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A Study on Efficient Energy Utilization by Data Centers in Cloud Computing

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ABSTRACT- As the advancements are going on its peak position in computational operations and revolutionizing the IT world in the past decades, computing has now become the utility for every task in the real world. In recent years, the term "cloud computing" comes in IT field. Cloud is a fairly growing and new technology, which is famous for providing computing infrastructure as a service on demand over the internet. However, Cloud applications hosted on data centers consume huge amounts of energy causes number of issues like huge impact on environment by data centers through CO_2 emission and higher energy costs etc. Therefore, to reduce the impact of these issues a new term Green Cloud computing comes that gives solutions for these problems by saving energy of data centers. This paper gives an insight into, how energy efficient algorithms worked for giving an eco-friendly environment.

Keywords: Cloud computing, Green cloud, data centers, energy consumption, SLA.

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1. INTRODUCTION

The cloud is a fairly growing technology, with the rapid development of cloud services the storage of data in the cloud increases day by day. Cloud computing is mainly defined with five attributes: scalability, multitenancy, rapid elasticity, pay as you go and self-provisioning of resources [1]. These five attributes define all the characteristics of cloud computing. Furthermore, cloud also provides a convenient way for accessing stored data on the cloud by users from anywhere and anytime on any device with internet connection. Cloud computing supports number of services defined as "XaaS", where "X" can be software, platform or infrastructure as a service. When a cloud is available for general public or all users publicly access the cloud services in demand called public cloud. When cloud is personally used by a single organization for its own work, then it is called private cloud. When both public and private cloud merges then hybrid cloud is formed [2].

Mainly three-layered service model is used in cloud computing as in Fig 1. When some software are provided by Cloud service provider to cloud users with no worries to install, update or purchase a Software, then it is named as SAAS. If a Platform is given to consumers for developing and deploying their applications on cloud then simply it is called as PASS. IASS basically gives only infrastructural based resources like storage space, Network bandwidth, servers etc.

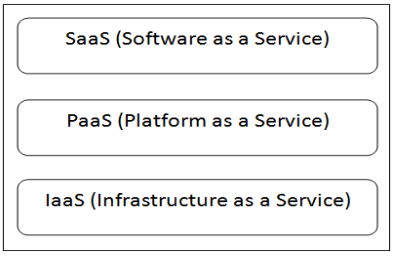

Figure 1: Service Models

Over last decades, cloud services become more interactive or popular due to parallel computing operations performed by data centers. Data centers are the core concept of cloud computing which mainly consist of hardware facilities that are properly configured. So, cloud service provider considers that data centers have the highest computing capability. As cloud computing is the best paradigm for providing on demand resources. To fulfill the demands of all customers for requesting resources at one time requires a lot of energy. Because number of servers work at same time that consumes lot of power consumption. So, such a large amount of energy and power consumption is the big concern. As operation cost is also increased by consuming lot of power and energy while allocating resources or services to users.

When data centers consume power for computational operations then lot of heat is produced. After the generation of heat; cooling of system requires whose cost is nearly $2 to $5 million per year [3]. So, firstly a power saving technique is required for making the data centers hardware capabilities more efficient. Our main focus is to how energy is managed efficiently so that computing cost and power used by data centers is reduced. As the number of servers work for satisfying user demands are generated dynamically; if the number of server will be reduced for performing user tasks then this will gives great support for increasing the overall energy efficiency

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of data centers. Through server virtualization or consolidation of virtual machines is proved as an excellent work in green cloud computing [4]. It is necessary for every cloud provider that gives a satisfaction or degree of assurance of cloud resources called SLA. So, the SLA acts as the negotiator between a cloud service provider and users for accessing the services of cloud. Before deploying a data-file, application or infrastructure to cloud a consumer needs an SLA. So, it is also a big issue while reducing the energy consumption of data centers with less violation of SLA.

Green cloud computing is produced not only to reduce the computing costs or efficient processing of all processors but also minimize the energy or power consumption of data centers. Green cloud computing is nothing it just reduces the number of servers for performing multiple tasks than already used. To achieve a green cloud computing paradigm it is essential that main focus of work is to manage the energy efficiently for the resources of data centers.

2. RELATED WORK

Several challenges and issues come for reducing energy consumption by data centers in green computing pay much attention in today's research community. As huge efforts being performed for building an energy efficient model so that operational cost and power consumption reduced. There are number of algorithms proposed for efficient utilization of resources with different types of computations. Motive of each algorithm is that each provides energy efficient model that helps to achieve all the requirements of users for resources with QoS defined in SLA [5]. Such type of systems are worked for green cloud computing. In these systems work is performed for power or energy management.

The first research work for managing the power has been defined in [6]. Author proposed a technique for managing power used by data centers. The main focus of work was to manage the power by using cluster-based system. Heterogeneous cluster of physical machines was used for minimize the power consumption. A power on/off technique was used for increasing the productivity of work. The proposed algorithm in [6] not only works for scheduling the resources but also minimizes the power consumption by putting idle server on sleep mode. The main problem that found is that reconfiguration operations are more time consuming as used algorithm only add/remove one node at a time. Pinheiro et al. [6] have proposed a phenomenon for saving the energy consumption by turning idle servers into off mode from on mode. Main focus was only on saving energy nothing was done for live migration of VM if the dynamically load increases on servers.

M. Gupta et al. [7] have suggested the idea of efficient energy utilization by inter-net service provider (ISP). As all above proposed algorithms worked for efficient resource allocation to servers so that energy is saved. But in [7] all attention was paid on Network routing. By putting all switches, routers and network interfaces into sleep mode when they not worked for the efficient utilization of energy. Network traffic was also reduced by efficient routing mechanism. R Nathuji et al. [8], worked for the power management of servers through live migration of VMs by using heuristic operations. But the proposed algorithm not strictly followed the SLA rules. Violation of SLA was more due to the variations performed by the workload during live migration.

Raghavendra et al. [9] have suggested, for data center environments a number of key challenges are there like power management, heat management and electricity consumption. On these challenges individually work is performed but, in this author, combined all the challenges and work by coordinating all these solutions. But as there are some limitations found at the end of work, this approach also have some flaws. It failed to support the SLAs conditions. As SLA is the agreement between consumer and cloud provider, its support is essential for giving better energy efficient results.

Kusic et al. [10] addressed the problem of power management for virtual systems with heterogeneous environment. Work was performed using Look Ahead Control (LLC) and special filter was used for predicting the future request count. But the proposed model is not reaching the boundaries of optimal or efficient results. It used heuristic approaches that were not well suited for large system. Execution time was also increased due to the complexity of the used model.

A Kansal et al. [11] worked for the problem of scheduling using virtual heterogeneous environment. Main focus of the work was to minimize the energy consumption. Author found out that during workload consolidation as different types of resources were present; performance was degraded. For the optimal utilization of different types of resources the proposed algorithm was worked for the solution of bin packing problem faced during worked consolidation.

In [12] author gave a new turn for energy saving through Network paths by Internet Service Provider (ISP) rather than Cloud Service Provider (CSP). Lot of research was started from this idea on energy saving of network interfaces. Similarly [13] [14] also worked for the energy saving and improve the network performance. All proposed algorithm worked for Network traffic management [13][14] proved that while optimal utilization of network devices the performance of whole network is scaled and only those network paths followed that consumes less energy.

L. Thomas et al. [15] suggested how data was transferred on a network by using network aware scheduling algorithm. [15], Also worked for saving the energy through meta scheduling of resources. Message passing interface (MPI) problem was encountered and investigated that how message was transferred on network paths with minimum energy utilization.

Cheng-Jen Tang et al. [16], discussed as the growth of cloud computing increased the demand of energy consumption by data centers also rapidly increased. For power consumption by data centers some patterns were used by traditional methods. As technology changed the methods used for energy consumption by data centers are also changed. Now computation-based methods are adopted by CSP for making efficient energy use by data centers. The best way for managing the power consumption

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resource request forecasting is used. New approach was adopted that worked for calculating the number of future requests by predictions. So the power demand is accurately predicted for future use and energy used by data centers is controlled with the help of dynamic adjustment of load.

Rajkumar Buyya et al. [17] worked for green computing environment by efficient scheduling mechanism and migration of VMs. Algorithm was used for allocating resources to physical machines, then migration of VM from one physical machine to another was performed based on the available load. Minimization of Migration (MM) algorithm was used in which VMs migration was based on threshold values. The proposed algorithm was best suited for reducing the energy consumption without violating the SLA requirements.

Hugo H. Kramer et al. [18], in data centers huge number of servers present and each server have number of VMs. From users' number of requests comes for different services to servers and each server has efficiently work for requests to fulfill their needs. For efficiently and robust performance a cluster was formed which is made up of different servers but same type of requests. A virtualization method or technique was adopted by server named as server virtualization so that energy is maintained efficiently. A proper cluster architecture and modern server-based cluster platform was used. For allocating a request to server; an efficient server was selected from a particular cluster with cluster optimization. A column generation technique was used for solving all the issues related to efficient energy consumption.

R.Karthikeyan et al.[19], as rapid development of deploying applications on cloud increased the power consumption of data centers. Data centers are the main part of distributing load on different machines. As number of servers is hosted and depends on their utilization- energy is consumed. Main focus by the author is to reduce the energy consumption load and operational cost with the help of some heuristic approach as live migration of VMs. When load was increased on a server then there was a need for migrating the VMs without effecting the execution and response time. Migration of VM was also selected in two ways either regular or live. In regular migration server have to pause while migrating VM, But author selected the live migration technique for ensuring the less energy consumption and QoS.

S. Subbiahet et al. [20] discussed that power consumption by data centers becomes a big challenge for IT world. The utilization of resources is directly proportional to the energy used by data centers. In this, author worked for a private cloud environment with efficient energy usage model. Data centers consumes lot of power while consolidation, migration and virtualization. So, a power aware algorithm was used for efficient allocation of resources to each VM. Author proposed a model in which whole infrastructure was monitored for availability of resources then a energy model was applied for optimum use of power. Whole focus given on energy consumption by data centers but future work of this paper is to reduce the cost for allocation of resources to host, so that QoS is attained with minimum maintenance and operational cost.

C. M. Wu et al. [21] defined a new technique called DVFS (Dynamic Voltage Frequency Scaling) used for scheduling the resources to data centers. As number of jobs or applications are requested by customers at one time. For completing all the jobs in an efficient manner, a proper scheduling of resources is required when all the jobs executed in a less time than automatically rate of power consumption is decreased. From this algorithm it was concluded that increasing the resource utilization will decrease the power consumption.

D. M. Batista et al. [22] discussed that energy efficiency in cloud computing becomes the hot topic of research. In cloud environment data centers are responsible for consuming huge amount of power compared to other energy consumption resources around worldwide. So, focus is to reduce the power consumption as much as possible by data centers. Author worked for the placement of VMs on hosts so that total number of used hosts reduced in their computing. Two heuristic techniques were used one was based on evolutionary computing and other was based on Knapsack problem. For implementing these techniques, a homogenous environment is designed and simulation is performed.

In [23], data centers in cloud computing environment have the responsibility to manage the requested tasks, network traffic and optimize the power consumption. Main focus was given for reducing the power usage by data centers through efficient resource allocation mechanisms. Author proposed a genetic algorithm for managing the tasks in power efficient manner. In this paper a static allocation of independent tasks to machines is used. But when the concept of dynamic task allocation comes this approach was failed. Another limitation of this work is that it only supports for homogenous environment.

L. Xu et al. [24] gave a new path or way for reducing the energy consumption and its impact on environment by proposing a new approach based on virtual data centers. All the heuristic algorithms used the concept of virtualization technology in two ways, either using virtual machines or virtual server environment. In [25], for establishing the communication through network between VMs, virtual data centers were used. For moving steps towards green environment virtual data center approach proved a less emission of CO_2 by virtual data centers and reduces the overall energy consumption. W. Kwon et al. [25] solved the problem of power by proposing a newer power shared framework based on power supply capacity and power consumed by servers. The proposed model supported power redundancy which helped to reduce the concept for installing extra power supply to servers that mounted on racks. By sharing the power at each server that already worked and attached with main power supply board the total power consumption is reduced.

C. T. Chang et al. [26] paid attention on the power of physical machine either run or turned off. The whole process worked for saving the energy consumption by physical machines. Migration of Physical machine is performed on the basis of some computations. A heuristic technique with some computations like calculates the ratio of resource weight of VM over physical machines was applied. The results of this

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approach realized that allocation of resources or load to running physical machines helped to achieve the goals of efficient energy consumption in green cloud computing. Proposed work is applicable only for usage by CPU and memory for allocation of resources other factors like bandwidth, disk spaces etc. might be implement in future.

3. ARCHITECTURE OF GREEN CLOUD

The main focus of this paper is for enabling an efficient resource allocation, to achieve the green computations for data centers. *Figure 2* shows the green cloud computing high level architecture with main four entities: Consumers/Brokers, Green Service Allocators, Virtual machines and last but not least physical machines. The various components are:

(i) **Consumers/Brokers:** Brokers just have to submit all the requests that come from worldwide users to cloud.
(ii) **Resource Allocator with Green concept:** It basically provides interaction between brokers and cloud. For supporting efficient energy management resources number of components worked as:

a) **Green Negotiator:** Provides communication between customers and cloud providers to finalize the SLA documentation.
b) **Energy Monitor:** It monitors all physical machines for turning into power on/off mode.
c) **Service Analyzer:** It just analyzes the requirements of the requests that are submitted for operations. All decisions are taken before accept or reject the requests.
d) **Service Scheduler:** Scheduling of resources to VMs is performed by service scheduler.
e) **Consumer Profile:** Check the profile of all requested users for resources, so that special privileges or priorities given to users.
f) **VM manager:** It just checks whether the VM are available or not for performing user requests. If migration of VM is required than it is also the task of VM manager.
g) **Pricing:** All charges of the service requests are decided on the bases of demanding resources.

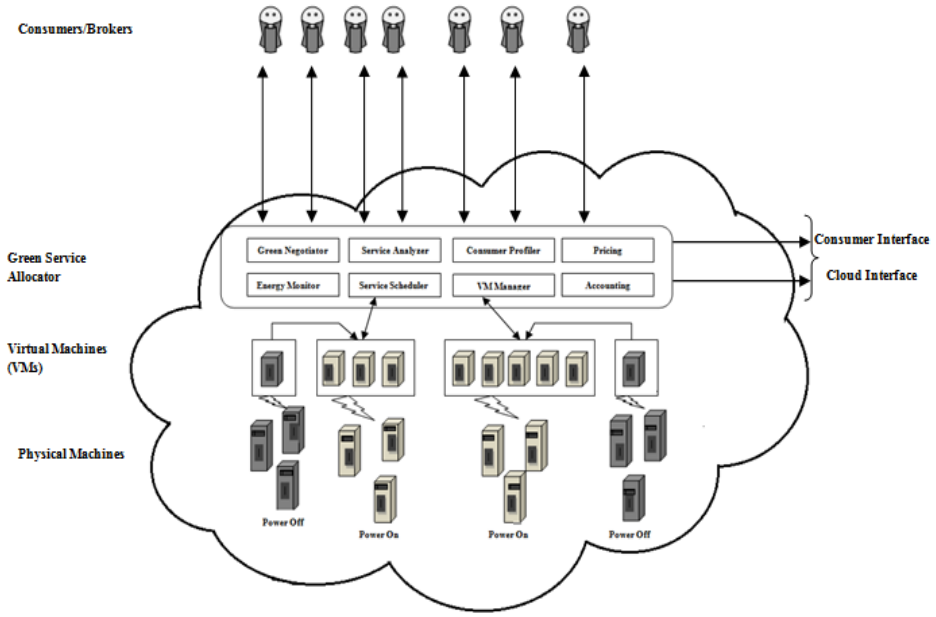

Figure 2: Green Cloud Architecture [5]

(iii) **VMs:** When large amount of requests comes from user side for resources and it is complicated for completing all the requests efficiently by single machine then there is a need to create an imaginary environment for meeting accepted requests. So virtual machines have imaginary environment that dynamically initialized and finished on a actual single physical machine. VM provides greater flexibility by partitioning various resources on a single machine.
(iv) **Physical Machines:** These are the actual servers that help for creating virtualized resources to fulfill the user requirements with infrastructure services.

4. VIRTUALIZATION TECHNOLOGY FOR MINIMIZING THE ENERGY CONSUMPTION

When multiple operating systems or VMs run on a single server on node it reduces the power of hardware in use. As virtualization creates an imaginary environment for performing simulations or experiments that are not possible to implement in a real word due to some constraints like cost, infrastructure or time. Virtualization plays an important role for saving energy with less power consumption by data centers. In data centers, performing consolidation through virtualization number of

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physical machines reduces; a single machine runs multiple jobs at a time. SLA is part of a service contract in which services are properly defined with various aspects like scope, quality and responsibility. Basically, it is a contract between the cloud service providers and consumers.

SLA is the essential part for each various service. When any user wants to move his application on its hardware to cloud then he should need to achieve some service levels as customer level, service based or multilevel SLAs. As data centers have number of characteristics like bandwidth, power, time etc. So, SLA for cloud services mainly focus on data center characteristic so that customers are aware about up to date and consistency of an evolving cloud provider.

5. CONCLUSION

Power consumption by computing resources is increased day by day as technology grown up shown in *figure 3* Saving energy of data centers becomes big challenge in cloud computing. To optimize the use of resources with the help of effective resource allocation algorithms is a big concern. The resource utilization by process or tasks is directly related to energy consumption. Number of operations has been performed for saving energy like consolidation of VMs, migration of VMs or scheduling algorithms. But each has some problems, mostly the violation of SLAs. In future a hybrid algorithm may be proposed with less consumption of energy by data centers.

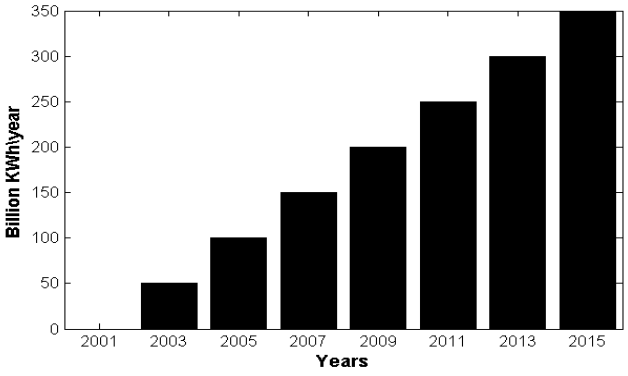

Figure 3: Energy Consumption by data centers per year

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