

# Lab Validation Report

## Workload Performance Analysis: Microsoft Windows Server 2012 with Hyper-V and SQL Server 2012

Virtualizing Tier-1 Application Workloads with Confidence

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### ESG Lab Reports

The goal of ESG Lab reports is to educate IT professionals about data center technology products for companies of all types and sizes. ESG Lab reports are not meant to replace the evaluation process that should be conducted before making purchasing decisions, but rather to provide insight into these emerging technologies. Our objective is to go over some of the more valuable feature/functions of products, show how they can be used to solve real customer problems and identify any areas needing improvement. ESG Lab's expert third-party perspective is based on our own hands-on testing as well as on interviews with customers who use these products in production environments. This ESG Lab report was sponsored by Microsoft.

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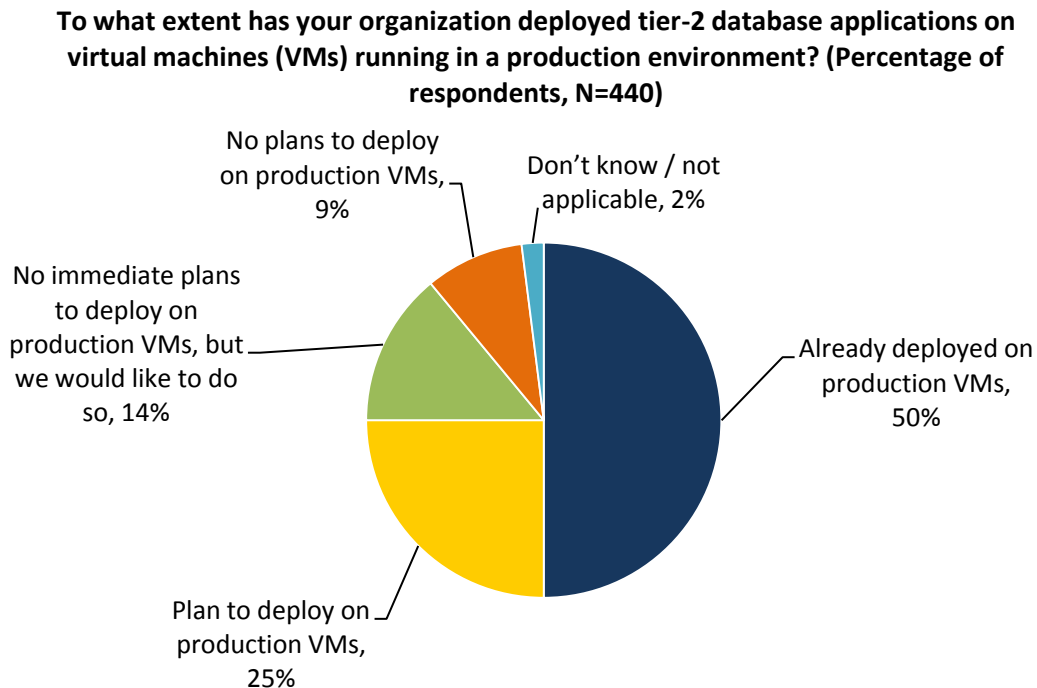
## Introduction

This ESG Lab report documents the results of independent, hands-on testing of the performance, scalability, and efficiency of [Microsoft's](#) Windows Server 2012 with improved Hyper-V virtualization. ESG Lab tested with a tier-1 virtualized Microsoft SQL Server 2012 application workload to confirm that Hyper-V can be used to increase scalability, maintain enterprise-level performance, and reduce the total cost of ownership.

## Virtualized SQL Server Deployments

Many organizations are reaping the benefits of server virtualization, including lower IT capital and operational costs; greater IT efficiency; and improved application provisioning, maintenance, availability, and backup/recovery processes. As administrators gain confidence in virtualization technologies, they strive to improve agility and enhance the availability of IT services. Respondents to a recent ESG survey were asked to what extent their organization has deployed tier-2 database applications (i.e., Oracle Standard, Microsoft SQL, etc.) on virtual machines in a production environment. Of the 440 respondents, 50% had already deployed tier-2 database applications on production-based VMs, with 25% planning to in the near future (see Figure 1).

*Figure 1. Production Environment Virtualized SQL Server Deployments*

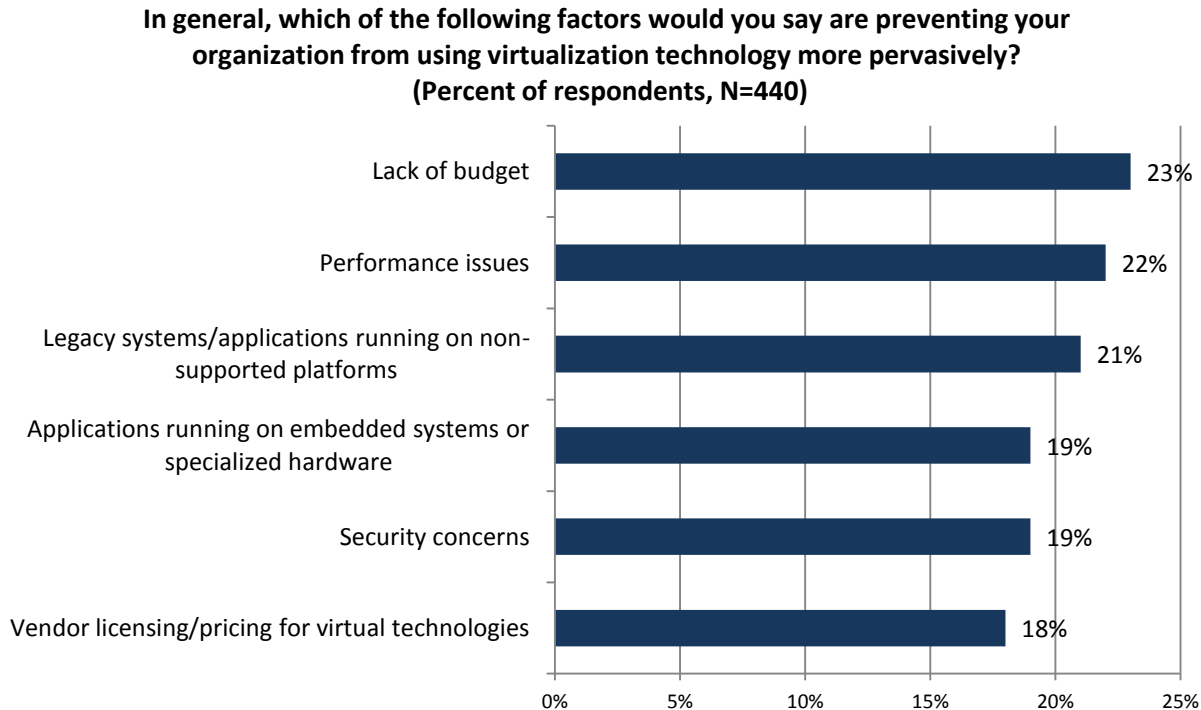


*Source: Enterprise Strategy Group, 2012.*

For the more mature organizations surveyed that have deployed and are currently deploying virtualized database applications, uptime and performance are the two most important metrics in gauging the success of their virtualization deployments. Many of these early adopters have now virtualized entire infrastructures, including business-critical tier-1 applications such as SQL Server. In other words, application performance is a top criterion for virtualization success that is being addressed by the early adopters who have fully embraced server virtualization.

As organizations move toward being 100% virtualized, the performance, scalability, and reliability requirements of mission-critical tier-1 applications can inhibit virtualization growth. ESG research confirms that hesitation; according to research conducted with IT professionals, 59% of organizations have not yet virtualized their tier-1 applications, and they cite performance as a major reason. ESG recently conducted a survey asking respondents which factors were preventing their organizations from using virtualization technology more pervasively. As Figure 2 shows, the key concerns were budget and performance; of the 440 respondents, 23% stated lack of budget, while 22% remain concerned with performance issues.<sup>1</sup>

*Figure 2. Top Factors Preventing More Pervasive Virtualization Technology Usage*



*Source: Enterprise Strategy Group, 2012.*

In addition to performance, multi-user applications present some additionally challenging questions for virtualization users, such as:

- Will the virtualized infrastructure scale as our needs grow?
- Can we ensure that performance SLAs for virtualized business-critical applications will be met?

Despite these virtualization challenges, experienced organizations with more mature virtualization deployments are rapidly moving beyond the initial benefits of consolidation, finding that more extensive use of virtualization can help improve application backup/recovery, bolster application availability, and automate IT processes. They have come to realize that the critical metrics in a virtual environment are those focused on availability and performance, and they measure the success of their virtualization efforts not only by their ability to reduce costs and increase efficiency, but also by their ability to meet application performance requirements. Because the benefits of virtualization are extremely compelling, ESG expects to see an increasing number of organizations looking for ways to leverage the technology for their tier-1 applications.

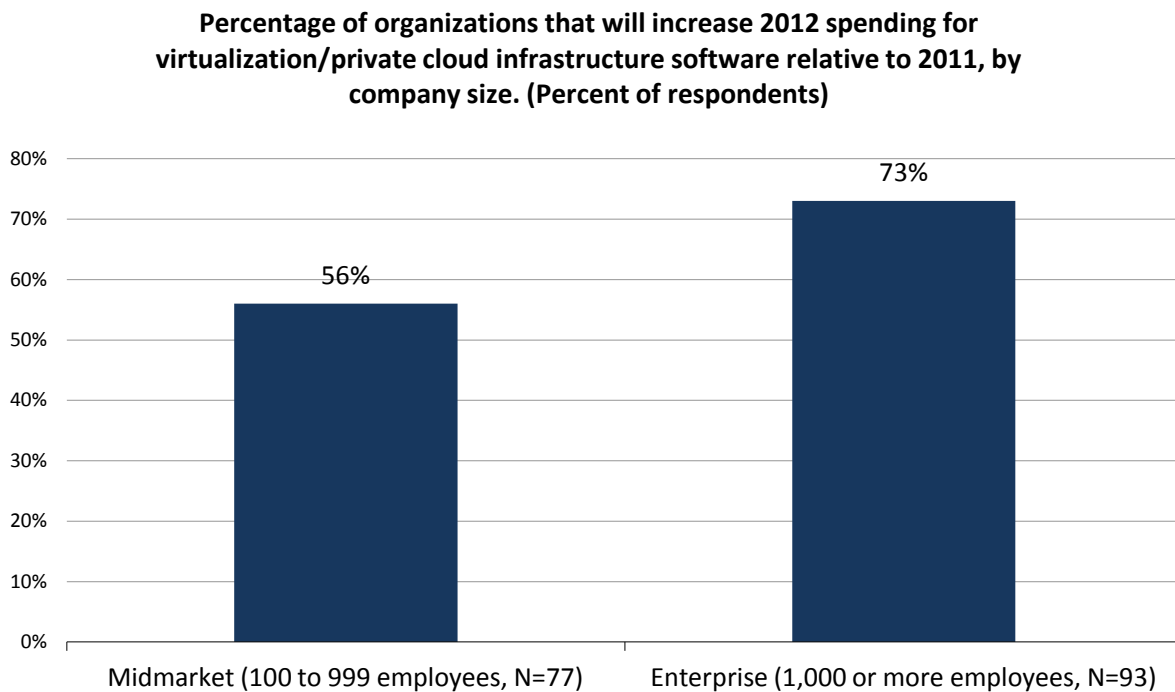
<sup>1</sup> Source: This data comes from a custom research project conducted by ESG on behalf of Microsoft on the topic of virtualization and private cloud trends in May 2012. All other ESG research references in this lab report come from this research project, unless otherwise noted.

## Overcoming Virtualization Concerns

Businesses continue to embrace the value of server virtualization and show a steady rate of virtualization adoption, increased production use, and improved consolidation ratios. 61% of respondents have greater than 50% of their organization's x86 servers virtualized. 63% of respondents have between 21% and 60% of their virtual machines running in a production environment. Fifty one percent have more than ten virtual machines per physical server. While these indicators continue to increase, the research also unveils that the majority (61%) of deployments have 500 or less virtual machines.

Figure 3 shows the results of a recent ESG survey that asked respondents to identify the extent to which their organization's 2012 spending for virtualization/private cloud infrastructure software will change relative to 2011. More than half (56%) of midmarket organizations expect their 2012 spending levels for virtualization technology to increase, while nearly three-quarters (73%) of their enterprise counterparts anticipate higher budget allocations for the technology compared with 2011. The consistent increases in budgetary funds allocated for virtualization spending reflect the continued growth in both usage and adoption as organizations—regardless of size—look to take advantage of the benefits offered by the technology.<sup>2</sup>

*Figure 3. 2012 Virtualization Spending Increases by Company Size*



*Source: Enterprise Strategy Group, 2012.*

<sup>2</sup> Source: ESG Research Report, [2012 IT Spending Intentions Survey](#), January 2012.

## Microsoft Windows Server 2012 with Hyper-V

Microsoft's Windows Server 2012 offers customers new functionality designed to optimize virtualization and cloud computing while capitalizing on existing investments. Understanding the opportunities and challenges that consolidation, virtualization, and cloud computing offer, Microsoft has built numerous enterprise-level features into this operating system for organizations and service providers of all kinds. At a high level, these features will help customers to:

- Build private clouds and leverage cloud services that can scale easily while minimizing security risks.
- Manage infrastructure efficiently with maximum uptime, so that they can leverage the power of many servers with the simplicity of one.
- Build open, scalable web platforms that support geography-spanning applications.
- Support today's business environments that require "anytime, anywhere" information access, regardless of the infrastructure, network, device, or application they choose for access.

Hyper-V in Windows Server 2012 provides organizations with massive scalability to transform data centers into a complete cloud platform. Hyper-V greatly expands support for resource allocation, now supporting up to 64 virtual processors and 1TB of memory for virtual machines. Other new features related to virtualization include:

- *Virtual Fibre Channel (FC) support* – Providing direct connections to FC host bus adapter (HBA) and SAN fabric from Hyper-V virtual machines for higher performance and availability.
- *Live storage migration* – Supporting high availability while moving virtual hard disks between hosts.
- *Guest NUMA* – Virtual processors and guest memory are grouped into virtual NUMA nodes and the virtual machine presents a guest topology based on the underlying physical topology of compute and memory resources. With guest NUMA, the guest workloads can use their knowledge of NUMA and self-optimize based on this data. It ensures the guest operating system creates the best, most optimal mapping between virtual and physical resources which in turn this ensures that guest operating systems and applications can ensure the most efficient execution, best performance, and most linear scale.
- *SR-IOV Networking* – Introduces a new high-throughput, low latency networking solution that surfaces a portion (a virtual function) of a physical NIC within a virtual machine and can deliver >10GB performance without sacrificing key mobility features like Live Migration.
- *New VHDX Format* – Support for up to 64TB of virtual hard disk capacity; built-in resiliency; an additional 4KB logical sector to improve performance for certain workloads and applications.

Combined, these new features help ensure that virtualized infrastructures support the configuration of large, high-performing virtual machines to sustain enterprise-level workloads that meet the scalability needs of all-sized organizations.

## Microsoft SQL Server 2012

Microsoft SQL Server 2012 is a relational model database server that's used to develop and deploy database applications, improve IT and developer efficiency, and deliver highly scalable and manageable business intelligence services. As a key component of the cloud-ready information platform, SQL Server 2012 helps organizations quickly build solutions and unlock breakthrough insights across private and public clouds with confidence.

- *Mission-critical Confidence* enables mission-critical performance and availability.
- *Breakthrough Insight* unlocks new insights with rapid data exploration and visualization.
- *Cloud on Your Terms* allows for the fast creation and scaling of business solutions.

New tools and enhancements in SQL Server 2012 provide innovative breakthroughs that can be leveraged throughout the organization. With new, cloud-ready technologies, customers remain agile and future-proof for application symmetry across servers, private clouds, and public clouds. New features include:

- *AlwaysOn*, which provides high availability and advanced disaster recovery.
- *Column Store Index*, which enables astonishingly fast speeds for common data warehouse queries.
- *Power View/PowerPivot*, which speeds data discovery with Excel-like functionality and familiarity.
- *BI Semantic Model*, which provides multiple ways of building business intelligence (BI) solutions.

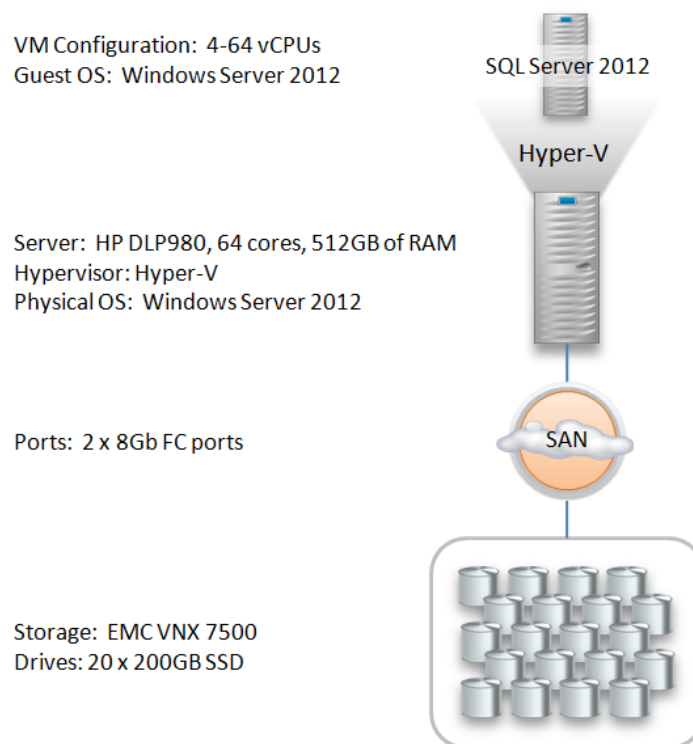
## ESG Lab Validation

ESG Lab performed hands-on testing of a virtualized tier-1 application workload in Redmond, Washington. The workload used during ESG Lab testing was designed to emulate the database activity of users in a typical online brokerage firm as they generated trades, performed account inquiries, and did market research. The workload was composed of ten transaction types with a defined ratio of execution. Four of the transactions performed database updates, and the rest were read-only.

The workload was deployed in a single virtual machine with a goal of stressing the Windows Server 2012 Hyper-V virtualization, as well as CPU utilization. The workload generated a high level of I/O activity with small access sizes and spent a lot of execution time at the operating system kernel level. These characteristics, combined with a large, cache-resident working set, created a workload that was well suited for evaluating the efficiency of Hyper-V.

An overview of the test bed used during ESG Lab testing is shown in Figure 4. A single SQL Server 2012 virtual machine was configured with between four and 64 virtual CPUs and 64GB of RAM on a single HP DLP980 with 64 CPU cores and 512GB of RAM. The server was connected to an EMC VNX7500 storage array by two 8GFC paths. A single RAID 10 LUN was created from 20 200GB SSDs. Two physical servers outside of the main deployment were used to generate the measured OLTP workload.

Figure 4. ESG Lab Test Bed



Windows Server 2012 was installed on the host and guest machines with a goal of testing the scalability and efficiency of Hyper-V virtualization. For Hyper-V scalability testing ESG Lab measured a workload of 40 concurrent users as vCPUs were added to the virtual machine running a 75,000 customer SQL Server 2012 database application. For Hyper-V efficiency testing ESG Lab measured the potential overhead of Hyper-V by comparing the performance of a single virtual machine to an identically configured physical machine.



## Hyper-V Scalability

The sum of the number of transactions processed per second and the average response time for the ten transaction types were monitored as virtual CPUs of a single virtual machine scaled from four to 64. The OLTP workload and concurrent user counts remained constant for each test. The number of brokerage transactions per second scaled linearly as up to 64 vCPUs were added to a Hyper-V-enabled SQL Server virtual machine. The results are summarized in Figure 5 and Table 1.

Figure 5. Brokerage OLTP Hyper-V Virtual CPU Workload Scalability

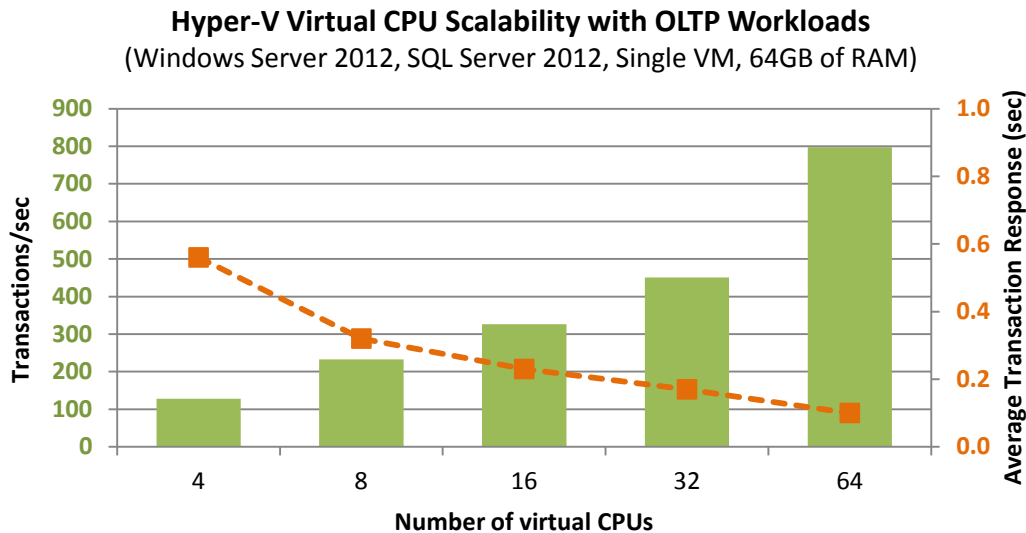


Table 1. Brokerage OLTP Hyper-V Virtual CPU Workload Scalability

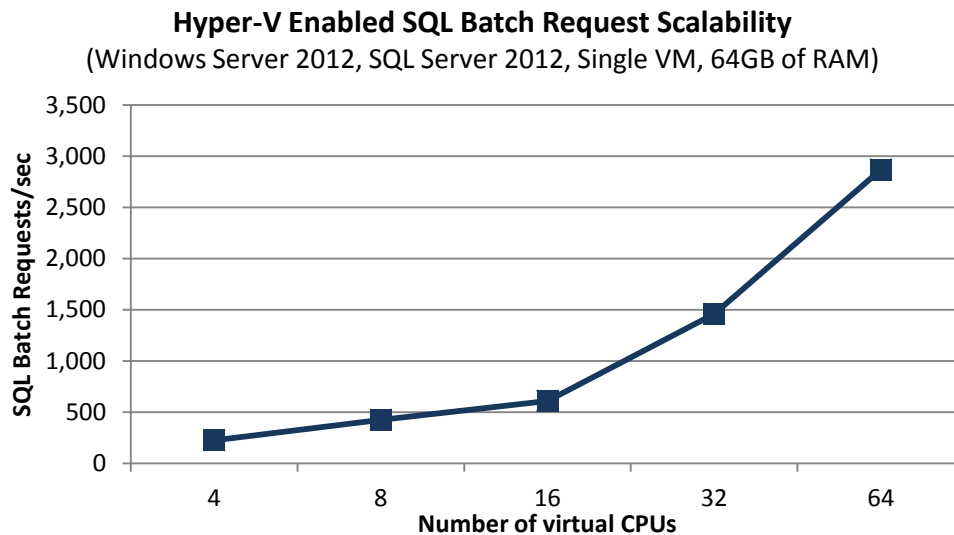
Virtual CPUs (Total)	Virtual CPU Utilization	SQL Server Batch Requests/Sec	Transactions/Sec	Average Transaction Response Time (Seconds)
4	99.5%	225	128	.56
8	98.8%	425	233	.32
16	97.1%	610	326	.23
32	83.0%	1460	451	.17
64	41.7%	2870	797	.10

### What the Numbers Mean

- The number of transactions processed per second at the application level is a good measure of the amount of work that a virtualized infrastructure can handle.
- A virtual machine running a SQL Server 2012 database supporting 75,000 brokerage customers and ESG Lab tested a constant workload that simulated 40 concurrent users.
- The virtual machine was configured with four to 64 virtual CPUs and 64GB of RAM with a goal of showing Server 2012’s new Hyper-V scalability potential.
- As more vCPUs were allocated to the virtual machine, utilization decreased and the performance of a workload that was bottlenecked by compute resources noticeably improved.
- SQL Server batch requests increased from 225 to 2,870 and transactions per second increased from 128 to 797 as the number of vCPUs running on a single virtual machine increased from four to 64.
- ESG Lab recorded average transaction response times starting at .56 for the four vCPU test case, and getting as low as .10 for the 64 vCPU test case.

As shown in Figure 6, 2,870 SQL Server batch requests per second were recorded during the 64 vCPU test. To put this into perspective, Microsoft documentation indicates that “over 1,000 batch requests per second indicate a very busy SQL Server.”<sup>3</sup> Of course, this is a relative number that depends on the power of the hardware used to deploy SQL Server applications. In this case, the efficiency of Hyper-V running on a powerful multi-core HP DLP980 server and an EMC VNX 7500 storage array with 20 200GB SSDs provided more than enough horsepower to support a “very busy SQL Server.”

Figure 6. Brokerage OLTP SQL Server Batch Request Scalability



### **Why This Matters**

Server virtualization aggregates multiple workloads on physical servers, often increasing the randomization of I/O and creating storage bottlenecks that affect application performance. With the increasing demands of IT, users have less tolerance for poor application performance. In addition, many organizations resist moving tier-1 applications to virtual servers for fear that workload aggregation will slow performance. ESG research on virtualization revealed that after budget concerns and lack of legacy application support, performance issues were the key concern preventing organizations from expanding their virtualization deployments.

ESG Lab confirmed that the performance and scalability of Server 2012 with Hyper-V makes it possible to consolidate a tier-1 database application workload with confidence. Now with the ability to allocate up to 64 vCPUs, processor heavy workloads previously not considered for virtualization can now leverage the scalability potential of Server 2012 with Hyper-V. ESG Lab measured a six times performance improvement with five-time faster response times for a CPU intensive OLTP workload with a 75,000 customer database.

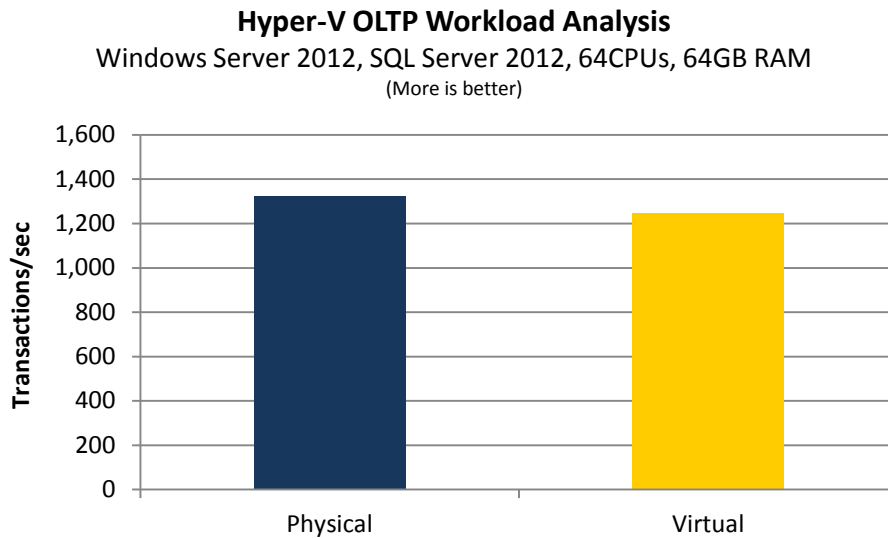
<sup>3</sup> [http://www.sqlteam.com/forums/topic.asp?TOPIC\\_ID=64044](http://www.sqlteam.com/forums/topic.asp?TOPIC_ID=64044)

## Hyper-V Efficiency

Testing was performed with a goal of quantifying the manageably low difference in performance between the brokerage application running in a Hyper-V virtual machine and a native physical server. Performance of a single virtual machine was compared with the performance of the native physical server after it was identically configured to use the same resources (64 CPU cores and 64GB of RAM).

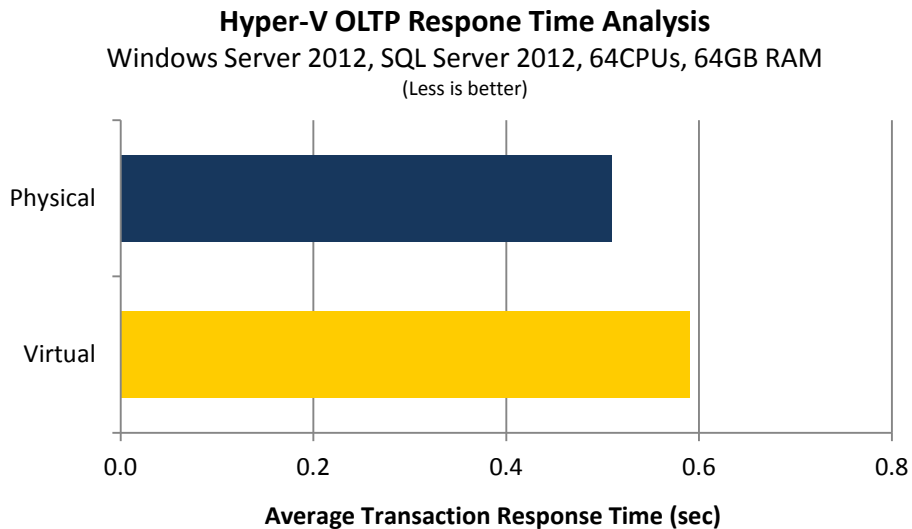
An OLTP workload that deliberately hit a CPU bottleneck in the virtual environment was tested. The same workload against the same database was tested on the physical server. As shown in Figure 7, an OLTP workload running on a 75,000 customer database deployed in a Hyper-V virtual machine processed just over 6% fewer transactions per second compared to the same workload running on a similarly configured physical server (1,245 transactions per second in the virtualized environment, compared to 1,325 in the physical deployment).

*Figure 7. Hyper-V Virtualization Overhead Analysis*



The average transaction response times were also monitored and, as shown in Figure 8, the physical server completed transactions 13% faster than the virtual machine (.59 seconds in the virtualized environment, compared to .51 seconds in the physical deployment).

*Figure 8. Hyper-V Virtualization Overhead Analysis*



## **Why This Matters**

A bare metal hypervisor sits between the server hardware and the operating systems, and applications that rely on that hardware. As a result, the hypervisor introduces some degree of performance overhead compared with an application running alone on a physical server. High overhead would limit the types, and number, of applications that can be virtualized per physical server.

ESG Lab testing confirmed that Windows Server 2012 Hyper-V and SQL Server 2012 have the performance and scalability to support tier-1 OLTP application workloads with confidence. The increased scalability of a Hyper-V enabled virtual machine in Windows Server 2012 with 64 vCPUs and 64GB of RAM increased the number of supported transactions by six times that of the same virtual machine with 4 vCPUs. Dramatically lower response times were also witnessed with the 64 vCPU test case completing transactions five times faster than the 4 vCPU test case.

ESG Lab measured a Hyper-V overhead of just over 6% for a busy tier-1 database application workload. ESG Lab believes that this manageably low performance and response time impact is easily justified given the compelling consolidation, manageability, and cost saving benefits that can be achieved with Hyper-V, especially given the continuously improving performance of industry-standard server hardware.

## ESG Lab Validation Highlights

- ☑ With new support for up to 64 vCPUs, ESG Lab took an existing OLTP workload that was vCPU limited by the maximum allowed configuration of four vCPUs imposed by Windows Server 2008 and increased the performance by six times with Windows Server 2012 Hyper-V. Average transaction response times also improved by five times from four vCPUs to 64 vCPUs.
- ☑ Manageably-low Hyper-V overhead of 6.3% was recorded when comparing the performance of a physical server with a virtual machine configured with the same number of virtual CPU cores and the same amount of RAM. A reasonable response time difference of 13.2% was also witnessed when comparing physical to virtual.

## Issues to Consider

- ☑ “Utility-class” database applications are a great place to start with the consolidation of Microsoft SQL Server applications with Hyper-V. These applications have modest performance and availability requirements and are often deployed with third-party software applications or developed within departments of an organization. High rates of consolidation and savings can be achieved by consolidating this class of SQL Server application workloads onto a fewer number of servers. Capacity planning and performance analysis of existing SQL Server applications is recommended not only to determine if a SQL Server workload is suitable for virtualization, but also to plan the amount of processor, memory, and network resources that need to be configured within each virtual machine.
- ☑ The test results presented in this report are based on benchmarks deployed in a controlled environment. Due to the many variables in each production data center environment, capacity planning and testing in your own environment is recommended.
- ☑ Default server BIOS, operating system, and SQL Server settings were used during ESG Lab testing. As expected after any benchmark test of this magnitude, analysis of the results indicates that tuning would probably yield slighter higher absolute results. Given that the goal of this test was not to generate a big number, ESG Lab is confident that the results presented in this report meet the objective of demonstrating the performance and scalability of tier-1 application workloads running in a consolidated Hyper-V environment.

## The Bigger Truth

The next wave of server virtualization adoption is well underway. Virtual server technologies have been proven to deliver significant business value, reducing both OPEX and CAPEX and keeping virtualization at the top of the IT priority list. In addition, organizations are leveraging virtualization to gain mobility and agility, in many cases deploying private clouds and taking advantage of fast and easy provisioning from public cloud providers. ESG noted in its 2012 IT Spending Intentions survey that a full 74% of respondents reported that their organizations would increase spending on cloud computing this year.<sup>4</sup>

But while customers continue to enjoy efficiency improvements, they want to move past the initial consolidation gains and virtualize more mission-critical applications. However, the workload aggregation of virtual server environments can create an “I/O blender” effect, with multiple types and sizes of workloads overloading disk spindles, stressing networks, and consuming server processing resources. These challenges can affect application performance, often preventing expansion of virtual environments and limiting its benefits. And while performance is high on the list of factors preventing organizations from expanding their virtual deployments, it is far from the only one. ESG research indicates that the capital costs of adequate infrastructure, security concerns, and skills deficits remain stumbling blocks for many organizations.

ESG Lab demonstrated that Windows Server 2012 with Hyper-V improves on the existing ability to offer great scalability and performance by increasing the number of vCPUs that can be allocated to virtual machines. Workloads that used to be difficult to virtualize due to heavy server processing can now be deployed with confidence. An OLTP workload that was bottlenecked at four vCPUs noticeably improved as more vCPUs were added to the virtual machine. ESG Lab witnessed a six times performance improvement with a five times faster response time.

The efficiency of Hyper-V was measured by comparing the performance of the same OLTP workload run on an identically configured physical and virtual server. Transactions/sec performance was only 6.3% better on the physical server. ESG Lab feels that this manageably low overhead can be easily justified given the proven benefits of server virtualization technology and the ever-increasing power of the latest servers with hardware-assisted virtualization performance optimization.

Microsoft Windows Server 2012 was designed to help data centers implement cloud-optimized IT today and in the future. It is the type of foundation required to support the needs and expectations of today’s user, who demands maximum information access with fast performance and minimal interruption, regardless of location or endpoint device. The new and enhanced storage features bring enterprise levels of performance, scalability, availability, reliability, and efficiency to market in an affordable package. Microsoft is helping make virtualization and cloud computing easier and faster to deploy, leveling the playing field for enterprises and service providers of all kinds.

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<sup>4</sup> Source: ESG Research Report, [2012 IT Spending Intentions Survey](#), January 2012.

## Appendix

Table 2. ESG Lab Test Bed

Software	
Hypervisor	Windows Server 2012 with Hyper-V
Native O/S	Windows Server 2012, build 9200
Guest O/S	Windows Server 2012, build 9200
Database	Microsoft SQL Server 2012, version 11.0.2100.60
Workload Generator	Windows Server 2008 R2 SP1, Enterprise (64-bit), SP1, version 6.1.7601
Hardware	
Server	HP DLP980 Intel Xeon x7560 2.27GHz, 64 cores, 512GB RAM
SAN	EMC VNX 7500 20 x 200GB SSDs 2 x 8Gb FC paths
Virtual Machine Configuration	
Virtual CPUs	Four to 64 virtual CPUs
RAM	64GB



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