Efficient Mapping for VM Allocation Scheme in Cloud Data Center

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Abstract

The allocation of virtual machines in the cloud data center has been a challenge in recent years. The needed resources for virtual machine (VMs) allocation map to the available resources of physical machines (PMs). The efficient allocation of the virtual machines is one of the optimization problems in order to resolve the underutilization of resources in cloud data center. The recently studies emphasized this optimization problem. This paper presents the proposed efficient mapping scheme of virtual machines (VMs) allocation in the cloud data center and then evaluates the efficiency of the proposed allocation scheme. In the presented mapping scheme, the VM allocation problem solved as Bin-packing with BestFit algorithm (BF) and the binary search concept is integrated. The efficiency of the proposed mapping scheme of VMs allocation is verified through the CloudSim simulator. According to the experiment results, the proposed binary search based VMs allocation requires less processing time than the existing one.

Keywords— *Bin-packing, BestFit, Binary Search, Cloud Data Center, Virtual Machine allocation, mapping scheme, CloudSim*

I. INTRODUCTION

The advent of cloud computing technology has turned the IT industry into a part of the modernized world, and large cloud data centers are serving the millions of on demand services for computing resources, storage, networks and applications based on a pay-per-use model. The virtualization technique enables the sharing of physical resources by allowing the number of virtual machines to be allocated to the sets of physical machines (PMs) in Data Center. The effectively utilize the resources of PMs become an important issue in IaaS. The proper VM allocation algorithms play as an important role in order to achieve a better utilization of PMs' resources in cloud data center. The Bin-packing model is an effective model to solve the virtual machine allocation problem. It enables to reduce the number of used PMs due to its packing techniques. There are recent studies [1, 2, 6, 7, 8] to resolve the VMs allocation problem in Data Center by applying Bin-packing model with FirstFit or BestFit scheme.

We proposed the resource management model and efficient VMs allocation algorithm in [3]. In which, the VM allocation algorithm applied the Bin-packing and BestFit Descending concepts to solve the utilization problem. The proposed algorithm considers not only the utilization of resources of PMS but also the reduction of mapping to suitable PMs for VMs allocation. In order to reduce the mapping and allocation time, the binary search mechanism is used in the proposed algorithm. Two resources- CPU and memory are used as configuration parameters for VMs allocation. The simulation result verifies that the proposed VMs allocation is an efficient mapping of VMs allocation.

The rest of the paper is organized as follows. Section II describes about the related work. Section III presents the proposed VMs allocation model and proposed VMs algorithm. Section IV explores the experiments and comparative analysis which verify our contribution. Section V conclude this paper and describes our future work.

II. RELATED WORKS

The efficient VMs allocation becomes a key factor and it is still a problem in cloud data center. The improper VMs allocation causes the underutilization of resources of PMs in data center. In [4], their proposed algorithm (RVMP) is able to scale down the active PMs in order to minimize the power consumption of IaaS cloud. In their study, the resource usage factor is contributed in their resource usage model in order to efficiently utilize the resources of the active PMs. In [1], Dynamic Resource Management Algorithm (DRMA) was proposed, and it can solve the resource utilization problem in a certain period of time, and the bin-packing and best fit method is used to solve resource allocation problem. For their simulation, two resources- CPU and RAM are used as configuration parameters. In [6], a virtual machine dynamic forecast scheduling (VM-DFS) is proposed in order to optimize the VMs allocation according to the forecast of future consumption in a cloud computing environment. VM-DFS analyzed historical memory consumption and predicted future memory consumption and allocated VMs to the most proper PM in the cloud datacenters. The problem of VMs allocation is formed as the

problem of bin-packing and used first-fit decreasing method. VM-DFS was based on dynamic deployment, time series forecasting theory, and binary packaging models. According to the experimental result, it can reduce the number of active PMs relatively. In [7], author explored two works- mapping of VMs to PMs and mapping of tasks to VMs and examined how these two works influence in each other. In [8], the author explored two heuristic algorithms–Modified BestFit Descending (MBFD) method's performance and contribution of Migration Minimization (MM) to consolidate VMs in a cloud data center. According to their study, these algorithms are practically useful for the issue of consolidating VMs. Our study focuses on modifications to existing models with an optimized VMs allocation algorithm based on binary search contribution [3] and verify the efficiency of mapping for VMs allocations by CloudSim simulator in this paper.

III. PROPOSED VIRTUAL MACHINES ALLOCATION MODEL

In cloud computing environment, Data Center is a specialized IT infrastructure that houses the number of physical machines. In our proposed model, Data center includes the number of physical machines (PMs) and that can host the number of virtual machines (VMs). There are two modules- VM manager and allocation manager in the cloud data center as shown in Fig.1. The VMs manager keeps tracks the resources of PMs in the cloud data center and the incoming VMs requests as well. Before allocation of VMs, the VM manager sorts the requested VMs and PMs in descending order according to their resources. The allocation manager allocates the VMs to the most proper PMs through the proposed Efficient VMs Allocation Algorithm. Here, we consider two resources-CPU and RAM for allocation problem. Initially, all PMs in the cloud data center are active.

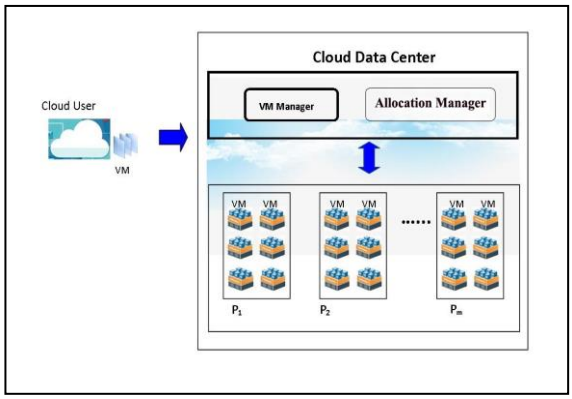

Figure 1. The proposed VMs allocation model

The CloudSim simulator enables to implement the cloud computing environment. The proposed VMs allocation model that describe in Fig. 1, is simulated by using the CloudSim 3.0. The CloudSim simulator provides DataCenter class, vm class, Cloudlet class. The DataCenter class is used for creating a Datacenter with a number of PMs and the vm class is used for creating virtual machines (VMs). The Cloudlet class is used for creating the tasks run on the virtual machines. In our proposed model, we consider the part of VMs allocation to suitable PMs in Data Center and not consider the part of task allocation to suitable VMs. To simulate the proposed model, the number of PMs and the number of VMs are created by DatacenterBroker class and then Datacenter class is created with those PMs. These VMs and PMs are keeping in sorted list before mapping and allocation. The BinaryVmAllocationPolicy class is created to maintain the Data Center allocation policy. The proposed model simulation handles with a SimulationStartingPoint main class.

A. Proposed VMs Allocation Algorithm

The efficient VMs allocation algorithm was proposed in our previous work [3].

Input: P, V, m, n
Output: P_{active}, VSetp, s, c=0
where P is PM list, V is VM list
P_{active} is currently active PM list
VSetp is current VM list in for each PM
m is number of Virtual Machine
n is number of Physical Machine
c is number of active PM
s is number of non-active PM
BEGIN
Sort P by CPU and Memory in descending order
Sort V by CPU and Memory in descending order
for each $p \in P$
VSetp ← Null ; // initially no running VM set for each PM
endfor
for each $v_i \in V$, $i \in \{1,2,..,m\}$
first← 1; last ← n;
do while (first≤ last) // mapping to the best fitted PM
mid←(first + last)/2;
if ($v_i^{mem} > p_{mid}^{mem}$ && $v_i^{CPU} > p_{mid}^{CPU}$) then
last← mid-1;
else if ($v_i^{mem} < p_{mid}^{mem}$ && $v_i^{CPU} < p_{mid}^{mem}$) then
first← mid+1;
endif
enddo
if ($v_i^{mem} \le p_{mid}^{mem}$ && $v_i^{CPU} \le p_{mid}^{mem}$) then $q \leftarrow p_{mid}$;
else $q \leftarrow p_{mid-1}$;
endif
$VSet_q \leftarrow VSet_q \cup \{v_i\}$
$q^{CPU} \leftarrow q^{CPU} - v_i^{CPU}$; $q^{mem} \leftarrow q^{mem} - v_i^{mem}$
if q is not belongs to P_{active} then
$P_{active} \leftarrow P_{active} \cup \{q\}$;
c++;
endif
endfor
s=m-c;
END

Figure 2. The proposed VMs allocation algorithm

In this proposed algorithm, we consider the resource utilization of PMs and mapping to suitable PMs for VMs allocation. It is important that, the PM needs to be host the more number of virtual machine for better resource utilization. Bin-packing model can handle the resource utilization issue. The proposed algorithm uses the Bin-packing with BestFit Descending method to handle resource utilization. Moreover, we consider the VMs allocation in linear fashion is time consuming task while mapping and allocating to the proper PMs. In this algorithm, the contribution of binary search based mapping can handle this time consuming issue and can reduce the allocation time efficiently.

In the proposed algorithm, the list of PMs and VMs need to be sorted in descending due to binary search method. The detail steps of the VMs allocation algorithm is described in Fig. 2.

IV. EVALUATION

The proposed VMs allocation algorithm is evaluated with complexity analysis and running time analysis. And then compare with the ordinary linear allocation algorithm.

A. Complexity Analysis

The Bin-packing heuristics with BestFit decreasing approach can be adapted to the proposed allocation problem. The complexity of algorithm is O(log n) and it is faster than the ordinary sequential based mapping. The allocation time would not too much increase even there are more PMs exist for mapping to allocate.

B. Run Time Analysis

The proposed model is evaluated with the average time taken parameters that is measured while mapping to find out the closest match PM with the needs of VMs' allocation. The experiment is carried out by deploying CloudSim 3.0 with Window 7 OS, RAM 4.0 GB, processor core i5 and Eclipse IDE Oxygen version. The proposed binary search based VMs allocation is simulated with seven experiments. We setup four types of VMs and PMs as shown in Table 1 and Table 2.

TABLE1. VMs Specification

Type	RAM (MB)	CPU (core)
Small	128	2
Medium	512	4
Large	512	8
Ex-Large	1024	16

TABLE 2. PMs Specification

Type	RAM (GB)	CPU (core)
Small	128	2
Medium	512	4
Large	512	8
Ex-Large	1024	16

TABLE 3. Experiment Setup of Four Types of PMs

#Experiment	# PMs	Small	Medium	Large	Ex-Large
1	5	1	1	1	2
2	10	2	2	2	4
3	20	4	4	4	8
4	50	12	12	12	14
5	70	17	17	17	19
6	100	25	25	25	25
7	150	35	35	35	45

For each experiment, we create four types of 20 VMs including 5 Ex-Large, 5 Large, 5 Medium, and 5 Small and four types of PMs 5, 10,20, 50, 70, 100 and 150 respectively. We setup four types of PMs for seven experiments are described in Table 3.The experiments do 20 times repeatedly in order to get the correctness of simulation result and find the average time taken of mapping for VMs allocations are recorded as shown in Table 4.

TABLE 4. Average Time Taken of Mapping the Requested VMs with PM

Number of Hosts (PMs)	Number of VMs	Average Time Taken (mili seconds)
5	20	146.3
10	20	155.15
20	20	158.33
50	20	160.82
70	20	167.6
100	20	188.8
150	20	191.9

According to the experimental results, the average time processing of the proposed binary search based mapping does not becomes too large even increasing the number of PMs. This shows that the proposed VMs allocation is more efficient in processing time while mapping to find out the most suitable PMs.

C. Comparative Analysis

In this paper, the experiments are done for VMs allocation algorithm based on ordinary sequential based mapping and the proposed binary search based mapping and then compare their average time taken of VMs allocation. For experiments for both linear and binary based allocation,

the setup configuration of VMs and PMs are the same with Table1,Table2 and Table 3. The average time taken of both VMs allocations are as shown in Table 5. According to the average time taken in mapping for VMs allocation, the proposed allocation algorithm can reduce in mapping time.

TABLE 5. Ordinary Sequential Mapping vs Binary Mapping

Number of PMs	Number of VMs	Average Time processing Sequential Based Mapping (mili seconds)	Average Time processing Proposed Binary search based Mapping (mili seconds)
5	20	146.9	146.3
10	20	157.17	155.15
20	20	160.34	158.33
50	20	162.85	160.82
70	20	173.6	167.6
100	20	195.8	188.8
150	20	201.9	191.9

As shown in Fig.3, the proposed binary search based mapping is faster than that of ordinary sequential one.

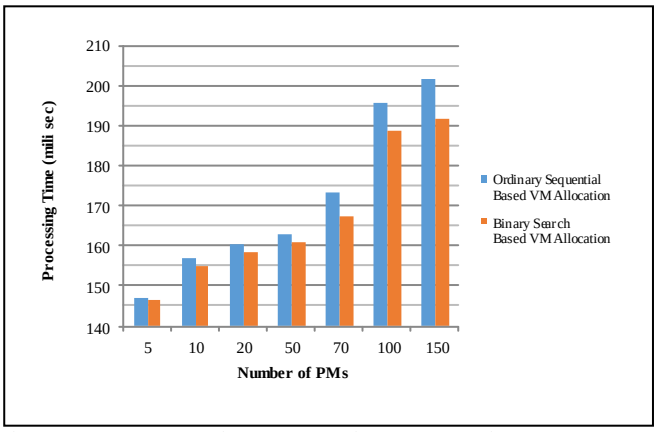

Figure 3. Average Time Processing Comparison

It is the contribution of the binary search during the mapping for VMs allocation. There is no doubt that the proposed VMs allocation is more efficient in mapping compare with the existing one.

V. CONCLUSION AND FUTURE WORK

In this paper, the efficient VMs allocation algorithm is presented and evaluates the efficiency of the proposed VMs allocation algorithm through CloudSim. For experiment of VMs allocation, two resources i.e memory and CPU are configured as resources' parameters. The comparative analysis shows that the average time taken of the proposed VMs allocation algorithm is faster than the existing one due to the contribution of binary search based mapping. In order to be an efficient the VMs allocation in Cloud Data center, the optimization problems- resource utilization and energy reduction are important. In the future, the effective policies and efficient algorithm would be integrated in the proposed VMs allocation model for resolving these optimization issues.

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