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E-waste Reduction via Virtualization in Green Computing

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Abstract

As Virtualization, Green Data Center, Cloud computing, grid computing, Power optimization are the technologies of green computing. This study focuses on need of E-waste reduction that support through virtualization to save over all expenditures on hardware resources that is costly and even after some time causes e-waste. It is aimed to highlight the harms of the e-waste, importance of its reduction, how it can be reduced through virtualization, functionality of Virtualization and its contribution as an essential feature in Green Computing. Innovation in the technology to reduce energy/power consumption, creating data centers and virtual environment to optimize the use of computing in Information & Communication technology, revealed as Virtualization. Through systematic Research, it is revealed that virtualization is an optimization technique which is used to find the solution of resource management, server utilization, load balancing, e-waste collection and recycling etc. It has been changing information facilities due to its capability to consolidate hardware resources and decrease energy costs. Thus, harmful effects of computing on environment can be reduced which cause environmental sustainability.

Keywords: E-waste; Virtualization; Recycling; Power Optimization; Green Computing.

1. Introduction

Cloud computing is emerging as a critical information communication technology to heavily impact our daily lives in the future. It is an emerging trend in computing. When there is increasing attention being paid to the need to manage energy consumption across the entire information and communication technology (ICT) sector then data center energy has received much attention recently [1] because there are very huge data centers used in industries today and environmentally, these systems can produce e-waste, harmful gases with heat.

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Now-a-days cloud based system produces a great amount of power and produces CO_2. Since many servers don't have a good quality cooling system [2]. With the increasing growth of large data storage and computational demand, E-waste control for Green Computing is known to be a broad area and hot field for research. To capitalize various IT resources, Cloud computing has produced an ultimate and impressive ways to virtualized servers and data centers and to make energy consumption efficient. The IT resources consume huge amounts of power and energy, which in turn produces shortage in energy and change in global climate. Therefore, there is a need of way to find the solution that cannot only make energy efficient but minimize the operational cost as well as hardware cost that is recycling which make them eco-friendly. To solve environment related issues in the field of IT, Green IT is named to be an important step [3]. The main role of green computing is to make the use of computing and energy consumption as efficient as possible with minimal and low impact on the environment [5]. Green computing reduces energy consumption of computing, resources during peak operation, save energy during idle operation, use eco-friendly sources of energy, reduce harmful effects of computing resources, reduce computing wastes and enable more energy efficient use of computing power. These features are supported by latest technique of Virtualization.

Virtualization, Green Data Center, Cloud computing, grid computing, Power optimization and E-waste control are the technologies of green computing. Virtualization refers to the creation of virtual version of a resource that divides the resource into single or multiple execution environments [6]. This is critical in cloud computing as it enhances scalability since every server is allocated enough storage and computing power needed by a client. The increased demand for user capacity requires more power and capacity. Virtualization is changing the IT environment where most companies have been able to adopt it as a measure that allows for better utilization of hardware and reduction of costs [7], one of the major benefits of virtualization is the green computing.

This paper focuses on E-waste reduction that support through virtualization to save over all resources on hardware that is costly and even after some time causes e-waste and energy consumption in the data centers and known as green cloud computing. Here we discuss harmful effects of electronic waste over our environment, importance of its reduction, e-waste reduction through virtualization and some virtualization technique for saving energy that are beneficial for our environment to make it Green.

2. Background

E-waste is electrical or electronic waste which includes all components of electrical devices, discarded when it becomes useless or it reached at the end of its life. According to WEEE Directive, "Electrical or electronic equipment which is waste including all components, sub-assemblies and consumables and are part of the product at the time of discarding." Dumping process of e-waste is highly increased day by day because of its excessive consumption. There is a way to reduce at some level through virtualization. In daily life computing become part of our life, demand of storage media increased, people use mailbox at high demand etc, these all supported by virtualization. Virtualization has been changing information facilities due to its capability to consolidate hardware resources and decrease energy costs. Virtualization is the means of establishment in a new, effective era of cloud computing. Cloud computing is a topic that is given increased attention from IT managers in companies [1]. Before this time, various other technologies were discussed in the market which may be

considered as predecessors of the term Cloud Computing like "Grid Computing" [8],"Computer in the Cloud" [9] or "Dreaming in the Cloud" [10]. Cloud computing model enable convenient and on demand network access universally to a shared pool of configurable computing resources (i.e. network, storage, servers, applications, services etc.) that can be rapidly provisioned and released with minimal management effort or service provider interaction [11]. The issue of energy consumption in information technology equipment has been receiving increasing attention in recent years and there is growing recognition of the need to manage energy consumption across the entire information and communications technology (ICT) sector [12].

2.1 History

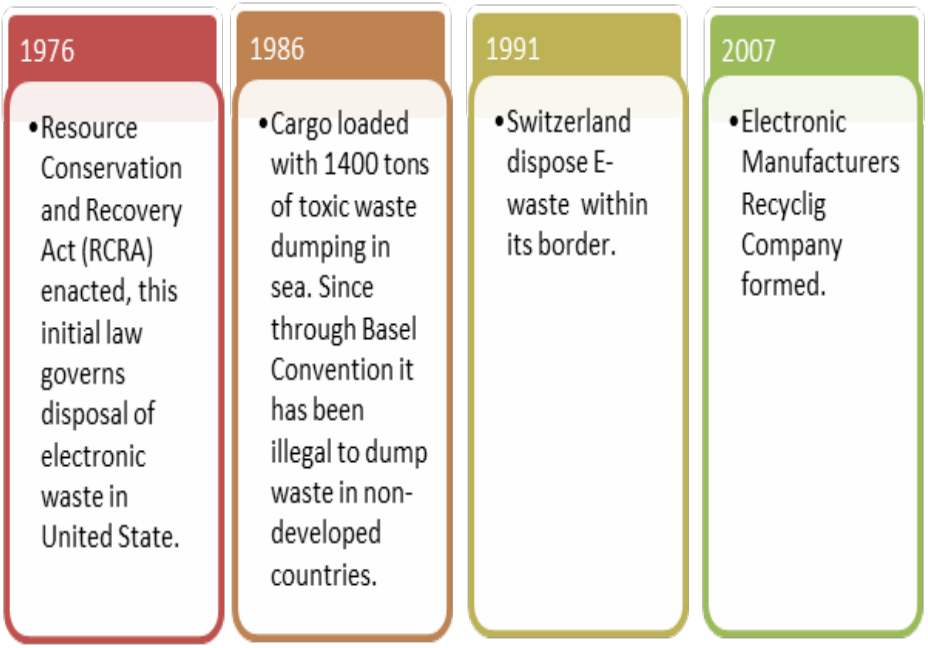

Figure1: History of E-waste Control

Generally, disposal of electronic waste begins in mid of 1970s. According to “History of Electronic Recycling”:

3. Literature Review

3.1 What is E-waste?

E-waste is an abbreviation of electrical/electronic waste which means waste of electrical and electronic equipment’s including personal computer (keyboard, mouse, monitor, printer, CPU, scanner etc.), refrigerator, television, mobile phones, air conditioners, etc. According to Basel Action Network “E-waste encompasses a board and growing range of electronic devices ranging from large household devices such as refrigerators, air conditioners, cell phones, personal stereos, and consumer electronics to computers which have been discarded by their users.”

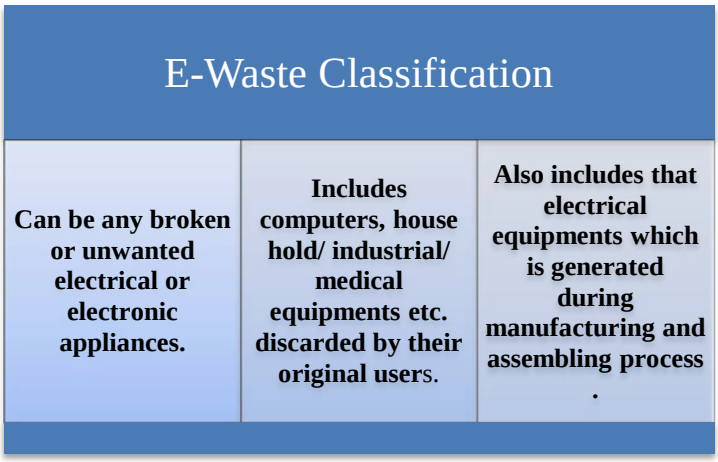

Figure 2: E-waste Classification

Following graph represents some house hold appliances that were measured by PowerPoint representatives; these products dominantly produce e-waste.

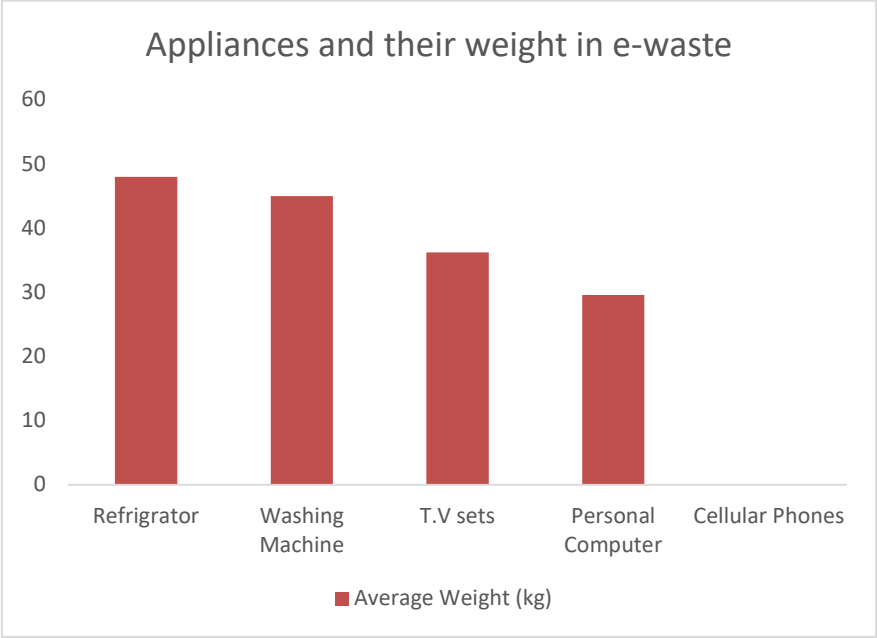

Figure 3: E-waste representation in home appliances

3.2 E waste effect on human and environment

Electrical or electronic waste usually in landfills through garbage that effect environment and human health badly as it causes possibility of hazardous metals leaching into the groundwater which penetrate gradually in our supply of resources. It is seriously threatening due to its adverse effects on all the living individuals including humans, plants, animals etc. as it is one of the major factors for increasing air and water pollution. Hazardous metals known as toxins in e-waste that includes copper, lead, mercury, cobalt, iron, cadmium, Sulphur, nickel etc. These toxic components can lead human health to disorder of his natural structure and causing many

problems including heart problem, liver, kidney and brain problem, birth defects and skeletal damage. This toxic waste even effects on nearly every system in human body.

3.3 Recycling of E-waste

E-waste recycling process is highly productive work that goes through several steps. These steps are described below that how recycling of e-waste managed.

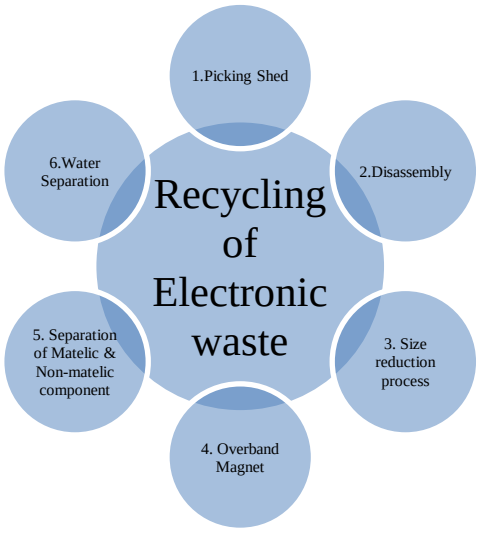

Figure 4: Recycling of E-waste

1. **Picking:** This process performs manually to sort items or components that should not be crushed or removed such as batteries, toner cartridges, UPS battery systems to check their quality.
2. **Disassembly:** After sorting all components by hand, the second step is to isolate all parts and then categories these components in core materials that further continue the recycling process for reuse these isolated components.
3. **Size reduction process:** Initially size reduction process is to break into small fragments that are less than 2 inches in diameter. At the next step, recycling plant break down these fragments in even more smaller pieces for refine separation process of all components. This refinement extracted all dust particles that ensure this method environment friendly.
4. **Over-band Magnet:** This process removes all magnetic materials including steel and iron fragments by using over-band magnet from the refined material.
5. **Separation of Metallic & Non-Metallic components:** After separation of magnetic material, metallic components such as aluminum, copper, brass etc. is separated from nonmetallic components such as glass or plastic. This process of separation done through magnets or optical identification.
6. **Water Separation:** In the last step of recycling process, separation between non-metallic components. Plastic is separated from glass by using water. After separation of all components they are resold as raw material for reuse in manufacturing process.

This process of making valuable thing from waste material is also one of the solutions of e-waste problems.

3.4 E-waste and Virtualization

N computing announced that "its technology is helping schools, businesses and organizations worldwide dramatically reduce carbon emissions by cutting energy consumption up to 90 percent. With more than 500,000 virtual PC seats deployed in 70 countries, N Computing has cut electricity consumption by 88 million kilowatts per year, compared with the same number of PCs. This represents a reduction of 55,000 metric tons of carbon emissions into the atmosphere". In this way, virtualization minimize electronic waste to reduce IT impact on the global climate and make environment more sustainable to prevail.

3.5 Virtualization support in Green Computing

Virtualization results in far more efficient use of resources, including energy. Virtualization's purpose in a simple way is to virtualize and make a single piece of hardware function as multiple parts. Different user interfaces isolate different parts of the hardware; thereby making each one behaves and functions as an individual. Installing virtual infrastructure allows several operating systems and applications to run on a lesser number of servers, helping to reduce the overall energy used for the data center and for its cooling. This saves energy tremendously in a way that per server would translate 7000 Kilo Watt hours per year, which is extra ordinary potential for energy saving, in this virtualization is the best to practice green computing especially in data centers.

3.6 Role of types of virtualization in e-waste reduction

Types of virtualizations are following:

- **Hardware Virtualization:** Hardware virtualization also knows as server virtualization. Server Virtualization allow user to run multiple applications and operating systems on a same server and on same time. Individual systems need power and separate hardware equipment's that cause e-waste. Server Virtualization purposed the solution that decrease hardware demand and manage power consumption and cooling process.
- **Software Virtualization:** Software Virtualization involves the creation an operation of multiple virtual environments on the host machine. It improves sharing of computing tasks and reduce hardware and software demand which saves power, reduce cost, less emission harmful gases as well as reduces e-waste through minimize the scale of consumption of energy and resources.
- **Memory Virtualization:** Physical memory across different servers is aggregated into a single virtualized memory pool. It provides the benefit of an enlarged contiguous working memory that results in power saving, reduce heat and fulfill cooling requirements, it makes data centers green and efficiently saves energy.
- **Storage Virtualization:** It smartly manages storage into central database server. Many servers provide this facility that result in reduction of carbon footprint and reduce demand in hardware storage resources
- **Data Virtualization:** In data virtualization, presentation of data as an abstract layer which is

completely independent of database systems and data structure that lets you easily manipulate data. It also decreases data input and formatting errors.

- **Network Virtualization:** Software-defined networking (SDN), is an implementation of network virtualization. It reduces demand of electronic resource, carbon footprints and emission of harmful and hazardous gases in environment.
- **Desktop Virtualization:** It allows virtual desktops to be centrally managed on a server and run by the end user on a thin client machine. This is perhaps the most common form of virtualization for any regular IT employee. It reduces the need of individual desktop for each employee.

Every type of virtualization plays vital role in e-waste reduction to contribute in green computing for sustainable and Eco-friendly environment. This convenient innovation minimizes the load and consumption of resources as well as provides security.

3.7. Challenges occur and appropriate ways to overcome

a) Comprehensive management of Virtualization types

Virtualization is known for efficient use of resources, but it still occupied some challenges at meeting the demand of Virtualization Technology, hard Reality of Server Management, continuous management of switching in virtual environment, network design and its management tools, complex troubleshooting on virtual machines, network support for VM migration, infrastructure issues and challenging storage support for virtual server.

Solution: Estimated solution for these challenges are making dynamic infrastructure management, distributed virtual switching mechanism can be practiced for the management of switching issue and applying automation of many manual tasks. These solutions improve virtualization for reducing electrical or electronic waste efficiently.

b) High power and energy consumption

Reduction of energy consumption of cloud computing system and data center is a challenging task because computation of data and applications are constantly increasing in a rapid state that increase the demand of disks and large servers for the efficient working in the required period of time.

In cloud computing high energy efficiency can be achieved by replacing traditional cloud data centers with most powerful and energy- efficient servers. These servers use more advanced internal cooling systems with less energy consumed by their fans. It is important because reduction of energy consumption in internal servers is amplified by savings in the cooling systems and cloud datacenter power distribution.

3.8. Solutions of high energy consumption

- First, there is the total cost of ownership (TCO) for cloud computing environments, which includes the

energy cost of operating a cloud datacenter. To minimize the TCO, overall power dissipation must be decreased in the cloud data centers.

- Secondly, there is the peak capacity of the power sources for cloud datacenters and electrical current limitations of the power delivery network in the cloud datacenter, which set a limit on the peak power draw at the server and datacenter levels. Maximizing cooling efficiency is another way to lower the energy cost of cooling a cloud datacenter by deploying computer room air conditioning (CRAC) units and air handling units with demand-driven, variable frequency drive (VFD) fans within heat exchanges to match variable heat loads with variable airflow rates.
- Finally, minimizing this energy consumption can result to conceal cost reduction. Apart from the enormous energy cost, heat released increases with higher power consumption, thus increases the probability of hardware system failures. Reduction of energy consumption has vital outcomes on the total productivity, reliability and availability of the system. Therefore, minimizing this energy consumption does not only reduce the huge cost and improves system reliability, but also helps in protecting our natural environment.

4. Discussion

Dumping of electronic waste is a bigger matter now-a-day in approximately all region of the world. Waste of computer components usually found in landfill through garbage that latches under the ground which pollute water. Acids and sludge obtained from melting computer chips cause pollution and acidification in air and soil. Excessive use of electronic resources and their waste can badly affect human health and environment sustainability. To make our environment sustainable, we must minimize the use of toxic components that are mainly responsible in very huge amount, computing technology have one of the major contribution in electronic waste i.e., mouse, keyboard, motherboard, memory chips, floppy disks, hard disks, sockets, printers, monitors, RAM and other computer chips etc. As computing is an emerging trend of this developing phase, so special attention is being paid on energy consumption, electronic waste and relief of environment from hazardous material. Virtualization provides a way in this regard to minimize the consumption of hardware components and provide virtual layout to the users. Resources are smartly designed, they have strong data centers on server side instead of many floppies and hard disks on each user side. Also provide virtual storage and virtual environment of learning in form of single screen instead of individual system in class room or at meeting room. But management of all types of virtualization and energy consumption is most dominant, for resolving these challenges and take to proper advantage of virtualization in e-waste reduction, it is essential to map these issues with refined steps of solution.

5. Conclusion

This study encompasses the E-Waste reduction through Virtualization Technology. Virtualization is an optimization technique which is used to find the solution of resource management, server utilization, load balancing, e-waste control and recycling etc. It has been changing information facilities due to its capability to consolidate hardware resources to decrease energy costs and electronic waste. There are still some issues in management of resources at server virtualization and network virtualization, by mapping these issues it will be

more efficient. Thus, harmful effect of computing on environment can be reduced by controlling e-waste and proper implementation of virtualization at major level which cause environmental sustainability as well as make computing "Green".

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