Abstract

This ESG Lab Review documents the results of a recent Nutanix performance analysis that focused on real-world performance scalability and sustainability.

The Challenges

As hyperconverged technologies hit the mainstream and now serve as direct competition to legacy technology vendors, buying criteria have begun to expand. They are no longer just about simplicity and cost savings. Organizations are now also prioritizing requirements such as performance, scalability, and reliability – recognizing that technologies like the cloud and software-defined storage will be far less complex and more cost-effective than a traditional siloed approach. Organizations want all the benefits of hyperconverged infrastructures, but also need to ensure that hyperconverged infrastructures can deliver predictable, scalable, sustainable, enterprise-class performance for mission-critical workloads.

Nutanix Enterprise Cloud Platform

The Nutanix Enterprise Cloud Platform delivers a complete IT infrastructure with the agility, scalability, and simplicity of the cloud and the security, performance, and cost predictability of a traditional on-premises infrastructure. The architecture is a scale-out virtual computing platform leveraging web-scale engineering principles innovated by leading cloud companies such as Google, Facebook, and Amazon. The highly distributed architecture creates a fully integrated compute, virtualization, and storage environment that is 100% software-defined. This integration eliminates the complexity of traditional SAN and NAS environments, as well as their reliance on costly, special-purpose hardware that commonly requires IT personnel with specialized skill sets.

With its fully distributed approach, Nutanix spreads all data and processes across the entire cluster, improving resource utilization, scalability, and performance predictability. Active data tiering automatically places frequently requested data in the highest performance storage tier. Additionally, data locality ensures that data is always proximate to the application – serving data directly from direct attached storage, and minimizing expensive network latency.
Performance Analysis

ESG audited complete and detailed results from performance tests using multiple hybrid and all-flash Nutanix configurations that simulated real-world application workloads. The testing used industry-standard application workload generation tools that exercised all aspects of the Nutanix Enterprise Cloud Platform to highlight performance speed, scalability, and stability.

Testing focused on workloads commonly found in production environments. Four real-world workloads were simulated:

- Microsoft SQL Server online transactional processing (OLTP)
- Oracle Database online transactional processing (OLTP)
- Microsoft Exchange email environment
- Citrix XenDesktop VDI environment

The SQL Server database workload was generated using Benchmark Factory, a performance and code scalability testing tool that simulates database users and transactions. For the Oracle OLTP workload, the widely adopted and publicly available Silly Little Oracle Benchmark (SLOB) kit was used. The Exchange environment leveraged Jetstress, a Microsoft tool often used to size and validate an Exchange Server configuration. The tool of choice for the VDI environment was Login VSI.

In all cases, compute and storage resources were exercised, so that the testing emulated real-world performance of HCI solutions containing shared compute and storage resources. All tests and results are meant to present meaningful application performance data that is likely to be achieved in a production environment. It should be noted that the tests did not exercise the Nutanix platform to its maximum specified scalability, rather the relative scalability within the systems used for the testing. Based on the linear results reviewed, ESG expects that adding additional systems would have allowed performance to scale out farther. Although testing focused on consistent application performance distribution that taxed all cluster resources, it should also be noted that total aggregate storage performance may be a relevant evaluation criteria for more storage-intensive workloads where CPU is not a constraint. This is particularly applicable when evaluating HCI solutions to add external scale-out block storage for Unix workloads on Solaris or AIX, and specialized bare-metal x86 servers commonly used to minimize software licensing costs in large SQL Server, Oracle, and SAP database environments.

OLTP with Microsoft SQL Server

An all-flash Nutanix NX-3460-G5, four-node appliance running Acropolis software v5.0 was used for the OLTP workload. Each appliance consisted of dual Intel Xeon E5-2680v4 processors with 14 cores, running at 2.4 GHz. Six SSDs were leveraged, offering 11.5 TB total capacity and 256 GB of RAM. Dell’s Benchmark Factory was used to generate the OLTP database workload that emulated the database activity of users in a typical online brokerage firm as they generated trades, performed account inquiries, and executed market research. The workload was composed of multiple transaction types with a defined ratio of execution—some performed database updates, requiring both read and write operations, while others were read-only. The estimated read/write I/O ratio was 90 reads to 10 writes.

Four Windows Server 2012 R2 VMs running SQL Server 2016 were configured with 26 vCPUs and 64 GB of RAM. The databases were sized at 300 GB (scale factor of 32). Four agents were used to generate a total of 80 concurrent users per VM (totaling 320 cluster-wide users), so that all users interacted with the database as quickly as possible (no think time). Test runs were completed for each VM count (one to four) to highlight predictable performance scalability as the demanding OLTP workload exercised more resources in the cluster. It should be noted that IOPS and transactions/sec do not have a 1:1 correspondence. In most cases, a single transaction comprises multiple read and/or write I/Os. Another important metric difference is latency. Storage latency is often associated with IOPS, while the transaction response time as reported in this analysis is specific to the OLTP workload, which exercises both compute and storage. As shown in Figure 1, ESG analyzed the transactions/sec and average transaction response in seconds.
ESG reviewed data showing consistent performance scaling as the concurrent database instances increased from one to four, while average transaction response times remained very low. The total number of transactions/sec averaged 2,658 per database instance, with the lowest-yielding SQL Server VM producing 2,635 transactions/sec and the highest-yielding SQL Server VM producing 2,703 transactions/sec. This showed a twofold benefit: not only consistent OLTP performance scalability as more nodes are added to the cluster, but also an even workload distribution that predictably consumed resources without impacting the other SQL Server instances. Even more impressive to ESG was the average transaction response time, which accounted for more than just storage latency, factoring in database responsiveness with compute being a factor. The Nutanix solution consistently delivered ultra-fast speeds of .031 seconds per transaction with all four nodes running the workload. This application performance correlated with average storage read latency of 0.95 ms and average write latency of 1.59 ms.

**OLTP with Oracle Databases**

Next, ESG analyzed results of an emulated real-world transactional workload running on an Oracle database. Two all-flash Nutanix NX-9460-G4 appliances were used for this portion of testing, containing dual Intel Haswell E5-2680v3 processors with six SSDs offering 9.6 TB total capacity and 256 GB of RAM. Sixteen total VMs (running Red Hat Enterprise Linux [RHEL] 7.2 with six vCPUs and 32GB of RAM) were configured with a single instance Oracle database. Each VM was given a 100GB vDisk for RHEL, a 100GB vDisk dedicated for the Oracle Cluster Registry (OCR), and sixteen 125GB vDisks for Oracle database data files and online redo logs. Also, Linux Udev was used for disk persistency.

SLOB was used to efficiently generate realistic system-wide, random, single-block, and application-independent SQL queries. The tool exercised all components of the server and storage subsystems by stressing the physical I/O layer of Oracle through SGA-buffered random I/O, without being limited to a specific load-generating application. ESG analyzed the total number of read and write IOPS, as well as overall latency as the workload scaled from four to sixteen SLOB instances across two appliances (eight nodes), with each instance handling 24 concurrent users.

The IOPS and latency results of the SLOB testing are shown in Figure 2. Performance scaled consistently while response times remained very low. It is important to note that in the case of the 16 SLOB instances, two instances were run on each node, generating a high transactional workload that puts a heavy burden on the CPU of each database server. A general rule of thumb for acceptable latency in OLTP databases is 10 ms. Not only did ESG review data with consistent latency as the number of instances increased, but even at the largest scaling point, read latency did not exceed 1 ms and log file write latency peaked at 1.64 ms at the highest scaling point. By yielding this level of performance, ESG feels this platform could easily support the demands placed on it by large ERP applications.
ESG dug deeper on the eight-instance test case with a total of 375,249 IOPS to analyze how the overall result was distributed across nodes. This is an important aspect of a hyperconverged infrastructure: having an even distribution of the workload across all the nodes in the cluster helps to validate the underlying infrastructure’s ability to properly meet the application’s resource consumption requirements. The results are shown in Figure 3. ESG observed that the workload was distributed very evenly among all eight SLOB instances, averaging approximately 46,906 IOPS with very little variation between instances, with a minimum of 44,446 IOPS and a maximum of 48,087 IOPS.

**Figure 3. SLOB Workload Distribution**

Source: Enterprise Strategy Group, 2017
Why This Matters

Delivering high levels of performance is a requirement for IT environments that rely heavily on mission-critical OLTP databases. This is especially important in dynamic environments where data growth and constant accessibility is a given. The ability to easily meet these database performance and scalability requirements is essential for anyone evaluating hyperconverged infrastructures. The challenge is that some organizations feel there is too much overhead between the virtualization and the essential underlying services that must always be running to not only ensure proper functionality of the hyperconverged infrastructure, but also to meet strict application performance SLAs. The perception is that for transaction-heavy applications that exercise both compute and storage, hyperconverged solutions will be unable to deliver predictable and consistent performance at scale.

ESG confirmed that Nutanix delivered consistent application performance scalability as a workload increased its demands on the underlying storage. Real-world testing exercised both storage and compute to highlight the type of performance organizations can expect in their own OLTP database environments. Both OLTP database environments delivered predictable performance as the number of database instances doubled, including an even distribution of cluster-wide IOPS and consistently low response times, even at higher scalability data points.

Microsoft Exchange

For the Exchange workload, ESG validated Nutanix’s ability to meet the Jetstress storage performance requirements of a best-practice designed, highly-available Exchange environment. An all-flash Nutanix NX-3460-G5, four-node appliance running Acropolis software v5.0 was used for the test. The nodes consisted of dual 14-core Intel Xeon E5-2680v4 processors running at 2.4 GHz with 256 GB of RAM. The all-flash storage configuration consisted of 24 total disks, and when assigned a Nutanix replication factor of 2, offered 33.8 TB of total formatted capacity. Allowing for N+1 node redundancy and conforming to Microsoft’s recommended maximum multi-role server memory guidelines, Jetstress was configured to emulate up to 20,000 mailboxes with a mailbox size of 1 GB and an I/O rate of 1.0 IOPS per mailbox. Twelve 1.85 TB databases (four per node) were used to meet mailbox capacity requirements. A response-time goal of 20 milliseconds or less for database reads was required to pass the test. These values are defined by Microsoft as a limit beyond which end-users will feel that their e-mail system is acting slowly. It should be noted that in a best-practice designed Jetstress test such as this, parameters are tuned to provide the target number of user required IOPS with latency being the result of measure. The aggregate IOPS and latency performance results are shown in Table 1. A thorough review of all results definitively showed that the Nutanix appliances passed all tests, with database read latency staying well below the 20 ms pass/fail threshold. Most impressive to ESG was the database read latency, which never exceeded 0.85 ms. This result outperforms reference 3-tier platforms with separate compute and all-flash storage.

Table 1. Jetstress - Exchange 2016 Storage Performance on Nutanix

<table>
<thead>
<tr>
<th>Database Disk Transfers/sec</th>
<th>Database</th>
<th>Transaction Log</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reads/sec</td>
<td>Read Latency</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>22,163.70</td>
<td>0.84 ms</td>
</tr>
<tr>
<td></td>
<td>15,160.22</td>
<td></td>
</tr>
</tbody>
</table>

As explained earlier, an even distribution of the workload across all the nodes in the cluster is an important aspect of a hyperconverged infrastructure. With that in mind, ESG further analyzed the Jetstress results to understand how the Exchange database instances performed compared with each other. As shown in Figure 4, the workload was evenly distributed across the twelve database instances, averaging approximately 1,847 IOPS with very little variation between instances, with a minimum of 1,834 IOPS and a maximum of 1,860 IOPS. Database read latency also showed very little variation, averaging 0.84 ms with a minimum of 0.83 ms and a maximum of 0.85 ms.

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Why This Matters

Microsoft Exchange is a lifeline for many businesses, functioning as the primary means of communication, collaboration, and business workflow. IT executives treat Microsoft Exchange as one of the most critical applications they support, and they strive for an optimal balance of performance, availability, and cost-effectiveness. Therefore, slow response time or unpredictable performance can have major impacts to a company’s bottom line, including loss of sales, loss of customer goodwill, loss of productivity, loss of competitiveness, and increased costs.

ESG Lab confirmed that the Nutanix platform easily handled the storage density and performance requirements of a real-world designed Exchange 2016 environment. When configured to meet Microsoft’s recommended maximums, both IOPS and response times easily passed Microsoft requirements. The Nutanix platform delivered consistent storage performance, while response times were impressively low, remaining under 0.85 ms for database reads and under 0.82 ms for transaction log writes.

Virtual Desktop Infrastructure (VDI)

ESG Lab audited the performance of a VDI implementation using the Nutanix reference architecture and Acropolis software v5.0 best practice guidelines. Several different Nutanix appliances were used in the configuration to host the test harness and Citrix XenDesktop services and infrastructure, but ESG focused on the desktop density of one, four, six, and eight-node Nutanix NX-3460-G5 appliances hosting the actual desktops. The clients were configured to run Windows 10 (x64) and included common applications such as Office 2013, Internet Explorer, and Adobe Reader; and were configured with 2 vCPUs and 3 GB of RAM.

Login VSI, the industry-standard VDI benchmarking tool, was used as the test harness. Login VSI validates application performance and response times for various predefined VDI workloads with a goal of showing desktop density potential for a given set of hardware and software components. Results are presented using easily understandable Login VSI metrics that represent the number of concurrent sessions running when the VDI environment reaches a saturation point. The workload used for testing was knowledge worker v4.1, which implemented testing by starting each session and then executing anywhere from five to nine applications, while attempting to consume 100% CPU and an average of 8.5 IOPS per virtual user. This process was started every 30 seconds on each new session with response times as the key metric monitored. Four tests were run at four different scaling points—one, four, six, and eight nodes—with each node handling 150 sessions.
ESG focused on two core metrics as reported by Login VSI (Figure 5): VSI Index Average and VSImax v4.1. The VSI Index Average, represented by the slightly upward trending blue line, serves as an average response time measurement, but leverages built-in rules to help factor in spikes while not offsetting the overall average. As more sessions are started, the VSI Index Average gradually increases. VSImax v4.1 shows the number of concurrent sessions that can be active before the infrastructure is saturated, and is primarily used to provide insight into the potential scalability that an environment can sustain while meeting acceptable performance requirements. The VSImax score is the point where the VSImax average crosses the VSI Threshold (straight red line). This signifies the point at which performance becomes unacceptable. It should be noted that a VSIbase gets determined during the baseline phase, which takes 30 VSI samples, eliminates outliers, and averages the remaining times. This metric helps to prevent incorrect or misleading results.

The results of the eight-node, 1,200 session test are shown in Figure 5. The cluster easily supported the performance demands of 1,200 knowledge workers. With the VSI threshold set at 1,720 ms, ESG reviewed data showing the VSImax average staying below the threshold, meaning the cluster could have supported even more users. As the 1,200th session executed tasks, the VSImax average was 1,334ms. During testing, cluster-wide CPU utilization, IOPS, and latency were monitored through Prism, Nutanix’s management platform. CPU ramped up from just over 20% to a peak of 89.8% once all desktops were online and executing tasks. During test ramp-up, IOPS peaked at 23,857. During the actual testing, storage IOPS averaged 8,720, while latency peaked at 5.63ms.

Figure 5. Login VSI Results for 1,200 Sessions on Eight Nutanix Nodes

Working backwards, ESG reviewed the results from the one, four, six, and eight node tests, analyzing the predictability of scaling the knowledge worker Login VSI workload. Figure 6 highlights the scalability results. The Nutanix platform easily handled the 150-sessions-per-node scaling factor from one to eight nodes. Four theoretical data points are also shown to highlight the perfect scalability potential of the Nutanix platform. Even more impressive is that at all measured data points, there is more than enough head room from CPU and storage resources to not only support more sessions per node, but to handle unpredictable bursts of performance while still delivering a positive experience to all end-users.
Why This Matters

Implementing a virtual desktop infrastructure can be a challenge for IT staffs. Performance is always a top concern and challenge due to the unpredictability of end-users using the solution. All it takes is a single user transferring a massive file or many small files, and the entire deployment can be brought to its knees. A platform that can easily handle both the large bursts of IOPS during boot storms and the demanding steady states of power users is a start, but being able to easily scale based on organizational growth is equally important.

ESG confirmed that a Nutanix cluster, based on the Nutanix VDI reference architecture and best practices, supported the scalability demands of a dynamically growing VDI deployment. As a workload driven by Login VSI ramped up and hit steady state, cluster-wide CPU, IOPS, and latency were monitored, proving that an even heavier load could comfortably be supported and still deliver a positive end-user experience. With a scaling factor of 150 sessions per node, from one to eight nodes, up to 1,200 sessions ramped up and completed common knowledge worker tasks while infrastructure latency remained well below the Login VSI average response time threshold.
The Bigger Truth

Organizations want the simplicity and scalability of the cloud, while being able to predict costs for mission-critical applications with high-performance SLAs. These “wants” align well to the shifting evaluation criteria and priority lists of organizations looking to adopt hyperconverged technologies. It is no longer just about cost-savings and simplicity, but also performance, scalability, and reliability. High levels of reliable and scalable enterprise-class performance have become less of a wish, and more of an expectation. Unfortunately, evaluating performance is particularly difficult with hyperconverged offerings, since the underlying resources are shared throughout the infrastructure.

ESG audited performance results and validated that the Nutanix Enterprise Cloud Platform meets the demanding performance requirements of multiple dynamic, mission-critical applications. The Nutanix platform passed a Jetstress test with significant storage performance headroom, delivering IOPS and latency results that far exceeded the expectations of even the most demanding Exchange environments at some of the largest global organizations. Real-world testing exercised both compute and storage resources to meet the high transactions and latency demands of scalable OLTP database deployments in both a SQL Server and Oracle production environment typically found in industry-leading brokerage houses and online retailers. Also, one to eight node VDI clusters delivered exceptional performance results with the type of linear scale required to run large-scale enterprises, call centers, and health facilities.

As hyperconverged technologies continue to mature, Nutanix remains at the forefront by being able to satisfy the performance requirements and expectations of even the most performance-demanding organizations. If you are looking to modernize your IT infrastructure to gain the benefits of both the cloud and on-premises deployments, ESG suggests looking at Nutanix.
### Appendix

#### Table 2. Test Bed Configuration

<table>
<thead>
<tr>
<th>OLTP with Microsoft SQL Server 2016</th>
<th>Platform</th>
<th>All-flash Nutanix NX-3460-G5 running Acropolis software v5.0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Node specifications</strong> (four total)</td>
<td></td>
<td>2 x Intel Xeon E5-2680v4 processors (14 cores at 2.4 GHz) 256 GB RAM 6 x SSDs (11.5 TB total capacity)</td>
</tr>
<tr>
<td><strong>VM configuration</strong> (one per node)</td>
<td></td>
<td>Windows Server 2012 R2 SQL Server 2016 SP1 26 x vCPUs 64 GB RAM</td>
</tr>
<tr>
<td><strong>Database</strong> (one per VM)</td>
<td></td>
<td>300 GB database (scale factor of 32) 80 x concurrent users (no think time)</td>
</tr>
<tr>
<td><strong>Workload generation tool</strong></td>
<td></td>
<td>Benchmark Factory</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OLTP with Oracle</th>
<th>Platform</th>
<th>All-flash Nutanix NX-9460-G4 running Acropolis software v5.0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Node specifications</strong> (eight total)</td>
<td></td>
<td>2 x Intel E5-2680v3 processors (12 cores at 2.5 GHz) 256 GB RAM 6 x SSDs (9.6 TB total capacity)</td>
</tr>
<tr>
<td><strong>VM configuration</strong> (up to two per node, sixteen total)</td>
<td></td>
<td>Red Hat Enterprise Linux [RHEL] 7.2 6 x vCPUs 32 GB RAM</td>
</tr>
<tr>
<td><strong>Database</strong> (one per VM)</td>
<td></td>
<td>Oracle Database 12.1.0.2 16 x 125 GB vDisk (Oracle database data files and online redo logs) 24 x concurrent users</td>
</tr>
<tr>
<td><strong>Workload generation tool</strong></td>
<td></td>
<td>Silly Little Oracle Benchmark (SLOB)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Microsoft Exchange 2016</th>
<th>Platform</th>
<th>All-flash Nutanix NX-3460-G5 running Acropolis software v5.0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Node specifications</strong> (three total)</td>
<td></td>
<td>2 x Intel Xeon E5-2680v4 processors (14 cores at 2.4 GHz) 256 GB RAM 6 x SSDs (11.5 TB total capacity)</td>
</tr>
<tr>
<td><strong>VM configuration</strong> (one per node)</td>
<td></td>
<td>Windows Server 2012 R2 Exchange 2016 (ESE 15.01.0669.032) 14 x vCPUs 96 GB RAM</td>
</tr>
<tr>
<td><strong>Database</strong> (four per node)</td>
<td></td>
<td>4 x 1.85 TB 1 GB per mailbox 20,000 x mailboxes (10,000 active, 10,000 passive; 20,000 active tested) 1 DAG 6 x servers per DAG (3 x servers tested) 6,666 x mailboxes per server 2 x mailbox copies per database 1,666 x mailboxes per database 22.26 TB total database size for performance testing</td>
</tr>
<tr>
<td><strong>Workload generation tool</strong></td>
<td></td>
<td>Jetstress 2013 (15.01.0466.031) 1 IOPS per mailbox (0.8 + 20% headroom)</td>
</tr>
</tbody>
</table>
## Virtual Desktop Infrastructure (VDI) with Citrix XenDesktop

<table>
<thead>
<tr>
<th>Platform</th>
<th>Hybrid Nutanix NX-3460-G5 running Acropolis software v5.0</th>
</tr>
</thead>
</table>
| Node specifications (up to eight total) | 2 x Intel Xeon E5-2680v4 processors (14 cores at 2.4 GHz)  
512 GB of RAM  
2 x SSDs and 4 x HDDs (9.12 TB total capacity) |
| VM configuration (150 per node) | Windows 10 (x64)  
2 x vCPUs  
3 GB RAM |
| Workload generation tool | Login VSI  
*knowledge worker v4.1* workload profile |

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