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Low-Code and No-Code Development

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***Abstract*—Going digital is now a requirement for a business to survive and remain competitive. The digital transformation enables businesses to respond to continually changing markets in a timely and adequate manner. This change isn't without its difficulties. One of these is the ever-increasing need for qualified software engineers. Low-code Platforms have emerged to alleviate this stress by providing persons with expertise in fields other than programming to create digital systems capable of resolving business-related issues. This article offers an opinionated vision as well as a two-stage strategy with rules for ushering in a new era of software creation in which anyone can create software without writing code.**

Keywords—Low-Code Platform, Design to Code, Out Systems, Front-end Development

I. INTRODUCTION

Cloud computing has become the most popular IT initiative in recent years. Virtualization is becoming more prevalent and is growing into new fields of information and communication technology. Virtualization has various benefits, including lower hardware prices, accessories, energy consumption, security, and failure tolerance. It also preserves the environment and streamlines administration, leading to increased system availability and management. The main goal is to abstract real computer resources and create a virtual environment in which they may function and new system components can be added. Virtualization allows many operating systems to operate on the same computer at the same time, which simplifies administration in cases when everything is confined to the management of a single physical machine.

It is critical to have quick access to hardware resources including RAM, CPU power, storage (HDD), network interface cards (NICs), and other components, which is performed by specialized software known as hypervisors. VMWare's vPlayer, vSphere, and vCenter are the most well-known hypervisors on the market, followed by Citrix's XenDesktop and XenServer, Microsoft's Hyper-V, Oracle's VM-Server and VirtualBox, and MAC's Paralleles. Type-2 hypervisors include VirtualBox and VMWare Workstation. Following the installation of the operating system, a hypervisor or virtual machine management (VMM) is installed, allowing users to run several guest operating systems inside their own environment. Both VirtualBox and VMWare Workstation make use of complete virtualization.

We may say that complete virtualization is a nearly flawless replica of genuine hardware. It allows the guest operating system to virtualize the hardware, removing the need for it to be changed in order to perform in the provided environment. A native operating system is intended to be used in its original environment, not for VM customization. The benefit is that it improves system security, scalability, and flexibility. Many operating systems may live on a single physical server thanks to this technology.

II. LITERARY REVIEW

This research focuses on the virtualization and performance of the utilized hypervisor, one of the key challenges in VMM architecture.

The objective of the technique is to examine and contrast the outcomes of the various groups. VirtualBox and VMWare are examples of commonly used hypervisors. Examples of virtualization software include Workstation, VMWare Fusion, Solaris Zones, and Parallels. Bonnie ++, Iozone, and LMbench are examples of software used for benchmarking. LINPACK, HD Tune Pro, and ATTO are employed for testing.

Numerous publications and discussions exist around the definition of the comparative method as a tool for assessing the performance of a number of VMs with a variety of configurations for usage in a variety of application types. Frequently, these research justify and complement one another.

In general, the findings of these research support and stimulate the creation of bigger data centers and, in some cases, cloud environments. Different host operating systems' effects on the performance of a virtual machine have also been explored. Barham and others introduced the Xen idea and likened it to VMWare's User-Mode Linux. Clark strengthened the Xen performance evaluation procedure by comparing XenoLinux against the x86-based IBM zServer.

Using IOZONE, Netperf, and SysBench, Xianghua Xu analyzed the performance of Xen, KVM, and VMWare, concentrating on overall performance and VM scalability. The

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bulk of surveys and comparisons utilize virtual machines (VMs) such as Xen and KVM.

This essay analyzes previously neglected features of Virtual Box and VMWare performance. Since the most current research focuses on efficiency and proper operation in a virtual environment, it is essential to choose an appropriate virtual infrastructure management system.

III. HYPERVISORS

A. *Introduction*

A hypervisor, commonly referred to as a virtual machine monitor or VMM, is software that generates and operates virtual machines (VMs). A hypervisor allows a single host computer to handle numerous guest VMs by sharing its resources, such as memory and processor, virtually.

B. *Functions*

Hypervisors enable the use of more of a system's available resources and boost IT mobility since guest VMs are independent of the host hardware. This means they can be easily moved across servers. Because a hypervisor allows numerous virtual computers to operate on a single physical server, it reduces:

- Space
- Energy
- Maintenance requirements

C. *Benefits*

Utilizing a hypervisor that hosts several virtual machines has various advantages:

- Speed

In contrast to bare-metal servers, hypervisors enable rapid construction of virtual computers. This greatly simplifies the provisioning of resources for dynamic workloads.

- Efficiency

Hypervisors, which run several virtual computers on the resources of a single physical system, allow for more efficient use of a single physical server. Executing several virtual machines on a single physical computer saves money and energy over running the same work on multiple underutilized real systems.

- Flexibility

Because the hypervisor separates the operating system from the underlying hardware, the programme is no longer reliant on specific hardware devices or drivers. Operating systems and their related applications may run on a range of hardware types thanks to bare-metal hypervisors.

- Portability

Many operating systems may operate on the same physical server thanks to hypervisors (host machine). Because virtual machines are separate from physical machines, they may be transported. IT teams may move workloads from machine to machine or platform to platform and distribute networking, memory, storage, and processor resources across several servers as needed. When an application requires more processing power, virtualization software provides continuous access to other computers.

D. *Type-1*

A bare-metal hypervisor or type 1 is a software layer that sits directly on top of a real server and its hardware.

The name bare-metal hypervisor is derived from the absence of any software or operating system. A Type 1 hypervisor has shown to deliver exceptional performance and reliability because it does not run within Windows or any other operating system.

Type 1 hypervisors are their own operating system, albeit a very basic one, on which virtual machines can run. The hypervisor operates on a physical system used only for virtualization. It is unusable for any other use.

Type 1 hypervisors are primarily employed in business environments.

E. *Type-2*

This hypervisor operates on the operating system of the actual host computer.

Because of this, Type 2 hypervisors are known as hosted hypervisors. Unlike type 1 hypervisors, which run directly on the hardware, hosted hypervisors have one software layer behind them. Type 1 hypervisors are predominantly utilized in business environments.

1) *VMWare*

VMware Workstation Pro is a hypervisor of type 2 that is compatible with Windows and Linux. It is packed with powerful features and integrates well with vSphere. This enables the portability of applications across desktop and cloud platforms.

There is no free edition, thus it comes with a price tag. Try VMware Workstation Player if you wish to examine VMware-hosted hypervisors for free. This is the most basic version of the hypervisor that is ideal for sandbox situations.

VMware has developed Fusion, a software similar to Workstation for MacOS users. There are less features, but the price is also lower.

2) *Virtualbox*

A free, dependable software with sufficient capabilities for personal use and the majority of small business use cases. VirtualBox is resource efficient and has proven to be an effective desktop and server virtualization solution. It supports up to 32 vCPUs per virtual machine, PXE Network boot, snapshot trees, and much more.

IV. METHODOLOGY

We will compare and analyze the performance of type 2 hypervisors VirtualBox and VMWare using the following tools and procedures:

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Test/Tool Name	Description
Geekbench	CPU bench Mark
Bonnie++	Disk Benchmark
Hardinfo	Full CPU Benchmark
Sysbench	CPU, File, Memory
iPerf	Network Performance
Build-Linux-Kernel	Time to build kernel
Build-Apache	Benchmarking Apache Webserver
Bytemark	Expose the capabilities of the system CPU, FPU, Memory
Compress-7zip	Benchmarking compression
Gnupg	Encryption time test
Hbase	Benchmarking Apache Hbase for read-update
John-the-Ripper	Benchmarks for all Hashing Algorithms
Ramspeed	Memory throughput benchmarking
Startup-Time	Start-up time of applications with background I/O
Blogbench	Fileserver Stress Benchmark

Figure 1 : Tools / Tests for Benchmarking

A. *Filebench Tool*

For performance analysis of both hypervisors we first propose a hypothesis to calculate the total processing time. Filebench is a tool that generates an environment for a large number of loads and is very flexible.

The total processing time or the workload depends on the random and sequential read time and write time components. The access of the file system depends on the benchmark, the guest OS, virtual hardware processing, hypervisor processing, and host OS-FS. The following table sums up the comparison:

Table 1 : Comparison of Components

Component	VMWare	Oracle VirtualBox
BenchMark	Same	Same
Virtual Hardware Processing	relies on Itself for full emulation	relies on Itself for full emulation(here we expect performance difference)
Hypervisor Processing (Time required to receive request)	generates workstation delay	generates virtualbox delay
Host OS	MS NTFS	MS-NTFS

The performances were analyzed for various numbers of VMs Installed(1,2 and then 3) using the Filebench tool. The workload tests conducted had the following results;

i) Web Server Benchmark Results:
In these results, the differences were in the virtual hardware processing and the hypervisor processing, These had a great effect on the better results of VirtualBox.Here the random read performance was a major dominating factor. The cache had a low effect

ii) File Server Benchmark Results
File Server majorly depends on all kinds of transfers and thus, the results are almost identical. We see that VMware has a better result. The similarity in results is due to the fact that both the hypervisors are NTFS based.

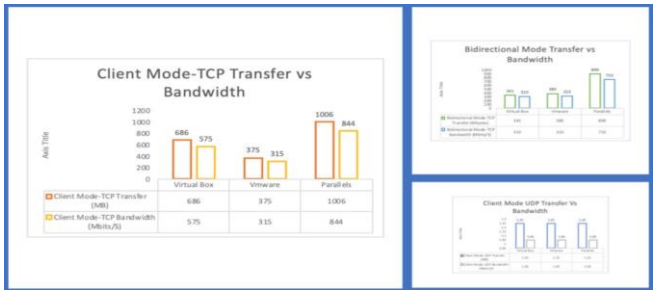
iii) Random File Access Benchmark Results
As file server results, random access is based on random read time and random write time. The differences in the expected file access time is reduced due to caching of host OS. We don't see a major difference in the performance here, VirtualBox is better here.

iv) Varmail Benchmark Results
The performance of varmail is based on a random write time component. For this case, VMware fares well. The major difference is produced due to Hypervisor and virtual processing time.

After all the tests are concluded we understand how performances are similar in most cases with Virtual Box performing better. Both the virtualization tools have their advantages depending on the use case scenario.

B. *GeekBench*

Primate Labs' Geekbench is a cross-platform benchmarking tool that measures the CPU performance of comparisons in single-core and multi-core modes. Geek bench executes a variety of tasks, including numerical, graphical, and AI/ML procedures. VMware outperforms VirtualBox in terms of single-core performance, as shown by the findings. VirtualBox lags well behind VMWare in multicore performance, performing about four times less than it. Comparing the performance of individual parameters, we find that VMWare slightly outperforms Virtual Box.



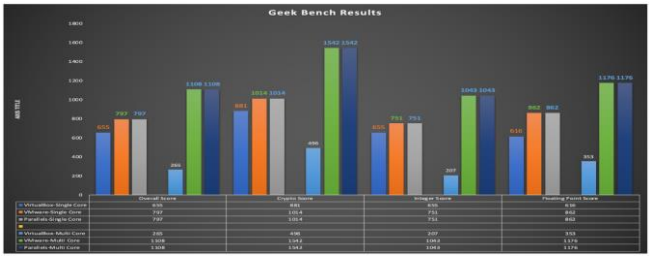


Figure 2 : Geekbench Crypto, Integer, Floating Point results

C. *Bonnie++*

Bonnie++ is a benchmarking tool for file and disc performance that measures the performance of hypervisors in terms of disc writes and latency. According to the graph below, VirtualBox has the highest write Mb/s for block-data sequential input, output, and latency. VMWare has lower latency and superior CPU performance. Consequently, Virtual Box is the hypervisor with the lowest performance in this test.

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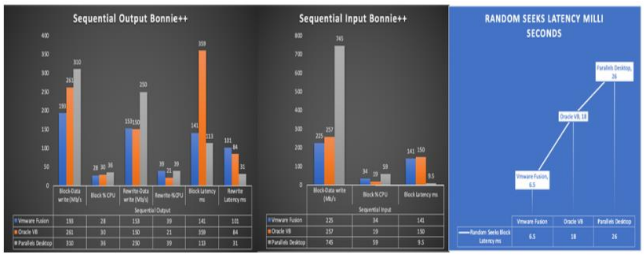

Figure 3 : Bonnie++ File and Disk performance

D. Hardinfo

Hardinfo is a system profiler for LINUX systems that identifies the system's software and hardware. It also tests the CPU against a variety of metrics, including CPU Blowfish, GPU Drawing, and Cryptohash, and produces a summary of the measured results. Based on the graph result, we can see that Virtual Box performs less efficiently than VMWare.

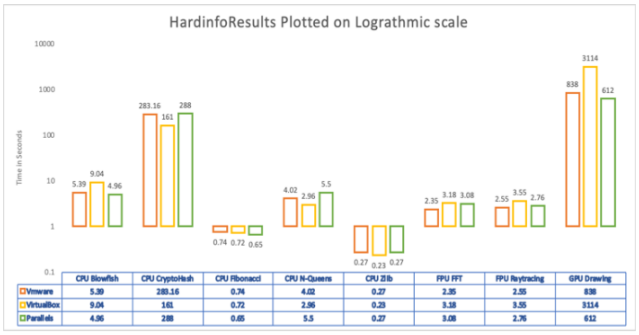

Figure 4 : Hardinfo Benchmark Test results

E. Sysbench

Sysbench is an open-source utility for benchmarking memory, CPU, and File I/O performance. The graph below depicts a performance comparison between the hypervisors in terms of memory, File I/O, and CPU. While the majority of the parameters display equivalent performance between the two, VMWare outperforms VirtualBox in terms of File rites/sec, Throughput MB/s, and file write latency.

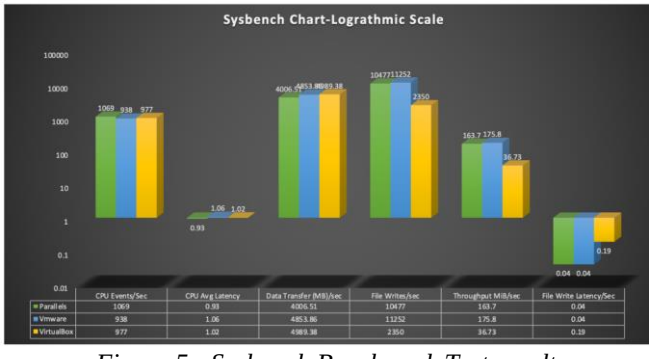

Figure 5 : Sysbench Benchmark Test results

F. Ramspeed Benchmark

Ramspeed is used to benchmark memory throughput and executes four tests: Copy, Scale, Add, and Trace. According to the graph presenting test results below, VirtualBox performs less efficiently than VMWare.

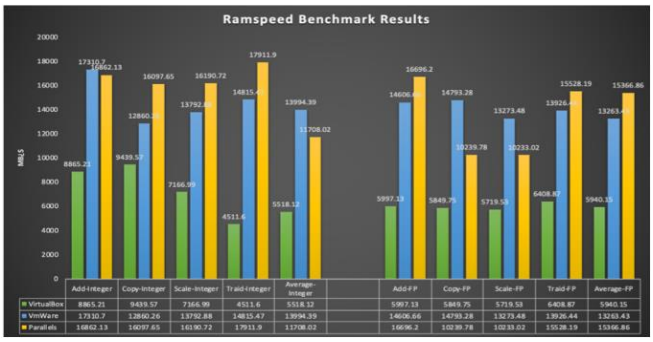

Figure 6: RamSpeed Benchmark Output

G. Network Throughput Benchmark using iPerf

iPerf is a tool for diagnosing network speed by measuring the maximum throughput of a virtual machine. Here, TCP and UDP ports, transfer rate, and bandwidth were examined, and the findings indicate that UDP and bandwidth performance is equivalent, while VirtualBox beats VMWare for TCP performance.

Figure 7 : iperf Network throughput Benchmark

H. Timed Kernel Compile

Using the Phoronix Test Suite, a Linux kernel compilation is performed to compare compilation times. Results indicate that VMWare has a shorter compilation time, whereas Virtual Box has a significantly longer compilation time, which slows programme execution.

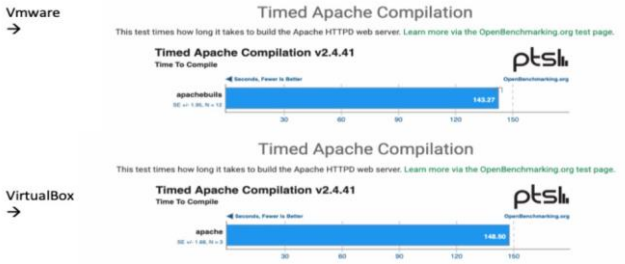

Figure 8 : Timed Kernel Compilation of Guest OS

I. Build Apache

Timed Apache compilation using the Phoronix Test Suite is used to measure web server compilation. The graph demonstrates that Virtual Box and VMware have comparable compilation times.

Figure 9 : Timed Apache Compilation

J. John the Ripper

John the Ripper is a CPU-bound test run with the Phoronix Test Suite that contains benchmarks for all supported hashing techniques. VMware has fared better than Virtualbox due to its highly paravirtualized implementation, as indicated by the graph of results.

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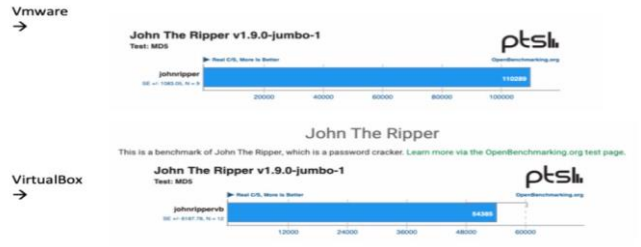

Figure 10: John Ripper MD5 Test

K. Compress-7Zip

The 7Zip compression benchmark tool evaluates the capabilities of virtual machines to compress huge files in a virtual environment. VMware compresses greater files than Virtual Box, while Virtual Box has nearly four times less throughput.

Figure 11: 7Zip Compression Benchmark Output

L. Blogbench Performance Test

BlogBench simulates and stresses a file server with random reads, writes, and rewrites. The results of this test demonstrate that Virtual Box is the superior product.

Figure 12: Blogbench Benchmark Output

M. GNUPG Performance Test

GNUPG measures the time required to compress a file in the VM, which is a crucial test for security performance given that encryption is one of the most important security features of the VM. The graph below demonstrates that VMWare is a faster hypervisor than Virtual Box, taking approximately half the time.

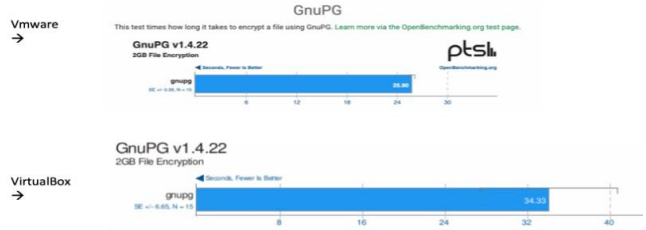

Figure 13: GNUPG Benchmark Output

N. NIC Test (Netperf)

Netperf is used to measure performance in networking and provides a test for unidirectional throughput. [1] The results of the tests are as follows. Through the tests we observe that Oracle Virtual Machine has a better performance.

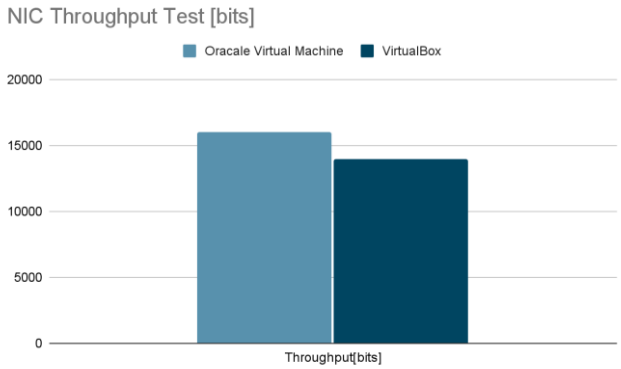

Figure 14 : NetfPerf Test results

F. *Linux Filesystems*

We also perform the comparison of both the hypervisors using Linux filesystem. A quick introduction of all the Linux filesystems are as follows:

i) Ext3: It is a journaled file system used in linux kernel.It is an upgraded version of ext2. It has three modes- Journal(to keep track of changes in FS), ordered(changes in fields of meta-data) and writeback mode.

ii) Ext4: Increases performance and reliability by addition of metadata and journal checksums.

iii) ReisurFS: has extensive recovery capabilities and is faster than Ext4

iv) XFS: It has the functionality of allocation groups with its own nodes table and a list of free space

v) JFS: It allows flexible file manipulation on disk as it is extent based.

Both the type 2 hypervisors were passed to test on the above file system to understand which is better. We performed tests as extra small file test results as well as extra large test results. It can be summarized in the graph below:

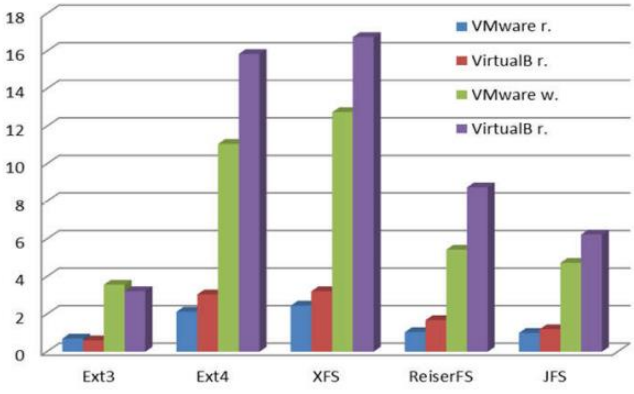

Figure 15 : Small Test Results

We observe that Ext4 and XFS have the same performances and are better than the others. Ext3 is the lowest of all. Here, VirtualBox is better than VMWare.

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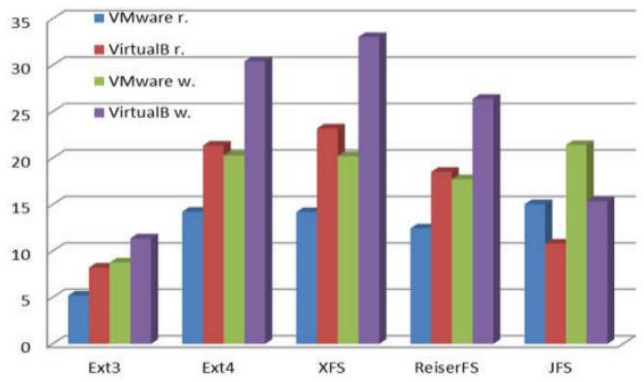

Figure 16 : Large Test Results

We observe that Ext3 is the lowest. Ext4 and XFS have the same performance. ReiserFS VirtualBox is better. Ext3 is the lowest of all. Here, VirtualBox is better than VMWare. For others it's quite the opposite. Overall we observe that VirtualBox showed significantly better results for all 5 filesystems. There might be a difference due to lower disc block overhead, Reiser File System is the best testing tool for the same.

V. RESULTS AND INFERENCE

Both the virtualization tools have their advantages depending on the use case scenario. This can be seen from the results of the tests compared above.

We attempted to compare performance based on Web Server Performance Benchmark, File Server Benchmark, Random File Access Benchmark, and Varmail Benchmark using the Filebench tool, and the results showed that in most cases the performances are comparable, with VMWare demonstrating superior performance. In the case of the Geekbench benchmarking programme, the outcomes demonstrated that VMWare offers superior CPU performance in both single-core and multi-core modes. VirtualBox is inferior to VMware in terms of CPU and memory utilization. The Bonnie++ file and disc performance benchmarking tool reveals that VirtualBox has the greatest write Mb/s for block-data sequential input, output, and latency, although VMWare has significantly lower latency and faster CPU performance, and hence provides superior compilation. The performance comparison between the hypervisors in terms of memory File I/O and CPU reveals that despite the majority of the criteria portray identical performance, VMWare outperforms VirtualBox in terms of File writes/sec, Throughput MB/s, and file write latency. In comparison to VMWare, VirtualBox's performance degrades in the memory throughput benchmark Ramspeed.

Using iPerf to assess network speed performance, VirtualBox outperforms VMWare for TCP. Comparing compilation times using the Phoronix Test Suite, VMWare has the shorter compilation time, whereas Virtual Box has a significantly longer compilation time, resulting in worse application performance. Comparing Apache compilation times using the Phoronix Test Suite revealed that Virtual Box and VMware have comparable compilation times. The 7Zip compression benchmark tool indicates that VirtualBox has a worse throughput than VMware based on the VM compression capability of huge files in a virtual environment. The CPU-bound John the Ripper test revealed that VMware fared better than Virtualbox due to its highly paravirtualized implementation, whereas Virtualbox performed the worst. VirtualBox performed better in BlogBench, which simulates a file server's load and stresses it with random reads, writes, and rewrites. Using Netperf's unidirectional throughput test, Oracle Virtual Machine demonstrated superior performance. In a study of two hypervisors utilizing the Linux filesystem, Virtual Box demonstrated superior performance for small files by 17 to 35 percent and for large files by 30 to 40 percent.

VI. CONCLUSION

Depending on the use scenario, both virtualization systems provide benefits. The comparison of the aforementioned experiments' outcomes demonstrates this. In a comparison of two hypervisors leveraging the Linux filesystem, Virtual Box performed 17-35 percent better on the small files test and 30-40 percent better on the large files workload. In the majority of the 16 test scenarios utilizing multiple performance benchmarking tools and tests, VMWare performs better than VirtualBox. However, VirtualBox also outperforms VMWare in other situations. The results of testing conducted on Linux File Systems demonstrated that VirtualBox was superior. This could be due to the fact that the Hardware specs utilized to conduct the performance comparison favor one system over another. VirtualBox is a free, straightforward, and high-quality virtualization solution that is suited for both home and basic professional use cases. VMWare provides a comprehensive virtualization solution for the aforementioned. Both of them provide quick virtualization options.

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