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A Systematic Review On Interference In Cloud Computing Environment

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Abstract-
Transmutations through cloud computing affect every aspect of computing; that could be measured in terms of performance. Furthermore, to support the performance enhancement in cloud environments "Virtualization" has been proved to be a notable evaluation. Additionally, in virtualization virtual machines are the instruments to harness the potential of cloud computing. Cloud infrastructure is shared among various users through virtualization. Virtualization enables applications of diverse nature to execute in isolation under distinct Virtual machines within a physical machine. Moreover, virtualization leverages higher utilization of physical resources. Among the said benefits of virtualization, live migration of VMs leads to the load balancing and energy saving benefits. Despite the said benefits of virtualization, violation of virtualization leads to the contention for the shared resources. Further, raising the performance interference issues. Conversely, limiting the interference leads to a higher demand for physical resources. Therefore, understanding the interference severity among the co-scheduled Virtual machines (VMs) has a great potential to improve the shared resources utilization. To investigate the interference and address the related challenges in this paper an in depth study has been carried out which covers the "interference source" to schedule the resource capacity in maximum by incorporating the bin-packing policies.

I. Introduction

Cloud computing is pervasive and is being applied in many research areas such as healthcare, DNA alignment etc. Application Performance is a critical concern among the top five issues, since the emergence of cloud computing. To improve resource utilization, further scalability "virtualization" comes into the limelight of various researchers. Virtualization is known to be the backbone of cloud computing. Virtualization is an innovative approach to deliver

maximum computing capabilities in the presence of limited shared hardware resources. Further, virtualization in Servers enables the execution of more than one VMs in isolation leads to the effective utilization of the server resources. Virtualization is highly effective and is the backbone of cloud computing. Nevertheless, the interference among the VMs for the shared resources leads to performance degradation. This phenomenon is caused when a VM tries to allocate a higher amount of resource violating the allotted resource budget. Therefore VMs scheduling is one of the critical aspects which needs to be addressed properly. Measuring the impact of interference in performance degradation is a crucial factor needed for proper attention [1].

Applications that get executed in the cloud computing environment are critically affected due to the "interference" issue and leads to the performance degradation. The said issue becomes more severe satisfying the isolation aspects (for the hardware resources) among the various Virtual machines (VMs) [2]. Nevertheless, there are some resources such as CPU, memory which impose minimal interference among the VMs. While, hypervisor does not partition the low level devices such as cache and main memory effectively. Contention for the said resources raise the performance variability among the various VMs. Contention could exist among cache-to-cache and disk-to-disk. Application characteristics play a key role in the interference intensity.

II. Scope of Virtualization

In this section a concise view in terms of the scope of virtualization has been discussed. Virtualization is an approach which prepares the hardware cloning for the actual Physical machines with the help of the hypervisors. Hypervisor is a software which provides abstraction for the virtual machines and helps to mitigate the chances of interference in cloud infrastructures. The first and foremost benefit of virtualization is that, a diverse characteristic of applications in the perspective of hardware with software could be executed on the physical machine effectively.

Another important scope in the perspective of energy consumption in the presence of interference needs to be investigated. To mitigate this challenge, optimization of server energy has been proven to be beneficial [16]. Further, to get seamless facilities of virtualization, live migration of virtual machines has great scope to provide different alternatives (Physical machines) without hindering the cloud services [17].

III. Classification of Interference

Virtualization allows more than applications to share the available resources, further improving the physical hardware. It could be noted that the cloud interference has been subcategorized as, Network interference, inter VM interference and application performance interference. Among these interferences Network and application performance has been further categorized. Network interference occurs when more than one VMs compete during the communication to the Physical machine. Further, Application performance interference

which denotes the interference of the applications for the resources such as file system. Some attempts to classify and investigate the interference have been attempted for the Multicore environment also [18][19]. The classification, categorizes interference in three categories, higher sensitive, moderate, and low sensitive for the shared resources,

IV. Cloud Computing Challenges in the perspective of Interference

Cloud computing is evolving at a high pace, and has carried various challenges in terms of managing the shared resources. Nevertheless, performance degradation of cloud resources are characterized as misallocation of virtual machines, storage, and networks. In various studies it was identified that isolation in virtualization under VMs in PMs are not advantageous in all scenarios. And due to contention performance is impacted and degraded when cloud services are executed in VMs. The well known challenge in cloud computing is scheduling of shared resources in the dynamic environment at the same time satisfying the changing user needs [3][4]. The source of this challenge is that- each user has its own workload to be on the server side to ensure the service level agreement (SLA). And due to the interference SLA violation occurs frequently.

Scheduling the VMs to various physical machines sometimes fails and leads to the performance interference challenge. This phenomena accelerates another challenge that performance of one VM starts depending on the behavior of another co-located VM. Further leads to the contention among the VMs and it impacts performance adversely. Similarly, Concurrently accessing the VMs in the presence of an isolation aspect for shared memory leads to the inter-VM communication challenge[5]. The source of interference problem is intrinsic to the applications diverse types and amount of required resources. For example, applications (web search) which are latency centric needed to meet the deadline and lower response time. Therefore, most of the researchers have selected the web applications as a suitable alternative to calculate the interference sensitivity in the presence of dynamic workload. Among the said challenges, partitioning of shared resources among the Virtual machines is a critical issue, as some resources could be easily partitioned like CPU, others may not be such as memory bandwidth. Furthermore,interference leads to performance degradation. The present hypervisors are unable to provide sufficient isolation for the low level hardware resources. Some resources for whom isolation is not achievable are cache, and memory bandwidth.

Among the various challenges there is a need of understanding the VM migration and its effects on interference. Although, there are some notable effects that have been already identified which influence the cloud computing such as connectivity concern, also quality of service. Among these issues, the possibility of having affected the parameter in the said situation is quality of service.

V. Approaches to address VMs Interference effects

To address the performance interference issue the approaches are broadly classified into three categories- hardware partition, VM placement and distinct policies related to scheduling and allocation[9][10]. Hardware partitioning approach divides the hardware resource among the VMs to provide the necessary isolation. In the VM placement approach, the workload characteristics of the VMs are analyzed to avoid the VMs allocation which have contending behavior to the same resource. There are various approaches to address the interference effects of VMs. Similarly, there are bin packing oriented VM placement algorithms used to allocate the VMS. Their approaches are effective to a limited extent as they did not consider the VMs characteristics before making the placement decision [11].

Two approaches to address the interference issue are- either scheduling the interference sensitive VMs in a time gap to the same host; or to place them in distinct hosts. Choices of VMs are limited in the first approach while migration of VMs from one host to another host would be an additional overhead in the second approach [21]. In another context, a similarity indexing based approach to address the performance interference has been proposed. The approach is illustrated in Figure-1.

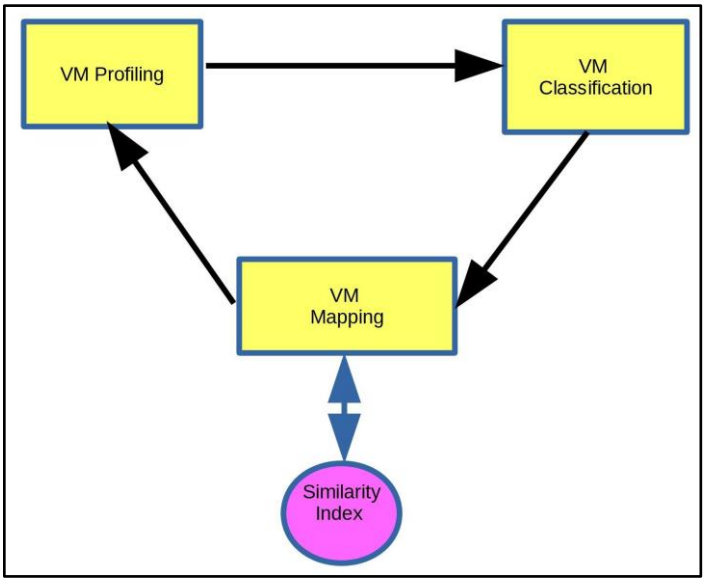

Figure-1 Similarity Indexing based approach for VM Placement

To address the interference for the above scenario, “configuration manager” has been proposed. Configuration manager monitors the interference and after detecting the interference, reconfigures the applications to mitigate the interference among the low level resources. The benefit of the configuration approach is that Interference in the public cloud has the characteristics of short lived. And application configuration suitts better as compared to the infrastructure configuration. Public clouds have higher possibilities in the performance of the applications. To address the interference issue, a “virtual machine placement” based approach has been proposed in the literature [3]. The proposed strategy

mitigates the interference in the first place. Additionally, addresses the communication cost and load balancing issues.

To minimize the interference sensitivity, prediction based approaches have proved to be effective. In [6], a Cloudscope based system has been proposed to predict the interference among the co-located applications. The proposed system, after predicting the interference, shuffles the VMs to the distinct physical servers aiming the minimum interference. Similarly, a machine learning based system, which detects the performance degradation among the VMs due to interference has been proposed. The said approach detects the interference, when various web services are in execution. The proposed strategy suffers in terms of higher computation due to the involvement of machine learning algorithms.

VI. Interference effects on performance

Unpredictable application performance is one of the key effects of the interference. Now, the question might be why is the performance unpredictable. Identified reason of the said phenomena: interference affects the applications performance due to the concurrent execution of applications on the physical machine in totality. Interference among the VMs affects the network and I/O bandwidth. In case of interference each resource is affected differently in different scenarios. For example, CPU centric applications result in nearabout 14% performance degradation. Whereas, applications related to memory and disk led to the performance degradation to a maximum of 90%. During the event of interference and further contention raise the concern to the cloud infrastructure. And resources such as cache, CPU, memory, disk and network get affected.

VII. Interference-aware scheduling

Scheduling of resources is a key approach adopted by cloud computing vendors to provide the performance specific services. The presence of Interference among VMs could be related to the CPU intensive, I/O intensive and network intensive workloads. The interference occurs when such workloads get executed in parallel manner. Additionally, these workloads when scheduled independently are more prone for interference [1]. In [5], the authors have proposed a system called Cloudscope for predicting interference between co-located workloads in a multi-tenant environment.

The policies available in the literature to address the interference through scheduling belong to the twofold categories; static and dynamic. Static policies schedule the interference sensitive applications before the execution. Whereas, dynamic based policies are based on investigation and classification of applications to estimate the interference level and scheduling them in non-contending manner [14]. Further, a scheduling policy must ideally have two phases- a classification and scheduling phase. Classification phase should have to identify which applications should be scheduled together and vice-versa. Further, on the

basis of the outcome of the first phase, scheduling decisions should be carried out in the cloud computing environment.

VIII. Parameters affecting interference sensitivity

Table-1 Identified parameters for estimating the performance interference

Ref.	Algorithm	Approach	Parameter
Mosoti, et al. [12]	K-means clustering algorithm is used to find out the characteristics/similarity of VMs.	Estimating the similarity of incoming VMs.	Similarity index (SI)
Anu, V.R et al. [13]	Interference aware live VM migration strategy (IALM).	Minimizing the energy consumption by mitigating the VM to different PMs	Energy consumption
Vinícius Meyer [14]	A machine learning-driven classification scheme.	Interference-aware application classifier	Resource utilization, Qos requirement.
Amiya K [2]	Inter parameter dependency approach	Reconfiguration of parameters in an intelligent way.	Average response time
Gupta, A[15]	Host Selection Migration Time,	Live migration optimization technique	migration time

IX. Live migration of Virtual Machines and Interference

Live migration of Virtual machines have great potential for the VMs to migrate their data from one VM to another VM. However, live migration has some challenges also. To manage the resources in a dynamic environment for the applications of the data centers etc, live migration of VM would have significant importance. The VM migration and interference are interrelated. Nevertheless, available VM migration techniques considers only load balancing and energy consumption issues and less attention has been given to the interference in the said environment [22]. The consequences of the interference in the said scenario leads to the performance degradation and violation of service level agreement. Various approaches addressing the VM migration and mitigating the interference have been detailed in Table-2. The need of VM migration has come into the concern as resource management did not have

fine tuned in the present scenario. Therefore, the instability of VM leads to the performance degradation further limiting the quality of service to the users.

Frequent migration of VM is not good for the cloud computing users. Now the question might come: why the migration of VM? The answer is, when applications load increases, VM migration plays the role of redistribution of application loads by load balancing among the physical machines. VM migration is an attractive approach in the perspective of maintaining the Service level agreement between the user and the service providers. The activity of VM migration is hidden to the user and is performed in the background.

Ideally, the VM migration did not lead to any adverse effects, however, delay on user response is generated due to the interference. Scaling of the resources considering the load threshold is a well known technique on interference mitigation [23]. In some cases VMs isolation violation leads to security threats. Where, a malicious VM could redirect its load to a particular PM and lead to violate the SLA [24]. One of the known drawbacks of live migration of VM is that a VM moved from one PM to another PM might disturb the working and resource utilization of the destination PM [25].

The advantage of Live migration of VM is explored in data centers for load balancing, maintenance of PM in online mode, power management and fault mitigation.

Table-2 Approaches to address the live migration of VMs

Ref.	Approach	Innovation	Benefits	Parameters
K.R. Remesh Babu et al. [22]	Prediction oriented approach to mitigate the interference	Interference prediction in the perspective of the resource scaling.	Reduces the number of migrations for VMs.	Threshold range
Hajer Toumi et al. [23]	Stream mining technique	Effective resource provisioning	Server load prediction as per the variability of application load	Prediction accuracy
Bloch, T [24]	Live migration of VMs	Memory migration	Optimization of Live migration of VMs process	Total transferred data, down time.

Rachael Shaw [26]	Predictive modeling and classification of workload.	ensemble based VM consolidation algorithm	Improvement on energy efficiency	Service violation

Conclusion

Cloud computing is a pay for service platform that integrates innovative techniques such as virtualization, live VM migrations. Understanding the interference is one of the well known bin-packing schemes that leads to the performance degradation. Considering the above aspect in this paper, a detailed investigation on interference issues, challenges and mitigation alternatives has been explored. The Scope of virtualization is not limited to the users satisfaction but also, technically it satisfies the Service level agreement among the users and the providers. The interference effects not only affects the performance while affecting the energy consumption factors also. To mitigate the interference phenomena VM scheduling based approaches have also been discussed and found to be useful to a large extent. Besides, the scheduling, isolation and hardware partitioning based approaches have equal impact to mitigate the interference. Finally the said aspects are investigated and summarized. In future, an in depth analysis of interference in the presence of Live migration of VMs could be explored.

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