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A Survey of Virtual Machine Placement Algorithms in Cloud Computing Environment

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Abstract—In cloud computing, there are many strategies used for virtual machine (VM) placement. Objectives for VM placement are to reduce the number of physical machines required, VM allocation time and to reduce resource and power wastage. Various VM placement algorithms and the problems of existing techniques are analyzed and discussed here. The evaluation of those algorithms is given with the factors like live migration, performance, Qos, overload avoidance etc. After analyzing the issues in each method, finally a theme about the improvement over this scenario is also given for the future deployment.

***Keywords** - vm placement, migration, threshold, overload avoidance, QoS, green computing.*

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I. INTRODUCTION

Cloud computing refers to distributed environment where computing resources are distributed over a network. The main three service models are Software as a Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS),which are made available to consumers as subscription-based services under the pay-as-you-go model [1]. Due to virtualization in cloud infrastructure, the placement of VM in an appropriate server is one of the major research problems [2]. A virtual machine (VM) is an operating system (OS) or application environment that is installed on emulated hardware instead of being physically installed on dedicated hardware. The end user has the same experience on a virtual machine as they would have on dedicated hardware. A virtual machine (VM) shares physical hardware resources with other users but isolates the operating system or application to avoid changing the end-user experience. Virtualization saves costs by reducing the need for physical hardware systems. Virtual machines more efficiently use hardware, which lowers the quantities of hardware and associated maintenance costs, and reduces power and cooling demand. They also ease management because virtual hardware does not fail. Administrators can take advantage of virtual environments to simplify backups, disaster recovery, new deployments and basic system administration tasks. VMs can easily move, be copied and reassigned between host servers to optimize hardware resource utilization.There are a lot scheduling algorithms have been proposed to meet the different goals such as energy-saving, timesaving, CPU load balancing, Performance enhancements, but very few of them consider the disk load for performance enhancement is observed by this survey. Many applications perform a huge amount of disk operations, such as data mining, signal processing, etc. which often cause a performance bottleneck [3].

Some of the VM placement algorithm surveyed and the issues of the same algorithm are anlaysed and discussed. From this study, more than one virtual machine having disk intensive task when executed on the same physical host takes more time than the virtual machines having CPU intensive task is observed.

To overcome the observed issues in existing algorithm a Threshold based Placement scheme is proposed for disk intensive task executing in cloud computing environment. The main objective of the paper is to enhance the performance of VM and also reduce the number of physical machine used by selecting the most suitable host for the virtual machine in cloud architecture.

The remainder of this paper is organized as follows: Section 2 gives a detailed background about the VM placement algorithms, Section 3 gives the discussion over this algorithms in the perspective of improving their efficiency and a new algorithm is proposed in order to overcome some of the issues that are found from analysis and finally Section 4 gives the conclusion and future work of this survey.

II. BACKGROUND

Cloud computing delivers infrastructure, platform, and software (application) as services, which are made available as subscription-based services in a pay-as-you-go model to consumers. It is the long-held dream of computing as a utility, has the potential to transform a large part of the IT industry, making software even more attractive as a service. Clouds [2] aim to power the next generation data centers by architecting them as a network of virtual services (hardware, database, user-interface, application logic) so that users are able to access and deploy applications from anywhere in the world on demand at competitive costs depending on users QoS (Quality of Service) requirements [5].

CLOUD COMPUTING MODELS

Infrastructure as a Service (IaaS), [6] is a service oriented model. The users of IaaS can access the virtual hardware resources including virtual machines, virtual networks and virtualized storage through cloud. The most prominent service provider is Amazon EC2.

Platform as a Service (PaaS),[11] is a service platform that developers can use to deploy their own applications. The platform contains a pattern of compute power for hosting some features of the application as well as some of the software such as mail server, web servers, databases, etc. The famous PaaS service providers include Amazon Web Services and Google App Engine.

The basic cloud model is Software as a Service (SaaS),[12] which has applications, offered to end users through a web browser or thin client, which is completely stored managed and updated in the cloud. Some of the SaaS service providers are Microsoft's online update service, Trend Micro Internet Security and so on.

VIRTUAL MACHINE

To gain the maximum benefit from cloud computing, developers must design mechanisms that optimize the use of architectural and deployment paradigms. The role of Virtual Machine's (VMs) has emerged as an important issue because, through virtualization technology, it makes cloud computing infrastructures to be scalable. VM allocation is a keyword used in cloud computing for virtual sharing of physical machine among the data centres. It provides the knowledge of allocated VM to a particular data centerId. This allocation is based on different policies that make it efficient and easy to understand. These allocation policies can be implemented at virtualization level. The virtualization of cloud elements takes place at the infrastructure layer. Depending on these allocation policies, cloud infrastructure is highly structured and scalable. Therefore developing an scheduling algorithm for virtual machines is an important issue. In this paper an analysis of existing Virtual Machine's (VM's) scheduling algorithms have been done.

VIRTUAL MACHINE PLACEMENT

Virtual machine placement is the process of mapping virtual machines to physical machines. In other words, virtual machine placement is the process of selecting the most suitable host for the virtual machine. The process involves categorizing the virtual machines hardware and resources requirements and the anticipated usage of resources and the placement goal. The placement goal can either be maximizing the usage of available resources or it can be saving of power by being able to shut down some servers. The autonomic virtual machine placement algorithms are designed keeping in mind the above goals. Most of the time each physical machine in the cloud hosts more than one virtual machine, but the maximum number which a physical machine can host is dependent on the physical hardware resources. The main advantage of using virtualization technology is that it reduces the hardware acquisition costs and maintenance costs, which mean very less amount of upfront capital is required by the business, thus can result in significant savings for the company. The Automating of process of virtual machine placement has become a necessity because of the growth of the number of data centres.

VIRTUAL MACHINE PLACEMENT APPROACHES

Some of the approaches for virtual machine placement are explained in the subsequent paragraphs. The placement problem is a non deterministic problem. Following are some of the algorithms that have been used to solve the virtual machine placement problem.

A. BIN PACKING ALGORITHM

The bin packing problem is a combinatorial NP-hard problem. In it, objects of different volumes must be packed into a finite number of bins of capacity V in a way that minimizes the number of bins used. Many variations of this problem are present, such as 2D packing, linear packing, packing by weight, packing by cost, and so on. The applications of these problems include, filling up containers, loading trucks with weight capacity, and creating file backup in removable media. For example, in [9] the Physical machines can be considered as bins and the VM's to be placed can be considered as objects to be filled in the bin.

It can be used to find the actual mapping of virtual machines to available physical machines. It is possible to minimize the cost of running data centre by tightly packing the VMs required to be running at a time onto the least number of PMs possible. However, care should be taken so as to avoid overloading which results in SLA violations. The Physical machines can be considered as bins and the VM's to be placed can be considered as objects to be filled in the bin. A 3-stage algorithm is presented in [9].

- Formulate a pattern of past demands.
- Forecast the future demand based on the pattern of past demands
- Map or Remap VMs to PMs, this is known as Measure-Forecast-Remap(MFR)

The algorithm aims at minimizing the number of hosts required for VMs, if the probability of overloading the server in the interval is fixed. The last stage of the algorithm uses bin packing. The demand in the next interval is predicted on the basis of demand in the prior interval. Based on the solution to this heuristic, the VMs are packed onto the PMs. The paper [9] uses first fit approximation.

B. GENETIC ALGORITHM

A genetic algorithm (GA) is a search technique used to find exact or approximate solutions to optimization and search problems. Genetic algorithms are categorized as global search heuristics as given in [10]. They are inspired by evolutionary biology such as inheritance, mutation, selection, and crossover. A typical genetic algorithm requires: a genetic representation of the solution domain and a fitness function to evaluate the solution domain. The solution domain can be represented as the physical machines with a resource provisioning capacity. The fitness function can be defined over the number of bins in the solution. The aim would be to deliver a solution that is nearly optimal in terms of the number of bins used and the efficiency of packing of the bins.

A variation to genetic algorithm known as Grouping Genetic Algorithm can also be applied to the VM Placement problem. These algorithms can take into account additional constraints while optimizing the cost function. [11] This is particularly useful in cases where we need to operate on groups. The Grouping Genetic Algorithm can be thought of as a bin packing problem where the aim is to not only find a solution with highest packing efficiency but also to satisfy the constraints. The algorithm in [11] gives a mechanism to take into account VM interference.

C. SKEWNESS ALGORITHM

This algorithm [12] uses a concept of skewness. This skewness gives the level of utilization of the servers, provided that quantifies the unevenness in the utilization of multiple resources. This helps us to migrate the virtual machines based on the measures of utilization of servers. Here the probability of migration is more when compared with other dynamic algorithms. However this provides a green computing concept using cold spot solvers and avoids overload by using a hotspot solvers.The skewness of the resource utilization is calculated. This has to be minimized. Calculate the temperature using a resource utility threshold. Define a hot-spot and if the temperature of the server is more than the hot-spot threshold then the server is overloaded. Thus it will require virtual machine migrations to decrease the overload. Define a cold-spot and if the temperature of the server falls below the cold-spot thresholds then also it will require VM migrations so that the server can be shut down. Also define a Green computing whose thresholds which will reduce the active servers without affecting the performance of the system.

D. LINEAR PROGRAMMING ALGORITHM

A traditional analytical approach is linear programming which is explained better in [13]. For example, Chaisiri et al. [14] presented a nice algorithm for optimal placement of virtual machines on physical machines. The goal is that the number of used nodes is minimum. They provided approaches based on linear and quadratic programming. In [15] and [16], the authors described linear programming formulations of server consolidation problems. They also designed extension constraints forallocating virtual machines to a specific set of physical servers that contain some unique attribute, restricting the number ofvirtual machines in a single physical server, ensuring that some virtual machines are assigned to different physical serversand limiting the total number of migrations. In addition, they developed an LP-relaxation-based heuristic for minimizing the cost of solving the linear programming problem.

The constraints guarantee that each virtual machine is mapped to a single physical server and the virtual machine demands allocated in each physical server do not overload its capacity. Thus Overload avoidance is provided. Since the objective function is to minimize the total number of physical servers, Green computing is provided. Since the VM demand change is considered thus the Quality of service is maintained.The time required to obtain an optimal solution is more using linear programming approach but the best solution is always guaranteed. Thus performance factor is moderate.

E. ANT COLONY SYSTEM ALGORITHM

Ant colony system algorithm for virtual machine placement in cloud computing [13] is an initial placement technique which improves power efficiency and resource utilization. This develops an ant colony system is used for multi-objective optimization. This work also focuses on the provision of QoS.The objective of ant colony algorithm to be introduced in this VM placement scheme is to provide a multi objective solution for the problem which cannot be dealt by the prior algorithm stated above. This algorithm which is stated in [13] works as follows: in an initialization phase, the parameters are initialized and all the pheromone trails are set to τ_0. In the iterative part each ant receives all VM requests, introduces a physical server and starts assigning VMs to hosts. This is achieved by the use of a pseudo-random-proportional rule, which describes the desirability for an ant to choose a particular VM as the next one to pack into its current host. This rule is based on the information about the current pheromone concentration on the movement and a heuristic which guides the ants towards choosing the most promising VMs. A local pheromone update is performed once an artificial ant has built a movement. After all ants have constructed their solutions, a global update is performed with each solution of the current Pareto set.

F. BATCH SCHEDULING ALGORITHM

Batch scheduling of consolidated virtual machines based on their workload interference model [17] formalize the concept of interference for a consolidated multi-tenant virtual environment. Here a mathematical model is used to model the interference of a consolidated virtual environment using the Processing utilization vector and network utilization vector. A version of 0-1 knapsack problem is developed to periodically determine whether to resume or stop the virtual machines. This method has certain amount of power savings thus having a scope for green computing. However it does not emphasize on QoS factors.The consideration of Network utilization and processor utilization in the knapsack formulation provides a good performance by minimizing the workload interference.

III. RESULTS AND DISCUSSION

This survey gives a projection of various virtual machine placement algorithm and their evalution through various parameters.

REQUIRED PARAMETERS

The parameters considered are based on how the objectives of VM placement are achieved.

Live Virtual Machine Migration capability: In case of dynamic virtual machine placements we have to consider the live migration of the Virtual machines from one physical machine to another. This may happen due to certain factors like increase in the load in a certain physical machine leading to overload or it may happen that the servers may be underutilized and due to that the migration takes place. This can be measured by obtaining the percentage of the virtual machines that can be migrated.

Green Computing: This is the amount of the servers saved in the multiplexing of the virtual machines. This metric shows how much power efficient the algorithm or the system is. Also due to such power saving there are many benefits. One of the most important benefits is the reduction of the fuels burnt to keep the data center running. This reduction has a positive effect on the environment. This can be measured by the amount or percentage of the servers saved when compared with conventional methods or the server consolidation rate.

Overload Avoidance: This factor of the VM placement algorithm gives the amount to which it can avoid the servers to collapse under the load of the virtual machines. An overload is detected by the virtual machine's current resource allocations and its future demands which can swamp the server on which it is placed on. This is to be avoided by detecting such virtual machines based on their time series analysis of the history of this virtual machine usage. This parameter is measured by the amount of virtual machines migrated.

Performance: Performance is characterized by the amount of useful work which is done by the virtual machines in the given time and with the resources allocated. Thus a good virtual machine placement algorithm will try to maximize Short response time, High throughput, Low utilization, High availability, etc.

QoS (Quality of service): A QoS of a virtual machine placement would give a good placement of virtual machines onto physical machines such that the application requirements, consisting of the resources, are fulfilled. In cloud this is framed as a service level agreement (SLA). If the created VMs cannot provide the computing environments to satisfy the QoS requirements of running applications, it will pay penalties due to the service level agreements (SLAs) with users. QoS can be measured by the amount of the virtual machines not being placed by any of the physical machines. The higher the degree of such VM, the lower will be the QoS and vice versa. This can also be modelled as the rate of SLA violations.

COMPARISON OF EXISITNG ALGORITHMS

The algorithms discussed in the previous chapter were compared as per the above requirements and presented in Table 1.

Algorithm	**Live VM Migra-tion**	**Green Computing**	**Over load Avoidance**	**Performance**	**QoS**
Bin Packing	Medium	Yes	Yes	Low	Yes
Genetic	Low	Yes	No	Medium	Yes
Skewness	High	Yes	Yes	Medium	Medium
Linear Programm-ing	Low	Yes	Yes	Medium	Medium
Ant Colony system	No	Medium	No	Medium	High
Batch Schedulin-g	Medium	No	No	High	No

IV. RELATED WORKS

The problem of virtual machine placement has attracted considerable attention recently. The work on virtual machine placement is based on whether the placement of the virtual machines is static (or initial) or dynamic. In static or initial virtual machine placement, there are many works done on initial placement strategies. Some of these are Multi-Objective optimization (refer [13]) for Initial machine placement in cloud data center, multi-objective ant colony system algorithm for virtual machine placement in cloud computing, energy efficient virtual machine placement algorithm with balanced and improved resource utilization in a data center, Multidimensional resource allocation algorithm in cloud computing, Virtual machine placement for predictable and time-constrained peak loads, Interference aware VM placement. Optimal Placement Algorithms for Virtual Machines [18] is a work which describes the problem of VM placement using linear programming and quadratic programming. These all use some approaches such as linear programming, integer linear programming, and genetic algorithms, and other heuristic algorithms.

After initial placement of the virtual machines onto the physical machines the problem is that of varying loads in the various virtual machines which cause the servers to be underutilized or sometimes they get overloaded and cause much downtimes. This required the dynamic placement of the virtual machines. Some of these works include development of some architecture for placement of these virtual machines. Server consolidation with migration control for virtualized data centers is a work given in [16] that proposes an LP formulation and heuristics to control VM migration. Virtual Machine Placement for Predictable and Time-Constrained Peak Loads uses binary integer programming for load balancing with dynamic placement.

All the methods in the category of dynamic mapping of VM involve the VM migration from one physical machine to another. Optimizing the live migration of virtual machine by CPU scheduling[19] improves migration liveliness at the cost of application performance. Dynamic Resource Allocation Using Virtual Machines for Cloud Computing Environment [12] gives a concept of skewness which checks the underutilization of the resources and also develops methods for green computing. Dynamic Placement of Virtual Machines for Managing SLA Violations provide a management algorithm reduces the amount of physical capacity required supporting a specified rate of SLA violations. Batch scheduling of consolidated virtual machines based on their workload interference model [17] also uses interference aware technique for solving server consolidation.Developing resource consolidation frameworks for mouldable virtual machines in cloud [20] is a paper investigates this issue and develops a Genetic Algorithm (GA) to consolidate mouldable VMs.

V. PROPOSED APPROACH

There are a lot scheduling algorithms have been proposed to meet the different goals such as energy-saving, timesaving, CPU load balancing, Performance enhancements, but very few of them consider the Disk I/O load for performance enhancement is found. More than one virtual machine having disk intensive task when executed on the same physical host takes more time than the virtual machines having CPU intensive task. This scheme based on the disk threshold value and best fit decreasing algorithm for selecting VM for migration and for placing the VM on proper host respectively. The local managers which are the part of VM monitor resists on each node and are responsible for keeping continuous check of when to migrate a VM and utilization of the node. The end-user sends its service request along with some CPU performance parameters like MIPS (Million Instruction per second), RAM, memory and network bandwidth to a global manager which in turns intimates the VM monitor for VM placement. The local manager reports the global manager about the utilization check of its node. And thus, global manager keeps the check of overall utilization of the resources.

DISK THRESHOLD BASED PLACEMENT ALGORITHM

This scheme is divided into two parts:
1. Selection of VM for migration and
2. Placing the VM on proper host.

1. Selection of Vm For Migration

First the disk utilization of all VM are calculated as shown below

$$utilization\ of\ all\ VMs = \frac{totalRequestedIOMips}{totalIOMipsfor\ that\ Vm}$$

In [21] it is considered that if the CPU utilization is above 80%, the upper threshold value will be 0.8.The Disk will be considered overloaded when the utilization is above this value so we migrate some of the VMs. If a host's disk is getting utilized under 30%, disk will be consider underutilized. This underutilized host will serve as candidate for virtual machine placement.

Upper threshold value calculation

Temp = Sum+ (BW / BW (host)) + (Ram/Ram (host))
Tupper =1-(((Puu* temp) + Sum) - ((Pul * temp) + Sum))

Lower threshold value calculation

Temp = Sum + (BW / BW (host)) + (Ram/Ram (host))
Tlower = 1 – ((Pl * temp) + sum), if CPU utilization is < 30
= 0.3, if CPU utilization is >= 30%

Live migration using threshold

1. Sort the VM list in the decreasing order of its VM utilization.
2. For each host in host list compare the current host utilization value to the upper threshold value of that host .if the value is greater than threshold value go to 3 else go to 4
3. Get the each VM for the current host .if VM utilization is greater than the or equal to the upper threshold value, add the VM into migration list
4. If host utilization value is less than lower threshold value then, add the host into target host list.
5. Return the migration list and target list.

2. Placing of VM

The output of the previous result is given to this placement algorithm.
1. Sort the VM list in the decreasing order of its VM utilization.
2.For the each host in target host list, if host has enough resources for VM then select the host as destination for VM migration else do nothing.
3. Return allocation.

BENEFITS

The execution time obtained by applying Threshold Based scheme is less. On the other hand, Threshold scheme favours for comparatively less computing resources as the local manager reports about the utilisation periodically. So load is uniformly distributed over the hosts. More than one virtual machine having disk intensive task when executed on the same physical host takes more time than the virtual machines having CPU intensive task. Very few of the algorithms consider the Disk I/O load for performance enhancement. Threshold scheme mainly concentrates on that and thus overthrown the demerit of other existing algorithms thus helps to execute faster when it comes to disk intensive task.

VI. CONCLUSION

The VM placement is one of the research problems in cloud infrastructure. Each of the virtual machine placement algorithms works well but only under certain specific conditions. Thus, it is important to choose a technique that suits the needs of the cloud user and cloud provider. So the working and the analysis of various VM placement algorithms with different objectives were surveyed and also some of the pitfalls are found out. To overthrow one of such issue called disk I/O load, disk based migration approach for VM placement is proposed. In future, the proposed approach is to be simulated along with other approach for testing its efficiency.

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