



Minimization of Energy Consumption in Cloud Using Green Computing

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Abstract: Cloud computing has witnessed tremendous growth in the past few years. This exponential growth of cloud computing has led to uneconomical energy consumption in data processing, storage, and communications which has led to the environmental degradation, because of the carbon emissions. Therefore, it is the need of hour to use green IT to save the environment. The green cloud computing (GCC) approach is a part of green IT; it aims to reduce the carbon footprint of datacenters by reducing their energy consumption. The various facts and challenges faced in the Green IT environment are discussed in this research. A survey is also done on the solutions proposed by researchers and practices to be followed in data centers for improving energy efficiency.

Keywords: Green computing Green design, Carbon footprint, Green manufacturing, optimization

I. INTRODUCTION

Use of Computers are increasing in our daily lives. The immoderate use of computers has negative impact on our environment. Computers require large amount of electricity that also increased cost factor. What will happen if electricity shortage will arise?

It's very necessary to consume electricity in a very proper manner. As our lives migrate toward the digital world so, there is no provision to reduce the usage of computers in our day to day life the only thing we can do is to minimize its energy usage. Today, resources are available but what about future? Another issue is the carbon footprints or the unnecessary production of greenhouse gases.

Data centers consume incredible amounts of energy. About 0.5% of global electric power consumption is because of data centers. The third major issue is cooling that consumes huge amount of energy in data centers. Utilizing 100% of electricity is not possible but the wastage of electricity can be minimized. The fourth issue is concerned with software and hardware. Utilization of CPU by organizing different architectures is a hardware issue and the optimum design of algorithm and its implementation is the software issue. The unavoidable issue is how electricity is being wasted by computers in our daily lives by ignoring some common action The aim here is to optimize computing power so as to minimize electricity usage and wastage. "Earth is home of millions of species. Let's do our part to protect the environment and save our lives". Saving energy has become primary concern in the view of economic, environmental and marketing aspects in every field.

Hence, Green computing is the solution developed to overcome these issues. Green Computing is capable to reduce the environmental impacts of Global warming by reducing the use of harmful materials and maximizing energy efficiency. It is the eco-friendly use of computers and their resources. Green Computing may be defined as manufacturing, designing, disposing and using of computers, servers and associated subsystems efficiently with no impact on the environment. Also Green Computing is used to meet business demands in a cost effective, energy-efficient, flexible and in secure manner. It is used to achieve minimum energy consumption and efficient processing and utilization of computing infrastructure. Following techniques are used to support Green Computing [1]:

- Green use: This approach is used to minimize electric consumption in computers and other peripheral devices and using them in eco-friendly manner.
- Green disposal: It is the recycling of unwanted electronic materials.
- Green design: To design energy efficient computers, servers, printers and other peripheral devices.
- Green manufacturing: The wastage that comes out from electronic devices should be minimized so as to decrease the impact on environment.

II. RELATED WORK

This section describes the research method used for this review paper. The aim of this work is to find out the techniques which are useful for reducing energy consumption in cloud computing datacenters from previous studies.

Green Cloud Computing usage and implementation has rapidly grown in the recent years. Cavdar et al., [2, 3] introduced green grid and also proposed some parameters. The main parameters that have been defined include Power Usage Effectiveness (PUE) [4] and Data Centre Efficiency (DCE) metrics [5], TDP (Thermal Design Power) [3], etc. PUE being the common one. Wikipedia states "PUE is a degree of how efficiently a computer datacenter uses its power with the value varying from 1.0 to infinity. A value of 1.0 means 100% efficiency and full power usage by IT equipment's. Table I explains some parameters proposed for data centers.

III. MINIMIZING ENERGY SOURCE BY USING GREEN COMPUTING TECHNIQUES

To minimize electricity usage in computers is necessary and can be improved in the following manner [6].

- Buy energy efficient computers.
- Buy appropriate hardware for the job for example a 19-inch monitor uses more power than 17-inch monitor and also the usage of hardware that is prepared from harmful materials should be reduced.
- Solar computers may be used as a new source of energy which is the natural source available and can be involved in computers to make green computing successful.

- The efficient power management should be used to increase the life-span of the product.
- Nuclear power plants that emits less carbon can be used to minimize the electricity.

Research indicates that use of CRT monitors consumes more power than LCD monitor's. LCD monitor can use one-half to two-thirds the energy of a CRT monitor so replacing CRT with

Table 1. Green metrics power measurement [2, 3]

Metric	Explanation	Formula
Power usage Effectiveness (PUE)	It is the fraction of total energy consumed by the service of a data Centre to the total energy consumed by IT equipment's	$PUE = \frac{\text{Total facility energy}}{\text{Total Equipment energy}}$
Carbon Usage Effectiveness (CUE)	It is a calculation of green- house gases (CO ₂ , CH ₄) release in atmosphere by the data Centre	$CUE = \frac{(\text{Total CO}_2 \text{ emission from total energy used for service of data Centre})}{(\text{Total energy consume by IT equipment})}$
Water Usage Effectiveness (WUE)	It is calculation of yearly water used by data Centre like for cooling, energy Production	$WUE = \frac{\text{Annual usage of Water}}{\text{Total energy used IT Equipment}}$
Energy Reuse Factor (ERF)	It calculates the reusable energy Like hydro power, solar power etc. used by data Centre	$ERF = \frac{\text{Used for reused energy}}{\text{Total energy used IT Equipment}}$
Energy Reuse Effectiveness (ERE)	It is a parameter for measuring the profit of reuse energy from a data Centre	$ERE = \frac{\text{Total energy-reused energy}}{\text{Total energy used IT Equipment}}$
Data Centre Infrastructure Efficiency (DCiE)	This factor is used to calculate The energy efficiency of a data Centre	$DCiE = \frac{\text{Total IT equipment power} * 100\%}{\text{Total facility power}}$
Data Centre Productivity (DCP)	It calculates the amount of useful work done by data Centre.	$DCP = \frac{\text{Total Useful work}}{\text{Total resource used to do this Work}}$
Compute Power Efficiency (CPE)	It determines the total amount of power is truly used for computing.	$CPE = \frac{\text{IT equipment utilization energy}}{PUE}$
Green Energy coefficient (GEC)	It measure the amount of green energy used to provide services to data Centre.	$GEC = \frac{\text{Green energy consumed}}{\text{Total energy consumed}}$
Space, Wattage and Performance (SWaP)	It is used for work out the space and energy required by the data Centre.	$SWaP = \frac{\text{Performance}}{\text{Space}^3 \text{power}}$
Data Centre Energy Productivity (DCeP)	It calculates the quantity of useful work done by data Centre as compare to total energy consumed to make this work	$DCeP = \frac{\text{Total Useful work done}}{\text{Total energy used to do this work}}$

LCD can be used to reduce electricity source and also flat screen can lead to less eye strain.

IV. MINIMIZING WASTAGE FOR CLEAN ENVIRONMENT

One of the issues is the carbon footprints or the unnecessary production of greenhouse gases. Reduction in emission of carbon is critical for clean environment. Wasted computers should be recycled in-order to minimize environmental effects. Green computing helps in optimizing the wastages of hardware coming from computers in the following way [7] [8]:

- Disposal of batteries without polluting environment as it contains carbon mixture chemicals.
- Hardware that is wasted can be used for educational purposes.
- E-wastage of computer related hardware should be used in Nanotechnology that requires tiny parts which will make less harm to the environment and on the other hand a new technology will be emerged that will help the world.

V. MINIMIZING ELECTRICITY WASTAGE

According to law of thermodynamics the energy efficiency cannot be 100%. Some of the energy will be wasted in one form or other. Electricity cannot be fully utilized by computers but the energy that is wasted in the form of heat can be minimized. One such solution is- when energy is transformed from one form to another, the emitted heat should be absorbed and utilized for producing electricity which will solve the economic issues of hardware cost, power consumption cost, maintenance cost.

VI. MINIMIZING COMPUTING POWER

Computer- the powerful device for complex computation and for processing large amount of data. However, to obtain power of this machine fully, we need to utilize it in the best way and this can be achieved through:

- Optimum architecture.
- Designing optimum Algorithm.

In parallel computing, cloud computing, network based applications optimum architecture is used. Designing optimum Algorithm involves efficient practice of solution.

- i. In parallel computing we need to utilize processing power of each parallel computer otherwise it will result in loss of energy.
- ii. Applications should make connection to the network only when required otherwise if connection is maintained unnecessarily for large amount of time without communication, it will lead to loss of energy.
- iii. Various virtualization models have been developed based on architecture design and the number of maturity levels achieved are as follows [9] [10].
 - a. Level 0- This level is intended for home usage of computers and is represented using name local with dedicated applications and fixed infrastructure.
 - b. Level 1- In department or in organization this level is used and with shared applications and virtual infrastructure it is being described.
 - c. Level 2- For data storage centers this level is used and is defined using name data center with shared application and virtual infrastructure.
 - d. Level 3- For cloud computing we have level 3 and is described using name cloud with software as a service application, virtual infrastructure and virtual ownership.

Each level is used to maximize the use of computer power.

- iv. Design of software should be optimum. Computers should not be indulged in doing unnecessary processing. However, algorithms should be designed to fully optimize the processing time. Load balancing also plays an important role here [11].
- v. Cooling: Huge amount of energy is consumed in data centers and it can be reduced. At the initial stage, it was reduced by using mechanical refrigerator. It supplied chilled water to the IT equipment's. Now pre cooling also known as free cooling is used. The use of mechanical cooling is minimized by free cooling. For instance, the data- Centre's of Facebook are in Sweden which has dry and cold. Microsoft kept their servers in open air in order to cool the servers. River water is used by Google to cool their data Centre [2].

VII. MINIMIZING OTHER COMMON IDEAS

- Shut down your computer when not in use for large amount of time.
- Print smarter! Take print out only when required. Complete the transaction via e-documents that supports green computing. Keep printer switched off in idle state also print double sided.
- Make efficient usage of server by adopting virtualization techniques.
- Use monitor sleep mode, hard disk sleep mode, system standby mode or hibernate mode when your computer is in idle state.
- Batteries should be disposed without polluting environment as it contains carbon mixture chemicals. Further upgrade the equipment's when necessary instead of replacing entirely computer system.

VIII. CONCLUSION

Green Technology is the movement of making environment friendly. In this survey paper various energy effective strategies are defined to make data centers eco-friendly. Energy saving strategies saves a sufficient amount of power and of course cut down the carbon footprint. Though in this paper, we have found new ways to save vast amounts of energy while minimally impacting performance. We are proceeding to an era where green computing will be used in each and every field of computer usage.

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