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Live Virtual Machine Migration Techniques, Survey and Research Challenges

Sheetal Kumar[1]*, Deepti Malhotra[2]

[1]*CS and IT, Central University of Jammu, Samba, India
[2]CS and IT, Central University of Jammu, Samba, India

E-mail: aryan.cgc@gmail.com, deepti433@yahoo.com

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***Abstract*—** Cloud computing is a vibrant technology in today's world. It delivers a platform independent service which is reliable, scalable, on demand etc. Cloud computing rely on allocating resources to achieve reliability and economy of extent similar to utility, Virtualization is key concept of cloud computing, it is a technique which allow multiple operating system run simultaneously on single physical server, it is used for balancing the loads on servers, managing the fault occurred and uses comprehensive strategy for energy consumption and system maintenance. There are two type of techniques used in migration i.e., pre copy and post copy, this research paper discusses study of various types of VM live migration, their classifications and relative scrutinizing of these methodologies and challenges in migrating virtual machine.

***Keywords*—** Pre-copy, virtualization, post-copy, cloud computing.

I. Introduction

Cloud computing is outlined as railroading which aims at providing reduced cost, ascendible computation capableness and service to endeavour on demand of extension. In simple words, it is the sharing of resources in an open environment.
The amount of resources provided in the cloud system for the client is increased when their requirements are as per utilization.
Privileges of cloud computing can be stated as:-

- Reduced cost: - cloud computing saves the money of an organization by paying the technology or services which we are accessing.
- Intensifying storage: - Excessive data can be stored on a private computing system of an organization.
- Flexibility: - it provides more flexibility than traditional computing methods.

There are various services which cloud render: -

- Software as a service(Saas):-
  This layer provides ready to use application services for the customer. Saas customers have no need of software or hardware to buy, install or maintain or update.
- Platform as a service(Paas):-
  It offers platform oriented services. Customer is responsible for application deployment and secure access to the application.
- Infrastructure as a service(Iaas):-
  Here customer regulate underlying cloud framework as network server, operating system or storage.

Virtualization is an important concept in cloud computing. Virtualization became important and common in cloud computing. This technology divides the machine into several VM which further allow multiple OS operating on single machine.
In this paper Section I presents the introduction phase, Section II presents the related work of virtualization. Section III represents the comparison of various virtual machine migration frameworks. Section IV comprises of various research challenges Section V includes performance metrics Section VI represent conclusion and in the end Section VII represents references.

A. Virtual Machine Migration (VMM) Techniques

Virtualization is a technology which allows multiple OS simultaneously run on the same physical machine. VMM is a significant technique used for administration of clusters and data centers. It separates software and hardware. It eludes remaining dependencies and offers better balancing of load where resource and energy both are used reliably and efficiently. (VMM) provide the capability to transfer from source to destination node. It manages the clusters and data centers. Virtual machine migration provides efficient utilization of resource, balancing the load and saving energy. Virtual machine migration can be done with two techniques: live(hot) and non live(cold) migration

- *Cold migration (non live)*: In this VMM technique the VM is firstly suspended on the source node and all the

memory and processor state is transferred from source to destination point and then the VM is resumed on the destination node, here user can see the suspension of service during migration.

- *Hot migration (live)*: During live migration the user didn't notice the service disturbance and where the migration status is not suspended.

There are two techniques in live migration. These are pre copy and post copy.

- *Post copy*: Firstly, the migration is suspended on the source node with minimum processor state is transferred to the destination node where further the virtual machine is resumed and start fetching the memory pages.
- *Pre copy:* It has two phases i.e., warm up phase and stop and copy phase. In warm-up phase hypervisor copy all the memory pages from host to the destination node whereas VM is still running on source machine. While copying from source to destination some pages might be changed and hypervisor mark those pages as dirty pages, further dirty pages copied again from source to destination until recopied rate is not less than page dirtying rate or some threshold. In stop-copy stage, VM stops on the source machine and resumed on the destination machine.

Live migration provides load balancing and energy management, online maintenance:

- *Energy management*: The management of energy is one of vital aspect of migration, virtual machine provides the facility of server consolidation where energy is efficiently used and managed within the servers and machines.
- *Online maintenance*: Using virtual machine without interruption, upgradation of system is required for maintenance and availability so that service can be used continuously.
- *Load balancing*: During accessing the service sometime servers are overloaded, therefore to maintain the load balance by shifting load to underutilized server is effective and reliable.

VM migration techniques	Conclusion	Advantages	Disadvantages
Pre-copy migration[1]	Firstly the memory pages transferred to goal node and after that processor state is transferred	Downtime in migration is less than one second	Overhead due to duplicate page transferred
Post-copy migration[2]	Firstly the execution state is transferred and then all the memory pages are fetched from destination node	Only once memory pages are transferred	More downtime than pre-copy

II. Related Work

Clark et. al.[1] provide the basic concept of live migration where he identified the writable work set pages are marked by the hypervisor and pages are transferred from source to the destination and iteratively it copies all the memory pages and if some pages were changed during migration it will be marked as dirty pages and further recopied until it is less than some threshold or maximum iteration reached. After transfer of memory pages the processor state is also transfer to destination node.

Hines et. al.[2] design and implemented post copy live VM migration where they able to minimize total migration time and page transferred compared to pre-copy. key components involved are demand paging, dynamic self-ballooning, active pushing and prepaging and implemented on Xen and Linux based platform.

Hiren et. al.[8] proposed modify optimized pre-copy approach where they compare the dirty page rate D with certain threshold T and further apply the optimized approach for high dirty rate and basic pre-copy approach to low dirty rate.

Liu et al.[9] presented design and implementation of Hierarchical copy algorithm, which presents page layering outline into live VM migration. Based on liveness characteristics of memory page, they extended monitoring time of memory image to avoid exceptional memory. dirty page is verified from "0/1" token to define alteration periods and able to minimize both total migration time and downtime for high dirty page rate.

Jin et al.[10] design and implemented the memory compression method where the data at source node is compressed and further decompressed on the target node, they implemented the compression algorithm on Xen hypervisor.

Ma et al.[11] they present an approach where frequently updated pages are transferred in the last round of iteration, it is an improved pre-copy approach which seeks to minimize total downtime and total migration time .

III. Comparative Analysis of Common Virtual Machine Migration Frameworks

Author's	Year	Proposed framework	Features	Tools	Technique / algorithm	Issue solved
Clark et. al.[1]	2005	Live migration of VM	Basic idea of live VMM	Delta Compression, Page Bitmap	Memory Compression Technique, Frequently updated memory pages	Improved pre copy approach
Sapuntzakis et. al.[3]	2002	Optimizing the migration of virtual computers	Ballooning is used to reduce the compressed memory size	demand paging and hashing	Copy-on-write,	Migration of complete image of OS over a network
Huang et al.[4]	2007	High performance VMM with RDMA over modern interconnects	OS-bypass and RDMA, Myrinet, Quadrics	InfiniBand	RDMA	This technique minimize the total migration time by 80% and the downtime by 77%
Luo et. al.[5]	2008	Incremental whole-system migration of live VM	whole-system live migration	Block-bitmap	Incremental migration algorithm and three phase migration algorithm	Able to achieve negligible downtime and migrate VM back to source in minimum total migration time
Bradford et. al.[6]	2007	Live wide-area migration of VM including local persistent state	Using local storage wide area migration	-	pre-copying and write throttling with block level solution	Minimize service interruption
Voorsluys et. al. [7]	2009	Cost of live VMM in Clouds and performance evaluation	strict SLAs	Xen VMs	-	Migration overhead is acceptable but cannot be disregarded
Hines et. al.[2]	2009	Post copy live migration of VM	Dynamic self-ballooning implementation	-	demand paging, , prepaging and active pushing	reduces the total migration time and the number of pages transferred compared to pre-copy

IV. Various Research Challenges Involved In Live Vm Migration

- *Migration over WAN network*

It is one of the major challenge of live migration where we have to face the variations in the bandwidth over wide area network and migration with heavy workload and large size is nearly impossible within time.

- *Resource availability*
  During migration we need to take better decision, which further helps in resource allocation and provide better availability of resources wherever needed.
- *Workload during migration*
  As dealing with heavy workloads on cloud system, sometime large application systems such as SAP ERP can't handle efficiently and require huge memory.
- *Various performance aspects*
  VM migration is directly based on the network and the state of system which include both memory and processor state. We need a high link speed to migrate the system with minimum total migration and down time, also need to identify page dirty rate so that migration takes minimum downtime.

V. Performance Metrics

VM migration performance analyzed on some metrics are:

- *Preparation time:* Initial time of migration when it is starts on the source node.
- *Down Time:* During this time interval there is no any migration of memory as well as processor state takes place between source and destination.
- *Resume Time*: After the down time when virtual machine again started executing on the destination machine or time when machine is resumed.
- *Pages Transferred*: In all the above time virtual machine transfer memory as well as processor state, so it is the total amount of pages migrated from source to destination machine.
- *Total Migration Time*: Time required in migrating the virtual machine from source to destination node.
- *Application Degradation:* While migrating the application from one machine to another there might be possibility of application loss or degradation.

VI. Conclusion

Virtualization is one of significant technology for cloud computing and VM migration plays vital role in virtualization. it allows multiple OS concurrently run on single physical server, VM migration can efficiently balance the load and utilize the resources effectively. In this paper migration techniques, framework and their models are discussed.

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