Live Migration:Challenges and Solutions

Surabhi Sachdeva
School of Engineering & Technology
K.R Mangalam University
Gurgaon, Haryana

Neeraj Gupta
School of Engineering & Technology
K.R Mangalam University
Gurgaon,Haryana

***Abstract*—Virtualization reduces the operational cost by increasing the resource utilization level by integrating heterogeneous environments and provide resources to users and applications. A vast improvement in system security, reliability and availability of resources at reduced cost can be achieved at system level, storage level, and network level through this technology. Live migration allows transfer of a running virtual machines between two servers without halting them. The major issues to be considered while performing such activity are optimizing resources between processes, fault tolerance, load balancing, power management, system maintenance, etc. The current paper surveys various solutions concerning live migration of resources between virtual processes running across distant physical nodes in clusters. Various metrics that should be taken into consideration for performance evaluation of migration algorithms are also discussed.**

Keywords—Resources; live migration; virtual machine; virtualization; performance metrics; problems; solution.s

I. INTRODUCTION

There has been an enormous increase in the computational power in the last few years. Leading to increase in the resource consumption like memory, system services, power, etc. For example, it is estimated that the power consumption will grow over 1000 billion kWh in year 2020 as compared to 300 billion in last decade[6]. Virtualization helps to judiciously utilize the resources while enhancing efficiency, agility and gain flexibility. The resources to various application are provided through an abstract layer which hides physical complexity of hardware and software working environment. This abstraction layer, hypervisor, splits up a physical machine into several virtual machines as illustrated in Figure 1.

As the application grew in the virtualized environment the host machine resources become scarce. This can lead to problems like inaccessible network services, lower throughput, deadlocks, inefficient execution of system calls, memory access problems. In large cluster and datacenter the problem can in the form of large downtime, maintenance issues, and sometimes shutting down of servers. To resolve the resource conflict and avoid failover of the VMs, one or more VM could be live migrated to another physical server. Migration refers to the transition of a running virtual machine from one system to another without halting the virtual machine. The major advantages of this feature are load

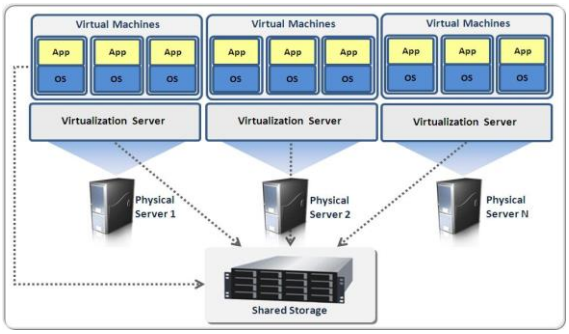

Fig 1: Virtualization Process[15]

balancing, energy management, online maintenance, consolidation of VM's. The two techniques of migration are pre-copy memory migration and post copy memory migration. However, there are various challenges that need to be addressed to carry out such operation. The current paper reviews problems and their proposed solutions in the literature comparing their salient features. The main objective is to aim is to attract the attention of researchers so as to optimize the migrating tools, ensuring smooth migrating process from the host machine to target machine. This paper is organized as follows. Section II presents various metrics that help in evaluating various migration algorithms. Section III gives insight into major challenges facing migration process. The literature survey is carried out in section IV. Section V concludes the paper.

II. KEY METRICES

The key performance metrics that needs to be taken in consideration for evaluating the algorithm are given below:

- Migration downtime- The time for which the service of VM is unavailable.
- Resume time- The time between resuming the VM's execution at the target, and the end of migrati

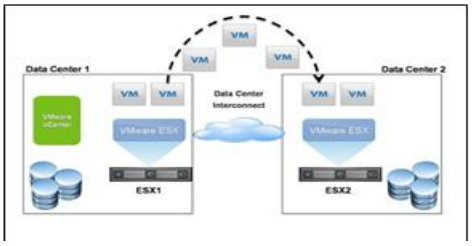

Fig 2: Process of Live Virtual Machine Migration [16]

- Pages transferred- The total amount of memory pages transferred, including duplicates, across all of the above time periods.
- Total Migration Time (TMT)- It is the summation of migration time and resume time. This is the time during which the services of migrating VMs are unavailable.

$$TMT = Preperation\ time + Migration\ time \quad (1)$$

- Live migration time (LMT)- It is defined as the difference between the migration time and the downtime.

$$LMT = Migration\ Time - Migration\ downtime \quad (2)$$

- Application Degradation- This is the extent to which migration slows down the applications executing within a VM.
- Migration Bandwidth- The most prominent factor that affects the performance of live migration is the migration bandwidth which is inversely proportional to migration downtime.

$$Migration\ bandwidth \propto \frac{1}{Migration\ Downtime} \quad (3)$$

III. CHALLENGES IN LIVE MIGRATION

Various research challenges that needs to be addressed:

- Improper VMs migration scheduling and migration bandwidth allocation.
- To find a migration plan such that the total migration time and total migration downtime are minimal.
- Existing works on live VM Migration ignore the inter-VM dependencies and underlying network topology.
- Traffic sensitive VM migration scheduling and migration bandwidth allocation.
- The problem of network contention between the migration traffic and the VM application traffic for the live migration of co-located Virtuamachines.
- Migration mechanisms suffers from longer migration times when migrating virtual machines running large computation and memory intensive workloads.
- Performance penalty of multitier applications during migration.
- Lack of security in live virtual machine migration along with lacking performance.
- Energy efficient scheduling of virtual machines in cloud data centers.
- Quality evaluation of Infrastructure-as-a-service models.

IV. LITERATURE SURVEY

Authors in [17] proposed a model for handling request in the cloud environment as shown in figure 3. When a request is submitted by the user to the cloud, it arrives at the cloud management unit (CMU) which maintains a queue. When the queue is full, the request is immediately rejected, otherwise requests wait in physical machine queue. Each physical machine handle only one job at a time. There are four states of a PM: active, hot, warm and cold. On accepting a job, hot PM turns into active and on finishing it gets turned into hot. Deploying a job on warm PM needs extra warm up time. If no hot PM is available, then newly created job gets rejected, otherwise job is dispatched to a hot PM with resources like CPU, RAM, Disk capacity. Active, warm & hot PM are called alive PM which may get failed whereas cold PM never gets failed. Time-to-failure (TTF) and time-to-repair (TTR) are the up periods and down periods determined by failure rate and repair rate of job. Arrival time rate is an independent exponentially distributed random variable. Requests at CMU are divided into X jobs which is a discrete random variable with probability Pr {X=1} = g_i ($i \geq 1$) mean $E[X] = g^- < \infty$. Processing time is independent exponentially distributed random variable.

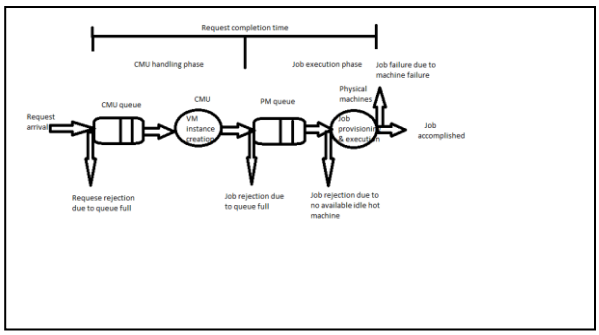

Fig 3: Process model [17]

Request Completion Time = CMU Handling phase + Job Execution Phase (4)

Tusher Kumer Sarker, et al. in [19] addressed the issues of traffic-sensitive VMs migration scheduling and bandwidth allocation for migrating processes. Migration scheduling algorithm was proposed in order to migrate a set of candidate VMs with minimal total migration time and total downtime. The proposed algorithm selects the sequential & parallel migrating strategy, allocates bandwidth to the migrating VMs appropriately. A dynamic bandwidth adoption strategy is proposed to improve the performance of algorithm comparing with a random scheduling algorithm. It considers inter VM dependencies & underlying network topology. It was shown that total migration time & total downtime increases linearly with the increasing number of migrating VMs. Further, by reducing the data transfer during migration, migration time and migration downtime can be reduced.

K. Chanchio, et al. in [20] proposed a mechanism to migrate large, memory intensive VM. It was observed that pre-copy mechanism may take long time to migrate the memory intensive VM. To alleviate this problem, the updated

VM state on the destination must be transmitted to the backup copy on the source regularly. Post copy mechanism suffer a long downtime when migrating a VM running memory intensive applications. To reduce the downtime, a mechanism is guaranteed to reduce the number of dirty pages generated by the guest.

Umesh Deshpande, et al. [21] discussed about defragmenting a data center during migration to obtain resources with specific purposes. There are two types of migration process:

(i) Pre-copy migration- Low service downtime for VM migration in executing read-mostly workloads are provided by this mechanism.

(ii) Post-copy migration- It is low network overhead and allows quick consolidation or eviction of VMs.

Migration traffic and network traffic are the two different types of traffic. If direction of both the above mentioned traffics compliments each other than contention can be minimized. VM applications which are generally having inbound traffic contend with the incoming migration traffic at the destination host which increases the total migration time and degrades the performance of VM application. An approach called traffic-sensitive live migration reduces the network contention for the simultaneous migration of VMs running network-bound applications, the mentioned migration technique uses a combination of Pre + Post copy migration technique for migration of co-located VMs. Thus, decreasing total migration time and application degradation. According to authors, total migration time of a VM is affected by the amount of data transferred and the available bandwidth. More the amount of data transferred, more will be the total migration time.

X. Feng *et al.* [22] study the performance of live VM migration technology in WAN. Measurement-based approach is used to evaluate and compare the performance of most frequently used live migration technologies under given network conditions. They used pre-copy approach to transfer data for their underlying memory allocation mechanism although data transfer protocol could be different. Authors compared their results using VMotion and XenMotion. It was concluded that VMotion generates much less data transferred than XenMotion. Performance quality of VMotion degrades dramatically under network suitable for live migration over WAN compared to VMotion. Latency increases, performance decreases dramatically.

Sangeeta Sharma**,** et al. in [23] proposed a technique for efficient transfer of volatile memory. In order to manage cloud resources, virtual machine migration comes into play. They are used to migrate processes from overloaded machine to under loaded machine. The various migration methods like stop and copy, pre-copy, post-copy are available. Authors concluded that there is need for an efficient virtual machine live migration technique, when low bandwidth is available.

H. Liu**,** et al. [24] provided with solutions to reduce the migration cost without degrading application performance. Key idea was to migrate several tightly coupled VMs instead of a single VM. It was observed that there is a performance penance of multitier applications during migration when run on different VMs having different memory access patterns. Because of data intensive nature and limited bandwidth, performance degradation occurs. Authors proposed VM Buddies to coordinate and synchronize protocol to ensure all VM complete their migration simultaneously. It avoids splitting multiple tiers between data centres to minimize the performance penalty on multitier applications.

Lei Yu**,** et al. [26] proposed stochastic load balancing scheme to provide probabilistic guarantee against resource overloading with virtual machine migration while minimizing the total migration overhead.

Somayeh Soltan Baghashahi et al. [27] proposed greedy algorithm to reduce total migration time while transferring virtual machine from one data centre to another within a cluster. The experiments were carried out in CloudSim [ ]. It was concluded that bandwidth plays a very important role in the virtual machine migration.

Changpeng Zhu et al. [28] addressed the multi-objective optimization problem. On the basis of performance model, a bandwidth allocation algorithm was proposed for live VM migration by balancing the migration time and the migration's impact on VMs. The experiment results shown improvement in the performance of live VM migration to 76% in comparison with the approach in QEMU.

Chaima Ghribi et al. [25] presented two algorithms for energy efficient scheduling of virtual machines in cloud data centres, which shown minimize energy consumption and migration costs compared with slightly faster heuristics.

Authors proposed a linear integer program corresponding to an exact allocation algorithm coupled with an efficient exact VM migration algorithm to reduce energy consumption via consolidation.

V. CONCLUSION

Live migration of process has received a lot of attention from both academia, researchers and industries worldwide. It provides us with the ability to better manage the resource at our disposal. However, there are challenges that need to be addressed to design better tools that can provide seamless transfer of the application from the host machine to target machine even in heterogeneous environments. The current paper summarizes the key metrics and issues that need to be addressed for migrating processes. The advent of cloud computing, which is empowered by virtualization requires further exploration and research concerning this area.

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