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A Study on Virtual Machine Selection, Placement and Migration Techniques

Kalpana Ettikyala, CSE Department, CBIT, Gandipet, Hyderabad, India. ekalpana_cse@cbit.ac.in

Dr. Y Vijayalata, IT Department, GRIET, Bachupally, Hyderabad, India. vijaya@griet.ac.in

Abstract- Cloud computing is handled by virtualization technology. Virtualization simplifies the delivery of services in cloud computing and it provides a platform for optimizing the complex IT resources in scalable manner and hence it makes cloud computing so cost effective. The concerns like heterogeneity and scalability of physical resources, migration cost and temporary workloads make the virtual machine (VM) consolidation complex. VM placement and VM migration act as foundation to the VM consolidation process. Here, we present a study of different VM Selection, Placement and VM Migration techniques with a comparison between those techniques.

Keywords-- Virtualization, VM Consolidation, VM Placement, VM Live Migration, VM Selection.

I. INTRODUCTION

Virtualization in cloud computing is a technique to run several operating systems simultaneously on one physical machine, has become a key concept in data centers, mainly operated by the benefit of application isolation, resource sharing, portability, fault tolerance and cost efficiency. VM consolidation allows running several VMs on single physical machine (PM). A special middleware called hypervisor or VM monitor abstracts from physical hardware resources and supply so called virtual machines which acts like real computers with their own (virtual) hardware resources. Live migration describes the process of migrating (copying) a VM from one PM to another PM, while the VM is still powered on. VM Placement allows provisioning of resources for VMs according to the workloads and actual placement of VMs on PMs. VM Selection helps to select which VMs has to be migrated from an overloaded host.

The further sections describe VM consolidation, VM placement techniques, VM live migration techniques, VM selection policies and a comparison between those techniques.

II. VM CONSOLIDATION

VM (Virtual Machine) consolidation can give important advantages to cloud computing by facilitating better use of available data center resources. VM consolidation can be static or dynamic. In static, hypervisor allocates the physical resources to the VMs based on top load demand which leads to resource wastage because always workloads are not at peak. In dynamic, hypervisor changes the VM size (capacity) according to the current workload demand which helps to use data centers 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.

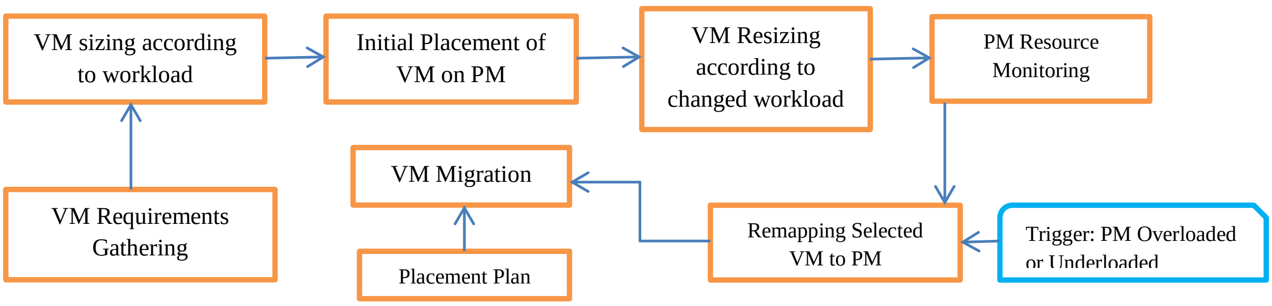

Figure 1: VM Consolidation Steps

The concerns like heterogeneity and scalability of physical resources, migration cost and temporary workloads make the VM consolidation complex.

The fundamental considerations for efficient VM consolidation are:

1. **Host Under load Detection:** This helps to reduce number of active hosts by migrating all VMs from an under loaded host and making that host to switch to low power mode.
2. **Host Overload Detection:** This helps to avoid violating the Quality of Service requirements by

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migrating some of the VMs from an over loaded host to another active host.

3. **VM Selection:** This helps to select which VMs has to be migrated from an over loaded host.
4. **VM Live Migration**: It is a technique that migrates the entire OS and its associated application from one PM to another. The VM is migrated lively without disturbing the application running on it. The VM migration helps to conserve PM energy, load balancing among the PMs and to achieve failure tolerance (in case of sudden failures). VM migration has to be done with, minimum service downtime and minimum resource consumption during migration process.
5. **VM Placement:** This helps to place selected VM for migration, on other active host.

VM placement and VM migration act as foundation to the VM consolidation process.

A.Virtual Machine Placement

This involves two main steps: Provisioning of resources for VMs according to the workloads (VM sizing) and actual placement of VMs on PMs. The placement technique should consider many resources like CPU, disk storage, RAM, network bandwidth, etc. to decrease the energy consumption and also to maintain the performance. The main objective of VM placement in VM consolidation is to save energy or load balancing to deliver good QoS to the applications running in VMs [16].

The VM Placement algorithms categories according to their placement objective [17]:

Power based technique: The goal of this technique is to map VMs to PMs in such a way that hosts can be fully utilized and the other idle or underutilized hosts can be switched off.

Application Quality of Service based technique: These algorithms map VMs to PMs with the goal of maximizing the QoS delivered. These algorithms can utilize host resources in a better way and can reduce host overload situations which lead to save in cost, by continuously monitoring VM activity and using advanced policies for dynamic workload placement.

Constraint Programming: This technique is preferred when we are aware of VM demands before computing the cost functions. The algorithms that use constraint programming are easily extendable to consider extra constraints. As number of constraints increases, time taken to generate optimal solution also increases [18].

Bin Packing technique: This technique is preferred for dynamic VM placement mainly when demand is heavily variable. It is preferred when all PMs have same memory and processing abilities. These algorithms can also be modeled with constraints. Multidimensional Bin packing algorithm can also be preferred for VM placement, where dimensions are memory and number of processing units [1, 17]. This technique is heuristic based one which may not give optimal solution but gives good solution in considerable amount of time.

Stochastic Integer Programming: This technique is preferred when there are two or more uncertain parameters on which cost depends [20].

Genetic algorithm (GA): This technique is useful to solve bin packing problem with particular constraints. It is preferred for static placements where demands are static for a period of time and it is also preferred for specifying VM-VM and VM-PM interference constraints [19]. The grouping GA needs high computing time and more computing resources than bin packing.

B. Virtual Machine Live Migration

It is a technique that migrates the entire OS and its associated application from one PM to another. The VM is migrated lively without disturbing the application running on it. The migration of VM refers to transfer of its memory, internal state of virtual CPU and devices. The main parameters in VM live migration are downtime (i.e., time during which virtual machine service is not available) and migration time (i.e., time taken to transfer a VM from source host to destination host without affecting its availability).

The VM Migration techniques categories according to their objective [2]:

Fault Tolerant Migration Techniques: This allows VMs to run even on the failure of any part of the system which helps to improve availability of PM and avoids degradation of performance of applications. Here VM is migrated based upon prediction of failure occurred.

Load Balancing Migration Techniques: This technique helps to improve scalability of PMs in cloud by distributing the load across PMs and it also helps in reducing resource consumption, avoids bottlenecks and over provisioning of resources.

Energy Efficient Migration Techniques: The PMs, even when they are at low utilization they consume about 70 percent of their maximum power consumption. Hence, we need migration techniques that save energy of hosts by optimum resource utilization.

VM Live Migration Techniques:

Post-copy technique: Here, in a short period of time the needed kernel data structures are transferred to destination host and then VM is started (at destination). The other pages are transferred on demand. This technique has less downtime but more total migration time [4, 5].

Pre-copy migration: This technique copies iteratively memory pages from source PM to destination PM without

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interrupting VM execution during migration. Dirty pages (pages that have been modified at source PM during transfer, because VM execution is not interrupted) have to be retransferred again. If the speed of modification of pages at source is high during migration then the migration time also increases. But at the destination PM pages will be clean (i.e., updated ones) so VM at destination PM can be activated at any time [6]. This technique is modified in **modification of pre-copy approach** by including a preprocessing phase, which causes amount of data to be transferred to be reduced [7].

Hybrid pre and post copy: Here one round of pre-copy is done before virtual CPU state transfer and then followed by post-copy of remaining dirty pages. It improves live migration process [8].

Memory compression: In this technique each iteration data to be transferred is compressed and at destination PM compressed data is decompressed. Here additional overhead is time taken to compress and decompress pages [9].

Delta page transfer: This technique maintains a cache which stores previously transferred memory pages by which transmission of dirtied pages can be optimized (by sending only the difference between cached page content and page content that is going to be transferred) hence network bandwidth consumption can be reduced [10].

Data deduplication: This technique uses hash based finger print technology which identifies identical data inside the memory and disk of a VM and optimizes the live migration process [13].

Adaptive prepaging: This approach identifies the pages which may be used by VM in further and transfers those pages beforehand which help in fast transfer of VM [12].

Content based hashing: If destination PM needs pages present in the memory of other VMs, it has to search which VMs in the network has a copy of specified page and moreover other VMs are active so, page content may change over time. This technique solves above problem with hash table which allows to locate the nodes that has a copy of given page using its hash value [13, 14].

Multiple VM Migrations: If virtual clusters (multiple VMs) has to be moved to different locations, it needs huge data to be transferred over network which increases the CPU and network overhead, and this results in performance degradation of applications running in PM. This technique identifies the identical data of co-located VMs in a PM and transfers that data only once to the destination PM which improves the performance and, optimizes the memory and network overhead of migration [12, 15].

C. VM Selection Policies

When overloaded host is identified, we need to select which VM has to be migrated from it and then place it on the other active host according to placement plan.

MIMT[21]

Policy that selects a VM, which requires minimum time to complete a migration, relatively to other VMs allocated to the particular host. Parameter used in this policy is CPU utilization.

MAMT[21]

Policy that chooses the maximum number of VMs which must be migrated from the host in order to reduce the CPU utilization for the host with heavily loaded. Parameter used in this policy is CPU utilization.

HPGT[21]

Highest potential growth policy migrates VM that has the lowest usage of the CPU relative to the total CPU capacity of VM for a host with heavy load. Parameter used in this policy is CPU utilization.

RC[22]

Random choice policy selects a VM to be migrated according to the uniformly distributed random variable. Parameters used in this policy are CPU, RAM, and Bandwidth.

MC[22]

Maximum Correlation selects the VM that has the highest correlation of CPU utilization with other VMs. Parameter used in this policy is CPU utilization.

MMS[23]

MMS policy selects a VM with the minimum memory size to migrate compared with the other VMs, allocated to the particular host. Parameter used in this policy is Memory.

LCU[23]

LCU policy chooses a VM with the lowest CPU utilization to migrate compared with the other VMs allocated to the particular host. Parameter used in this policy is CPU utilization.

MPCM[23]

Minimum Product of Both CPU Utilization and

Memory Size selects a VM with the minimum product of both CPU utilization and memory size to migrate compared with the other VMs allocated to the particular host. Parameters used in this policy are CPU utilization and Memory.

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III. COMPARISONS OF VM PLACEMENT AND VM LIVE MIGRATION TECHNIQUES

Table 1. VM Placement Techniques

Technique	Method	Input parameters							Output	
		PM			*VM*					
		CPU (MIPS)	*RAM (MB)*	*BW (Mbits/s)*	*CPU (MIPS)*	*RAM (MB)*	*BW (Mbits/s)*	*Size*	*Allocation of VMs*	*Average running time*
CP-based VM Placement algorithm[18]	Constraint Programming	Yes	Yes	yes	yes	yes	Yes		Yes	Yes
Modification of Best fit decreasing[1]	Bin Packing	yes	Yes		yes	yes			Yes	
Stochastic VM Multiplexing [20]	Stochastic Integer Programming	yes	yes					yes	Yes	
GA energy efficient VM placement Algorithm [19]	Genetic Algorithm	yes	Yes		yes	yes			Yes	Yes

Table 2. VM Live Migration Techniques

Technique	Parameters considered							Single/Multiple VMs
	VM size	*Page dirty rate*	*Network traffic*	*CPU cycles*	*Downtime*	*Network bandwidth*	*CPU utilization*	
Pre-copy [3]		Yes	Yes		Yes			Single
Pre-copy + memory compression [7]		Yes			Yes			Single
Pre-copy + delta page transfer [8]		Yes	Yes		Yes	Yes		Multiple
Pre-copy + Post-copy [6]		Yes			Yes			Single
Pre-copy + multiple migrations [12]		Yes	Yes		Yes	Yes		Multiple
Pre-copy + Content based hashing [13]		Yes			Yes			Multiple
Pre-copy + data deduplication [11]		Yes			Yes			Single

IV. CONCLUSIONS

This paper has presented a study and comparison of different VM Placement, VM Selection and VM Live Migration techniques. The analysis from study include that, in VM Placement, performance factors to be taken into consideration vary from cloud provider to cloud provider. In VM Migration, performance depends on parameters like VM size, Page dirty rate, Memory, Network traffic and CPU. Depending on factors like varying workloads and constantly changing demands of applications, there is a need to continuously optimize VM placement and VM Selection algorithms. New techniques for VM Live Migration with reduced migration time and downtime has to be developed.

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