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A Waste and E-Waste Management – An Overview

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Abstract

Waste is a significant environmental issue across communities and industries alike. Efforts in reducing, reusing and recycling waste are increasing in order to promote a sustainable natural environment. Effective waste management starts with knowledge; knowledge is gained through the understanding of information and information through the collection and analysis of sound data. The waste management sector is rapidly expanding but not without technology solutions that enable this transformation of data into knowledge. This paper focuses on the issue of the waste management and the role of IT to support management activities and specifically portrays about E – Waste Management and its strategies.

Keywords: Waste, EWaste, IT, Cloud, SaaS, PaaS, Iaas, ICT, 3 Rs, RFID, EPR.

1. Introduction

Waste management is all the activities and actions required to manage waste from its inception to its final disposal. This includes collection, transport, treatment and disposal of waste together with monitoring and regulation. It also covers the legal and regulatory framework that relates to waste management encompassing guidance on recycling etc. The role of technologies in waste management towards the sustainable development presents the most significant IT technologies that have contributed to the identification and implementation of new forms of economic and social development that takes into account the evaluation of the environmental impact of products throughout their life cycle. Technologies such as decision support systems (DSS), remote sensing and geographical information systems (GIS), online web services, virtualization and cloud computing are analyzed in terms of the innovator role and of the impact on the sustainable development of society.

At ISWA's 2015 World Congress in the City of Antwerp, UNEP and ISWA presented "Global Waste Management Outlook (GWMO)". David C.Wilson reported the global challenges of the waste management sector for the next decade and presented various shocking facts after two years of his study. They are 2 billion people on our planet, do not have currently access to solid waste collection at all. That is 27% of the world population. Solid waste management is accounted for 3% of the global greenhouse gas (GHG) emissions. He also stated that ICT solutions and 'big data' are a key driver to take global waste management to the next level. The potential positive impact of improved waste management on reducing GHG emissions across the economy will be around 15-20%.A major focus of the GWMO is on the 'governance' factor required to make waste management happen in practice. A 'toolkit' has been developed to help select a suitable set of actions. A "data revolution" is an essential gear wheel of the 'toolkit' that was developed to facilitate taking the next appropriate steps in developing specific waste management system at the national or local level. On a global scale, the industry is currently lacking the availability and reliability of waste and resource management data. And the cliché "You cannot manage what you cannot measure" has never been more applicable to the waste industry. David Newman, President of the International Solid Waste Association, said that bringing advanced technologies, such as Waste to Energy plants, to the developing countries, is not the real challenge. The real challenge is how to finance those projects. Economy of scale is necessary to lower the costs for technologies and funding opportunities may be an enabler to help develop the waste management industry on a global scale. Data and performance indicators are vital to drive the change towards a more sustainable waste management industry. Therefore, the industry must work towards a system where a city's municipal solid waste management system can be benchmarked against other city's using indicators and highlight areas for improvement. And this information must be publically accessible, online, to drive the awareness around waste disposal behaviour.

ICT industry is focusing on solutions for the waste industry for almost 20 years now, this raised the question about how to make ICT systems for waste collection and treatment affordable and available to all countries including the underdeveloped countries and emerging economies. Waste managers and policy makers are working hard on defining and implementing policies including a governance structure to improve the waste management systems locally. Having a cloud solution for waste collection, recycling and material resource trading, we have a system that can collect the data and present the performance indicators that are necessary to drive the waste revolution. It is not so hard to make our systems available to any country provided that it has access to the internet.

In this paper, we firstly reviewed about the Global Waste Management outlook. The rest of the paper is as follows: Section II delineates central principles of waste management including waste hierarchy, resource efficiency, polluter pays principle, World Wide Waste handling practices and Disposal solutions. Section III discusses about E waste management and its strategies. Section IV is about Technologies for E-Waste management and Section V concludes the paper.

2. Central Principles of Waste Management

There are a number of concepts about waste management which vary in their usage between countries or regions. Some of the most general, widely used concepts include:

2.1 Waste Hierarchy

The waste hierarchy refers to the "3 Rs" reduce, reuse and recycle, which categorize waste management strategies in terms of waste minimization. The aim of the waste hierarchy is to pull out the maximum practical benefits from products and to generate the minimum amount of waste. The waste hierarchy is depicted as a pyramid because the basic premise is for policy to take action first and prevent the generation of waste. The next step is to reduce the generation of waste i.e. by re-use. The next is recycling which would include composting. Following this step is material recovery and waste-to-energy. Energy can be recovered from processes i.e. landfill and combustion, at this level of the hierarchy. The final action is disposal, in landfills or through incineration without energy recovery. This last step is the final resort for waste which has not been prevented, diverted or recovered. The waste hierarchy represents the progression of a product or material through the sequential stages of the pyramid of waste management.

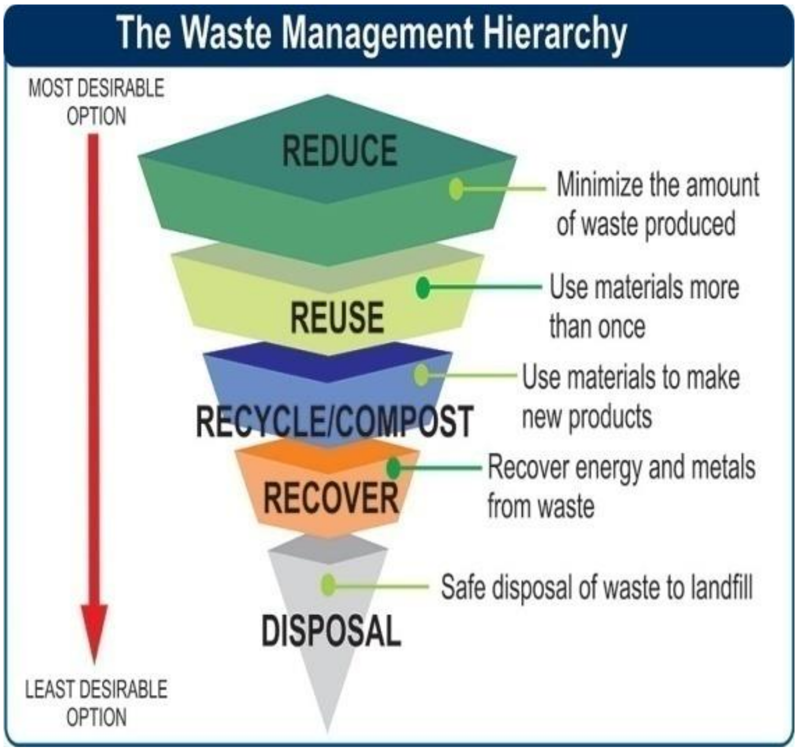

Figure 1 – Waste Management Hierarchy

2.2 Resource Efficiency

Resource efficiency reflects the understanding that current, global, economic growth and development cannot be sustained with the current production and consumption patterns. Globally, we are extracting more resources to produce goods than the planet can replenish. Resource efficiency is the reduction of the environmental impact from the production and consumption of these goods, from final raw material extraction to last use and disposal. This process of resource efficiency can address sustainability.

2.3 Polluter Pays Principle

The Polluter pays principle is a principle where the polluting party pays for the impact caused to the environment. With respect to waste management, this generally refers to the requirement for a waste generator to pay for appropriate disposal of the unrecoverable material.

Throughout most of history, the amount of waste generated by humans was insignificant due to low population density and low societal levels of the exploitation of natural resources. Common waste produced during pre-modern times was mainly ashes and human biodegradable waste, and these were released back into the ground locally, with minimum environmental impact. Tools made out of wood or metal were generally reused or passed down through the generations.

However, some civilizations do seem to have been more profligate in their waste output than others. In particular, the Maya of Central America had a fixed monthly ritual, in which the people of the village would gather together and burn their rubbish in large dumps.

2.4 World Wide Waste Handling Practices

Curb-side collection is the most common method of disposal in which waste is collected at regular intervals by specialized trucks. This is often associated with curb-side waste segregation. In rural areas waste may need to be taken to a transfer station. Waste collected is then transported to an appropriate disposal facility. In some areas, vacuum collection is used in which waste is transported from the home or commercial premises by vacuum along small bore tubes. Systems are in use in Europe and North America.

Pyrolysis is used to dispose of some wastes including tires, a process that can produce recovered fuels, steel and heat. In some cases tires can provide the feedstock for cement manufacture. Such systems are used in USA, California, Australia, Greece, Mexico, the United Kingdom and in Israel. The RESEM pyrolysis plant that has been operational at Texas USA since December 2011, and processes up to 60 tons per day. In some jurisdictions unsegregated waste is collected at the curb-side or from waste transfer stations and then sorted into recyclables and unusable waste. Such systems are capable of sorting large volumes of solid waste, salvaging recyclables, and turning the rest into bio-gas and soil conditioner.

In San Francisco, the local government established its Mandatory Recycling and Composting Ordinance in support of its goal of zero waste by 2020, requiring everyone in the city to keep recyclables and compostables out of the landfill. The three streams are collected with the curbside "Fantastic 3" bin system - blue for recyclables, green for compostables, and black for landfill-bound materials - provided to residents and businesses and serviced by San Francisco's sole refuse hauler, Ecology. The City's "Pay-As-You-Throw" system charges customers by the volume of landfill-bound materials, which provides a financial incentive to separate recyclables and compostables from other discards. The City's Department of the Environment's Zero Waste Program has led the City to achieve 80% diversion, the highest diversion rate in North America.

2.5 Financial Models

In most developed countries, domestic waste disposal is funded from a national or local tax which may be related to income, or notional house value. Commercial and industrial waste disposal is typically charged for as a commercial service, often as an integrated charge which includes disposal costs. This practice may encourage disposal contractors to opt for the cheapest disposal option such as landfill rather than the environmentally best solution such as re-use and recycling. In some areas such as Taipei, the city government charges its households and industries for the volume of rubbish they produce. Waste will only be collected by the city council if waste is disposed in government issued rubbish bags. This policy has successfully reduced the amount of waste the city produces and increased the recycling rate.

2.6 Disposal Solutions

2.6.1 Incineration

Incineration is a disposal method in which solid organic wastes are subjected to combustion so as to convert them into residue and gaseous products. This method is useful for disposal of residue of both solid waste management and solid residue from waste water management. This process reduces the volumes of solid waste to 20 to 30 percent of the original volume. Incineration and other high temperature waste treatment systems are sometimes described as "thermal treatment". Incinerators convert waste materials into heat, gas, steam, and ash.

Incineration is carried out both on a small scale by individuals and on a large scale by industry. It is used to dispose of solid, liquid and gaseous waste. It is recognized as a practical method of disposing of certain hazardous waste materials (such as biological medical waste). Incineration is a controversial method of waste disposal, due to issues such as emission of gaseous pollutants.

Incineration is common in countries such as Japan where land is more scarce, as these facilities generally do not require as much area as landfills. Waste-to-energy (WtE) or energy-from-waste (EfW) are broad terms for facilities that burn waste in a furnace or boiler to generate heat, steam or electricity. Combustion in an incinerator is not always perfect and there have been concerns about pollutants in gaseous emissions from incinerator stacks. Particular concern has focused on some very persistent organic compounds such as dioxins, furans, and PAHs, which may be created and which may have serious environmental consequences.

2.6.2 Recycling

Recycling is a resource recovery practice that refers to the collection and reuse of waste materials such as empty beverage containers. The materials from which the items are made can be reprocessed into new products. Material for recycling may be collected separately from general waste using dedicated bins and collection vehicles, a procedure called kerbside collection. In some communities, the owner of the waste is required to separate the materials into different bins (e.g. for paper, plastics, metals) prior to its collection. In other communities, all recyclable materials are placed in a single bin for collection, and the sorting is handled later at a central facility. The latter method is known as "single-stream recycling."

The most common consumer products recycled include aluminium such as beverages cans, copper such as wire, steel from food and aerosol cans, old steel furnishings or equipment, rubber tiers, polyethylene and PET bottles, glass bottles and jars, paperboard cartons, newspapers, magazines and light paper, and corrugated fiberboard boxes.

PVC, LDPE, PP, and PS are also recyclable. These items are usually composed of a single type of material, making them relatively easy to recycle into new products. The recycling of complex products (such as computers and electronic equipment) is more difficult, due to the additional dismantling and separation required. The type of material accepted for recycling varies by city and country. Each city and country has different recycling programs in place that can handle the various types of recyclable materials. However, certain variation in acceptance is reflected in the resale value of the material once it is reprocessed.

2.6.3 Reuse Recoverable materials that are organic in nature, such as plant material, food scraps, and paper products, can be recovered through composting and digestion processes to decompose the organic matter. The resulting organic material is then recycled as mulch or compost for agricultural or landscaping purposes. In addition, waste gas from the process (such as methane) can be captured and used for generating electricity and heat (CHP/cogeneration) maximizing efficiencies. The intention of biological processing in waste management is to control and accelerate the natural process of decomposition of organic matter.

2.6.4 Energy Recovery

Energy recovery from waste is the conversion of non-recyclable waste materials into usable heat, electricity, or fuel through a variety of processes, including combustion, gasification, pyrolyzation, anaerobic digestion, and landfill gas recovery. This process is often called waste-to-energy. Energy recovery from waste is part of the non-hazardous waste management hierarchy. Using energy recovery to convert non-recyclable waste materials into electricity and heat, generates a renewable energy source and can reduce carbon emissions by offsetting the need for energy from fossil sources as well as reduce methane generation from landfills. Globally, waste-to-energy accounts for 16% of waste management.

The energy content of waste products can be harnessed directly by using them as a direct combustion fuel, or indirectly by processing them into another type of fuel. Thermal treatment ranges from using waste as a fuel source for cooking or heating and the use of the gas fuel to fuel for boilers to generate steam and electricity in a turbine.

2.6.5 Pyrolysis

Pyrolysis is a process of thermo-chemically decomposition of organic materials by heat in the absence of oxygen which produces various hydrocarbon gases. During pyrolysis, the molecules of object are subjected to very high temperatures leading to very high vibrations. Therefore, every molecule in the object is stretched and shaken to an extent that molecules starts breaking down. The rate of pyrolysis increases with temperature. In industrial applications, temperatures are above 430 °C (800 °F). Fast pyrolysis produces liquid fuel for feedstocks like wood. Slow pyrolysis produces gases and solid charcoal. Pyrolysis holds promise for conversion of waste biomass into useful liquid fuel. Pyrolysis of waste plastics can produce millions of litres of fuel. Solid products of this process contain metals, glass, sand and pyrolysis coke which cannot be converted to gas in the process.

2.6.6 Resource Recovery

Resource recovery is the systematic diversion of waste, which was intended for disposal, for a specific next use. It is the processing of recyclables to extract or recover materials and resources, or convert to energy. These activities are performed at a resource recovery facility. Resource recovery is not only environmentally important, but it is also cost effective. It decreases the amount of waste for disposal, saves space in landfills, and conserves natural resources.

Resource recover uses LCA (life cycle analysis) attempts to offer alternatives to waste management. For mixed MSW (Municipal Solid Waste) a number of broad studies have indicated that administration, source separation and collection followed by reuse and recycling of the non-organic fraction and energy and compost/fertilizer production of the organic material via anaerobic digestion to be the favoured path.

As an example of how resource recycling can be beneficial, many of the items thrown away contain precious metals which can be recycled to create a profit, such as the components in circuit boards. Other industries can also benefit from resource recycling with the wood chippings in pallets and other packaging materials being passed onto sectors such as the horticultural profession. In this instance, workers can use the recycled chips to create paths, walkways, or arena surfaces.

2.6.7 Sustainability

The management of waste is a key component in a business' ability to maintaining ISO14001 accreditation. Companies are encouraged to improve their environmental efficiencies each year by eliminating waste through resource recovery practices, which are sustainability-related activities. One way to do this is by shifting away from waste management to resource recovery practices like recycling materials such as glass, food scraps, paper and cardboard, plastic bottles and metal.

2.7 Avoidance and Reduction Methods

An important method of waste management is the prevention of waste material being created, also known as waste reduction. Methods of avoidance include reuse of second-hand products, repairing broken items instead of buying new, designing products to be refillable or reusable (such as cotton instead of plastic shopping bags), encouraging consumers to avoid using disposable products (such as disposable cutlery), removing any food/liquid remains from cans and packaging, and designing products that use less material to achieve the same purpose (for example, light weighting of beverage cans)

2.8 Benefits

Waste is not something that should be discarded or disposed of with no regard for future use. It can be a valuable resource if addressed correctly, through policy and practice. With rational and consistent waste management practices there is an opportunity to reap a range of benefits. Those benefits include:

1. **Economic** - Improving economic efficiency through the means of resource use, treatment and disposal and creating markets for recycles can lead to efficient practices in the production and consumption of products and materials resulting in valuable materials being recovered for reuse and the potential for new jobs and new business opportunities.
2. **Social** - By reducing adverse impacts on health by proper waste management practices, the resulting consequences are more appealing settlements. Better social advantages can lead to new sources of employment and potentially lifting communities out of poverty especially in some of the developing poorer countries and cities.
3. **Environmental** - Reducing or eliminating adverse impacts on the environmental through reducing, reusing and recycling, and minimizing resource extraction can provide improved air and water quality and help in the reduction of greenhouse gas emissions.

3. E-Waste

Urbanization and economic growth over the past few years have increased the consumption of resources and caused the menace of excess waste generation. With rapid technological advances, large number of electronic products has become obsolete and their replacement has led to increase in generation of electronic waste (E-Waste). The rising volume of E-Waste around the world is an unavoidable by - product of this growth and has to be managed properly. Improper management of such highly toxic waste can pose serious threat to environment and its people. To overcome such Problems, every country has laid down certain set of goals, which are representative of present and future needs of the society or nation, and deploys its available resources for the attainment of such set goals. Waste of Electrical and Electronic Equipment (WEEE) or E-Waste management is one such goal. In Developed countries, E-Waste is handled by more of a mechanized and systematic way, whereas, in developing countries, like India, approach is more manual and labour intensive.

This approach indicates a strong interrelationship between human beings and E-Waste handling in terms of livelihood and health hazards. Thus, a more human oriented approach is required towards the management of E-Waste in developing countries. The E-Waste menace is largely recognized a major area of environmental concern. The major strategies that have led to the formulation of E-Waste management plans around the world are

• Reduction in amount of E-Waste generated through effective resource utilization, reuse and recycling;

• Environmentally sound management (ESM) of E-Waste for protection of human health and environment from the hazardous fractions present in it; and

• Recovery of scarce and precious materials as a step towards sustainable development.

Several nations have implemented E-Waste management plans according to their areas of need and concern. The European Union is considered as a stern legislation provider and focuses on most of the aspects of E-Waste handling, Japan is considered as they mainly focus on Reduction of E-Waste generated by reuse and recycling. India, as a new entrant in both legislative and management fields and as a representative of developing countries, is analyzed to assess the challenges and opportunities that exist in the field of E-Waste management.

The advance in technology improves the capabilities of the computer devices, while reduces its cost, size and weight, but the technology did not lengthen the useful age of the computer devices. Most of the computer devices have an average lifespan of less than two years; moreover, today, it is always cheaper and more convenient to buy a new machine than upgrading the existing unit. Electronic waste (E-Waste) or Waste Electronic and Electrical Equipment (WEEE) refer to electronic products. Without proper management and control on the disposal of E-Waste, most of these discarded electronic devices eventually end up at the landfill.

As commented by Hamilton in her paper "There are 130,000 computers are trashed in United State each day and these discarded stuffs mainly go to landfill". In the earlier days, the disposal of electronic devices are mainly due to damages, but in today technology boom, damages is no longer the only reason for disposing of electronic devices, where technical worn out, better cost of ownership, new product features, better aesthetic outlook and emotional value are having strong influences to the disposal of the devices. Due to the uncontrolled disposal of electronic devices, E-Waste had became a global dilemma where E-Waste had populating ever-growth landfill area and the United Nation had warned that the E-Waste problem at the developing countries like China, Africa and India could be a double or even quadruple with the next decade .Acceptable forms of E-Waste include Computers, Monitors, Printers, Toner Cartridges, Mobile Phones, iPods/MP3 Players, Televisions, DVD Players, Telephones, Cables/Wires etc.

3.1 E-Waste Rules (2011), India

In order to reduce and manage the growing menace of E-Waste, Ministry of Environment and Forests (MoEF) has proposed the E-Waste (management and handling) rules, 2011 framed under the Environment Protection, Act 1986 for ESM of E-Waste. ESM is defined as taking all steps to ensure proper management of E-Waste to protect health and environment from hazardous substances present in EEE by E-Waste rules. The status of India as per the quantification process is not well defined. It was estimated that 19000 tons of E-Waste was recycled out of 144,143 tons available for recycling out of 382,979 tons of E-Waste generated in 2007 in India. It was estimated 482,000 tons of E-Waste generation in 2011 as per 6% compound annual growth rate .Presently, E-Waste generation is mounting at the rate of 15% since 2005 and expected to reach 1.2Million tones by 2020 . E-Waste is largely controlled by the unorganized sector. This informal sector causes damage to the environment with the emission of toxic fractions from E-Waste due to the use of primitive methods for resource recovery.

3.2 E-Waste Management Strategies

Management of waste has been a critical concern for ensuring sustainability in organizations. There are a number of documented studies out there in the published literature which are highlighting this concern to an extent. For example, consumer behaviour on waste mobile recycling ;management of old electronic waste ; green software development model; decisive factors in green supply chain practices under uncertainty ; a literature and practice review to develop sustainable business model archetypes ; sustainability and business to business marketing; creating small business sustainability awareness ; a strategic approach to develop green supply chains ; review of sustainability terms and definitions; a European case study of business sustainability model are few to highlight.

However, it is an open question to explore the ways in which software companies manage their waste to maintain zero waste in their day to day business activities. Thus, this research focuses on exploring the following research questions by analyzing the sustainability reports of software development companies.

1. What types of wastes are generated by software development businesses?
2. How waste could be managed in a software development business?
3. Which waste management strategies and best practices multinational world class software development firms could learn from large scale Indian software businesses?

The type of wastes which are generated by the software businesses has to be identified and documented in order for it to be treated in an effective and environmentally friendly manner by the software development organizations. For example, E-Waste is a major type of waste generated by the used electronic items by the companies that has to be sorted in a manner which will not harm the environment .Likewise; there could be a number of waste types which has to be handled by the software companies in order for them to generate effective waste management strategies. Therefore, our first question looks at identifying the types of wastes that has to be tackled by the software companies.

The know-how of managing waste in a software development environment is tackled as the second question in the research documented in this paper. The ways in which companies manage waste could well be analyzed through looking at the existing best practices on waste management companies are adapting. For example, reuse and recycling is one of the widely used strategies for waste management according to the published literature.

4. Information Technologies

4.1 RFID (Radio Frequency Identification)

Traditionally the waste management industry has been a late adopter of new technologies such as RFID (Radio Frequency Identification) tags, GPS and integrated software packages which enable better quality data to be collected without the use of estimation or manual data entry.

Real time monitoring of status of bins, estimation of amount of waste in and around bins, surveillance for monitoring the movement of vehicles, optimization of routes and reallocation of bins according to the estimated waste, availability of management information system (MIS) reports for effective planning of resources schedule, and providing transparency in civic administration are the functions of this technology. The figure shows the garbage truck

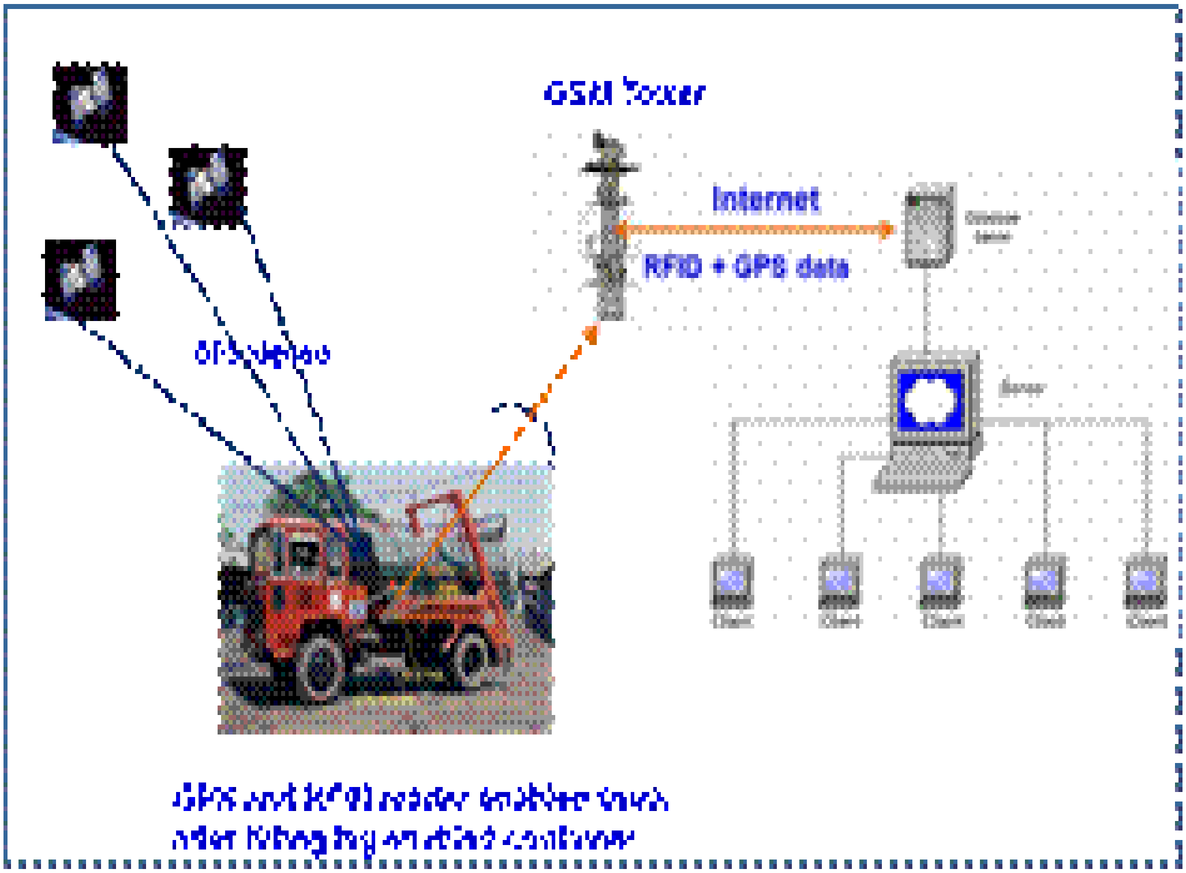

Figure 2: Technical architecture of the RFID system

4.2 EPR (Electronic Pollutants Recycling) system in the electronics recycling market at home and abroad

Lee et al. (1998) reported about how to apply the EPR pairs of Taiwan containers, packaging materials and other 10 categories of items for recycling process; Fishbeni (2000) describes the EPR system in the United States would apply to the recovery of the carpet achieved great success story; Yamaguehi (2002) the EPR system in Japan, the specific application, as well as for the OECD to the EPR system, the interpretation of the relevant provisions of the different views put forward their own; Thomas (2003) elaborated Sweden will EPR system used in waste electrical and electronic products (WEEE) recycling; Gonzalez a Torre et al. (2004) introduced the European waste bottles and packaging materials such as environmental policies and reverse logistics initiatives; Mr Tong Ka-Fu, Zhang Zhiqiang (2003) discussed the EPR system in waste management in the specific application; Teng Yan, Feng-Chun Lin (2004) to the international countries and regions, the implementation of E-Waste legislation and its effects were compared. The literature suggests that here are already many countries have begun to respond positively to the EPR system used in waste management in the specific practice.

4.3 Cloud based information platform for e-waste recycling

Cloud computing is one of the new information technologies, which enables web based information. The cloud based information platform consists of three level services: 1) web-based information platform for all the stakeholders, which share information on the platform; 2) SaaS (Software as a Service) based ERP (Enterprise Resource Planning) management system for recyclers, who can lease the application from the platform operator, without having to invest in the software license or infrastructure; 3) expansion of the platform to collection platform and transaction platform for the recovered material. The above mentioned three platforms are considered as three sub-clouds, which are integrated in the E-Waste recycling cloud.

4.3.1 New Technologies Used in the Platform

With the rapid development of information and telecommunication technologies, IT based service as become more sophisticated and integrated with business and organization, which further drives the service innovation. IT service itself has been undergoing transformation. The old IT service mode is based on license, while new IT service focuses on SaaS (Software as a Service) paradigm, which relies on web-based service .Cloud computing, as an innovative distributed computing, can provide dynamic resource buffer, virtualization and highly usable next generation of enterprise data centre. Cloud image is used to represent the Internet or some large networked environment, the cloud is a virtualization of resources that maintains and manages itself. One major kind of cloud computing is SaaS (Software as a Service), through which users can get software service from internet, without having to invest massively in software or infrastructure. They can lease the web-based software from service provider, which is responsible for the operation, upgrading and maintenance of the software related technology.

4.3.2 Functions of the Platform

The proposed E-Waste recycling platform includes three levels of information:

1) Web based information & management platform, on which all the stakeholders (such as ecyclers, management authorities, producers etc.) are integrated in the platform. Through internet browser the stakeholders can access the platform to input information and extract information from the platform. All the data are stored in the central database server.
2) SaaS based platform for ERP system for recyclers and major collectors. To meet the requirement of information reporting to the municipal environmental protection bureau or the E-Waste fund centre, recyclers need to construct information system (ERP) system for inbound and outbound operation. SaaS mechanism is a suitable way for E-Waste recyclers. The information system is run online, which allows the recyclers to save the investment for the infrastructure. The system is run in the cloud, which is here 2 Cloud Computing includes three types of services: 1) IaaS (Infrastructure as a Service); 2) PaaS (Platform as a Service); 3) SaaS (Software as a Service), called "E-Waste recycling cloud" or E-Waste recycling platform
3) Extended platform with collection platform and transaction platform integrated. The collection platform integrates all the collectors and their operation, while transaction platform provides an electronic market for the recycled material for the buyers and sellers. Figure 5 shows the structure of the cloud based E-Waste recycling platform. Fig 5. Structure of the Cloud based E-Waste Recycling Platform.

4.3.3 Advantages of the Information Platform

This integrated platform can ensure quick and consistent information delivery. The stakeholders can communicate easily, without problem of system heterogeneity. Information can be easily updated and delivered to the parties involved. Producer: provide information of their product, especially about the toxic material contained in the product, and instruction of the collection & treatment. Management authorities, including local environmental protection authority, provincial management authorities and state council level authorities, share the management responsibility to control and monitor the operation of the E-Waste recycling operation. Recyclers: exchange information with producer, collectors, management authorities, third party service providers etc. Other stakeholders can access the platform to contribute and to share the information.

Third party service providers, which claim the producer service responsibility, can also access the corresponding information on the platform. This platform allows simultaneous information sharing among stakeholders. Each stakeholder has its own power to access specific types of information. Especially for the recyclers, they cannot have access to other recyclers' data. The data security issue is currently the major obstacle to push forward the SaaS mechanism, because the recyclers are concerned about the information leaking to competitors. The innovative web (cloud) based service, such as IT service, logistics service and quality inspection service; etc., are part of the "producer services" In principle, these services can be hosted as web-delivered services, which can help improve the efficiency of the total service system. .Thus the companies are left with their core recycling business and their competitiveness can be enhanced. Furthermore, in the cloud based E-Waste recycling network, financial flow and material flow can be integrated in the information management platform.

4.3.4 Operation of the Cloud based Information Platform

Operator of the integrated platform can be the central E-Waste fund management center or a third party IT service provider. Because Cloud computing and SaaS mechanism is new to customers who needs time to develop trust in them, the investment and operation cost at the beginning stage should be covered by the government. Both the information platform and the ERP system for recyclers are free for all the stakeholders. The government should support the system until the system becomes mature.

5. Conclusion

As one of the major resource regulation industries, Waste and E-Waste recycling can help solve resource shortage and environmental pollution problem, ensuring sustainable development.

The information technologies such as RFID, GPRS, EPR , Cloud based platform etc can support the waste management practices efficiently. The government regulations pertaining to waste and E-Waste management would further enhance the waste management strategies of software development firms.

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