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RFID
Opportunities for mobile telecommunication services

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RFID – Opportunities for mobile telecommunications services

Abstract: The technology for radio frequency identification (RFID) enables data to be transmitted by a tiny portable device, called a tag, which is read by an RFID reader and processed according to the needs of a particular application. It is only recently that the technology has begun to take off in the mass market. Analysts predict that RFID will revolutionize areas of industry, such as supply chain management and the retail business, for example by reducing costs with better stock management. This paper focuses on the application of RFID technology in mobile telecommunication services. Several ideas for applications as well as possible areas for standardization efforts are presented. Apart from purely technical concepts, the challenging aspects of security and privacy are discussed.

1. What is RFID?

Entering the search-term “RFID” into Google web-search produces more than 14.4 million results. In the public sphere the abbreviation has been around for some time, but what *is* this Radio frequency identification (RFID) all about?[1] In a few words, it is a method of remotely storing and/or retrieving data from small objects, so-called RFID tags. These tags contain antennae to receive and respond to queries from an RFID reader. A typical RFID system consists of two main components, tags and readers.[2] (see chapter 1.2.)

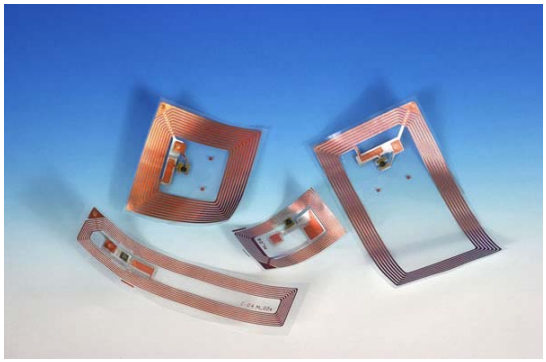
1.1. Old technology, new implications

Although it has become popular only in recent years, the concept of RFID is not new. It was used in the Second World War to distinguish enemy planes from friendly ones[3] and as early as 1948 a research paper on "Communication by Means of Reflected Power"[4] was published. As the components for RFID-systems - tags and readers - have become smaller and cheaper, the technology has begun to take-off, in a variety of different areas (see chapter 1.4.).

1.2 How RFID works

An RFID system consists of two main components, **tags** and **readers**.

A **tag** (also called transponder or transceiver) is a small device equipped with a microchip carrying data and an antenna. There are two types of tags; active and passive. **Passive tags** require no power and are much more common. Incoming radio waves induce an electrical current in the antenna, just strong enough to feed the tag’s circuit and send out a response. Due to constraints in the on-board power supply, passive tags have a relatively short range of operation (from about 10 mm up to about 5 metres, but typically a few centimetres) and can only transmit a limited amount of information. Yet, the lack of a power supply gives passive tags their unique and main selling point, that they can be very small in size. One of the smallest passive RIFD chips, Hitachi’s "µ-chip"[5], is only 0.4mm x 0.4mm in size and barely visible with the naked eye. It contains a unique 128-bit number that is written onto the chip during the manufacturing process and cannot be changed.



RFID tags Foto: TI

Active tags function the same way as their passive counterparts, except that they have their own power source and thus longer ranges (dozens of metres) and more memory. Because of this power source, active tags today are bigger and more expensive. Becoming smaller and cheaper, they might be the choice of the future. For example, a new generation of active tags called "Dice" was presented by YRP Ubiquitous Networking Labs in April 2005[6]. They are about 15mm x 15mm x 15mm and according to the manufacturer, the battery will last for 2 years and 3 months if the tag communicates every 5 minutes. If manufactured in volume, the price of a "Dice" tag will might be at the “lower end of several dollars".

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[1] An excellent RFID glossary can be found here: http://www.autoid.org/SC31/2004/oct/31nXXXX_SC31_Glossary_20041002.doc

[2] For an introduction to the basics of RFID-tagging see e.g. Robertson, I.D., Jalaly, I.: “RFID Tagging Explained” in IEE Communications Engineer, February 2003, p. 20-23..

[3] For technical details of the IFF (Identification, Friend or Foe) -system see e.g. http://jproc.ca/sari/sariff.html

[4] Stockman, Harry: "Communication by Means of Reflected Power" Proceedings of the IRE, pp1196-1204, October 1948. In his paper Stockman states: "...considerable research and development work has to be done before the remaining basic problems in reflected-power communication are solved, and before the field of useful applications is explored."

[5] http://www.hitachi.co.jp/Prod/mu-chip/

[6] More information on the following site: http://ubiks.net/local/blog/jmt/archives3/003710.html

A **reader** communicates with a tag in order to capture the data stored in the tag. The reader usually sends a low-power radio signal to activate the tag and the tag then sends data back to the reader. Most readers are – as their name suggests – only capable of reading data, although some also have the capability to write to certain tags. Normally, readers forward the data to other systems (such as PCs) for subsequent processing. In comparison to tags, readers consume more power, are larger - and more expensive.

RFID systems use radio-signals to communicate, but only certain frequency bands are available for license-free use. There is international variation in the frequencies and power levels available for RFID systems. Due to different national regulations, an RFID system produced in one country may not work in another country.[7] Four different kinds of frequencies are currently used[8]: Low frequency (125 to 134 kHz), High frequency (13.56 MHz), Ultra High Frequency (868 to 956 MHz), and Microwaves (2.45 GHz). The main differences are in the Ultra High Frequency band, where for example the EU (865-868 MHz, 869.4-869.65 MHz), the USA (902-928 MHz), Korea (908.5-914 MHz), Australia (918-926 MHz) and Japan (950-956 MHz) use different frequencies and the power limits.

1.3. Out in the wild: Current RFID applications

Implementations of RFID technologies have seen a boom in recent years. Many parts of industry are using these technologies to some extent. Naming particular applications of RFID technology would thus lead to a very long list – without being close to comprehensive.[9] Therefore, only some sectors are named below, the footnotes provide further information on applications in the particular field:

- **Transport and logistics**: toll management[10], tracking of goods[11], etc.
- **Security and access control**: tracking people (students etc.)[12], controlling access to restricted areas, etc.
- **Supply chain management**: item tagging, theft-prevention, etc.
- **Medical and pharmaceutical applications**: identification and location of staff and patients[13], asset tracking, counterfeit protection for drugs[14], etc.
- **Manufacturing and processing**: streamlining assembly line processes, etc.
- **Agriculture**: tracking of animals[15], quality control, etc.
- **Public sector**: passports[16], driver's licenses, counterfeit protection for bank notes, library systems[17], etc.

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[7] http://www.liberty-human-rights.org.uk/privacy/rfid-parli-briefing.pdf

[8] The White paper "Demystifying RFID: Principles & Practicalities" by the Auto-ID Center (October 2003) addresses this topic more in-depth (full text here: http://www.autoidlabs.org/whitepapers/CAM-AUTOID-WH024.pdf).

[9] A more complete list can be found in Lara Srivastava's background paper: "Ubiquitous Network Societies: The Case of Radio Frequency Identification" that was produced for ITU's Strategy and Policy Unit's (SPU) workshop on "Ubiquitous Network Societies" in spring 2005 (full text: http://www.itu.int/osg/spu/ni/ubiquitous/Papers/RFID%20background%20paper.pdf). Videos of sample RFID applications can be found for example at Accenture: http://www.accenture.com/xd/xd.asp?it=enweb&xd=services\rfid\insights\rfid_insights_prototypes.xml

[10] E.g. Singapore's Electronic Road Pricing System (ERP) (details here: http://www.automedia.com.sg/lta.htm)

[11] Authorities in South Korea announced in March 2005 that the port of Busan, which is the third largest port in the world will implement an RFID tracking system for containers.(see: http://www.eetimes.com/news/semi/showArticle.jhtml;jsessionid=MFLCDAE20AU5EQSNDBGCKH0CJUMEKJVN?articleID=60407369&_requestid=712272)

[12] E.g. a school in the Wakayama prefecture in Japan uses RFID to track student's attendance in class-rooms, which bus-stop they get off and other things (more information: http://blogs.zdnet.com/BTL/index.php?p=1207) Nevertheless some schools like the Brittan Elementary School in Sutter (California, USA) have decided to abandon experimental RFID programs because of privacy concerns (more information here: http://epic.org/privacy/rfid/children.html)

[13] A patient tracking-system has recently (April 2005) been implemented in the hospital of the German City of Saarbrücken (more information here: http://www.heise.de/english/newsticker/news/58842). Additional information on patient tracking provides the CRM magazine article „Using RFID To Keep Track of Patients" from March 2005 (fulltext here: http://www.crmbuyer.com/story/crmsystems/rfid-patients-41829.html)

[14] More details can be found for example in the US-Food and Drug Administration (FDA)'s report „Combating Counterfeit Drugs" (full text: http://www.fda.gov/oc/initiatives/counterfeit/report02_04.html)

[15] The Website of the US Food Safety Research Information office provides a good list of projects for electronic animal identification (http://www.nal.usda.gov/fsrio/research/fsheets/fsheet12.htm).

[16] An important standard for RFID enabled passports is the ICAO „e-passport" standard (more information here: http://www.aware.com/products/compression/icaopack_gg.html). E.g. the United States' Department of State is working on the introduction of such passports beginning by late 2005, but prefers to call them "contactless smart-cards" instead of using the apparently more controversal description "RFID" (more information here: http://www.technewsworld.com/story/42349.html)

[17] E.g. the Vatican Apostolic Library has announced that it will subsequently implant RFID tags in its 1.6 million volumes (more information here: http://www.rfidgazette.org/2004/07/vatican_library.html)

- **Sports and leisure**: tracking runners[18], automated payment for ski lifts[19], ticketing[20], etc.
- **Shopping**: facilitating checkout procedures[21], etc.

1.4. Boom times ahead: Analysts expect market growth

Analysts expect to see a tremendous development of the worldwide RFID markets in coming years and foresee growth rates in double-digits. Nevertheless, there are dramatic differences between forecasts on how much the market will grow. A recent study by Frost & Sullivan[22] estimates revenues to grow to 11.7 billion USD by the year 2010. But, a new study published by Research and Markets[23] is a little less enthusiastic, predicting revenues of just 3.8 billion USD in 2011. To achieve this, the researchers estimate the average market growth to be 67 per cent per year. Another study published by IDTechEx[24] in spring 2005 sees continuing growth, and predicts 26.90 billion USD in 2015.


RFID-tagged pallets in a store in Neuss Foto: Metro

The various existing studies of RFID market growth do not only differ in their perception of the future but also when it comes to describing the existing situation. Frost & Sullivan saw a total revenue of 1.7 billion USD in 2003, whereas according to Research and Markets, RFID markets valued at some 503 million USD in 2004. IDTechEx sees the global market for RFID at 1.94 billion USD in 2005.

The differing results of the studies (existing market volume, growth rates, etc.) might be explained in part by the different definitions of the term “RFID market.” It has to be determined whether this includes both RFID products and integration services or the products only.

1.5. Constraints

1.5.1. Pricing

The ultimate incentive for deployment of RFID technology is cost. Only cheap tags (and readers) will allow businesses to implement RFID-solutions on a broader scale. Lars Godell, analyst at Forrester, explained almost three years ago: “It is starting now, but it won't have a big impact for a while. It will take time for the chips’ prices to get low enough and until systems are implemented"[25]. A widely perceived goal in terms of pricing is the “5-cent-tag” (0.05 USD per tag). Industry consortium the Auto-ID-Center, now EPC Global, emphasises that only a tag-price in that range would make widespread RFID tagging commercially viable.

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[18] One of the solutions for tracking runners, bikers etc. is the „ChampionChip“ that was first used in the Berlin Marathon in September 1994. (for more information see: http://www.championchipus.com/home.html).
[19] Many ski-areas in diffrent parts of the world use RFID systems. An example is the Dolomiti area in Italy (more information here: http://www.oracle.com/corporate/press/2005_mar/dolomiti.html)
[20] E.g. all tickets for the soccer world cup finals 2006 in Germany will be equiped with an RFID tag to prevent counterfeiting (more information here: http://fifaworldcup.yahoo.com/06/en/030218/4/9s.html)
[21] RFID technology for speedy self-checkout is used for example by the German retailer Metro in its RFID Innovation Center in the city of Neuss (more information here: http://www.rfidjournal.com/article/articleview/1082/1/1/ and here: http://www.future-store.org/)
[22] The report (June 2004) entitled “World RFID Based Applications Market” is available here: http://www.frost.com/prod/servlet/report-homepage.pag?repid=A686-01-00-00-00&ctxst=FcmCtx1&ctxht=FcmCtx2&ctxhl=FcmCtx3&ctxixpLink=FcmCtx4&ctxixpLabel=FcmCtx5
[23] The report (March 2005) entitled 'RFID: Market Opportunities, Strategies, and Forecasts, 2005 to 2010'.is available here: http://www.researchandmarkets.com/reports/c14660/
[24] The report (April 2005) entitled “RFID Forecasts, Players and Opportunities” is available here: http://www.idtechex.com/products/en/view.asp?productcategoryid=72
[25] Cited from the RFID Journal, 17 June 2002, http://www.rfidjournal.com/article/articleview/12/1/52/

“At 5¢, our research shows that total demand will be explosively larger”, wrote Sanjai Sarma of the Auto-ID Center in 2001.[26]

Currently, prices for tags are far from being that low, and worldwide demand is not sufficient for prices to come down soon. Currently, a passive tag costs around 0.40 USD. But the manufacturers promise that prices will fall: “Users need to see that there is a roadmap toward the 5-cent tag, and step by step our volumes and production costs are going the right way to pass savings onto our customers," says Stav Prodromou, of tag-manufacturer Alien Technology.[27] Analysts differ about when exactly to expect the 5-cent-tag. A study published by ARC in 2004 indicates that the supply chain RFID tag market will not reach the 5 cent price point until 2008. Nevertheless, the report states that “individual suppliers may be able to reach there through the combination of high-volume contracts and low-cost form factors.”[28]

1.5.2. Security and Privacy Issues

Further constraints that could hinder a boom of RFID technology are security and privacy issues. A main security concern is that eavesdroppers could be able to read RFID tags without knowledge of the owner. This is very delicate especially in the case of RFID-equipped passports etc. Anybody spying on RFID chips could potentially obtain personal information on the passport holder.

Researchers have found that security and privacy issues are of different importance to customers in different regions of the world. "Overall, Asians are not as worried about security issues as Americans are"[29], says Renia Lopez, strategy consultant at Fusion. Notwithstanding, security and privacy issues have to be addressed by the industry as they will be decisive for a *truly* global success of the technology.

1.5.2.1. Concerned consumers

A main privacy concern, of importance namely in business-to-consumer (B2C) relations, is the ability of RFID systems to track persons and goods without consent. Because RFID tags are getting smaller and smaller, it is easily possible to hide tags in such a way that consumers are unaware of their presence. This could be an attractive option to businesses as they would be able to profile and identify consumer pattern and behaviour. In recent years, RFID technology has encountered massive criticism by various consumer groups such as Consumers against Supermarket Privacy Invasion and Numbering[30] (CASPIAN), Electronic Privacy Information Centre[31] (EPIC) or the Electronic Frontier Foundation (EFF)[32]. In a statement issued in November 2003[33], various consumer groups have requested a moratorium on the use of RFID technology in consumer products to provide enough time to assess the impact of the technology. Companies using RFID technologies like Benneton[34], Gillette[35] or Tesco[36] faced consumer boycotts.

Demonstration against RFID equipped super-market (Metro’s Future Store) Foto: CASPIAN

[26] The white paper (November 2001) „Towards the 5¢ Tag” is available here:http://archive.epcglobalinc.org/publishedresearch/MIT-AUTOID-WH-006.pdf
[27] Cited from the RFID Journal, 1 April 2004, http://www.rfidjournal.com/article/articleview/857/1/1/
[28] The report (August 2004) „RFID Systems in Manufacturing Supply Chain Outlook” is available here: http://www.arcweb.com/research/pdfs/Study_rfid.pdf
[29] Quoted from RFID Journal article „RFID enabled Credit Cards Apt to lead“, 25 March 2005 (full text here: http://www.rfidjournal.com/article/articleview/1468/1/1/).
[30] http://www.nocards.org/ and http://www.spychips.com/
[31] http://www.epic.org/privacy/rfid/
[32] http://www.eff.org/Privacy/Surveillance/RFID/
[33] http://www.eff.org/Privacy/Surveillance/RFID/RFID_Position_Statement.pdf
[34] http://www.boycottbenetton.com/
[35] http://www.boycottgillette.com/
[36] http://www.boycotttesco.com/

In fact, consumers become more and more aware of RFID technologies and its possible threats to privacy. In the USA, the "RFID Consumer Buzz"[37] survey by market intelligence company BIGresearch saw the percentage of people having heard of RFID go up from 28 per cent in September 2004 to 41 per cent in March 2005.[38] Interestingly, notwithstanding the greater familiarization with the technology, the level of concerns regarding possible privacy problems remained relatively constant at 65 per cent.

1.5.2.2. Concerned policy makers

Policy making in various parts of the world has responded to such fears, debating legal solutions to the problem. Some sort of binding and non-binding privacy guidelines[39] on the protection of personal data could be such a measure. The guidelines would have to be adhered to by businesses using RFID technologies. These guidelines could be modified for certain sectors of the industry to include specific needs, but should nevertheless maintain a set of core standards, such as a notification of the use of RFID tags, limits of the amount of data collected, the guarantee that information on the chip is destroyed after the intended use has been achieved, an option for the customer to have the data on the RFID chip destroyed upon request, a user's right to read the information on the tag etc.

US-researcher Simson Garfinkel has developed an "RFID Bill of Rights"[40]. He calls for the right to know whether products contain RFID tags, the right to have RFID tags removed or deactivated when products are purchased, the right to use RFID-enabled services without RFID tags, the right to access an RFID tag's stored data and finally the right to know when, where and why the tags are being read. [41]

Additional to approaches like policy guidelines or the "Bill of rights", legally binding options are under debate. E.g. in the European Union, the "Article 29 Data Protection Working Party"[42] of the Commission's DG Internal Market has been dealing with the data protection issues related to RFID technology. The group issued a working document[43] in early 2005. It contains different concerns "about the possibility for some applications of RFID technology to violate human dignity as well as data protection rights". In particular, the group fears that businesses and governments could use RFID technology to pry into the private sphere of individuals. In a public consultation, several business associations responded in a joint statement: "RFID technology – as any technology – can be abused or misused"[44]. The Business Associations explain that they do not see "the need for any changes in data protection laws, as the use of RFID technology is well protected by existing laws".

In the US, a long discussion on privacy implications of RFID technology started when the Department of State announced that it planned to issue RFID enabled passports[45]. Privacy groups and researchers criticized that it was not planned for the data on the chip to be encrypted[46] which meant that data could potentially be read by unauthorized third parties. According to media reports, the government received more than 2400 critical comments on the plan. It subsequently announced in late April 2005 that it was "taking a very serious look" at implementing a privacy solution.[47]

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[37] http://www.bigresearch.com/rfid.htm
[38] http://www.rfidjournal.com/article/articleview/1491/1/1/
[39] An example on how such guidelines could look has been discussed e.g. by the the APT Standardization Program (ASTAP)'s Expert Group Meeting on Information Security during its 2005 meeting in Bangkok (Thailand). Full text here: http://www.aptsec.org/meetings/2005/astap9/documents/ASTAP05-FR09-EG.IS-03%20Guideline%20Protection%20Privacy%20for%20RFID.doc
[40] Full text here: http://www.technologyreview.com/articles/02/10/garfinkel1002.asp
[41] A good read on the topic of privacy is also: Stephanie Perrin: "RFID and Global Privacy Policy" in: Simson Garfinkel and Beth Rosenberg (eds.), RFID: Applications, Security, and Privacy, 2005, p.95-122 (full text of the chapter here: http://anonequity.org/files/Perrin%20-%20RFID%20and%20Global%20Privacy%20Policy.pdf)
[42] This group has been set up under Article 29 of Directive 95/46/EC. The full text of the directive can be found here: http://europa.eu.int/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=EN&numdoc=31995L0046&model=guichett
[43] http://europa.eu.int/comm/internal_market/privacy/docs/wpdocs/2005/wp105_en.pdf
[44] http://www.iccwbo.org/home/e_business/FINAL_ICC_EICTA_ICRT_JBCE_response_Art29_WP105_RFID_and_privacy_31March05.pdf
[45] More information on the initial plan can be found in a proposal in the US Federal Register: (full-text here: http://a257.g.akamaitech.net/7/257/2422/01jan20051800/edocket.access.gpo.gov/2005/05-3080.htm)
[46] No Encryption for E-Passports, Wired News 24 February 2005 (full text here: http://www.wired.com/news/privacy/0,1848,66686,00.html)
[47] Feds Rethinking RFID Passport, Wired News 26 April 2005, (full-text here: http://www.wired.com/news/privacy/0,1848,67333,00.html)

1.5.2.3. Creative researchers

Bearing in mind the concerns of customers, researchers at various places are developing methods of avoiding attacks against security and privacy of information in RFID systems. Three examples are described below:

Blocker Tags: These tags were developed by RSA Laboratories scientists in conjunction with Prof. Ronald Rivest[48]. In size, appearance and cost they are similar to RFID tags. Blocker tags help to maintain the privacy of consumers by "spamming" any reader that attempts to scan tags without the right authorization. The blocker tags suggest to the reader that there are many tags in its proximity – even if there are none. At the same time the tags do not interfere with the normal operation of RFID systems in retail environments.

Kill Switches: Newer RFID tags (such as EPCglobal Gen 2 tags[49]) are usually equipped with a "Kill Switch". This allows the RFID tags to be partially or fully disabled. With these switches a consumer can thus have an RFID tag disabled before leaving a store. The possibility of stealth tracking and profiling would not occur.

Anonymous authentication: In scenarios where RFID is used for authentication purposes, an anonymous authentication scheme as proposed in the Trusted Computing Group's Direct Anonymous Attestation[50] could enhance user's privacy. Researchers have developed a concept of devices that prove group membership without revealing the identity of the particular person. As Burton Kalinski, Chief Scientist of RSA Laboratories put it: "Practical privacy and authentication solutions for these settings remain a research challenge"[51].

1.5.3. Standards

The next chapter (Chapter 2) of this paper will be devoted to the question of RFID standardization. It will be shown that a broad variety of players in RFID standardization exist. They develop standards that are crucial to the advancement of the RFID industry. Unfortunately a lack of harmonized, globally accepted, cross-sector and interoperable standards on RFID tag data structures, network components and protocols between those components exists. All participants must work together to ensure that missing, fragmented or proprietary standards do not hinder RFID deployment.

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[48] *The Blocker Tag: Selective Blocking of RFID Tags for Consumer Privacy*. In V. Atluri, ed. 8th ACM Conference on Computer and Communications Security, pp. 103-111, full text here: http://www.rsasecurity.com/rsalabs/node.asp?id=2060.

[49] The Industry Week article „RFID Strategy -- What Does The Gen2 RFID Standard Mean To You?" gives a good overview over Gen 2 tags (full text here: http://www.industryweek.com/ReadArticle.aspx?ArticleID=9622)

[50] http://eprint.iacr.org/2004/205.pdf

[51] http://www.rsasecurity.com/rsalabs/staff/bios/bkaliski/publications/other/kaliski-future-authentication-it-defense-2005.ppt

2. RFID and standardization

It is understood that the use of any modern technology requires some form of harmonization at national and international level. Standardization ensures compatibility and interoperability between different manufacturers and technical applications. On its website, the International Telecommunication Union (ITU) notes that standards for information and communication technologies (ICT) "…are growing in importance not only because of globalization but also because the ICT sector is one of the pillars in today's economy"[52]. Or, as noted on the International Organization for Standardization's (ISO) website: "It is when there is an absence of standards that their importance is brought home."[53] These findings of course also apply to RFID. The following chapter will deal with the standards landscape and present areas for future standardization initiatives.

2.1. Key players

Various players are involved in working with and standardizing RFID technologies. This sub-section aims to present some major players in RFID standardization activities and spectrum allocation. This non-comprehensive list is presented in alphabetical order. State-driven initiatives are listed at the end. Those interested in further information on RFID standardization can also find a large number of resources on the web.[54]

2.1.1. Automotive Industry Action Group (AIAG)

The Automotive Industry Action Group[55] (AIAG), an association of 1600 members involved in the automotive and truck manufacturing supply chain, has been developing RFID specifications for the automotive industry. A general standard exists (ARF 1[56]: Application Standard for RFID Devices in the Automotive Industry) and is accompanied by several standards dealing with special sectors of the automobile supply chain, such as AIAG B-11[57], a standard to identify tires and wheels with RFID. AIAG B-11 has been developed together[58] with EPC global (see Chapter 2.1.3.). AIAG also holds regular conferences on the use of RFID in the automotive industry.[59]

2.1.2. European Article Numbering (EAN)/ Uniform Code Council (UCC)

The European Article Numbering (EAN) and the Uniform Code Council (UCC) which administers and manages the EAN·UCC standards system in the USA and in Canada, launched the Global Tag Initiative (GTAG) in March of 2000. It is a standard that covers UHF RFID technology and data formats. The air interface aspects of GTAG have now been merged with ISO 18000 Part 6. EAN International and UCC started EPCglobal (see Chapter 2.1.3) as a joint venture.

2.1.3. EPCglobal

EPCglobal[60] is a joint venture between EAN International and the Uniform Code Council (UCC). It aims to promote the Electronic Product Code (EPC), a technology that has been developed by the Auto-ID Centre. The EPC is used for item identification, for example in supply chain management. The ultimate stated aim of the EPC global consortium is to create a global standard that would boost RFID rollout.

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[52] http://www.itu.int/aboutitu/overview/o-s.html
[53] http://www.iso.org/iso/en/aboutiso/introduction/index.html#one
[54] Another, more detailed list of RFID-standards can be found on the website of the Association for Automatic Identification and Mobility: http://www.aimglobal.org/standards/rfidstds/RFIDStandard.asp; A summary provided by AutoID.org lists international projects relating to automatic data capture:http://www.autoid.org/standards/project_summary.htm; A standards-map can be found here: http://www.autoid.org/presentations/rfid_%20activities/rfid_issues.htm
[55] http://www.aiag.org/
[56] https://mows.aiag.org/source/doc_info.cfm?product_code=ARF-1
[57] https://mows.aiag.org/source/doc_info.cfm?product_code=B-11
[58] http://www.rfidjournal.com/article/articleview/1156/1/1/
[59] Presentations of the last summit are available here: http://www.aiag.org/forms/2004RFIDSummitFinalPresentationPart1.pdf and here: http://www.aiag.org/forms/ 2004RFIDSummitFinalPresentationPart2.pdf
[60] http://www.epcglobalinc.org/

EPCglobal's most recent standard is the Electronic Product Code (EPC) Class 1 Generation 2 protocol, for RFID applications using UHF frequencies.

Companies like Philips[61] or Impinj[62] have announced that they will support the Generation 2 protocol. It will eventually replace the older EPCglobal standards Class 0[63] and Class 1[64] Generation 1. As appropriate, EPCglobal submits its standards to ISO for review and ratification. ISO considers EPC as being a subset of its standards. Currently, EPCglobal has submitted the Generation 2 standard to ISO for approval as ISO 18000-6C.[65] This is a big step forward as former standards (Class 0 and Class 1 Generation 1) were incompatible with ISO standards.

Observers also remark that there is a fundamental difference between a consortium-drafted purpose-specific RFID standard for the Air Interface (EPCglobal) and an all-purpose standard by worldwide users and suppliers.

It will be interesting to follow the relationship between EPCglobal and ISO as EPCglobal gradually introduces new classes of tags. A road map has been set up by the Auto-ID Centre, which developed EPC Class 1. This roadmap proposes five classes of tags. Each will have a greater functionality than the class below it. The next would thus be Class 2. Working groups in EPCglobal's Hardware Action Group (HAG)[66] are currently developing this standard.

2.1.4. European Radiocommunication Office (ERO)

At a European level, the European Radiocommunication Office (ERO)[67] has been working on radio-communications policies and frequency allocation also important to RFID technologies. The ERO is the permanent office that supports the Electronic Communications Committee (ECC)[68]. This committee, in turn, is the telecommunications regulation committee for the European Conference of Postal and Telecommunications Administrations (CEPT)[69]. The ERC Decision ERC/DEC(01)04[70] of 2001 addresses the use of non-specific short range devices (SRDs), such as RFID, in certain UHF frequency bands. Other important CEPT regulations related to RFID technologies include: CEPT/ERC 70-03 (Relating to the use of SRDs), CEPT T/R 60-01 (Low-power radiolocation equipment for detecting movement and for alert, EAS), CEPT T/R 22-04 (Harmonisation of frequency bands for Road Transport Information Systems, RTI)

2.1.5. European Telecommunications Standards Institute (ETSI)

The European Telecommunications Standards Institute (ETSI) has also been very active in the field of RFID standardization. Last year, ETSI TG34 (Electromagnetic compatibility and Radio spectrum Matters[71]) completed in cooperation with EPCglobal, the standard EN 302 208, which allows readers to use more power and operate in a wider UHF band. Before that ETSI had already developed the ETSI EN 300-220 standard.

[61] http://www.eetimes.com/news/latest/showArticle.jhtml?articleID=160401580
[62] http://www.electronicsweekly.com/articles/article.asp?liArticleID=39222&liArticleTypeID=1&liCategoryID=1&liChannelID=2&liFlavourID=1&sSearch=&nPage=1
[63] http://www.epcglobalinc.org/standards_technology/Secure/v1.0/UHF-class0.pdf
[64] http://www.epcglobalinc.org/standards_technology/Secure/v1.0/UHF-class1.pdf
[65] http://www.rfidjournal.com/article/articleview/1468/1/1/
[66] http://www.epcglobalinc.org/action_groups/hag.html
[67] http://www.ero.dk/
[68] http://www.ero.dk/ecc
[69] http://www.cept.org/
[70] http://www.ero.dk/documentation/docs/doc98/official/pdf/DEC0104.PDF
[71] http://portal.etsi.org/portal_common/home.asp?tbkey1=ERM

2.1.6. International Air Transport Association (IATA)

The International Air Transport Association (IATA) is studying RFID-technologies for airline baggage management.[72] A sub-group of the Baggage Working Group[73] (BWG) is responsible for this. IATA has already adopted 13.56MHz and ISO/IEC 15693 in its Recommended Practice for airline baggage RF identification (RP1745).[74]

2.1.7. International Civil Aviation Organization (ICAO)

Within the framework of the International Civil Aviation Organization (ICAO), the Technical Advisory Group on Machine Readable Travel Documents[75] (TAG/MRTD) has been working on international travel documents (e.g. a passport or visa) containing eye- and machine-readable data. Specifications for the design of these travel documents are contained in ICAO Doc 9303[76]. An annex to that document[77] contains provisions on contactless integrated circuits, referring in particular to the ISO/IEC 14443 standard.

2.1.8. International Committee for Information Technology Standards (INCITS)

Within the International Committee for Information Technology Standards (INCITS), the Technical Committee T6 deals with RFID standardization[78]. T6 has developed NCITS 256, an RFID standard for use in item management. INCITS is accredited by the American National Standards Institute (ANSI).

2.1.9. International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC)

The International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) have undertaken major activities to standardize RFID technologies in various areas. The work on RFID standardization in ISO and IEC has been carried out mainly under ISO/IEC Joint Technical Committee 1 (JTC 1) subcommittees 17 (Identification Cards and personal identification)[79] and 31 (Automatic Identification and Data Capture Techniques)[80]. Inside of SC31, WG4[81] is responsible for RFID for Item Management. Other groups within the ISO framework that work on RFID topics include ISO TC 23 / SC 19 (Agricultural electronics)[82], ISO TC 104 / SC 4 (Identification and communication) [83] and ISO/TC204 (Transport Information and Control Systems)[84].

. ISO and the International

The ISO standards on RFID include:

Cards:

- ISO/IEC 10536 (ISO/IEC JTC1 SC17/WG8) - Close coupling cards
- ISO/IEC 14443 (ISO/IEC JTC1 SC17/WG8) - Proximity cards
- ISO/IEC 15693 (ISO/IEC JTC1 SC17/WG8) - Vicinity cards
- ISO/IEC 10373 (ISO/IEC JTC1 SC17/WG1/8) - Identification cards - Test Methods

[72] http://www.iata.org/whatwedo/simplibiz/rfid/
[73] http://www1.iata.org/Whip/Public/frmMain_Public.aspx?WgId=46
[74] A presentation on IATA-regulations and their relation to ISO standards can be found here: http://www.autoid.org/SC31/2004/aug/827b_ISO_Standards_for_IATA.ppt
[75] http://www.icao.int/mrtd/Home/index.cfm
[76]http://www.icao.int/mrtd/download/documents/Biometrics%20deployment%20of%20Machine%20Readable%20Travel%20Documents%202004.pdf
[77] http://www.icao.int/mrtd/download/documents/Annex%20I%20-%20Contactless%20ICs.pdf
[78] http://www.ncits.org/tc_home/t6.htm
[79] http://www.sc17.com/
[80] http://www.hightechaid.com/standards/RFID_Standards_SC31.htm
[81] http://usnet03.uc-council.org/sc31/sc31_wg4.cfm
[82] http://www.iso.org/iso/en/stdsdevelopment/tc/tclist/TechnicalCommitteeDetailPage.TechnicalCommitteeDetail?COMMID=999
[83] http://isotc.iso.org/livelink/livelink.exe?func=ll&objId=651505&objAction=browse&sort=name
[84] http://www.iso.org/iso/en/stdsdevelopment/tc/tclist/TechnicalCommitteeDetailPage.TechnicalCommitteeDetail?COMMID=4559

Items:

- ISO 10374 (ISO TC 104) - Freight containers - Automatic identification
- ISO/IEC 15960 (ISO/IEC JTC1 SC31 WG2/4) - RFID for Item Management; - Transaction Message Profiles
- ISO/IEC 15961 (ISO/IEC JTC1 SC31 WG2/4) - RFID for Item Management; - Host Interrogator - Tag functional commands and other syntax features
- ISO/IEC 15962 (ISO/IEC JTC1 SC31 WG2/4) - RFID for Item Management; - Data Syntax
- ISO/IEC 15963 (ISO/IEC JTC1 SC31 WG2/4 - Unique identification of RF Tag and Registration Authority to manage the uniqueness
- ISO/IEC 18000 (ISO/IEC JTC1 SC31 WG4/SG3) - RFID for item Management; Air Interface
- ISO/IEC 18001 (ISO/IEC JTC1 SC31 WG4) -Information technology - RFID for Item Management - Application Requirements Profiles

Animals:

- ISO 11784 (ISO TC 23/WG19) Radio-frequency identification of animals - Code structure
- ISO 11785 (ISO TC 23/WG19) Radio-frequency identification of animals - Technical concept
- ISO 14223 (ISO TC 23/WG19) Radio-frequency identification of animals - Advanced Transponders

2.1.10. International Telecommunication Union (ITU)

The International Telecommunication Union is the United Nation's specialized agency for telecommunications. Two of its three sectors are dealing with RFID-related issues: the Radiocommunication Sector (ITU-R), and the Telecommunication Standardization Sector (ITU-T).

As global spectrum coordinator, ITU-R plays an essential role in the management of the radio-frequency spectrum. It is governing the use of the radio spectrum by some 40 different services around the world. ITU-R Study Group 1[85] is responsible for spectrum management.

The Telecommunication Standardization Sector (ITU-T) creates globally agreed and globally accepted ICT standards. ITU-T recently set up a correspondence group on RFID in the framework of its „Technology Watch" and a dedicated e-mail reflector on the matter for initiating studies on the technology. Additionally, ITU-T is to hold a workshop on RFID standardization issues in the first quarter of 2006. ITU-T's Study Group 6 is working on a draft recommendation on "Radio Frequency Identification (RFID) Tag component suitable for different outside network plant applications"[86]. ITU's Strategy and Policy Unit (SPU) organized a workshop on „Ubiquitous Network Societies"[87] in spring 2005, where RFID issues played a major role.

2.1.11. Universal Postal Union (UPU)

The Universal Postal Union[88] (UPU) is the UN specialized agency for cooperation between postal services. UPU's Technical Standards Board has been developing standards to use RFID technologies in postal applications for several years. Among these standards are: S25-1G (Data Constructs for the Communication of Information on Postal Items, Batches and Receptacles), S23-1 Part A,B,C,G (RFID) and Radio Data Capture (RDC) Systems), UPU

[85] http://web/ITU-R/study-groups/rsg1/index.asp
[86] http://www.itu.int/ITU-T/studygroups/com06/sg6-q4.html
[87] All presentations of the workshop are available here: http://www.itu.int/ubiquitous/presentations.html
[88] http://www.upu.int/

RF 0001.2 (Identification and Marking using RFID Technology: Data Schemes), UPU Snn-1 (Identification and Marking using RFID Technology: Reference Architecture and Terminology), UPU Snn-3 (Identification and Marking using RFID: System Requirements and Test Procedures)

2.1.12. State driven standardization initiatives

Additionally to the above-mentioned organizations and consortia, state driven initiatives might eventually play an important role in RFID standardization. China is one example: Earlier this year, the Standardization Administration of China[89] announced the creation of an RFID Tag Standards Working Group that seeks to develop RFID standards in line with specifications from EPCglobal and ISO - but with some modifications to satisfy special needs in the country. The importance of this announcement is illustrated by the fact that multinational companies, such as General Motors decided to hold off using RFID in its assembly and supply-chain operations until the Chinese government decides on its standard.[90]

Another example is Japan, where the Ministry of Economy, Trade and Industry[91] (METI) formed a consortium of Japanese firms to work on RFID issues.[92] This "Hibiki" (ring) consortium includes companies like Hitachi[93], NEC[94] and Dai Nippon Printing[95]. In early 2005, the Hibiki consortium presented a proposal of an RFID standard to ISO for consideration.[96]

In 2004 Korea's Ministry of Information and Communication (MIC)[97] started to promote RFID technology investments as part of its "IT 839 strategy"[98]. In Feb 2005, Korean industry launched a "Mobile RFID Forum". The forum aims to commercialise mobile-phone-based RFID services in 2007.

China, Korea and Japan signed a Memorandum of Understanding[99] on common standardization efforts for RFID applications in the spring of 2005. It brings together Japan's Ubiquitous ID Center, the Chinese Academy of Sciences' Institute of Computing Technology and the Korea RFID Association for future work on the technology.

2.2. The need for standardization

In general, RFID standardization is needed in the following areas:

- **Air Interface, Protocols**: Communication between tags and readers, readers and readers, RFID systems and other wireless communication systems
- **Data Stuctures** - Organization of the data (e.g. on a tag)
- **Conformance** - Tests ensuring that products meet the standards
- **Applications** – Use of the technology for a particular purpose

Today, various RFID standards already exist. They usually focus either on a specific area (Air interface *or* data structure etc.) or a specific sector of application. Experts at the "ITU Workshop on Ubiquitous Network Societies"[100] re-emphasised in April 2005 that there are two main areas where standardization of RFID technologies is lacking. The first area is identifiers and codes, the second area is data formats, frequencies and protocols for

[89] http://www.sac.gov.cn/english/home.asp
[90] http://www.rfidinsights.com/news/showArticle.jhtml?articleId=160700451
[91] http://www.meti.go.jp/english
[92] http://www.eetimes.com/story/OEG20031117S0020
[93] http://www.hitachi.com/
[94] http://www.nec.com/
[95] http://www.dnp.co.jp/index_e.html
[96] http://www.rfidjournal.com/article/articleview/1396/1/51/
[97] http://www.mic.go.kr/eng/index.jsp
[98] http://www.mic.go.kr/eng/res/res_pub_it839.jsp
[99] More information here: http://english.etnews.co.kr/news/detail_top.html?id=200504180001&art_grad=9
[100] http://www.itu.int/osg/spu/ni/ubiquitous/

communication. Consortiums like EPCglobal mainly address the first area. Nevertheless, especially the second area still needs much work.

2.3. Possible working areas for ITU-T

This chapter will present some ideas for particular areas of standardization where ITU-T could become active.

- **Mobile RFID technologies:** As the main focus of this paper this topic will be presented in more detail in Chapter 3.**Privacy/Security issues:** This includes encryption technologies for the data on the tags to prevent unauthorized reading. Anonymous authentication to enhance user's privacy is another possible field of study.

- **Impact of RFID on networks**: Additional services based on the use of RFID technologies will generate more traffic in both fixed and mobile networks. Further study will have to research how big this impact is and how network design must respond to the challenges. The Cisco-commissioned IDC-report "Planning for Proliferation: The Impact of RFID on the Network"[101] generally expects both an impact on network traffic and design. The report for example. recalls the fact that the question of network traffic is about more than just about reading tags: "A tag read can generate the sourcing and retrieval of data from anywhere on the network" – and thus generate a significant rise in network traffic.

- **Internetworking Technologies:** Further research is needed on how RFID technologies can integrate into existing network environments. In the short run, this is important e.g. in the context of RFID application in mobile phones, where other wireless technologies such as bluetooth are likely to be present. In the long run, internetworking may become extremely important when it comes to integrating RFID devices into Next Generation Networks (NGN)[102].

- **RFID-IPv6 mapping issues:** Although active and passive RIFD tags will coexist in the future, many of the currently passive RFID tags will subsequently evolve towards active tags, which have networking capabilities. This will mean that a large number of tags will need network addresses for communications[103]. IPv6[104] will play an important role here. But tags themselves do not necessarily have be equipped with IPv6 addresses until needed.

This list is not exhaustive. Among other topics that could be addressed by ITU-T are for example business models, service capabilities, architecture at network and service capabilities levels, signalling protocols, quality of service. Apart from technical standardization, frequency management issues are important for an implementation of the technology. ITU-R is an important player in this field.

[101] http://newsroom.cisco.com/dlls/2005/Whitepaper_031105.pdf
[102] More information on NGN technology can be found on the ITU-T website: http://www.itu.int/ITU-T/ngn/
[103] The White paper „Internet and Auto-ID Architecture" by the Auto-ID Center Japan (October 2003) addresses this topic (full text here: http://www.autoidlabs.com/whitepapers/KEI-AUTOID-WH002.pdf).
[104] see e.g. http://www.rfida.com/nb/ipv6.htm

3. RFID based Mobile Telecommunications Services

RFID based mobile telecommunication services can be defined as services that provide information on objects equipped with an RFID tag over a telecommunication network. The RFID reader is installed in a mobile device such as a cell phone. This is a fundamentally new approach compared to most existing RFID applications. There, the readers are considered to be stationary while the tags are considered to be mobile. This would now change. The implementation of RFID in mobile telecommunications services would lead to a scenario where the tags are stationary and readers (that are integrated in the cell-phone) become mobile. There would also be applications where the mobile phone can be both, tag and reader at the same time.

Integrating RFID capabilities into mobile devices extends the use of RFID technology beyond the supply chain management etc. into areas like customer service, marketing or brand management. RFID based mobile telecommunications will play an important role in bridging offline objects with information accessible on data-networks. Services that use the information stored on RFID tags and communicate with peer objects will help to create an environment of "smart objects". Mobile phones are an excellent platform for user communication with such smart objects.

A first implementation of this concept already exists and will be detailed in section 3.2. The Near-Field Communications (NFC) protocol is designed for short-range communications over distances of a few centimetres. It can thus be used to implement RFID services in mobile networks. But NFC is *not equal* to RFID services in mobile networks, it is rather a subset of it. Other standards for RFID-based mobile telecommunications services could still be developed.

The use of RFID technologies in mobile communication undoubtedly has a promising future. A report[105] published by Forrester Research three years ago already predicted that RFID will bring growth to the mobile telecom industry: "Enterprises, as well as chip makers, equipment makers, solution providers, and telcos, will all benefit," the report says.

3.1. Application scenarios

Various technical implementations for RFID in mobile telecommunications already exist. For example, Nokia has developed a first RFID-enabled cell phone in cooperation with Verisign. The Nokia 5140 RFID Kit[106], a GSM phone with RFID reading capability[107] was introduced in March 2004. Another handset with RFID functions, the Nokia 3220, is to be launched this summer.[108] The systems use the NFC protocol that is detailed in section 3.2. The Canadian Company Wireless Dynamic[109] claims that it has developed the world's first Secure Digital (SD) card with RFID functionalities. This card could be used to equip existing hardware such as cell phones and personal digital assistants (PDAs) in order to provide RFID functionalities. There are several application scenarios[110] for the use of RFID in mobile telecommunication services:

3.1.1. Information retrieval

In this scenario, the mobile phone is equipped with an RFID-reader and aids to retrieve additional information on tagged items. The information would be stored in a database, which is accessed via the mobile network. Consumers could use this feature for example in supermarkets to obtain additional information on products, e.g. if they contain allergens etc. Comparing prices with on-line services such as Froogle[111] right in the shopping mall would

[105] http://www.forrester.com/ER/Research/Report/Summary/0,1338,15084,00.html
[106] http://www.nokia.com/nokia/0,,55738,00.html
[107] The phone is based on Nokia's phone model 5140 and uses the ISO 14443A standard for the RFID components.
[108] http://press.nokia.com/PR/200411/966879_5.html
[109] http://www.wdi.ca/products.shtml
[110] The scenarios presented in this paper are in part inspired by those developed by Nokia on their website: http://www.nokia.com/nokia/0,,55739,00.html
[111] http://froogle.google.com/

also be easy with an RFID-equipped mobile phone. The application scenario would also be interesting for target-groups like service technicians (to obtain additional information on items to be serviced) or machine operators (to obtain new work instructions for a particular machine).

Information retrieval via RFID enabled mobile phones could also be used for advertisements. Posters or paper-copies of advertisements could carry a small RFID-tag. Anybody interested in more information on the advertised product or event would just have to hold his mobile phone close to the tag. The information would then again be retrieved from a database.[112] The delivered information could also be multimedia-content: For example, the RFID equipped cell phone could provide a free preview of a movie when the user reads an RFID tag that is attached to the movie poster. Thus the combination of RFID and mobile telecommunications provides an interesting new approach to brand management and special promotions that could be attractive to companies and (tech-savvy) customers alike.

3.1.2. Data transmission

Another application possibility is the transmission of data from a tagged item to a central database over the mobile network. This could be used e.g. for security guards to prove that they visited certain sites. The location and a valid timestamp would be transferred to a database as a proof that work has been done accurately. The same concept of data transmission could also be used for reading e.g. electricity meters. Service staff would read a tag attached to a meter and then automatically transfer the meter readings via the phone. Later, the transmitted information will be used for the pricing.

3.1.3. Automated messaging

Automated messages could be generated whenever a mobile phone comes near a tag. This could be used e.g. in a system to set up an attendance control system. A single mobile phone could be used to report presence in the office, a construction site, a field office etc. Another application would be automated progress reports back to office, e.g. for service technicians. They could easily report on their work done by an automated message when they move their phone close to a tag on the serviced machine.

3.1.4. Voice services

Voice services are also an attractive field for using RFID technologies in mobile phones. One possible application in this scenario are visual phone directories. This could e.g. be used at the reception desk of companies with a display of pictures of all the persons working in the company. A mobile phone in proximity to a tag attached to the photo would then initiate a call to the respective person. This would help to simplify making phone calls for persons with physical limitations, for children, or the elderly.

3.1.5. Device integration

Mobile phones could use their RFID capabilities also to “understand” their environment and to communicate with it. Information retrieved from tags in the environment can indicate to the phone e.g. that it is being placed in a car. The phone could then activate certain functions that are only used in a car (support for hands-free etc.). This feature could also be used to block cell-phone use in certain areas, such as planes or hospitals. The RFID equipped cell phone would switch itself off when noticing such a sensitive environment.

[112] The beer-company Heineken has already run an advertisement campaign that uses barcode technology (for details see: http://www.h-e-l-l-o.org/ or http://www.textually.org/picturephoning/archives/007994.htm). If these barcodes were replaced by RFID tags, it would be a perfect example for the presented concept.

3.1.6. Presence indication

Presence indication with RFID-enabled mobile phones would work the opposite way to the device integration that was presented in Chapter 3.1.5. In this scenario, unlike in the previous ones, the RFID equipped mobile phone does not act as a reader but carries an RFID tag. RFID equipped cell-phones might thus have to be equipped with both a reader *and* one or multiple RFID tags. In the scenario of presence indication, the RFID tag on the phone would then enable readers in the environment to identify the phone – and respectively the person carrying it. For example, the location data of a person in a building could be used to provide automatic login to a computer systems or to customize the login to the person's credentials.

3.1.7. Mobile payment

RFID-equipped mobile phones could also be used in payment solutions. RFID chips in the phone or on its surface could store personal information that is necessary for the payment process. In proximity of a point of sale (such as a ticketing terminal or a vending machine) a payment would be initiated upon request of the user. This type of service is already particularly popular in Asia. Note that also in this scenario, the phone is used for carrying a tag and not as a reader.

3.2 Near Field Communications (NFC)

A concept that is already used for RFID enabled mobile phones is the near-field communications (NFC) protocol. That is an ISO/IEC 14443 compatible short-range communication protocol operating over distances of a few centimetres, which uses the 13.56 MHz high-frequency range. The reader provides power to the chip in the passive RFID tag by inductive coupling.

The technology is supported by companies like Philips, Sony, Nokia, Samsung and Motorola as well as the credit card firm Visa. A report[113] by ABI Research, published last summer, gives NFC-enabled mobile phones a market share of 50 per cent by the year 2009.

NFC is already standardized in various bodies like ISO/IEC (18092[114], 21481), ECMA (340, 352 and 356), ETSI TS 102 190.

NFC-enabled phone and ticket terminal
Foto : Philips

The NFC standards outline the transport protocol and data exchange methods as well as mechanisms for data collision control during initialisation, and more. NFC operates at data rates of 106 kbits/s and 212 kbits/s. Higher transmission speeds can be achieved between dedicated NFC devices. Here up to 424 kbits/s are foreseen with potential for higher bit rates.

NFC communication is half duplex, i.e. devices follow a "listen before talk" policy. As the NFC protocol supports both active and passive modes of operation, all NFC devices must support both modes. The setting that both parties can read and write data as well as transmit differs from RFID. One thing is similar though: The initiating device (the reader in terms of RFID) controls the exchange of data in an NFC environment.

Nokia, Philips and Sony founded the Near Field Communication (NFC) Forum[115] in March 2004 to promote the use of the technology in consumer electronics, mobile devices and PCs. The Forum aims to ensure interoperability between devices and services. At the moment,

[113] http://www.abiresearch.com/products/market_research/Near-Field_Communications_(NFC)
[114] http://www.iso.org/iso/en/CatalogueDetailPage.CatalogueDetail?CSNUMBER=38578&scopelist=
[115] http://www.nfc-forum.org/home

two working groups exist, on technical and marketing matters. Apart from the founding members, more than 20 other companies work in the NFC forum. The list of participants includes names like Matsushita, Microsoft, Motorola, Samsung, Texas Instruments and others.[116]

S2C[117], the interface between the NFC chipset and the smart-card controller, has been developed by Philips. Observers are debating whether S2C should be called a proprietary standard. Philips denies this: "This is an open standard, and we are ready to have others access to it", says Philips manager Sour Chhor.[118] Nevertheless, non-member companies complain about difficulties to obtain technical details for the interface.[119] No chip-manufacturer aside from Philips has yet agreed to supply NFC chips.

3.3. Field tests

The following sub-section will provide some samples of how RFID technology in combination with mobile phones is already in use in various regions of the world. The list is far from being comprehensive.

3.3.1. Information retrieval

Countries like Japan are undertaking a larger number of projects on enhancing food-safety with mobile technologies. Many of these projects use RFID technologies. One particular project is the development of "Integrated Food Traceability Systems" that utilize Ubiquitous ID Technology. A field trial took place in February and March 2005 at the Mitsukoshi Department store in Nihonbashi, Tokyo (Japan)[120] and the Keikyu Store, Noukendai Branch, Yokohama (Japan). Customers could get information on the product history of certain pieces of tagged fruit and meat. To access that information both terminals in the store and specially equipped mobile phones could be used. Apart from that a new information system for the fish business is currently being deployed in Japan [121]. The company DoCoMo Sentsu (subsidiary of NTTDoCoMo) and the Marine Fishery Systems Association have created a tracking system for fish products. Consumers can scan the barcode with their cell phones and determine even the name of the fisherman who caught the fish, the cooperative the fisherman belongs to and where the operations were conducted. In Korea, a beef tracking and data system by which consumers can obtain information on their steaks (about its origin etc.) is being set-up by the Carrier KTF.[122]

In Japan, some location-based services with RFID equipped mobile devices are being tested. RFID tags are placed in public venues; pedestrians may then use handheld devices to obtain additional information on their surroundings. A pilot project was set-up in Tokyo's Asakusa district and ran from 12 April to 31 May 2005.[123] RFID and infrared technologies were combined in the project. Around 80 locations were equipped with tags. A mobile device used in the proximity of a tag could be used to display information in the form of text, photographs or moving images. Information was available in English, Chinese, Korean and Japanese.

In Japan, RFID-based services for mobile telecommunications were tested for the first time in 2003 at Tokyo's Roppongi Hills[124] complex. During their shopping, customers were located using their phones. They were then sent information about the area, targeted promotions, entertainment options, and customized shopping information etc.

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[116] For details see: http://www.nfc-forum.org/news/NFCForum_pr_022405.pdf
[117] http://www.semiconductors.philips.com/acrobat_download/other/identification/S2C_survey_10.pdf
[118] Cited in: Walko, John:"A ticket to ride" in: IEE Communications Engineer February/March 2005, p. 13.
[119] http://www.wirelessnetdesignline.com/news/53700206
[120] More information here: http://www.t-engine.org/news/pdf/TEP050202-u01e.pdf
[121] See news report on the project: http://www.engadget.com/entry/7202187107686387/
[122] http://www.smartmobs.com/archive/2004/10/05/ktf_to_trace_im.html
[123] More Information here: http://ubiks.net/local/blog/jmt/archives3/003574.html and here:
[124] More information on this trial project by DoCoMo can be found here: http://www.nttdocomo.com/corebiz/alliances/roppongi.html

In France, according to a large technology-manufacturer, a field trial of location-based city guide with RFID-equipped mobile devices is scheduled in summer 2005.

3.3.2. Mobile payment

Mobile payment with specially enabled phones is already quite popular in some regions of the world, namely in Asia[125]. Different technical approaches are in use. In Japan NTT DoCoMo has sold far more than one million cell phones with mobile payment functionalities.[126] Various handsets of these so called ”wallet phones“ are available. As of November 2004, these handsets can be used at 13,000 shops and 2,700 vending machines. NTT DoCoMo hopes to sell 10 million of these handsets by the end of March 2006.[127] Other Japanese operators have announced plans to offer RFID-enabled handsets in the near future.

Japan's largest train company, East Japan Railway Company (JR East), has announced that it will implement a payment solution that would enable mobile phone users to conduct all ticket-related transactions such as reservations, purchases and fare collection.[128] The project is called ”Mobile Suica” and should be launched in January 2006. Major mobile phone carriers — NTT DoCoMo Inc., KDDI Corp. and Vodafone Inc. — are expected to support the service. The handsets use Sony’s Felica[129] NFC technology that is compatible with ISO 14443A.

The Felica Technology is also used in a Japan Airlines’ check-in service that has been installed at 44 airports throughout the country as from April 2005.[130] Contactless chipcards and RFID-enabled cell phones can be used to speed-up the boarding procedure. Passengers board ”touch and go“ and head directly to their gate without seeing a check-in counter.

In Germany, Nokia and Philips have teamed up with the public transport authority for Frankfurt's greater area, the Rhein-Main Verkehrsverbund (RMV). In April 2005 they presented a ticketing solution that uses Philips’ NFC-technology to allow Nokia 3220 mobile phones to access an existing contactless smart card ticketing infrastructure.[131] A first trial started in the city of Hanau. Some 200 test-customers can buy, store and use tram and bus tickets with their mobile phones. They then receive a monthly bill.

Korea is in the avant-garde of mobile payment applications. The company SK Telecom introduced the Moneta[132] system a few years ago, whereby customers with credit cards supporting the system can insert an additional chip for mobile payments into their specially equipped handsets. The data stored on the chip can then be transferred via infrared or and RFID connection.

In the United States, the recently presented report ”Mobile Payments at the Physical Point-of-Sale: Assessing U.S. Market Drivers and Industry Direction“[133] by the Smart Card Alliance[134] details some smaller pilot projects, including one in Dallas, which ran from February to October 2003. Consumers were issued RFID enabled cellphones for payments in restaurants, gas stations and convenience stores. The report also predicts a strong market for RFID-enabled payment systems using mobile phones, if certain issues are resolved. The report notably calls for strong collaboration among the stakeholders: financial institutions, mobile phone carriers and manufacturers and retailers.

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[125] A good overview on mobile payment in general, not only limited to RFID, is provided by the Aricle „Mobile Payment: A Journey through Existing Procedures and Standardization Initiatives“ by Stamatis Karnouskos published in: IEEE Communications Surveys & Tutorials, October 2004 (full text available here: http://www.comsoc.org/livepubs/surveys/public/2004/oct/KARNOUSKOS.html)
[126] http://www.nttdocomo.com/presscenter/pressreleases/press/pressrelease.html?param%5Bno%5D=509
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[129] http://www.sony.net/Products/felica/
[130] More information here: http://www.jal.com/en/press/0000090/90.html
[131] More information here: www.rmv-get-in.de and http://press.nokia.com/PR/200411/966921_5.html
[132] More information e.g. here: http://www.sktelecom.com/eng/cyberpr/press/1188907_3735.html
[133] Full text here: http://www.smartcardalliance.org/alliance_activities/mobile_payments_pos_report.cfm
[134] http://www.smartcardalliance.org/

4. Conclusion

Many experts see RFID as an enabler for ubiquitous computing [135]- the integration of computation into the environment: any device, anytime, anywhere. RFID enabled mobile phones could be a first step in this direction. The combination of mobile phones and RFID technologies promises great potential in the market for mobile telecommunication services. As in many fields of ICT, the search for the killer application has begun. Field trials in some sectors and some regions of the world have recently started (see section 3.3). However, the development of services is far from being complete. While a broad range of services can be imagined, along the lines of the scenarios detailed in section 3.1, only attractive propositions will convince customers to adopt the technology. One has to await the implementation of mobile payment systems to see whether similar systems will prove to be attractive enough to push the new technology.

Apart from the search for the killer application, a variety of technical questions still need a tremendous amount of work and study. As detailed in this paper, the standardization landscape for RFID technologies in general (chapter 2) and for RFID-enabled mobile telecommunication services (chapter 3) in particular is unsatisfactory. Depending on one's point of view, one can see either a lack or an excess of standards. Regardless of which of the two standpoints one adheres to, it is true to say that a lack of harmonized, globally accepted, cross-sector and interoperable standards on RFID tag data structures, network components and protocols between those components exists.

This paper presents a non-exhaustive list of topics that might be interesting for future standardization work: In order to foster global RFID standards for data formats, interoperability, interference problems etc., cooperation between the different standards bodies, manufacturers and users is necessary. Only a holistic and inclusive approach can succeed in promoting RFID in order to ensure a widespread adoption of the technology. In order to do that, an "All-Star approach" might be considered useful. Bringing major players in RFID standardization together at one table could help to broaden the understanding of the participants. ITU's unique combination of membership – from the private sector (service providers and manufacturers) and the world's governments - seems to make it an obvious choice as a place for this work, particularly given the fact that RFID standardization deals with both technical and regulatory aspects. ITU's Standardization Sector (ITU-T), would be in an ideal position to drive studies towards a common platform for various RFID applications.

Among areas to be addressed are security and privacy issues (see sub-section 1.5.2). As RFID technology in mobile telecommunications – and RFID in general – are highly dependant on user acceptance, the user's hearts (and wallets) can only be won if industry, researchers and policy-makers work hand-in-hand in taking-up these issues. Security and privacy issues will be decisive for the success of the technology and thus have to be addressed as a priority. This is an area where work seems to be at an early stage.

Additional studies are also needed to assess the exact impact of RFID on fixed and mobile networks. It seems obvious that additional services based on the use of RFID technologies will eventually lead to increased network traffic. It still remains to be quantified how big that impact will be and how network design has to respond to this challenge. Further research is also needed on how RFID technologies can be integrated into existing and future network environments. Again, ITU-T is in an excellent position to examine how RFID services could converge for example with Next Generation Networks (NGN). At the network level, the present NGN initiative intends to give the necessary platform to support service capabilities involving RFID devices. In this context, the issue of RFID-IPv6 mapping is another important field of study, as many active RFID tags of the future will have to be integrated into communication networks, using an identifier that most probably will be or have a direct relation with an IPv6 address.

[135] Details can be found for exapmle in Luigi Battezzati's presentation "RFID as an enabler of the ubiquitous" at ITU's Strategy and Policy Unit's (SPU) workshop on „Ubiquitous Network Societies" in spring 2005 (The presentation can be found here: http://www.itu.int/osg/spu/ni/ubiquitous/Presentations/5_battezzati_RFID.pdf).