Performance Characterization of Microsoft SQL Server Using VMware Cloud on AWS

Performance Study - April 14, 2020

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Executive Summary

VMware Cloud™ on AWS brings VMware's enterprise software-defined data center (SDDC) to the AWS Cloud. It enables customers to easily migrate their existing virtual infrastructures to seamlessly run their business-critical applications like SQL Server, in the cloud, using the same VMware vSphere® environment that they have traditionally used on-premises.

The purpose of this paper is to answer a question that many customers have today: how do workloads that have traditionally been run in an on-premises infrastructure perform when transitioned to the cloud? The benchmark results show the answer is SQL Server continues to perform great within a VMware Cloud environment, for both small and large OLTP database VMs/workloads.

Introduction

VMware Cloud on AWS, powered by VMware Cloud Foundation™, integrates VMware flagship compute, storage, and network virtualization products—VMware vSphere, VMware vSAN™, and VMware NSX®—along with VMware vCenter Server® management. It optimizes them to run on elastic, bare-metal AWS infrastructure. With the same architecture and operational experience on premises and in the cloud, IT teams can now get instant business value via the AWS and VMware hybrid cloud experience.

The VMware Cloud on AWS solution enables customers to have the flexibility to treat their private cloud and public cloud as equal partners and to easily transfer workloads between them—for example, to move applications from DevTest to production or burst capacity. Users can leverage the global AWS footprint while getting the benefits of elastically scalable SDDC clusters, a single bill from VMware for its tightly integrated software plus AWS infrastructure, and on-demand or subscription services. For more information, visit our VMware Cloud on AWS Resources [1] page.

VMware vSphere, regardless of whether it is on-premises or in the VMware Cloud, provides an ideal platform for business-critical applications, including databases, ERP systems, email servers, and emerging technologies such as Hadoop. A full discussion of the benefits is included in the whitepaper "Virtualizing Business-Critical Applications on vSphere [2]."

A business-critical application that is often run on vSphere today is Microsoft SQL Server, which is "one of the most widely deployed database platforms in the world, with many organizations having dozens or even hundreds of instances deployed in their environments [2]." Consolidating these deployments onto modern multi-socket, multi-core, multi-threaded server hardware as virtual machines on vSphere is an effective solution.

VMware Cloud on AWS is ideal for customers looking to migrate their SQL databases to the public cloud or extend the capacity of their data centers for existing applications that leverage SQL Server.

Test Environment

For our tests, we deployed a three-server software-defined data center (SDDC) from our VMware Cloud on AWS portal.

The servers of the SDDC used Intel Xeon E5 2686 v4 processors with 18 cores running at 2.30 GHz with 512 GB of RAM. (Figure 1).

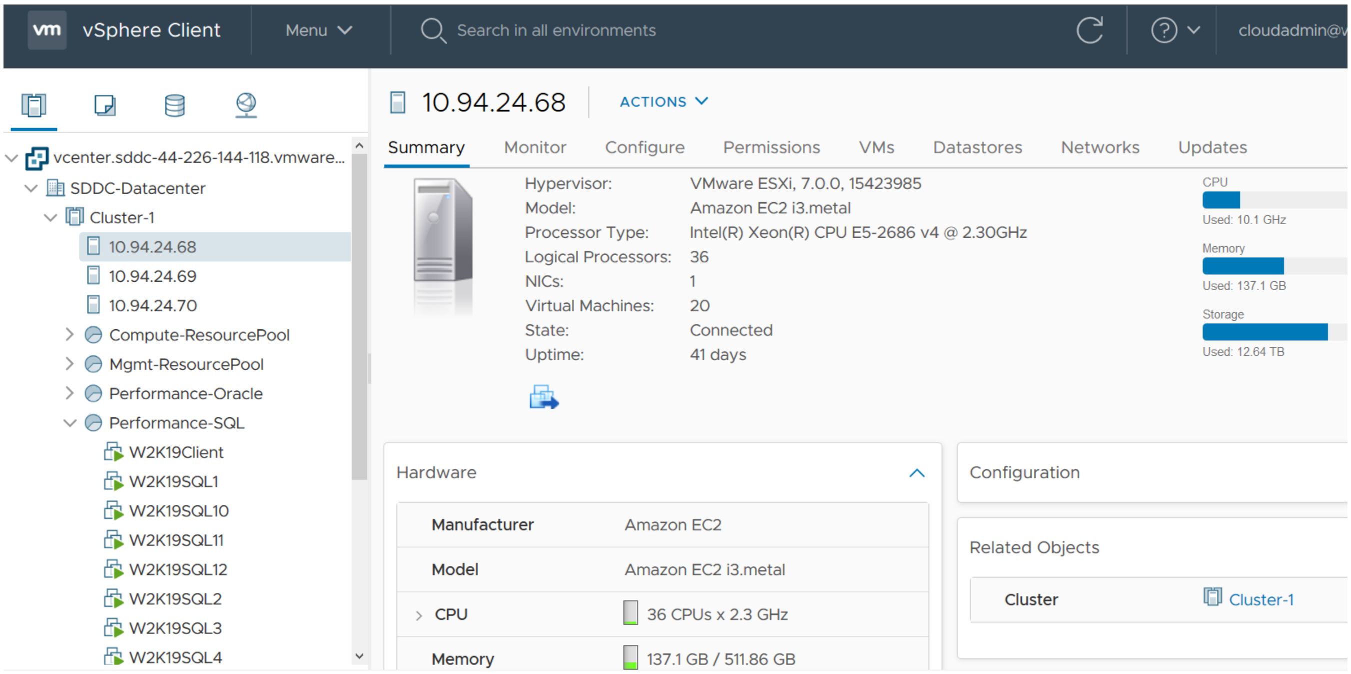

Figure 1. Screenshot of the test environment

On VMware Cloud for AWS, vSAN is used for the storage. It used the 8 NVMe devices that were in each of the three servers. Each NVMe had a capacity of 1.7 TB, so the entire cluster had 24 NVMe devices and a total raw capacity of approximately 31 TB (Figure 2). Deduplication and compression features of vSAN are enabled on VMware Cloud on AWS which will provide additional effective capacity. As part of the automatic deployment, management and workload datastores are created. The management datastore is for things like the vCenter and NSX-related VMs. The workload datastore is where all the VMs that are created or migrated into the environment are stored. This is where all the SQL Server database VMs that were created for these tests were stored.

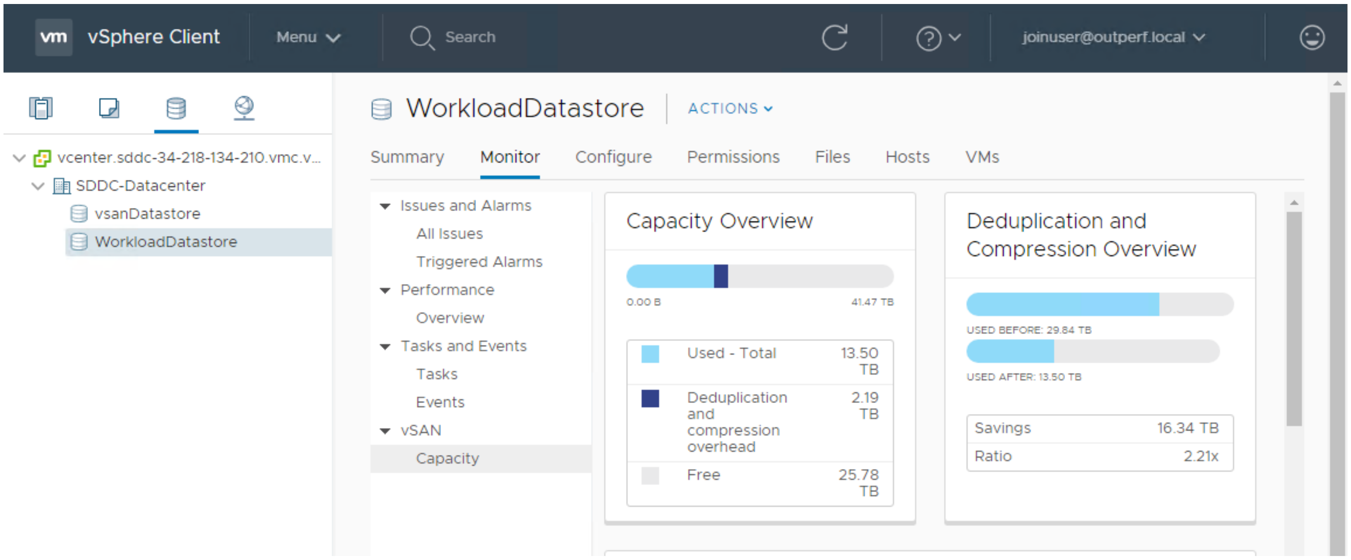

Figure 2. Screenshot of workload datastore configuration

Figure 3 shows a four node SDDC on AWS and its major components. We configured only the VMs that comprised the SQL Server database and load driver. The rest of the components and configuration were done automatically as part of the deployment from the VMware Cloud on AWS portal.

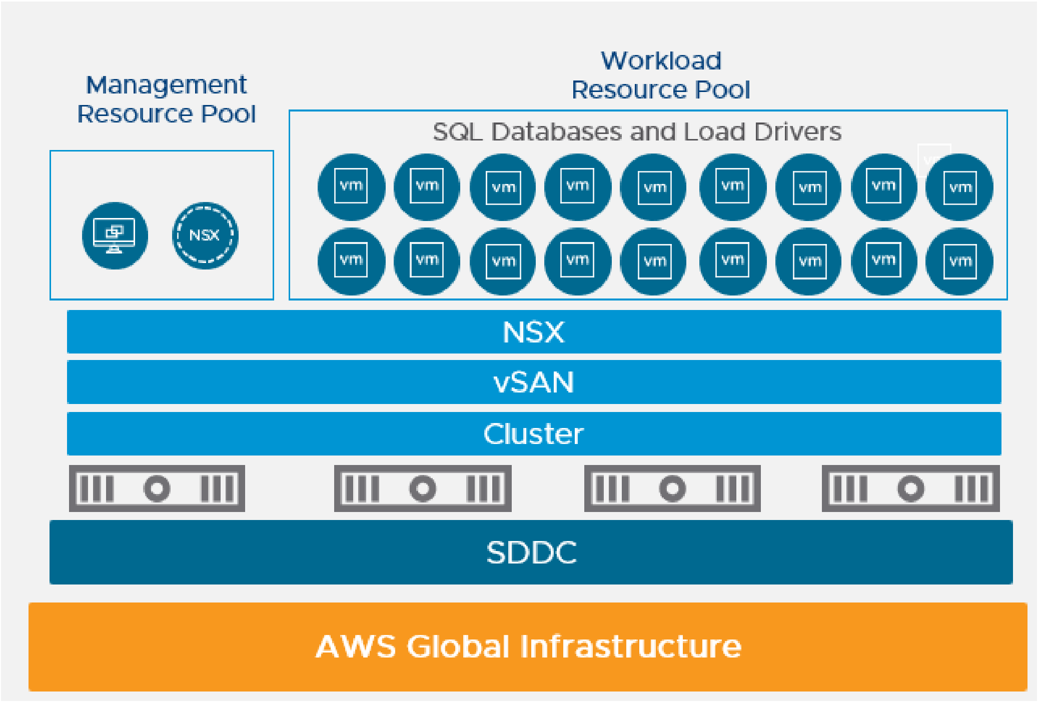

Figure 3. Cloud testbed configuration

Test Workload

We used the workload from the open-source benchmark DVD Store 3 [3]. DVD Store simulates an online store that allows customers to log on, search for DVDs, read reviews from other customers, rate the helpfulness of reviews, and purchase DVDs. DVD Store uses many common database features to support these operations, including tables, indexes, triggers, stored procedures, transactions, foreign keys, simple queries, and complex multi-join queries. The benchmark includes a client program that generates load against the database by simulating the actions of users on the site. Each simulated user thread does the full set of steps for a user from logon through purchase. The workload reports throughput in orders per minute (OPM).

For each test configuration, the number of user threads was increased with each iteration until the throughput reached its maximum level. We observed the maximum throughput corresponded to a host CPU utilization of between 90 and 99 percent.

DVD Store 3 allows for any size database to be created. For these tests, a 70 GB database was used for each SQL Server instance. Each VM ran four separate database instances, resulting in a total on-disk database size of 280 GB.

It is important to note that while DVD Store can be tested with a variety of database servers (SQL Server, Oracle, MySQL, and PostgreSQL), the performance results are not directly comparable.

Virtual Machine Configuration

Windows Server 2019 was installed as the guest operating system (OS) for all of the VMs we tested (both the load-driving client VM and the database servers). SQL Server 2019 Enterprise Edition was the database engine used within all database server VMs. We adhered to the Best Practices Guide for Microsoft SQL Server [4], and do not have any specific additional caveats for deploying SQL Server within VMware Cloud on AWS.

The database servers were configured with 128 GB of RAM, while the number of vCPUs varied depending on the test. We configured the load driver VM with 10 virtual CPUs (vCPUs) and 32 GB of virtual RAM.

The VMs used the VMXNET3 virtual network adapter and paravirtual SCSI (PVSCSI) adapters. We assigned data and log disks to separate PVSCSI adapters.

Scale-Up Performance

Scale-up performance tests used a VM configured with 8 vCPUs, then 16 vCPUs, and finally 32 vCPUs. A separate VM running the DVD Store driver, generated the load. The load-driver VM and the SQL Server database VM both ran in VMware Cloud on AWS, but they were on different physical hosts in that cloud.

The 8 vCPU VM achieved approximately 12,000 OPM, while the 16 vCPU VM achieved approximately 24,000 OPM, indicating that doubling the virtual CPUs resulted in double the database performance. Increasing the virtual CPUs to 32 resulted in just over 45,000 OPM, which while not quite another doubling of performance, still indicates very good scaling (Figure 4).

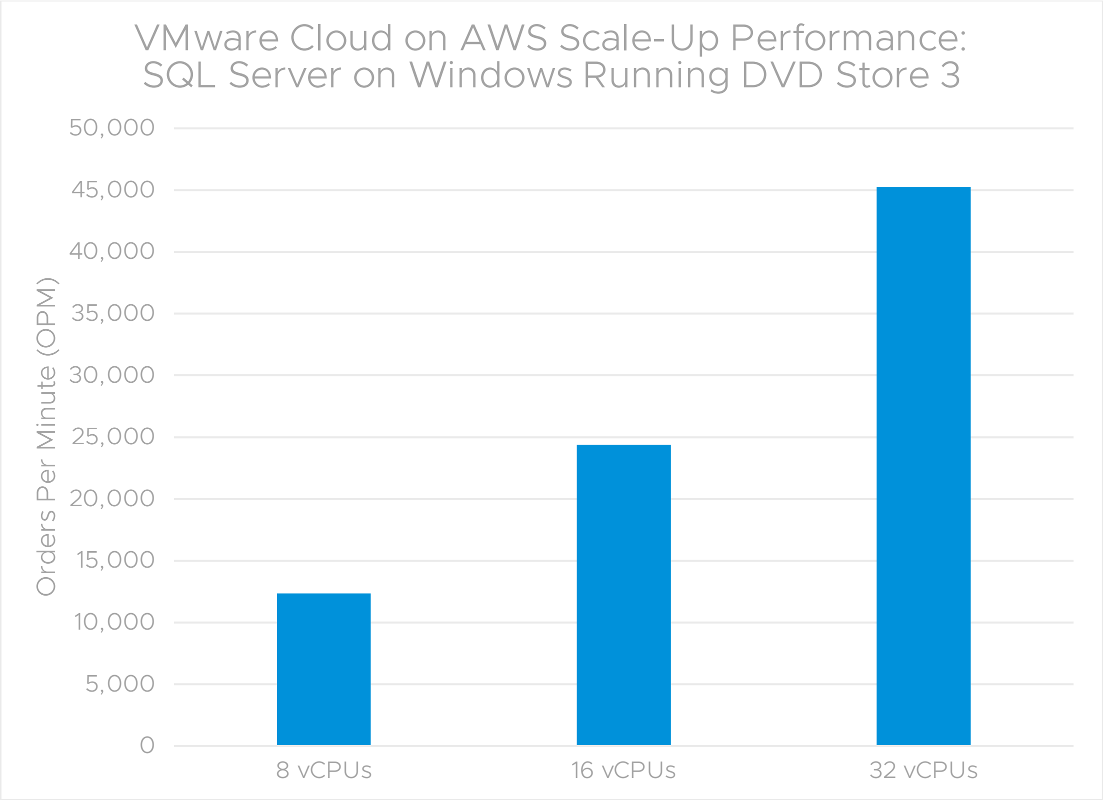

Figure 4. SQL Server Scale-Up Performance (adding processors)

Scale-Out Performance

Another way to measure performance is with multiple VMs running at the same time, which is known as scale-out performance. The setup is the same as the previous, single VM scale-up tests, but the workload driver system now spreads the worker threads across a number of target SQL Server database VMs simultaneously. The database VMs are spread out across the cluster, based on the best load balancing as determined by vSphere's Distributed Resource Scheduling (DRS). The total number of OPM achieved across all the SQL Server database VMs is then reported for each set of VMs.

Currently, VMware Cloud on AWS supports up to 16 hosts per cluster and up to 10 clusters per SDDC. In these tests, we used one cluster with only 3 hosts in our SDDC. The performance of the scale-out tests is largely due to the number of hosts. If more hosts were added to the SDDC, then more VMs could be run and the total amount of throughput achieved would be higher. An SDDC with more physical hosts would be capable of achieving higher scale-out performance than what we measured with the 3 host SDDC for these tests.

8 vCPU VMs

We performed the first set of tests with 8 vCPU VMs. We increased the number of VMs up to the maximum that successfully ran, which, in this case, was 12.

The scaling, as measured in throughput, from 1 to 12 VMs is good, starting at 12,000 and peaking at 120,000 OPM (Figure 5).

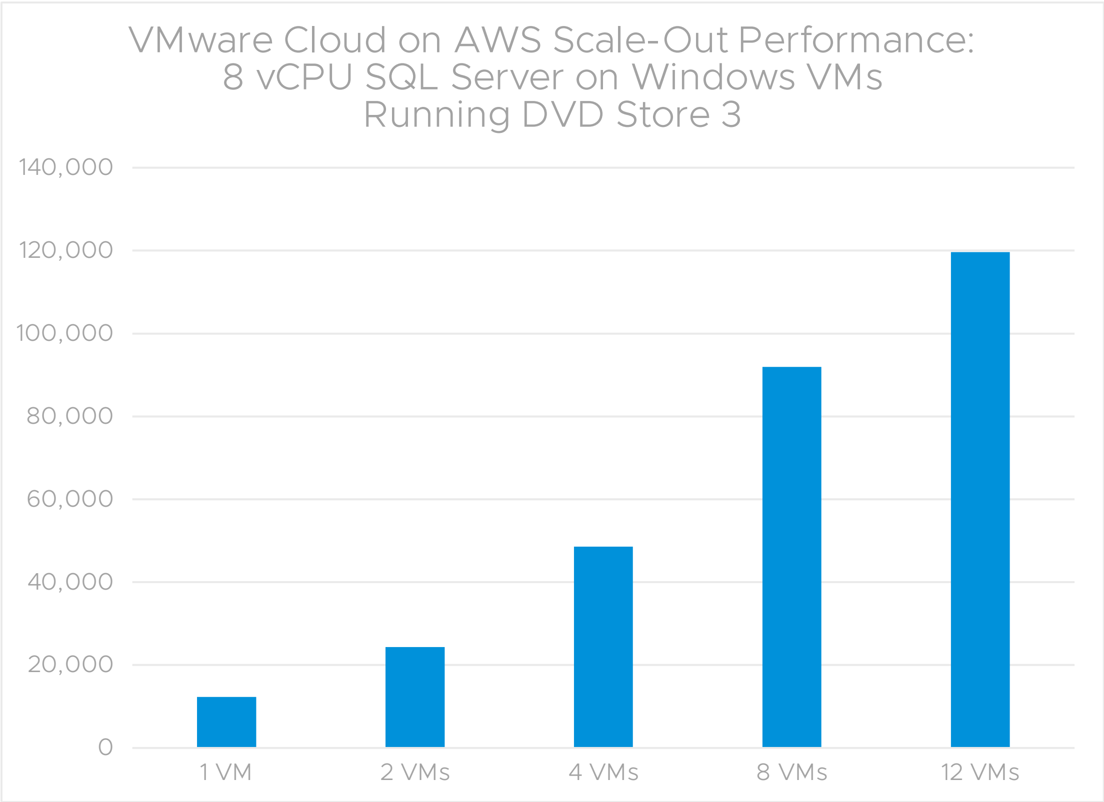

Figure 5. Scale-out performance with 8 vCPU VMs

16 vCPU VMs

The next test case used 16 vCPU VMs in a scale-out test scenario. Each processor in the physical servers that were used for the SDDC had 18 cores. The 16 vCPU test case dealt with VMs that were just two cores smaller than the NUMA node size of the physical server.

In this round of tests, the scaling remains strong up through 6 VMs, but levels off with 8 (Figure 6). With 6 VMs, each of the 3 physical servers could hold 2 database VMs, but with 8 VMs, there was a CPU bottleneck. Fortunately, with VMware Cloud on AWS, you can add hosts to your SDDC [5] to increase the amount of compute and storage capacity.

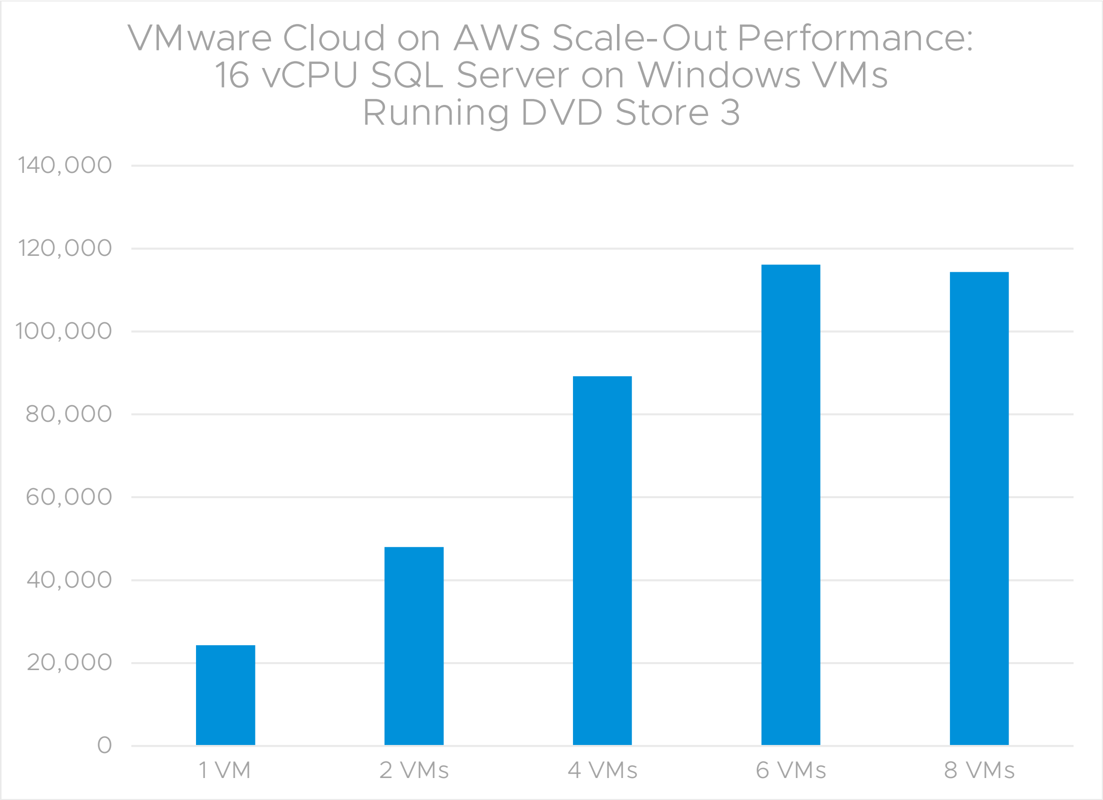

Figure 6. Scale-out performance with 16 vCPU VMs

Each host had 36 cores, with the three-node SDDC having a total of 108 cores. With six 16-vCPU VMs, there were 96 vCPUs allocated, which means that the cloud had 12 cores not allocated to a database VM. With 8 VMs, the number of vCPUs goes up to 128, meaning that there were more vCPUs allocated than the cloud had physical cores. Even with the overprovisioning of vCPUs, the total aggregate database throughput did not drop considerably.

Conclusion

The results from this performance study show that customers running SQL Server database workloads within VMware Cloud on AWS can expect to attain the high performance that they have come to expect from their on-premises vSphere datacenters.

References

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About the Author

David Morse is a staff engineer on the Performance Engineering team at VMware. He has 20 years of benchmarking experience at VMware, Dell Inc., and NCR Corp.

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