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An Optimal Multiple VMs Migration Technique to Improve Migration Time and Service Downtime

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ABSTRACT: In cloud computing Virtualization is a key technology that allows several operating system instances to run on the same host machine, to enhance resource utilization and to improve the application response time. Virtualization needs a software layer called as hypervisor, on top of the hardware layer. Virtual Machines are run on top of the hypervisor, which provides hardware resources to the VMs (Guest Machines). Virtualization enables complete utilization of a physical machine in a cost-effective manner. However, varying and continuous load from multiple users may overload a physical machine and creates overhead on performance, reliability and other service-level-agreement (SLA) parameters. In addition to enabling higher utilization of hardware resources, migration of VMs from one host to another in same DC or another DC is needed. Past research works confirmed that two important parameters affecting live migration are downtime and total migration time. Traditional pre-copy and post-copy approaches can reduce the downtime but the total migration time is too long due to repeated retransmissions. Therefore, to improve the service downtime and total migration time and to migrate multiple VMs An optimal technique was proposed. This paper contains analysis of performance metrics like application service downtime, total migration time and amount of data transferred. CPU, memory and storage data is transferred during the process of VM migration and we identify the category of data that needs to be transferred in each stage.

KEYWORDS: Cloud Computing, Virtualization, VM Live Migration, Pre-copy, Post-copy, Optimal Technique, Performance Metrics, Multiple VMs Live Migration.

I. INTRODUCTION

Cloud Computing is considered as a utility based system for the dynamic provisioning of IT resources and services. Cloud is a parallel and distributed computing systems consisting of a collection of inter connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service level agreement (SLA) established through negotiation between the service provider and consumers [1]. For providing on-demand and flexible provisioning of resources and services, it needs to utilize resources efficiently without any interruption due to maintenance and setup issues. For this purpose, resources are shared among various users in such a way that the requirement of all users can be fulfilled.

The popularity of cloud computing circulates around the concept of **Virtualization**. Virtualization technology was developed by IBM in 1960 to maximize the utilization of hardware resources because powerful and expensive mainframe computers were underutilized. It is a thin software layer running between Operating System (OS) and system hardware. This technique enables multiple operating system instances to run on a single physical machine at the same time separating hardware from a single operating system. Each guest operating system is controlled by a virtual machine monitor (VMM), also known as the hypervisor [2]. This special middleware, hypervisor, abstracts from physical hardware resources and provides virtual machines acting like real computers with their own (virtual) hardware resources. There are three virtualization techniques. **Full Virtualization:** All operating systems in full virtualization communicate directly with the VM hypervisor, so guest operating systems do not require any modification. Guest operating systems in full virtualization systems are generally faster than other virtualization schemes [3]. **Para**

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Virtualization: Para virtualization requires that the host operating system provide a virtual machine interface for the guest operating system and that the guest access hardware through that host VM. An operating system running as a guest on a para virtualization system must be ported to work with the host interface [3]. **Emulation:** the virtual machine simulates hardware, so it can be independent of the underlying system hardware. A guest operating system using emulation does not need to be modified in any way [3].

There will be multiple virtual machines running on top of a single physical machine. When one physical host gets overloaded, it may be required to dynamically transfer certain amount of its load to another machine with minimal interruption to the users. This process of moving a virtual machine from one physical host to another is termed as **VM Migration**. Virtual Machine Migration methods are divided into two types: **Hot (live or Online) migration** in which virtual machine keeps running while migrating and does not lose its state and in **Cold (non-live or Offline) migration** in which the currently running services will be terminated first and then VM is transferred to new physical host and the state of the VM loses and user can notice the service interruption in cold migration. The state consists of its memory contents and local file system. Popular hypervisors, such as Xen and VMware, allow migrating an OS as it continues to run [4].

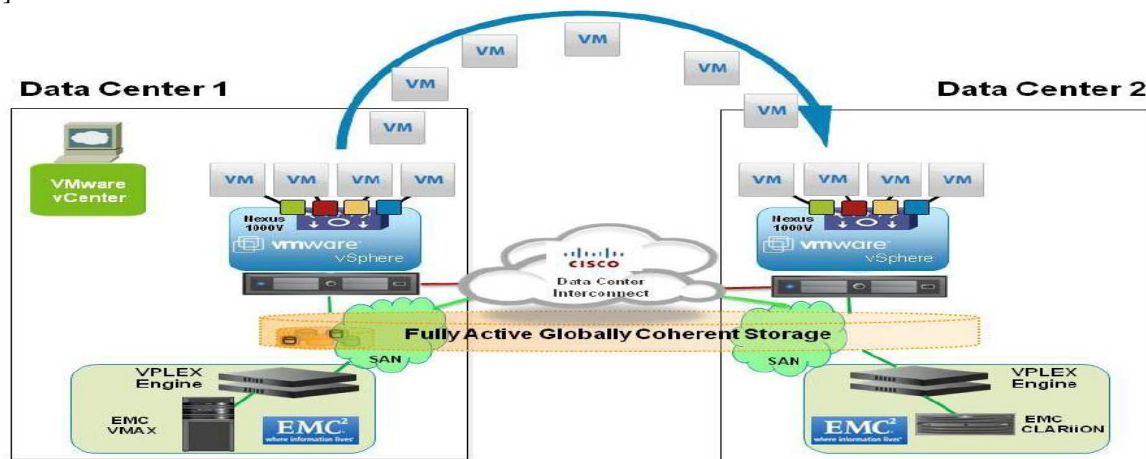


FIG.1 VM MIGRATION ACROSS DATA CENTRES

There are certain situations when there is a need of migration of VMs from one host to another host. Some situations are as follows [5]:

Fault Tolerance: If one physical host faces some problems and does not run tasks which are running on its Virtual Machines should not suffer. All VMs on the physical host will be migrated to some other host which is running properly.

Load Balancing: There can be a situation when one host has multiple VMs handling multiple tasks and there is another host which has no VM or less number of VMs with less number of tasks, then some VMs of overloaded host can be moved to under load host to balance the load.

Reduce Energy Consumption: In a situation where a host is running with less number of tasks or no tasks and some other host is running with more tasks, then all the tasks of first machine can be moved to the other machine and the former can be switched off to save power.

VM live migration technology has attracted considerable interest for data centre management and cluster computing in recent years. **Live migration** [7] is emerging as an impressive technology to efficiently balance load and optimize VM deployment across physical nodes in a data centre. The prime advantage of 'live' migration is approx-zero downtime, which is an important feature when live services are being served in a cloud data centre [6]. Live Migration is useful in various situations:

- VMs on a failed host machine can be migrated to working host machine.
- Working VMs on a host machine can be migrated to another host machine to optimize resource utilization.
- VMs on over loaded physical machine to other machine for load balancing.

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VM migration controller (Migration Software) migrates a single VM or multiple VM's (cluster VM set) on Local-Area Network (LAN) or Wide-Area Networks (WAN) network for efficient management of the resources. If VM migration is performed within LAN [8] servers then it is easy to handle because storage migration is no longer required. Also, the network management within LAN requires minimal effort because IP address of the corresponding server remains unchanged. VM migration over a WAN [9] network takes a considerable amount of migration time because the transfer of storage migration, limited availability of network bandwidth, IP address management, packet routing, network congestion, and the faulty behaviour of WAN links having considerable overheads.

II. RELATED WORK

Live migration is an extremely powerful tool for cluster and cloud administrator. An administrator can migrate OS instances with application so that the machine can be freed for maintenance. Similarly, to improve manageability, OS instances may be rearranged across machines to relieve the load on overloaded hosts to perform the live migration of a VM, its runtime state must be transferred from the source to the destination while VM still running. Live migration process can be classified into two steps:

- i) Switching the control to the destination.
- ii) Transferring the data (memory/disk) to the destination.

The two common methods of live migration can be easily differentiated based on different iterations of the steps mentioned above.

1) Pre-copy approach: In this, first Memory is transferred and after this execution is transferred. The pre-copy method is used to transfer the memory to the destination node over a number of iterations.

There are two phases in Pre-copy approach: Warm-up phase and Stop-and-Copy phase. In **Warm-up phase** VM memory migration phase, the hypervisor copies all the memory pages from source to destination while the VM is still running on the source. If some memory pages change during memory copy process dirty pages, they will be re-copied until the rate of recopied pages is not less than page dirtying rate. In **Stop-and-Copy phase**, the VM will be stopped in source and the remaining dirty pages will be copied to the destination and VM will be resumed in destination.

Pre-copy approach steps are:

- i) Memory and VCPUs are reserved on the destination host.
- ii) When the migration is issued, a check on page writes is initiated and all the RAM contents are transferred to the destination. This is the first iteration.
- iii) In the subsequent steps, only the pages that have been dirtied since the last iteration are transferred until the iteration limit is reached or the memory of dirty pages in iteration is low enough.
- iv) The execution of VM on source is stopped and CPU state, registers, Virtual devices state and last memory pages are transferred to the destination.
- v) VM is resumed at the destination. Pre-copy is well proven for read intensive workloads but in case of write intensive VMs, large set of dirty pages result in performance degradation. This is possible when the data write rate is more than the network bandwidth. KVM, Xen, and VMware hypervisor use the pre-copy technique for live VM migration.

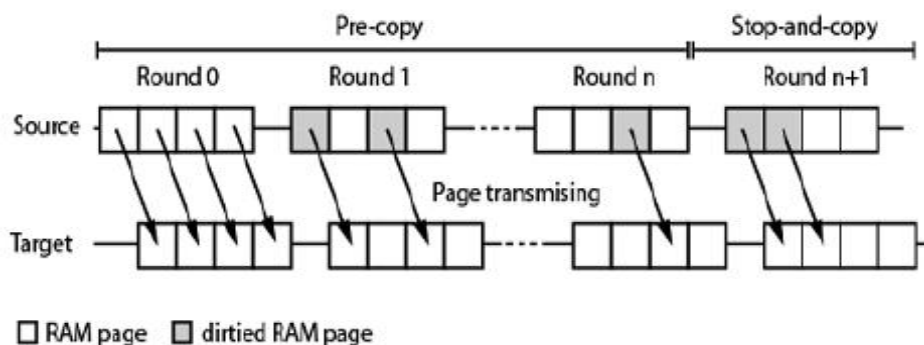


FIG.2 LIVE MIGRATION ALGORITHM FOR MEMORY TRANSFER

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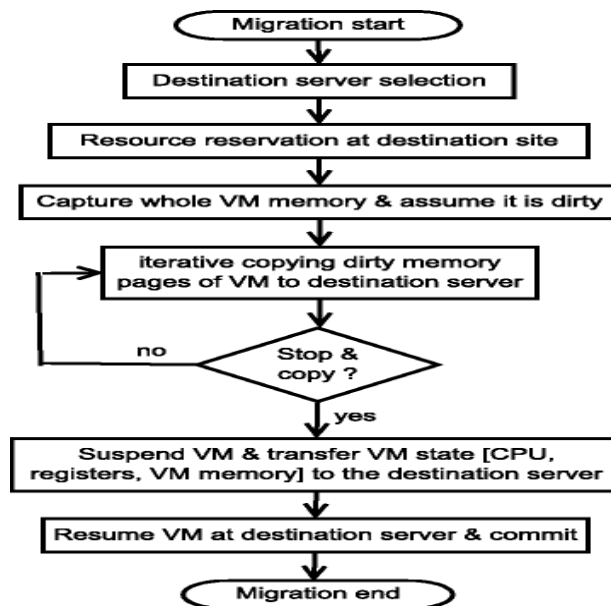


FIG.3 BASIC STEPS IN PRE-COPY APPROACH

Disadvantage of Pre-copy approach: Pre-copy technique focus to keep downtime small by minimizing transferred VM's state, so application service is running without interruption or VM transfer is seamless. But it increases total migration time due to the repeatedly transfer of dirty pages.

2) Post-copy approach: In post-copy migration technique, processor state transfer before memory content and then VM could be started at the destination server. To optimizing live migration of VM's [10] post-copy technique was proposed.

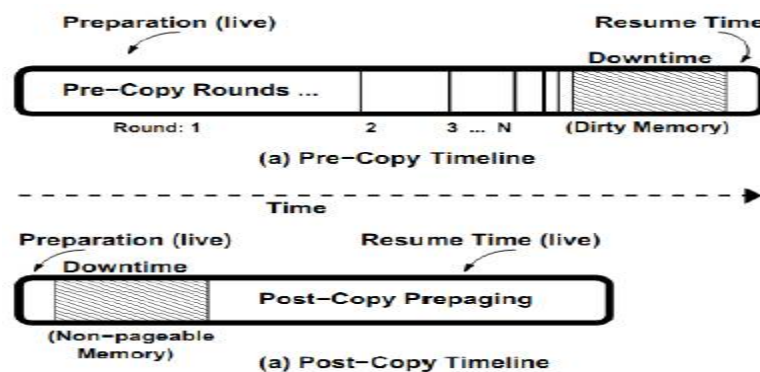


FIG.4 TIME-LINE FOR PRE-COPY AND POST-COPY

Post-copy approach steps are:

- i) Stop the VM at the source.
- ii) VCPU registers and states of devices are copied to the destination VM.
- iii) Resume the execution at the destination.
- iv) If the VM tries to access a not yet fetched page, then a network page fault occurs and the page is transferred to the destination (Demand paging). This is the most trivial form of post-copy.

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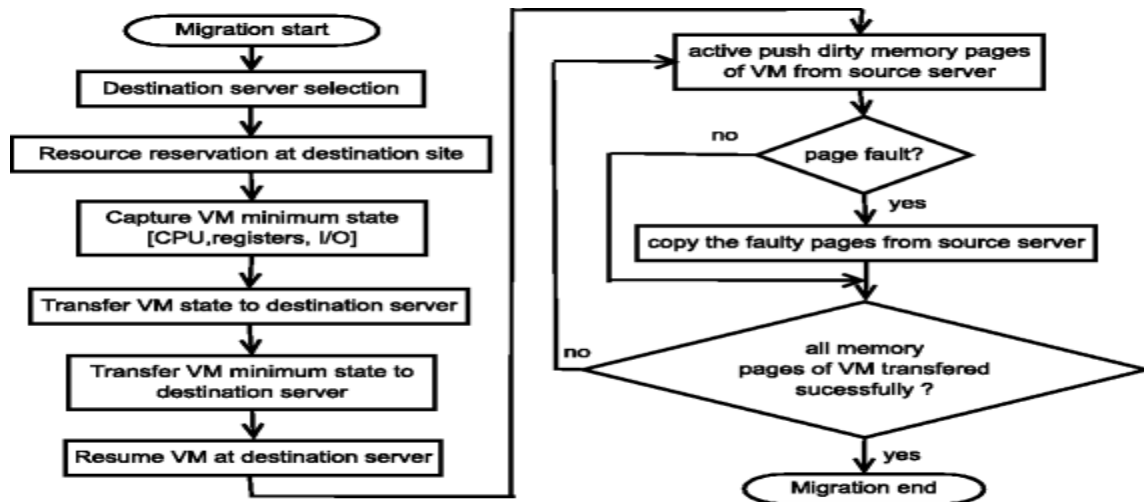


FIG.5 BASIC STEPS IN POST-COPY APPROACH

Post-copy has the ability to minimize network page faults, by pushing future requested pages from the source server before they are faulted by running VM. For this active push approach used with adaptive pre-paging. [12] Different metrics are available to compare the performances of the post-copy and pre-copy technique using Xen hypervisor. The results show that different migration metrics like total migration time, pages transferred, and network overhead has improved, VM having a range of workloads. To avoid sending of all duplicate pages, the post-copy technique is used with adaptive pre-paging [13].

Disadvantage of Post-copy approach:

- In the post-copy technique, the entire memory page is transferred at most once and it reduces network page fault by active push memory pages before they are faulted at the target server. During migration free pages are also transmitted in both approaches which increase total migration time.
- As compared to pre-copy, post-copy technique reduces the number of pages transferred and total migration time. But, the post-copy technique has more downtime than pre-copy technique due to migration latency of page fetching before VM can be resumed on the target server. Another disadvantage is, if any kind of failure occurs during the migration then recovery may not be possible.

Performance Metrics: The performance of any live VM migration strategy could be gauged by the following metrics. [11]

- Migration Time:** This is the time between initiating migration process and transferring the VMs processor state to the target node, during which the VM continues to execute and dirty its memory.
- Down Time:** This is time during VMs execution is stopped. It includes the transfer of processor state.
- Pages Transferred:** This is the total amount of memory pages transferred, including duplicates, across all of the above time periods.
- Resume Time:** This is the time between resuming the VMs execution at the target and the end of migration, all dependencies on the source are eliminated.
- Total Migration Time:** Total time taken by migration process from start migration process to finish the migration process. Total time is very important because of it affects the release of resources on both source and destination nodes.
- Application Degradation:** When Virtual machine migrated from one host to another, the application performance is degraded which is running on that VM.

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III. PROPOSED WORK

In order to minimize the total Migration Time, total Service Downtime and to Migrate Multiple Virtual Machines one new approach was proposed in this paper.

Optimal Technique:

The proposed optimal approach includes both pre-copy and post-copy VM migration phases to improve the total migration time and service downtime. It works in five phases:

- i) **Migration activation phase:** under this phase required resources are reserved at the destination server.
- ii) **Bounded iterative pre-copy rounds:** in this phase, it identifies and transfers VM working-set to the destination server.
- iii) **VM state transfers phase:** VM minimum state is recorded and transfers to the destination server.
- iv) **VM resume phase:** transferred VM is resumed at the destination server. The last
- v) **On-demand paging phase:** VM requested faulty pages (due to read/write operations) are bring at destination server from source server for continuing VM execution and synchronization with source VM image.

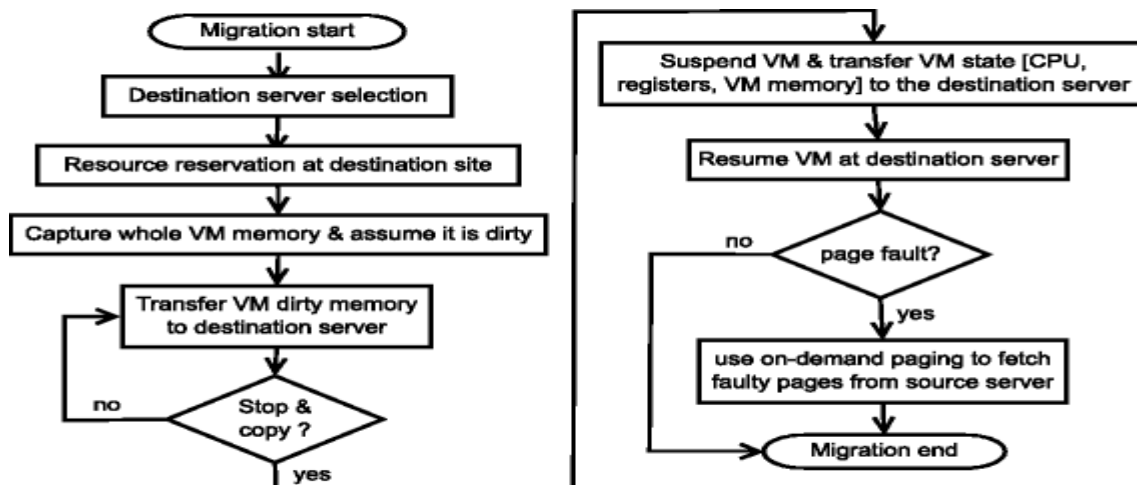


FIG.6 BASIC STEPS IN OPTIMAL APPROACH

The key observation behind multiple VM migration is that VM's having the same OS, applications, or libraries can contain a considerable number of identical pages. So during the multiple VM migration track, all the identical pages across co-located VM's and transfer the single copy of these identical pages, at source server side this is done by migration controller. Hence, migration controller initiates the parallel migration of all co-located VM's to the target machine. At the target server, migration controller prepares the server for reception of incoming migrant VM's.

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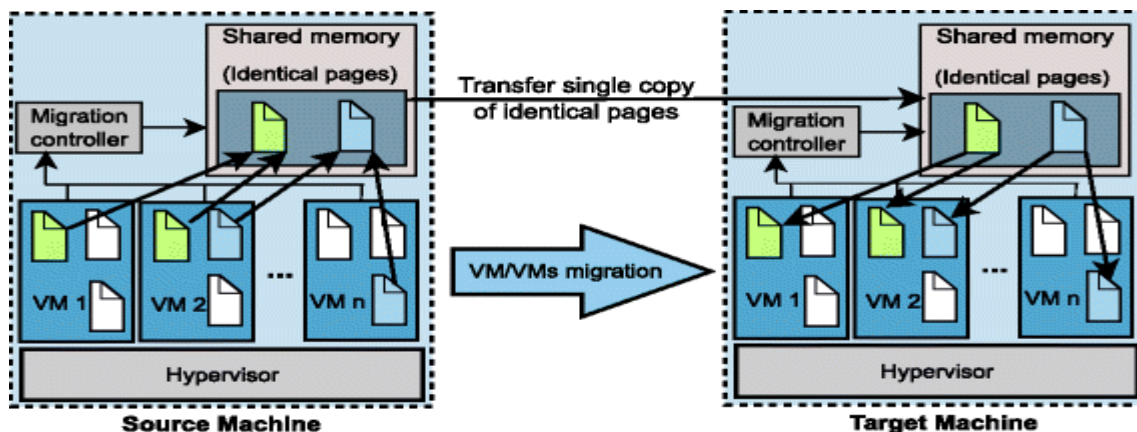


FIG.7 STEPS FOR MULTIPLE VMs MIGRATION

Algorithms to transfer Multiple VMs from one host to other host:

Algorithm to select overloaded host:

Input: host h

Output: True or False indicating host has been overloaded or not

1. Get host h from host list;
2. Upper Threshold = 1.0
3. $VM_h = \text{getVmListFromHost}(h)$;
4. $\text{totalRequestedMips} = 0$
5. for each VM V_i of VM_h
6. $\text{CurrentRequestedMIPS} = V_i.\text{getCurrentRequestedTotalMips}()$;
7. $\text{TotalRequestedMips} += \text{CurrentRequestedMIPS}$;
8. End;
9. $\text{Utilization} = (\text{totalRequestedMips} / h.\text{totalMIPSO f host}) + 0.65$;
10. If utilization \geq upper Threshold
11. Return True;
12. Else
13. Return False;

This algorithm has been used to detect whether a host is overloaded or not. Calculate the Utilization based on currentMIPS and totalMIPS of the host. If the Utilization goes beyond the Upper Threshold (which has been set to 1.0). Then the host is overloaded. Otherwise the host not overloaded.

Algorithm to select List of VMs on overloaded host:

Input: Overloaded Host h

Output: List of VMs to migrate

1. $\text{GetVmToMigrate}(\text{host})$
2. $\text{MigratableVms} = \text{getMigratableVms}(\text{host})$;
3. if ($\text{migratableVms.is_Empty}$)
4. Return;
5. Minimum Metric = max_value;
6. for each VM in migratableVms
7. if ($\text{VM.isInMigration}()$)
8. Continue;
9. Metric = $\text{VM.getRam}()$;

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10. if (metric < minimum Metric)
11. Minimum Metric = metric;
12. VmToMigrate = vm;
13. Return vmToMigrate;

Algorithm to transfer Dirty Page list from VMs:

Input: VM list to migrate, page transfer rate R

Output: Total migration time Tm

1. LIVEMIGRATION (M, R) $i \leftarrow 1, j \leftarrow 1 \quad V_i \leftarrow M$
2. WHILE each VMj in VMList
3. $T_{pre} \leftarrow (I_j + R_j) \quad T_j \leftarrow V_i / R.$
4. $SC \leftarrow V_i * (10/100)$
5. $S_j \leftarrow SC/R$
6. $T_{mig} \leftarrow T_j + S_j$
7. $T_{post} \leftarrow (C_j + A_j)$
8. $j \leftarrow j+1$
9. $T_{down} \leftarrow T_{down} + S_j$
10. $TM_j \leftarrow (T_{pre} + T_{mig} + T_{post})$
11. $TM \leftarrow TM + TM_j$
12. until last VM to migrate
13. Return TM
14. End function

Where, i, j denotes iteration

V_i denotes VMs to be transferred T_{pre} denotes Pre copy phase time

I_j refers to Initialization R_j refers to reservation

T_j denotes migrating dirty pages

R refers to transfer rate

SC denotes Stop Condition

T_{mig} denotes migration time

T_{post} denotes Post copy phase time

C_j refers to commitment

A_j refers to Activation

TM_j denotes Migration time of jth VM

TM denotes Total Migration time

IV. CONCLUSION

Live VM migration is the process of moving a running VM or multiple VM's from one server to another. The services running on VM's must be available all the time to the users, hence they must be migrated while they are continuously running. This is possible only if VM's are migrated with zero downtime. The motivation behind live VM migration is - load balancing, proactive fault tolerance, power management, resource sharing, and online system maintenance. This Proposed work contains 5 stages optimal approach of Live VM migration and present basic steps used in the migration process also mentioned the important performance metrics which affects the migration overheads in all the approaches. Finally, Algorithms for migration of multiple VMs also proposed.

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