Challenges and proposed solutions in order to achieve green computing

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Abstract—Computers become the requirement of present generation. It facilitate lots of things like data storage, fast communication weather forecasting, etcetera at one side, but it is becoming the big source of pollution on the other side. So existing Technologies want to manufacture the computers and its components in minimal resources with lesser use of those products which causes pollution. This approach is called Green IT or green computing. So green IT can be described as "It is the study or approach for the designing, manufacturing, using, and arrangement of computers, servers, and related components-such as HDMI cables, monitors, printers, storage devices, and networking & communications systems effectively& efficiently." Every organizations and companies want to adopt green IT but due to some reasons it faces difficulties. This paper will discuss about it that what kind of obstacles comes in the way of green computing or how can we remove all that problems which comes in its way. So we can say that this paper has two major objectives:

  I.   Review of various challenges/hurdles in achieving an efficient green computing environment

  II.   Proposed solution to manufacture various components which can be more and more eco-friendly & how can we achieve sustainable IT environment.

Keywords— Mutation testing, mutants, execution cost reduction, Object-oriented software system

I.   INTRODUCTION

The expansion of Information Technology has critically changed our life style. It will not be hyperbole that every person is using mobile phones and laptops in present days. However IT has given us- Prosperity, fast communication system, analyzing and keeping the records of data by replacing the handwritten records in hardcopies, etc. But on the other hand it has created some problems. It has been expending the pollution. In some regards it is responsible for CO_2 emission. And the e-wastes of the IT products are responsible for soil pollution as well as air pollution. According to **OECD (Organization for Economic Co-operation and Development), in 1990 there was 6169592.14 tons of CO2 equivalent, thousands emission in USA which has been increased to 6665700.866 tons of** CO_2 equivalent, thousands in 2011. [1] So IT professionals are thinking about those products which can be more and more eco-friendly. As written in Wikipedia **"Green Computing,**

Green IT or Green Technology is the practice and study of environmentally sustainable computing." And in View of Webber and Wallace **"the reduced environmental impact from running an information technology (IT) department" [2].**

A computer can have following components:
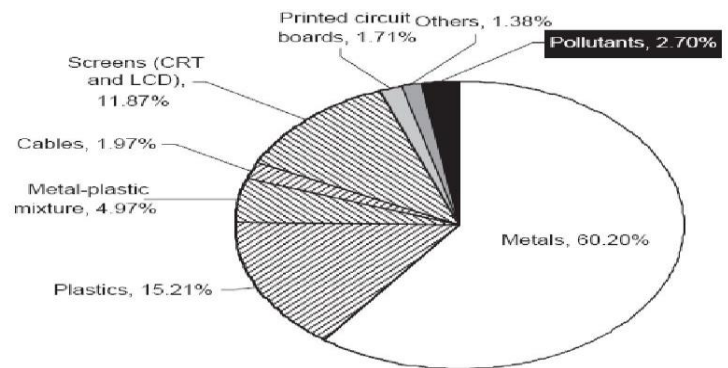
Fig 1: Components of Computer

Green IT can be described as, "green computing is the study of effectively and efficiently designing, manufacturing, using, and recycling of computers and its components like servers, network systems, communication systems, monitors, HDMI cables, USB cables & printers, etc." In 1992, the U.S. Environmental Protection Agency launched Energy Star, a voluntary labeling program that is designed to promote and recognize energy-efficiency in monitors, climate control equipment, and other technologies. This resulted in the widespread adoption of sleep mode among consumer electronics. The study of green computing based to reduce the harmful impact on the environment. So it can be say that in recent years, companies of the computer industry are going to green in their best interest, both in terms of public relations and reduced costs but green IT faces obstacles, in this paper I will discuss about all that obstacles which hurdle green, how we can eliminate it, and how can we implement green IT.

II.   CHALLENGES/HURDLES IN ACHIEVING AN EFFICIENT GREEN COMPUTING:

A.   **Awareness About Green Computing:**

Lack of awareness about green computing is one of the biggest obstacles in implementing green IT. During my research I have asked several people about green computing but scarcely 3 or 4 people out of every 10

people were able to tell me the correct impact of green computing. I have asked to 25 students and 15 educationists and I found that only 28% people were familiar with appropriate meaning of the terms like CO2 emission, and its role of higher expenditure in polluted environment. Secondary it is also very interesting fact that from 1972 to 2016, green IT has never found the place of theme in world environment day. This means that even if the government is encouraging public and Private Companies in implementation of Green IT, but it seems that global environment Organization on issues such as manufacturing sustainable products of IT is not as serious as required.

III. CHALLENGES OF REENGINEERING PROCESS AND BUSINESSES PRACTICES, REVISING PROCEDURES:

In present days have adopted many type of principals and technologies in order to build the computer such digital electronics gates buses, registers, etc. So it is one of the challenges, without losing the efficiency and specifications of computer how can be implementing green IT. However many companies have been storing those computers, which are not really operational. Because they are so outdated computers and software to recycle them is a big challenge. Consider, if a machine is not operable then before fixing the problems of it we have to be ensure about this fact that the data could be manually wiped or not. And on the other hand if a computer is operable but very old such as windows 3.1 then minimum no. of software can be use in wiping data. So the Reengineering process is also a stumbling block in achieving Green IT.

A. privacy issues:

Any person never want, their personal information to fall into the wrong hands, but attorneys must also suppose the privacy of their client's information. As some cases were arisen, in 2007 a cyber-security expert picked up a $500 computer at an exchange assembles. By using simple software, he was able to extract from the computer, which had been used by a mortgage company, the credit reports of about 300 people. As well, he was also able to access the user names and passwords the company's employees had used to access credit bureaus. And in 2005 a report, Inside Edition purchased 25 computers from thrift stores in various eastern U.S. cities. The television program crew also acquired four computers for free at a town dump. The computers were turned over to an expert who found that none of them had been cleaned of information. The machines included financial and personal information that could have been used to commit identity theft and fraud. [3]So privacy issue is big barrier in implementation of

green IT. Because information can be access at the time of fixing problem of hard drive ROM or RAM.

B. Costly Equipment's:

Cost is one of the biggest obstacles, which are preventing the progress of businesses to all that persons who want to adopt green IT. As published in a report, Businessman often believe it that they can save much cost to following traditional technology in comparison of manufacture Energy reducing equipment. According to Gartner projects, 75 percent of companies will consider the energy and CO2 footprint of hardware during purchasing in following years. And to moderate the carbon emission and we have to develop more powerful components. So cost will definitely increase to adopting green IT.

C. Fear Of Decreasing The Efficiency:

It is a big challenge that if a computer will be made more and more eco-friendly then same way that would be efficient as normal computers. Since changing in technology is related to the efficiency, speed, versatility, diligence and other specifications of computer and the green will must affect all these things so it is a condition of uncertainty that the computer behave like normal computer or it will lost some specifications in various regards.

Barriers in Green Computing (A Brief Survey)

Table: 1-Barriers in Adopting green Computing

Barrier/Hurdles	Survey (in percentage)
Cost	20%
Privacy issues	7%
Lack of Products available	13%
Lack of awareness about Green IT	28%
Fear of decreasing efficiency	4%
No champion within IT department	3%
Difficulties in replacing existing Technology	20%
Repetitive reengineering challenge	5%
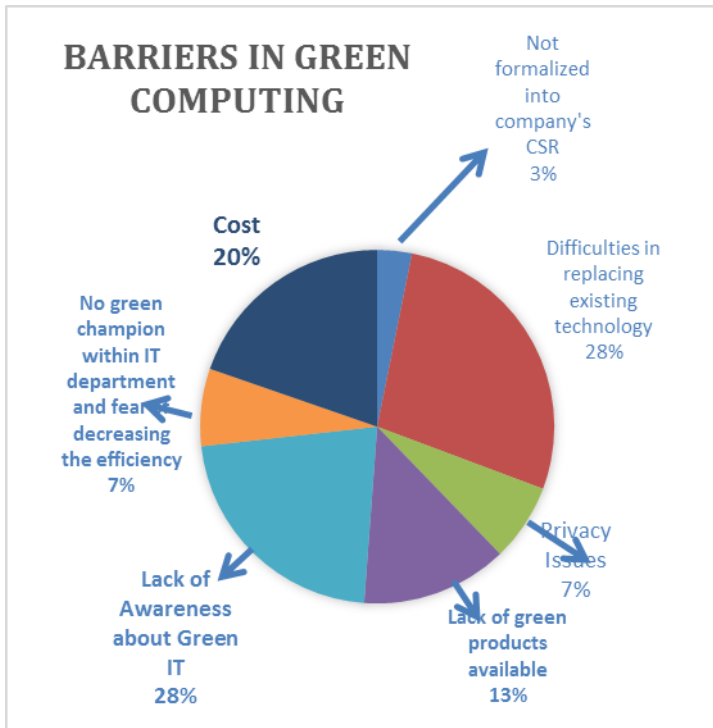
Fig: 2-Barriers in Adopting green Computing

IV. Proposed solution to manufacture various components which can be more and more eco-friendly and how can we implement sustainable Green IT:

A. To Increase People's Awareness Of Green IT:

It is huge step in sustaining green IT, since awareness directly belong to the energy saving and recycling of e-wastages. Because governmental and nongovernmental organizations, companies has been taking many steps to develop green computing. As we have discussed earlier Energy star is voluntary program launched for reducing energy and lots of thing available that can help in reducing energy and in developing green IT. In terms of awareness of people we can follow some of these steps-

➢ Google's Blackle search engine is search engine based on colors energy consumption. It uses to take minimum energy in comparison of normal browsers. Companies should do advertise of it.

➢ According to a survey some People are familiar with term operating system, but they do not know that what kind of operating system can save more energy. Often I saw that Mac which is consuming less power than windows operating system is not known by many people and they should try to use it.

➢ By spreading awareness objectives of Energy star program and its features.

➢ A computer can be recycled and disposed of safely to save our environment. So people should believe in recycling.

➢ People should not keep their laptops in sleep mode for a long time and also not print wasteful papers.

➢ Today everyone says that they care about environment but many people are even not familiar with the terms that are produces harmful impacts on our environment. According to a survey 19-27% people are aware about the terms like CO_2 emission and role of highly polluted environment. So people should be aware about it.

B. Build A Green Data Center For Reducing Energy:

Data centers take so much energy to operate itself, and in previous years the cost of the energy usage by data centers touched sky like increment expense. But this can't be avoided, the reliability, capacity supply and others issues of the data centres has been minimized with the increment of the cost. So data centres require their own specific strategy for being green. Here is a little approach to make the data centers green [7].This is depend on the daily usage bill as well as the monthly. The data center energy consumption should be measured and then it can be listed as follows.

Level	Do you ...
Basic	Review your monthly electricity bill?
Check your electrical equipment on a regular basis for capacity planning?	
Intermediate	Have automated metering and reporting of load and consumption for electrical circuits?
Review equipment energy efficiency when purchasing?	
Advanced	Monitor energy consumption per rack, device, and circuit?

|	
Analyse historical data monitoring and reporting?	
Use real-time reporting of energy consumption for departments to understand impacts of changes and deployments?	
Use data to negotiate favourable power rates with the utility company?	

Table: 2-Steps to build a green data Center
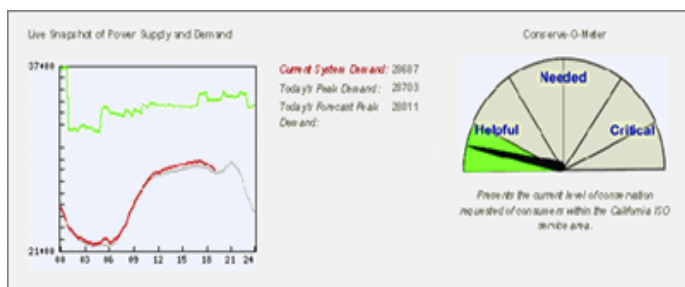
Fig.3: California ISO goes as far as to provide real-time data to the public on its Web site

C. **By Virtualization:**

Virtualization is a technique which directly impact the environment. Virtualization introduced by IBM in 1960 but it is implemented by windows x86 in 1990s. By using virtualization a system administrator could combine several physical system into virtual machines on one single, powerful system thereby unplugging the original hardware and reducing power and cooling consumptions. For implementation of such kind of virtualization Intel Corporation and AMD have built proprietary virtualization enhancements.
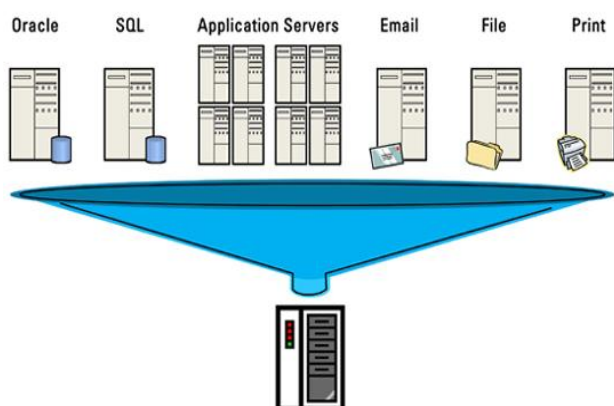
Fig 4 Virtualization

Advantages of Virtualization can be listed as following:

1. Planned downtime is eliminated by migrating virtual machines from one physical server to another server.
2. Dynamically balance workloads across a server group and provide automatic failover for virtualized applications
3. Resource allocation are better monitored and managed.
4. Virtualization exponentially increases a server group's ability to share resources.
5. Server utilization rates can be increased up to 80% as opposed to an initial 10-15%.

D. **To Increase The Life And Efficiency Of Batteries:**

Laptops uses lithium-ion batteries which considers as best battery in present days. Which takes much time in charging and presents less productivity of its life. Thus Battery Scientists are thinking about the best replacement of li-ion batteries. Which will not only help to increase the life of battery it will be much eco-friendly than li-ion batteries

1) Spongy Silicon Based Electrode Li-Ion Batteries:

Currently almost Li-ion batteries uses graphite electrodes in storing and discharging of energy. If graphite based electrodes will replaced by Silicon bases electrode then it will be 10 times more energy. In this regard **"Department of Energy Pacific's Northwest National Laboratory (PNNL)"** has given an opinion that such kind of batteries can be double or triple energy storage capacity over current standard of Li-ion batteries.

2) Sodium-Ion Batteries:

Sodium-ion batteries are used in electrical cars like Tesla Model S. French researchers gave a suggestion about to place in laptops. Its 6.5 cm sized battery could manage 90 watt-hours per kilogram which make it comparable to Li-ion batteries but with a 2000 cycle lifespan, which should be improved.

3) Silver-Zink Batteries:

Technically it cannot be considered as a new technology. It was used in NASA's Apollo spacecraft of the 1960s and 1970s because it has so good capacity of storing electricity. The technology wasn't widely adopted back then because those silver-zinc batteries could be charged only a few times before they stopped working. But it can be made with some improvements that allow silver-zinc batteries to be recharged as often as lithium-ion batteries. And when the batteries will reach the end of their useful

Type	Chemistry	C rate	Time	Temperatures
Slow charger	NiCd Lead acid	0.1C	14h	0ºC to 45ºC (32ºF to 113ºF)
Rapid charger	NiCd, NiMH, Li-ion	0.3-0.5C	3-6h	10ºC to 45ºC (50ºF to 113ºF)
Fast charger	NiCd, NiMH, Li-ion	1C	1h+	10ºC to 45ºC (50ºF to 113ºF)
Ultra-fast charger	Li-ion, NiCd, NiMH	1-10C	10-60 min	10ºC to 45ºC (50ºF to 113ºF)

life, the silver and zinc can easily be recovered and recycled into new batteries, reducing environmental impact.

4) Aluminum Graphite Batteries:

Standford University have developed Aluminium Graphite battery that will fully recharged only in just a minute. Since aluminium graphite are flexible, long lasting & charge ridiculously in nature so it uses in the formation of batteries. The biggest drawback of such kind of batteries are the less efficiency. It holds about half power of Li-ion batteries.

5) Lithium Air Breathing Batteries:

Lithium-ion batteries releases oxygen when it emitting the energy. It uses oxygen as oxidiser rather than materials. Dollas University is developing lithium-air forward, it will oxidise the oxygen when it is draining the energy. In a report Dollas University said that it took 5-10 years to complete the project,

6) Bio Plant Charger:

The bio plant charger uses the process of photo synthesis. It will a plant pot that attach the power of photosynthesis to charge the device. The current technology uses organic materials that reacts with water and organic matter from photosynthesising. This creates a reaction that generates enough power to charge the device Bio-chargers provide two or three charge per day at the rate of 3.5 V and 0.5 A via USB port that is attached as a rock in the plant. Still this technology needs lots of effort to fulfil the requirements.

7) Turbo charger/Super Charger or Ultra-fast charger:

Current chargers use to take much time to charge the batteries. Generally it take 200-250 V electricity and produces only 3.42 AMP/19V/65W DC current. This takes 1.6 KWH/hour. If charger take 3 hr to charge the battery it would be 1.6*3=4.8 KWH electricity. To minimize such kind of consumption of electricity Turbo charger/Super charger is introduced. Turbo charger takes nearly half of time to charge the battery than the normal chargers. Companies like Tesla, MSI GT70 Motorola are manufacturing such kind of chargers.

Report of various chargers of time consumption to charge the battery"

**Table: 3-Charger's Description and time calculation (Battery university.com/ultra_fast_chargers)**
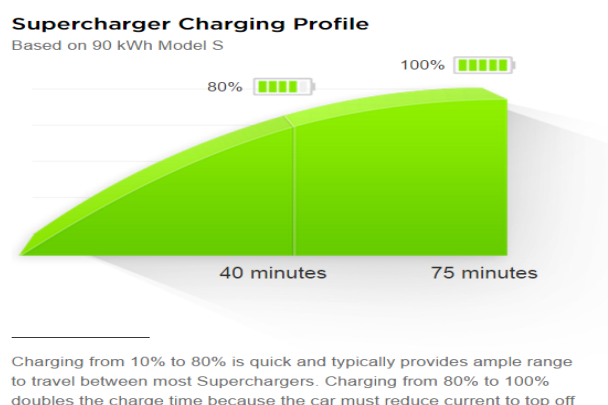
Fig 4 Super charging Graph

8) Other Options To Improve The Saving The Energy:

➤ As maximum possible computer/laptops should switch on the optimized battery or power feature or battery saver mode it can be done by visiting the control panel of pc.

➤ RAM should be at optimum level since it helps to performance of computer less performer computers always become the source of lots of energy wastage.

➤ Inspecting the battery. Battery uses metal terminal which requires to be clean. The unclean surface of metal terminal creates obstacle in the flow of electron so it should always clean.

➤ Defragmentation of hard drive helps to operate the system as efficiently as possible. Rearranging the fragmented file takes less time in searching the file and thus it helps in power saving.

➤ Turn off the unnecessary applications like-WIFI, Bluetooth, screen saver. Disable unused devices and ports to reduce the power consumptions.

➤ Do not overcharge your battery it decreases the efficiency of battery and consume too much electricity. So unplug the device when it is not in use.

E. **Recycling The Computers:**
Selling Report of 2014

	Computer Sales in 2014 by Manufacturer (Desk-Based and Notebook)	
	Manufacturer	**Computers Shipped**
1	Lenovo	58,000,000
2	HP	52,000,000
3	Dell	41,000,000
4	Acer	24,000,000
5	Asus	22,000,000
6	Others	104,000,000
	Total	301,000,000
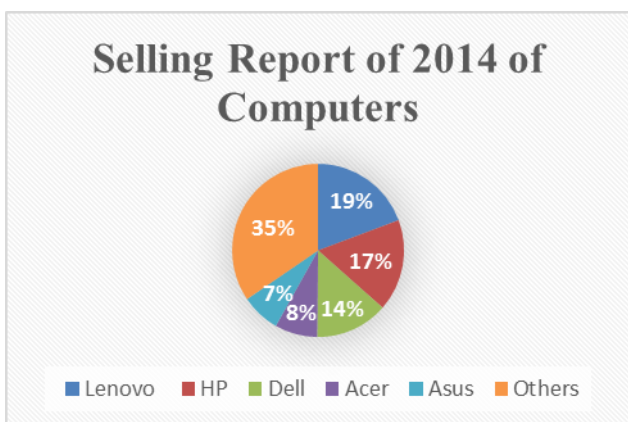
Fig 5 Selling Report of 2014

Recycling is one of the key factor in Green IT .Since people often discard the unwanted electronic devices randomly. So instead of discarding in such manner we should discard used or unwanted electronic equipment in a convenient and environmentally responsible manner. As discussed earlier computers have toxic materials and many component which causes pollutions that can emit harmful emissions into environment. Evolution of computer technology is in progress so no. of new products of each companies arrived in market. Thus the old and unused computers become e-wastage.

Current Recycling process of e-wastage:
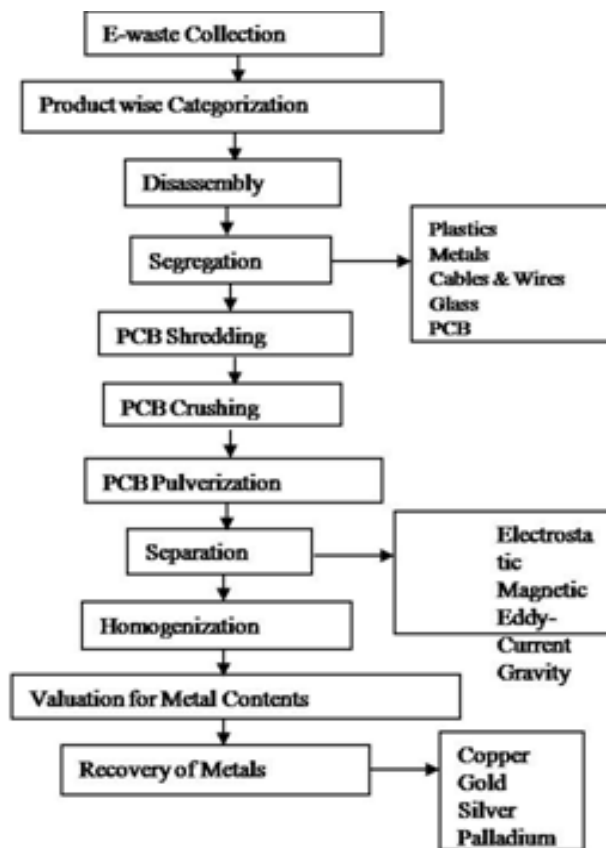
Fig 6: Process of Recycling

However many companies like Apple, Dell, HP, Fujitsu, and IBM are providing exchange offer that you can exchange your old pc or laptop to with new one. But still it is facing much problems since cheap or middle capital companies are not able to provide such kind of facility. These companies must be encourage to provide exchange facility. The Indian government

Plan to clean India "Swachchh Bharat Mission" is now helping in dumping and recycling the e-wastage in march 2016 Government of India has changes the rule of e waste management so companies should participate in e waste management system. Thus recycling of e-wastage and Swachchh Bharat Mission can be done simultaneously.

V. **Conclusion & Future Scope**

This paper presented that what are barriers in green computing & how can we implement green computing. In brief it can be say that it is study and practice of efficient and eco-friendly computing resources development. Present situation says that it is not only thought of

environmental organizations but it has got attention from IT industries too. Companies belonging to the computer industries showing interest to adopt green computing both in terms of resources and public relations. It is not only the responsibility of companies that they make eco-friendly components it is the responsibility of people's too. As we have seen that awareness about Green IT & Energy star program can play a crucial role in adoption of Green computing. According to a report e-wastage system will be the one of the most growing sector in IT in 2020. So lots of technologies are asking about improvement and new innovations such areas like recycling of plastics, metals, mixed metals and plastics, & recycling of toxic acids too.

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