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# Survey on Energy-Aware Cloud Computing Algorithms: A Review

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**Abstract:** Cloud computing is an elastic model which is used to satisfied changing needs of users. It provides pay as you go services (PaaS, SaaS, and IaaS) to the users. The growing trend of cloud computing has raises the concern of energy efficiency in cloud computing because a data center consumes lots of energy and emits carbon-dioxide in the environment. Today, the main focus of researcher has been diverted from cloud resource management to energy management. Various algorithms on VM allocation, migration, task scheduling and load balancing have been developed to ensure minimum energy dissipation in cloud data center. The main focus of this paper is study the existing algorithms and to analysis the best algorithms.

***Keywords***: *energy efficiency, vm-migration, load-balancing, vm-allocation*

## I. INTRODUCTION

Cloud computing is a service delivery where resources are provided to the users through internet. It is dynamic scalable technology which is developing to satisfy changing requirement of users. It is a pay per use model. In this model a large task is divided in smaller tasks which are allocated to systems having multiple servers. This assignment is done based on various allocation techniques. In 2013, various companies such as Apple, Google, and Microsoft has opted this technology to provide quick and efficient services to the users. This technology was supposed to achieve billion dollars. But, the high consumption of energy in cloud data centers proved to be a greatest hindrance in the boom development of this technology. On an average, energy consumption of one data center is equal to 25000 households [1] which is about 2% of worldwide energy consumption [2]. This increased energy consumption raises the emission of $CO_2$ which causes the green house effect [3] on the environment and on other side this increased energy consumption also raises the cost of services. Due to this, the main focus of researcher is diverted from resource management in cloud computing to energy efficiency in cloud computing. Energy efficiency in cloud computing can be achieved by focusing on various parameters like task scheduling, load balancing, VM migrations and VM allocations. The objective of this paper is to study and review various algorithms that are developed on these techniques and contributes towards energy efficiency.

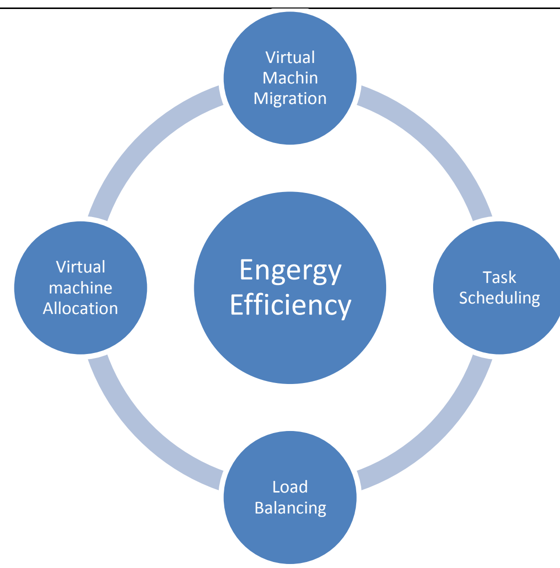


Figure.1 representing various ways to improving energy efficiency in cloud computing

## II. LITERTURE ON VM MIGRATION

**VM Migration**: Among these parameters, my concerned area is VM migration. It is a technique in which one or some VMs are migrated to another hosts to achieve: load balancing, online maintenance, energy management etc. [3]. If the VMs migration is not done judiciously, it adversely affects the performance of running application or incurring the overhead caused by memory pre-copy, extra network load, extra communicational dependency between virtual machines [4].

 

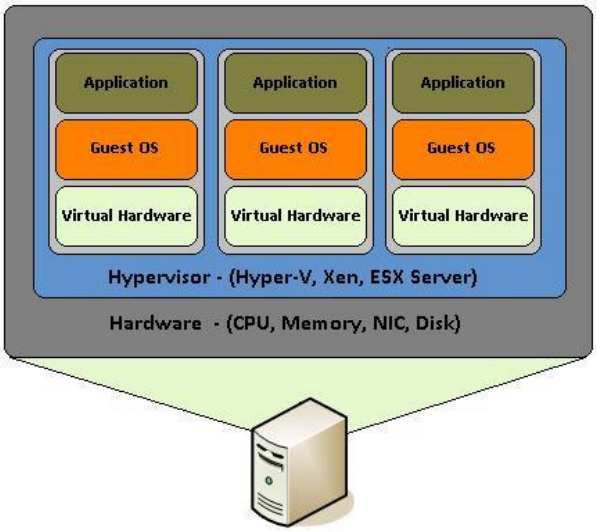


Fig.2

Figure.2 Shows virtualization over single physical machine

The selection of VM for migration and physical machine for placement is a crucial issue in reduction of energy dissipation. A special attention is required for the aforementioned problem which attracts lots of researchers' attraction now days.

VM Migration policies are comprised of three main components [5]:

- Source Host Selection
- VM Selection
- VM Placement

In the first step, host machine is selected from where VMs are to be migrated. This selection may be due to the overheating of the server, server consolidation or underutilization of the server. In the next step, one or more VMs are selected which are to be migrated. The VM selection is a crucial issue because wrong selection may some time lead to deterioration of QoS. Many algorithms such as Random Choice (RC), Minimization of Migration (MM), Minimization of Migration Time (MMT), Maximum Correlation (MC), and High Potential Growth (HPG) are used for VM selection. The problem of these VM selection algorithms is that some time the wrong VM selection leads to increase in migrations and under utilization of system capacity.

In VM placement, the destination host machine is selected where the selected VMs are to be placed. BFD, MBFD, PCA-BFD, UP-BFD are some algorithms that can be used for optimal host destination host selection.

***Random Choice (RC):*** In RC algorithm, selection of VM from physical machine is made randomly [6, 7]. This algorithm has lowest computation time O(1) but the results of this algorithm are not highly optimized because there are high chances of wrong VM selection.

***Minimization of Migration (MM):*** The task of MM is to select minimum number of VMs that are to be migrated. MM algorithm works on upper and lower threshold values [8]. The basic idea of MM is keep the total CPU utilization of a host between pre decided threshold values. If this utilization is less than the lower threshold value then the current PM is turned off after migrating all the currently allocated VMs to another PMs. Some VMs are migrated to other PMs if total CPU utilization of host exceeds the upper threshold value.

***Minimization of Migration Time (MMT):*** The purpose of MMT algorithm is to select VM (v) which has lowest migration time [9]. The selection is made in the following way:

$$v \in V_j \mid \forall\, a \in V_j, \frac{\text{RAMu(v)}}{\text{NETj}} <= \frac{\text{RAMu(a)}}{\text{NETj}}$$

Here $RAM_u(a)$ is the RAM utilization by machine a and $NET_j$ is the spare network bandwidth of host j.

***Maximum Correlation Policy (MCP):*** In this algorithm Multiple Correlation Coefficient [10] is used. The purpose of this method is to find out those VMs that has highest dependency between CPU utilization and other VMs [11]. This algorithm works on the belief that if there is maximum correlation between CPU utilization of VMs then there is highest probability of server overloading

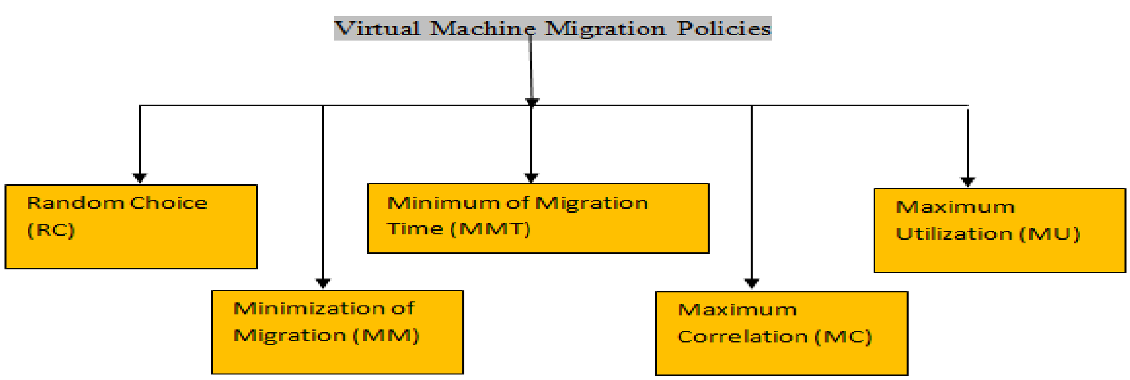


Figure 3 Show Various Policies of VM Migration.

 

## III. LITERATURE ON VM PLACEMENTS:

Mapping of VMs to physical machine is called VM placement. The objective of VM placement is to enhance resource utilization and to reduce energy consumption. This is done by accumulating workload on minimum number of physical machine and turning off idle machine without scarifying SLA parameters. But, the selection of VM for VM placement is a crucial issue because [12] reports that sometimes the overhead increases due to the repetitive iterations of memory pre-coping which results in low application performance. Along with this, it increases network load also. Lots of efforts have been done by the researcher to enhance placement policies. In this section, various VM placement algorithms have been discussed that are useful to solve aforementioned problems.

***Random Choice (RC):*** In RC algorithm, selection of PM is made randomly that can accommodate the migrated VM [13]. If no such PM is found then a new PM is turned on to accommodated. Since the selection of PMs is random there are more chances of sparse VM placements.

***First Fit (FF):*** In FF algorithm, all PMs are sorted in an order and a VM is assigned to the first PM if it can accommodate it. Otherwise the next PMs in the list are checked sequentially until the PM with sufficient resources is found. For the next VM placements the search criteria again starts from the beginning of the PM list.

***First Fit Decreasing (FFD):*** Working of FFD algorithm is same as FF algorithm except that all the VMs which are to be migrated are arranged in descending order and starting from the first VM allocation is done using FF algorithm sequentially.

***Best Fit (BF):*** In BF algorithm the PM with least number of resources that are enough to accommodate a targeted VM is selected for placement [14]. The benefit of this technique is minimal residual resources of physical machine. Minimal residual resource is the difference between capacity of PM in term of total resources and the utilized resources of the PM including the target VM.

***Best Fit Decreasing (BFD):*** In BFD algorithm, VMs are firstly arranged in the descending sequence according to their resource requirement and then BF algorithm is applied to this sequence one by one. BFD utilizes smaller machines first and keep the larger machines for future use which increase the mean resource utilization ratio [15]. The short coming of BFD algorithm is that it does not focuses on the power efficiency of a machine. The PM with lowest power consumption is not considered first for VM placement.

***Modified Best Fit Decreasing (MBFD):*** This algorithm is a variant of BFD. In the former, that PM is selected which shows minimum change in power utilization after the VM placement [9]. The MBFD model calculates energy consumption by the formula as:

$$P_{AP} = k \,.\, P_{max} + (1\text{-}k)\, P_{max} \,.\, u$$

Here k is the power consumed by an unused server i.e. it is minimum power that will be used by the server. It is considered 70% here because an idle server consumes at least this power and u is the CPU utilization. $P_{max}$ is the maximum power consumed when host is completely utilized. $P_{AP}$ is power consumption after placement. Now, after calculation of $P_{AP}$ , $P_{diff}$ is calculated as:

$$P_{diff} = P_{AP} - P_{BP}$$

The machine with minimum $P_{diff}$ value is selected for VM placement.

***Power and Computing Capacity-Aware Best Fit Decreasing (PCA-BFD):*** PCA-BFD is a modification of BFD algorithm [16]. In this algorithm, ratio of maximum power consumption ($P_{max}$ ) and maximum CPU utilization ($CPU_{max}$) is calculated. The PMs are then arranged in ascending order according to this ratio and the server with least ratio is chosen for placement.

$$R = P_{max} / CPU_{max}$$

The lower ratio here shows that a server gives higher CPU utilization at low power consumption.

***Energy Aware and Performance per watt Oriented Best Fit (EPOBF):*** This algorithm sorts the VMs according to the start time first or finishing time first [17]. The selection of PM is done on the basis of performance per wall (G) calculated as:

$$G = MIPS / watt$$

Here MIPS is maximum instruction per second. The PM with highest G value is selected for placement.

## IV. LITERATURE ON LOAD BALANCING:

Load balancing remains another important issue in past couple of years. The main objective of load balancing is to ensure that all machines have equal workload. It ensures that all devices perform equal tasks in given amount of time.

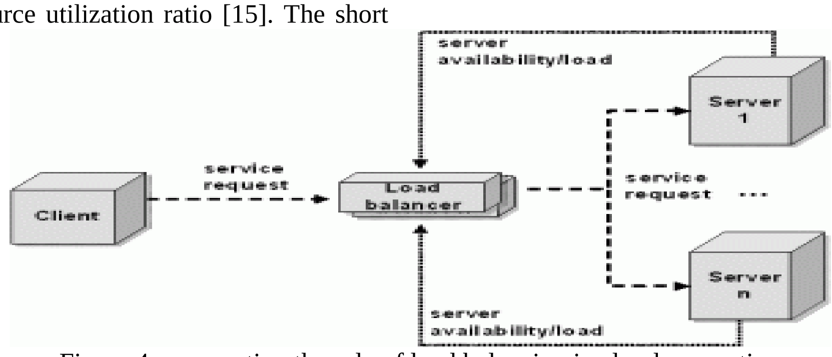


Figure 4 representing the role of load balancing in cloud computing

 

Various algorithms on load balancing have been since developed to ensure smooth functioning of data centers. These algorithms have been categorized as: static algorithms and dynamic algorithms.

**STATIC ALGORITHMS*:*** These are the load balancing algorithms that works on compile time. In static algorithms, all the servers are assigned a specific weight and the numbers of task are assigned to the server according to their weights. This section focuses on various static load balancing algorithms.

***Round Robin (RR) Load Balancer:*** In RR Load balancer algorithm, all the jobs have same time quantum and the time is allocated in circular manner. All the nodes are arranged according to the processing time. When one VM is assigned a job then it is moved to the rear end of the queue. The demerit of this algorithm is that the larger task takes long time and some time due to short time quantum more context switches may occur.

***Weighted Round Robin (RR)*** Scheduling Algorithm: In this algorithm, instead of assigning equal jobs to all nodes, a weight is assigned to each node and the requests are received as per the assigned weights.

**DYNAMIC ALGORITHMS:** In these algorithms there is constant check on the nodes. The work is distributed to the nodes at run time. Base upon the different properties of nodes such as network bandwidth, a weight is assigned to the nodes and the node with minimum weight is preferred over the higher weighted nodes. In this section, various dynamic load balancing algorithms have been discussed.

***Ant Colony Optimization (ACO):*** It is a nature inspired algorithm is which load balancing is performed by applying ant behavior in search of food. In this algorithm traversing of nodes is done. An ant traverses the network starting from head node to the width and length of the network. Ants make forward and backward moves on the network. In forward move, ants move in forward direction by encountering an overloaded or under loaded node. If the overloaded node is discovered then a backward move is performed to the previously encountered under loaded node. If this node is still under loaded then some work of an overloaded node is shifted to this node. To keep record about status of nodes, a pheromone table is maintained which is updated on each node visit. Benefit of this algorithm is faster information collection but, it takes long time to search if the network is overloaded.

## V. CONCLUSION AND FUTURE SCOPE

In this work, from the study of migration algorithms we can conclude that MMT algorithm is best in terms of minimum performance degradation because the VMs that take minimum time to migrate are chosen which results in lesser network traffic and lower energy consumption as compared to MM and MC algorithms. With the lowered network traffic, disruption time also decreases which further reduces SLA violation.

An efficient selection of PM for VM placement is another crucial factor in reduction of energy consumption. PCA-BFD algorithm can be considered best among many algorithms because of its efficient server selection criteria. But, due to this selection criteria, SLA violations may increase because it consolidates the selected VMs on minimum number of PMs. As the processes continue execution, their resource requirement may increase which leads to SLA violation. On contrary, MBFD has minimum SLA violations. Again purpose of load balancing algorithms is to enhance resource optimization. Performance of dynamic algorithms can be much better than static algorithm because decision is taken on the spot. But, these algorithms are difficult to implements

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