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A Performance Impact Model of Virtual Machine Live Migration in Real-Time Application

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Abstract*— Virtualization technology has become commonplace in modern data centers and cluster systems. Virtual machine(VM) follow a technique called live migration which helps in migrating OS instances across distant physical data centers and clusters with high performance, improved resource management and fault tolerance. Moreover, live migration often allows workload movement with a short service downtime. But service levels of host operating system are likely to be negatively affected during a live VM migration because of service downtime. For this reason, a better understanding of its effects on system performance is highly desirable. So that correct algorithm can used to perform the live migration. This paper, presents a performance impact model of live migration of host operating system instance on a virtual machines, which makes use of proposed algorithm for live migration.

Keywords*— Virtualization, Virtual machine, live migration, performance ,cluster.

I. INTRODUCTION

In the present world with fast development of networking, network infrastructures and the growing size of real time application data's, there is huge demand for storage/data centres. The flexible resource management has become significantly important for Data Centre. A need arises for approach that changes the economics of the data centre by resource sharing.

A. Virtualization

Virtualization is technique that allows creating a replica of the existing system, without making changes to available physical resources. The purpose of Virtualization is to share resource of existing system, utilization and distribution to their maximum potential, reduce infrastructure costs in terms of physical resources, hardware, new network setups, system setups, and infrastructure maintenance. Virtualization hides resource of the physical system from the user and provides an abstract computing platform to the user in terms of running a applications that are not currently supported by the existing systems or running multiple instances of same or other alternate operating systems on same machine without memory partition. Virtualization in broad terms comes in various forms like Para-virtualization, Full virtualization, and container-based virtualization. Virtualization further can be in various forms like Operating Systems, Applications and Storage level virtualization.

B. Virtual Machine

Virtual Machines (VM) is tool a software implementation that helps in Virtualization of physical machines like desktop, servers, etc wherein a copy of the existing operating system came be installed in that virtual machine. This operating system that is installed in virtual machine is called guest Operating System (OS) with shared CPU cores, shared memory, shared NIC and shared disk drives over a same physical machine comprising its own layers of hardware, software and operating system which is called Host OS.

The purpose of designing Virtual Machines [1] is to

- To allow strong existence of isolated multiple OS on the same computer.
- Provide an instruction set architecture (ISA) that is somewhat different from that of real machines [1].
- Testing of new developments
- It allows application provisioning, system maintenance and increase availability by storage transfers.

In a virtual machine system, the technologies that play key role are virtualization, the resource scheduling, the migration technology and the security technology .Use of these technologies determining overall performance characteristics of the virtualized system. Traditionally, the virtual machine system focused only on sharing of processor resources among domains. However, this caused poor and/or unpredictable the quality of service of system because the sharing of other resource was not taken into consideration. With the rapid growth of hardware and software resources, the performance evaluation of this resource service in virtual machine system is becoming more important. Therefore, it becomes a key factor to improve the service performance of virtual machine system.

C. Virtual Machine Architecture

Figure 1 above demonstrates a simple VM architecture for a Datacentre Server machine. Virtual Machine comprises of its own guest Operating System which can be hardware, so VM function independently of its Host OS, which is totally isolated on a physical machine . Virtual machine get executed over a Virtual Machine Monitor (VMM) or hypervisor.

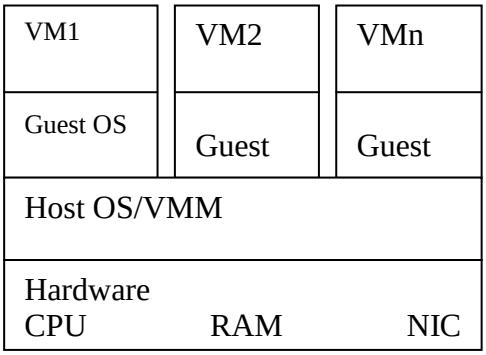

Figure 1: Virtual Machine Architecture

VMM is software designed to make virtual machines start/play which boot the guest OS once When a guest operating system is running, VMM manages the CPU and hardware during virtual machine operations, and it constantly monitors the VMs running over it. It acts as a bridge between these VMs and hardware/software. Creating an isolated environment in which the guest operating system and applications run close to the hardware at the highest possible performance rate.

II. BACKGROUND

A. Major VM Hypervisor

With increase in popularity of VM worldwide, many big vendors came out with their solutions to implement the Virtualization technologies. Virtualization support companies brought down into market their own hypervisor with varied functionalities but with a common functionality of VM migrations in order to create an abstraction layer between physical machines and virtual machines in their datacenters.

Following companies brought the Open-source and licensed software [2]:

- *VMware:* This software is designed to provide complete infrastructure solution for Virtualization in datacenters. That includes ESXi server hypervisor on which virtual machines are created; vMotion is used for managing the VM migration and central storage communication in the form of iSCSI/NAS.

- *Microsoft:* Microsoft Corporation for its datacenter designed hypervisor named MS Hyper-v with NAS for multiple VM migrations at the same time.

- *XEN:* XEN-Motion is hypervisors for standard Linux OS to support para-virtualization technology. One important property of XEN –Motion is guest VMs know the hypervisors and run efficiently without virtual emulated hardware.

- *KVM:* Kernel based Virtual Machine, is fully designed for standard Linux kernel that works on full virtualization of hardware technology along with dedicated QEMU process, the emulation of the VMs on host machines is carried out considering them as Linux process running in guest mode. Therefore no guest VM modifications for its execution are required on new physical machine to which it is migrated.

- *OpenVZ:* OpenVZ along with Parallels Computer Servers offers a solution for VM migration. It works on container-based virtualization for Linux systems and creates secured containers which act as independent server on physical machine to get better server utilization and resource availability.

B. Live migration

Live migration of virtual machines (VMs) is a process of transitioning a VM from one virtual machine monitor (VMM) to another (VMM) of distinct physical machines which is at distance without halting the guest operating system on source server .Performance of live migration, mainly dependent upon how migration handles four key aspects: CPU state, memory state, and storage content.

CPU state: During process of live migration CPU state needed to be context switched from one host to another.

Memory content: The memory state of VM has to be transferred to the destination host. It includes the memory state of both the guest OS and all running processes within the VM. Hypervisors is one which identifies the memory state to be

transferred and avoid transferring the contents of unused memory have the potential to substantially reduce migration time.

Storage content: Storage content is an optional part of live migration. If both the source and the destination machines through connected to Storage network, its needs only the transfer of memory contents is called memory migration. If the destination host cannot access storage network, then content needs to be synchronized from the source to the destination. This is called storage migration. Storage plays an important part in live migration.

C. Design Of Benchmark

Live virtual machine migration takes a copy of running VM and moves it from one physical machine to another [3]. The performance of any live virtual machine migration strategy can be measured by the following metrics.

- *Downtime:* when no CPU cycle is used by any of applications that resident at VM , neither at the source nor at the target system, it consists of the time necessary to suspend the VM functioning on the source, transfer the VM state to the destination, load the device state, and activate the migrated VM on the remote host.
- *Total Migration Time:* Duration between the time the migration is initiated and the time the migrated VM gets synchronized with the original VMs state.
- *Total Data Transmitted:* the total data is transferred while synchronizing the both VMs' state [3].

When a VM is performing a live migration between two machine it is important that this migration happens in a manner that balances the requirements of minimizing both *downtime* and *total migration time*.

i) Migrating Memory: To satisfy this trade-offs between these requirements by generalizing memory transfer into three phases:First phase of memory transfer is called **Push phase .**In this phase source VM continues running while certain memory pages are pushed across the network to the new destination. Pages modified during this process must be re-sent to destination to maintain consistency. Second phase is called **Stop-and-copy phase** the source VM is stopped, when pages that are pushed over network are copied across to the destination VM, and then the new VM is started. Third phase is called as **Pull phase** in this phase new VM starts its execution and while executing if it access to a page that has not yet been copied, there is page fault happens in pulling of page across the network from the source VM. Practically algorithm that is used to implement live migration select one or two of this three phase.The two categories of live migration algorithms include: Pre-Copy (with stop-copy-resume) and Post-Copy of VM .

ii) Pre-copy algorithm: Pre-Copy is most commonly used technique in VM tools to perform live migration of VMs [2].

- Step 1: Memory pages are pushed to network while the VM is still running on the source host.
- Step 2: This pushed page are copied to destination host while the source host maintains the newest memory image until migration is finished as seen in ***Figure 2***.
- Step 3: At the end of Pre-copy migration phase, the host VM is suspended and the remained memory image is copied to destination host. The remaining new memory images are called Dirty Memory. This phase is also called as Stop & Copy migration phase.
- Step 4: The migration includes transfer of the persistent state of the VM (i.e. its file system), transfers of the volatile state of the VM i.e. RAM contents and CPU state, and the redirection of network traffic. Once the state transfer is completely over, the VM continues to run in the new physical machine, in VM resume phase.

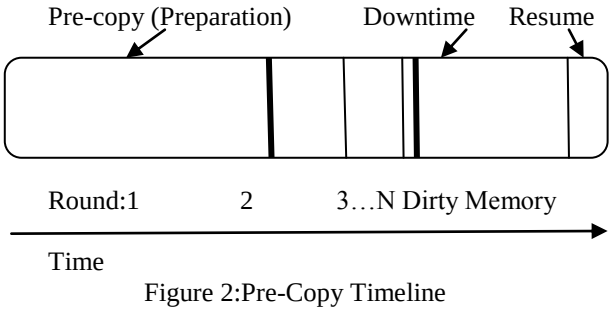

Figure 2:Pre-Copy Timeline

This algorithm generates large amount of redundant dirty pages at destination host till the time VM is suspended at the source. As a result, the migration time for extra page delivery increases.

*iii) Post-Copy algorithm :*In Post-Copy, it works in two phases: [1]

- Step 1: In the first phase, VM is suspended on the source host, and its VCPU context and minimal memory work-set is copied to destination host.
- Step 2: In the second phase, VM will start it's execution on the destination host, and the left memory page continue get transfer to destination host. The source host will resume its execution as shown in ***Figure 3***.after post-copy of pages

Though it saves the migration time initially but then the frequency of requests for disk dirty pages from destination machine for old data to the source increases the load on the server as well as to the network communication further.
Under Post-copy migration the fetching of page is done in various schemes: Post-copy via Demand Paging, Post-copy via Active Paging, Post-copy via Pre-paging.

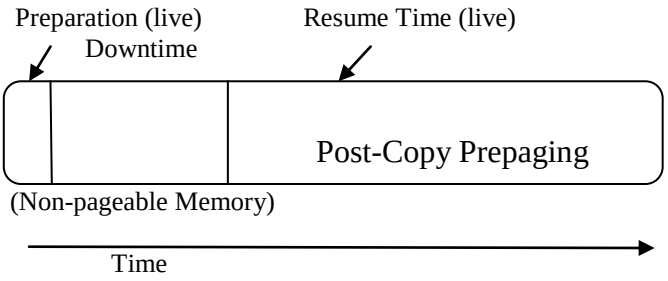

Figure 3: Post-Copy Timeline

Downtime is a critical metrics because it captures the how many interrupts the user or application in VM will get during live migration. When a small application needed to be migrated downtime will be less because its memory pages can be transferred during pre- copy phase without interrupting the application. Migration time is next important metrics to measure the performance of the system. First this is the Time that decides how quickly the VM relocates to satisfy the system requirement such as performance and reliability of the system. Second, during the migration, the application on both the source and destination hosts can be impacted by the migration and applications performance may degrade substantially [3][4].From the perspective of the applications, the VM migration time is also called as performance degradation time.
Live VM migration can consume resources such as CPU cycles, I/O bandwidths and Network bandwidth on both the source and destination host, because the algorithm used for live migration involves iterative copying of a VMs memory contents across network. Resources available to migration can have a significant impact on total migration time[7].The migration`s I/O bandwidth needed dependent on the amount of memory pages needs to transfer cross network used to connect source and destination system Therefore this paper is proposes to use migration performance model to decrease total migration downtime.

IV. PERFORMANCE MODEL-DESIGN OVERVIEW

The cluster model can be created by connecting pool of virtual machine to a physical server which can act like a Network Attached Storage server. In which memory pages can be stored while migration is happening .NAS preferable use local disks of each system used in pool.
The Performance impact model time line is show in ***Figure 4***

- **Stage 0: Preparation Phase:** when a physical host wants to start an active migration it can preselect the target host based on resources required to receive migration. To speed up any future active migration and to reduce performance degradation time, a target host resources has to be guaranteed.

- **Stage 1: Reservation:** Initially a request from a VMM is issued to migrate an OS from source host A to destination host B. Confirmation of resource availability on destination host B is necessary and reserve a VM container of that size is fixed by VMM. Failure to confirm resources means that request failed and the VM simply continues to run on source A without stopping its function.

- **Stage 2: Pre-Copy:** During the first iteration, all pages are copied and transferred from source host A to destination host B. Same copy of memory pages is send to NAS to put it in local disk. In future iterations copy only those pages dirtied during the previous memory transfer phase can be obtained from NAS disk.

- **Stage 3: Stop-and-Copy:** We suspend the OS instance that is running at source host A and redirect cpu state and remaining inconsistent memory pages on the network to destination host B. Same memory copy can be send to NAS device so that it get stored in same local disk. At the end of this stage there is a consistent suspended copy of the host A VM is available on both host A , B and NAS disk. The copy at A is still considered to be primary and is resumed in case of failure.

- **Stage 4 : Commit: Destination** Host B indicates to source host A that it has successfully received a consistent OS image send by source host A. Host A consider this message as commitment of the successful live migration . Now destination host B becomes the primary host.

- **Stage 5: Activation:** The OS instance on destination host B is now activated. Post-migration attach back device drivers to the new machine and start advertising IP addresses.
- **Stage 6 : Storage:** Network storage stored copy of OS instance using RAID 5 technique because whole local disk drive has to be transferred in case if new migration request is active.

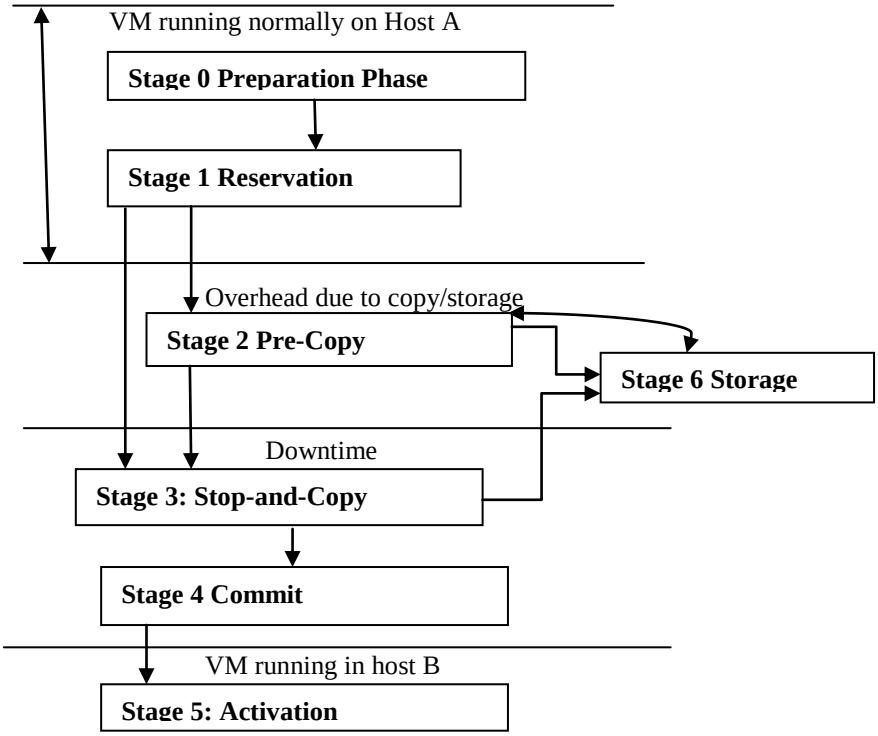

Figure 4: Migration Timeline

V. CONCLUSIONS

Integrations of live migration in virtual machine help in reusability of resource in cluster and datacenter .This performance impact model helps in reducing the traffic in network during live migration because of NAS storage. This NAS use RAID 5 method which can create a mirror of data stored in disk so that dirty page can be easily accessed. So total migration time can be decreased .If migration time decreases the downtime of host OS A will decrease. This mirror helps in reducing transfer of dirty page from A to B, so in turn reduces network traffic. This mirroring also leave way to a new algorithm suspend and copy which can be used in live migration.

FUTURE SCOPE

Performance of virtual machine live migration can be measured using suspend –copy algorithm implementation .The effective storage management of NAS in cluster of virtual machine can be explored in future work and load balancing of resource can also be added to this model in future.

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