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Design/Implementation of a Novel Technique in Virtualization to Reduce E-Waste

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Abstract: In today's IT industry, E-waste management is one of the main burning issues which are the biggest problem for the IT industry as well as for environmental concerns. Recycling of E-waste and lesser production of new electronic product comes under E-waste management. Aggregation of E-waste generates various problems such as environmental pollution, resource shortage, loss of precious elements and also affects the human health. This in turn makes sustainable development hard and makes the ideology behind implementation of a greener IT inconsistent and impossible to achieve. Reduction in the manufacturing cost of new products and proper utilization of e-waste is possible by e-waste management. Along with the current methodology of recycling e-waste, the rising trend of Virtualization, Cloud computing, Carbon reduction and various other new technologies are used for e-waste management. This paper highlights the hazards of E-wastes, the need for its appropriate management and we also propose a novel technique for process management in virtualization which in turn helps to reduce e-waste.

Keyword: E-waste, cloud computing, virtualization, greener IT, environment, human health, pollution, carbon reduction.

I. INTRODUCTION

Reducing carbon emissions directly saves electricity and electronic equipments; datacenters on the other hand need more efficient cooling techniques to save power. Telework and tele-presence is another way through which a considerable amount of energy can be saved as the person works from home, could indirectly help in reducing the use of various energy consuming resources. Cloud computing is one of the foremost ways which can be used to diminish electronic waste by doing the entire computational work on the cloud thereby saving energy consumed by the numerous hardware resources. Another significant way to prevent electronic wastage is the use of electrical grid, where a grid is used for electric or power supply instead of standalone power generating systems. Electric consumptions through standalone microprocessors are also a big concern for which various power management techniques are used. Virtualization is also a key technique that helps in saving e-waste in various forms. It is the design of a virtual version of something, for instance an operating system, network resources, a storage device or a server. The idea behind it is lesser hardware wastage in process management, memory management and resources management, thereby leading to lesser e-waste. It therefore makes e-waste easier to manage. This entire concept is inspired from the fact that "Prevention is better than cure". Speaking of prevention the paper also provides a report on how the various communities of people handle their e-wastes, and on the basis of that an algorithm is proposed, using the concepts of virtualization, that can be used in helping our cause of reduced e-waste generation and hence better e-waste management and to make a greener IT environment.

II. REDUCTION OF E-WASTE USING ICT

Information and communication technology (ICT) can be used to reduce carbon footprints, e waste and energy consumption to achieve green IT. Following are the major methods and technologies which helps in green IT:-

A. *Reducing ICT-related Carbon Emissions*

One of the major consumers of electricity in modern times has been the PC, laptop desktops and servers. People are becoming more aware of a need to reduce the electrical requirement of these devices and computers. The ICT sector is in the forefront of achieving a considerable reduction in electricity use and the resulting CO_2 footprint. Energy Star requirements and many more regional, national or international requirements and standards must be passed by data centers, main frames and various other computing devices. Various applications like power distribution, smart grid, intelligent transport system, medical record management etc see the effects of ICT in their electricity consumption.

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B. Calculating Savings

Reduction of carbon emissions and electrical cost, data centre efficiency and various other measures are employed in the assessment of the collective result on Green IT investments. It has been estimated that low carbon economy can be achieved through smart grid savings, more efficient road transportation and travel substitution. It will help attain CO2 reduction and reduce energy spending substantially.

C. Data Centers

Data centers are the major consumers of most ICT related electricity with additional cost of ICT power and cooling equivalent to nearly half the price of the hardware itself. The design of Yahoo's data center is a series of long, narrow rows, allowing for easy air flow; and hydro-electric power provided by the state's power authority. Also as the site is located at a cold climate area effectively only 1% of the electrical requirement is spent in cooling. Though the facility cost about $150 million it is expected to save Yahoo over $100 million in power costs over the next fifteen years.

D. Telework and Telepresence

Telework and Telepresence, two of the least understood elements in Green IT, are rapidly being included in the public and private sectors as a means of reducing e-waste and saving energy. Teleworking has been actively used by the private sector companies like IBM, Microsoft, Sun Microsystems, Bank of America, Procter and Gamble, and Cisco for decades. It is claimed that considerable amounts of energy is saved and e-waste avoided with employees working at their homes. As fewer hardware resources like PCs, printers, copiers and various other equipments have to be installed at the work premises, the e-waste is reduced. Though it is difficult to measure the effects of Telework, the benefits of Telepresence can be more easily estimated as the cost of travelling is reduced. With more and more companies using these elements the effective reduction in e-waste will be quite substantial.

Perhaps the least understood element in Green IT measurements is the contribution of Telework to energy savings. At one end of the estimation scale are the optimists like technology writer Kate Lister who says, "If the 40% of employees who could work from home did so half of the time (approximately the national average) it would reduce. But there are some reports that question the savings from working from home. A recent UK study found that the typical teleworker generates a third more CO2 over a year than an office worker. Telework is generally regarded as both a productivity enhancer and a differentiator in recruiting employees, although the private sector has been more actively using it than the public sector. Companies like IBM, Microsoft, Sun Microsystems, Bank of America, Procter and Gamble, and Cisco have been teleworking for decades and have also claimed significant additional savings in real estate; that is, releasing buildings and offices because the work is being done at home or client site. Nearly half of IBM's workforce of over 300000 teleworks. While teleworks' benefits are not easy to document, the business case for telepresence, the use of technology to hold meetings and other work sessions normally requiring travel is easier.

E. Cloud Computing:

Scaling is one of the key concepts in cloud computing. It provides scaling of design, scale of use, and even reverse scaling of cost per unit. The common technology provides an average of 140 servers per administrator, but with scaling many cloud providers can now provide as many as 1000 or more servers per administrator [9]. It is evident that scaling can reduce a huge amount of e-waste with server to administrator ratios improving by up to seven-fold. [9]

Many companies today are migrating towards cloud computing for data storage and resource virtualization. This also helps in reducing e-waste drastically as many companies depend on the existing cloud service provider's servers and data centers instead of installing its own servers.

Cloud computing is both a metaphor and an indicator of the significance of Green IT. Every time an organization shifts a workload of storage or processing to the cloud they are reducing their overall electricity usage, since the massive new data centers used for cloud services are all striving, like the Yahoo and Capgemini facilities mentioned above, to reduce power usage drastically. Major reductions in cost are achieved in the cloud, too. Shelton Waggoner, Associate Vice Chancellor and CIO at UC Berkeley, says that savings on the cloud for can be of the order of 90% for large volumes of storage– from $30 per month per GB to $2.20 per month–and also nearly that much for servers: "A common metric for an efficiently run organization is 140 servers per administrator. At scale, many cloud providers are now reaching ratios of more than 1000 servers per administrator, or a seven-fold improvement. The key in both situations is that the solution requires scale – scale of design, scale of use, and (reverse) scale of cost per unit".

F. The Electronic Grid:

Power providers, who prepare for the electronic grid infrastructure, are contributing to a significant expense related to Green IT. A Pike Research report stated that there will be a $200 billion investment in this field, indicating the global shift towards Green IT. Additionally increased investment in the "smart grid" also indicates that this will be the best return of investment and a large amount of capital budget to grid infrastructure projects like transmission upgrades, substation automation, and distribution automation. This shows the global shift towards Green IT and a worldwide improvement in reduction of e-waste the companies.

G. Power Management Technologies:

AMD's Cool 'n' Quiet and Intel's Speedup Step are

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leading examples of implementation of energy-saving technologies at the microprocessor level. Likes of these can be either implemented at the entire processor or in some particular areas only, like Intel Core and AMD Cool Core product lines. Aims for leveraging PC power management systems have been set by the Climate Savers Computing Initiative.

H. Dematerialization:

The shift of material, physical goods like mail, movies, newspaper, music, books, income tax filings and cheques into their electronic counterparts over the internet deserves a mention in any discussion related to Green IT due to their "savings". But in order to show the magnitude involved, consider for example, 3000KWH+ electricity is involved in manufacture of 100 tons of paper which is 140 times more than the CO_2 required to reading it online.

I. Virtualization:

Virtualization is a set of techniques that leads to efficient server management through higher utilization and reduction in energy expenses. Through the use of intelligent virtual machine allocation, improved data center automation and resource reclamation of under-utilized CPUs, virtualization can reduce e-waste. In the past, individual servers, sometimes thousands of them in one data center, were using only 5 to 15% capacity, waiting for work, so to speak. But over a million servers had been virtualized by 2008 and, by one estimate, the combination of virtualization of servers and storage plus improving air flow could alone reduce data center operating costs by half.

III. Survey Report of Awareness about E-Waste and its Effects

A. Data from Households

Around 20 people were surveyed. 11 out of 20 preferred selling their old products directly to the scrap dealer to get money in return. 4 went in for exchange offers while purchasing new products. Only 3 reused their old things and remaining directly disposed off their old products to garbage.

B. Data from Banks

25 bank employees from two different banks were included in survey. 16 people said that they gave all old equipments to contractor, who supplied them with new products as per the requirements in exchange for the old and used ones. 6 people said that they reuse the old products. Sadly onle 3 people out of 25 said that they sell their E-waste to the scrap dealer and purchase new items for bank use.

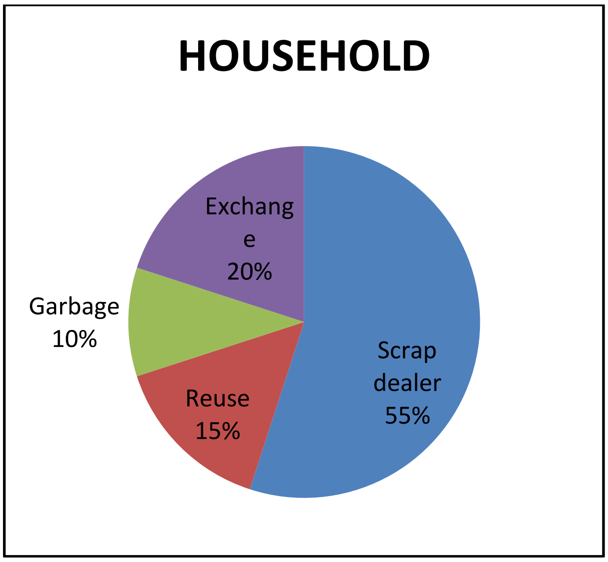

Fig. 1. Pie Chart showing responses of people from households

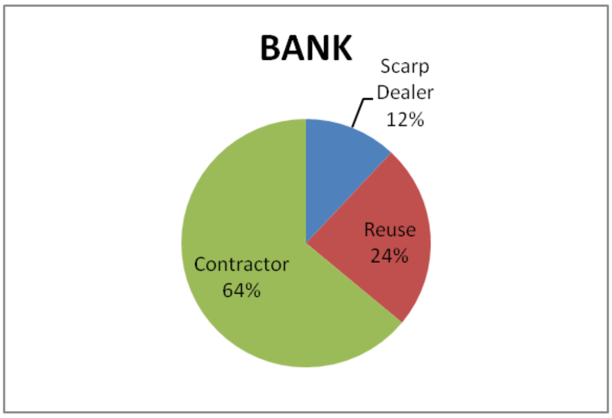

Fig. 2. Pie Chart showing responses of people from Banks

C. Data from Schools

20 teachers were included in the survey. They said that they gave all e-waste and old items to the school contractor in exchange for new ones and update their products and facilities according to their requirements . Rest sold to scrap dealer. Only 10% old possesions are reused in all.

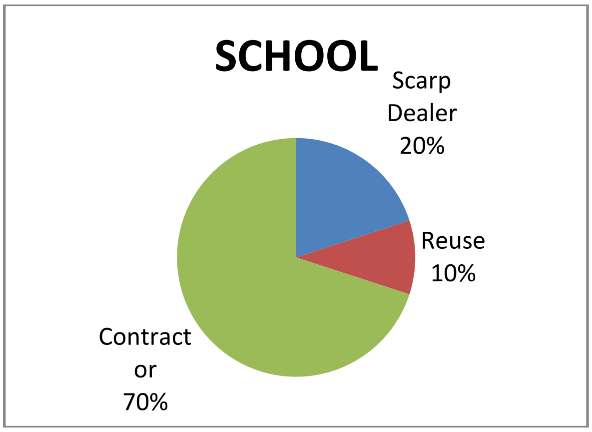

Fig. 3. Pie Chart showing responses of people working in Schools

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D. Data from Academic Institution (VIT)

At VIT, many professors were included in the survey. Each professor had a different point of view regarding E-waste. Questions were asked to professors and the conversations were summarized.

On questioning about the e-waste pollution and its effect, 40% said that they were aware of e-waste and its effects and practiced recycling. 33% had heard of it, but knew very less, remaining 27% were entirely unaware e-waste pollution and its effect.

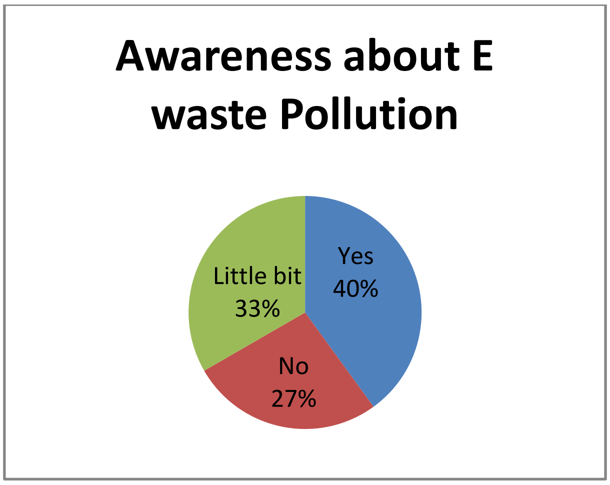

Fig.4. Pie Chart showing responses of people from an Educational University on their awareness of E-waste

When asked questions about the choice between scrap dealer and take back policy or exchange offers 47% people choose scrap dealers although 53% people choose exchange offers and take back policy.

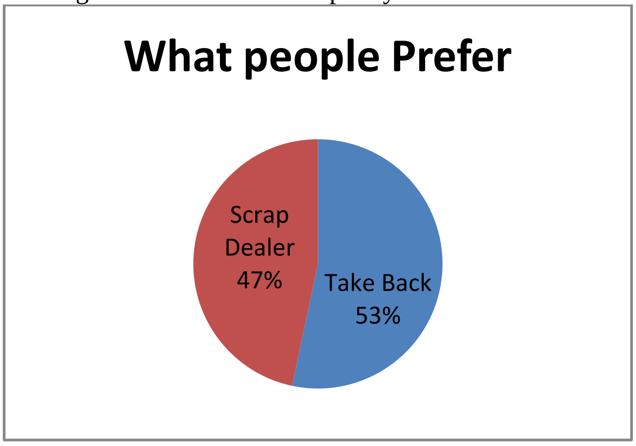

Fig. 5. Pie Chart showing responses of people from an Educational University on their preferences about e-waste

The third question was what people did with their e-waste? 43% people replied that they kept their e-waste as it is, 14% threw it or give it to garbage collectors remaining 43% people resell their e-waste.

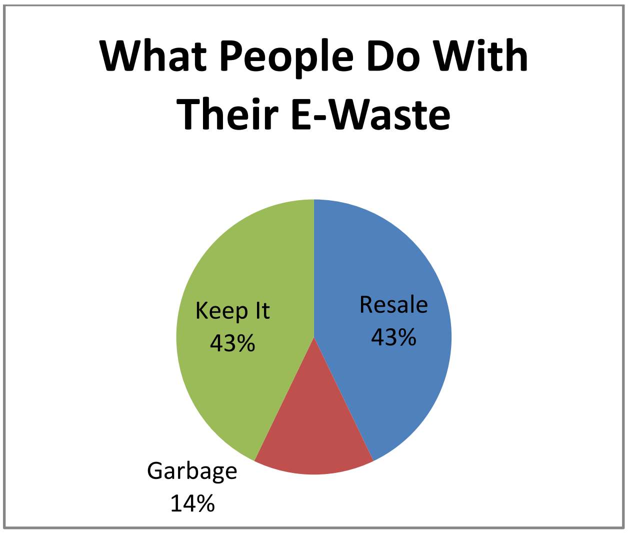

Fig. 5. Pie Chart showing responses of people from an Educational University on what they do with their e-waste

E. Challenges in Virtualization

1) Loosening of Storage Throttle on Virtual servers

2) To solve direct sharing/Communication between 2 or more virtual OS.

3) To solve Process and Resource Management

IV. PROPOSED ALGORITHM USING VIRTUALIZATION TECHNIQUES

This paper proposes two algorithms that could be used in Virtual OS, namely resource management algorithm and process management algorithm.

A. Loosening of Storage Throttle on Virtual servers

When more than one process is waiting for server, then server consolidation decides which process should be assigned to server services. Here, server consolidation refers to a set of rules and regulation that find out the efficient way to which process will be processed in server process. The algorithm proposed here inherits some properties of process management, which tries to minimize the server's process time.

To reduce the waiting time and to utilize the processor this paper presents a new algorithm. The basic idea is to make quantum time dynamic for each process queue. For that the process should be divided in to the different queues. The number of queues should be decided at the run time. To divide the processes in the queues, the limit should be calculated first. The formulae to calculate limits are as follows:

Limit1= (H.B.T. – L.B.T.+1)/N
Limit2= (L.B.T.+Limit1)
Limit3= (L.B.T.+Limit2)
H.B.T.=Highest burst time of the process
L.B.T.= Lowest burst time of the processes
N= No. of queue(determined at run time)

Like this the limit will be determined for each queue and according to the limit processes will be filled in the queues. Once the queue has been made, the quantum period will be decided for each process queue separately. To calculate the quantum period for each process queue the formulae is:

$$T_{(b)} = \frac{\left(\sum B(i)\right)}{N}$$

B(i)= Total of processes in ith queue
N= No. of processes in ith queue

Once the quantum time has been calculated for each queue the dynamic variation of quantum period will be implemented to reduce the waiting time. The formulae to determine the dynamic variation of quantum period is:
if $(T_b - B_i) < (B_i / 2)$ then

$T_{di} = T_b + (T_b - B_i)$
Where
T_b = Quantum time of any process in queue
$B_{i=}$ Allotted quantum period to that queue
T_{di}= time quantum allotted to the i^{th} process

Using this formula each process is allotted a dynamic quantum time and gets executed according to that.

B. Resource Management using Virtual Operating System

Algorithm:-

Input:-

R=total resources, P=total processes
AR= allocate resources NR= need resources
MR= max resources RR= request resources

Structures:-

Available resources: vector[1..R] – AR [m] – currently AR for resource m.
Maximum resources: mat[1 2 3..P, 1 2 3..R] – MR[n,m] – maximum number of instances for resource m.
Allocation resources: mat[1 2 3..P, 1 2 3..R] – process n currently holds AR[n,m] instances of resource m.
Need resources: mat[1 2 3..P, 1 2 3..R] – process n may need additional NR[n,m] instances of resource m.
Need[n,m] = MR[n,m] – AR[n,m].

1) Efficient Algorithm for using Resources in Server Virtualization

RR = request vector for process Pi. If RR [j] = m then process p wants or the need of m instances of resource r.
i. If RR<= NR, then go to step 2. Else process has exceeded its maximum need of resources.
ii. If RR <= AR, then go to step3. Else process (pi) has to wait till resources are not available.
iii. When to provide requested resources to Process by modifying the state as follows:
AR=RR;
Allocation resources=AR + RR;
NR= NR – RR;
If state is safe then the resources are allocated to process (Pi).
Else state is unsafe.

V. CONCLUSION

It can be concluded that E-waste is a big problem for current as well as the future world. It is one of main problem faced by IT industry and for environment. By using virtualization, e-waste can be managed by the reduction of hardware and resources used. Green IT concept can be achieved by using the optimal usage of resources available, by spreading awareness among the people and by implementing laws, rules and regulation. By combining IT and environmental resources, it can reduce and recycle the e-waste. Lesser production and proper utilization of existing hardware and resources by implementing virtualization reduces the requirement of recycling and conserves the natural resources, which will result in making the IT industry more eco-friendly and Greener.

In our future work, we would be proposing some techniques involving cloud computing to reduce e-waste.

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