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Research Article

Green Computing Beyond the traditional ways

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Abstract

Over the past years, green computing has become a concerning Issues for government, commercial organizations and even individuals in society. In this paper, firstly the green computing will be defined and discussed briefly, secondly the impact of it is effects on the environment and consumable resources will be explained through statistical info-graphic collected around the global. Finally, the road map strategies will be drawn beyond the traditional techniques, in order to take actions against IT negative environmental and financial influences.

Keywords: Green Computing, Green IT, Datacenter, eco-friendly, green cloud, sustainability, power management.

1. Introduction

In terms of rising awareness about computing environmental impact, green computing is gaining significant importance. With increasing global warming, energy consumption and e-waste, the idea of green computing is broadly taken into remarkable consideration by both the government and businesses as their contribution in moral practices for sustainable improvement.

Green computing or green IT concept has been used since 1992 with the commencement of the Energy Star program, this provided a voluntary label awarded to computing products which offered maximum efficiency while consuming minimum energy. The rating was awarded to refrigerators, television, monitors, air conditioners, and other household devises. Soon after that, the Green computing term where used to cover the computer related products such as, USBs, printers, monitors, communication systems, servers and network systems [1] [2]. Today, this term is broadly use with every aspect of energy consuming actives, the reason for that is explained below.

2. Green Computing key points

a. Sustainability of Environment – this make sure of productivity and diversity of biological system through minimizing the undesirable production process effects, starting with product design then green manufacturing and ending with safe disposal. Moreover, it is not just take care of environment, it also ensure the social and economic sustainability as shown in figure 1 [4].

- b. Utilizing the resources green computing is instigate the designers in order to utilize the recourses in an environmental friendly ways, for instances, datacenters, computer, smart phones, light, heat, electrical powers etc.
- c. Reducing Cost- there is a significant saving in the product costs by utilizing resources efficiently through green computing.
- d. Better Corporate and Social Image Green computing is provide a grate help for the businesses to improve their corporate reputation by meeting regulatory requirements and compliance. It also offers a better way for meeting customers and employees sustainability demands [3].

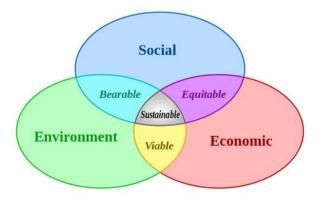
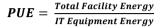


Figure 1 Confluence of three constituent parts [4]

3. Power usage effectiveness (PUE)

It is one of the most common metric used when talking about green computing, is a measure of how much energy is used by the a datacenter and how efficiently uses energy. PUE is therefore expressed as the ratio of total amount of energy used by a facility to the energy provided to computing equipment. Anything apart from a computing device in a datacenter can be considered as a category of facility energy consumption, such as lighting, cooling and ... etc. as shown in figure 2.



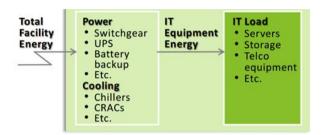


Figure 2: Power Usage Effectiveness [9]

For instances, a PUE of 2.0 shows that the facility total energy usage, is two times bigger than the energy usage for the IT equipment alone. Currently, there is no complete data set that can illustrate the true spread of PUE. It was firstly developed by The Green Grid Association. PUE values can range from 1.0 to infinity; an ideal PUE is 1.0 which indicates 100% efficiency. However, it is the inverse of datacenter infrastructure efficiency (DCIE), which is also developed by The Green Grid [9].

4. Points of Focus

There are varies products and facility where green computing should be implemented due to their bad reputation in consuming energy and some other environmental considerations:

4.1 Datacenters

Current developments in communication and digital technology are causing major growth demands in the industry of Information Technology (IT). Datacenters provide safe, clean and stable environment for servers to be online 24/7, more industries and companies need to provide or store data for their clients. As a result, the needs of data storage and processing are increased rapidly [7].

Datacenter facilities are consider to be huge consumers of energy, according to The U.S Department of Energy, the datacenter facilities are responsible of consuming 1.5% of the world's total energy use in 2010, also explained that datacenter consume up to 100 to 200 times more energy than standard office buildings [6]. An estimated 91 Terawatt-hours (TWh) of electricity were datacenters consumption In U.S 2013, which is equivalent to the 34 large coal-fired (500-megawatt) power plants output for one year. By 2020, datacenter electricity consumption in U.S. is expected to increase to approximately 140TWh annually, which is equal to the annual output of 50 power plants, producing nearly 100 million metric tons of carbon pollution per year. As a result, costing U.S companies \$13 billion annually in electricity bills [8]. Datacenters were consumed about 1.3% of the total global electricity in 2010, or about 200 TWh. Furthermore, by 2025 it is expected that will increase to 1,400 TWh, which will be roughly 6% of the total global electricity consumption [10].

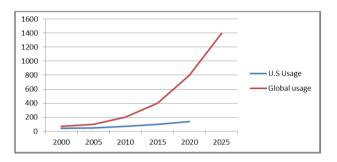


Figure 3: Projection of Datacentres Electricity Use

Formerly, electricity has been considered as an overhead expense, similarly to the space cost. However, datacenter require its own specific strategy with growing of power costs, reliability, capacity, supply, and environmental consideration [11]. There are some tactical actions can increase datacenter efficiency, including:

A- Decrease Electricity Consumption in Cooling Process.

In an ordinary datacenter, nearly half of the power available is consumed by the IT equipment, and the rest mostly use for cooling. Considerable amount of that power can be saved by reducing cooling inefficiencies, this can be done through choosing suitable location for a datacenter, having right location can help in cooling process for instance, making sufficient use of outside air (Microsoft are building new datacenters in cold climate such as Finland to reduce cooling costs), the reason behind overarching of Internet infrastructure is to construct a modern datacenters without need for any mechanical refrigeration [13].

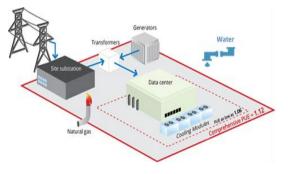


Figure 4: Google data center located close to the vital resources [14].

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Moreover, right location also means political stability of the region (Geopolitical Ownership Considerations), on the other hand, natural disasters (earth quack, flood, tornados ...etc.) and other global risk issues should be considered carefully. Finally, resource availability and cost of power and water is also crucial as shown in the figure 3.

B- Virtualize and Consolidate.

Inefficient server utilization is one of the major causes of waste (high PUE) in most datacenters. Virtualizing can improve overall utilization by 10 to 30 percent in typical of dedicated servers, and occasionally more than 50 percent. This also rescues a stranded power in the process and significant amount of rack space.

C- Monitor Aisle Temperatures.

It is recommended to implement a hot/cold-aisle configuration and improve the cold-aisle inlet temperatures to 27°C/80°F. Conversely, this might produce more hot spots which waste power. Therefore, it is essential to balance the network equipment in the datacenter. This can be implemented through monitoring the cold-aisle temperature, in order to take full advantage of cooling efficiency and minimize heat issues. As presented in the figure 5, several parallel racks which holds IT equipment's placed with the same orientation, this considered as inefficient design, since most modern equipment's are taking cold air from front and letting the relatively hot air from the back, therefore the exhausted air from first row will be consumed by second row and so on, as a result, the temperature will increase gradually forming a hot spot problem [15].

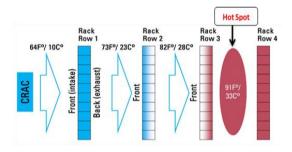


Figure 5: How temperature increase gradually and become a hot spot [15]

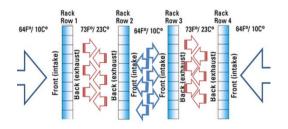


Figure 6: Hot aisle/cold aisle row Design

To resolve this situation, the rack rows should be oriented in a way that the fronts of the IT equipment face each other. Moreover, the backs of the IT equipment racks should also face each other, this design know as Hot aisle/cold aisle row layout as shown in figure 6.

4.2 End User

Yet, the growth in end user power consumption is in fact greater than in the datacenters. The processing that occurs in the datacenter represents only a fraction of its entire information processing. There can be 10 times as many rack servers and departmental servers for every datacenter processor. Furthermore, there can be from 50 to more than 250 end-user computers for every datacenter machine, while 100 to 300 watts is the average desktop computer consumption of electricity. In the United States and Western Europe almost 100000000 workers are using computer every day. Keep in mind that each of these computers consumes 100 watts of power, and some computers have additional devices such as, speaker, printers, scanners, webcams ...etc. which draw additional electricity. According to this conservative figure, computers draw about 10 Giga watts of electricity from the world power, and this estimate just for United States and Western Europe, it does not count Eastern Europe, China, India and the Middle East, , where consumption rates are growing dramatically [16].

There are strategies for overcoming this issue, some of these strategies must be applied on businesses and organization, and the other part involve the end users:

- Monitor the power usage of your organization by 1undertaking a simple step, just count the number of pc the organization is using and the age of these PCs, there are a good correlation between the number of PCs is used and the amount of consumption. Typically, the first step would be isolating energy consumption outside the datacenter and measure it. The main part of the power used of an establishment's physical space is used up by office IT equipment for instances, PCs, printers and copiers. Currently, businesses normally have to depend on approximation to estimate their power usage. However, using some software tools which developed specially for this purpose such as, CMDB, ITIL and SMS can provide a great assistant.
- 2- Educating organization employees about the power consumption possibly will result in a 10% energy savings. There many source of information that can provide a good guidance of how to save energy, for example, one can start educating him/herself and other by googling "How much electricity do PC use" [12]. The common guidance recommendation include:
 - a. Simply let your computer sleep in idle time, configuring the power management settings on PCs come at first step.

- b. In case of unexperienced user the third party computer tools can used for configuring the power management settings, in order to reduce the power consumptions.
- 3- Organization should set some power reduction goals, 20% of electricity reduction by desktop computers in the first year could be a good start. If it is not possible for organizations to measure this immediately, they can use other relevant metrics such as, "hours on". For second year the organization can set 10% power reduction goals and so on.
- 4- Measuring, Recoding and reporting back the energy usage with the results to employees and manager can encourage them to do more. Without having result report the efforts might be hampered.

5. Saving energy beyond the traditional way

In this section the latest development of green computing will be debated beyond the traditional boundaries.

5.1 Using Cloud Computing

The use of cloud computing approach interacts directly with the notion of sustainable improvement, this can be beneficial in three aspects: economic, social and environment. Cloud environmental practice include: Saving electricity, reducing cooling energy requirements and space. Flexibility and Cost savings of operations are between the most commonly mentioned profits related to a decision to implement the cloud computing solution. Some features of cloud's ICT (information and communication technologies) infrastructure offer an identification model as the one providing green benefits. The basic aspects of the model let you to identify a number of environmental paybacks which could be accomplished by migrating the IT resources to the cloud computing solution. These aspects might contain:

- Multi tenancy and dynamic provisioning: Programmed processing of computing environment provide instant supports for user needs, working under the cloud might release or acquire the resources, where it is appropriate according to the user demand automatically. Thus datacenters maintain active servers according to current demand. Additionally, virtualization technology that make possible to connect different resources in one boundless set of resources, which is possible to release them to all customers immediately in more selective way, that increasing the level of their use. It can be said that cloud computing would never exist without virtualization model [17].
- Optimal server utilization: conventionally, most of servers stay idle of 85-95% of the time consuming almost as much power as they do when they are active. Virtualization allows hosting of multiple applications over one server. The energy

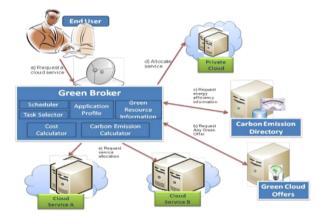
consumption is reduced and the number of active servers is decreased [18].

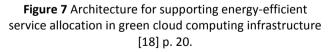
• Energy-efficient client devices (thin clients): now it is possible to reduce the amount of energy is consume by the client nodes in the public cloud model, through small energy-efficient devices.

5.2 Green Cloud Architecture (Carbon Monoxide Aware)

One of the newest progresses of green computing awareness is the Green cloud architecture. The purpose of this incorporated cloud-based technology solution, is to provide a high-level architecture for supporting power efficient service allocation for both users and providers. In cloud providers prospective, this model will lower their electricity bills without losing their market share. Through applying the green cloud infrastructure, the demand for high-level computing services on the user's side can be achieved, also saving energy on the provider's side.

Figure 7 illustrates architecture of energy-efficient service allocation in green cloud. The Green-Broker provide the complete access to all services which are registered in public directory. Green-Offer directory is encourage the providers to list their services with discounted rates and green hours. A usual cloud-broker rent cloud services and schedule applications, also is responsible to select these offerings based on end user requirements. Each demand is investigated according to the time, price and considering the maximum quality and minimum CO2 emission.





5.3 Datacenter sustainability improvements

Previously in this report, some tactical actions where described for increase datacenter efficiency, additionally, cloud green computing can provide best practices to make datacenters operation green. To build environmental datacenter, a number of top practices in key areas has been suggested for enhancing sustainability:

- Using renewable sources of energy such as, fuel cells, solar energy generation, cogeneration and wind power generation.
- Also there are new Cooling methods which have a great advantages over traditional ways for instances, nano-fluid cooling systems, free cooling, liquid cooling, and in-server, in-rack and in-row cooling which are been used by corporations like SprayCool, spot cooling, using cable grommets to decrease cool air leaks.
- Using new Building design for example, optimizing floor layout, heat insulation, and recycling water.
- ICT platform, dedicated racks & servers, middlewarefacility linkage and virtualization technologies.
- Utilizing the latest power efficient IT equipment such as, servers and processors [18].

5.4 Solar Computing

These days, the world is slowly paying more and more attention to solar energy. Solar power is a natural nominee for cost effective, supplying efficient and sustainable energy to emerging markets. For instances, Taiwanese manufacturer VIA Technologies Inc. which are solar panel technology in cooperation with one of the major and leading solar product manufacturers which is Motech Industries. VIA company listed a main advantage of using their technology [19]:

- Solar power is a clean energy (non-polluting).
- Solar panels are quiet in operation, it is ideal for places where a noisy generator would be disturbing such as, classroom, hospitals, shops and ...etc.
- Virtually, the minute the capital cost has been covered, solar power can be considered as a free energy, as they don't require refueling and they are self-sufficient.
- Also Solar panels are virtually maintenance free and reliable and, more or less requiring only annual changes, for instance, water replacement in deepcycle batteries.

5.5 Telecommunications-related technologies

These teleconferencing, also are regularly implemented in green computing initiative. Improvements of communications equipment with the assistance of computer networking systems have made it possible for employees to work from remote locations, furthermore, the telecommuting companies accepted this as a feasible option. As a result, it provide better satisfaction between the two parties. Furthermore, increased profit, reduction of gas emissions related to travel, slighter costs for workplace space, lighting, heat and ... etc. [20].

6. Discussion: General Approaches and Solutions

As stated previously in this paper, some significant methodologies could be employed, In order to reach social awareness and enhancement of green technology, here are some general green boundaries to work around [12]:

First of all, green design: government can use regulatory processes that improve environmental quality, although enhancing economic. Additionally, environmental groups must encourage business and manufactures for power efficient design and inventive management. In more practical and advance level, designing recyclable electronic devices such as, computers, printers, monitors, communication systems, servers and network systems and cooling equipment.

Secondly, green manufacturing: process of production of electronic devises for instances, computers and associated devices, it include techniques of manufacturing recyclable components with minimal impact on environment. This method provides economic paybacks such as, long-term cost savings, and business process efficiency enhancements.

Thirdly, Green Use: consumption of electricity from computers and their peripheral subsystems should be reduced in environmentally manner.

Finally, Green Disposal: regulating "take back" policy on manufacturers regarding full responsibility for lifecycle the products they have produced, include Recycling undesirable/used devices and other electronic-waste by IT vendors. Furthermore, reusing and Refurbishing existing old computers and other electronic associated devices.

Conclusion

To sum up, desktops PCs in fact use more energy than datacenters. Moreover, the amount of power consumed by desktops PCs and the effects they have on the environment globally are major. However, one cannot take too lightly datacenter consumption and it is significant impact on biological system. Consumption of electricity is defiantly worth managing from financial, moral and an ethical perspective, by observing the information offered here, business, organizations and government department can begin to manage energy usage so that, together, we can all provide a better future for next generation.

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