Mobile RFID Application for Waste Management System

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ABSTRACT

Processing and recovery is a key functional element in waste management system (WMS). Reuse, recycle and recovery of valuable components of waste stream are given much attention in WMS in both developed and developing countries. Source separation as a best practice for management of junk and recyclable materials is known to every industry. Since 1980 many technologies are used in recycling industry. Many industries are learning the importance of new technologies in recycling industries, such as radio frequency identification (RFID). This technology has been used widely by many organizations in some industrialized countries. This paper exposes some applications of Mobile RFID technology in Product self-management, with emphasize on solid waste management as well as environmental implications of Mobile RFID.

Keywords : *Radio frequency identification (RFID), Recycling, Waste Mangement.*

1. INTRODUCTION

Solid waste departments and private waste management companies are suddenly buying radio frequency identification (Mobile RFID) tags by the hundreds of thousands, only to throw them in the garbage — specifically, embedding them in garbage and recycling bins. In Cleveland, Mobile RFID is part of a $25-million dollar solid waste modernization program. The tags will link trash and recycling bins to owners, aiding management's efforts to cut costs and increase recycling. At Phoenix-based republic services, Mobile RFID tags are part of an incentive program designed to boost recycling quantities [1].

Waste processing facilities are not designed to separate Mobile RFID chips except possibly in dedicated streams, such as waste electrical and electronic equipment (WEEE), and the design of recyclable items is not oriented to through-life optimisation, often paying little attention to the end-of-life (EOL) phase of a product. Product design is still driven by commercial considerations, including the imputed cost of compliance with environmental and other regulations. If design ignores EOL, it is because the designer does not bear those costs or cannot capture its benefits and/or the regulations already in existence are not effectively enforced [2].

Mobile RFID technology is linked to recycling in two complementary ways. As objects, tags contain a variety of materials whose recycling is desirable on environmental grounds. These materials vary with the type of tag and their significance will increase as tags become more pervasive. Also, tags can themselves contribute to the efficiency and effectiveness of recycling at various stages in the lifecycles of a wide range of products, ranging from simple items to complex objects containing a variety of materials [3].

The risks arising from the first element and the opportunities from the second have been discussed or studied in specific contexts, but have not yet found their general application. To provide an empirical evidence base for policy, this study aims to:

(1) Clarify the issues and evidence relating to the environmental impacts and recycling methods of Mobile RFID tags.

(2) Assess the environmental advantages of using Mobile RFID to improve recycling.

As regards the use of Mobile RFID to improve recycling, short-run developments are likely to involve extending and "joining-up" existing pilots with others in the field of waste handling, as well as the development of new methods for using existing tags, e.g., by the inclusion of new data useful in waste collection and disposal.

In the medium term, the deployment of Mobile RFID as part of a general trend to improve waste handling is likely to produce behavioural changes and the emergence of new business models and even changes in sectoral organisation possibly through the development of new intermediary markets for aspects of smart waste handling or changes in patterns of vertical integration along the EOL product chain. In addition, policy would begin to adapt to new possibilities, especially as regards improved traceability and waste stream measurement [4].

Over the long term, the new possibilities may be realised through novel whole-systems approaches to waste handling and eventually to new forms of integrated lifecycle management.

2. MATERIALS AND METHODS

A common Mobile RFID system usually consists of tags, readers, application software, computing hardware and middleware. The low frequency Mobile RFID which is used for waste management consists of reader, antenna and passive low frequency tags. In this paper the main components of Mobile RFID system applicable in waste management system (WMS) are discussed. Mobile RFID tag in principle is a microprocessor chip, consists of an integrated circuit with memory. Each tag has its own identity. These tags are mounted on the container or waste bins [5,6].

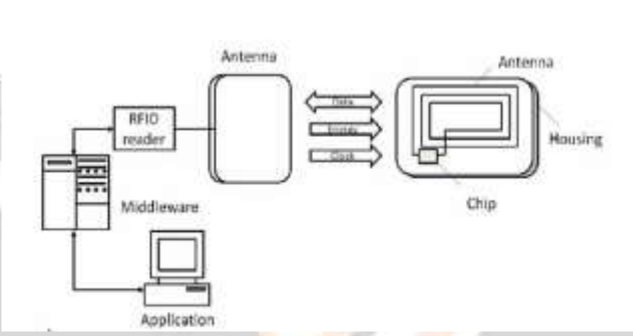

Fig 1. Basic layout of an MOBILE RFID data-carrying device, the transponder and other main components of an MOBILE RFID system

The identity of each tag is broadcasted to a reader with the same frequency and the same tag protocol. Antenna acts as a communication channel between the tag and the reader. The antenna can transmit data from its sideways and front. Design and sitting of the antenna are very crucial for coverage area and precision. To energize the tag, the antenna gets energy from the reader's signal, the antenna then sends the receiving data from the reader. The reader is a piece of equipment that reads the data and prints the data to the compatible tags [7].

Exact location of the tags is identified through communication between tag and reader. These data can be transferred to a server through a computer network, by which, the movement of the item can be tracked and traced. Therefore it is necessary that the frequency of tag and reader be the same and complies with specified regulation. At present, four types of readers are available: handy, vehicle-mount, post –mount and hybrid. The first three types can read either passive or active tags, while the last one is able to read both passive and active tags, through switching mechanism [8,9,10].

2.1 Understanding Mobile RFID

Mobile RFID is a wireless data collection technology to identify physical objects in a variety of fields. A Mobile RFID system typically consists of a tag or transponder generally physically attached to an object, containing a small computer chip or memory that uniquely identifies itself. Furthermore, a Mobile RFID system also consists of a reader or transceiver that sends radio signals into the air to activate a tag through an antenna, read the data transmitted by the tag and sometimes even write data on a tag. Figure 1 shows a basic layout of a Mobile RFID tag and system.

An Mobile RFID tag is like a barcode that can transmit its identifying numbers as a radio signal. This means that it is not necessary to see an Mobile RFID tag or even be close to it to scan it, as opposed to a barcode, which must be scanned with a handheld reader [11].

Automatic identification is a term given to a host of technologies that identify objects, collect data about the objects and enter data directly into a computer or computer system. This family of auto-ID technologies typically includes Mobile RFID, optical character recognition (OCR), bar codes, smart cards and biometrics (Figure 2).

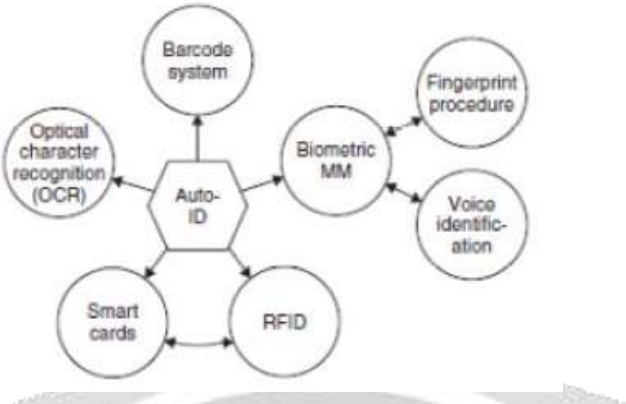

Fig. 2 Source: Finkenzeller (2010)

Instead, small readers placed on waste and recycling trucks can automatically detect and read Mobile RFID tags. The readers are small radios with antennas that constantly emit a signal. When an Mobile RFID tag comes within range, the reader's signal supplies the tag with the tiny bit of power required to activate it. The active tag transmits its data, and the reader records it. The data on an Mobile RFID tag is a series of numbers that identify the object to which it is attached. A tag may also store the name and address of a trashcan's owner as well as other information [12].

Mobile RFID has advantages and disadvantages compared to the other technologies. Compared to bar-coding technology, Mobile RFID tags do not require line-of-sight reading and Mobile RFID scanning can be done at greater distances. Bar codes might be much cheaper, but Mobile RFID tags can store significantly more information than bar codes, but most importantly, their unique serial number allows tracking of individual items. On the other hand, the main difference between Mobile RFID tags and smart cards is that the latter are more advanced and secure than the former. One of the advantages of the smart card is that the data stored on the card can be protected against undesired access, and it is hence suitable for uses such as identity credentials and payment cards. On the negative side, smart cards are more expensive and more vulnerable to external factors and have a limited read range compared to Mobile RFID. Finally, the advantages of OCR technology is the high density of information and the ease of reading data, but it is more expensive than Mobile RFIDs and requires complicated readers [13].

2.2 Types of Mobile RFID Tags

Mobile RFID tags come in many different shapes and sizes – e.g., in the form of coins, as glasstube transponders, integrated into mechanical keys, as part of wristwatches, and as paper thin transponders. Depending on the functions and uses of Mobile RFID, the material to which it will be attached and the type of environment in which Mobile RFID is expected to function e.g. its capacity to survive in harsh environments, will determine the frequency of operation, the source of the power it will need to operate, but also the design for the length of life. The features of Mobile RFID System are shown in Fig 3.

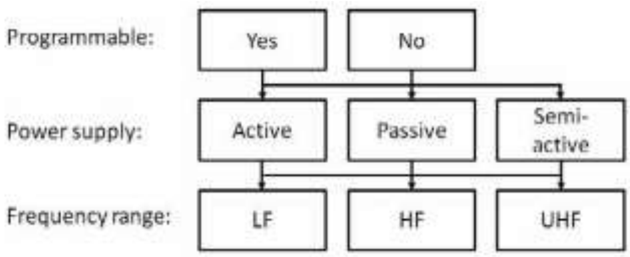

Fig 3. The features of MOBILE RFID systems

The material of the object being tagged and the read range required are determining factors in selecting what frequency is needed in the design of a tag. Magnetic and electromagnetic signals may be altered depending on the environment in which signals flow.

Depending on the usage, tags are designed to operate in the low frequency (LF, frequencies from 30–300 KHz), high frequency (HF, from 30–300 MHz) or ultra-high frequency (UHF, from 300– 3000 MHz). LF Mobile RFID is most popular for access control, but also for animal and human ID, whereas HF tags are widely used for smart cards and asset tracking and supply management. The wide frequency ranges offered by UHF makes this technology ideal for tracking large and expensive objects (Dobkin, 2008).

A tag needs energy/power to be able to send and receive data to the reader. Depending on how tags obtain their power to operate, tags are classified as passive, semi-passive and active tags. Passive tags have no power of their own, and hence only work when supplied with the radio signal from the reader. Semi-active tags also called semi-passive tags are battery assisted tags, which means that the tag is able to function independently, although they do not have active transmitters. Active tags have their own power source battery or an active transmitter. Their read-and-write range is potentially greater. They are usually applied in special areas where the higher costs and higher detail level of information stored are
justified.

Another interesting classification of Mobile RFID tags refers to read-only and read-write tags. Read-only tags contain a non-changeable programmed identifier that remains during the chip's life; in other words, the information on the tag cannot be changed. Read-only tags are generally inexpensive but cannot be reused and can only store a limited amount of data [14,15].

Read-write tags are more sophisticated because of the possibility they offer to reprogram the tag with new information, which means that tags can be erased and reused, thereby significantly reducing costs while contributing to environmental sustainability. Furthermore, read-write tags can store and process information locally, which is particularly valuable when dealing with high-volume, complex supply-chain applications.

The Mobile RFID market has seen an important growth in the last few years of contactless smart cards. This type of technology is used to protect personal information and deliver secure transactions. Applications using contactless smart cards include government and corporate identification cards, documents and electronic passports and visas and contactless financial payments.

2.3 Active and Passive MOBILE RFID Tags

Passive tags can only store a limited amount of information and have low read ranges. On the positive side, passive tags tend to be simple, small, inexpensive and lightweight, have a longer life and tend to be more resistant to harsh environments. Furthermore, passive tags tend to have a vast number of applications in a variety of industries and sectors [16].

Active tags are the most sophisticated types of tags. The fact that they have their own power means that they may contain more processing power to implement additional functionalities. Active tags are often used with sensors and by real time location systems. On the negative side, active tags can only be used for a specific period of time, as the batteries contained within them have a limited life. Active tags are typically used for locating large assets, such as shipping containers.

Active tags have higher pricing than other types of tags due to higher material and manufacturing costs. In both cases, the performance of each of these tags and the business requirements they fulfil vary greatly. Hence, a full business case should be considered when determining the type of tag that best fits the needs of the business.

Table 1. Comparison of some of the typical features of passive vs active MOBILE RFID

Feature	Passive	Active
Size and weight	Small (or thin)	Large
Cost	4 €cents to <1€	3€ to a <100€
Life	Virtually	3 to 7 years

	unlimited	
Range	Up to 30 metres	Up to 30 metres
Reliability	Excellent	Good
Sensor input	Little or none	Any
Can emit continuous signal	No	Yes
Area monitoring/geofencing	Rarely	Yes
Multi-tag reading	Fair or none	Excellent (e.g., thousands)
Location using a beam	Yes, but only short distance	Yes, at long distance
High-speed reading	Fair	Excellent
Data retention	Small to medium (e.g., 1 Kbit)	Medium to high (e.g., 1 Mbit)
Very slow signal power	No	Yes – no need to get the signal and back because semi-active and fully active tags emit their own signal and the battery boosts it
Security features of signal and processing	Limited	Excellent
Event signalling	No	Yes
Electronic manifest	No	Yes
Data logging	No	Yes

3. COMPOSITION OF MOBILE RFID TAGS

Mobile RFID has a very large potential for growth. Different market research companies have carried out estimates, which all differ depending on the underlying assumptions, like those related to technological breakthroughs. Other differences concern the inclusion criteria for different products and services as part of the estimates. However, they all agree that the global market size is likely to increase significantly within the next decade. In fact, some market research companies like IDTechEx expect the global market to grow by almost four times in 10 years.

3.1 Setting the Scope

In this study we mainly focus on Mobile RFID tags that are likely to end up in waste streams where those tags might relevantly influence processes or be exposed to the environment. This is mainly determined by the following factors

- The type of tag
- The number of tags
- The application type
- The product-related application area

- The waste stream the tag is likely to end up in.

3.2 Type of MOBILE RFID Tag

Mobile RFID tags are distinguished according to their energy supply into passive, active and semi-active tags. Passive tags occur mainly in two formats: label form tags and encapsulated tags. Active and semi-active tags occur almost exclusively in encapsulated formats. Active MOBILE RFID tags are used mainly to track containers, vehicles, assets and people [17].

3.3 Number of Tags

According to IDTechEx, in 2010 the share of active tags worldwide was less than 3 percent with a total of approximately 60 million tags compared to 2.250 billion passive tags. The share of active tags is presumed to fall under 2 percent until 2016 and then fall under 1 percent until 2021 which equates to 790 million tags compared to 242,700 billion passive tags forecast for 2021. Regarding SALs, it is too early to be sure of the market penetration potential of these tags. Market shares of tags by shape show that in 2010 more than 80 percent of the tags sold worldwide were passive smart cards and labels, the rest fobs, discs and keys. The market share of passive smart cards and labels is predicted to continuously grow in the future and to reach nearly 90 percent in 2016 [18].

3.4 Application Type

To be able to determine whether an Mobile RFID tag will end up in waste it is important to know where the tag is usually attached. According to the expert consultation, most passive labels are attached to CPGs, made out of cardboard, paper and plastics. Today most passive labels are adhesive labels, but they are also used in the form of a dry inlay, which can be integrated into cardboard and other packaging. SALs are likely to be applied in a similar manner. Passive encapsulated tags are mostly used in the form of keys, cards and fobs or when used in rough environments. They are also stuck on or screwed to containers, rollcages and other durable assets, as they are usually not replaced during the lifetime of the object.

3.5 Relevance for Waste Stream

The most important criterion to evaluate the impact of tags on the waste management industry and its processes is the identification of the waste stream in which the tag is likely to end up. As active tags are electronic devices with a power supply in the form of a battery, with regard to their disposal, “it is generally accepted that interrogators and active Mobile RFID tags fall into the category of ‘electronic devices’ and therefore fall under the scope of the WEEE Directive”. Hence, it can be assumed that these tags are disposed of in separately kept waste streams that follow adequate treatment routes and rarely end up in mixed waste streams, such as municipal solid wastes [19].

4. APPLICATIONS OF MOBILE RFID IN WASTE MANAGEMENT

- Mobile RFID Tagged Containers Truck System – Vehicle Computer, Mobile RFID Reader, Antennas, GPS, WAN, WiFi, Vehicle Monitoring. Handheld Mobile RFID Computers for exceptions – wireless real-time data transmission (wide area cellular) with GPS(Figure 4)
- Mobile Visualization and Mapping Software
- Trash and Recycling Container Tagging (Figure 5)
- MOBILE RFID Event Capture Vehicle Software
- Vehicle Monitoring Software
- Mobile RFID for Manual Sanitation (Figure 6)
- Engineering and Installation Services
- Operational Consulting Services

Fig 4. Mobile RFID for Waste Mangement

Fig 5. Trash and recycling Container Tagging

Fig 6. Mobile RFID for Manual Sanitation

5. RESULTS & DISCUSSION

Mobile RFID is a fast growing technology in a wide variety of fields. Mobile RFID has successfully applied in supply chain management, manufacturing and logistics, but its range of applications extends far beyond these areas. RFID has many applications in the field of environment (Thomas, 2009). Perhaps one of the best ways to manage the source separation program efficiently is the usage of RFID technology. This technology plays an important role in MSW collection operations. RFID is getting more attention in different industries. Today many companies in industrialized countries have applied this technology in real-world environment. RFID is an emerging technology, and it has a wide variety of applications in many fields. Some of them are listed below (Ngai *et al.*, 2006).

- Animal detection.
- Aviation.
- Building management.
- Construction.
- Enterprise feedback control.
- Fabric and clothing.
- Food safety warranties.
- Health.
- Library services.
- Logistics and supply chain management.
- Mining.

- Municipal solid waste management.
- Museums.
- Retailing.

The rapid growth of RFID applications in different fields could accumulate the spent tags antenna and readers on municipal waste streams. It is anticipated that the consumption of RFID tags will reach 2 trillion tags each year. Thus the huge amounts of copper, silver compounds, silicon, adhesives, plastics contained in these tags end up in municipal solid waste globally. This is the main concern in the recycling of plastic, paper, glass, steel and aluminium (British Glass, 2005).The vast usage of RFID technlogy bears some risk of dissipating both toxic and valuable substances to municipal waste, and may cause disruption of the existing, recycling process.

6. CONCLUSION

Wide spread application of Mobile RFID tags typically containing hazardous materials on consumer products may cause the potential risks in terms of the irreversibility criterion. These tags are categorized as small electronic components. These components are not large enough to separate them relatively easy from non-electronic waste streams. Today, microelectronic components such as Mobile RFID tags are increasingly embedded in commonly used consumer goods. Separation of these small components for special treatment is not economically feasible. Microelectronic components attached or embedded to packaging materials, may cause the potential mid-or-long term risks with respect to resource management, pollution control or recycling processes.

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