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A Review of Virtual Machine Placement algorithm in Cloud Datacenters for Server Consolidation

[1] C.Pandi Selvi, [2] Dr.S.Sivakumar

[1] Assistant Professor of Computer Science, CPA College, Bodinayakanur.

[2] Head and Associate Professor of Computer Science, CPA College, Bodinayakanur.

Abstract: **- Cloud datacenters contain the number of servers, that there are some servers put in idle, as workload is distributed to all the active servers on the network called server virtualization. In order to minimize the number of active servers, we use server consolidation technique. The four major steps in server consolidation technique are namely hosted overload detection, host under-load detection, virtual machine selection & migration and virtual machine placement. Virtual machine placement is the process of mapping physical machine to virtual machine for maximizing the resource utilization, minimizing energy consumption and maximizing the cloud profit. In this paper, an effective virtual machine placement algorithms and widely used approaches, parameters and optimization techniques to reduce the total energy consumption in data centers are analyzed.**

Keywords**: Virtual Machine, Server Consolidation, Virtual Machine Placement.**

I. INTRODUCTION

In cloud datacenters the cloud service providers have been attracted by millions of clients, who are sharing the computing and sharing resources using servers. By adding virtualization platform to the server, the server can operate its original workload as a virtual machine, often increasingly the total utilization of physical server from 50% to 80% of its computing capacity and then decreasing the energy saving [1]. By keeping these two challenging aspect in mind many effective approaches for server consolidation have been introduced. In server consolidation, a number of virtual machines (VM) placed on a few number of physical machines (PM) to optimize resource utilization, energy consumption and profit for cloud users [2]. It requires four major steps namely (i) host overload detection, where the user should set a threshold limit in order to decide when a certain host/server is over-utilized. This limit can be called as 'Hot Threshold'. (ii) Host under-load detection, where the under-loaded server is freed up & it can be switched to sleep/idle mode to save power, this stage is called 'Cold Threshold'.(iii) VM Selection and Migration, where the virtual machines is selected either from overloaded or under-loaded host for migration. (iv) VM Placement, where the virtual machine selected in previous step is then placed on some other physical machine according to a suitable VM to PM mapping criteria called virtual machine placement. Virtual Machine Placement (VMP) is the one such technique used in cloud management system to increase the energy efficient in cloud [3]. This placement technique in virtual machine can have two major goals, one is power saving, to obtain an energy efficient with resource utilization and another is quality of service, to obtain an maximal fulfillment of quality of service requirements [4]. The reminder of paper is organized as follows section II presents the approaches in VMP algorithms. Section III explains the classification of dynamic VMP algorithms and section IV presents the parameters used in VMP algorithms. Section V presents optimization method for VMP algorithms followed by the conclusion and future work to the researchers on Section VI.

II. APPROACHES IN VMP ALGORITHMS

Virtual machine placement maps the physical machine to dynamic machine with several parameters and limitations.VMP technique for an efficient server consolidation of server depends on two ways of approach static and dynamic as follows. Static approach algorithms mainly do offline calculation; take as an input the information that is formerly collected. Dynamic approach algorithms implemented on timescales and do the online VM placement, including VM migrations. One important difference between static and dynamic VMP algorithms is the fact that dynamic solutions consider potential VM migrations and therefore require large amount of resources than static solutions, which can badly affect the performance of the hosted applications. Since the static solutions is primitive and outdated Singh, 2016 [5]. We are interested to study dynamic VMP algorithms.

(i)Static Approach

In static approach placement of VM to PM mapping is not changed for a long time and no migration is done with workload changes during that time. Static placement of

VMs is done either in system startup or in offline mode. No prior mapping is done, only the initial placement of VM is done. This initial placement does not bother about the states of VM to PM or arrival rate of user request. The disadvantages of static approach are that the resources are allocated to satisfy peak load demands but most of the time, VM is not working in peak load. Halder in [6] defined an algorithm that the initial placement of VM and resources are used for energy consumption.

(ii)Dynamic Approach

In dynamic approach an existing placement of VM to PM is present and migration is done with workload changes during that time. The main goal of dynamic VMP is to achieve optimum solution for already present mapping of VMs at minimal cost. The rate of user request and the states of VM to PM are considered for taking a decision in algorithms. Lovasz in [7] introduce an algorithm by increasing or decreasing the time period. Running the algorithm in short period makes the server will turn on or off, as a result server's lifetime will decreases. Therefore running algorithm in long time interval will makes the server be over loaded. The algorithm presented in these papers is contain too long period for consolidation of server may lose energy saving, because on that time period several servers may go to standby mode, but they find them too late and until then they stay running and consume energy[8]-[10].

III. CLASSIFICATION OF DYNAMIC VMP ALGORITHMS

Dynamic VMP algorithms are one of the key mechanisms in datacenters for designing an efficient server consolidation in cloud. The principle based on the migration of VMs into few PMs can achieve both increasing the utilization of cloud and reducing the consumption of energy in cloud data centers. There are four types of dynamic VMPs algorithm namely Constraint programming algorithm, Bin packing algorithm, stochastic integer programming algorithm and Genetic algorithm. These algorithms are used to achieve the minimizing number of active host, minimize service legal agreement (SLA) violation, minimize response time, maximize reliability and maximize resource utility.

A) Constraint programming algorithm

In constraint programming algorithm the user need to state their constraint and the solver who needs a solution would find the solutions, which satisfy all the constraint. Constraints are known as relationship between the variables or unknowns each taking the value in a given domain. Constraint need to be identified in order to solve problems by means of Constraint Solving Techniques (CST). CST is a kind of logic programming. To find optimal solutions for virtual machine placements CST is used. For virtual machine placement problem the constraint programming are allowed to find the available servers and migrate the VMs to these servers, by treating them as two constraints it finds the optimal solution. Zhang [11] applied a few constraints to cloud resource allocation model to reduce the cost of resource usage and gives a good quality of service. The goal of application is to improve the performance measure and work load types. Dupont [12] proposed a new scheduling problem which is flexible for energy aware resource allocation called VM repacking scheduling problem. In this problem the author considered SLA as a constraint. The constraint allows the user to automatically derive on SLA constraint. Dong [13] introduced two staged VM scheduling algorithm. In first stage the author combined best fit of bin packing with min-cut hierarchical clustering algorithm. In second stage, the allocated VMs are reducing the optimal solution using this algorithm leads to minimum number of active PMs which is achieved by modeling network traffic as Quadratic Assignment Problem (QAP).

B) Bin packing algorithm

In bin packing algorithm, objects of different sizes must be packed into finite number of bins each its size are minimized by the number of bins used. There are some variants used in classic bin packing problem as 3D, 2D, linear, pack by volume, pack by weight, minimize volume, maximize value, fixed shape objects etc.. . The bin packing algorithm for an dynamic virtual machine placement used to find actual mapping to VM's to available PM's ,it is possible to minimize the cost and time of the server consolidation in data centers. W.Song [14] proposed an online bin packing algorithm with variable item size bin packing and compare this algorithm with black box, gray box and vector dot algorithms. The algorithm proposed by the author used only CPU and memory. It supports 'change' operation for dynamic resource allocation.VMs to PMs is minimized in size and SLA violation is reduced. Y.Zhang [15] introduced heuristic algorithm for VM placement includes the aware allocation of resources. In single or multidimensional resource requirement, dominant residual resource allocation and its variation are proposed. C.Lin [16] ,formulated multi stage algorithm for effective virtual machine placement .on the first stage dynamic round robin (DRR) is used and second stage a fusion of DDR with first fit algorithm are proposed. The proposed fusion algorithm reduced the power consumption.

C) Stochastic integer programming algorithm

Stochastic integer programming (SIP) is a framework of modeling optimization problems in the field of mathematical optimization, where problems are formulated with known or unknown parameters. The goal of the SIP

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algorithms is to find a solution which is feasible for all such data and optimal stochastic programming has two stages formulated for energy optimization in data centers. Here, the future demand of VM is unknown and therefore an application is also unknown and therefore some VMPs techniques use this approach to project the suitable VM-PM mapping.[17] N.Bobroff introduced a dynamic server consolidation and migration algorithm. In that algorithm the SLA violation decrease and reduce the demand of the servers and therefore reduce the cost in datacenters. The algorithm has three steps one is measuring historical data and second is forecasting future demand and third is remapping VM to PM .These three steps are known as Measure-Forecast-Remap (MFR) algorithm. Speitkam [18] use an LP relaxation based heuristic algorithm. This is NP Hard optimization that solves the server consolidation and historical workload analysis. This algorithm explained about two different models applying constraints to solve virtual machine placement in server consolidation. In this optimization model the data pre processing and capacity of the data planning are used to achieve optimal placement. M.Chen [19] proposed effective VM sizing by estimating the VM resource demand on an aggregation of servers from assigning VM to PM in the probability. The VM sizing in this algorithm is effective done and aggregation demand and correlation demand is calculated.

D) Genetic algorithm

Genetic algorithm is said to an evolutionally computation. It performs natural solution from all possible solution. Each algorithm begins with initial set of node and each solution can be represented by tree. Virtual node is represented by child node and physical node is represented by parent node and global resources and manger is represented as the root node. Mi [20] introduced a genetic algorithm based approach (GABA) using adaptive self reconfiguration of VM reallocation. It is a heterogeneous on physical machines. It can be search online optimal solution for the problem. By changing the workloads, forecasting module is used. GABA deals with multi objective optimization and resulting conservation of power. Ferdus [21] proposed (MDVPP) multi dimensional vector packing problem. It is NP Hard for VM placement. It focus on load balancing the cloud resource utilization. Ant colony optimization- meta heuristic approach is used for effective computation based on time. Geo [22] proposed an algorithm that minimizes the power consumption and wastage of VM placement problem using Ant colony system. The resources were effectively balanced along different servers. This problem is modulated as Multi objective algorithm and named as VMPACS.

IV. PARAMETERS USED IN VMP ALGORITHMS

Another aspect is parameters, which is considered in dynamic VMP algorithms. The parameters hardware utilization, network traffic, cooling systems, performance impact, reliability, migration overhead is considered and each parameter affect the user experience and operational cost in data centers.

(i)Hardware utilization: Hardware utilization refers to the usage of processing resources in cloud data centers. For server consolidation in virtual machine placement algorithms, the most used resource provisioning is hardware utilization. Hardware resources like CPU, Memory disk and network are considered for optimization algorithms. Actually hardware utilization varies depending on the amount and time of the task. Song in [23] used the hardware the CPU & memory for effective optimization of the servers in data centers. Benglazov & Buyya in [24] utilized the CPU, memory and network for calculating the amount of time used for server consolidation. Gmach in [25] proposed an algorithm for placement of virtual machine by using CPU and memory. Deng in [26] used CPU, memory and disk for the server consolidation task.

(ii)Network Traffic: Network traffic is also called as data traffic which means it moves data across the network on a particular time. In a given network proper organization of data transfer ensures the quality of service in network. In cloud data centers, communication between virtual machines called network traffic; it will affect the performance and quality of service. Meng in [27] proposed an algorithm that topology of network and patterns in network traffic increase datacenter performance in the service. Kilazovich in [28] proposed an algorithm with two aspects 1) virtual machine placement in server consolidation minimize the online PMs 2) hotspots are used to prevent traffic pattern.

(iii)Cooling System: Data center ensure that the enough cooling and ventilation is necessary to keep all the servers within the desired temperature range. The cool air gets into the server and the hot air sent out from the server, which will reduce the power usage for cooling system will significantly reduce the total power usage. Tang in [29] developed an algorithm for job scheduling that minimizes inlet air temperature. As a result hotspots is minimized and heat recirculation is also been minimized, which decreases the cooling equipment energy consumption. Pakbaznia in [30] proposed a power and thermal management framework. To optimize air conditioning power consumption by dynamic voltage and frequency technique are reduced by choosing the temperature for cold air.

(iv)Performance Impact: In Server consolidation, the virtual machine placement introduces a degree of performance interference between virtual machines, which causes an impact in system throughput and over all datacenter performance. There are two major groups for performance interference is discussed below.

(a)Inter VM Performance Degradation: The factor that affects application performance is inter VM performance degradation. In server consolidation, several VMs are packed in PMs will not guarantee the performance interference between VMs and hence lead to decrease the QoS may violate the SLA. The resources like CPU, memory disk and network could be affected by performance interference.

(b)Software Aging Performance Degradation: The factor that affects service performance is software aging performance degradation. Software aging is nothing but system performance faces degradation over a period of time. In [31] the total running time for software rejuvenation decreases due to occurrence of application performance and failures. In [32] VM and VMM are the software used that have the resources such as files and memory for software aging in cloud.

(v)Reliability: Reliability refers to two aspects in data centers, namely computer related hardware or software components. Hardware reliability can lead due to failures in performance degradation and SLA violation to the end users. Server consolidation would reduce the reliability by turn off the idle PMs. Hence on-off cycle will reduce server's life cycle. Gong in [33] explains that the performance degradation and hardware failures lead to the service unavailability by SLA violation and proposed a server consolidation in dynamic virtual placement of algorithms and considers a reliability and lifetime. Guenter in [34] presented a service provisioning framework that has the three factors as cost, performance and reliability.

(vi)Migration overheads: A technology VM migration is more attractive in server consolidation. In live migration both source and destination host need resources. In VMP algorithms, the VM migration could increase the overall performance and efficiency of data center. In [35] the live migration is done with the resources like CPU, memory in both source and destination PMs. In [36] the CPU overhead can be easily accepted from application above 30% of default CPU. Virtual machine placement algorithm based on dynamic approach works well with certain parameters to get the objectives. Table 1: shows the comparative analysis of parameters used in VMP algorithms to choose the technique that suits the needs of the cloud users and cloud providers.

Paper	Approach	Parameters						Objectives
		Hardware Utilized	Network Traffic	Cooling system	Performance	Reliability	Migration	
Meng et al. [37]	Dynamic	CPU, Memory	Yes	No	No	No	No	Maximize the network scalability
Xiong et al. [38]	Dynamic	CPU, Memory	No	No	Yes	No	No	Maximize resource cost and performance requirement
Kilazovich et al . [39]	Dynamic	CPU	Yes	No	No	No	No	Minimize number of active host and avoid hotspots in data center
Tang et al. [40]	Dynamic	CPU	No	Yes	No	No	No	Minimize the inlet temperature (leads to lower energy consumption
Deng et al. [41]	Dynamic	CPU, Network, Disk, Memory	No	No	No	Yes	Yes	Maximize hardware lifetime Minimize energy consumption

Table 1: Comparative analysis of parameters used in VMP

V. OPTIMIZATION METHOD FOR VMP ALGORITHMS

Optimization method used to solve dynamic VMP algorithms, formulated and solved using exact method, heuristics and meta heuristics. Since the dynamic virtual machine placement problem can be mapped to a NP-hard bin-packing problem, it is often formulated and solved using various heuristics and meta heuristics method. In virtual machine placement algorithm for server consolidation, the parameters considered during decision making and method used for VMs to PMs be an important factor is quality of approach in final. Therefore the algorithm and approaches is used to solve the virtual machine placement. The optimization technique is classified as in Fig 1.

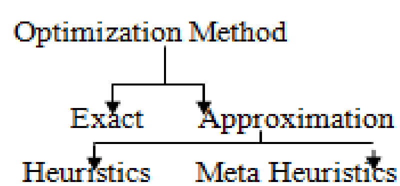

Fig 1: Classification of Optimization Method

Exact solutions are used to solve the optimal solution in finite amount of time. VM to PM mapping used as mathematical approach to solve the problem. Heuristic problem is dependent technique, not guarantee for finding optimal solution and try to find out the solution in short time period. Meta Heuristics problem is independent technique. It is opposed to Heuristics and try to find out (near) optimal solution.

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The solution usually takes more time than quick heuristic problem. Table 2: shows the comparative analysis for optimization method using the algorithms in paper [42]-[46].

		Optimization Method		
Algorithm	Paper	Exact	Heuristics	Meta Heuristics
Constraint Programming	Takahashi et al. [42]	Yes	No	No
Bin Packing (i)First Fit Decreasing	Hermenier et al. [43]	No	Yes	No
(ii)Best Fit Decreasing	Buyya et al. [44]	No	Yes	No
Stochastic Integer Programming	Chaisiri et al. [45]	Yes	No	No
Genetic Algorithm	Provost et al. [46]	No	No	Yes

Table 2 : Comparative Analysis for Optimization method.

VI. CONCLUSION

This study has discussed the virtual machine placement techniques for reducing data center energy consumption as an important challenge for development in IT and services for industry and the academic. Our brief explanation of cloud data centers optimization techniques provided by virtualization technology used to understand the paper contents and significance. Various approaches in VMP algorithms for efficient server consolidation in cloud are classified under five points of view: time of applying the technique, constraints, requirement during optimization process, the algorithmic method to find optimal solution and the objective functions.

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