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Green Computing: A Review on Energy Efficient Cloud Computing

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Abstract - *Cloud Computing is a dynamic space for efficient use of computer resources. Data Institutions that install Cloud applications come in with a lot of power, they donate at high operating costs and carbon footprints in the air. Therefore, Green Cloud computing is needed not only to save energy but also to save energy and reduce operating costs. Over energy consumption of data centres have become a major problem for cloud operators. This is because they use a lot of energy calculating the energy of 3% of the earth's electricity. Henceforth Green computing is the vital research area. In this paper we have discussed different parameters to measure the power consumption; we have also reviewed the work of different authors.*

1. INTRODUCTION

India's 72.2 % of population resides in the rural areas and villages. India's huge population has a great potential to make it an economic as well as an IT superpower, but the major obstacle is the lack of infrastructure for the development of the Educational schools and colleges in rural areas. With the introduction of the new cloud computing paradigm these problems can be easily eliminated because it doesn't require the end users to have any type of infrastructure, as all of them are delivered as services (whether it be infrastructure as a service (IaaS), Platform as a service (PaaS), Software as a service (SaaS) on a pay per-use basis (utility computing) virtually which makes it easier and cheaper for the people living in rural areas to actively involve themselves in the this sector.

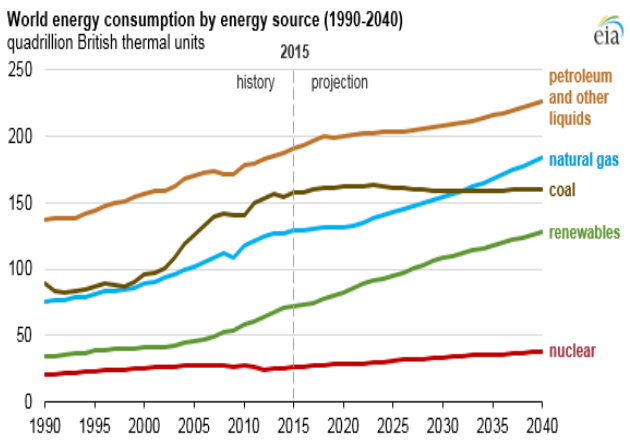
What is cloud?

Developers today can avoid scalability and availability worries in case their site turns into the next big thing by developing upon the cloud. Cloud-based development involves in some sense, the outsourcing, of various parts of the application out of the server and into the cloud. So instead of storing images, videos and other objects in the file system, they are stored on the cloud. Instead of using a local database, a cloud-based database is used instead. Batch-processing and other functionalities are also performed on the cloud. In other words, developers using the cloud will move most or all of the components of a web application into the cloud. The most significant benefit of course is that the cloud´s capacity is theoretically limitless as compared to that of some local servers, saving the need to frantically add hardware or worry at all if traffic explodes. There are different characteristics of cloud computing as:

- On demand self-service- A consumer may have provision for computing capabilities.
- Broad network access- Capabilities are available over the network and access through standard mechanism.
- Resource pooling- Provider's computing resources are pooled to serve consumers.
- Rapid elasticity- Capabilities can be rapidly and elastically provisioned to quickly scale out and rapidly released to quickly scale in.
- Measured service- Cloud system automatically control and optimize resource use by leveraging a metering capability.

The name Green computing came about with was introduced by the Energy Star program in 1992 by the U.S. Environment Protector Energy Star is the type of label provided computers and other electronic products. Energy Star a system that reduces energy consumption while maximizing it efficiency. One of the first ways to go green the computer was a sleeping activity on the computers. How to Sleep a function that puts the computer in standby mode at a set time.

Cloud computing is a model that provides computing resources on demand or on rental basis and so users can pay only for resources they use. The excessive energy consumption data centers has become a major concern to cloud computing practitioners. This is because they consume a great deal of energy accounting for 3% of global electrical energy consumption. The U.S. Energy Information Administration's latest International Energy Outlook 2017 (IEO2017) projects that world energy consumption will grow by 28% between 2015 and 2040. Cloud computing has low ROI, excessive energy consumption has a negative impact on the environment, which is carbon dioxide (CO2). The ICT industry is estimated to contribute about 2% of global CO2 emission, which contributes greatly to greenhouse effect – this emission is equivalent to the aviation industry. Worldwide datacenter energy consumption rose steadily from year 2000 to 2010.



The CPU, disk storage, memory and network are the main consumers of energy in a server. The CPU consumes the largest portion of energy supplied to a server in a data center followed by the memory. However, due to improvements in the CPU efficiency, it no longer dominates energy consumption. On the other hand, energy consumed by processor greatly depends on processor types. For example, new Intel processor have power saving mechanisms. Energy consumed by a data center can be saved up to 50% by efficiently performing VM consolidation. For example, efficient VM consolidation can ensure VMs are packaged in the least number of servers so that other servers are shut down thus saving more energy. This is because an idle server consumes 70% of the power when it is fully utilized.

Why Green Computing: There are several factors which mould us towards this:

- The rapid growth of the Internet
- Increasing equipment power density
- Increasing cooling requirements
- Increasing energy costs
- Restrictions on energy supply and access
- Low server utilization rates
- Growing awareness of IT's impact on the environment

In this paper we will discuss about green computing and its future, further in next section we will elaborate different studies carried in this field, in section IV will discuss parameters used for power consumption, section III will compare some study and at last we will compare this study.

2. LITERATURE SURVEY

A. Sathya Sofia et. al. at 2015 said that Clouds are rapidly becoming an important platform for scientific applications. For executing large programs in cloud, the class of programs can be decomposed into multiple sequences of tasks that can be executed in different VMs. Users have to pay for the resources they use according to some pricing model. Cloud applications consume huge amount of energy, this also cause high operational cost. So this work introduces green computing in cloud called green cloud. Green computing is the study of efficient and eco-friendly computing resources in order to reduce energy consumption, carbon emission, etc. In recent years, companies in the IT industry have come to realise that going green is in their best interest that is reduced costs. Energy consumption at different levels in cloud computing system was discussed. This work discuses several techniques for reducing energy consumption in cloud and evaluates the CPU energy with power consumption. It also works on memory consumption techniques and presents the results for that. It compares the memory consumption with power consumption and present results for the same [1].

Anubha Jain et. al. at 2013 said that moving towards Cloud Computing, high performance computing usage of huge data center (DC) and huge cluster is increasing day by day and energy consumption by these DC and energy dissipation in environment by these DC is also rising day by day. The large amount of CO2 dissipation in environment has generated the necessity of Green computing (saving energy by recycling it and reusing it over a period of time and minimizing the wastage in terms of usage of resources). More processor chips generate more heat, more heat requires more cooling and cooling again generates heats and thus we come to a stage where we want to balance the system by getting the same computing speed at decreased energy consumption. In this paper we proposed different ideas towards green cloud computing approach [2].

Gaurav Jindal et. al. at 2012 saud that The concept of green computing has begun to spread in the past few years, gaining increasing popularity. Besides the widespread sensitivity to ecological issues, such interest also stems from economic needs, since both energy costs and electrical requirements of IT industry around the world show a continuously growing trend. Green computing is the environmentally responsible use of computers and related resources. Such practices include the implementation of energy-efficient central processing units (CPUs), Servers and Peripherals as well as reduced resource consumption and proper disposal of electronic waste (e-waste). Green computing is the study and practice of efficient and ecofriendly computing. The principle behind energy efficient coding is to save power by getting software to make less use of the hardware, rather than continuing to run the same code on hardware that uses less power. Author first discuss the connotation of green computing and sketch researcher's view on the next generation of IT systems for green computing. Subsequently, this paper helps to identify key issues relevant to green computing and evaluate different approaches to these problems [3].

He Ba et. al. at 2013 said that Cloud computing provides an approach to accessing shared computing resources. However, a traditional cloud is composed of powerful but energy-hungry workstations. The growth of the population of mobile devices such as smart phones and tablets provides huge amount of idling computing power. In this paper, we describe the design and implementation of a mobile computing system prototype named GEMCloud that utilizes energy efficient mobile devices (e.g., smartphones and tablets) as computing resources. Author mainly focused on the evaluation of the energy efficiency of this system by providing comprehensive tests on the mobile devices. We provide performance comparisons among various mobile devices and workstations. The results show that the smartphones and tablets have lower individual computing power but much higher energy efficiency. The lower computing power can be made up by recruiting more devices, while the energy efficiency is harder to improve

given the same type of devices [4]. Author has given performance comparison of the workstation as follows:

	Idle	1 Core 1 Task	2 Cores 2 Tasks
Power (Watt)	395.6	407.8	420.3
Computing Time (Sec)	NIA	40.0	40.0
Total Energy (Joule)	NIA	16,322.0	16,824.4
Energy Per Task (Joule)	NIA	16,322.0	8412.2
	4 Cores 4 Tasks	8 Cores 8 Tasks	16 Cores 16 tasks
Power (Watt)	438.7	466.9	506.4
Computing Time (Sec)	40.1	40.2	40.6
Total Energy (Joule)	17,586.8	18,751.1	20,538.4
Energy per Task (Joule)	4396.7	2343.9	1283.7
	32 Cores 32 Tasks	64 Cores 64 Tasks	
Power (Watt)	588.8	658.1	NA
Computing Time (Sec)	41.0	50.1	
Total Energy (Joule)	24,150.8	32,981.2	
Energy Per Task (Joule)	754.7	515.3	

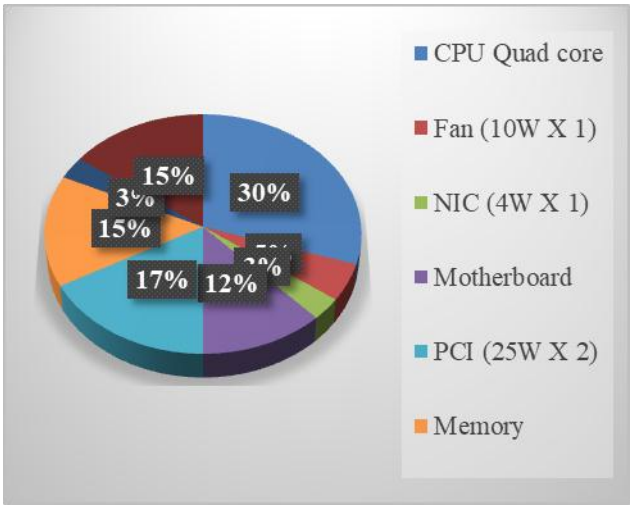


Fig. 2 Power Consumption

Kavita Arjun Sultanpur et. al. 2018 focusing on the cloud server maintenance and scheduling process and to do so, we are using the interactive broadcasting energy efficient computing technique along with the cloud computing server. Additionally, the remote host machines used for cloud services are dissipating more power and with that they are consuming more and more energy. The effect of the power consumption is one of the main factors for determining the cost of the computing resources. With the idea of using the avoidance technology for assigning the data center resources that dynamically depend on the application demands and supports the cloud computing with the optimization of the servers in use. The proposed algorithm is based on the concept of broadcasting with cache concept to get, the request at faster pace. From result simulations, it has been concluded that proposed technique worked well for managing tasks in terms of various parameters like delay = 140 load= 43, energy consumption = 3.5 and CPU mis-utilization = 45 with broadcasting [5].

3. COMPARISON

S. No.	Year	Author/ Title	Description
1.	2009	Robert R. Harmon, Nora Auseklis/Sustainable IT services: Assessing the impact of green computing practices	This paper provides a review of the literature on sustainable IT, key areas of focus, and identifies a core set of principles to guide sustainable IT service design.
2.	2013	Dr. Pardeep Mittal, Navdeep Kaur/ Green Computing – Need and Implementation	This research paper shows the importance of Green computing. Author concern about the Green computing, its needs and steps toward Green computing by a common man
3.	2017	Laith Farhan, Rupak Kharel, Omprakash Kaiwartya, Mohammed Hammoudeh and Bamidele Adebis/ Towards Green Computing for Internet of Things: Energy Oriented Path and Message Scheduling Approach	In this paper, an energy-oriented path selection and message scheduling framework for sensor enabled wireless network environments has been presented. It was shown, form the design, development and analysis of the proposed framework, that the cooperation between path selection and message scheduling approach significantly improves energy efficiency in sensor enabled wireless network environments.
4.	2014	Sukhpal Singh, Inderveer Chana/Energy based Efficient Resource Scheduling: A Step Towards Green	Authos have developed EBERSF and implemented proposed resource scheduling algorithm and tested the performance in a

		Computin	simulated Cloud environment. **QoS Parameter** / **EBERSF** Energy Savings / 23.391 %
5.	2011	Anton Beloglazov, Jemal Abawajy, Rajkumar Buyy/ Energy-aware resource allocation heuristics for efficient management of data centers for Cloud computing	This work advances the Cloud computing field in two ways. First, it plays a significant role in the reduction of data center energy consumption costs, and thus helps to develop a strong and competitive Cloud computing industry. Second, consumers are increasingly becoming conscious about the environment.
6.	2018	Kavita Arjun Sultanpure, Abhishek Gupta, L. S. S. Reddy/An Efficient Cloud Scheduling Algorithm for the Conservation of Energy through Broadcasting	Author concluded that proposed technique worked well for managing tasks in terms of various parameters like delay = 140 load= 43, energy consumption = 3.5 and CPU mis-utilization = 45 with broadcasting
7.	2013	He Ba, Wendi Heinzelman/Mobile Computing - A Green Computing Resource	Author introduced GEMCloud, a mobile cloud computing system that provides computing resources to the user from energy efficient mobile devices. Author provides performance comparisons among various mobile devices and workstations. The results show that the smartphones and tablets have lower individual computing power but much higher energy efficiency. The lower computing power can be made up by recruiting more devices, while the energy efficiency is harder to improve given the same type of devices.
8.	2013	Saket Bhushan, Manoj Chaudhary/An Improvement in Power Management in green Computing using Neural Networks	Author proposed new technique for energy conservation in green computing. This novel technique is based on neural networks. The neural network is having capability of learning from the past experiences. The dynamic clustering approach is used with the neural networks for the energy conservation. The proposed technique is implemented in NS2 and simulation results are shown in the graphical form.

4. PARAMETERS USED FOR MEASURING POWER CONSUMPTION

- Thermal Design Power (TDP): It is the measurement of maximum amount of power required by cooling of computer system to dissipate. It is the maximum amount of power which a computer chip can take when running a real application.
- PUE (Power usage Effectiveness): It is used for comparison of energy used by computing application and infrastructure equipment and the energy wasted in overhead. Value of PUE depends on the location of data centers and construction done for that data center.

$$PUE = \frac{\text{Total Facility Power}}{\text{IT Equipment Power}}$$

Perfect efficiency would give data center a PUE of 1.0. PUE for most of the data centers lies in the range of 1.3-3.0. If a dat acenter has PUE 1.5 then it means when IT equipment has consumed 1kWh, data center has consumed 1.5 Kilo watt hours (kWh) of energy and 0.5 kWh energy has wasted in unfruitful work(it's just an overhead) such as IT equipment cooling, grid power conditioning, lighting of that location and other unfruitful work.

- DCiE (Data Center infrastructure Efficiency) : It is the reciprocal of PUE. PUE and DCiE are most commonly used metrics that were designed for the comparison of efficiency of data centers.

$$\text{DCiE} = \frac{1}{\text{PUE}} = \frac{\text{IT Equipment Power}}{\text{Total Facility Power}}$$

- Performance per Watt: It quantifies the energy efficacy of individual computer architecture or computer hardware. It is the processing rate that can be remitted by a processor for each watt of power absorbed by it. This must be high. It

measures the rate of computation that can be delivered by a computer for every watt of power consumed by it. Normally it is measured in FLOPS (floating-point operations per second) and MIPS (million instructions per second).

- Compute Power Efficiency: It is a measure of the computing efficiency of a datacenter. As each watt consumed by server or cluster did not draw fruitful work all the time, some facility consumed power even in idle state and some consumes power for computing. Although 100% of facility capacity will never be used, but still we want maximum output from the electrical power which datacenter has taken. CPE is defined as:

$$CPE = \frac{\text{IT equipment utilization}}{PUE}$$

$$CPE = \frac{\text{IT equipment utilizationXIT equipment power}}{\text{Total facility power}}$$

- GEC (Green Energy coefficient): It is a measure of green energy (energy that comes from renewable sources) that is used by the facility of a datacenter. For evaluating the environment friendly nature of a data center this metric is used. It is selected as a PUE metric by green grid organization in November 2012. Energy consumed is measured in kWh. It is defined as:

$$GEC = \frac{\text{Green Energy Consumed}}{\text{Total Energy Consumed}}$$

- ERF (Energy Reuse Factor): It is a measure of reusable energy (energy that is reused outside of a datacenter) that is used by datacenter. For making cloud, environment friendly data center should use renewable energy such as electricity generated by wind power, hydro power etc. ERF is selected as a PUE metric by green grid organization in November 2012. It is defined as:

$$ERF = \frac{\text{reused energy used}}{\text{Total Energy Consumed}}$$

- CUE (Carbon usage Effectiveness): It is a measure of carbon dioxide emission in environment by the data center. It is selected as a PUE metric by green grid organization in year 2012. It is defined as:

$$CUE = \frac{E_{CO_2}}{E_{IT}}$$

E_{CO_2}:Total carbon dioxide emission from total energy absorbed by the facility of a data center.
E_{IT}:Total energy consumed by IT equipment's

- WUE (Water usage Effectiveness): It is a measure of required water by a data center annually

$$WUE = \frac{\text{Water used annualy}}{E_{IT}}$$

- Data Center Productivity: It is a measure of amount of fruitful work yielded by datacentre.

$$DCP = \frac{\text{Useful work done}}{T_{resource}}$$

$T_{resource}$:Total resource taken to produce this useful work

- Data Center Energy Productivity: It is a measure of amount of fruitful work yielded by datacenter with respect to energy consumed to yield this work.

$$DCeP = \frac{\text{useful work done}}{T_{energy}}$$

T_{energy}:energy taken to produce this useful work This metric depends on period of time for which DCeP has been calculated.

- SWaP (Space, Wattage and Performance): It is a Sun Microsystems metric for datacenters. It is developed for computing the energy and space requirement of a datacenter.

$$SWaP = \frac{\text{Performance}}{\text{Space X Power}}$$

- Estimating Power Consumption: An estimate of power consumption (P) at any specific processor utilization (n%) can be calculated if power consumption at maximum performance (Pmax) and at idle (Pidle) are known. Use the following formula:

$$P_n = (P_{max} - P_{idie}) \times \frac{n}{100} + P_{idie}$$

5. Conclusion

Green computing is the vital research area, as most the organization are moving towards cloud computing because of it's low cost and high configuration resources are available with ease, on the other hand the power consumption of these cloud data centres are very high. Due to high energy consumption, there is need of power resource, which increases carbon emission. As a conclusion if we apply some efficient algorithm for packet delivery, organizing VM's then power consumption can be reduced, further efficient routing protocol can applied for power transmission over grids of battery such as:

- AODV
- AODV based on TOPSIS
- AODV based on fuzzy

REFERENCES

[1]. Kavita Arjun Sultanpure1, Abhishek Gupta2, L. S. S. Reddy, An Efficient Cloud Scheduling Algorithm for the Conservation of Energy through Broadcasting, International Journal of Electrical and Computer Engineering (IJECE) Vol. 8, No. 1, February 2018, pp. 179~188 ISSN: 2088-8708, DOI: 10.11591/ijece.v8i1.pp179-188

[2]. Gaurav Jindal, Green Computing "Future of Computers", International Journal of Emerging Research in Management &Technology ISSN: 2278-9359 2012

[3]. He Ba, Wendi Heinzelman, Mobile Computing - A Green Computing Resource, 2013 IEEE Wireless Communications and Networking Conference (WCNC): SERVICES & APPLICATIONS

[4]. Anton Beloglazov , Jemal Abawajy , Rajkumar Buyya Energy-aware resource allocation heuristics for efficient management of data centers for Cloud computing, Future Generation Computer Systems 28 (2012) 755–768

[5]. Sukhpal Singh1 and Inderveer Chana, Energy based Efficient Resource Scheduling: A Step Towards Green Computing, International Journal of Energy, Information and Communications Vol.5, Issue 2 (2014), pp.35-52 http://dx.doi.org/10.14257/ijeic.2014.5.2.03

[6]. Laith Farhan, Rupak Kharel, Omprakash Kaiwartya, Mohammed Hammoudeh and Bamidele Adebis, Towards Green Computing for Internet of Things: Energy Oriented Path and Message Scheduling Approach, https://doi.org/doi:10.1016/j.scs.2017.12.018

[7]. Robert R. Harmon1, Nora Auseklis, Sustainable IT Services: Assessing the Impact of Green Computing Practices, PICMET 2009 Proceedings, August 2-6, Portland, Oregon USA © 2009 PICMET

[8]. Saket Bhushan [1], Manoj Chaudhary, An Improvement in Power Management in green Computing using Neural Networks, IOSR Journal of Computer Engineering (IOSR-JCE) e-ISSN: 2278-0661, p- ISSN: 2278-8727Volume 13, Issue 4 (Jul. - Aug. 2013), PP 53-58

[9]. Sathya Sofia, Implementation of energy efficient green computing in cloud computing, Int. J. Enterprise Network Management, Vol. 6, No. 3, 2015