also allow for the inexpensive implementation of concepts which require the exact identification of objects, such as the management of important document files with RFID or the automatic documentation of handling and processing procedures.
Mobile phones have the potential to become RFID readers available to anyone. The development of compatible product-related services for the end-consumer can add a completely new perspective to item-level tagging projects and can help increase the ROI from RFID infrastructures.

Differences between EPC and NFC

The Electronic Product Code is a 96bit number that can resemble the well known barcode structures, supplemented by a serial number identifying a single product instance instead of the product category. In addition to that numbering scheme, EPCglobal has also defined standardized network components for linking virtual data to items identified through EPCs, and for imparting this information in a standardized way amongst different partners over supply chains. The goal of this EPC network is to provide the infrastructure for a global Internet of Things.
The most common frequencies for RFID technology are UHF and HF operating at 860-960Mhz and 13.56Mhz respectively. Due to the larger range of UHF, EPCs are currently exchanged by means of the standardized UHF EPC Class 1 Gen 2 (ISO/IEC 18000-6C). A comparable standard for EPC tags operating in the HF band has not yet been adopted.
In contrast to this, NFC technology is operating at 13.56 MHz (HF Frequency). NFC is composed of two standards. The first is the basic NFC standard (NFCIP-1) which was approved by the International Organization for Standardization as ISO/IEC 18092. It specifies the interface and protocol for NFC devices. Devices compatible to ISO/IEC 18092 are also able to read smart cards, which are themselves compatible to ISO/IEC 14443, so-called proximity coupling devices.
The second important NFC standard is NFCIP-2, ISO/IEC 21481. It broadens the abilities of compliant devices to also enable the communication with smartcards compliant to ISO/IEC 15693, so-called vicinity coupling devices.
EPC and NFC are both based on RFID technology. While EPC is standardized in its UHF version, and will in all likelihood become available in an HF version later this year, NFC is only available as HF technology. An HF EPC standard could be implemented by NFC devices, however, UHF EPC Class 1 Gen 2 cannot.
The development and adoption of EPC and NFC are driven by two different non-profit organizations, EPCglobal and the NFC Forum. While NFC is strongly influenced by companies from the payment industry, telecommunication providers and mobile phone producers, EPC global has strong ties to consumer packaged goods producers and the retail industry. However, a number of hardware manufacturers are a part of both organizations.

The steps necessary to harmonize EPC and NFC

As already shown, the major barriers for accessing the EPCglobal infrastructure by means of NFC-enabled phones are the different frequency bands. On the one hand, mobile phones could implement the current EPC Gen 2 standard, which would require the integration of UHF readers into mobile phones. At present, commercially available mobile phones with integrated

UHF readers do not exist. One reason is managing the part-overlap of UHF RFID with the communication frequency used by mobile phones. Another reason is that NFC phones operating at HF are fully compatible with the established smartcard standards that are currently used for various business applications, whereas a UHF infrastructure for end-consumer applications does not exist. However, should a business application for UHF RFID for end-consumer applications become feasible, the technical barriers could be tackled.

On the other hand, the Hardware Action Group at EPCglobal has reached a consensus on developing an EPC Class 1 Gen 2 based on HF which will, in all likelihood, be backward compatible with ISO 15693. Accordingly, current NFC devices could implement this HF EPC Class 1 Gen 2 using today's NFC infrastructure. However, the current item-level tagging activities do not show a clear preference towards either HF or UHF technology. Furthermore, the item-level tagging plans of the two most prominent EPC advocates in the retail industry, Wal-Mart and Metro, remain vague. While Wal-Mart is seen to be a strong supporter of using UHF at the item level, Metro hasn't taken a prominent part in the discussion recently.

Whereas EPCglobal focuses it standardization efforts mainly on data interchange and the linkage of items with data, the NFC-Forum promotes the coupling of items with services. If the EPC network is also to become a global infrastructure for end-consumer applications, this infrastructure will need to have the ability to manage services related to items. New mechanisms for the management of services, and a service discovery, need to be developed to transform the EPC network into a suitable infrastructure for NFC applications. Simultaneously, the promoters of NFC applications have to acknowledge the need for a global infrastructure for networked items in order to manage the complexity of an emerging *Internet of Things* on mobile phones.

Conclusion / Summary

In this paper we have presented an overview of EPC and NFC technology, discussed potential benefits, elaborated on the potentials of their common use and identified the steps necessary to make the integration of EPC and NFC a reality. While it is difficult to predict which kind of EPC tags (HF of UHF) are most likely to be used for item-level tagging in the future, NFC will soon become a common feature in mobile phones, above all due to the numerous existing NFC compatible applications. NFC phones will thus constitute the first large RFID reader infrastructure for the wider public.

The traditional Internet became a commodity only after the advent of the world wide web. We believe that NFC could trigger a similar revolution of RFID applications. Thus, a combining of the strengths of EPC and NFC today is important to prepare the ground for the *Internet of Things* tomorrow.

References are available on request