An Effective Mechanism for Virtual Machine Placement using Aco in IAAS Cloud

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Abstract: Cloud computing provides an effective way to dynamically provide numerous resources to meet customer demands. A major challenging problem for cloud providers is designing efficient mechanisms for optimal virtual machine Placement (OVMP). Such mechanisms enable the cloud providers to effectively utilize their available resources and obtain higher profits. In order to provide appropriate resources to the clients an optimal virtual machine placement algorithm is proposed. Virtual machine placement is NP-Hard problem. Such NP-Hard problem can be solved using heuristic algorithm. In this paper, Ant Colony Optimization based virtual machine placement is proposed. Our proposed system focuses on minimizing the cost spending in each plan for hosting virtual machines in a multiple cloud provider environment and the response time of each cloud provider is monitored periodically, in such a way to minimize delay in providing the resources to the users. The performance of the proposed algorithm is compared with greedy mechanism. The proposed algorithm is simulated in Eclipse IDE. The results clearly show that the proposed algorithm minimizes the cost, response time and also number of migrations.

Keywords: Cloud Computing, Virtual Machine Placement, Ant Colony Optimization, Greedy Mechanism.

1. INTRODUCTION

Cloud computing is perpetually a boon to revolutionize today’s information technology. It is one of the most powerful paradigms used for hosting services and for provisioning on-demand requests. It allows cloud providers to provide virtual hardware, runtime environments and services. It is employed for accessing the resources virtually through World Wide Web. Virtualization technology is one of the fundamental components of cloud computing, especially in case of infrastructure-based services. It allows creation of secure, customizable, and isolated execution environment for running applications, without affecting other user’s applications. The virtual machine placement is defined as the process of choosing the foremost appropriate host for each virtual machine request. Optimal Virtual Machine Placement (OVMP) owns a foremost problem in cloud infrastructure management, that contains a large variety of attainable optimization criteria and different formulations are used. In this paper we describe, how efficiently the virtual machines are placed in the physical machines based on the specifications needed by the clients using the ant colony optimization technique. This optimization technique
minimizes several objectives like resource wastage, time consumption, cost and number of migrations. In this paper we interpret the problem of virtual machine placement by four Strategies.

- To find the matched list for each virtual machine request from the resource database
- To place the virtual machine on the physical machine having minimum cost and response time using ACO
- Monitor the virtual machines periodically
- Migrate the virtual machine if the physical machine is overloaded

2. RELATED WORK

Michael cardosa et.al [1] proposed energy – efficient technique for mapReduce in a cloud environment. This technique place mapReduce VM’s within the cloud in a manner that is not only an efficient spatial fit for utilizing CPU, memory, network and storage resource efficiently but also a balanced temporal fit collocating jobs of similar runtime on each physical machines. Kangkang Li et.al [2] proposed an approach to minimize the total job completion time of the input VM requests through a reasonable VM placement schedule. Hieu Trong Vu et.al [3] presented a VM Placement algorithm in heterogeneous cloud data centers that minimize network congestion while energy consumption is unchanged. Ashwin kumar sarma [4] et.al proposed an algorithm that combines both multi objective algorithm and ant colony optimization. The multi objective genetic algorithm is extensively compared with ant colony optimization. Pathan noumankhan sayeedkhan et.al [5] has done a disk I/O load based virtual machine placement algorithm i.e. FFDL and proposed a static disk threshold based migration algorithm to optimize the performance of the virtual machine. When more than one virtual machine enter into cloud the FFDL algorithm places the vms in the same manner as greedy algorithm by conclusion we conclude that execution time obtained by applying static threshold based scheme is less than execution time obtained by applying FFDL algorithm. Mahyar Movahed Nejad[6] et.al proposed an auction based models for provisioning and allocation which allow users to submit bids for their requested VMs. Mayank Mishra et.al [7] proposed a Bin-packing approach to minimize the number of physical machines PMs used. This new innovative VM placement approach which does a tight packing of VMs keeping into consideration the required stability. Guoliang Xue et.al [8] proposed a service-aware approach to enhance survivability in virtualized data centers. A fundamental problem is to determine how to map each SVI to a data center network with minimum operational costs satisfying each VM’s resource requirements. This problem can be divided into two sub problems: VM Placement (VMP) and Virtual Link Mapping (VLM). Alex delis et.al [9] proposed Nefeli, a hint-based VM-scheduler that serves as a gateway to Iaas clouds. Users aware of the flow of tasks executed in their virtual infrastructure and the role of each VM plays. Daniel Espling et.al [10] proposed an approach called integer linear programming scheduling for service owners to influence placement of their service components by explicitly specifying service structure, and placement constraints between components.

3. PROPOSED SYSTEM ARCHITECTURE

The system architecture of the proposed work is shown in the figure: 1. The cloud users submit their virtual machine requests which are arranged in VM Queue. The requests are processed in First come First serve basis. The cloud resource broker forwards the request to the
Resource Finder. The resource finder finds the matched resources to place the virtual machines that satisfy hardware, software and QOS constraints. The resource finder finds the matched list using Tanimoto coefficient. The placement manager gets the information about cloud resources stored in resource repository. The objective of placement manager is to optimally place the virtual machine on the physical machine. The Placement manager is integrated with Ant colony optimization algorithm. After placing the virtual machine on the physical machine, Monitor periodically monitors and updates the status of the physical machines in the Resource Repository. If the monitor finds, any physical machine gets overloaded then, it invokes migrator. The migrator migrates the virtual machine placed in the overloaded physical machine to some other machine.

4. IMPLEMENTATION

Let the number of physical machines in cloud environment are $|PM|$. The number of virtual machines submitted is $|VM|$. Placement of virtual machines in the physical machines in cloud computing is a challenging task. The virtual machine placement problem can be viewed as “placing a virtual machine on physical machine, which is optimal in terms of minimizing number of migrations thereby minimizing the cost and maximizing satisfaction of cloud users”.

Some attributes taken into account for optimal placement of virtual machines are:

- User requests are heterogeneous and arrive at regular time interval $t$ are handled using First Come First Serve basis.
- A Virtual Machine $VM_i$ can be placed on physical machine $PM_j$ if it satisfies hardware requirements, software requirements and QOS.
- Optimal Placement of virtual machine on physical machine in such a way to minimize migration is NP-Hard problem, and such problem can be solved using Meta heuristic algorithm.

![Proposed System Architecture](image)

Fig. 1. Proposed System Architecture

A. VM Placement Problem

The number of possible mapping of virtual machine to the physical machine is given as $|VM||PM|$. Such mapping space is really large enough. In order to find optimal mapping of virtual machine to physical machine Ant colony based optimization technique is proposed in this paper.
B. Objective

The objective is to place a virtual machine on a physical machine which is having minimum cost and having faster response time which in turn minimizes migrations and maximizing the user satisfaction. Virtual machine placement problem is defined as a set of virtual machines \( \{VM_1, VM_2, \ldots, VM_n\} \) that has to be optimally placed on a set of physical machines \( \{PM_1, PM_2, \ldots, PM_m\} \). Each virtual machine \( VM_i \) has a set of matched resources represented as \( ML_{VM_i} \). The constraint allows an optimal placement of virtual machines.

Objective Function:

\[
\text{Min } f(PM) = w_1 \cdot \text{Cost}_{VM_i, PM_j} + w_2 \cdot \text{RespTime}_{VM_i, PM_j}
\]

Constraints:

\[
\text{Cost}_{VM_i, PM_j} \leq \text{Cost}_{VM_i, PM_j}
\]

\[
\text{RespTime}_{VM_i, PM_j} \leq \text{RespTime}_{VM_i, PM_j}
\]

\[
X_{VM_i, PM_j} \left\{ \begin{array}{ll}
1 & \text{if PM}_j \text{ is chosen for } VM_i \\
0 & \text{else}
\end{array} \right.
\]

Where \( \text{Cost}_{VM_i, PM_j} \) represents cost to place virtual machine \( VM_i \) on physical machine \( PM_j \). \( \text{RespTime}_{VM_i, PM_j} \) represents response time of virtual machine \( VM_i \) on physical machine \( PM_j \). The above multi-objective function can be solved by using Ant Colony Optimization. In this paper, Ant Colony Optimization based placement manager has been proposed for optimal placement of virtual machines on physical machines.

C. Algorithm

When the cloud Broker receives virtual machine requests, first it invokes the Resource finder to find the list of matched resources to place virtual machine. The Resource Finder is implemented with Tanimoto coefficient. The proposed algorithm outputs matched list for each virtual machine represented as \( ML_{VM_i} \). A physical machine \( PM_j \) is considered as a matched resource and included in \( ML_{VM_i} \) if and only if the resource has the highest similarity with the virtual machine request. The similarity between virtual machine \( VM_i \) and physical machine \( PM_j \) is computed as

\[
\text{Sim}(VM_i, PM_j) = \frac{VM_i, PM_j}{\|PM_j\|^2 - VM_i, PM_j}
\]

Let the set of matched resources be indicated as \( ML_{VM_i} \). After selecting the matched resources, the Placement manager is invoked to place a virtual machine on each physical machine. Fitness matrix will be constructed as shown in equation:7. The matrix is constructed as, if a physical machine \( PM_j \) is a matched resource for the virtual machine \( VM_i \) then fitness value will be computed using the objective function specified above. If a physical machine is not a matched resource, then the fitness value will be set as \( \infty \).
The general algorithm of the entire proposed work is given in Algorithm 1.

The OVMP Algorithm works as follows: The input to the algorithm is the list of virtual machines and physical machines in the cloud environment. For every virtual machine, Resource Finder is invoked, whose aim is to find the list of matched physical machines. Once the matched list is obtained, the placement manager is called whose objective is to place virtual machine into physical machine.

Tanimoto coefficient is used to find matched list for each virtual machine. If the tanimoto similarity is above 0.90, then the physical machine is considered as matched list for processing the virtual machine. The algorithm for Resource Finder is given in Algorithm 2. Having found the matched list for each virtual machine $VM_i$, the proposed Ant Colony Optimization based placement manager will be invoked. Ant Colony Optimization is a probabilistic technique for solving NP-Hard problems. The algorithm is inspired by the behavior of ants. Parameters of ACO algorithm is: i) prior desirability indicated by $\eta$ represents the objective function ii) Posterior desirability indicated by $\tau$ represents the trail level iii) pheromone evaporation coefficient $\rho$ range between 0 to 1 iv) $\tau_0$ initial pheromone coefficient. Algorithm 3 depicts the function of placement manager. The Placement Manager returns the optimal mapping of virtual machines to the physical machines. Once the virtual machines are placed in to the physical machine, status of the physical machine and response time of the virtual machine are monitored periodically. The monitor reports the status of overloaded physical machine and calls migrator to migrate the virtual machine placed in it. Algorithm 4 shows the function of monitor. The Monitor calls the migrator with overloaded physical machines and virtual machines.
The migrator migrates the virtual machine to other matched physical machine by calling placement manager. Algorithm 5 shows the function of migrator.

5. EXPERIMENTAL RESULTS AND DISCUSSION

The proposed Ant colony optimization based placement is compared with Greedy mechanism. The Simulation experiment is performed by generating five schedules. The comparison is made with Cost for Placement, response time, Number of migrations, resource wastage and user satisfaction for each schedule.

5.1 Comparison of Cost

Greedy mechanism uses the heuristic that the physical machine which is having faster response time is the best. But unfortunately the physical machine chosen would not be having minimum cost. Thus cost is more in greedy mechanism. But ACO chooses a physical machine
having minimum cost and faster response time. Thus cost is minimum in ACO when compared with greedy mechanism. Cost is computed as

$$\text{Cost} \leftarrow \sum_{i=1}^{|VM|} \text{Cost}_{VM_i, PM_j}$$  \hspace{1cm} (8)

5.2 Comparison of Response Time

Response time represents amount of time it takes to respond to the user request for service running in a virtual machine. In general, response time should be minimum. The response time of a schedule is computed as

$$\text{ResponseTime} \leftarrow \sum_{i=1}^{|VM|} \text{RespTime}_{VM_i, PM_j}$$  \hspace{1cm} (9)

The Greedy mechanism uses the heuristic that physical machine which is having minimum cost is the best one to place the virtual machine. That physical machine may not respond faster. Thus in Greedy mechanism response time increases when compared to ACO. Since ACO chooses a physical machine which can respond faster as well as having minimum cost.

5.3 Comparison of Number of Migrations

Since Greedy mechanism does not place a physical machine having minimum response time, the number of virtual machines need to migrate is more. Since migration is more the cost for placement is also more. But ACO chooses a physical machine having minimum response time and cost. Thus number of migration is less when compared to Greedy.

5.4 Comparison of Resource Wastage

In Greedy mechanism, more number of physical machines are powered on, which results in wastage of power. Since number of migrations is more in Greedy mechanism, more number of physical machines are powered on. But in ACO, number of physical machines used is minimum which reduces power.
6. CONCLUSION AND FUTURE WORK

With the increasing prevalence of large scale cloud computing environments, how to efficiently place VMs into available computing servers has become an essential research problem. Using ant colony optimization technique, our proposed VM placement algorithm could make remarkable improvements over the existing solution. The goal is to efficiently obtain a set of non-dominated solutions that simultaneously maximizes the resource utilization and minimizes the number of migrations over the existing VM placement algorithm. The proposed algorithm is tested with some instances from the literature. We also making more ecofriendly IT infrastructures with reasonable amount of on-demand operating cost to improve the quality of IAAS of cloud computing along with efficient time management. In future, we would like to implement the virtual machine placement in real time environment.

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