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# A Study of Energy Saving Techniques in Green Cloud Computing

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**Abstract**

Cloud computing focus on the data computing efficiency where as green cloud computing is a new thinking which is based on cloud computing architecture and focuses on the energy efficiency of device and computing. Green Cloud Computing is an approach used to improve the utilization of computing resources those are being used in cloud computing network such as storage, servers, its application, and services and reduce energy consumption of these resources which improves power efficiency. This is done by various technologies such as virtualization and virtual machines migration. This paper reviews the various techniques purposed by the different authors to make cloud computing more energy efficient. The main objective of this paper is to study and analyze the concept of energy efficient data centre architecture, resource allocation and optimization.

**Keywords:** Cloud Computing, Energy efficiency, Virtualization.

## 1. INTRODUCTION

Cloud computing applies virtualization concept for efficient use of hardware and software. It aims to provide ease to its end users with the help of on demand self-service, broad network access, resource pooling, rapid flexibility and measured performance. The emergence of Cloud computing is changing the ownership-based approach to subscription-oriented approach by providing access to scalable

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infrastructure and services on-demand [2]. In cloud computing resources (hardware or software) are made available by one or more provider. These resources can be used by different users on the paid basis. These services provided by cloud computing are broadly classifies as: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS).Cloud service providers such as Amazon, Sales force, Microsoft, Google, IBM and Sun-Microsystems has established many new data centres for hosting cloud applications, business application, gaming portal, media content delivery and scientific processing. For running these data centres a huge amount of energy is required [3]. Power is required for monitors, console, network peripherals, cooling fans of processor and cooling system. As in 2012 the power consumption of data centres was around 38 Giga Watt(GW) which is around 63% more than energy consumption of 2011[4]. Although cloud computing provide financial benefits but its power consumption and carbon emission has became a major environmental concern. Data Centres store large amount of data in cloud and large amount of energy is wasted in the form of heat on cloud. Cloud has become one of the major sources to global warming because of many global warming gases like carbon dioxide, carbon monoxide etc. are released during the electricity generation process. According to Department of Energy (DOE) report [6], Data Centres consumed 1.5% of all electricity in the U.S. in 2006 and their power demand is growing at the rate of 12% an year. These concerns can be resolved by using green computing.

Green computing is defined as an environment sustainable computing. Green computing efficiently manages its resources by keeping environment at centre. The main objective of green computing is to increase the energy efficiency and reduce $CO_2$ emission.

The researchers have provided a variety of software and hardware solutions to the problem of energy efficiency in cloud operation by minimizing the impact of cloud computing on the environment. Virtualization technology can be used to get better resource isolation and less energy consumption through live migration and consolidation. The researchers suggest three types of solutions for making cloud computing green cloud computing that is environment friendly. First solutions software optimization, second hardware optimization and third is network optimization. Further there are two software approaches that are used for reducing energy consumption: reducing the energy consumed by memory and reducing the energy consumed by memory. In this paper we consider all types of approaches and classify them into two categories: approaches using virtualizations and without virtualizations.

## 2. ENERGY SAVING STRATEGIES

Energy consumption and performance of the system depend on many factors. Some simple techniques provide basic energy management for servers in Cloud environments, i.e. turning on and off servers, putting them to sleep. Other techniques for saving energy include use of Dynamic Voltage/Frequency Scaling (DVFS) [7] and use of virtualization techniques for better resource utilization. Various researchers

have put many efforts to reduce the energy consumption in clouds and data centres. In this part we present latest research efforts by researcher that attempt to deal with them.

## 3. ENERGY SAVING TECHNIQUES OF VIRTUALIZATION

One of the techniques that are being commonly used in cloud environment is virtualization. Virtualization helps in decreasing the hardware and operating cost by assignments of multiple virtual machines (VMs) to single server. The assignment of multiple VMs helps in consolidating the task and turning off other physical machines by lowering the consumption of energy. Live migration refers to moving the virtual machines from one physical server to another transparently. The migration of virtual machines is found to be a useful technique for making the systems more energy efficient. VMM could be done by using different algorithm like first fit, Monte Carlo, Round Robin etc. The major technique being used in virtual machine migration is Pre-Copy.

**Table 1.** A summary of various energy efficient techniques

| S.No | Author | Technique used | Strengths | Virtualization | Tools used |
|---|---|---|---|---|---|
| 1. | Kim *et al* (2007)[5] | Applies DVFS to provide a balance between power consumption and tasks deadline | Both DVS schemes reduce much energy consumption with little degradation of deadline missing | No | GridSim Toolkit |
| 2. | Kusic *et al* (2009) [6] | DVFS, Virtual Machine, consolidation, server power switching | Reduce power consumption, To minimize performance loss | Yes | Develop their own tool |
| 3. | Buyya *et al* (2010)[7] | Resource allocation and scheduling adaptive utilization | Quality of services<br>Minimize energy consumption , satisfy performance, Green resource allocator, DVFS | Yes | CloudSim |
| 4. | Belonglazov and Buyya (2010)[ 8] | Effective dynamic relocation of VMs, Minimization Migration, Highest Potential Growth, Random Choice, DVFS | Minimize power consumption, satisfy performance requirements | Yes | CloudSim |
| 5. | Lago *et al* (2011)[9] | Virtual Machine Scheduling and Migration | Algorithm is capable of performing the scheduling of Virtual Machines in non federated homogeneous and heterogeneous data centres, also improve power consumption in loads | Yes | CloudSim |

| | | | | | |
|---|---|---|---|---|---|
| 6. | Feller *et al* (2011)[10] | Virtual Machines Consolidation by Using Ant Colony Optimization | ACO provides superior energy gains through better sever utilization and require less machines | Yes | Develop their own tool kit |
| 7. | Jang *et al* (2011 )[11] | Propose BCFS and BNF policies | The consumed energy ,the average elapsed time to schedule a VM and the average waiting time of VM in running queue are measured | Yes | MPSim simulator |
| 8. | Calheiros *et al* (2011)[12] | Applies DVFS to provide a balance between power consumption and SLA | It results in reduction of energy consumption without violating SLA | No | CloudSim Toolkit |
| 9. | Murtazaev and Oh(2011) [13] | Applies Virtual consolidation method by utilizing FF and BF bin packing | It reduce the energy consumption in homogeneous data centres by minimizing the number of active servers | Yes | Develope their own simulation kit |
| 10. | Sharma and Sharma (2012)[14] | Load balancing Algorithm | Good in reducing energy, pricing and time | Yes | CloudSim |
| 11. | Wang *et al* (2012)[15] | Maximizing resource utilization | Put into account QoS | Yes | CloudSim |
| 12. | Chen *et al* (2012)[16] | Energy Consumption modelling ,and analysis approaches | It helped to identify the relationship between energy consumption and running tasks in cloud environments, as well as system configuration and performance<br>The analytical results correlated system performance and energy consumed which can be important for developing energy efficient mechanism | No | Not implemented |
| 13. | People *et al* (2012)[17] | Workload Allocation | Efficiency can achieved by minimizing the packet loss and efficiency using the residual server capacity with respect to traffic patterns and optimization can achieved by selecting the sever that have speed matching with packet arrival rate | No | OPnet and NS-2 |

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|---|---|---|---|---|---|
| 14. | People *et al* (2013)[18] | Workload Scheduling | An exponential relationship between power cost and sever utilization was found which was used | No | Java Based dedicated tool |
| 15. | Ghribi *et al* (2013)[19] | Virtual Machine Scheduling and Migration | By using the approach of combining the allocation algorithm with migration algorithm in a linear integer program, a significant amount of energy can be saved depending upon system loads | Yes | Java based Simulator |
| 16. | Kord and Haghighi (2013)[20] | Utilizes MCC method to provide a balance between power consumption and SLA. | It measure the total energy consumption and SLA violation<br>This algorithm requires information from the hardware level | Yes | CloudSim toolkit. |
| 17. | Cao and Zhu (2013)[21] | EARES-D utilizes DVFS to schedule DAG workflow based on earliest completion time for a workflow | It results in reduction in energy consumed and improved resource utilization | No | CloudSim Toolkit |
| 18. | Li *et al* (2013)[22] | Consider load balancing of physical resources in virtual Machines placement<br>Migrates the virtual machines to heavy loaded servers | The algorithm showed that multi dimensional resources have well balanced utilizations and good power savings | Yes | CloudSim Toolkit |

## 3. CONCLUSION

The paper starts by introducing the concept of cloud computing, green computing and then the various techniques by which Information technology is moving towards Green IT. An efficient and effective use of computing resources in cloud make it Green Cloud computing, Some approaches discussed in this paper use workload allocation and scheduling and sever profiling without use of virtualization others make use of virtualization technique. Reducing carbon emission and energy consumption in cloud computing data centres make an open challenge and orient toward making green data centres. The study reveals that there are many energy

efficient frameworks for cloud computing and data centres that make cloud computing a Green cloud computing.

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