Performance Evaluations on Various Virtual Machines for different Cloud-Based Workloads

Ishaan Kalra[1]*, Parth Ahuja[2]

[1]Undergraduate Student, Department of Computer Science and Engineering, Maharaja Agrasen Institute of Technology, New Delhi 110086, India, Email: kalraishaan16@gmail.com

[2]Undergraduate Student, Department of Computer Science and Engineering, Maharaja Agrasen Institute of Technology, New Delhi 110086, India, Email: aryanahuja14@gmail.com

Abstract: Cloud computing provides users with multiple virtual machines (VMs) as needed to manage system resources such as processing, storage, and networking. It's one of the popular topics right now, because of its massive computer capacity for scientific workloads. Currently, the scientific community is ready to work over the cloud as it is considered a resource-rich paradigm. The traditional way of executing scientific workloads on cloud computing is by using virtual machines. In an enterprise firm, selecting public cloud service providers is growing more difficult. This paper will assist in bringing down doubts about using a public cloud service provider and will lay. This study emphasizes the importance of processing, storage, and infrastructure as service factors that influence cloud service provider selection by comparing these three cloud service providers (AWS, Microsoft Azure, and Google Cloud Platform) in terms of service, pricing, and benefits, as well as popular VM throughput augmentation approaches. It also addresses throughput and efficiency issues with VMs and containers in the cloud, as well as resource provisioning efficiency, by merging four distinct methods: hyperthreading (HT), vCPU core selection, vCPU affinity, and vCPU isolation. The proposed solution is to implement four basic techniques to reduce the effect of virtualization. These strategies are also utilized to improve the effectiveness and power of virtual machines and containers for scientific workloads. The findings suggest that permitting hyperthreading, CPU core separation, appropriate numbering, and allocation of vCPU cores can increase virtual machine throughput and performance.

Keywords: cloud computing, virtual machines, hyperthreading, throughput.

1. Introduction

The way we run our businesses and provide them to the general public is changing thanks to the internet. When the word 'the cloud' is added to the term computing, it gives it a multi-dimensional meaning. Rather than storing all of the information and programming on a computer or server, it is stored 'in the cloud.' There are three types of cloud computing (IaaS, PaaS, and SaaS), each with different levels of access and protection. Because each model is primarily used for processing, storage, and infrastructure services, choosing a cloud computing model is quite challenging for a consumer. There is not a single model that matches every firm's information-handling needs, therefore if a company chooses to model, they'll need to know which model employs which service feature. The client is responsible for making an informed decision when selecting a model. Cloud computing has recently emerged as the most promising computing paradigm for scientific workloads, providing a flexible and on-demand infrastructure. Grid and utility computing have influenced it. High-performance applications necessitate a lot of processing power in a short amount of time. High throughput computing, on the other hand, entails a massive amount of computer power over an extended period, such as months or years. Because of the shared kernel, comparing the performance of the container to that of bare metal is likewise not possible. The efficiency and availability of scientific workloads are the most critical factors to consider while optimizing VMs/containers. In virtualized and containerized scientific cloud settings, challenges relating to efficiency and throughput must be addressed directly to reap the benefits of cloud computing. This article presents a strategy for resolving the difficulties of performance and throughput to overcome the aforementioned challenges. We also consider VM, container performance, and efficiency issues, and investigate effective resource provisioning by integrating four distinct methods: hyperthreading (HT), vCPU core selection, vCPU affinity, and vCPU isolation. This research focuses mostly on scientific workloads. We combine four well-known approaches to achieve real-time performance and greater virtual machine and container throughput which include hyperthreading technology, vCPU core selection per virtual machine/container, physical CPU isolation, and virtual machine/container vCPU core pinning.

2. Literature Review

Nicolo Maria Calcavechia, Ofer Biran, Erez Hadad, and Yosef Moatti [1] investigated different methods for placing Virtual Machines in Clouds. Even though there has been a great deal of exploration done on the issue of placing Virtual Machine in cloud framework yet the dynamic nature of the approaching stream of virtual machine sending stream has been disregarded. A pragmatic model of cloud management framework under a flood of requests has been talked about in this paper. Additionally, a creative strategy named Backward Speculative Placement is likewise discussed. BSP method is talked about in two methods. Taking care of the recurring optimization and a surge of deployment requests are thoroughly discussed in this paper. The creators have utilized a generic MIP solver to compare the results, which shows the advantages of the BSP procedure. To put it plainly, the creators have checked historical demand traces of deployed VMs, BSP projects and tracked down the VMS relationship angle in the most effective manner.

Minder Chen and Yiching Liou [2] have reviewed the advantages of various virtualization approaches. Virtualization's impact on the IT industry has also been highlighted and analyzed by the authors. ITIL, or Information Technology Infrastructure standard, has been used to assess the effects of virtualization on the IT sector and to analyze virtualization technologies. Virtualization, according to the authors, will result in better IT infrastructures and services. It will also assist IT firms in lowering their prices and expenses. Furthermore, virtualization has been acknowledged as having an impact on advanced and better IT services. The paper concludes that virtualization will improve IT infrastructure while also allowing for the establishment of new advanced dynamic IT infrastructures.

Cloud computing and its challenges have been examined by **Yashpalnish Jadeja and Kirit Modi [3].** Parallel computing, distributed computing,

grid computing, and, most recently, cloud computing have all been briefly mentioned in IT history. The principles of Cloud Computing have been thoroughly examined by the authors. This study presents an alternative perspective on the notion of cloud computing. The writers have now moved on to discussing cloud computing architecture. The benefits of cloud computing are clearly defined. Furthermore, the difficulties of cloud computing have been explored. Various advantages of cloud computing are explored, including economic effectiveness, uninterruptible services, easy management, and green computing. Finally, the writers have shed light on cloud computing concerns.

The topic of migration-based virtual machine placement in cloud systems has been debated by **Kangkang Li, Huanyang Zheng, and Jie Wu [4].** The writers begin by defining the fundamental concept of cloud computing. They've talked about the working time of physical and virtual machines in the future. The authors' research focuses on using a correct virtual machine channel to reduce the total job completion time of input virtual machine requests. The authors propose using emulated VM migration to place virtual machines offline. As a heuristic technique, the migration algorithm is used. This paper also looks at and discusses a hybrid method in which a batch is used to accept incoming virtual machines.

Virtualization in Cloud Computing was discussed by **L. Malhotra, D. Agarwal, and A. Jaiswal [5].** It begins with a fundamental overview of cloud computing, including its definition and history. The concept of virtualization will be thoroughly examined in this paper. Virtualized technology architecture has also been disputed and thoroughly explained. Basic topics such as virtual servers, forms of virtualizations, virtualization technology benefits, and cloud computing benefits are also explored. Different obstacles to cloud computing, such as infected apps, large data loss, and data integrity, have been examined carefully by the authors. Finally, the future of virtualization and cloud computing, as well as cloud computing issues, are examined.

A comprehensive and extensive description of Cloud Computing was provided by **Peter Mell and Timothy Grance [6],** which covered essential features of Cloud Computing. Cloud computing's main properties and service models have been discussed by the authors. They also discussed cloud deployment options such as private, public, communal, and hybrid clouds.

PD Patel, Miren Karamta, M.D. Bhavasar, and M.B. Potdar [7] have discussed cloud computing migration approaches. The process of live migration has been discussed by the authors. They've also provided a full survey on live virtual machine migration in cloud computing. Load Balancing Migration Techniques, Fault Tolerating Migration Techniques, and Energy Efficient Migration Techniques are only a few of the categories discussed by the authors. In addition, performance measurements are discussed. In addition, a full examination of live virtual machine migration in the cloud is provided. Finally, the authors discussed several obstacles and issues.

In his study, R.M. Sharma [8] presents a fresh perspective on the effects of virtualization in cloud computing. The author has covered the fundamental concepts of cloud computing, virtualization, and its interconnection. The effects of virtualization in cloud computing are discussed in this paper. It also includes an overview of virtualization architecture and layers of abstraction. The benefits of virtualization were

also mentioned by the author. Resource maximization, flexibility, availability, scalability, hardware usage, and increased security are just a few of the benefits. In addition, the author distinguishes between traditional and virtual servers. It also provides a quick overview of prominent cloud services. In short, this article provides thorough information on several elements of virtualization.

Virtualization and cloud computing have been discussed by **Yuping Xing and Yongzhao Zhan [9].** The basis of virtualization and cloud computing are discussed in this paper. Moving forward, they have talked about several cloud computing concerns and issues. The paper examines the problems and suggests a possible solution.

An approach for placing a virtual machine in a virtual cloud was presented by **R. Suchithra and N Rajkumar [10].** Consolidating servers is a technique for minimizing the number of physical servers. The authors explain how this technique aids in cost reduction and energy conservation. The consolidation strategy necessitates a smooth VM movement. Unfortunately, virtual machine migration is an expensive operation that makes it difficult to properly place virtual machines. The authors present an effective virtual machine placement algorithm based on the idea of a bin-packed algorithm. Multiple test scenarios were utilized to ensure that the approach was feasible. Their research demonstrates that their proposed algorithm reduces the number of necessary virtual machine migrations.

A survey on load balancing in cloud computing was conducted by **Shilpa V Pius and TS Shilpa [11].** The authors have chosen several new load balancing approaches and conducted a thorough analysis. The goal of this survey is to stimulate amateur research into a more effective load balancing algorithm. The writers described a cloud model and had a lengthy discussion on load balancing. Several load balancing difficulties are explored, including virtual machine migration, energy management, stored data management, and automated provision of services. Different types of load balancing algorithms will be described in this paper. Several surveys on load balancing were included in the literature, and the authors attempted to discern between them. They have given us a lot of information on these polls. To summarize, this paper covers the fundamentals of cloud computing as well as the issues of load balancing.

Xiong Fu and Chen Zhou [12] published a study on the selection of virtual machines and their deployment in the cloud computing environment for dynamic consolidation. Dynamic consolidation, according to the authors, is an effective approach to reduce energy consumption and increase physical resource use. The authors explored how various scenarios can lead to service level agreements being violated by service providers and users. To address this issue, the authors advise taking CPU consumption into account when picking virtual machines, as well as developing a variable that symbolizes resource satisfaction. A novel virtual machine placement policy was also provided by the authors. It implies that a virtual machine should be placed on a host with the lowest correlation coefficient. CloudSim was utilized in this research to execute simulations. The authors' proposed technique outperforms existing techniques, according to the results of these simulations. In terms of virtual machine migration time, service level agreement violation, and energy usage, the technique is superior. The study presented an excellent method for dynamic consolidation in the cloud computing environment, which is backed up by data gathered from CloudSim simulations.

3. Comparison of Cloud Service Providers

3.1. Service

AWS (Amazon Web Services) provides almost everything in terms of distributed computing. It has a stronghold in a variety of fields, including design and monitoring. It is well-favored in the industry because of its extensive and diverse contributions, venture-friendly administrations, global reach, and open and adaptable features. AWS, like Azure, offers a wide range of services and solutions for individuals and organizations in terms of foundation, processing capacity, storing, and organizing, among other things. The registration power of Microsoft Azure is one of its best features. The business enables users to transmit and manage virtual machines on a scale that can scale to any size requirement in minutes. It's a unique feature compared to Amazon and Google. Azure also allows for seamless integration with Microsoft tools, as well as open-source support and hybrid cloud capabilities. Google's particular expertise is significant, and their industry-leading devices in deep learning and computerized reasoning, regard, and information examination are important preferences. Google Cloud provides several cloud administrations for engineers, including open-source support, the ability to move data, discounts, and flexible contracts. It's designed specifically for cloud-based businesses and includes DevOps skills to help assist teams. GCP provides more emphasis and adaptability towards inquiry and scientific gadgets since Google is founded on an analytical foundation.

3.2. Pricing

Amazon's prices are extremely focused on all other cloud services. It delivers an hourly installment explanation for the highlights use, as well as a free arrangement limited capacity and registration ability, which may be useful for people and new businesses before they acquire. The estimation approach is based on three factors: interest, sport, and possession. On an hourly basis, you can pay for the administration's use on a month-to-month basis. It can also determine evaluation with their estimating adding machine. Microsoft's evaluation varies and is based on the kind of goods that the development team uses. It offers paid-in-advance or regularly scheduled installment options, with a cost based on each instance of usage. As should be evident, Microsoft is extremely adaptable, and valuation is done on-demand for specific tasks. Among the three specialty organizations, Google Cloud has the best value. GCP offers a pay-as-you-go compensation system that charges per minute or second of usage.

3.3. Advantages

The experience is an unavoidable advantage of Amazon. The company has been in the cloud advertising business for almost 14 years, and it employs the best and most experienced engineers and architects in the world. AWS is owing to a plethora number of numerous advancements in these devices and puts up a stiff fight against its rivals. Nonetheless, the expense of AWS' infrastructure can be perplexing. As a result of this experience, the company is the most undertaking generous cloud specialist co-op, allowing anyone to take a shot at AWS with ease. Microsoft Azure is a strong competitor to AWS. At this time, Microsoft Azure is the fastest cloud service available. It is appropriate for large-scale business development since it has a high calculating capacity and all of the other Microsoft

features are consolidated into one framework and procedure, giving it additional power. Microsoft Azure has an endeavor foundation (supporting Windows). It is attempting to achieve compatibility with them. GCP has some of the greatest cloud security available. It has more than 500 security engineers working on it, thereby offering a different level of cloud security than the rest of its competitors. GCP will be the ideal choice for high-security operations such as banking, finance, and defense applications.

4. Reasons for choosing Cloud Service Providers

4.1. Enhanced Features

When picking a service provider, one must be aware of the increased characteristics of each service provider, because, as previously stated, AWS has better features than Microsoft Azure and Google Cloud Platform, according to the best knowledge collected from a thorough literature review.

4.2. Familiarity with Brand

Microsoft Azure and Google Cloud Platform take advantage of this because they are more familiar than AWS.

4.3. Security

As we all know, security is a top priority these days, which is why all CSPs strive to improve their security regularly. However, GCP security outperforms AWS and Microsoft Azure.

4.4. Suitable for Organization

It goes without saying that while selecting a cloud service, one must consider the CSP that is the best and provides the best service for one's firm. Many businesses employ hybrid cloud services, but a comparison of AWS, Microsoft Azure, and Google Cloud Platform reveals that none of them are ideal for every sort of business. Each has its own set of needs, but AWS has more acceptable services than Microsoft Azure and GCP.

4.5. Service Features for Cloud Service Providers

4.5.1 Storage Features

Cloud computing is a physical place from which computing resources are accessed. It's a pool of resources that clients can access on demand. This section highlights significant service elements to consider while selecting a CSP. The storage properties are discussed in this study report.

Object storage: It takes a piece of data and turns it into an object. Information is stored in different storehouses rather than files in folders, and processing a storage group is rushed through connected information and an exclusive identifier.

File storage: It keeps records of information about a specific piece of data in a folder so that it can be linked to other data. It's also known as categorized storage, and it works in the same way that paper files are stored. While giving access to data, the workstation system wants to distinguish the pathway to discover it.

Block storage: It divides a folder into individual blocks of information and saves these blocks separately, for example, disconnected chunks of information/data. Each piece of information is given a unique address. As

a result, they do not want to be stored in a file arrangement.

Disaster recovery: It is a very helpful feature of the cloud because nowadays, almost all small and medium-sized organizations' data is on the cloud, and if data is corrupted or lost by mistake or malicious traffic, organizations can easily restore the data using disaster recovery, a facility that allows the backup and rescue of remote technologies on a cloud-centered stage. A cloud-based disaster recovery solution allows the customer to evaluate the entire cloud DRP service on a scale of more, less, or various.

Backup: Another imperative element of the cloud is that CSPs provide a capability for consumers to back up their data regularly, with options such as hourly, daily, and weekly backups.

Archiving: It is a cloud strategy in which companies utilize archiving techniques to create a separate storage device and archive data on a device when some data is not being used at the moment. The process of transferring data that is no longer being used to a different storage device for long-term storage is termed archiving. Archived data is stored on a low-cost storage level, allowing for a reduction in the most significant storage usage as well as associated costs.

4.5.2 Computation Features

Virtual server: It's also a key element of the cloud these days. Virtual servers (VS) are commonly used by businesses for a variety of reasons. Cloud services are essential in today's technological environment. Every firm requires cloud services in one form or another, such as SaaS, PaaS, or IaaS. Rather than using dedicated servers, the VS uses the new OS to distribute hardware and software resources. One of the advantages of VSs is that they are less expensive and provide faster resource control, and they are widely used in Web hosting. A VS should ideally simulate committed server functionality. Rather than running many committed servers, many VSs were run on a single server.

Platform as a Service: It is a useful feature of the cloud that allows anyone to construct any application without having to worry about infrastructure or platform. Arrange for cloud devices to run specific software, even if they are just used mostly for functions. PaaS provides designers with a framework that they can build upon and use to create customized apps. Servers, storage, and networking can all be managed by an organization or a third-party supplier, but the application's administration can be handled by the developers.

Scaling: It refers to an IT resource's ability to effectively manage growing or shrinking difficulties. It is one of the most admired and useful characteristics of cloud computing, as businesses understand how to measure higher or lay lower to meet needs based on season, goals, development, and other factors.

Virtual Private Servers: It is a widely used feature because of the low cost of VPS and the fact that CSPs provide customer support 24 hours a day, seven days a week. CSP services are used by organizations that are unable to operate private clouds due to expensive hardware, and it handles several virtual private servers on a single physical server. Hosting, often known as "Private Cloud," is sometimes reliant on servers created using a virtualization approach. Multiple dedicated slots on the same virtual machine with one architecture are available on a VPS. Each slot can have its own set of resources. The technology method, in general, is based on a time-shared or resource-shared trend.

4.5.3 Infrastructure Features

Following storage and computation, the following features will highlight significant management or infrastructure elements.

Server Management Services: It is a cloud computing infrastructure feature. Typically, cloud management mentions on-demand services that are suggested across the IaaS paradigm. IaaS is a simple cloud distribution pattern that allows access to configurable resources from shared pools. Computers, servers, networks, storage, applications, and services are all configurable resources. Data sharing and storage is a cloud capability.

Cloud deployment: It examines the utilization of infrastructure as a service (IaaS), platform as a service (PaaS), and cloud as a service (CaaS) (PaaS), and software as a service (SaaS), as well as responses that users may access on demand.

Logging: The logging functionality can show you all logs from which you can learn about the computation history.

Monitoring: Monitoring is also a crucial aspect; data and records are monitored, and information is collected from each node using this feature. It's a framework that lets you put monitoring capabilities for a variety of other facilities and apps in the cloud.

Server Automation: It aids the consumer in making excellent judgments when operating or managing a system or network. It's an integrated solution that uses public, virtual, and physical cloud systems to systematize or automate specifications, patching, and configuration of operating systems, application components, and storage resources. It also streamlines processes for efficiently completing the complexities of continually changing virtualized settings.

5. Methodology/Experimental Setup

The experimental setup and connectivity of Virtual Machines in a cloud-based platform are shown below. The different nodes in the CPU are aggregated as compute nodes.
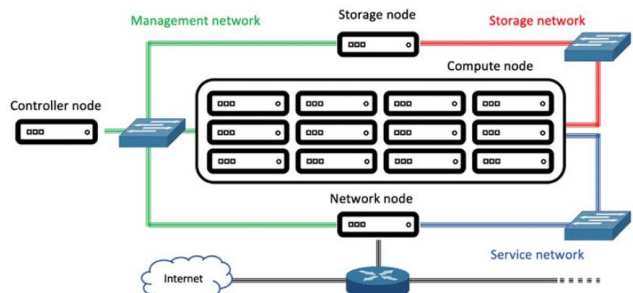
Fig. 1 – Experimental setup.

The experimental configuration uses the operational private cloud environment to assess the efficiency and output of virtual machines and containers. For our all experiments, we utilized the cloud virtual machine monitoring system, which is an abstraction layer source cloud management solution. The test is carried out by executing concurrent requests using bash files and increasing the number of requests by a factor of 10 and monitoring how the VM handles such a high number of parallel execution of requests which simulates concurrent traffic load.

Table 1 - The testing virtual machines

Cloud Provider	Machine Type	CPUs	Memory(in GB)
AWS	t4g.nano	2	0.5
AWS	t4g.micro	2	1
AWS	t4g.small	2	2

AWS	t4g.medium	2	4
AWS	t4g.large	2	8
AWS	t4g.xlarge	4	16
AWS	t4g.2xlarge	8	32
Azure	B1ls	1	0.5
Azure	B1s	1	1
Azure	B1ms	1	2
Azure	B2s	2	4
Azure	B2ms	2	8
Azure	B4ms	4	16
Azure	B8ms	8	32
GCP	e2-standard-2	2	8

GCP	e2-standard-4	4	16
GCP	e2-standard-8	8	32

The purpose of this process is to determine the CPU performance of a certain worker node in our cloud computing environment for workloads.

To obtain better performance, HEPiX[13] recommends using the preferred version of OS and kernel (CentOS 7 or Scientific Linux 7 and Kernel 3.1), the default operating system and kernel available for the virtual machine is utilized in this setup.

6. Results and Discussions

The below table comprises the details of all the configurations of the first test. In this result section, the performance difference of configurations can be seen clearly.

Table 2- Results of Virtual Machines in Google Cloud Platform

Machine Type	CPU	Memory (in Gib)	Number of Concurrent requests	Average Sleep time in seconds	CPU(max) %	Memory Used (in GB)	Average Duration	Status of request
e2-standard-2	2	8	1	5	0.61	1.05	<6 seconds	Successful
e2-standard-2	2	8	10	5	0.61	1.05	<6 seconds	Successful
e2-standard-2	2	8	100	5	2.92	1.05	<6 seconds	Successful
e2-standard-2	2	8	1000	5	15.27	1.05	<20 seconds	Successful
e2-standard-2	2	8	10000	5	86.66	1.50	<2 minutes	Successful
e2-standard-2	2	8	100000	5	99.64	1.87	<20 minutes	Successful
e2-standard-2	2	8	1000000	5	99.7	1.81	<4 hours	Successful
e2-standard-2	2	8	1	10	0.67	1.06	<6 seconds	Successful
e2-standard-2	2	8	10	10	0.67	1.06	<6 seconds	Successful
e2-standard-2	2	8	100	10	3.12	1.06	<6 seconds	Successful
e2-standard-2	2	8	1000	10	16.36	1.08	<25 seconds	Successful
e2-standard-2	2	8	10000	10	99.68	1.28	<3 minutes	Successful
e2-standard-2	2	8	100000	10	99.66	1.35	<21 minutes	Successful
e2-standard-2	2	8	1000000	10	99.56	2.09	<4 hours 10 min	Successful
e2-standard-2	2	8	1	15	0.66	0.48	<16 seconds	Successful
e2-standard-2	2	8	10	15	0.66	0.48	<16 seconds	Successful
e2-standard-2	2	8	100	15	3.27	0.48	<16 seconds	Successful
e2-standard-2	2	8	1000	15	16.39	0.48	<30 seconds	Successful
e2-standard-2	2	8	10000	15	87.45	1.26	<3 minutes	Successful
e2-standard-2	2	8	100000	15	99.49	1.44	<22 minutes	Successful
e2-standard-2	2	8	1000000	15	99.66	1.46	<4 hours 10 min	Successful
ec2-standard-4	4	16	1	5	0.17	1.08	<10 seconds	Successful
ec2-standard-4	4	16	10	5	0.17	1.08	<10 seconds	Successful
ec2-standard-4	4	16	100	5	2.5	1.08	<10 seconds	Successful
ec2-standard-4	4	16	1000	5	6.14	1.08	<15 seconds	Successful

Machine Type	CPU	Memory (in Gib)	Number of Concurrent requests	Average Sleep time in seconds	CPU (max) %	Memory Used (in GB)	Average Duration	Status of request
ec2-standard-4	4	16	10000	5	42.77	1.77	<1 minute	Successful
ec2-standard-4	4	16	100000	5	99.73	2.29	<9 minutes	Successful
ec2-standard-4	4	16	1000000	5	99.78	2.33	<1 hour 40 min	Successful
ec2-standard-4	4	16	1	10	0.76	1.09	<15 seconds	Successful
ec2-standard-4	4	16	10	10	0.76	1.09	<15 seconds	Successful
ec2-standard-4	4	16	100	10	0.86	1.09	<15 seconds	Successful
ec2-standard-4	4	16	1000	10	5.93	1.09	<20 seconds	Successful
ec2-standard-4	4	16	10000	10	57.6	1.1	<1 minute	Successful
ec2-standard-4	4	16	100000	10	99.94	2.56	<9 minutes	Successful
ec2-standard-4	4	16	1000000	10	99.81	2.57	<1 hour 40 min	Successful
ec2-standard-4	4	16	1	15	0.16	1.09	<20 seconds	Successful
ec2-standard-4	4	16	10	15	0.16	1.09	<20 seconds	Successful
ec2-standard-4	4	16	100	15	0.23	1.09	<20 seconds	Successful
ec2-standard-4	4	16	1000	15	5.52	1.09	<22 seconds	Successful
ec2-standard-4	4	16	10000	15	53.25	1.41	<1 minute 10 sec	Successful
ec2-standard-4	4	16	100000	15	99.8	2.54	<9 minutes	Successful
ec2-standard-4	4	16	1000000	15	99.8	2.56	<1 hour 40 min	Successful
ec2-standard-8	8	32	1	5	0.11	1.15	<7 seconds	Successful
ec2-standard-8	8	32	10	5	0.11	1.16	<7 seconds	Successful
ec2-standard-8	8	32	100	5	0.31	1.17	<7 seconds	Successful
ec2-standard-8	8	32	1000	5	2.32	1.17	<20 seconds	Successful
ec2-standard-8	8	32	10000	5	17.67	1.3	<2 minutes	Successful
ec2-standard-8	8	32	100000	5	96.64	2.87	<5 minutes	Successful
ec2-standard-8	8	32	1000000	5	98.78	2.89	<53 minutes	Successful
ec2-standard-8	8	32	1	10	0.11	1.19	<13 seconds	Successful
ec2-standard-8	8	32	10	10	0.11	1.19	<13 seconds	Successful
ec2-standard-8	8	32	100	10	0.32	1.19	<13 seconds	Successful
ec2-standard-8	8	32	1000	10	2.12	1.19	<15 seconds	Successful
ec2-standard-8	8	32	10000	10	20.65	1.19	<40 seconds	Successful
ec2-standard-8	8	32	100000	10	98.09	2.91	<5 minutes	Successful
ec2-standard-8	8	32	1000000	10	98.16	2.86	<53 minutes	Successful
ec2-standard-8	8	32	1	15	0.12	1.18	<20 seconds	Successful
ec2-standard-8	8	32	10	15	0.25	1.18	<20 seconds	Successful
ec2-standard-8	8	32	100	15	0.25	1.19	<20 seconds	Successful
ec2-standard-8	8	32	1000	15	3.92	1.21	<20 seconds	Successful
ec2-standard-8	8	32	10000	15	22.08	2.49	<40 seconds	Successful
ec2-standard-8	8	32	100000	15	97.78	2.88	<5 minutes	Successful
ec2-standard-8	8	32	1000000	15	98.88	2.9	<53 minutes	Successful

Table 3- Results of Virtual Machines in Amazon Web Services

Machine Type	CPU	Memory (in Gib)	Number of Concurrent requests	Average Sleep time in seconds	CPU (max) %	Memory Used	Average Duration	Status of request
t4g.nano	2	0.5	1	5	0.141	124MB	<10 seconds	Successful
t4g.nano	2	0.5	10	5	0.141	124MB	<10 seconds	Successful
t4g.nano	2	0.5	100	5	0.141	124MB	<10 seconds	Successful
t4g.nano	2	0.5	1000	5	0.141	97.7MB	<1 minute	Successful
t4g.nano	2	0.5	10000	5	89.2	389MB	<8 minutes	Successful
t4g.nano	2	0.5	100000	5	90.1	389MB	<14 minutes	Unsuccessful
t4g.micro	2	1	1	5	26.69	111MB	<6 seconds	Successful
t4g.micro	2	1	10	5	26.69	112MB	<6 seconds	Successful
t4g.micro	2	1	100	5	26.69	112MB	<6 seconds	Successful
t4g.micro	2	1	1000	5	26.69	112MB	<1 minute	Successful
t4g.micro	2	1	10000	5	96.98	908MB	<4 minutes	Successful
t4g.micro	2	1	100000	5	96.8	920MB	<31 minutes	Successful
t4g.micro	2	1	1	10	0.603	145MB	<11 seconds	Successful
t4g.micro	2	1	10	10	0.603	145MB	<11 seconds	Successful
t4g.micro	2	1	100	10	0.862	145MB	<11 seconds	Successful
t4g.micro	2	1	1000	10	45.3	145MB	<1 minute	Successful
t4g.micro	2	1	10000	10	97.1	918MB	<5 minutes	Successful
t4g.micro	2	1	100000	10	98.4	924MB	<52 minutes	Unsuccessful
t4g.small	2	2	1	5	1.475	114MB	<6 seconds	Successful
t4g.small	2	2	10	5	1.475	114MB	<6 seconds	Successful
t4g.small	2	2	100	5	1.475	114MB	<6 seconds	Successful
t4g.small	2	2	1000	5	12.2	114MB	<13 seconds	Successful
t4g.small	2	2	10000	5	87.8	696MB	<2 minutes	Successful
t4g.small	2	2	100000	5	99.6	1.30GB	<13 minutes	Successful
t4g.small	2	2	1000000	5	99.1	1.33GB	<2 hours 10 min	Successful
t4g.small	2	2	1	10	0.35	117MB	<11 seconds	Successful
t4g.small	2	2	10	10	0.44	117MB	<11 seconds	Successful
t4g.small	2	2	100	10	1.44	121MB	<11 seconds	Successful
t4g.small	2	2	1000	10	11.94	270MB	<20 seconds	Successful
t4g.small	2	2	10000	10	89.925	970MB	<2 minutes	Successful
t4g.small	2	2	100000	10	99.1	1.45GB	<12 minutes	Successful
t4g.small	2	2	1000000	10	99.13	1.45GB	<2 hours	Successful
t4g.small	2	2	1	15	0.466	108MB	<16 seconds	Successful
t4g.small	2	2	10	15	0.466	108MB	<16 seconds	Successful
t4g.small	2	2	100	15	1.525	108MB	<16 seconds	Successful
t4g.small	2	2	1000	15	13.175	108MB	<25 seconds	Successful
t4g.small	2	2	10000	15	82.625	781MB	<2 minutes	Successful
t4g.small	2	2	100000	15	99.15	1.57GB	<12 minutes	Successful
t4g.small	2	2	1000000	15	99.19	1.57GB	<2 hours	Successful
t4g.medium	2	4	1	5	0.28	113MB	<21 seconds	Successful
t4g.medium	2	4	10	5	0.28	113MB	<6 seconds	Successful
t4g.medium	2	4	100	5	0.28	113MB	<6 seconds	Successful

Machine Type	CPU	Memory (in Gib)	Number of Concurrent requests	Average Sleep time in seconds	CPU (max) %	Memory Used	Average Duration	Status of request
t4g.medium	2	4	1000	5	2.87	1MB	<13 seconds	Successful
t4g.medium	2	4	10000	5	18.3	1.29GB	<2 minutes	Successful
t4g.medium	2	4	100000	5	99.1	1.34GB	<13 minutes	Successful
t4g.medium	2	4	1000000	5	98.9	1.32GB	<2 hours	Successful
t4g.medium	2	4	1	10	0.44	111MB	<11 seconds	Successful
t4g.medium	2	4	10	10	0.44	111MB	<11 seconds	Successful
t4g.medium	2	4	100	10	1.46	111MB	<11 seconds	Successful
t4g.medium	2	4	1000	10	11.8	730MB	<18 seconds	Successful
t4g.medium	2	4	10000	10	83.1	1.33GB	<2 minutes	Successful
t4g.medium	2	4	100000	10	98.1	1.41GB	<13 minutes	Successful
t4g.medium	2	4	1000000	10	100	1.55GB	<2 hours	Successful
t4g.medium	2	4	1	15	0.36	118MB	<16 seconds	Successful
t4g.medium	2	4	10	15	0.36	118MB	<16 seconds	Successful
t4g.medium	2	4	100	15	1.63	118MB	<16 seconds	Successful
t4g.medium	2	4	1000	15	12.06	154MB	<25 seconds	Successful
t4g.medium	2	4	10000	15	87.6	1.58GB	<2 minutes	Successful
t4g.medium	2	4	100000	15	100	1.59GB	<12 minutes	Successful
t4g.medium	2	4	1000000	15	100	1.61GB	<2 hours	Successful
t4g.large	2	8	1	5	46		<6 seconds	Successful
t4g.large	2	8	10	5	0.965	112MB	<6 seconds	Successful
t4g.large	2	8	100	5	1.23	114MB	<6 seconds	Successful
t4g.large	2	8	1000	5	11.8	111MB	<16 seconds	Successful
t4g.large	2	8	10000	5	92	1.25GB	<2 minutes	Successful
t4g.large	2	8	100000	5	98.3	1.35GB	<13 minutes	Successful
t4g.large	2	8	1000000	5	100	1.42GB	<13 minutes	Successful
t4g.large	2	8	1	10	0.35	114MB	<11 seconds	Successful
t4g.large	2	8	10	10	1.51	135MB	<11 seconds	Successful
t4g.large	2	8	100	10	1.51	135MB	<11 seconds	Successful
t4g.large	2	8	1000	10	11.8	330MB	<20 seconds	Successful
t4g.large	2	8	10000	10	91.88	1.46GB	<2 minutes	Successful
t4g.large	2	8	100000	10	96.8	1.51GB	<12 minutes	Successful
t4g.large	2	8	1000000	10	99.5	1.61GB	<2 hours 2 minutes	Successful
t4g.large	2	8	1	15	0.1	120MB	<16 seconds	Successful
t4g.large	2	8	10	15	0.2	219MB	<16 seconds	Successful
t4g.large	2	8	100	15	0.2	221MB	<16 seconds	Successful
t4g.large	2	8	1000	15	11.1	696MB	<25 seconds	Successful
t4g.large	2	8	10000	15	97.2	1.45GB	<2 minutes	Successful
t4g.large	2	8	100000	15	97.8	1.57GB	<13 minutes	Successful
t4g.large	2	8	1000000	15	98.5	1.65GB	<2 hours 2 minutes	Successful

Machine Type	CPU	Memory (in Gib)	Number of Concurrent requests	Average Sleep time in seconds	CPU(max) %	Memory Used	Average Duration	Status of request
t4g.xlarge	4	16	1	5	3.3	170MB	<6 seconds	Successful
t4g.xlarge	4	16	10	5	3.3	170MB	<6 seconds	Successful
t4g.xlarge	4	16	100	5	5.64	178MB	<6 seconds	Successful
t4g.xlarge	4	16	1000	5	3.82	170MB	<10 seconds	Successful
t4g.xlarge	4	16	10000	5	34.91	1.69GB	<40 seconds	Successful
t4g.xlarge	4	16	100000	5	98.72	1.82GB	<6 minutes	Successful
t4g.xlarge	4	16	1000000	5	98.75	1.85GB	<56 minutes	Successful
t4g.xlarge	4	16	1	10	0.081	165MB	<11 seconds	Successful
t4g.xlarge	4	16	10	10	0.162	165MB	<11 seconds	Successful
t4g.xlarge	4	16	100	10	0.646	165MB	<11 seconds	Successful
t4g.xlarge	4	16	1000	10	5.66	166MB	<15 seconds	Successful
t4g.xlarge	4	16	10000	10	32.3	1.92GB	<45 seconds	Successful
t4g.xlarge	4	16	100000	10	99.2	1.88GB	<6 minutes	Successful
t4g.xlarge	4	16	1000000	10	99.2	1.89GB	<56 minutes	Successful
t4g.xlarge	4	16	1	15	0.522	166MB	<16 seconds	Successful
t4g.xlarge	4	16	10	15	0.12	184MB	<16 seconds	Successful
t4g.xlarge	4	16	100	15	0.558	166MB	<16 seconds	Successful
t4g.xlarge	4	16	1000	15	5.795	1.69GB	<20 seconds	Successful
t4g.xlarge	4	16	10000	15	42.45	1.87GB	<1 minute	Successful
t4g.xlarge	4	16	100000	15	98.5	1.88GB	<6 minutes	Successful
t4g.xlarge	4	16	1000000	15	98.92	1.90GB	<56 minutes	Successful
t4g.2xlarge	8	32	1	5	0.06	180MB	<10 seconds	Successful
t4g.2xlarge	8	32	10	5	0.08	181MB	<10 seconds	Successful
t4g.2xlarge	8	32	100	5	0.328	184MB	<10 seconds	Successful
t4g.2xlarge	8	32	1000	5	2.91	2.60GB	<10 seconds	Successful
t4g.2xlarge	8	32	10000	5	18	10.7GB	<1 minute	Successful
t4g.2xlarge	8	32	100000	5	87.76	14.7GB	<4 minutes	Successful
t4g.2xlarge	8	32	1000000	5	92.2	18.4GB	<40 minutes	Successful
t4g.2xlarge	8	32	1	10	0.06	207MB	<11 seconds	Successful
t4g.2xlarge	8	32	10	10	0.09	207MB	<11 seconds	Successful
t4g.2xlarge	8	32	100	10	0.29	207MB	<11 seconds	Successful
t4g.2xlarge	8	32	1000	10	2.96	210MB	<15 seconds	Successful
t4g.2xlarge	8	32	10000	10	23.64	5.27GB	<37 seconds	Successful
t4g.2xlarge	8	32	100000	10	88.46	10.5GB	<4 minutes	Successful
t4g.2xlarge	8	32	1000000	10	91.64	14.3GB	<40 minutes	Successful
t4g.2xlarge	8	32	1	15	0.058	174MB	<16 seconds	Successful
t4g.2xlarge	8	32	10	15	0.066	177MB	<16 seconds	Successful
t4g.2xlarge	8	32	100	15	0.091	179MB	<16 seconds	Successful
t4g.2xlarge	8	32	1000	15	2.97	1.92GB	<20 seconds	Successful
t4g.2xlarge	8	32	10000	15	27.295	5.85GB	<42 seconds	Successful
t4g.2xlarge	8	32	100000	15	81.02	12.0GB	<4 minutes	Successful
t4g.2xlarge	8	32	1000000	15	90.12	12.9GB	<40 minutes	Successful

Table 4- Results of Virtual Machines in Microsoft Azure

Machine Type	CPU	Memory (in Gib)	Number of Concurrent requests	Average Sleep time in seconds	CPU (max) %	Memory Used	Average Duration	Status of request
B1ls	1	0.5	1	5	0.141	124MB	<10 seconds	Successful
B1ls	1	0.5	10	5	0.141	124MB	<10 seconds	Successful
B1ls	1	0.5	100	5	0.141	124MB	<10 seconds	Successful
B1ls	1	0.5	1000	5	0.141	97.7MB	<1 minute	Successful
B1ls	1	0.5	10000	5	89.2	389MB	<8 minutes	Successful
B1ls	1	0.5	100000	5	90.1	389MB	<14 minutes	Unsuccessful
B1s	1	1	1	5	26.69	111MB	<6 seconds	Successful
B1s	1	1	10	5	26.69	112MB	<6 seconds	Successful
B1s	1	1	100	5	26.69	112MB	<6 seconds	Successful
B1s	1	1	1000	5	26.69	112MB	<1 minute	Successful
B1s	1	1	10000	5	96.98	908MB	<4 minutes	Successful
B1s	1	1	100000	5	96.8	920MB	<31 minutes	Successful
B1s	1	1	1	10	0.603	145MB	<11 seconds	Successful
B1s	1	1	10	10	0.603	145MB	<11 seconds	Successful
B1s	1	1	100	10	0.862	145MB	<11 seconds	Successful
B1s	1	1	1000	10	45.3	145MB	<1 minute	Successful
B1s	1	1	10000	10	97.1	918MB	<5 minutes	Successful
B1s	1	1	100000	10	98.4	924MB	<52 minutes	Unsuccessful
B1ms	1	2	1	5	1.475	114MB	<6 seconds	Successful
B1ms	1	2	10	5	1.475	114MB	<6 seconds	Successful
B1ms	1	2	100	5	1.475	114MB	<6 seconds	Successful
B1ms	1	2	1000	5	12.2	114MB	<13 seconds	Successful
B1ms	1	2	10000	5	87.8	696MB	<2 minutes	Successful
B1ms	1	2	100000	5	99.6	1.30GB	<13 minutes	Successful
B1ms	1	2	1000000	5	99.1	1.33GB	<2 hours 10 min	Successful
B1ms	1	2	1	10	0.35	117MB	<11 seconds	Successful
B1ms	1	2	10	10	0.44	117MB	<11 seconds	Successful
B1ms	1	2	100	10	1.44	121MB	<11 seconds	Successful
B1ms	1	2	1000	10	11.94	270MB	<20 seconds	Successful
B1ms	1	2	10000	10	89.925	970MB	<2 minutes	Successful
B1ms	1	2	100000	10	99.1	1.45GB	<12 minutes	Successful
B1ms	1	2	1000000	10	99.13	1.45GB	<2 hours	Successful
B1ms	1	2	1	15	0.466	108MB	<16 seconds	Successful
B1ms	1	2	10	15	0.466	108MB	<16 seconds	Successful
B1ms	1	2	100	15	1.525	108MB	<16 seconds	Successful
B1ms	1	2	1000	15	13.175	108MB	<25 seconds	Successful
B1ms	1	2	10000	15	82.625	781MB	<2 minutes	Successful
B1ms	1	2	100000	15	99.15	1.57GB	<12 minutes	Successful
B1ms	1	2	1000000	15	99.19	1.57GB	<2 hours	Successful
B2s	2	4	1	5	0.28	113MB	<21 seconds	Successful

Machine Type	CPU	Memory (in Gib)	Number of Concurrent requests	Average Sleep time in seconds	CPU(max) %	Memory Used	Average Duration	Status of request
B2s	2	4	10	5	0.28	113MB	<6 seconds	Successful
B2s	2	4	100	5	0.28	113MB	<6 seconds	Successful
B2s	2	4	1000	5	2.87	113MB	<13 seconds	Successful
B2s	2	4	10000	5	18.3	1.29GB	<2 minutes	Successful
B2s	2	4	100000	5	99.1	1.34GB	<13 minutes	Successful
B2s	2	4	1000000	5	98.9	1.32GB	<2 hours	Successful
B2s	2	4	1	10	0.44	111MB	<11 seconds	Successful
B2s	2	4	10	10	0.44	111MB	<11 seconds	Successful
B2s	2	4	100	10	1.46	111MB	<11 seconds	Successful
B2s	2	4	1000	10	11.8	730MB	<18 seconds	Successful
B2s	2	4	10000	10	83.1	1.33GB	<2 minutes	Successful
B2s	2	4	100000	10	98.1	1.41GB	<13 minutes	Successful
B2s	2	4	1000000	10	100	1.55GB	<2 hours	Successful
B2s	2	4	1	15	0.36	118MB	<16 seconds	Successful
B2s	2	4	10	15	0.36	118MB	<16 seconds	Successful
B2s	2	4	100	15	1.63	118MB	<16 seconds	Successful
B2s	2	4	1000	15	12.06	154MB	<25 seconds	Successful
B2s	2	4	10000	15	87.6	1.58GB	<2 minutes	Successful
B2s	2	4	100000	15	100	1.59GB	<12 minutes	Successful
B2s	2	4	1000000	15	100	1.61GB	<2 hours	Successful
B2ms	2	8	1	5	46		<6 seconds	Successful
B2ms	2	8	10	5	0.965	112MB	<6 seconds	Successful
B2ms	2	8	100	5	1.23	114MB	<6 seconds	Successful
B2ms	2	8	1000	5	11.8	111MB	<16 seconds	Successful
B2ms	2	8	10000	5	92	1.25GB	<2 minutes	Successful
B2ms	2	8	100000	5	98.3	1.35GB	<13 minutes	Successful
B2ms	2	8	1000000	5	100	1.42GB	<13 minutes	Successful
B2ms	2	8	1	10	0.35	114MB	<11 seconds	Successful
B2ms	2	8	10	10	1.51	135MB	<11 seconds	Successful
B2ms	2	8	100	10	1.51	135MB	<11 seconds	Successful
B2ms	2	8	1000	10	11.8	330MB	<20 seconds	Successful
B2ms	2	8	10000	10	91.88	1.46GB	<2 minutes	Successful
B2ms	2	8	100000	10	96.8	1.51GB	<12 minutes	Successful
B2ms	2	8	1000000	10	99.5	1.61GB	<2 hours 2 min	Successful
B2ms	2	8	1	15	0.1	120MB	<16 seconds	Successful
B2ms	2	8	10	15	0.2	219MB	<16 seconds	Successful
B2ms	2	8	100	15	0.2	221MB	<16 seconds	Successful
B2ms	2	8	1000	15	11.1	696MB	<25 seconds	Successful
B2ms	2	8	10000	15	97.2	1.45GB	<2 minutes	Successful
B2ms	2	8	100000	15	97.8	1.57GB	<13 minutes	Successful
B2ms	2	8	1000000	15	98.5	1.65GB	<2 hours 2 min	Successful

Machine Type	CPU	Memory (in Gib)	Number of Concurrent requests	Average Sleep time in seconds	CPU(max) %	Memory Used	Average Duration	Status of request
B4ms	4	16	1	5	3.3	170MB	<6 seconds	Successful
B4ms	4	16	10	5	3.3	170MB	<6 seconds	Successful
B4ms	4	16	100	5	5.64	178MB	<6 seconds	Successful
B4ms	4	16	1000	5	3.82	170MB	<10 seconds	Successful
B4ms	4	16	10000	5	34.91	1.69GB	<40 seconds	Successful
B4ms	4	16	100000	5	98.72	1.82GB	<6 minutes	Successful
B4ms	4	16	1000000	5	98.75	1.85GB	<56 minutes	Successful
B4ms	4	16	1	10	0.081	165MB	<11 seconds	Successful
B4ms	4	16	10	10	0.162	165MB	<11 seconds	Successful
B4ms	4	16	100	10	0.646	165MB	<11 seconds	Successful
B4ms	4	16	1000	10	5.66	166MB	<15 seconds	Successful
B4ms	4	16	10000	10	32.3	1.92GB	<45 seconds	Successful
B4ms	4	16	100000	10	99.2	1.88GB	<6 minutes	Successful
B4ms	4	16	1000000	10	99.2	1.89GB	<56 minutes	Successful
B4ms	4	16	1	15	0.522	166MB	<16 seconds	Successful
B4ms	4	16	10	15	0.12	184MB	<16 seconds	Successful
B4ms	4	16	100	15	0.558	166MB	<16 seconds	Successful
B4ms	4	16	1000	15	5.795	1.69GB	<20 seconds	Successful
B4ms	4	16	10000	15	42.45	1.87GB	<1 minute	Successful
B4ms	4	16	100000	15	98.5	1.88GB	<6 minutes	Successful
B4ms	4	16	1000000	15	98.92	1.90GB	<56 minutes	Successful
B8ms	8	32	1	5	0.06	180MB	<10 seconds	Successful
B8ms	8	32	10	5	0.08	181MB	<10 seconds	Successful
B8ms	8	32	100	5	0.328	184MB	<10 seconds	Successful
B8ms	8	32	1000	5	2.91	2.60MB	<10 seconds	Successful
B8ms	8	32	10000	5	18	10.7GB	<1 minute	Successful
B8ms	8	32	100000	5	87.76	14.7GB	<4 minutes	Successful
B8ms	8	32	1000000	5	92.2	18.4GB	<40 minutes	Successful
B8ms	8	32	1	10	0.06	207MB	<11 seconds	Successful
B8ms	8	32	10	10	0.09	207MB	<11 seconds	Successful
B8ms	8	32	100	10	0.29	207MB	<11 seconds	Successful
B8ms	8	32	1000	10	2.96	210MB	<15 seconds	Successful
B8ms	8	32	10000	10	23.64	5.27GB	<37 seconds	Successful
B8ms	8	32	100000	10	88.46	10.5GB	<4 minutes	Successful
B8ms	8	32	1000000	10	91.64	14.3GB	<40 minutes	Successful
B8ms	8	32	1	15	0.058	174MB	<16 seconds	Successful
B8ms	8	32	10	15	0.066	177MB	<16 seconds	Successful
B8ms	8	32	100	15	0.091	179MB	<16 seconds	Successful
B8ms	8	32	1000	15	2.97	1.92GB	<20 seconds	Successful
B8ms	8	32	10000	15	27.295	5.85GB	<42 seconds	Successful
B8ms	8	32	100000	15	81.02	12.0GB	<4 minutes	Successful
B8ms	8	32	1000000	15	90.12	12.9GB	<40 minutes	Successful

Figure 2 below shows the result. The primary goal of this test was to enhance the overall throughput of the physical system. Since the hyperthreading doubles the number of cores, we often allowed HT on a physical system with 16 cores; it doubles the cores up to 32. The efficiency of HEPSPEC06 [13] on the physical host (bare metal) is improved by up to 16 percent, as shown in the figure. As shown in the results, the CPU performance loss of VM is 18% and containers are up to 14% of configuration 1 compared to the physical machine. The size of the virtual machine or container can be adjusted based on the scientific workload to ensure that throughput and performance are balanced.
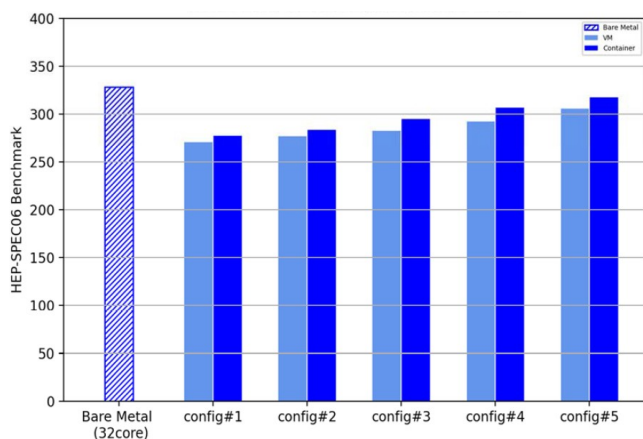
Fig. 2 - HEPSPEC06 Graph

It clearly shows that the containers can give a much better and near-real-time performance in a cloud environment.

Every consumer has his/her priorities, and every CSP has its services. With different features, it is very difficult for the consumer to know the features that Azure is offering from a storage perspective similar problems are present regarding finding the features provided by AWS from the computation perspective and also for Google's available features from an infrastructure perspective. Based on the review of many research papers are collected and divided into groups of all features concerning computation, storage, and infrastructure. It has been a big challenge to discuss every feature of the table individually and suggest the CSP, which offers good service features. That is why, based on many papers reviewed, some findings have been given as per the best of knowledge and understanding.

6.1. Amazon Web Services

If talking about AWS then it has more good features as compared to Azure and Google, AWS is more dominant in IaaS service than Azure and Google but as compared to Google and Azure, AWS is somewhat more expensive, and the security of AWS is also not much better.

6.2. Microsoft Azure

It also has good features, especially in all services. Microsoft Azure is a bit cheaper as compared to AWS. Microsoft is dominant in SaaS, and also in PaaS, service features are good as compared to AWS. Microsoft is a familiar name for people, and AWS is not much familiar as compared to Microsoft and Google.

6.3. Google Cloud Platform

It is a good competitor of AWS and Microsoft Azure because of its good security and low price. Google is dominant in PaaS as compared to AWS and Microsoft Azure. Also, in SaaS, Google is going up. As discussed earlier, AWS, Microsoft Azure, and GCP all are giving good services in all domains. In the cloud, all services use the same domain mostly, for example, SaaS, PaaS, and IaaS. All three services use storage, computation, and infrastructure, so that is the reason for making tables of features from the domain's perspective and not from the service perspective.

7. Conclusions

In this paper, the issues which are related to the efficiency and throughput of virtual machines and containers and also compared different virtual machine tiers in three of the most popular cloud providers, Amazon, Google & Microsoft. Also features offered by CSP companies are discussed as well as AWS, GCP, and Microsoft Azure are compared.

The configuration scenarios are used to analyze the performance overhead difficulties for scientific workloads in a cloud computing environment. The propose an approach that combines the four techniques and improves the overall throughput and performance of virtual machines and containers. A balanced view on virtualization and containerization efficiency and throughput is given. The analysis and experience can enable VMs or containers to create a cloud‑based environment that can deliver scientific workloads. One of the most promising pinning benchmarks, HEPSPEC06, is not used for performance evaluation, enhancements, and accomplishments in cloud computing environments, instead, we rely on time consumed and CPU performance.

Our experimental results show that the overall performance and efficiency of VMs and containers can be enhanced only when we choose the minimum cores for a VM or container, and the overall throughput of CPU cores is also able to be maximized when we make hyperthreading enabled. Pinning and isolating the CPU cores of physical hosts can improve performance in the cloud, especially for containerization. This research finds that there is a need for tuning in the virtualization layers that directly affect the performance to achieve the best performance and increase the throughput of a virtual machine.

8. Limitations & Future Scope

Although benchmarking is useful in a data-intensive cloud computing context, it is important to recognize that it has limitations. The experimental results presented in this study evaluate the differences between bare metal and virtual machines in a cloud-based scientific computing environment based on time consumed and CPU utilization, rather than any approved benchmarking such as HEPSPEC06. Because HEPSPEC06 is primarily focused on science-oriented computing, benchmarking applications may be limited when compared to other benchmarks that do not take a data-intensive environment like high energy physics into account. Therefore,

meaningful future research would be to find and evaluate specific working applications that show performance gaps.

Also, we have just considered one factor (hyperthreading) but much research shows that containerization with Docker and Kubernetes/OpenStack along with CPU isolation and CPU pinning can help in improving HEPSPEC06 score to near real-time scores. Also, our research focuses on general-purpose VM's and not dedicated VMs for storage/ computation.

REFERENCES

[1] Calcavecchia M.N.; Brian O.; Hadad E.; Moatti Y. (2012) VM Placement Strategies for Cloud Scenarios. *2012 IEEE Fifth International Conference on Cloud Computing*

[2] Chen M.;, Lioy Y. (2012). *Analyzing the Impact of Virtualization on IT Infrastructure Using the ITIL Framework* (Volume 4), Advances in Information Sciences and Service Sciences (AISS)

[3] Jadeja Y.; Modi K,(2012). Cloud computing-concepts, architecture and challenges; *2012 International Conference on Computing, Electronics and Electrical Technologies (ICCEET)*; pp. 887-880

[4] Li K.; Zheng H.; Wu J.; Du X (2014); Virtual machine placement in cloud systems through the migration process. *International Journal of Parallel, Emergent, and Distributed System;* pp. 393-410

[5] Malhotra L.; Agarwal D.; Jaiswal A. (2014); Virtualization in Cloud Computing; *Journal of Information Technology & Software Engineering.*

[6] Mell P.; Grance T. (2011). The NIST Definition of Cloud Computing; *National Institute of Standards & Technology;* Gaithersburg

[7] Patel D.P..; Karamta M.; Bhavsar D.M; Potdar M.B. (2014); Live Virtual Machine Migration Techniques in Cloud Computing: A Survey; *International Journal of Computer Applications.*

[8] Sharma M.R. (2014); The Impact of Virtualization in Cloud Computing; *International Journal of Recent Development in Engineering and Technology;* pp. 197-202

[9] Xing Y.; Zhan Y. (2012); Virtualization and Cloud Computing (Volume 1) *Future Wireless Networks and Information Systems*; pp. 305-312

[10] Suchithra R.; Rajkumar N. (2012); Efficient Migration- A Leading Solution for Server Consolidation; *International Journal of Computer Applications*

[11] Pius V.S.; Shilpa S.T. (2014); Survey on Load Balancing in Cloud Computing; *International Conference on Computing, Communication and Energy Systems*

[12] Fu X.; Zhou Z. (2015); Virtual machine selection and placement for dynamic consolidation in Cloud computing environment. *Frontiers of Computer Science(electronic)*

[13] HEPSPEC06 Benchmark. Available online: https://w3.hepix.org /benchmarking (accessed on 15 October 2015).