When Waste Becomes Intelligent:
Assessing the Environmental Impact of Microchip Tagging

Claudia Binder[1], Svetlana Domnitcheva[2]

[1] Natural and Social Science Interface
Department of Environmental Science
claudia.binder@uns.umnw.ethz.ch

[2] Institute for Pervasive Computing
Department of Computer Science
domnitcheva@inf.ethz.ch

ETH Zurich, CH-8092 Zurich, Switzerland

Abstract: With the development of object identification technology object tagging becomes more and more common. In this work we analyze how recycling processes can benefit from deployment of passive RFID tags and discuss how spreading small electronic chips in the environment by attaching them to many everyday objects may lead to additional problems.

Keywords: RFID, recycling, SWOT analysis.

1 Introduction

For computer scientists and many manufacturers, tagging objects with tiny, batteryless RFID (Radio Frequency Identification) chips has become an important research and deployment topic. Attaching a small chip carrying a unique ID makes it possible to mark everyday objects, associate with them information such as type of the object, its composition, history, purpose, expiration date, etc., and also access this information quickly.

There is a broad variety of microchips (tags) and reading equipment for them on the market, that differ in their size, memory, range of communication and other characteristics. Many systems dispose of anti-collision detection, which allows simultaneous recognition of several tags. Many shops are already successfully using such systems as prevention of shoplifting. Metro Group, Germany, has even recently opened a pioneer store fully equipped with RFID technology.

In the future, this technique could possibly be used to advance the process of waste collection and separation. We consider two ways in which it could be useful for waste management purposes: (i) Recycling of durable goods. Durable goods are composed of diverse materials, including smaller fractions of metals and toxic materials. Information on the composition of these goods allows for precise dismantling and recycling. (ii) Purity of short lived recycling goods. Recycling quality of glass, paper and plastics depends on the purity of the input goods, which might be improved in the separation process using the new technology.

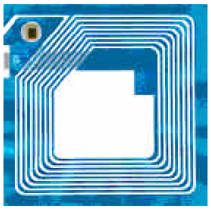
In this contribution we discuss the utility of RFID tags for improving waste management processes. We apply a SWOT (Strengths, Weakness, Opportunities Threats) analysis to provide a first overview of the potentials and drawbacks on utilizing this technology with focus on short-lived (i.e., PET, paper and cardboard, metals) and durable goods (i.e., furniture and electronics).

The paper is structured as follows: In section one we present the essentials of the RFID technology. Thereafter we evaluate qualitatively the technology using a SWOT-Analysis. Finally we conclude and derive further need for research.

2. Passive RFID tags

Passive RFID tags are one example of identification systems. These tags, in opposite to the active RFID tags, do not need their own power supply, since they take it from the electro-magnetic field generated by the reading antenna.

The tags can be very small (down to 0.4 square mm, with integrated antenna) and need no line-of-sight (as for barcodes) that makes them very unobtrusive. Modern RFID Systems like Phillips I-Code can detect a few hundred tags within a space of up to 1 cubic meter. Normally, such tags hold a non-rewritable unique ID; some of them have also a non-volatile read/write memory up to ~100 bytes [Römer K., et al., 2004]. There is a wide variety of RFID systems differing in their basic features. These include operating frequencies from 135 kHz to 2.45 GHz; access range, which may vary from 0 to 1cm for close coupling systems, is up to 1m for remote coupling, and from 1m to 10m for long-range systems [Finkenzeller, K., 2003].



RFID tags cannot be read if they are separated from the antenna by a material impenetrable for electro-magnetic fields. This reduces the application areas considerably. Fortunately, some RFID systems manage to overcome this weak point [MBBS Products].

The RFID technology is already deployed in many manufacturing processes, supply chains, supermarkets, or even for parcel shipping support. Still, the deployment of RFID tags in almost every object in our daily life is held back by the costs of the rather expensive reading equipment and also the single chips. The latter presently cost a few tens of cents and are expected to become very cheap.

Under the assumption of comprehensive deployment of RFID tags, many new application fields can be developed. Among other things also a sophisticated support system for recycling processes seems to be reasonable.

3. Application to waste management: exemplified for the canton Zurich

3.1. Short description of the case

In the canton Zurich about 235'000 t/ annum of household waste are separately collected [AWEL, 2003]. About 30% of these are organic wastes and 40% paper and cardboard. In addition, PET, glass and metals are collected separately. The unused potential for separate collection was estimated at 55'000 t per annum [AWEL, 2003]. Whereas the additional recyclable amount is low for glass (the rate of return of glass is already 92%; [Hilty et al, 2003]); additional 20% of paper and PET could be recycled; for metals (aluminum, tinplate, iron) it is even 50% [AWEL, 2003].

Concerning durables, since January 2003, stores are obliged to take back and dispose old furniture and electrical appliances. An early disposal fee has to be paid by consumers to ensure proper dismantling and recycling. In 2001, about 73% of the electronic waste was properly disposed of. About 8% was found in the refuse bag and the rest was brought to a collection place [AWEL, 2003]. For furniture no exact data exist, however, first estimates indicate that about 80% are incinerated [Speich, 2003].

3.2 System analysis

Figure 1 presents the analysis of the recycling system for short-lived goods from their use to their disposal. Prior to use the goods are marked with a passive RFID tag. The tag could support the separation process by the use of an enhanced disposal device, which yields separated goods for recycling and goods for incineration. Depending on the recycling process and the tag fixation technology, one will obtain pure recyclable good (e.g., PET), RFID tag or a mixture of both. Open questions are: (i) does it pay to separate the RFID tag from the recyclable good for future reuse? And if not, (ii) how will the remaining RFID tag affect the quality of the recycled good? If the tag did not support the recycling process, the good and the tag will be incinerated. Here the questions is: how does this affect the air, filter, and bottom ash quality?

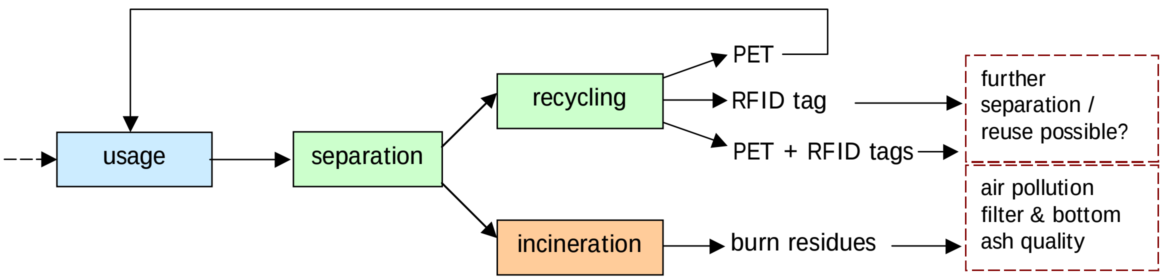


Figure 1: System analysis of the recycling system for short-lived goods

3.2 SWOT (Strengths, Weakness, Opportunities Threats) Analysis

Table 1 presents a SWOT analysis for the use of the RFID technology to support recycling of short-lived goods, such as PET and paper, and durables such as electronic devices and furniture.

Table 1: SWOT Analysis for use of RFID in waste management systems

Strength	Weakness (Problems)	Opportunities	Threats
Short-lived goods			
• Higher quality of input goods for recycling • Separation support at disposal time	• Large amount of chips in use • New separation technology • New recycling technologies • Standardized RFID code structure needed such as EPC [Auto-ID Center] • Separation at incineration plant not feasible	• Use of tagged goods for educa-tional purposes in schools	• Decreasing quality if chip residues enter production process • Responsibility for separation is remo-ved from the citizens
Durable goods			
• Knowledge of furniture or consumer electronics composition allows proper dismantling and recovery of parts	• Standardized RFID code structure such as EPC [Auto-ID Center] • Coordination among electronic devices manufacturers	• Knowledge of metals stocks (as future mines) • Link between design and waste management	• Privacy • Durability of the RFID technology smaller than lifetime of durables

4 Discussion and conclusions

This paper presented a SWOT analysis for the utilization of RFID tags in the waste management system. It was shown that within the waste management system, PET, paper and cardboard, as well as metals (i.e., tinplates, aluminum and iron) recycling could potentially benefit from tags, as the purity of the recycling input goods could be improved and the burden on the incineration plant could be relieved. However, technical feasibility and the large amount of tags needed to fulfill this goal do not make it yet a real option to take. In addition, the awareness regarding the generation of waste, which Swiss citizens have, might be jeopardized if consumers are not hold to separate and take responsibility for their waste produced. A high potential of the RFID system is seen in elementary education, where pupils could playfully learn with a feedback from the computer how and where which goods are to be disposed of.

Concerning durables the potential and the usefulness is likely to be much higher. If the restrictions of producing homogenized information within different industries and the problem with the increasing speed of technological obsolescence could be overcome, a link between production, i.e. design and waste management could be created which would allow for a reuse of the raw materials after use of the goods. Here the tags provide the basic information as to which raw materials can be found in which part of the good to be recycled. A vision could be that the metal stocks in buildings and appliances could be located based on tagged goods. This could provide a GIS map of the anthropogenic metal mines and thus, enable a more efficient future recycling procedure. Here the privacy issues are of high relevance and might inhibit such an application of RFID tags.

Further research should provide an in depth investigation of disposability and reemployment of used microchips as well as a cost benefit analysis of their application.

5 References

Auto-ID Center, http://www.autoidcenter.org

AWEL, Amt für Abfall, Wasser, Energie und Luft, 2003. Bericht zur Abfallplanung, 2002-2006 des Kanton Zürich, UD Print AG, Luzern.

Finkenzeller, K., 2003. RFID Handbook: Fundamentals and Applications in Contactless Smart Cards and Identification

Hilty, L., Behrendt, S., Binswanger, M., Bruinik, A., Erdmann, L., Fröhlich, J., Köhler, A., Kuster, N., Som, C., Würtenberger, F., 2003. Das Vorsorgeprinzip in der Informationsgesellschaft, TA-Swiss 46/2003, Bern.

MBBS Products, http://www.mbbs.ch/products/PE/products1.htm

Römer, K., Schoch, T., Mattern, F., Dübendorfer, T., 2004. Smart Identification Frameworks for Ubiquitous Computing Applications.

Speich, M. F., 2003. Der verborgene Nutzen von Brockenhäusern. Abfallvermeidung am Beispiel des Möbelflusses der Stadt Zürich, Diplomarbeit Nr. 5/03, Professur Umweltnatur- und Umweltsozialwissenschaften, ETH Zürich, Zürich.