A Survey of Cost Comparison between Containers and Virtual Machines

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***Abstract*—With the rise of Cloud computing, virtualization has become a big deal for managing resources. But there's a tricky balance between how well things perform and how much they cost in the Cloud, where you pay for what you use. Containers are like the new kids on the block, offering a way to solve these challenges. In this study, we dive into the costs of regular virtual machines and containers. We look closely at different things that affect costs and how they behave in different situations. We'll dig into how things work and look at some numbers to figure out which is better for saving money. After all that, we'll also discuss our findings and suggest areas for further research**.

Keywords: Cloud computing, virtualization, cost comparison, containers, virtual machines, resource management, performance, scalability, cost-efficiency**.**

I. INTRODUCTION

In today's ever-evolving technological landscape, virtualization has emerged as a pivotal tool for efficient resource management in cloud computing environments. The cloud's promise of scalability and flexibility has ushered in a new era of digital transformation, where businesses and organizations harness its power to meet dynamic demands. Within this landscape, optimizing costs while maintaining performance has become a paramount concern. Virtualization empowers us to isolate workloads and control resource allocation, but it has introduced an intricate balance between performance and cost-effectiveness.

The importance of cost-efficiency cannot be overstated. For businesses, every resource utilized must translate into value, and the cloud's pay-as-you-go model has intensified the spotlight on cost-effectiveness. As organizations scale their operations, misjudgments in resource allocation can lead to substantial financial consequences. Hence, the choice between containers and virtual machines in terms of cost holds not only technical but also financial implications that ripple across every layer of the organization.

However, the additional layers of abstraction that virtualization introduces can lead to compromised workload performance, resulting in suboptimal price-to-performance ratios for users (Felter, Ferreira, Rajamony, & Rubio, 2015). To address this challenge, container-based virtualization has garnered attention as a solution that simplifies application deployment while maintaining control over resource allocation (Felter, Ferreira, Rajamony, & Rubio, 2015).

This study's objective is to scrutinize the cost comparison between containers and virtual machines, aiming to ascertain which approach offers superior cost-effectiveness. By analyzing aspects like resource utilization, performance, security isolation, and overall cost, this study endeavors to provide comprehensive insights into the trade-offs between containers and virtual machines concerning cost-effectiveness in cloud computing environments. While existing studies consistently indicate that containers offer enhanced cost-efficiency compared to virtual machines, they come with the trade-off of reduced security isolation. Consequently, cloud providers often implement a hybrid VM + Container model, capitalizing on containers' cost benefits while harnessing virtual machines' security advantages. It's worth noting that, while containerization technologies have gained popularity for their performance and flexibility, virtualization remains more established in the context of cloud computing. Additionally, the influence of running a container on top of a virtual machine on container performance warrants further exploration (Mavridis & Karatza, 2017). Therefore, this study endeavors to compare the costs of regular virtual machines and containers, factoring in various cost-influencing elements and their behavior in diverse scenarios. The goal is to determine which option is more cost-effective and to pave the way for future research directions.

II. BACKGROUND

With the increasing adoption of cloud computing and the need for efficient resource allocation, organizations are constantly seeking ways to optimize costs while maintaining high performance and scalability. One approach to cost

optimization in cloud computing is the use of virtual machines or containers. Virtual machines have been widely used in cloud computing due to their ability to isolate workloads from one another and control resource usage (Felter, Ferreira, Rajamony, & Rubio, 2015).

However, the extra levels of abstraction involved in virtualization can reduce workload performance, resulting in worse price/performance for customers (Felter, Ferreira, Rajamony, & Rubio, 2015). According to a study on containers and virtual machines, container-based virtualization offers a simplified deployment of applications while still allowing control over allocated resources (Felter, Ferreira, Rajamony, & Rubio, 2015).

Cloud computing has traditionally relied on virtualization technology, with hypervisors like KVM creating and managing virtual machines based on user demands (Mavridis & Karatza, 2017).

Today, there is a growing trend towards the adoption of container-based virtualization, which offers a more lightweight alternative to traditional virtual machines. This technique allows a container to share the host kernel with user-space isolation. This shift towards container-based virtualization brings about the need for a better understanding of its performance and cost implications when compared to virtual machines. In recent studies, researchers have conducted performance comparisons between virtual machines and container virtualization. For example, a study compared Docker containers with kernel-based virtual machines and found that container virtualization holds promise in increasing performance. Although there is already solid research conducted on the capabilities and limitations of both virtual machines and container-based virtualization, there is a lack of research specifically focusing on the performance and cost implications of running containers on top of virtual machines. As a result, it is important to investigate the cost comparisons between containers and virtual machines to determine the most cost-effective solution for organizations utilizing cloud computing. In order to address this research gap and provide valuable insights for organizations utilizing cloud computing, this survey aims to explore the cost comparison between containers and virtual machines.

III. Related Works

Several studies have explored the utilization of virtual machines in cloud computing for workload isolation and resource control. For instance, in a study by Felter et al., the downsides of virtualization are highlighted, including reduced workload performance and worse price/performance for customers (Felter, Ferreira, Rajamony, & Rubio, 2015). In response to these limitations, recent advancements in container-based virtualization have been developed, with the aim of simplifying the deployment of applications while still enabling control over allocated resources (Felter, Ferreira, Rajamony, & Rubio, 2015). Container-based virtualization technologies, such as Docker, OpenVZ, and LXC, aspire to simplify the deployment of applications while retaining control of allocated resources (Zhang et al., n.d). Another significant motivation for the growing adoption of container-based techniques is their convenience in encapsulating, deploying, and isolating applications, alongside their lightweight operations and efficiency in resource sharing (Zhang et al., n.d).

Virtual machines have been extensively utilized in cloud computing due to their ability to isolate workloads and control resource usage (Felter, Ferreira, Rajamony, & Rubio, 2015). However, the additional layers of abstraction inherent in virtualization can adversely impact workload performance, leading to worse price/performance for customers (Felter, Ferreira, Rajamony, & Rubio, 2015) . On the other hand, container-based virtualization offers several advantages over virtual machines (Lee, Kim, & Yoo, 2018). Container-based virtualization, characterized by its lightweight architecture, provides high performance, resource efficiency, and an agile environment that enables faster deployment and easier management of applications (Lee, Kim, & Yoo, 2018). Consequently, containers have been widely adopted across various industries, including cloud data centers, mobile systems, and networks, due to their performance advantages, resource efficiency, and agility (Lee, Kim, & Yoo, 2018).

IV. Assessment

The assessment/evaluation section of the article "A Survey of Cost Comparison between Containers and Virtual Machines" aims to comprehensively compare the cost optimization potential of containers and virtual machines within the domain of cloud computing. This examination holds paramount significance, as it directly influences decisions regarding the deployment of workloads in cloud environments. The balance between cost-efficiency, performance, and resource allocation must be meticulously considered to make informed choices. This assessment delves into critical factors encompassing performance metrics, resource allocation capabilities, scalability, and the overall cost-saving potential.

A. Performance Evaluation:

The initial aspect of this assessment focuses on the performance characteristics of containers and virtual machines. Metrics ranging from CPU performance, memory throughput, disk I/O, load testing, to operation speed were subjected to scrutiny (Potdar et al., n.d). The study by Potdar et al. significantly contributes insights into this area by showcasing that Docker containers consistently outperform virtual machines across these metrics. This suggests that containers are better poised to execute workloads rapidly and efficiently.

B. Resource Allocation and Scalability:

Resource allocation and scalability are pivotal for efficient cloud resource management. Containers and virtual machines were assessed to determine their effectiveness in allocating resources to different

applications while adapting to varying workload demands. The research by Lee et al. underscores those containers, with their lightweight architecture, are better suited for resource allocation and scalability, potentially leading to cost savings by optimizing resource usage (Lee, Kim, & Yoo, 2018).

C. Cost-Saving Analysis:

The cost-saving potential of both technologies was critically analyzed. Factors such as licensing costs, infrastructure requirements, and overall operational expenses were taken into consideration. Felter et al.'s study indicates that virtual machines can incur higher costs due to reduced performance and resource usage (Felter, Ferreira, Rajamony, & Rubio, 2015). Conversely, container-based approaches offer an avenue for cost reduction by streamlining application deployment while maintaining efficient resource utilization (Felter, Ferreira, Rajamony, & Rubio, 2015).

D. Integration of Insights:

The insights from various studies by Potdar et al., Lee et al., and Felter et al. collectively contribute to a comprehensive understanding of cost optimization potential in cloud computing. While virtual machines possess their merit in certain contexts, the assessment suggests that containers have emerged as a favorable choice for achieving a balance between cost-efficiency and performance.

E. Future Directions:

While this assessment provides valuable insights into the cost optimization potential of containers and virtual machines, further research is necessary to explore evolving technologies, changing cloud computing landscapes, and emerging cost factors. The comparison presented here forms a basis for future studies to delve deeper into understanding the evolving relationship between these technologies and their impact on cloud economics.

F. Conclusion:

In conclusion, the "Assessment" section offers an in-depth exploration of the cost optimization potential of containers and virtual machines in cloud computing environments. The performance evaluation showcases containers' superiority across various metrics, and the assessment of resource allocation and scalability underscores their efficiency. The cost-saving analysis underscores the container-based approach's capacity to reduce expenses. By integrating insights from a variety of studies, this section provides a comprehensive perspective on how these technologies influence cost optimization within the cloud computing context.

V. DESCUSSION:

The discussion section of this article aims to explore and compare the cost implications of using containers versus virtual machines in various computing environments.

The cost comparison between containers and virtual machines is a topic of considerable interest in the field of cloud computing.

Container technology, such as Docker, has gained significant popularity due to its lightweight nature and ability to run multiple container instances on a single machine node.

This enables organizations to effectively utilize their hardware resources and reduce hardware costs. Furthermore, the ability to run multiple container instances on a single machine node also contributes to the creation of a redundant backup environment, which further enhances cost-effectiveness. In contrast, traditional virtual machines are heavier and require dedicated hardware resources for each instance. As highlighted by existing studies, containers offer improved cost-efficiency compared to virtual machines but at the expense of reduced security isolation. Therefore, cloud providers often employ a hybrid VM+Container model to protect their infrastructure assets, as it combines the cost benefits of containers with the security advantages of virtual machines. In addition to cost considerations, the performance aspect of containers versus virtual machines is also an important factor to consider.

Existing studies have shown that virtualization introduces additional layers of abstraction, which can negatively impact workload performance (Felter, Ferreira, Rajamony, & Rubio, 2015). One study conducted a performance comparison between virtual machines and container virtualization, specifically comparing Docker containers and kernel-based virtual machines. The results of this study indicated that container virtualization, specifically Docker containers, exhibited increased performance compared to kernel-based virtual machines (Felter, Ferreira, Rajamony, & Rubio-Martinez, 2015). Overall, the cost comparison between containers and virtual machines indicates that containers offer improved cost efficiency due to their lightweight nature and ability to utilize hardware resources more effectively, resulting in reduced hardware costs. However, it is important to note that containers do come with a trade-off in terms of reduced security isolation compared to virtual machines. Furthermore, the expansion of containers in cloud, fog, and IoT networks relies on various precursor conditions such as the design of more efficient container schedulers and the development of robust container management platforms. In conclusion, the survey of cost comparison between containers and virtual machines reveals that containers offer improved cost-efficiency by reducing hardware costs through effective utilization of resources, increased performance compared to kernel-based virtual machines, and potential for expansion in cloud, fog, and IoT networks. In conclusion, containers have been found to provide improved cost-efficiency when compared to virtual machines. This is due to their lightweight nature and ability

to utilize hardware resources more effectively, resulting in reduced hardware costs.

VI. Conclusions and Future Work:

In conclusion, the comparison between containers and virtual machines in terms of cost has shown promising results. In general, the use of containers, particularly Docker, has demonstrated comparable or better performance than virtual machines such as KVM (Felter et al., 2015). This suggests that containers can be a cost-effective alternative to virtual machines for certain workloads. Furthermore, the negligible overhead for CPU and memory performance introduced by both containers and virtual machines further supports their suitability for cost-efficient deployment. Moving forward, future research should explore the cost-effectiveness of containers and virtual machines in different scenarios and workloads. Additionally, further investigation is needed to understand the potential cost savings and performance benefits of using containers and virtual machines in combination for I/O-intensive workloads. Overall, this paper has contributed to the understanding of the cost comparison between containers and virtual machines.

It has been established that containers, specifically Docker, exhibit comparable or superior performance to virtual machines like KVM in terms of cost. This suggests that organizations looking to optimize cost while maintaining performance can consider using containers as a viable alternative to virtual machines. Further research should investigate the cost-effectiveness of containers and virtual machines in various contexts and workloads. Additionally, exploring the potential cost savings and performance advantages of using a combination of containers and virtual machines for I/O-intensive workloads would be beneficial.

References:

- Felter, W., Ferreira, A., Rajamony, R., & Rubio, J. (2014 July 21). An updated performance comparison of virtual machines and Linux containers. https://doi.org/10.1109/ispass.2015.7095802 .

- Mavridis, I., & Karatza, H. (2017). Performance and Overhead Study of Containers Running on Top of Virtual Machines. https://doi.org/10.1109/cbi.2017.69 .

- Lee, K., Kim, Y., & Yoo, C. (2018, January 1). The Impact of Container Virtualization on Network Performance of IoT Devices. https://scite.ai/reports/10.1155/2018/9570506 .

- Zhang, Qi et al. (n.d). A Comparative Study of Containers and Virtual Machines in Big Data Environment. http://arxiv.org/abs/1807.01842 .

- Potdar, A. M., Narayan, D. G., Kengond, S., & Mulla, M.

M. (n.d). Performance Evaluation of Docker Container and Virtual Machine. https://doi.org/10.1016/j.procs.2020.04.152 .