A REVIEW ON ENERGY EFFICIENT VIRTUAL MACHINE PLACEMENT TECHNIQUES

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Abstract: Virtualization is a key technique in cloud computing and it enables scalable delivery of services. Virtual Machine (VM) consolidation can become complex due to heterogeneity in resources, scalability of resources on demand, temporary and dynamically varying workloads, etc. VM Placement does allocation of resources for virtual machines based on workload and it is base for the VM consolidation, hence there is a need for efficient VM Placement techniques to consolidate workload on fewer physical hosts and thereby reduce energy consumption. This paper presents a detailed review on Energy-efficient VM Placement techniques along with the comparison in various metrics among them.

Index terms- **Virtual Machine, VM Placement, Energy consumption, CPU, Host**

I. INTRODUCTION

Data Centers housing large number of IT equipment such as servers, data storage, network devices, power and cooling devices etc. facilitate the development of varied services offered by the cloud. With the quick development of IT industry and increasing call for cloud services, the number of data centers have increased. These data centers consume large amount of energy to process its services which leads to increased energy consumption.

Today, the price of the energy a typical computing server consumes during its lifetime exceeds its purchase cost, and large scale computing and network systems are being established near power stations to reduce power transmission losses. In Grids and data centers, computing and networking equipment such as PCs, switches, routers, and servers powered on, even if they are idle which results in wastage of energy. The power consumption by computing facilities increases various financial, environmental and system performance concerns.

This growing energy consumption problem can be dealt using Virtualization in cloud computing. Using virtualization, several operating systems can be run in parallel, in the form of virtual machines, in a single host machine. Hypervisor or virtual machine monitor is responsible for abstracting physical machine hardware and allocate virtual hardware for VMs to process cloud workloads. VM Placement does allocation of resources for virtual machines based on workload and it is base for the VM consolidation.

There are two types of VM Consolidation: static and dynamic. In the Static VM Consolidation, virtual machine monitor allocates the physical resources to the virtual machines based on peak load demand which may lead to resource wastage because always workloads may not be at peak. In the dynamic consolidation, virtual machine monitor changes the VM size or capacity according to the current workload demand which helps to use data center resources efficiently. And VMs can be dynamically reallocated among the PMs (Physical Machines or hosts) according to their resource demand which minimizes the number of active hosts required to handle the workload.

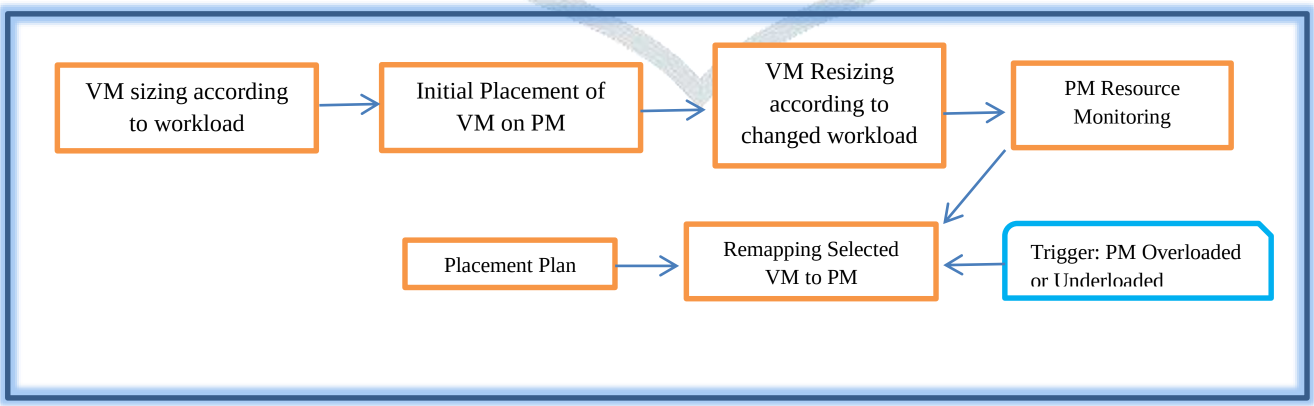

Figure-1: VM Placement process

II. RELATED STUDY

In this study, different Energy-efficient Virtual Machine placement techniques are presented.

Perla Ravi Theja[1] has proposed an Adaptive-Genetic algorithm that tracks host underload and overload detection, performs minimum migration time VM selection and places VM to host such that energy consumption and SLA violation are reduced. This algorithm uses local regression and interquartile range schemes to track CPU utilization dynamically.

M H Malekloo, N Kara[2] has proposed Multi-objective Ant Colony Optimization algorithm which focused on green cloud computing. This approach attains lower energy consumption in VM placement, reduces CPU energy wastage and also the energy cost required for the communication of traffic load among the VMs. It uses two complementary algorithms: ACO VMs placement and Multi-objective ACO VM consolidation which consolidates VMs on to less number of PMs(Physical machines).

M Soltanshahi[3] proposed a Krill Herd algorithm for energy aware VM placement. This approach aggregates the VMs and shuts down the idle servers to reduce energy consumption. Proposed algorithm was compared with the existing Genetic and MBFD algorithms when used with IQR and MAD as host overload detection and minimum migration time VM selection algorithms. Krill Herd algorithm has reduced the average energy consumption when compared to existing approaches.

H Wang[4] approach was towards green cloud computing. He proposed Space-aware Best Fit Decreasing algorithm and high CPU utilized VM migration as HS virtual machine selection algorithm. When used together, performs better than existing PABFD VM placement algorithm. In this SABFD approach, host with minimum available MIPS after VM being placed will be selected for VM placement. Here, algorithms are used for host overload detection are: IQR, LR, LRR, MAD and VM selection policies used are: MMT, RS, MC.

M Mohammadhosseini[5] has proposed Balanced based Cultural algorithm for VM placement(BCAVMP) which uses a new Fitness function to balance the VM allocation on to the physical Hosts, thereby reducing the resources wastage. This approach places VMs on to less number of Hosts, thereby reducing number of active servers in the data center which in turn reduces the average energy consumption of data center. In the proposed fitness function, two parameters were considered: 1.Sum of balance vector magnitudes of active hosts 2. Total energy consumption, which balances utilization of resources and can find solutions which require less energy.

N Garg[6] proposed Energy and Resource-aware VM Placement (ERAP) algorithm which considers CPU utilization and energy for VM placement on to physical Hosts. This algorithm works better when compared to existing techniques, in the metrics: : number of VM migrations, total energy consumption, number of hosts shut-downs and average SLA violation rate. Proposed technique sets host threshold to 0.8 utilization level and chooses the host with minimum energy consumption, which avoids host overloading and reduces energy consumption of data center on average.

Xiao-Fang Liu[7] proposed an Order Exchange and Migration Ant Colony System (OEMACS) algorithm, it’s an ACS(Ant colony system) based approach, which allocates VMs to minimum number of hosts and turns off the idle hosts to save energy. VM placement is done based on global search information which is distributed among VM pairs and this binds VM to host, there by host also records good VM groups from historical experience. This approach performs better when compared to existing approaches, in the metrics: energy consumption, effective utilization of resources.

A P Xiang[8] has come up with an approach for VM placement with multiple resources. It's a PSO-based algorithm which uses fitness function to place VMs on optimal host which in turn reduces energy consumption and effectively utilizes the resources. Proposed algorithm is compared with existing MBFD and MBFH and it performs better in energy savings. This technique considers CPU and disk resources in the VM placement to make it energy-efficient.

F Abdessamia[9] proposed a PSO-based VM placement algorithm for heterogeneous environment. This technique is modified one of PSO which performs better when compared to existing first-fit, best-fit and worst-fit algorithms and reduces the energy consumption. Algorithm is experimented using cloudsim tool.

Xiong Fu[10] used binary particle swarm optimization(BPSO) algorithm for energy-efficient VM placement, which uses fitness function to reduce number of active hosts in the data center. This approach focuses on CPU utilization and disk resources of host to reduce energy consumption.

A Ibrahim and M Noshy[12] proposed a power-aware VM placement algorithm based on particle swarm optimization (PAPSO) which maps VM to near and best appropriate Host. This technique uses minimization fitness function to place VMs to minimal number of Hosts to reduce energy consumption and number of active hosts in data center. It also reduces number of VM migrations and experiment is deployed in Cloudsim. Proposed algorithm is compared with existing PABFD and PAPSO out-performs PABFD in metrics: energy consumption, number of VM migrations, number of active servers, SLA violation rate.

Table-1: Comparison of Energy-efficient VM placement techniques

Reference	Algorithm	Resources considered	Experiment environment	Optimization
[1]	Adaptive-Genetic	CPU utilization and Network bandwidth	CoMon data project of PlanetLab, Cloudsim	Proposed algorithm performs better than exisiting virtualization schemes like ACO(Ant colony optimization),LR(local regression,IQR(conventional interquartile range), THR(static threshold), MAD(median absolute deviation) and there by reduces energy consumption, SLA violations
[2]	Multi-objective Ant Colony Optimization(MACO)	CPU, Network communication cost	Cloudsim	MACO approach performance was better than the existing FFD, ST in the metrics like energy consumption, reduction in CPU energy wastage and communication energy cost.
[3]	Krill Herd algorithm	CPU workload, memory, processing power	Cloudsim	Proposed algorithm is fastest collective intelligence algorithm which gave 35% reduction in energy consumption compared to existing GA, MBFD when used with IQR, MAD as host overload detection and minimum migration time algorithms.
[4]	Space aware best fit decreasing(SABFD), HS	CPU utilization, Host MIPS	Cloudsim, CoMon project workload data	SABFD VM placement algorithm is used with High CPU utilized VM selection for VM migration. This dynamic VM consolidation out-performs other DVMC plans and reduces the energy consumption of data center and assures SLA.
[5]	Balanced based Cultural algorithm for VM placement(BCAVMP)	CPU, Memory, Bandwidth	Cloudsim, CoMon project workload data	To analyze the performance of proposed algorithm, four metrics: total number of active servers, number of VM migrations, energy consumption, SLA violation. This approach consolidates VMs to less number of PMs to reduce energy consumption and uses resources in balanced manner using new fitness function while placing VMs on to PMs. Proposed algorithm is compared with existing PABFD in the combinational algorithms: IQR-MMT, LR-MMT, MAD-MMT and THR-MMT.
[6]	Energy and Resource-aware VM Placement (ERAP) algorithm	CPU utilization	Cloudsim, PlanetLab workload	ERAP approach performs better when compared with existing algorithms in the metrics: number of VM migrations, total energy consumption, number of hosts shut-downs and average SLA violation rate. This algorithm reduces energy consumption on average 13.12%. Proposed algorithm uses Host resources up to maximum threshold, which better utilizes the resources and increases the system performance. This algorithm is compared to the existing PABFD with LR, IQR, MAD, LRR host overload detection policies and MU, MMT, MC VM selection policies.
[7]	Order Exchange and Migration Ant Colony System(OEMACS)	CPU, Memory	Implemented using C++	OEMACS performs VM deployment on minimum number of active hosts and turns off the idle hosts which makes algorithm energy-efficient. VM placement is done based on global search information which is distributed among VM pairs and this binds VM to host, there by host also records good VM groups from historical experience. This algorithm is compared with existing FFD, RGGA, ACO, MACO and HACOPSO approaches and performs better than them, in reducing energy consumption and effectively utilizing the resources.
[11]	Hypercube framework	CPU, Memory	Matlab	This approach reduces energy wastage and utilizes resources effectively compared to ACS
[12]	Power-aware VM placement based on	CPU utilization	Cloudsim	PAPSO out-performs PABFD in metrics: energy consumption, number of VM

	PSO (PAPSO)			migrations, number of active servers, SLA violation rate.

III. CONCLUSION

This paper has presented a detailed review on recent Energy-efficient VM Placement techniques along with the comparison in various metrics among them. The techniques which were reviewed are under the categories: Genetic approach, Ant Colony Optimization and Particle Swarm Optimization. Most of the techniques focused on reduction of average energy consumption in the data center, but only few resources like CPU utilization level, memory, network bandwidth were taken into the consideration while research. There are other issues like Network latency, heterogeneous environment and workloads, dynamically changing workloads, VM resizing, which cannot be evaluated and tested with static input resources supplied at the beginning of simulation. Hence there is a need for techniques which can accept dynamic (run-time) workloads in parallel with simulation, to evaluate the accurate behavior of algorithm.

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