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Abstract

With 50 million metric tons of e -waste disposed worldwide each year, e-waste recycling has become an increasingly important issue globally. The U.S. alone generated a total of 3.01 million tons of e-waste in 2007, of which only 13.6% was recycled. Improper disposal of e-waste poses an immediate and prominent threat to environmental and public health. Many electronic vendors have initiated either the Expended Producer Responsibility or the Producer Stewardship and launched manufacturer-sponsored recycling programs. Many of these programs, however, are in trouble because of the fee generated for recycling, thereby blocking the road for effective actions. In this paper, we propose a third party recycler model as an alternative solution to e-waste recycling. The third party recycler works as the intermediary between consumers (source of e-waste) and electronic vendors (recipient of recycled items) to recycle disposed electronics properly. The proposed information system is composed of five modules and supports the business operations and functionalities of the third party recycler. We hope the third party recycler structure will be adopted globally in the near future.

Keywords: e-waste, recycle, extended producer responsibility, producer stewardship, information system

Introduction

"Computers don't have exhaust pipes, but their environmental impact is no longer invisible. The cumulative life cycles of billions of machines, from manufacture to usage to disposal, are combining into an environmental footprint large enough to attract widespread attention." [18]

The advent of modern computing technologies is now providing powerful, affordable, and easy-to-use electronic devices and equipments to individual and corporate business users in support of communication, collaboration, and business operations, most of which are now carried out in a global manner. As a result, people have become increasingly dependent on such devices and equipment and consume a large amount of electronics in their everyday activities.

Despite the benefits, fast-growing computing technologies, unfortunately, have a dark side. The life span of electronics has been continuously shrinking because of the introduction of more superior and technologically advanced items [16]. Consequently, older computing devices are being replaced at an accelerated pace and generating an astonishingly large amount of e-waste, the numbers of which number continue to increase every year. For instance, the world produces 20 to 50 million metric tons of e-waste annually [4]. China alone adds 2 million tons of e-waste and the number increases at rate of more than 10% each year, [20] American consumers replace their mobile phones every one and half years on average [14], producing 130 million discarded cell phones annually nation wide [12]. In China, 70 million mobiles phone and 5 million PCs are being discarded each year [21]. Likewise, more than 50 million PCs are disposed in the U.S. each year [18], with this number accounting for only 10% of the disposable computers [12]. The majority of defunct computers are not being used and simply collect dust.

In the past decade, governments and organizations worldwide have been investigating the causes and impacts of e-waste and have made great efforts to regulate the collecting and recycling of e-waste through legislative and public means. Extended Producer Responsibility (EPR) is so far the most widely adopted legislation, especially in the United States. Such recycling structure, however, has long been challenged by the fee generated for recycling and will be addressed by either the producer responsibility model or the consumer responsibility model.

In this paper, we propose a third party recycler model as an alternative solution to e-waste recycling. The third party recycler performs as the intermediary between consumers (source of e-waste) and electronic vendors (recipient of recycled items) to collect, inspect, recycle, and

distribute the usable parts of electronics and to dispose of unusable parts properly.

In this paper, the next section introduces the background of e-waste and challenges related to the recycling of it. In section three, we will discuss EPR, the most widely adopted solutions to e-waste recycling. This section will be followed by the introduction to the third party recycler solution and its system modules. The paper concludes with the contribution of the proposed model and the future plans for adoption of the model.

Background of E-Waste Recycling

Electronic waste (e-waste), sometimes called Waste Electrical and Electronic Equipment (WEEE), has been defined loosely to refer to any electronic products and appliances near or at the end of their useful life that have become obsolete, broken, or discarded [2] [19]. The European Union (EU)'s WEEE Directive uses ten product categories to describe e-waste to include IT and telecommunication equipment, household appliances, consumer equipment, and so forth [9]. Generally speaking, e-wastes are commonly seen as discarded computers (desktop and laptop), monitors, video game consoles, mobile phones, printers, telephones, fax machines, TVs, VCRs, DVD players, video cameras, stereo systems, digital music players, and other electronic equipment.

The prevalent problem of e-waste recycling mainly comes from three issues. First, the amount of e-waste generated each year is enormous and keeps rising. According to the 2007 report released by the United States Environmental Protection Agency (EPA), the U.S. generated a total of 3.01 million tons of e-waste in 2007, an increase of 37.4% from five years ago. Unfortunately, only 13.6% of the 3.01 million tons were recycled, leaving 2.6 million tons of e-waste dumped into landfills and incinerators [8]. According to Electronics Take Back Coalition, an environmental activist group, all human kind globally generate up to 50 million tons of e-waste every year [4]; however, only a small percentage of this amount of e-waste is being recycled and 70% of the global e-waste is being dumped in China at the rate of 2,800 tons per hour [20]. Although the percentage of e-waste recycled has been slowly rising in the past decade, in the U.S. it stubbornly stayed in the lower ten percent range.

Second, toxic substances in e-waste are another aspect to the resisting to recycling e-waste products.. E-waste contains toxic materials, such as lead, mercury, cadmium, brominated flame retardants (BFRs), plastics, and beryllium, all of which are harmful to humans and their environment [3]. In the U.S. and Europe, e-waste account from one to four percent of solid waste and is responsible for more than 70% of toxic waste annually [7]. Such hazardous material can leak into the groundwater when buried, contaminating the landfills, or it can enter the air through burning or dust [12].

Unlike clothes donated to the Salvation Army, e-waste has to be recycled properly because of the toxic material involved. Improper disposal of e-waste will pose an immediate and prominent threat to environmental and public health.

Some considerable amount of e-waste, meant to be recycled are, in fact, handled and processed through improper or even illegal means. Each year, tons of e-waste is transported to developing countries, such as China and South Africa, where valuable parts of materials, such as microchips, are stripped off by skilled workers and then later repackaged and resold to the electronics market. Some of these dangerous counterfeits made their way to, unfortunately, U.S. military computers and satellites [10].

The same story continues in the sweatshops of e-waste disassembling factories in India. Workers, some young children, dig in the piles of old computers, hard drives, and circuit boards, searching for precious metal such as gold, copper, and palladium [15]. Without the regulations from the local government, Indian produces 1.5 million tons of e-waste a year and illegally imports at least half of that amount from the West [15].

Last but not the least, individual consumers who are willing to dispose their used electronics properly often fail because of the lack of simple and convenient channels for recycling. Three out of four consumers find themselves clueless as how and where to dispose e-waste [12]. Instead of letting e-waste end up at the curb, governments and organizations around the globe are now taking effective actions toward the proper disposal and recycling of e-waste. Building a national e-waste recycling infrastructure for consumers and vendors becomes one of the most immediate and logical solutions for most countries.

Extended Producer Responsibility

The daunting fact of e-waste has caught the attention of heads of governments and organizations when they realized that a joint effort between the parties is more than necessary to address e-waste recycling successfully. Introduced by Organization for Economic Cooperation and Development in 1998 in U.S., the Extended Producer Responsibility (EPR), also called Producer Stewardship (PS), makes each producer responsible for "collecting and processing its own products at the end of their life" [16, p.337]. The European Union defines a producer as "any person

who 1) manufactures and sells own brand electrical and electronic equipment, 2) resells equipment produced by other suppliers under its own brand, or 3) imports or exports electrical and electronic equipment on a professional basis into a Member State" (European Union, 2002, p. L 37/27). The EPR, therefore, requests producers to take responsibility and minimize its negative environmental impacts from designing recyclable products in the first place (eco-design) to collecting those to be disposed at the end of the products' useful lives.

Some major electronic vendors have initiated producer stewardship and have launched manufacturer-sponsored recycling programs to facilitate the recycling of e-waste, making good public image by taking the stand in support of environmental protection and green IT. Among this league are some well-known leaders in the computing and related industry. In 2005,Apple Inc. launched an iPod recycling program that allows users to trade their used iPods for a 10 percent discount on a new one [18]. Sony launched the Take Back Recycling Program in U.S. in 2007, allowing consumers to recycle all Sony-branded products for free at 80 Waste Management Recycle America eCycling drop-off centers throughout the country [13]. As early as 1987, Hewlett-Packard (HP) launched a series of e-waste initiatives, one of which provides a pre-paid envelope to return the used printer cartridge for recycling with each new cartridge sold. By July 2007, HP has recycled more than 1 billion pounds of electronics and print cartridges around the world [13].

The vendor-sponsored recycling programs took a big leap toward effective e-waste recycling, largely because of pressure from government legislation. For example, in the U.S., so far 20 out of 50 states and New York City have passed e-waste legislation mandating e-waste recycling [6]. Another 13 states proposed the e-waste recycling law in 2009 to be voted by the states [5]. Similarly, in Canada, the Information Technology Association of Canada and Electro-Federation Canada together funded the Electronics Product Stewardship Canada (EPSC) in 2003 to "design, promote, and implement sustainable solutions for recycling end-of-life electronics." [1]. In Europe, the Directive on WEEE and the Restriction of Use of Certain Hazardous Substances (ROHS) have been adopted by member countries to guide the collection, treatment, and recycling of e-waste [17].

One big obstacle to the adoption of EPR initiatives appears to be the establishment of the fee structure to address the costs involved in e-waste collection, disposal, and management. The current suggestion is for the producers, as defined by EPR regulations, to take responsibility for the costs. In the U.S., nineteen of the twenty states who have passed the e-waste legislation are adopting a producer responsibility code which require manufactures and vendors pay for the recycling costs, which includes providing a free recycling option to consumers. By contrast, California switched such financial burden to the consumers (consumer responsibility), charging a $6 to $10 disposal fee on every computer and television purchased [11]. An often seen dilemma is that producers are not willing to pay for recycling because such costs, very likely, were not being considered in the initial pricing model; on the other hand, consumers are reluctant to take such responsibility because in some states, there is still option to trash e-waste for free, or they may choose not to recycle at all.

Third Party Recycler Solution

An alternative solution to e-waste recycling is to introduce a third party recycler, who performs as the intermediary between consumers (source of e-waste) and electronic vendors (recipient of recycled items) to collect, inspect, recycle, and distribute the usable parts of electronics as well as dispose unusable parts properly. Figure 1 illustrates the workflow of e-waste recycling through the third party recycler.

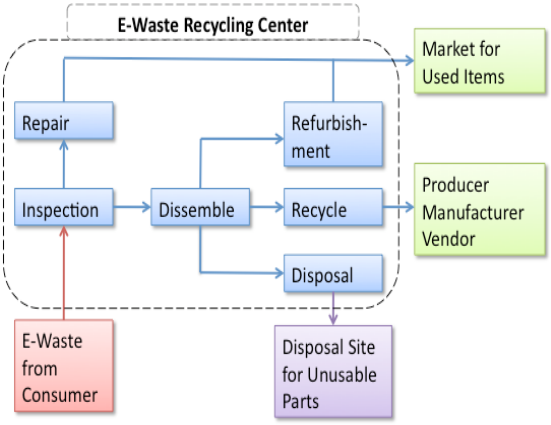

Figure 1: Workflow of E-Waste Recycling through Third Party Recycler

E-waste recycling starts with the consumer (individual or corporate business), who generates an order for his/her electronics. Such interaction can be initiated through web sites, short text messages on mobile phones, and phone calls made through a call center of the recycler. Items to be recycled will be picked up from the consumer, who may also drop them off at any designated location. Once arriving at the recycling center, items will first be inspected to determine whether they should be repaired or disassembled.. Electronics that can be reused will be repaired with data cleaned. For

those to be disassembled, a few options are available. Refurbishment will be recommended if, by replacing some key component(s), the item can perform all functionalities successfully. Some other parts of the disassembled items will be recycled and returned to the original producers or other manufacturers who are willing to take the recyclable parts. Plastics and metals recovered from recycled items can be used in new computers and other products. After disassembling, some parts can no longer be used and will be sent to the disposal sites to be treated properly. Both repaired and refurbished electronics will become available in markets and shops selling used items, often at a much lower price than a brand new piece of equipment..

The third party recycler model allows consumers to return used products for free, thereby eliminating the consumers' financial responsibility for e-waste recycling. To operate as a self-sustaining organization, the third party recycler can make a profit by reselling repaired and refurbished electronics to used-item markets and by selling recycled parts to vendors, manufacturers, and producers. (A more detailed analysis demonstrating the profitability for the third party recycler using economic models is presented in a separate paper.)

Five modules of the E-Waste Recycling Information System support the functionalities and business operations of the third party recycler (Figure 2). The Client Management module provides a real-time, online inquiry of recycling orders and the processing information. The Recycling Processing module manages the recycling center, documents the information of repair, disassembling, refurbishment, recycling, and disposal of electronics. Inventory is maintained in the Inventory Management module. The information system also includes accounting functionalities to process, analyze, and report and manage costs. The Logistics module collects, processes, and presents information to support the reversed supply chain through which producers are now recipients of recycled items.

Following the conceptual framework of the third party recycler information system presented in this section, a development team will analyze and design the proposed information system, to be completed by March 2010. The information system will first be prototyped and tested in mainland China. Evaluation of system tests will be used for future revision and improvements.

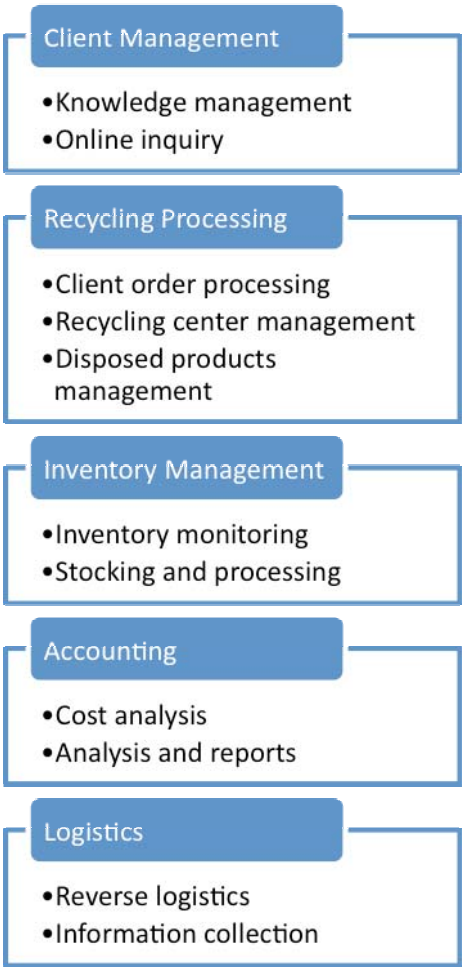

Figure 2: System Modules of the E-Waste Recycling Information System

Conclusions

E-waste recycling has become an increasingly important issue globally. Instead of letting millions of tons of e-waste be dumped to landfills, governments and organizations around the world are now taking effective actions toward the proper disposal and recycling of e-waste.. In this paper, we propose a third party recycler model as an alternative solution for e-waste recycling. The third party recycler serves as the intermediary between consumers (source of e-waste) and producers (recipients of recycled items). By reselling repaired, refurbished, and recycled electronics and parts to producers, the recycler is able to maintain profitability In order to be self-sustaining. The recycling service thus is provided free of charge to consumers including both individuals and corporate businesses.

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