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# A SURVEY ON ENERGY AWARE SCHEDULING IN GREEN CLOUD COMPUTING

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**Abstract**: Large amount of data growing together needs more computational power, in turn it also needs more energy to work on. Energy optimization and Green Cloud computing are big demand of the time. Reduction of energy consumption leads to reduction of cost, less heat dissipation, less cooling cost, less $CO_2$ emission, more battery time and more computing power for rest of applications. Energy aware schedulers are environment friendly and less error prone too. Many algorithms are developed to schedule resources in energy aware way, but they lack of real time task orientation, deadline-constraints and simultaneous energy consumption with reliability and system performance management. This paper deals with various problems and their solutions implemented or proposed for energy aware scheduling in IaaS cloud environment.

**Keywords:** Software, implemented, Reduction of energy

## Introduction

Software as a Service (SaaS), Platform as a Service(PaaS) and Infrastructure as a Service (IaaS) are three models of cloud computing, which are serving software, platform and computing infrastructure as service in an elastic, pay-as-you-go model. Computing infrastructure includes a simple computer node to a high-end server machine; these machines are not required to be purchase by consumer, but he can use these machines on lease and so it reduces energy consumption, capital expenditure, cost of updating hardware, cooling cost and maintenance cost of computing infrastructure. The focuses of consumer are directly shifted on its business based applications rather than on setting up and maintaining the hardware.

Most of the consumer devices are battery operated so power efficiency and energy aware computing are a need at consumer side while to reduce cooling cost, power and energy saving cloud service provider must take measures to energy aware best practices at its side.

Many individuals and researcher groups are working on energy aware algorithms and Green cloud computing to deal with the problems arising due to aforesaid context. Energy aware algorithms are adopting procedures to optimize energy consumption in balanced, power saver and high performance computing.

Data centers are using techniques to reduce the environmental footprints for both hardware and software as shown in figure 1.

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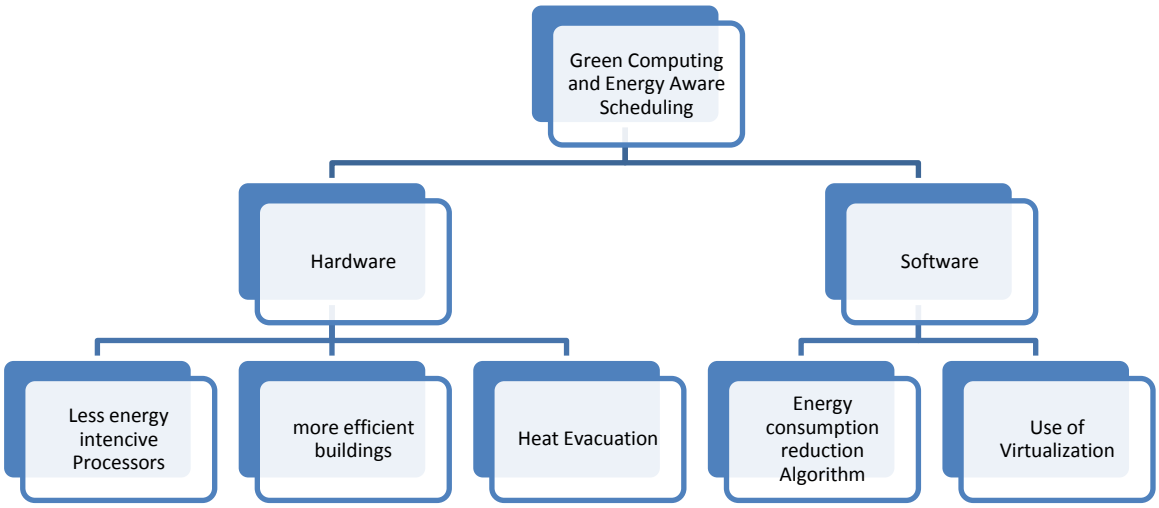


**Figure 1 Techniques to reduce the environmental footprints**

Different methods to reduce energy consumption in cloud environment as given in [1] are shown in figure 2.

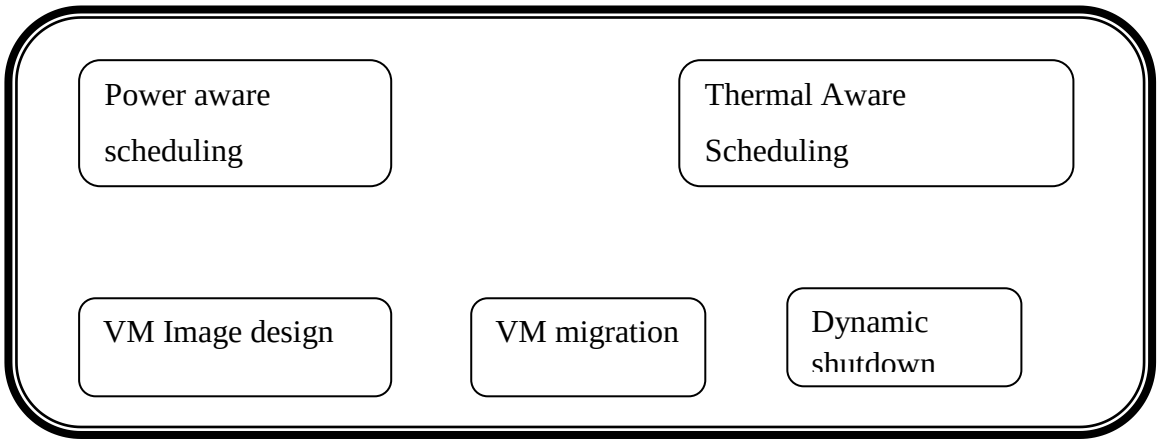


**Figure 2 Methods to reduce the energy consumption in cloud environment.**

The rest of the paper is organized as follows. In Section 2, we discuss large body of literature available in current context. issues in IaaS. Benefits of Green Cloud Computing are presented in Section 3. Tools and technologies for Green cloud computing are discussed in Section 4. Finally, concluding remarks are presented in Section 6.

## Literature Survey

There is a large amount of literature available on Energy-aware scheduling in cloud computing. Garg et al. discussed about requirement of energy-efficient solutions so that Cloud computing impact on environment can be minimized in [1]. They also discussed various elements of Clouds, which contribute to the total energy consumption and to enable green Cloud computing.

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Kim et al. investigated power-aware provisioning of virtual machines for real-time services. Their approach was (i) to model a real-time service as a real-time virtual machine request; and (ii) to provision virtual machines of datacenters using DVFS (Dynamic Voltage Frequency Scaling) schemes. They proposed several schemes to reduce power consumption and show their performance throughout simulation results in [2]. Lefèvre et al. explored the energy issue by analyzing how much energy virtualized environments cost in [3]. They provided an energy-efficient framework dedicated to Cloud architectures and they validate it through different experimentations on a modern multicore platform. They also showed on a realistic example that their infrastructure could save 25% of the Cloud nodes' electrical consumption.

Beloglazov et al. defined an architectural framework and principles for energy-efficient Cloud computing in[4]. Based on this architecture, they presented their vision, open research challenges, and resource provisioning and allocation algorithms for energy-efficient management of Cloud computing environments. They proposed energy-aware allocation heuristics provision data center resources to client applications in a way that improves energy efficiency of the data center, while delivering the negotiated Quality of Service (QoS). They conducted a survey of research in energy-efficient computing and propose: (a) architectural principles for energy-efficient management of Clouds; (b) energy-efficient resource allocation policies and scheduling algorithms considering QoS expectations and power usage characteristics of the devices; and (c) a number of open research challenges, addressing which can bring substantial benefits to both resource providers and consumers. They have validated their approach by conducting a performance evaluation study using the CloudSim toolkit. The results demonstrated that Cloud computing model has immense potential as it offers significant cost savings and demonstrates high potential for the improvement of energy efficiency under dynamic workload scenarios.

Zhou et al. presented a new virtual machine VM placement algorithm named ATEA adaptive three-threshold energy-aware algorithm to use historical data from resource usage by VMs in [5] . In ATEA data center hosts are divided into four classes: hosts with little load, hosts with light load, hosts with moderate load, and hosts with heavy load. ATEA algorithm migrates VMs on heavily loaded or little-loaded hosts to lightly loaded hosts, while the VMs on lightly loaded and moderately loaded hosts remain unchanged. They verified the effectiveness of the proposed algorithms by CloudSim toolkit utilizing real-world workload.

Negru et al. reviewed the methods and technologies used for energy-aware operation of storage systems in data centers in [6]. They also presented some of the key research challenges that arise when such energy-saving techniques are extended for use in cloud storage environments

Djemame argues the need to provide novel methods and tools to support software developers aiming to optimise energy efficiency and minimise the carbon footprint resulting from designing, developing, deploying and running software in Clouds, while maintaining other quality aspects of software to adequate and agreed levels in [7].

Younge et al. have presented a novel Green Cloud framework for improving system efficiency in a data center in [8]. To demonstrate the potential of framework, they presented new energy efficient scheduling, VM system image, and image management components that explore new ways to conserve power. They found new ways to save vast amounts of energy while minimally impacting performance.

Ramani et al. worked on VM migration mechanism in [9]. The objective of their research was reducing the energy

consumption with thermal aware load-balancing in a Cloud centre. Energy savings was achieved by continuous consolidation of VMs according to current utilization of resources and thermal temperature of computing nodes. Ramani et al. considered the situation of over-utilization, under-utilization using resource utilization threshold and control temperature of the host using temperature threshold.

**Benefits of Green Cloud Computing**

Some of the benefits of Green Cloud computing are discussed in this section:

1. Virtualization in cloud computing offers a better use of high-end machines. Virtualization possible the use of one machine in running many applications and improve server utilization rates.
2. Green Cloud computing data centres offers dynamic provisioning of computing resources so maintenance cost of hardware is reduced and reusability of hardware is possible.
3. Computing power as and when needed can be provisioned in Green Cloud computing so consumers are not needed to purchase high-end machines for very little use.
4. Leasing policies used in Green Cloud computing tries to reduce number of servers and consolidates the virtual machines on lightly loaded servers.
5. Cooling cost is also reduced by adopting the green computing principles.
6. Algorithms are used to optimize energy consumption in Green Cloud computing.

**Tools and Technologies for Green Cloud Computing**

OpenNebula, Eucalyptus, OpenStack are the tools, which can be used for IaaS cloud computing on Cloud Service Provider(CSP) side to provision virtual machines to consumers according to their needs and leasing policies.

Greencloud [10] is a sophisticated packet-level simulator for energy-aware cloud computing data centers. Greencloud focuses on cloud communications**.** It offers a simulation of the energy consumed by the data center IT equipment, such as computing servers, network switches, and communication links. GreenCloud can be used to monitor, allocation of resource, workload scheduling as well as optimization of communication protocols and network infrastructures. It is released under the General Public License Agreement and is an extension of the well-known NS2 network simulator.

**Conclusion**

Green Cloud computing and energy aware scheduling in clouds is vital for safe environment. Carbon Dioxide emission and wastage in manufacturing and packing of computer goods lead to environment pollution. Green Cloud computing offers reuse and full utilization of available resources thus saves energy for subsequent applications. This paper described Green Cloud computing and energy aware scheduling. Benefits of Green Cloud computing are also discussed. This paper may be useful for students, researchers and practicing engineers who are engaged in Green Cloud computing and energy aware scheduling.

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