A SURVEY ON VM CONSOLIDATION FOR ENERGY EFFICIENT GREEN CLOUD COMPUTING

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Abstract—Energy consumption has been a main concern to the environment as the scale of cloud data centers become larger due to the ease of internet usage, storage and processing on cloud. As a consequence of establishment of large number of data centers, the energy consumption grows rapidly. Also they contribute in the energy consumed worldwide and consequently to the environmental drawbacks like carbon emission. Virtualization technologies provide the ability to transfer virtual machines between the physical machines using live VM migration in cloud computing. Dynamic server consolidation is an efficient way for energy conservation in cloud by decreasing the total number of active physical machines. Its objective is to keep the number of power on systems as low as possible and hence reduce the excessive power consumed by the idle physical servers. Several protocols, heuristic algorithms, constraints based algorithms, need and challenges in consolidation are the main part of this survey.

Keywords: cloud computing, consolidation, green cloud, energy efficiency

1. INTRODUCTION

Cloud computing is an internet based on-demand computing, pay as you use model and accessing the computing resources of third parties. The Computing resources have become cheaper, powerful and ubiquitously available than ever before due to the rapid development in the processing and storage technologies and also the success of Internet. This led to the establishment of more data centers that have significant contribution in the energy consumed worldwide and consequently environmental drawbacks like carbon emissions.

The NIST definition for cloud computing [14]

“Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction”. This cloud model is composed of five essential characteristics, four service models, and three service models.

Essential Cloud Characteristics

1. On-demand self service
2. Board network access
3. Resource provisioning
4. Rapid elasticity
5. Measured services

Any traditional IT model must fall under or include the above mentioned essential characteristics to become a cloud model. Being cloud also has many challenges and some are mentioned below.

Challenges in cloud

1. Automated service provisioning
2. Virtual machine migration
3. Server consolidation
4. Traffic management and analysis
5. Data security

Virtualization [6]

Virtualization is a technique of abstracting physical resources and making them appear as logical resources. Deploy infrastructure service for physical assets. For a layman, virtualization can be mentioned as making the hardware resources appear as software resources. It may be implemented at storage, compute and network or application layers. The hardware architecture can be either X34 or X32 or X86. These architectures can run or host any one application so we go for virtualization which can host many applications in spite of its architecture.

The virtualization technique has become attractive since it has many benefits [6] like

1. Optimizing utilization of IT infrastructure
2. Reducing cost and management complexity
3. Reducing deployment time
4. Increasing flexibility.
5. Hardware Independence
6. No human intervention
7. Reducing downtime

Green Computing
It refers to foresee not only accomplishing the efficient processing and use of computing environment, but also reducing the energy consumption. Reducing carbon emission that causes global warming is the main goal of being green. Carbon di oxide emission is one of the most important reasons for energy consumption, so reducing energy consumption not only means conserving more energy sources for the future use but also means reducing CO2 emissions.

Reducing the overall energy bill of a data center resides first and foremost on energy aware data center design that includes hardware and software, use of solar power, renewable energy and the next is use of energy aware scheduling and placement policies. The different techniques available are denoted in the below section.

II. TECHNIQUES TO IMPROVE ENERGY EFFICIENCY OF DATA CENTERS[11]

- IT Infrastructure Improvements
  - Servers and Storages
  - Network Equipment
- Power Distribution
- Smart Cooling and Thermal Management
- Power Management Techniques
  - Provisioning
  - Consolidation
  - Virtualization
- others

Upon many techniques denoted, the survey here is about the Consolidation technique and it is described briefly in the following sections.

III. VM CONSOLIDATION

VM Consolidation [4] is a technique to reduce the number of active PMs by migrating and consolidating the VMs into reduced number of physical machines.

Consolidation includes two strategies: VM placement and VM migration.

1. VM Placement

VM Placement is the process of selecting the appropriate host for the given VM. For the efficient utilization of the resources, Virtual Machines should be placed on to the appropriate host. The VM placement algorithms try to achieve some goal. This goal can be either saving energy by shutting down some servers or it can be maximizing the resources utilization and the next is VM Migration.

VM Placement is of two types: Power based approach and Application QOS based approach. Power based approach is for energy conservation by shutting down some servers and the Application based approach is for maximizing the resource utilization and also maximizing QOS delivery by provider.

2. VM Migration

VM Migration is carried out after the initial VM placement in order to reduce the number of running physical machines by migration of few VMs and consolidate them into reduced number of PMs. Four steps are involved in the VM machine migration process. First step is to select the PM which is overload or under loaded, next step is to select one or more VM, and then select the PM where selected VM can be located and the final step is to transfer the VM. Selecting the appropriate host which best suits VM is one of the interesting task in the migration process, because wrong selection of host can increased the number of migration, resource wastage and energy consumption.

3. Types of Consolidation

Consolidation falls under two types namely static and dynamic consolidation. In static consolidation a new VM is placed to PMs for processing and no migration takes place here. In dynamic consolidation the VMs are migrated from one PM to another whenever a necessity occurs.

4. Advantages and challenges in consolidation

Advantages

- Reduce the amount of hardware,
- Reduce the data center footprints,
- Indirectly reduce power consumption,
- Cost reduction and
- Reduce staffing needs.

Challenge

How accurately to characterise an application’s resource requirements and resource usage over a time period.

IV. NEED FOR VM CONSOLIDATION

By 2014, energy costs contribute 75% by the data centers because of insufficient hardware usage and inefficient resource usage. Consequently, energy costs for operating and cooling the equipment of data centers have enlarged considerably up to a point where they are able to exceed the hardware acquisition costs. “For each watt consumed by the computing resources an additional 0.5-1 watt is required by the cooling systems and CO2 emission also contribute to significant Greenhouse effect”[16]. About 50% of electricity in the data center is consumed by the servers/storage and computer AC room consumes about 34% of power. So, one of the main problems in a data center is power consumption since it emits more heat as a consequence of more power consumption and needs more cooling devices to reduce heat generated when the number...
of physical systems increase which results in more costs. Henceforth finding a solution for energy conservation is essential for both improved ROI and efficient processing of resources. Also from business perspective reduction in energy consumption can lead to immense cost reduction. The solution is switching servers off which are in idle mode or put them in sleep or low power modes. This is achieved by the Dynamic VM Consolidation technique. The below table is the comparison of the existing works done by many researchers in consolidation of virtual machines for many reasons.

The following section describes some of the existing works performed regarding energy conservation using the virtual machine migration and consolidation techniques.

### V. RELATED WORKS ON ENERGY CONSERVATION IN DATA CENTERS

#### 1. Online Algorithm for Servers Consolidation in Cloud Data Centers [15]

Makhlouf Hadji et al proposed a novel and online linear programming algorithm based on b-matching theory [15] to solve the consolidation problem with minor SLA violations. To totally eliminate SLA violations, and to deal with dynamic workloads variations, the optimal amount of a resource pool are determined which is used to handle over used server problems.

The paper focuses on optimal and online repacking algorithm to reduce overall cost and to improve resource sharing and utilization and, also to find the optimal amount of resource pool to be used to handle the SLA violations. This problem can also be considered as a classical NP-Hard Virtual Machines placement problem in which to meet the user’s request we look for the number of servers to be used. The repacking is achieved via migrations while minimizing costs and interferences when migrating the VMs. The b-matching algorithm provides the best trade-off between convergence time which is 5 seconds for 3000 VMs and 900 PMs, optimality, scalability and cost and Results in fewer VM migrations. But, it requires more servers to reduce SLA violations.


Live migration of VMs plays an imminent role in power conservation and this technique is one of the popular and widely used techniques. Live migration is performed by many researchers. Li Y et al focused on the VM placement selection of live migration for power saving. They present a novel heuristic approach called PS-ABC[13]. The algorithm contains two parts. First is that it combines the artificial bee colony (ABC) idea with the uniform random initialization idea, the binary search idea, and Boltzmann selection policy to attain a more improved ABC-based approach with better global and local exploitation's ability. The other one uses the Bayes theorem to further optimize the improved ABC-based process to faster get the final optimal solution. As a combined result, the whole approach achieves a longer-term efficient optimization for power saving.

#### 3. Energy-Aware Ant Colony Based Workload Placement in Clouds [12]

Most of the workload consolidation approaches in practical until now are limited to a single resource like CPU and rely on relatively simple greedy algorithms [12] such as First-Fit Decreasing (FFD). Eugen Feller et al proposed a model in which the workload placement problem is considered as an instance of the multi-dimensional bin-packing (MDBP) problem and design a different, nature inspired algorithm based on the Ant Colony Optimization (ACO) meta-heuristic to figure the placements dynamically, according to the current load. They evaluated the ACO-based approach by comparing the proposed algorithm with one greedy algorithm (i.e. FFD). Their simulation results demonstrate that ACO outperforms the evaluated greedy approach as it achieves better energy gains through better server utilization and requires only fewer machines. This is the first work to apply Ant Colony Optimization on the MDBP problem in the context of dynamic workload placement and apply ACO in order to conserve energy.


Authors et al focused on the problem of an energy efficient initial VM placement, and described three new algorithms for the effective and efficient placement problem, one based on the novel heuristic bin packing algorithm First Fit Decreasing algorithm, and the next two were similarly based on one of the heuristic algorithms namely Best Fit Decreasing algorithm but modified approach of it. An energy efficient VM placement aims at reducing the number of active servers, by increasing the workload among the current active machines. The idea of the Authors is that “if the machine already has work to do, again increasing the amount of work will not increase the power consumption of the data center significantly. On the other hand, waking up a new machine will influence the power consumption of the data center more significantly, since, a machine in suspended or sleep state consumes a little fraction of the power of an active or running one”. The approach used to place the Virtual Machines to the Physical machines must be careful to not overload a host, since it is imperative not to
physical

eed for power consumption. Here the modification FFD is power aware that is if no VMs are allocated to a host, it suspends that particular host, greatly reducing the energy consumption.

The Power Aware Best Fit Decreasing Algorithm: [8]
The algorithm is similar to FFD, the main difference is that it calculates the increase in power usage after the allocation of the current VM in each host in data center, storing the lowest increase in power consumption. The VM is then allocated to the host that had the lowest increase in power consumption.

The Global Power Aware Best Fit Decreasing algorithm:[8]
Instead of looking to the increase in power consumption after the allocation of a new VM, this algorithm calculates the power consumption of the whole data center after simulating an allocation of VM in the current host and thus named as Global Power Aware Best Fit Decreasing (GPABFD) due to this. The proposed approach provides an efficient way for initial VM placement. But, does not provide an optimal solution i.e., there is no much difference in energy consumption.

5. VM Placement Strategy Based On Distributed Parallel Ant Colony Optimization Algorithm [10]
Distributed Parallel Ant Colony Optimization is another algorithm used for consolidation of VMs in recent times. The authors had proposed a Distributed Parallel Ant Colony Optimization (DPACO) algorithm of placement approach for VM live Migration on cloud platform. It executes the ant colony optimization algorithm parallelly and distribute[10] on several selected physical hosts in the first stage. Then it continues to execute the second stage ant colony optimization algorithm with calculated solutions of the first stage. The solution calculated by the second stage ACO algorithm is the optimal solution. Here performance per watt is assigned as the pheromone value.

The ant colony optimization is one of the solutions for VM placement problem but may stop before getting an optimal solution when the number of VMs and PMs are more. Hence here the author has proposed distributed and parallel ACO algorithm that is executed on several physical servers to get a better solution by increasing the iterative times for the large scale VMs live migration problem. Since the proposed algorithm runs distributed and parallel it can detect the physical host failures and adjust the solution simultaneously and results in lowest VM migration failure rate in VM migration events. But the main limitation of this approach is that the approach is appropriate for the case that all physical hosts in solution space are in a fast LAN and the same network environment.

6. Adaptive Virtual Machine Replacement for

Multi-dimensional Aware Server Consolidation in Data Centers[20]
The workload faced by the data centers changes often. For satisfying the varying application workload the authors had proposed adaptive management of the shared infrastructure via virtual machine migration or replacement. The authors had considered two objectives namely global VM replacement and resource efficiency. They proposed the system by considering VM replacement dual objective vector packing with minimum cost (VP-MCP). In order to solve the NP Hard problem they had proposed an Adaptive VM Replacement scheduling algorithm. The VM replacement is a kind of consolidation or grouping problem. Balancing of multiple resources improves system utilization and also migration cost must be included. To solve these objectives the authors hence proposed AVR scheduling algorithm since it is efficient in optimizing resource usage and also reduces migration cost.

7. Energy Aware Consolidation Algorithm based on K-nearest Neighbor Regression for Cloud Data Centers[17]
k-nearest neighbor regression algorithm simply called KNN regression is to calculate the average of the numerical target of the K nearest neighbors. (Source: Wikipedia) KNN has been used in statistical estimation and pattern recognition already in the early of 1970’s as a non-parametric technique. KNN does not limit its use in mining but also has extended to various fields. The authors proposed dynamic consolidation approach to reduce the number of active physical servers on a data center and hence reduce the cost spent on energy. The proposed system of this paper uses k-nearest neighbor regression algorithm monitors the resource usage in each host. Using the prediction results the consolidation algorithm determines when a host becomes over utilized and when a host becomes underutilized and perform migration of VMs accordingly. The proposed algorithm proved to be efficient in minimising power consumption and minimising SLA Violations by the simulation results. The paper splits the dynamic consolidation into four algorithms namely 1) Over-utilized host prediction: a host becomes over utilized when the prediction utilization value is more than the available CPU capacity. 2) VM selection: finding which VMs should be migrated from the under-utilized or over-utilized host. 3) VM allocation: choosing a host for allocating the selected VMs from the under-utilized or over-utilized host. 4) Under-utilized host prediction: a host becomes underutilized when the sum of future and current utilization is smaller than 10% of total hosts utilization. The dynamic consolidation algorithm runs continuously to find that the system state matches all the time. The selected VM from an over loaded or under loaded physical host is migrated to a host that is determined by the Power Aware Best Fit Decreasing algorithm (PABFD) and then the VMs are consolidated. The authors had thus proposed a system that foresees the CPU utilization of a host and also foresees over and underutilization of hosts for migration and power conservation.

Not only the migration technique is applied for energy conservation, the migration and consolidation techniques are applied also for balancing load among the servers and scheduling paradigms. The authors had proposed two exact allocation algorithm for energy efficient scheduling of VMs. Ghribi et al. had combined the energy efficient VM allocation to the hosts with a consolidation algorithm and thus it is seen as a combined algorithm for saving energy. The virtual machines are initially allocated to the physical machines using energy efficient bin packing problem. The aim of the algorithm is to reduce the number of physical servers to process the VMs or to increase the number of idle servers. Then the VMs are migrated and consolidated using a consolidation algorithm. The migration algorithm is combined with the allocation algorithm to reduce the overall energy usage of the servers. The proposed algorithm acts as an energy aware VM scheduler. The VM migration algorithm here used is integer linear program (ILP) to achieve consolidation. The objective of the proposed migration algorithm is to migrate a VM from source node to the destination node to decrease the number of active nodes and increase the number of VMs handled by the active nodes. The algorithm not only reduces the power consumed by the data center but also reduces the power during migration. The main advantage of the proposed system is that it also gains energy at high load.

5.9 Energy Aware Virtual Machine Placement Scheduling in Cloud Computing Based on Ant Colony Optimization Approach [19]

The paper proposes an approach based on Ant Colony Optimization for efficient VM Placement namely (ACO-VMC) to efficiently use the physical resource and reduce the number of active physical servers. Initially the number of physical machines and virtual machines are same in number then, the proposed algorithm ACO-VMC tries to reduce the physical servers one by one. The VM placement (VMP) means finding an apt server for processing the VM also the energy consumed must be less. The proposed VMP approach is formulated as a combinatorial optimization problem and is solved using Ant Colony Optimization. The main difference between other works from the proposed approach is that normally the pheromone is deposited between PMs and VMs but here the pheromone is deposited in between the VMs to find the possibility of placing them in a same server. But the heuristic value is considered between the VMs and physical servers. The heuristic value improves the algorithm further to place the VMs onto suitable physical servers.

10. Energy-aware resource allocation heuristics for efficient management of data centers for Cloud computing [1]

Anton Beloglazov et al had mainly focused on delivering the negotiated Quality of Service (QoS) using proposed energy-aware allocation heuristics algorithm to provide resources for the application clients in such a way that improves energy efficiency of the data centers. The paper aims at defining an architectural framework for energy efficient cloud computing. Investigating energy aware resource provisioning and allocation algorithms. Developing energy aware migration and consolidation algorithm. Also to explore the challenges in energy efficient resource allocation. The migration is performed using Modified Best Fit Decreasing algorithm (MBFD).

VI. CONCLUSION AND FUTURE WORK

Energy conservation is one of the main challenges in cloud infrastructure since the power consumption of the data centers increase day by day due to increase in data processing and computation etc., which results in increased capital expenditure. An effective technique for energy conservation in cloud data centers is VM Consolidation, which helps to reduce the power consumption by migrating VMs and consolidate them into reduced number of Physical servers. Some of the existing works using this technique were surveyed on.

There are also some other ways for achieving the objective like DVFS, application scheduling, operating system migration, energy aware scheduling and resource allocation etc., which will be surveyed in the near future.

REFERENCES


[11] Huaglory Tianfield PhD, Professor of Distributed Systems
Glasgow Caledonian University, United Kingdom E-mail:
h.tianfield@gcu.ac.uk“A vision on VM consolidation for green cloud computing”.


