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A Review On Energy Efficient Cloud Computing Algorithms

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Abstract

There is a great demand of powerful data centers (DCs) because high performance cloud computing is required in every field such as business and web applications. These DCs uses large amount of power and emits large amount of CO2 and heat in the environment. CO2 contributes to green house effect and to make the environment eco friendly, energy efficient cloud computing is required. To decrease the power consumption , if the size of DCs is minimized then performance is compromised and SLA violations takes place, so to get full performance with less power consumption green cloud computing approach is followed. There are different algorithms that decrease the power consumption with the help of virtualization and energy efficient scheduling of virtual machines (VMs).

Keywords: Energy efficiency, Cloud Computing, VM placement, VM migration, Virtualization, Energy Consumption.

1. INTRODUCTION

Energy efficiency in cloud computing is becoming very important due to the use of cloud computing in every field. With the fast development of cloud computing, the data center is becoming larger in scale and consumes more energy [1]. Green cloud computing is required because the CO2 emissions is so large by these DCs that it is contributing to global warming and the large amount of power consumption by these DCs is also required to be reduced [2]. Data centers are the facilities that support such huge data processing [3]. According to the Gartner Report [4], power consumption by the average DC is so much high that it can serve for power source for 25000 of homes.

In present time every business is upgrading from traditional to online and increasing the demand for servers because Cloud computing provides basically three types of services: Infrastructure as a service (IaaS), Platform as a service (PaaS) and Software as a service (SaaS) so large no. of business are shifting on online. At present some major cloud providers are Amazon Web Services , Microsoft Azure and Google App Engine [5-7]. So new DCs are made and that are doing more energy consumption every year. These new DCs will require cooling requirements that will lead to more emissions of CO2 and more power consumption [8]. So energy efficient cloud computing is required to minimize the power consumption [9].

An idle server consumes about 70% of its peak power [10]. That means even if the server is not in use it is using 70% of its peak power and that leads to the major energy inefficiency. So the major task of energy efficient cloud computing is to reduce this waste of energy by the servers. Intel's Cloud Computing 2015 Vision also focus on the need for dynamic resource scheduling which approaches to save energy of data centers by switching off the idle servers.[11]

To reduce the power consumption virtualization is used for cloud computing. Fig.1 [12], shows the VMs and Servers in cloud computing. The VMs emulates the physical environment and are used to reduce the hardware. As shown in the fig.1 [12] a Physical Server comprises n no of Virtual Machines and a Data Centre comprises of n no of Physical Servers. We can achieve Green Cloud Computing by saving energy by managing the VMs and Physical Servers. So an energy efficient algorithm manages VMs and Physical Servers and saves energy.

With the emergence of Cloud computing many companies are shifting from traditional to online services and they are using the services of DCs. Many companies do not have their own clouds; they outsource the cloud services from other companies (e.g. Amazon EC2)[13]. These companies act as cloud providers for the other companies. These companies offer reliable Quality of Service (QoS) to the costumers in a service contact which have Service Level Agreement (SLA) [14]. SLA typically have a technical definition in terms of mean time between failures (MTBF), mean time to repair or mean time to recovery (MTTR); various data rates; throughput; jitter; or similar measurable details[15]. To ensure QoS Cloud providers cannot compromise with the performance and thus work is being done to ensure performance and to minimize energy consumption.

Live migrations technologies can achieve the efficient management of resources in a cloud data center [16]. Energy can be saved by live migration but only a few research activities, have investigated the real scenario in which the impact of live migration on multi-tier applications is recorded[17],[18]. Various algorithms exists which minimize energy consumption. In these algorithms live migration of VMs is done to free the servers that have fewer loads and by shifting VMs from servers having fewer loads to servers having larger loads. The server should be switched off when they are idle and energy can be saved [19]. These energy savings are significant during different loads. [20] Presents scale up and down servers dynamically, aiming to improve resource utilization and implement load balance.

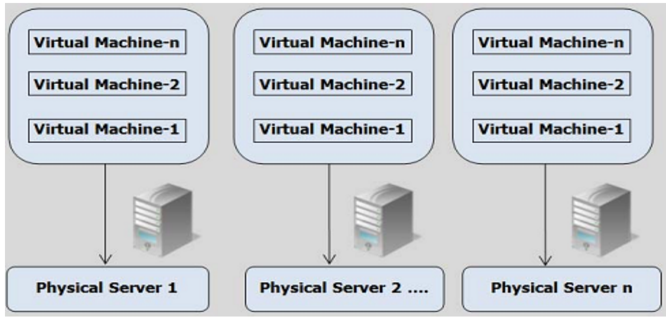

Figure1. Servers with Virtual Machines diagram.

2. ENERGY EFFICIENT CLOUD COMPUTING ALGORITHMS

There are many algorithms that are developed for achieving Green Cloud Computing. Few Algorithms are discussed below.

A. Exact VM Allocation Algorithm

This algorithm is extended Bin-Packing approach. It includes constraints and equalities in the algorithm as valid conditions [21]. In this algorithm the VMs are packed into a set of servers according to the power consumption.
This algorithm's main objective is to do optimization by limiting the server migration and capacity of servers. These two things are achieved by inclusion of valid constraints.

(1) Power capacity of a server cannot exceed from maximum power.
(2) SLA cannot be violated by cloud provider and VM should be allocated to only one server.
(3) When the server is idle it should be switched off.

B. Exact VMs Migration Algorithm

In this algorithm VMs migration is optimized[21]. During the completion of a VM there is a need to fill their place optimally with the other VMs that are running in the other servers to balance the load such that maximum utilization of a running server is achieved within their capacity limits.
The objective to migrate the VM from one server to other is that the servers that have less VM working on it should be made idle by optimally migrating VMs to other server that will lead to energy saving. There are constraints in VM migration to have optimal results.

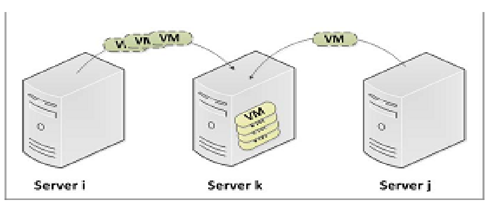

Figure2. Example of VMs' migration
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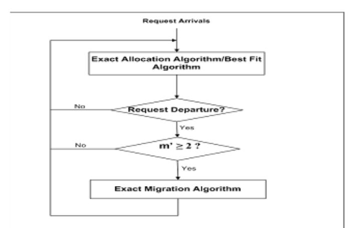

Figure3. Combination of migration algorithm with the two allocation algorithms

(1) When a VM 'is migrated from one server to other than the migration should be specific that means if a VM is migrated from server i to server j (see figure 2) [21], than it cannot be migrated to server $k \neq j$.
(2) A server maximum power cannot be exceeded. If a Server has reached its maximum power than no VM is migrated to that server.
(3) If VMs are migrated from server i to make it idle that its all VM should be migrated so that it can be switched off.
(4) Total no of empty servers are bounded by inequality .
(5)If a VM is to migrate that has very less time for completion and its migration time that is more than its lifetime than it should not be migrated.

C. Combination of allocation and migration algorithms

The allocation and migration algorithms are combined (figure 3) [21] to save energy.These algorithms are combined to optimally migrate VM and to use resources that are free after the completion of jobs.

D. Sorting VMs and PMs to Minimize the use of PMs

In this algorithm [22] PMs' minimization is done. In this the set of VMs and set of PMs are sorted accordingly.
(1) VMs are sorted in descending order according to requirement of cores and execution time.
(2) PMs are sorted according to the number of VMs running on them and resources left.

In this algorithm sorting is done so that the PMs that are already executing VMs have priority over other PMs that are not executing any VM. Suppose a PM_1 is executing VMs and PM_2 is in idle state then if a new VM is introduced and PM_1 has required cores to execute that VM then PM_1 will be selected for executing new VM.

This results in saving of energy. The sorting process for VMs happens in starting and whenever a new VM is allocated to PM sorting process of set of PMs is executed.

E. Sorting VMs and PMs to Minimize the use of PMs and Executing VMs with similar Execution Time on Same PM

In this algorithm VMs with similar execution time are executed on the same PMs that saves the energy consumption rate[5]. For example, suppose there are two PMs (PM_1 and PM_2) each one with 10 cores available. There are three VMs (VM_1, VM_2 and VM_3) with execution times in hours (8, 1 and 9) and 4 cores requires for processing. According to algorithm F the execution will be done such that PM_1 will be selected to execute VM_1 and VM_2 and PM_2 will be selected to execute VM_3.So in this PMs run for only 1 hour in 100% utilization thus wasting energy but if this execution is done according to proposed algorithm than PM_1 is selected to execute VM_1 and VM_3 and PM_2 is selected to execute VM_2 that means PMs will run on 100% efficiency for 10 hours and will utilize resources maximum and thus saves energy.

F. Energy-aware Migration Algorithm

In this algorithm migration of VMs is done optimally to save energy[12]. This algorithm is divided into three parts.

(1) Victim Selection.

In Victim Selection the Servers that are needed to be switched off to save energy are find out. Servers that are below the threshold value as PoT (Power off Threshold) are selected to switch off. When VMs complete their task the load on server decreases and when load is very less on the server their threshold value become less than Pot and then the VMs are migrated to other servers so that the victim server is switch off and energy can be saved.

(2) Target Server Selection.

In Target Server Selection the servers that are needed for VMs to place from Victim Server are find out. In this algorithm Target Server is selected on first-fit allocation method.

(3) Switch on Server.

In Switch on Server the Server are woken up from sleep mode. When the threshold value of a Server is above the WoT (Wake up Threshold) then the server that are in switch off mode are woken up so that load from the Servers whose value of threshold is reached to WoT is transfer to newly waken server. Few VMs are transferred to new Server to balance the load. In figure 4 it is supposed that PoT value is 1 and WoT value is 5 for Server Load.

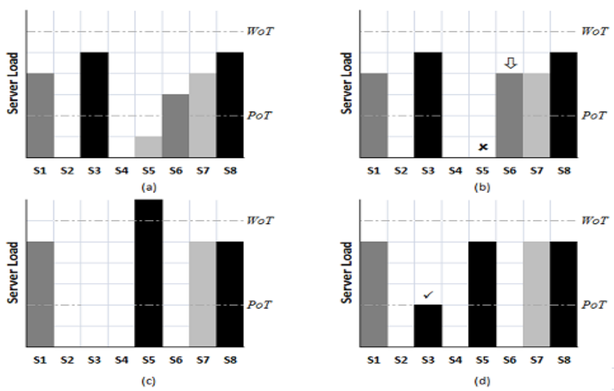

Figure4. Server load scenario: a) S5 is under PoT b) S5 switched off and VMs migrated to S6
c) S5 above WoT d) S3 is switched on.

3. Experimental Results

In this paper various algorithms are discussed and compared. Different Columns are used to compare the different algorithms on different parameters. First column specifies the name of algorithm. Second Column tells about the approach used while making the algorithm. Third Column tells about the energy saved by the proposed algorithm. Fourth column tells about the tool used for carrying out results and Fifth Column tells about the important factors considered while making the proposed algorithms.

These results are shown in tabular form in Table I.

Table1 I: COMPARATIVE STUDY OF ALGORITHMS

Algorithm	Approach used	Energy saved	Tool used	Factors Considered
Exact VM Allocation	Extended Bin-Packing	90% more than Best-Fit formulation and heuristic algorithm [21]	Java language implementation and CPLEX	Energy saving, memory, storage, minimize power consumption

Combination of allocation and migration algorithms	Extended Bin-Packing and Integer Linear Program (ILP)	95% more than Best-Fit formulation and heuristic algorithm [21]	Java language implementation and CPLEX	Minimization of active servers, maximization of ideal servers.
Sorting VMs and PMs to Minimize the use of PMs	Sorting applied to SPMs and SVMs	29% more than Custom Round Robin Allocations[22]	The UnaCloud Infrastructure [16]	VM execution time, PMs and VMs resources
Sorting VMs and PMs to Minimize the use of PMs and Executing VMs with similar Execution Time on Same PM	Sorting and Executing VMs with similar execution time on same PMs	30% more than Custom Round Robin Allocations[22]	The UnaCloud Infrastructure [16]	VM execution time, PMs and VMs resources
Energy Aware Migration Algorithm	First Fit allocation	22% more than Dynamic Round Robin[8] and Random Choice Method[13]	Custom Built Simulator	Load Balancing, minimization of active servers.

4. CONCLUSION

In this paper various algorithms are discussed that are saving energy in cloud computing. All algorithms are saving energy according to their various constraints that are making them energy efficient algorithms. In this paper, important techniques are discussed such as VMs placement and VM migration. In Exact VM Allocation cost of allocation is reduced and in Exact VMs Migration cost of migration is reduced. In Sorting VMs and PMs to minimize the use of PMs, main focus is on reducing the energy consumption and usage of fewer resources. These algorithms are saving useful energy in different processes that takes place in Virtual Machines. Significant energy savings are obtained in these algorithms. These energy savings varies during the different loads and scenarios. As we are introducing Cloud Computing in every field, these energy savings will helps in decreasing the power bills and making environment eco friendly that is very much valuable in present time.

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