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CSPR - Collection Segregation Processing and Recycling of E-Waste using Cloud

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Abstract: The Term E-Waste (Electronic Waste) is a growing severe threat to the mankind which causes serious health hazards, many countries have adopted several techniques in handling these E-wastes, and still the research is in progress. This paper suggests CSPR – Collection, segregation, Processing and Recycling of E-waste with the help of cloud environment. The paper narrates three predominant activities like E-Waste Accumulators (EWAs), Cloud Service Provider (CSP) and E-Waste Analyzing Sectors (EWAs), by which one can easily segregate the E-waste based on its type, study and may reuse or dispose the E-waste.
Keywords: E-Waste, WEEE, Hazards, EWA, CSP, PCB, Cloud.

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I. INTRODUCTION

Electronic waste (e-waste) management deals with the disposal of broken or obsolete electronic Components and materials. These materials may be valuable and recyclable, such as random access memory and reusable laptops. However, harmful materials, such as cathode ray tube monitors, require handling in disposal. Common discarded electronic products include computers, televisions, stereos, copiers and fax machines.

Electronic industry is the world's largest and innovative industry for its kind. Every year tons of electronic items are shipped over oceans, however, after their usage time they are become a complex waste matter which consists of many hazardous heavy metals, acids, toxic chemicals and non degradable plastics. Many are dumped, burnt or exported to recyclers. However, about 75% of e-wastes are uncertain for their use or finding ways to use them which includes refurbishment, remanufacture and reuse their parts for repair etc. While others are junks occupying usable space at houses, apartments, firms and industries. Most e recyclers were exporting the toxic materials such as leaded glass, circuit boards, and mercury lamps usually to China, Africa and India (Basel Action uploaded on 2013). Dismantling process takes much labor, in countries like China and some parts of India there are tones e- wastes junked and dismantled;

Dismantling is not only involved in unscrewing but also shredding, tearing and burning. The smoke and dust particle consists of carcinogens and other hazardous chemicals which causes severe inflammations and lesions including many respiratory and skin diseases. Circuits are burnt to hunt the valuable metals such as gold, platinum, cadmium but the wire coat of those consists of PVC and PCB which may produce erotic smoke, and carbon particles from the toners are carcinogens, they may lead to lung and skin cancer (Kevin *et al*., 2008). Due to the poverty some places in China such as city of Guangzhou still risking their health with e waste full of used computers and television sets, according to the data received in 2007 about 70 % of e- waste of the world reaches China and the rest to Africa and India, due to their cheap labor they have become the world's dumping station of e- waste, in Ghana about 20% of their population are working on e-waste; they use after reconditioning them (Basel Action uploaded on 2013)[1].

The remaining of the paper narrates the sources of E-Waste, health hazards, techniques adopted in various parts of the world and the proposed architecture with the usage of Cloud environment for deployment. Finally the paper is concluded with the references.

II. SOURCES OF E-WASTE AND IMPACT OF E-WASTE ON HEALTH AND ENVIRONMENT

First, E-waste is a new burden of our technologically advanced societies. With the rapid advent of technology and the high rate at which older forms of technologies are being discarded for newer forms, what happens to the electronic appliances which you bought only a few months ago? They get discarded. Many of us may unthinkingly discard them in our waste paper bins, putting little thought on the fact that, since most of such appliances and electrical substances are not biodegradable, they may release toxic substances and contaminate the environment when they are disposed with other household wastes. Hence has come into being a separate

classification of wastes known as e-waste. E-waste consists of discarded electronic and electrical appliances which have reached the end of their tenure or life and no longer serve the purpose they were intended for.

Fig. 1: Electronic Waste (Courtesy: www.google.com)

E-waste sources can be numerous. Electronic appliances which are used personally and in households are the most common sources of e-waste. Such appliances are usually personal computers, DVD players, laptops, television sets, mobile phones, mp3 players and so on. Many people think that e-wastes are only comprised of IT products, but electrical and other household appliances also form e-waste when they are discarded. Such items consist of washing machines, vacuum cleaners, toasters, drying machines, refrigerators, irons, air conditioners, coffee machines and related items. Lighting fixtures and appliances such as sodium lamps, fluorescent tubes, sewing machines, surveillance equipments, lawn mowers, coin slot machines and even electronic toy products such as train sets also form e-wastes. These items are broadly categorized as WEEE or Waste Electrical and Electronic Equipments.

The electronic scrap recycling methods are vital for such items since these appliances usually consist of toxic materials. Such materials, when improperly discarded, lead to environmental pollution. For instance, the cathode ray tubes which are common electrical appliances, consist of carcinogenic materials such as phosphor, barium, lead and other types of metals which are toxic and prove pollutant to the environment and ultimately for the health of humans.

If you look closely at the e-waste sources, the flame retardant chemicals which are present in cables, circuit boards, plastic casing are hazardous to health. While switches and flat screens contain mercury, semi conductors contain cadmium; cathode ray tubes in televisions contain lead, barium and even arsenic which are lethal and toxic for the environment. Thus, the sources of e-waste are numerous and each source has its own form of toxicity which makes it necessary to be disposed of properly to protect the environment and health of human beings [2].

Below two tables-1,2 Summarizes the source of e-waste and impact of it on health and environment.

Source of E-wastes	Constituent	Health Effects
Solder in printed circuit boards, glass panels and gaskets in computer monitors	Lead(PB)	• Damage to central and peripheral nervous systems, blood systems and kidney damage. • Affects brain development of children.
Chip resistors and semiconductors	Cadmium (CD)	• Toxic irreversible effects on human health. • Accumulates in kidney and liver. • Causes neural damage. • Teratogenic.
Relays and switches, printed circuit boards	Mercury(Hg)	• Chronic damage to the brain. • Respiratory and skin disorders due to bioaccumulation in fishes.
Corrosion protection of untreated and galvanized steel plates, decorator or hardener for steel housings	Hexavalent chromium (Cr) VI	• Asthmatic bronchitis. • DNA damage.
Cabling and computer housing	Plastics including PVC	Burning produces dioxin. It causes • Reproductive and developmental problems. • Immune system damage. • Interfere with regulatory hormones.
Plastic housing of electronic equipment's and circuit boards	Brominated flame retardants(BFR)	Disrupts endocrine system functions.
Front panel of CRTs	Barium (Ba)	Short term exposure causes: • Muscle weakness. • Damage to heart, liver and spleen.

Motherboard	Beryllium (Be)	• Carcinogenic (lung cancer) • Inhalation of fumes and dust. Causes chronic beryllium disease or beryllicosis. • Skin diseases such as warts.

Table 1: Effects of E-waste Constituents on Health
(Courtesy: Reference [2])

Sl.No	Hazardous Components	Effect of Hazardous components of e-waste
1	Arsenic	Can affect skin and can decrease nerve conduction velocity. Chronic exposure to arsenic may cause lung cancer and sometimes be fatal.
2	Lead	May affect kidneys, reproductive systems, and nervous connections. May cause blood and brain disorders, sometimes may be fatal.
3	Barium	Can affect heart muscle.
4	Chromium	Can damage liver, kidneys and may cause asthmatic bronchitis and lung cancer.
5	Beryllium	May cause lung diseases.
6	Mercury	Affects the central nervous system, kidneys and immune system, it impairs fetus growth. May cause brain or liver damage.
7	Cadmium	May cause severe pain in the joints and spine. It affects the kidneys and softens bones.
8	BFR (Brominates flame retardants)	Can harm reproductive and immune systems, may cause hormonal disorder.
9	Chlorofluorocarbon (CFC)	May affect the ozone layer. It may cause skin cancer in human and genetic damage in organisms.
10	Polychlorinated Biphenyl (PCB)	May cause cancer in animals, can affect the immune system, reproductive system, nervous system, endocrine system. PCBs persistently contaminate in the environment and cause severe damage.
11	Polyvinyl chloride (PVC)	PVC contains upto 56% chlorine and when burnt, produces Hydrogen chloride gas which in turn produces hydrochloric acid that is dangerous to respiratory system.
12	Dioxin	These are highly toxic to animals and can lead to malfunction of fetus, decreased reproduction and growth rates, affect immune system.

Table 2: Health Hazardous
(Courtesy: Reference [1])

A. E-Waste In Ghana, Africa

About 4 million tons of wastes are brought to Ghana from Antwerp and other parts of western world. Government of Ghana has signed in every international treaties but entry of e-waste is still there as the people of Ghana are not afford to purchase new electronic goods due to their poverty. And slum children and young men are used as collectors and dismantlers for cheap labour.

E-wastes includes camera, computers, TVs, refrigerators, drillers and many used electronic items. They are sold for cheap price but no warranty for its usage, while unusable items are burned and dumped there (Figure 2). The river has now become a dark muddy stream rich in heavy metal wastes. Fisher men have almost lost their hopes and catch contains heavy metals which can cause long-term impact to human beings. (Dateline uploaded on, 2011)[1].

Fig. 2: Disposal of E-waste
(Courtesy: Reference [1])

B. City of Guiyu, China and e-wastes

Guiyu was a peaceful paddy harvesting village in early days, but now it has become a junk yard of much of the electronic discards. Extraction of steel, Aluminum, plastic and Gold occurs in every corner of the village; about hundred thousand people are engaged with dismantling electronic items. After collecting the metals they simply burn the rest, the hazardous smoke spreads and causing variety of respiratory and skin diseases, they also wash vegetables here which also lead to stomach problems. Now the surface and well waters of Guiyu has become undrinkable (Figure 3), according to Basel Action Network the content of lead in river

Linjaing of Guiyu is between 1.9-24mg/ L whereas the WHO border line is 0.01 mg/ L. Thus they had to wait for water from 30 km away. Open dumping of plastic, and release of dioxins, hydrocarbons and toxic brominated compounds to the soil is a common hazard, In addition circuit boards are burnt which releases fumes consisting toxic lead, tin and mercury, and toxic irritant isocyanides. It was reported water and soil consist of very high levels of lead. (Basel Action uploaded on 2013)[1].

Fig. 3: E-Waste junkyard
(Courtesy: Reference [1])

C. E-waste in India

Globally the e-waste is growing by 40 million tons (MT) a year. In developed countries, e-waste constitution is 1 to 2% of the total municipal solid waste (MSW) generation and United State is 1 to 3% of the total MSW. In European Union in total amount of e-waste generation is 5-7 million tons per annum.

In India e-waste generation is growing at about 15% and is expected to cross 800,000 tons per year in 2012.A Central Pollution Control Board (CPCB) report said 65 cities in India generate more than 60-70% of the total e-waste, which comes from 10 states, that's are followed by Maharashtra, Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab in the list of e-waste generating states in India [2], [3]. The composition of e-waste is very diverse and contains over 1000 different substances, which falls under organic and inorganic fractions.

The growth of electronic waste is high in India, since it has emerged as an IT giant and due to modernization of lifestyle. However, there is no proper disposal system in our country that has led to enormous amount of electronic waste. There is a need to find a proper recycling and disposal technique, so that reduce the environmental pollution and health hazards. Estimated the total number of Personal Computers (PCs) emanating each year from business and individual households in India will be around 1.38 million, according to a report of confederation of Indian industries, the total waste generated by obsolete electronic and electrical equipment (EEE) in India has been estimated to be 146,000 tons per year. The results of field survey conducted in Chennai, metropolitan cities of India to assess the average usage and life of PC, Television (TV) and mobile phone shows that the average household usage of the PC ranges from 0.39 to 1.70 depending on their income. In case of TV, it varied from 1.07 to 1.78 and for mobile phones it varied from 0.88 to 1.70. the low income households use the PC for 5.94 years, TV for 8.16 years and the mobile phones for 2.34 years while, the upper class income uses the PC for 3.21 years, TV for 5.13 years and mobile phones for 1.63 years. Although the per-capita waste production in India is still relatively small, the total absolute volume of waste generated will be huge. The growth rate of the mobile phones 80% is very high compared to PC 20% and TV 18%.

According to TRAI, India added 113.26 million new cellular customers in 2008, with an average of 9.5 million customers added every month. Cellular market grew from 168.11 million in 2003-04 to 261.97 million in 2007-08. Microwave ovens and air conditioners registered a growth about 25% and refrigerator sales amounted to 4.2 million in 2006-07. Washing machines have always seen poor growth and the penetration level of colored televisions are increased three times in 2006-07. Solid waste management, which is already a mammoth task in India, has become more complicated by the invasion of e-waste, particularly computer waste in India. The preliminary estimates suggest the total WEEE generation in India is approximately 146,180 tons per year and which is exceeded 800,000 tons in 2012. The top states, in order of highest contribution to WEEE, include Maharashtra, Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab is shown in Table 3. The city wise ranking of largest WEEE generators is Mumbai, Delhi, Bangalore, Chennai, Kolkata, Ahmadabad, Hyderabad, Pune, Surat and Nagpur[4].

City	WEEE, Tons per year
Mumbai	11017.1

Delhi	9790.3
Bangalore	4648.4
Chennai	4132.2
Kolkata	4025.3
Ahmedabad	3287.5
Hyderabad	2833.5
Pune	2584.2
Surat	1836.5
Nagpur	1768.9

Table 3: Survey of E-Waste quantity (Approximate)
(Courtesy: Reference [4])

III. E-WASTE DISPOSAL TECHNIQUES ADOPTED IN INDIA

A. Landfilling

It is one of the most widely used methods for disposal of e-waste in India. Here, trenches are made on the flat surfaces and soil is excavated from it. Then waste materials are buried in it, which is covered by a thick layer of soil [5]

B. Incineration

It is a controlled and complete combustion process, in which the waste material is burned in specially designed incinerators at a high temperature (900-10000C) (MoEF 2008). Some plants remove iron from the slag for recycling. By incineration some environmentally hazardous organic substances are converted into less hazardous compounds [5].

C. Recycling

Recycling is a process of dismantling i.e., removal of different parts of e-waste containing dangerous substances like, PCB, Hg, separation of plastic, removal of CRT, segregation of ferrous and non- ferrous metals and printed circuit boards, hard drives, floppy drives, Compact disks, mobiles, fax machines, printers, CPUs, memory chips, connecting wires and cables can be recycled [5].

IV. IMPACTS OR AFTER EFFECTS OF DISPOSAL TECHNIQUES OF E-WASTE ADOPTED IN INDIA

A. Hazards Due To Landfilling

Land filling can leak. They are not completely tight throughout their lifetimes and a certain amount of chemical and metal leaching may occur. Mercury will leach when certain electronic devices, such as circuit breakers are destroyed, lead [5].

B. Hazards Due To Incineration

Disadvantage ofincineration are the emission of flue gases and the large amount of residues due to combustion. E-waste incineration leads to the annual emissions of cadmium and mercury. The incineration of brominated flame- retardants at a low temperature of 600-8000C may lead to the generation of extremely toxic polybrominated dioxins (PBDDs) and Polybrominated furans (PBDfs). Significant quantity of PVC is contained in e-waste, which makes the flue gas residues and air emissions particularly dangerous (MoEF 2008, research unit,Rajyasabha secretriate.2011,ShalabhAgrawal 2012,Divya Gupta 2012) [5].

C. Hazards Due To Recycling:

Recycling of hazardous products have environmental benefit, only if there is a goal to redesign the product to use non-hazardous materials. The hazard associated with disassembly stage is the possibility of accidental spillages of hazardous substances. For example, mercury, found within light sources(fluorescent tubes in scanners, photocopiers, etc.) as well as switches, could be released into the air of a recycling facility upon breakage of the shell(Puckett and Smith,2002) [5]. A hazardous emission into the air also results from recycling of e-waste containing heavy metals, such as lead, cadmium etc. [6].

V. PROPOSED METHODOLOGY: CSPRC (COLLECTION SEGREGATION PROCESSING AND RECYCLING USING CLOUD) E-WASTE MANAGEMENT TECHNIQUE

The Proposed architecture is as shown in the below figure 4, the cloud environment is considered to have three components namely E-Waste Accumulators (EWAs), Cloud Service Provider (CSP) and E-Waste Analyzing Sectors (EWAs).

The CSPRC consist of following steps.
a. Collection of E-waste
b. Segregation of E-waste
c. Processing and Recycling of E-waste

A. Collection Of E-Waste

E-Waste Accumulators(EWA)are responsible for collecting different E-waste from various end-users like home, office(s), industry and corporates, private and public organizations etc. following are the E-waste types identified in this paper,

- Home appliances (refrigerators, washing machines, dryers etc.)
- Small appliances (vacuum cleaners, irons, blenders, fryers etc.)
- Computer and telecommunication appliances (laptops, PCs, telephones, mobile phones etc.)
- Consumer electronics (video and audio equipment, musical instruments)
- Lighting devices (incandescent light bulbs, fluorescent tubes, gas-discharge lamps etc.)
- Electrical and electronic tools (drills, saws, gardening devices etc.)
- Toys, leisure (electronic toys, models, sports equipment)
- Medical devices (all medical equipment with the exception of implants)
- Monitoring devices (detectors, thermostats, laboratory equipment etc.)
- Vending machines

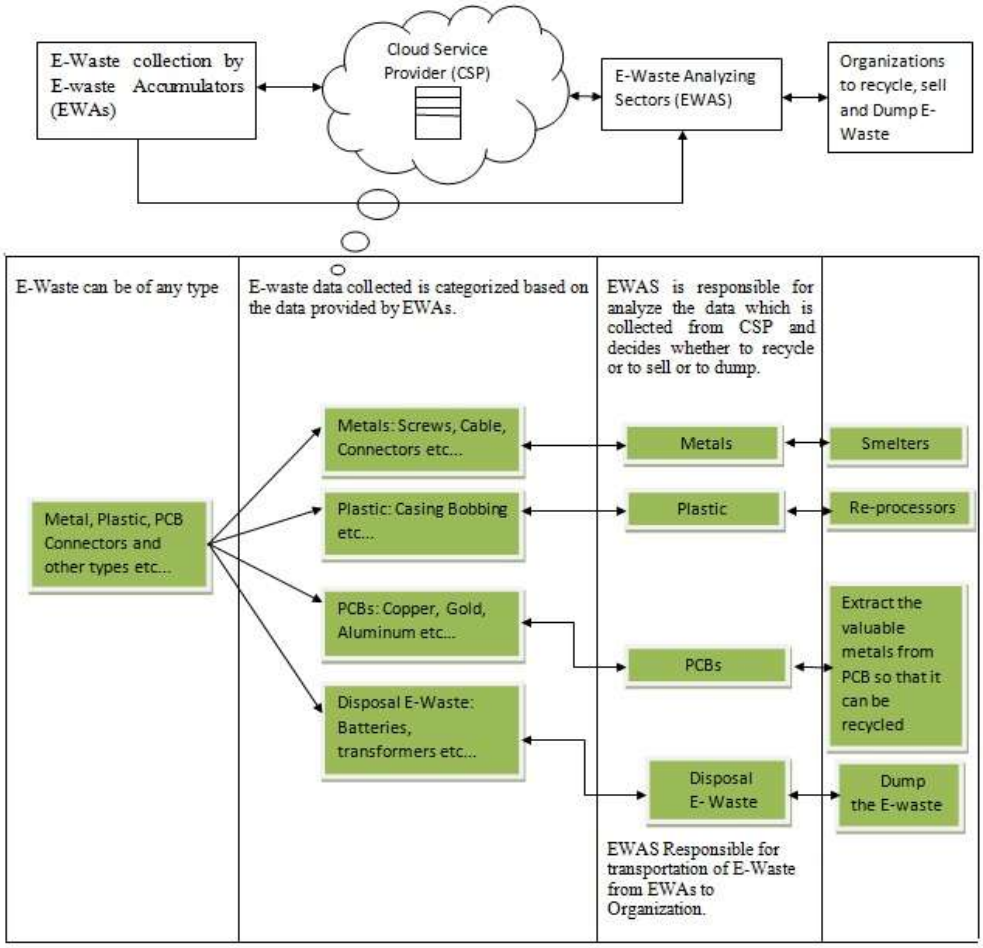

Fig. 4: Architecture of CSPRC

Collected E-waste includes non-ferrous and precious metals, alloys, glass, ceramics, organic polymers with toxic content, other substances like stabilizers, fillers and pigments. The collected E-waste is sent to Segregation. Once the task of E-waste collection is achieved, it has to be deployed in Cloud. In order to deploy, E-Waste Collectors must authenticate with Cloud Service Provider (CSP).This can be performed by User name and Password or any means of authenticity provided by the CSP.

B. Segregation Of E-Waste

Collected E-waste will be disassembled and segregated into different categories. These can be segregated through either manually, semi-automated or automated techniques. The main aim of segregation is to achieve Low cost, which is achieved with the usage of cloud.

C. Processing And Recycling Of E-Waste:

Once the E-waste is categorized, it has to be processed to check whether it can be repaired or sold or recycled. To process the E-waste, E-Waste Analyzing Sectors (EWAs) responsible for analyzing segregated E-waste must authenticate with Cloud Service Provider. EWAS are responsible for analyzing E-waste to recycle, to sell or to dump. For instance if the segregated E-waste is a glass, iron piece or plastic etc., can be sold to some parent organization for reuse else it might be recycled to develop new product.

The Printed Circuit Boards (PCBs) has 3% to 5% by weight of total e-waste. PCB consists of rich value of metals such as copper, silver, gold, palladium, platinum, tantalum and other metals in traces level. The recovery of all the metals requires professional skill, expensive equipments and machineries.

All these Analysis will be taken care from the E-Waste Analyzing Sectors (EWAS) and are also responsible for Transportation of E-waste to the respective Sectors to recycle or to sell or to dump.

D. Merits Of Proposed Architecture

In accordance with the study, this paper highlights the following merits with the proposed architecture,

- Virtualization can be achieved.
- Companies need not to purchase, repair or replace Electronic hardware if they sign up for CSPR cloud.
- Companies which are hosted by cloud can use Electronic hardware efficiently.
- Secure backup.

VI. CONCLUSION

This paper depicts the methodology for handling the E-waste in India, repeated study suggests that, handling of E-waste and its maintenance of data is at huge risk, hence the technique utilizes the cloud to achieve virtualization and easy handling of E-waste. Further the Electronic devices can be accorded with an RFID tag, which shall be more supportive in handling the E-waste without causing any hazards to health.

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