

A Review on Migration Techniques and Challenges in Live Virtual Machine Migration

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Abstract: Cloud computing is an internet based that provides shared resources on demand and manage them like networks, storage, servers, applications and services which requires optimum effort of management. Migration of virtual machine is gaining more importance today to improve utilization of resources, load balancing of processing nodes, isolation of applications, tolerating the faults in virtual machines, to increase the portability of nodes and to rise the efficiency of the physical server. VM migration is the most important feature of virtualization. With this feature an OS state is transferred from one computing node to another physical node. There are two different techniques of migration, first is pre-copy migration and the second is post-copy migration technique. The pre-copy approach transfers the memory prior to the transfers of the execution to destination node. On other side the post copy migration first transfers the execution and then transfers the memory. This paper provides the better understanding of virtual machine migration techniques and research challenges by comparing existing VM migration techniques of cloud computing.

Keywords: Cloud computing, pre copy, post copy, hypervisor, VM migration.

I. INTRODUCTION

Cloud Computing is computing over internet is a best method of accessing and managing user data without any requirement of infrastructure at the user's location. Cloud user can access their data remotely from any location at a less cost and it guarantees the management and other security related issues. It has more advantages compared to its disadvantages. The major advantage of using cloud computing is that the resources are in sharing mode and can be accessed simultaneously by multiple users by using the concept of virtualization.

Nowadays, the Cloud computing demand is on the rise in IT world. It is widely used in industry arena, government sector, in business and also in research and academic community. Cloud computing is not a new concept in the era of IT; it provides number of services to its end users in different service models like IAAS, PAAS and SAAS.

A. Virtualization

Virtualization is a most important feature of cloud computing to deals with number of devices and users over the network. It creates virtual environment on a single physical computer by abstracting the hardware details, which allows us to use multiple instances of operating systems (known as guest operating system) to handle number of processes simultaneously and separately by each guest OS (virtual machine). Virtualization also allows VM migration from one to another machine. Virtualization methodology divides the computer resources into multiple executable virtual machines through hardware and software portioning [2]. It create more low powered servers by less high powered servers, thus reduces overall cost in space, power and other infrastructure [7].

Hypervisor or VM manager is a core module or program which handles more than one virtual operating systems on a single host. It is a responsibility of hypervisor to provide resources and a processor to each virtual operating system on the same host. Hypervisor allocates required resources to each operating system and avoiding the dependencies between the host and the virtual machine. Hypervisor is of two types [8]:

1) Bare Metal (Type 1) Hypervisor

Bare Metal Hypervisor is a hypervisor (shown in Fig.1) that it is installed on the hardware and has a control over its available resources (like memory, CPU etc.) as no intermediary is required to access the resources. Examples: Hyper-V, VMware

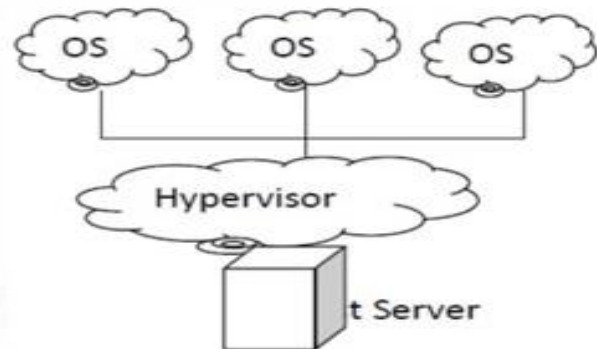


Fig. 1. Bare Metal (Type 1) Hypervisor

2) Hosted Hypervisor

Hosted hypervisor is a hypervisor (shown in Fig.2) that is installed in the operating system of a server and that operating system has a control over it. Example: Virtual Box, Xen, VMware Player.

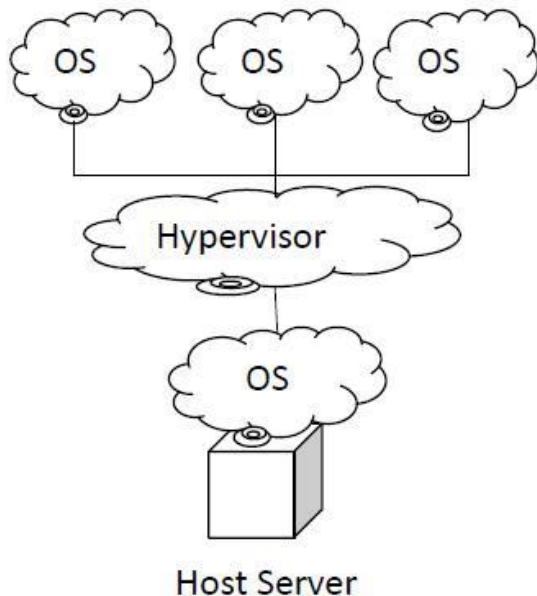


Fig. 2. Hosted Hypervisor

II. VIRTUAL MACHINE MIGRATION

Migration of VM's from one host to another without disrupting existing work [1], is categorized as:

A. *Non-live(Off-line) VM Migration:* Virtual machine at the source host is paused and then transfer all states of source host to the target or destination host and then finally resume the working of virtual machine at the target host. The major drawback of it is that it results in larger down time [8].

B. *Live VM Migration:* VM is transferred from one host to another with minimum possible disruption of services. It has following performance metrics [4][6][8]:

1) *Preparation Time:* Time between the start of migration process and virtual machine's processor state is sent to another host, during which the VM run continuously is called preparation time.

2) *Resume Time:* Time between the resuming of the virtual machine's running and migration end is called resume time.

3) *Pages transferred:* The amount of memory pages transferred including the copies of pages.

4) *Down Time:* Time during which the running of virtual machine is stopped. It contains sending of state of the processor.

5) *Total Migration Time:* Time between initiating phase of the migration to the end of the migration process. TMT is used for the resource releasing on both the source and the destination node.

C. Live Virtual Machine migration Techniques:

1) Pre-Copy migration

(i) *Warm-up phase:* This is an initial phase for the hypervisor to create copies of required memory pages to send to the destination node from the source node but during this process virtual machine is not halted by the hypervisor. If some changes are there in the pages of source node during the process of moving the duplicate copies, then memory pages will be duplicated again and again until the data reduplicating rate is less than the rate of moved page which does not contains the recent value i.e. the page being corrupted(dirty page) [2][10].

(ii) *Stop-and-Copy phase:* The VM is halted at the source node, the amount of data changed that is left will be moved to the destination node and virtual machine start processing at the destination host [2][10].



Fig. 3. Pre-Copy Migration

2) Post copy migration

In this migration technique VM is suspended from source host for some time, then the VM state is transferred to the destination host. Once it is received at destination, at the same time it starts working after resource allocation process even though most of the memory state is residing on the source host. When virtual machine tries to fetch the pages which are not being sent from the destination host; it will create page faults. The faults are recorded at the destination host then sent back to

the source host which will create faults of network and then immediately source host respond accordingly and sent all the faulty pages. In this case, it can degrade the performance of the application running on the virtual machine due to data transfer overhead (Fig. 4).

3) Hybrid Virtual machine migration [9]

Hybrid migration using properties of pre copy and post copy migration techniques (Fig. 5). It is divided into following five phases:

- (i) *Preparation Phase:* System resources required at the target host are reserved.
- (ii) *Bounded pre copy rounds Phase:* Identify the delimited pre copy rounds and working set of VM is transferred from sender server to the receiver server.

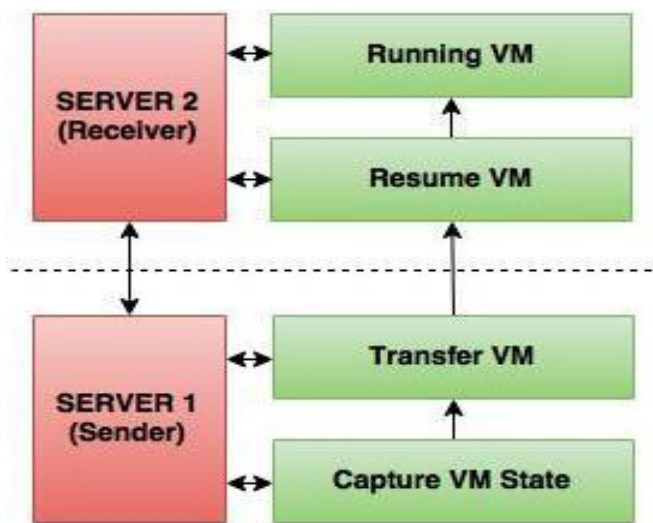


Fig. 4. Post Copy Migration

- (iii) *Virtual machine resume Phase:* At the receiver server, it launches the transferred state.
- (iv) *On Demand paging Phase:* On the basis of application, requests of read/write.

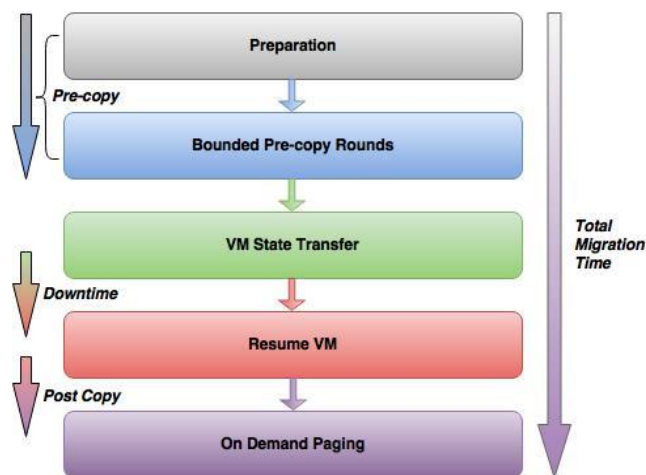


Fig. 5. Hybrid VM Migration

D. Post Copy variations [10] [11]

- 1) *Post Copy through demand paging:* In it, the pages are transferred only once and it will result in page faults when requesting the referenced page from the source node over the network. As a result, it will slow down the processing of the virtual machine as it increases the length of the resume time and creates the dependencies in the form of a page faults residing for unpredictable time periods.
- 2) *Post Copy through Active Pushing:* Dependencies is reduced in the form of a unfetched pages residing for unpredictable time periods; one way is to initiatively “push” the pages on the destination node from the source even though the VM continues running at the destination host. Active Push evades the sending of pages which are faulted in the destination virtual machine. Thus, pages are only sent once either by demand paging or active push.
- 3) *Post copy through Pre Paging:* It is very difficult to know the exact fault tolerance behaviour of pages but by estimating the faulty addresses to predict VM’s memory access pattern, we can expect better page pushing sequence to access the patterns and the occurrence of page faults in advance.

III. LITERATURE REVIEW

Qi Zhang et al [14] give the explanation to topics related to computing. He provides a better understanding on the topic of cloud computing, its layered architecture, its business model, types of cloud and the terms related to cloud computing like virtualization, VM migration, server consolidation and energy management etc. gives the direction towards the research challenges in cloud computing.

VMM facilitates system administrator to migrate an OS instance of one physical node to another without the disturbance of services of host on the OS being migrating.

VMM uses the resources of both the machines; the machine from which virtual machine is migrating and the machine to which it is being migrated [2]. It shrink the size of memory image on source host before sending it to the destination. The size is reduced according to the probability of change of data.

Virtual machine migration was first proposed by Clark et al [13]. Hypervisor (also known as virtual machine manager (VMM)) is a middleware between two physical nodes which facilitates abstraction from physical resources of one node to the other node. Through software emulation methods and virtualization of hardware systems, virtual machines are created. Virtual machines are acting as physical computers which have their own virtual RAM, Central Processing Unit, Network Interface Card and hard disk [12].

Virtualization is a way to run multiple guest OS on one physical node simultaneously and this is the core concepts in modern data centres. VMM is very useful tool for the administration of data centres and clusters. It provide appropriate separation between layers of hardware and software [10].

[4] Categorized the techniques which are used to minimize the downtime and consider the bandwidth which provides the better performance of virtual machine. The migration design, implementation and evaluation of pre copy, post copy and hybrid post copy techniques that results in minimum page faults incurred gives by [3].

Hines explains the post copy via pre paging strategy through Bubbling with single pivot and multiple pivots. Michael gives the design and implementation of post copy approach through Dynamic Self Ballooning on Xen and Linux based platforms [5] and also explain various Network aware virtual machine migration techniques. [15][16] Gives the comparative analysis of various techniques for live VM migration and detailed analysis, taxonomy, and research issues of virtual machine migration.

Migration memory problem were resolved by different researchers in different way, but still there is a need to optimize memory usage for host systems to decrease the memory requirement.

IV. COMPARISON OF VM MIGRATION TECHNIQUES

TABLE 1: Comparative analysis of various virtual machine migration techniques

VM Migration	Method	Advantages	Disadvantages
Non-Live Migration	Stop VM at Source then transfer	Simple Concept and easy to implement.	Down time is more

	memory and resume at destination.		
Pre-copy	First transfer the memory and then transfer the execution.	Down time < 1 sec. On aborting migration, system do not crash due to running VM in source host.	Overhead of duplicate page transmission
Post-copy	First transfer the execution and then the memory	Memory transferred in a single pass and has less network overhead.	More down time as compared to pre copy

V. RESEARCH CHALLENGES IN LIVE VIRTUAL MACHINE MIGRATION [4]

Challenges of Network based Live VM Migration

- 1) *Low Bandwidth over WAN:* Due to large image size, it is impossible to Translocate the live virtual machine across high latency low bandwidth WAN.
- 2) *Network fault:* In post copy, at destination host when a VM tries to fetch pages that have not transferred yet, it redirect towards the source host thus creates network faults as virtual machine at source host is suspended.
- 3) *Memory intensive applications:* It is used to reduce the overhead of post copy migration approach and I think it is more efficient instead of reusing memory concept.
- 4) *Memory state between clusters:* Live migration have a control over transfer of memory and CPU state between clusters of host systems which serves as a VDSM (Virtual Distributed Shared Memory) system.

B. Current Challenges in Post copy Live Virtual Machine Migration Technique:-

- 1) There is a challenge to reduce the overhead of Post copy migration technique occurs due to the generation of page faults at different time intervals during execution of VM at destination host. Each time, VM is suspended at destination host and waiting for re-transmission of required memory pages from source host to continue.
- 2) There is a need to minimize the amount of data transfer (memory pages and CPU state) over the network, between clusters of hosts to save the money and time that is spent on network.
- 3) The repetition in page fault detection is a main drawback of post copy approach, it should be optimized to reduce the number of cycles of memory re-transmission from

source host it will increase the reliability of post copy migration technique.

VI. CONCLUSION

In this paper, the features cloud computing like virtualization environment, virtual machines migration, consolidation of servers, hypervisors and transfer of memory pages are discussed. Some issues with the approaches of VM migration are discussed while methods, challenges and other technical issues in the process of migration are highlighted which indicates that still there is a need to provide optimal model for VM migrations.

There are few challenges in the improvement of post copy virtual machine migration technique. To reduce the overhead of Post copy technique there is need to further optimize the transfer of memory and CPU as a single VDSM system and page fault detection through shadow paging can be implemented in cloud environment to handle failure of target node in post copy migration approach to make it more reliable.

There are few network aware migration techniques available for VM migration in cloud environment. Pre copy and post copy migration techniques can be used as a hybrid approach would be the best solution if it is used with the concept of memory reusing during migration of virtual machines.

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