The role of RFID in the mobile phone

JUAN CARLOS LOPEZ CALVET

Juan Carlos López Calvet is Research Manager in Telenor R&D

The purpose of this article is to give a general overview of the RFID technology and the role it will play when included in mobile phones. The article gives an overview of the RFID market, the current status, the future of RFID and the markets that are driving the technology through the hype curve. It then goes through a description of why it makes sense to include RFID in the mobile phone and what is motivating the different players pushing the technology.

The article also includes a technology overview of the RFID and NFC technologies and finalises with a short conclusion of how mobile operators and other players are positioning themselves in order to take advantage of the opportunities provided by the inclusion of RFID/NFC on the mobile phones.

1 Introduction

As with any new promising technology, RFID is going through a hype where huge expectations are created followed by just as huge disappointments. The technology fans see a sea of opportunities while others fear that the technology will affect their privacy. But what is actually all this hype about?

RFID is in its most simple form just a bar code that can be read from a distance, and some of the most obvious advantages of this technology are:

- Objects do not need to be passed individually through a laser scanner.
- Many objects can be read at the same time from the same reader.
- RFID tags can hold more information than bar codes and therefore users or companies can benefit from richer information.

Based on these advantages, the applications that the technology has are almost endless, like locating and tracking an individual product in real time through production, supply chain and warehouse, contactless payments, positioning, personalization and identification just to name a few.

Along with all the opportunities come questions like: Are people going to monitor each item I'm wearing when I enter a store? Can anyone read the contents of my wallet from a distance? Am I going to be monitored and located everywhere I go?

And the answer is no, the technology is not there, neither for the advantages nor the concerns, but in very specific cases it can already provide a clear benefit for users and companies.

1.1 RFID today

Although RFID can be used in many areas, it is supply chain management that is currently driving the RFID hype due to the implications of the Wal-Mart and Department of Defence Mandates.

1.1.1 The Wal-Mart Mandate

Linda Dillman, Wal-Mart's CIO, publicly announced in June 2003 that the retailer would ask its top suppliers to tag pallets and cases beginning in January 2005. The news created a storm in the retail and consumer packaged goods industries.

Wal-Mart receives roughly 1 billion cases per year from its top 100 suppliers. Dillman said that the company would not be tracking every single case from the top 100 suppliers by January 1, 2005, but rather that it would ramp up over time. "Our goal is to track all pallets and cases." [7]

Dillman also indicated that Wal-Mart would start deploying EPC (Electronic Product Code) technology in the United States and would quickly move to implement it in Europe and then in the rest of its overseas operations.

Because of its size, Wal-Mart will have a major effect on how RFID technology is adopted. Consider a few facts. Wal-Mart's annual sales are greater than the combined sales of the entire semiconductor industry. Wal-Mart's sales are greater than the gross domestic product of Turkey. Wal-Mart imports more goods from China ($14 billion) than Japan does ($10 billion). And it employs more people than Ford, General Motors, Exxon Mobil and GE combined [10].

1.1.2 US Department of Defence RFID Mandate

Following in Wal-Mart's footsteps, the US Department of Defence asked its top 100 suppliers to put RFID tags on shipments.

 ISSN 0085-7130

The DOD suppliers are among the largest companies in the world. The top 100 include Boeing, General Dynamics, Lockheed Martin, Northrop Grumman and Raytheon. By endorsing EPC technology for tracking goods in the military supply chain, it could help spread EPC technology throughout the manufacturing sector because the military's top 100 suppliers also have divisions that make commercial airplanes, electronic components, trucks, ships and other products [9].

1.1.3 EPC and the "Internet of Things"

The EPC network, using RFID tags, will enable computers to automatically recognize and identify everyday objects, and then track, trace, monitor, trigger events, and perform actions on those objects. The technology will effectively create an "Internet of Things."

The industries and media are focusing on this "Internet of Things" for manufacturing, retail, transportation, health care, life sciences, pharmaceuticals, and government, offering an unprecedented real-time view of assets and inventories throughout the global supply chain. Once the products have unique identification codes and with mobile phones that can read such codes (like NFC mobile phones), the concept of the "Internet of Things" will not only be used for industry process, but it will also migrate to the consumer market, giving end users the possibility of accessing product information from their mobile phones.

The electronic product code uniquely identifies objects and facilitates tracking throughout the product life cycle, so when a reader scans an RFID tag on a case of milk, the tag will answer with an EPC number for the inventory management system, letting it know exactly which case of milk was just scanned.

The data structure of an electronic product code is described in the table below.

Electronic Product Code

01	0000B92	00056A	0004325F0
Header	EPC Manager	Object Class	Serial Number
0-7 bits	8-35 bits	35-59 bits	60-95 bits

- *Header:* This field tells the reader what type of number follows, in order to understand what the number represents, for example: a military unique identifier number or a complete EPC structure.

- *EPC Manager:* This field identifies the company or the company entity.

- *Object Class:* This field is a unique numeric identifier that refers to a specific product in an inventory or in a catalogue.

- *Serial Number:* This field is the specific instance of the object tagged. In other words, when an interrogator reads this object it knows exactly which unique object has been read and not only what type of object.

2 RFID market overview

2.1 Supply chain management

Due to the size of Wal-Mart and its 100 top suppliers, the media has been focusing on the use of RFID on the Supply Chain, but the reality is that it is early days and most of the RFID deployments for the supply chain are still in the pilot phase.

Europe has some interesting cases like the Metro Group, which is using RFID step by step throughout the entire process chain (http://www.metro-group.com.tr), and Marks & Spencer, who tested the ability to check stock deliveries and count stock quickly in stores using RFID tags. But in Scandinavia the picture is different. Most of the retail industry has just migrated to unified bar codes and are not expecting to do any investments for the use of RFID in the supply chain for the next three or four years.

Nevertheless, some niche areas could see the benefits of RFID, like fresh goods; e.g. monitoring the fish temperature as it goes through the supply chain. Such areas could give industries like retail a good opportunity to test the benefits of the RFID technology without having to make huge investments to include their whole line of products.

2.2 Asset management

There seems to be a common perception that there are other areas that will make use of the RFID technology before supply chain management, and the best candidate is Asset management.

By using active RFID tags companies have the possibility to better track and monitor their assets throughout a supply chain, in an enterprise, and dispersed into the field. This area has been commercial for some time now and due to the influence of Telecom Operators it got the name M2M or machine-to-machine.

From the point of view of RFID middleware providers like IBM and Oracle, RFID is only a small part of their M2M middleware offering, meaning that an M2M platform that is used to monitor the temperature of refrigerators can also be used to track goods going through the supply chain, for the middleware platform it is just a matter of handling different types of signals and giving them a business meaning.

The reason why asset management is more mature is because the cost of investment in technology in order to track expensive or important items is minimal compared to the value of loss or malfunction of such items, and this is the same reason why the supply chain is not yet mature, since the cost of monitoring a package of milk is much higher than the value that it brings. Some areas that could instantly benefit from M2M could be airports, oil platforms or any other industry that needs to track and monitor expensive assets (see Figure 1).

2.3 Workflow management

Workflow management is the area where the NFC and RFID technologies converge and is also gaining a lot of momentum. Mobile Workflow Management makes use of mobile phones enabled with RFID/NFC readers in order to automate information retrieval and data capture in the field. Some example applications are:

- *Service Information:* Get up to date service information by touching an item.
- *Automatic Search:* Touch a tag to automate extensive search strings.
- *Work order Generation:* Touch a tag attached to the machine and a new work order is available from a web page.
- *Failure Reports:* Touch a tag and get linked to a page to enter the reason for failure.
- *Materials Used Report:* Touch a tag and get linked to a page to enter the materials used.
- *Recording Travel Expenses:* Attach a tag to the dashboard of a car. Touch and enter beginning and ending mileage to have time stamped data for a travel expense form.
- *Time and Date Stamping (ex. Security):* Attach tags to sites that are visited by security guards. Get accurate time stamps and proof of work done.
- *Time and Attendance Recording:* For example, personnel could use personal tags to touch a single phone in the office, at a construction site or field office to clock in and out.
- *Automatic Meter Reading:* Touch a tag attached to a meter and the meter readings are recorded in the phone. Time stamp and tag information is available automatically.

The Norwegian company AD Columbi has been offering these types of services for some time using bar code scanners attached to mobile phones and is currently collaborating with Nokia for the usage of

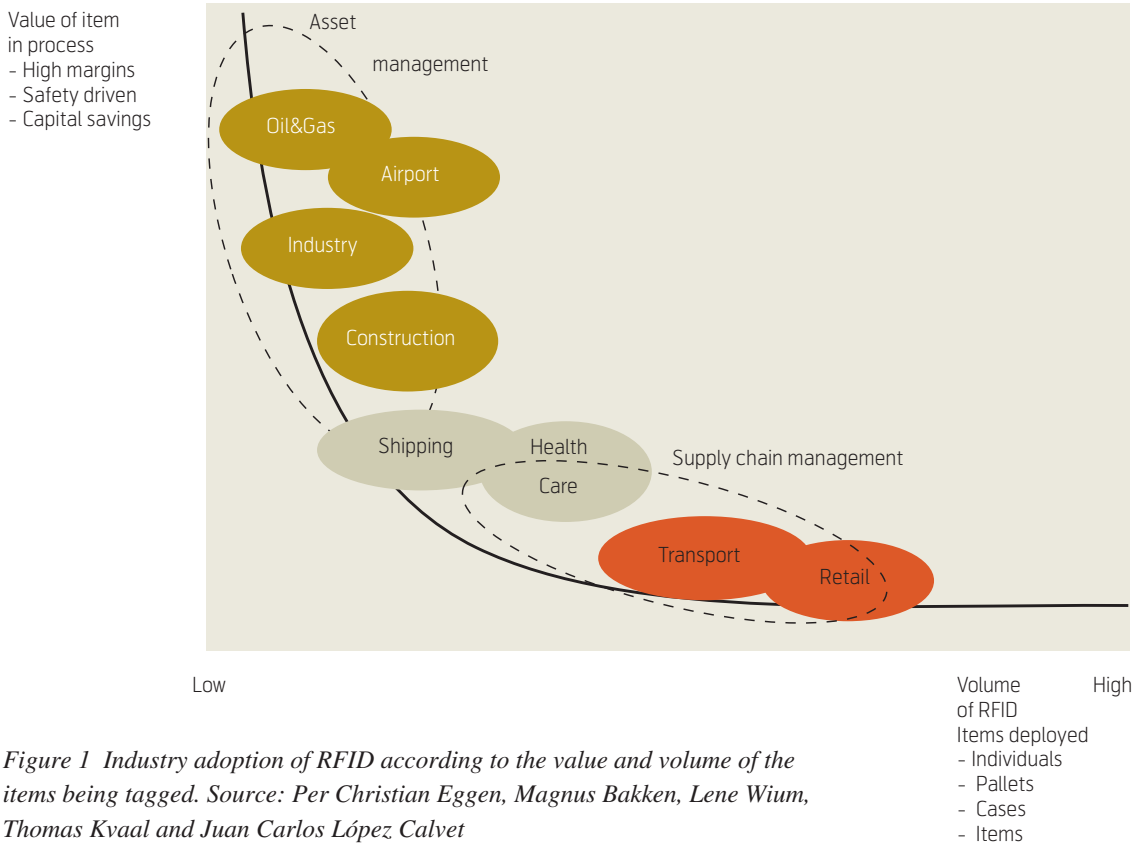

Figure 1 Industry adoption of RFID according to the value and volume of the items being tagged. Source: Per Christian Eggen, Magnus Bakken, Lene Wium, Thomas Kvaal and Juan Carlos López Calvet

ISSN 0085-7130

Global potential	Billion/year	RFID leadership
Library	0.1	Singapore
Museums, art galleries	0.1	Europe
Laundry	1	Europe
Tires	1	Europe
Military items	2	US
Blood	2	Europe/US
Test tubes	2	Europe/US
Archiving paperwork	2	US
Drugs	30	US
Books	50	Japan
Postal	650	Europe
Retail items	10,000	Europe/Japan/US

Table 1 Potential maximum yearly sales by 2020 or earlier for different types of item level RFID tagging [Source IDTechEx]

RFID/NFC enabled phones for customers like ISS Norge that uses the solution to inform their workforce about jobs to be done in a specific place by pushing the necessary information to the phone and register when the job is done by touching an RFID tag.

3 RFID in the future

3.1 EPC Generation 2

For most of 2004 there has been a lot of focus on the second-generation UHF standard of EPCGlobal[1)], but there are only few people who really understand how this new generation differs from the first-generation EPC standards (Class 0 and Class1). The biggest difference between these two standards is that there is now a single global protocol instead of the two (Class 0 and Class 1) that EPC previously had. The implication of a unified protocol is that readers will be able to read tags regardless of where they are manufactured.

Another important aspect of the UHF Gen 2 protocol is that it uses the available radio spectrum more efficiently, providing a much better performance in Europe than any other UHF protocol.

Finally and probably the most important addition to the new standard is that a Gen 2 reader will now be able to read active tags with sensors, which moves RFID from a pure supply chain management approach to a more general asset managing approach which includes a wider range of markets.

3.2 The facts about product level tagging

Item level is a term that usually refers to fairly small items in high volume. Item level tagging offers far more benefits than case and pallet tagging. They include crime reduction, error prevention and brand enhancement as well as cost, service and so on. It is only with item level tagging that the consumer will clearly see benefits.

Others with their own priorities are proceeding very rapidly to trial and roll out item level tagging with excellent paybacks, usually employing the well proven 13.56 MHz frequency where the environment and production quality are less of a problem.

There are fresh food items tagged in Botswana and Japan, survival equipment in France and cigarettes, videos and even artificial logs in the US. Supermarket items have been tagged in the Philippines. Most are trials of course, but gas cylinders and beer barrels tagged in Denmark, the UK, France and elsewhere have long been full rollouts with excellent paybacks of one year or so. And this is a worldwide phenomenon. Their objectives vary greatly of course, and the list changes by the day. Those that quietly get on with item level tagging are increasingly reaping rewards.

From Table 1 it is possible to conclude that while tagging pallets does increase supply chain visibility, item level tagging satisfies specialized needs that bring direct benefits.

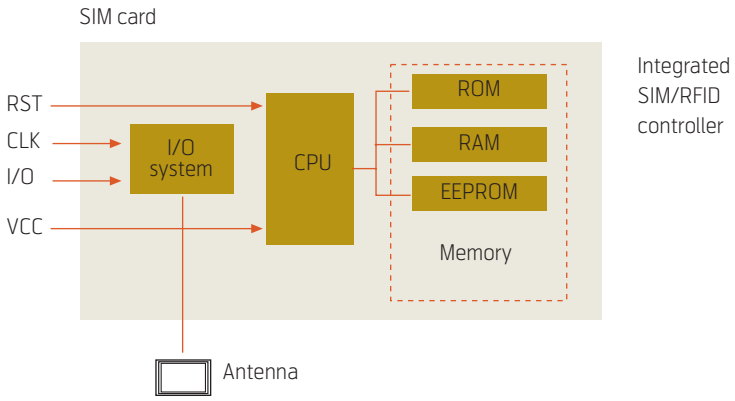

Figure 2 Sketch of an integrated RFID/SIM controller inside a SIM card

1) *EPCGlobal is leading the development of industry-driven standards for the Electronic Product Code (EPC) to support the use of Radio Frequency Identification (RFID).*

4 RFID and the SIM card

In March 2004 Telenor R&D filed a patent application for a SIM card with embedded RFID capabilities. The idea was to bring all the benefits of contactless cards into the mobile phone using the SIM card as a storage device. By doing so the mobile phone will be able to function as an electronic ticket, ID, key or credit card.

4.1 Merging RFID and GSM services

One of the main purposes of including the RFID technology into the SIM card was to be able to offer an alternative for the contactless card infrastructure being installed in different parts of the world (with the first beneficiary being contactless ticketing).

Including RFID into the mobile phone gives contactless cards the advantage of being able to be installed, updated and cancelled over the air through the services offered by GSM.

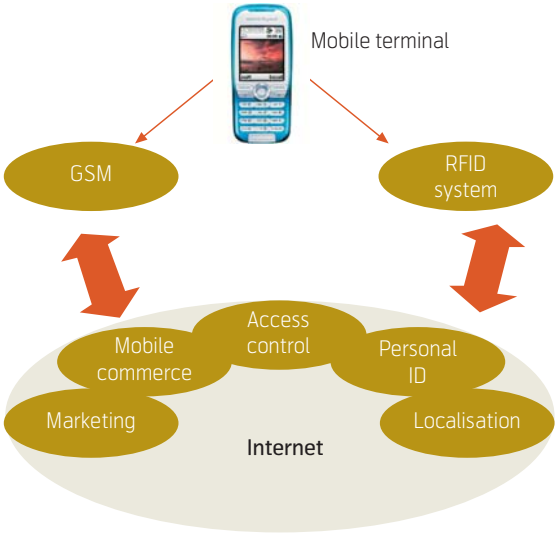

Figure 3 Merging of RFID and GSM services

4.2 The challenges of RFID in the SIM card

One of the biggest challenges of RFID in general is that it does not work that well when it is attached to metal or glass because the radio field gets distorted. Therefore, putting an RFID transponder in the heart of the mobile phone (the SIM card) is not an easy task, because the SIM card is usually placed under the battery and is surrounded by many different materials that disturb the RFID radio field.

In order to solve this challenge companies like Giesecke & Devrient made an adaptation of a Siemens mobile phone that connected an external antenna on the cover of the mobile phone to their dual interface SIM card (this type of SIM card has contactless capabilities, but need an external antenna).

Although solutions like this could offer many of the capabilities envisioned by Telenor R&D, we did not believe that the mass market was going to adopt solutions that were not fully integrated with the mobile phone and we did not believe either that mobile phone manufacturers would change their hardware designs to include an antenna for such SIM cards. Telenor R&D therefore opted to follow the NFC technology instead.

5 Near Field Communication (NFC)

5.1 NFC introduction

Near Field Communication is a short-range wireless technology optimized for communication between various devices without any user configuration. The goal of the NFC technology is to make two objects communicate in a simple and secure way just by putting them close to each other. NFC can also be used to start other communication technologies like Bluetooth and WiFi by exchanging the configuration and session data.

5.2 The NFC Forum

In April 2004 the NFC Forum was established by the three founding members Nokia, Philips and Sony, with the vision of bringing the physical world and the electronic world closer together. This was not a new vision, but was rather the Auto-ID lab's "Internet of Things" vision, which was brought to the consumer market. By placing tags and readers into objects, users would be able to interact with them by touching them with other NFC devices (e.g. mobile phones).

5.2.1 A winning team: Philips, Sony and Nokia

The initial founders of the NFC Forum saw the variety of opportunities that this technology would bring, but they also had an adequate background, which is why they were able to form a winning team.

Philips offerings are so broad that you could find their technology in almost any electronic device, but they provide two key elements into the NFC technology: The MIFARE standard, which is the most used contactless ticketing and payment standard in Europe with approximately 80 % of the market and the NFC chip itself.

Sony is also one of the biggest players in consumer electronics, but when it comes to the NFC technology they provide the FeliCa standard, which is the other biggest contactless ticketing and payment standard, mainly used in Asia.

And finally Nokia, who is one of the most dominant mobile phone manufacturers in the world. Because of their vast penetration of devices in the consumer market they are the perfect partner to bring this technology to the masses. The main reason why Nokia was able to bring this vision to reality before other mobile phone manufacturers is that they were already active in integrating the RFID technology on their mobile phones targeted at industry usage, such as mobile workforce management.

5.2.2 The NFC Forum grows quickly

From April to September 2005 another 44 members have joined the Forum from a wide variety of industries. There are four levels of membership, but the founding members remain in the same industries with the addition of VISA and Master Card, who together dominate the payment market.

Without having the insight on why these partners have joined the Forum, one could probably guess their motivation by grouping them into the following segments:

- *Mobile phone providers:* Nokia, Motorola, Samsung Electronics, Philips and Microsoft;
- *Semiconductor manufacturers:* Philips, NEC, Renasas and Texas Instruments;
- *Payment:* MasterCard International and Visa.

The fast growth of the Forum plus the relevance of the players involved give credibility to this emerging technology. Most of the players that Telenor has had contact with indicate that they are serious about their efforts towards the NFC technology and that we can expect devices to be launched with full support of their companies starting from 2006.

5.3 NFC applications

In order to emphasise the idea of close proximity, Philips (http://www.semiconductors.philips.com/markets/identification/products/nfc/index.html) has divided the NFC applications into the four following areas:

- *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. Also for simple data capture applications, such as picking up an Internet URL from a smart label on a poster.
- *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 downloading music, exchanging images 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 functionalities and services are offered.

5.4 NFC and the mobile phone

NFC adds intelligence and networking capabilities to the phone and creates many new opportunities to add product and service capabilities to the handset like digital transactions and sharing in very close proximities.

One of the main technological advantages of an NFC is that its chip can act as reader, but it can also act as a card, and is backward compatible with the contactless card standards. Therefore it makes a mobile phone an ideal device for making payments, since with a mobile phone you can control the interaction with the card (no one can read your card if you do not want them to), the mobile operator can update or cancel the card remotely and it is a device that users are already carrying.

When acting as a reader, an NFC mobile phone has the possibility to exchange data with other NFC devices, but most importantly it can trigger the download of content related to a specific object like a movie poster. For example: if a user walks by a movie poster, by just touching the poster it will trigger the browser, then the phone will automatically download information related to that movie, in what theatres it is being screened, and it will give the user the possibility to purchase tickets if desired.

5.5 The first NFC mobile phones are launched

On 9 February 2005 Nokia introduced the world's first Near Field Communication (NFC) product for payment and ticketing which was an enhanced version of the Nokia NFC shell for the Nokia 3220 mobile phone. It was the first mobile phone to deliver all the services envisioned by the NFC Forum, which are: service discovery, payment and ticketing.

5.5.1 Why the shell concept?

New technologies like NFC offer many exciting possibilities, but nowadays it is not easy to change a line of production just because a new technology is supposed to bring great benefits. In order to test the new capabilities of the NFC technology, Nokia decided to use one of their models in production (Nokia 3220)

that had the capability of communicating with the mobile phone cover, and by reusing this phone they were able to create a shell or cover with an embedded NFC chipset.

Users or companies willing to test the NFC capabilities are now able to buy an off-the-shelf Nokia 3220 with an extra NFC shell. But such as solution is only expected to be used in the first pilots and once the technology is proven we can expect mobile phones with full NFC integration offered not just by Nokia, but other mobile phone manufacturers like Samsung, SonyEricsson and Philips by 2006.

5.5.2 Why is it taking so long?

The main reason for the delay of NFC mobile phones is standardization. The NFC technology involves mainly semiconductor, SIM and mobile phone manufacturers. And all of them have to create standard interfaces to be able to communicate with each other. Once the interfaces are standardized it usually takes one year for phone manufacturers to go from design to production of a new mobile phone.

5.5.3 The role of the SIM card for the NFC technology

With the introduction of the NFC technology into the mobile phone, the SIM card takes a more important role not just for telecom operators, but also for payment, ticketing and SIM card providers.

When NFC functions as a contactless card, it requires a place to store critical information such as ticket numbers, credit card accounts or ID information. This storage place could be basically anywhere in the mobile phone (RAM), but since the SIM card has storage capacity and already offers a high level of security, there seemed to be a common agreement between all the companies involved in the NFC Forum to use the SIM card for storage of critical and sensitive information.

The only problem is that communication between the NFC chip and the SIM card does not exist today and therefore has to be standardized. This is one of the main reasons why NFC mobile phones have not yet been launched. The communication between the SIM card and the NFC chip requires a high-speed transaction time in order to offer a real alternative for today's ticketing and payment system. Users would never accept a new ticketing solution that is not easier or faster than the already available solutions offered by contactless plastic cards.

5.5.4 First NFC pilot efforts

Rhein-Main Verkehrsverbund (RMV), the public transport network operator for Frankfurt's greater area in Germany, launched a mobile ticketing project in early 2005 in the city of Hanau.

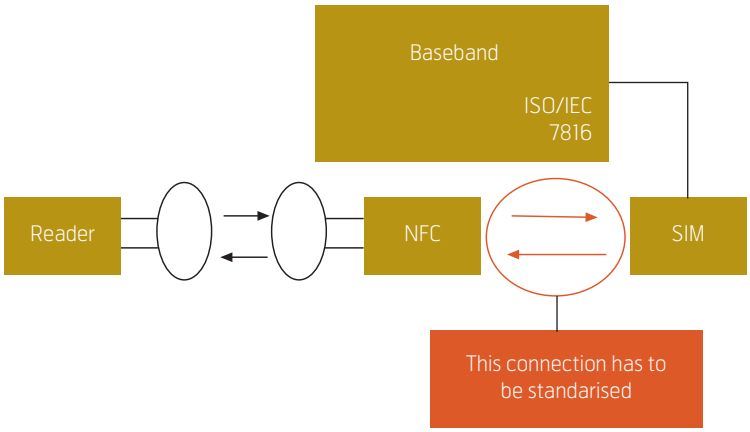

Figure 4 Using the SIM card as the storage unit for NFC transactions in a mobile phone

The project was the first live ticketing application based on NFC using mobile phones as a contactless ticket for an already existing ticketing infrastructure. The solution was tested in Hanau allowing customers to buy, store and use tickets with a Nokia 3220 NFC mobile phone.

Since the pilot used the first version of the NFC Nokia phones, it was not able to store the electronic ticketing information on the SIM card, but instead it used an integrated smart card controller in the phone.

The aim of the project is to provide partners (Nokia, Philips and RMV) with practical experience of NFC mobile phone ticketing that are compatible with already installed contactless smart card infrastructures.

Telenor R&D and Nokia are currently joining efforts to test the NFC technology together with the most relevant transport systems in Norway, since there is a national effort to migrate ticketing systems all around the country towards a contactless card infrastructure where travellers can use the same card in any kind of transport (train, ferries, subways and busses).

6 Market drivers for NFC

6.1 Contactless smart cards

Contactless smart cards have now reached a mature state with over 540 million cards on the market. There are two types of cards that have been dominating the arena: The FeliCa card developed by Sony and the MIFARE card developed by Philips based on the ISO 14443-A standard.

ISSN 0085-7130 © Telenor ASA 2005

ISO 14443 became a standard in 2001 and has two standard components (A and B). The cards come in different shapes and sizes, but they must comply with either A or B while readers and point-of-sale terminals must comply with both. The standard works on the 13.56 MHz frequency and several major transport systems in Asia have been in public service for more than a year. Other cities are in the process of switching to this new technology primarily to reduce maintenance costs, increase system reliability, security, provide greater convenience for users, and improve the processing speed, especially for busses.

Contactless smart cards can also be used to substitute magnetic strip cards for payment and authentication; they provide all the security features of smart cards plus the advantage of being contactless.

6.2 Ticketing

The main driver for contactless smart cards is that it has already an installed infrastructure of contactless ticketing systems around the world. Cities like Hong Kong and London were early adopters of this technology; Hong Kong with a solution called Octopus and London with a solution called Oyster. Most European countries are also migrating their ticketing systems towards contactless cards including Norway, which has a national effort to use one card that will be compatible with every transport ticketing system.

Not only are transport systems benefiting from the high-speed transaction time of contactless cards, but also event venues like football stadiums are applying this technology due to the drastic reduction of queues.

The football world cup arranged in Germany next year will bring massive attention from the media since it will only use contactless tickets in every venue. The tickets are personalized and unique to each person and cannot be transferred. Such a big event will trigger a wave of adoption of contactless ticketing systems around the world.

We can conclude that contactless ticketing systems are not just a hype, but are here to stay at least for the next ten years, and with such a big installed infrastructure the probability of using mobile phones as contactless tickets increases dramatically.

6.3 Service discovery

NFC service discovery is the concept of interacting with (tagged) objects in the real world through the use of an NFC enabled devices. The example most commonly used is that of a movie poster with an RFID tagged attached to it: when the user touches the poster with the NFC mobile phone, it can automatically download information about the movie, ringtones, logos or even purchase tickets. The main idea is to provide easy access to information related to the tagged object.

6.3.1 Industry will adopt NFC/RFID mobile phones first

This concept has many uses ranging from marketing – as the poster example – to workflow management for industry process automation. Nokia has clear plans to be a leader in this market by launching the first RFID/NFC mobile phone for the industry segment with their 5140 model.

The Nokia RFID phones are designed specifically for industry sectors ranging from security, services and utilities to health care and public administration. Some application examples include meter reading, maintenance and reporting of task completion.

Telenor R&D and the Norwegian company AD Columbi, who specializes in automation of processes like task completion through the use of mobile phones, have been cooperating in order to bring the first RFID pilots to the Norwegian market.

The main reason why the industry is more mature to adopt this technology is that companies specializing in the mobile workforce have a total control over which mobile terminals their mobile workers need in order to perform their tasks and are therefore not dependent on the penetration of this type of device in the market.

6.4 Payment

Contactless payment systems are penetrating the market just as quickly as the ticketing systems, and the most important success of such adoption is the agreement between credit card issuers to use a single RFID chip standard (ISO/IEC 14443). Since American Express, MasterCard and Visa are already rolling out their contactless payment cards for consumers, merchants are also moving quickly to upgrade their terminals to be able to handle RFID-based transactions. The standard agreed on by MasterCard, American Express and Visa is the same standard that is supported by NFC mobile phones and therefore fully compatible.

In contrast to ticketing systems, the US have been quicker to adopt payments through contactless cards, since they have a stronger credit card culture than Europe. MasterCard, Visa and American Express have been running pilots showing positive results for merchants, indicating that users who pay by contactless cards tend to purchase more items compared with consumers paying by cash.

Although the use of mobile phones in contactless payment systems could be a straightforward step technology-wise, there are some concerns surrounding privacy that must be addressed in order for the mass market to adopt this technology.

6.5 Privacy concerns

Users are increasingly more concerned about the privacy of information, and when it comes to RFID cards or phones that hold sensitive information such as bank accounts or credit card numbers, they are afraid that a thief will be able to read the card with a mobile RFID interrogator and steal all the data stored in the card. Such fears could be the biggest barrier for adoption of RFID based payments. Such concern might be due to all the negative media coverage that surrounded some of the early adoptions of RFID for supply chain management like Gillette, who had to cancel their RFID pilot due to a very aggressive movement towards the protection of privacy.

But the truth is that RFID payment devices offer a higher level of security than traditional payment cards. The ISO 14443, which is the standard adopted by credit card issuers (MasterCard, Visa and American Express) allows the account information in the card to be encrypted, giving each company the possibility to use a different encryption method and keys.

Unlike RFID for supply chain management, this standard is specified for very short-range communication (in the range of 10 cm) making it difficult to read from a long distance. Even if someone is able to read the data with a specialized long-range interrogator, the attacker will still have to crack the encryption algorithms to be able to make some sense of the data acquired. The concept behind using such a range is to guarantee that the card is read only when the user wants it to be read, just as it is today with contact or magnetic stripe cards.

When the cardholder waves the card by an RFID payment terminal, it turns the encrypted number into a digital signature, which is passed through the payment network and then decrypted to authorize the transaction. To further protect the account information, the digital signature changes each time a card is read. So even if a thief were to somehow access the digital signature, it could not be used to make another transaction.

The main challenge is therefore for card associations, banks and merchants to send a clear message to consumers that contactless payment systems are actually more secure than today's cards if they want consumers to comfortably adopt the technology.

7 Technology overview

7.1 RFID basics

RFID (Radio Frequency Identification) is a means of storing and retrieving data through electromagnetic transmission to an RF compatible integrated circuit. This RFID tag or integrated circuit is usually a single solid-state memory chip.

7.1.1 RFID system components

A micro controller or PC, a reader or interrogator, and a transponder or tag are the most basic components of an RFID system.

7.1.2 RFID readers

Readers or interrogators are used to identify objects by communicating with the tags using a wireless RF link. An interrogator is then used to "scan" the tag. The interrogator (controlled by some type of host computer) transmits an RF signal out to the RFID tag(s). In order for these tags to be read by the interrogator they must be presented in a defined RF area of saturation, known as an RF portal, or RF field of view. This RF signal first activates the RFID tag(s), and then interrogates each tag based on criteria received back to the interrogator from the first RF transmission.

7.1.3 RFID tags

RFID tags or transponders are basically a source chip with an antenna. When these tags are within the field of an RFID reader or interrogator they react by sending the information stored in their memory. This information could be an Electronic Product Code (EPC) number that gives the interrogator a unique identification number for that tag, meaning that the interrogator will not only know what type of object is in the field, but it will know specifically which unique object is in the field. There are two types of RFID tags, which mainly differ in tags that have a battery and tags that do not have a battery.

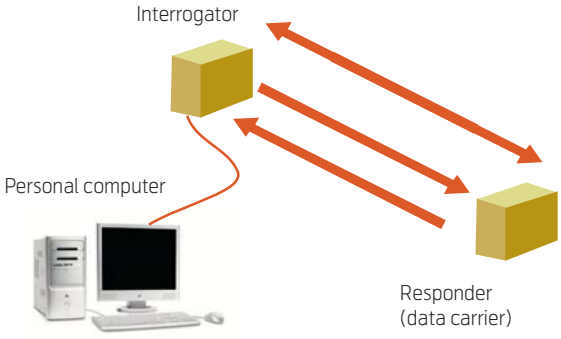

Figure 5 Basic elements of an RFID system

ISSN 0085-7130 © Telenor ASA 2005

7.1.3.1 Active RFID tags

Active tags have a source of power, usually in the form of a battery. The advantages of active tags are many, but the most obvious one is the ability to increase the range of readability through the use of an extra source of power.

Active tags can also be used to store status information like temperature, pressure, light, etc. This information can provide valuable information about the tagged objects since companies will be able to know not only where the object is at every step of the supply chain, but also how the object is handled over time.

The disadvantage of these types of tags is the price, which makes them affordable only when the value of the data received is bigger than the investment required in order get such data.

7.1.3.2 Passive RFID tags

Passive tags are tags without any source of power. These types of tags use the principle called inductive coupling to transfer the energy from one circuit (such as a conductive antenna and associated circuitry) to another by means of mutual inductance between the two circuits. It basically uses the energy provided by signals sent by the reader to send a signal back with the information stored on the tag.

These tags are much cheaper than active tags and are commonly used in pallets to increase visibility in the supply chain. Although the price of these tags is considerably lower, it has not yet reached the point where every single product can be tagged, but with increased adoption and economies of scale the price of tags is expected to reach the critical point for them to be used at item level.

7.1.4 RFID software

The last basic component in any RFID system is the software that controls the interrogators in order to synchronize when and where tags are read, filter the received data (since tags and readers communicate more than one time when they are within each other's field) and gives the data meaning for business processes.

7.2 NFC technical overview

7.2.1 ISO 14443

The ISO 14443 is the international standard for 13.56 MHz identification cards. This standard was initially designed for payment and ID cards and it was later modified to include contactless cards. This standard is most commonly used for payment and ticketing systems due to the higher security and faster communication that it provides. There are two types of ISO 14443 readers, A and B. They basically differ in speed, signal modulation, coding format and anti-collision method.

NFC is compatible with the broadly established infrastructure based on ISO 14443-A (Philips MIFARE technology), ISO 14443-B, as well as Sony's FeliCa card used for electronic ticketing in public transport and for payment applications.

NFC devices can operate in a reader mode that allows communication with a wide variety of contactless smart cards or RF transponders (tags). NFC devices can also work in a card emulation mode, which enables the NFC device to act as a smart card towards smart card readers, such as public transport and point of sale terminals.

7.2.2 NFC Philips transmission modules

Philips is currently providing two NFC transmission modules called pn511 and pn531, which are the modules that the first Nokia implementations are using. The following section is taken from the Short Form Specification of both modules, which can be downloaded from Philips website (http://www.semiconductors.philips.com/markets/identification/datasheets/).

The two chips provided by Philips (pn511 and pn531) are highly integrated transmission modules for contactless communication at 13.56 MHz. These transmission modules utilise an outstanding modulation and demodulation concept completely integrated for different kinds of passive contactless communication methods and protocols at 13.56 MHz.

The transmission modules support three different operating modes:

- Reader/writer mode for FeliCa and ISO 14443-A cards;
- Supports Card interface mode for FeliCa and ISO 14443-A/MIFARE in combination with secure µC;
- IP-1 mode.

Enabled in reader/writer mode the module internal transmitter part is able to drive a reader/writer antenna designed to communicate with ISO 14443-A /MIFARE or FeliCa cards and transponders without additional active circuitry.

The receiver part provides a robust and efficient implementation of a demodulation and decoding circuitry for signals from ISO 14443-A compatible cards and transponders. The digital part handles the complete ISO 14443-A framing and error detection

(Parity & CRC). The modules support contactless communication using MIFARE Higher Baud rates up to 424 kbit/s in both directions.

In the reader/writer mode the transmission modules support the FeliCa communication scheme. The receiver part provides a robust and efficient implementation of the demodulation and decoding circuitry for FeliCa coded signals. The digital part handles the FeliCa framing and error detection like CRC. The modules support contactless communication using FeliCa Higher Baud rates up to 424 kbit/s in both directions.

Enabled in card mode the transmission modules are able to answer to a reader/writer command either in FeliCa or ISO 14443-A/MIFARE® card mode. The modules generate the digital load modulated signals and in addition with an external circuit the answers can be sent back to the reader/writer.

Additionally the transmission modules offer the possibility to communicate directly to several NFC enabled devices in the NFC IP-1 mode. The NFC mode offers different communication baud rates up to 424 kbit/s. The digital part handles the complete NFC framing and error detection.

8 Strategy

8.1 Operators

The SIM card has always been the most important asset of GSM mobile operators, but regardless of many efforts to increase its value towards the user, operators have not been able to reap the benefits of having such an important asset in the heart of every GSM mobile phone.

The introduction of the NFC technology brings the unique opportunity to easily connect the SIM card with the physical world. All the visions of mobile payments can finally be realized without cumbersome WAP menus or slow SIM toolkit applications.

With the adoption of NFC, the SIM card will increase its value dramatically by storing the end user's most valuable information: credit card numbers, bank account numbers, personal IDs, plane tickets, bus tickets, bonus cards, etc. This gives operators the unique opportunity to offer a "real state" type of business to third parties such as credit card issuers, banks, transport companies, etc.

It is a win-win situation between mobile operators and third parties that offer some kind of contactless card services, since operators increase the value of their SIM cards and implicitly their relation with their customers; and third parties reduce their administration costs of delivery, storage, security and management of contactless cards.

8.2 Mobile phone manufacturers

For mobile phone manufacturers the main reason to adopt the NFC technology is the increased overall value of mobile phones. Mobile phones are already used by almost everyone throughout developed countries, but with the integration of NFC the mobile phone cam become the single most valuable asset for consumers, since it will not only be used as a means of communication but can potentially replace wallets, keys, tickets and IDs.

8.3 Semiconductor manufacturers

For semiconductor manufacturers like Philips it is just a matter of numbers. The mobile phone is by far the most purchased consumer electronic product, and the interest of mobile phone manufacturers towards this technology creates a big market for those in the NFC semiconductor business. The inclusion of the NFC technology in other consumer electronics like TVs, radios, MP3 players, etc. will also increase the opportunities for semiconductor manufacturers to sell their products.

8.4 SIM manufacturers

SIM card manufacturers, together with mobile operators have constantly been trying to increase the value of the SIM card, but the lack of cooperation with mobile phone manufacturers has rendered most of the efforts fruitless, since there is no guarantee that SIM toolkit applications developed by operators or SIM manufacturers will work in every single mobile phone on the market.

The value of the SIM decreased so much that questions were raised on the real need to include the SIM in GSM mobile phones. But with so much momentum and support from all the different industries interested in the introduction of the NFC technology the SIM card has guaranteed its place in the mobile phone as the security storage unit for sensitive information for the NFC technology.

8.5 End customers

The most important aspect of the adoption of the NFC technology in the mass market is the security concerns that have been raised by the hype of RFID in general. If the industry is able to manage such concerns by sending a clear and consistent message regarding the security advantages of the NFC technology, end users will surely adopt the technology due to the benefits that the technology can bring to their everyday life.

References

1 ABI research. *Near Field Communications*. Published Q3 2004. http://www.abiresearch.com

2 Forrester Collection. *RFID: The Complete Guide*. Spring 2005. http://www.forrester.com

3 Philips Semiconductors. *Near Field Communication PN511-Transmission module (Short Form Specification Revision 2.0)*. February 2004.

4 Philips Semiconductors. *Near Field Communication PN531-mC based Transmission module (Objective Short Form Specification Revision 2.0)*. February 2004

5 *Potential of the RFID technology for Telecom Operators*. Eurescom Project Report, January 2004.

6 *Guide to Smart Card Technology*. Cyberspace Center, Hong Kong University of Science and Technology, November 1998.

7 Wal-Mart Expands RFID Market. *RFID Journal*, 18 Aug 2003. http://www.rfidjournal.com/article/articleview/539/1/26/

8 Wal-Mart Draws Line in the Sand. *RFID Journal*, 11 June 2003. http://www.rfidjournal.com/article/view/462/1/1/

9 U.S. Military to Issue RFID Mandate. *RFID Journal*, 15 Sept 2003, http://www.rfidjournal.com/article/articleview/576/1/1/

10 The Wal-Mart Factor. *RFID Journal*, 17 March 2003. http://www.rfidjournal.com/article/articleview/346/1/27/

11 *Sony Ericsson M2M wireless communications*. http://www.sonyericsson.com/images/spgc/CWS31AFW_12781_36_0_4002.pdf

12 *Nokia Field Force Solutions*. http://www.nokia.com/nokia/0,,55738,00.html

13 *Near Field Communication Forum Launches Four Technical Working Groups*, 28 June 2005. http://www.nfc-forum.com

14 Item level RFID gathers pace. *IDTechEx*, 7 Feb 2005. http://www.idtechex.com/products/en/articles/00000140.asp

15 *NFC Technology*. Philips, 31 Oct 2005. http://www.semiconductors.philips.com/markets/identification/products/nfc/technology/index.html

16 Giesecke & Devrient. *(U)SIM card from G&D combines mobile and contactless technologies*. 31 Oct 2005. http://www.gi-de.com/portal/page?_pageid=44,94279&_dad=portal&_schema=PORTAL

Juan Carlos López Calvet is Research Manager in Telenor R&D. He studied Telematics at ITAM in Mexico City with a specialization on Elliptic Curves Cryptography. During his work as researcher at Telenor R&D he has filed a total of six patents in different areas ranging from security to e-commerce. He has won two second places in Telenor's business idea competition "Seed" and currently works on bringing emerging mobile technologies to the market.

email: juan.calvet@telenor.com