

**Technical Validation** 

# Optimizing Application Performance and Manageability with NVMe over Fibre Channel

Broadcom NVMe over Fibre Channel with VMware vSphere 7.0 Support

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# **ESG Technical Validations**

The goal of ESG Technical Validations is to educate IT professionals about information technology solutions for companies of all types and sizes. ESG Technical Validations 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 objectives are to explore some of the more valuable features and functions of IT solutions, show how they can be used to solve real customer problems, and identify any areas needing improvement. The ESG Validation Team'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.



#### Introduction

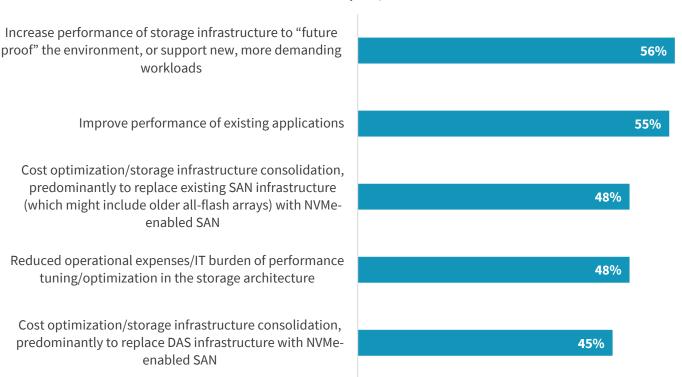
This ESG Technical Validation documents performance testing of Non-Volatile Memory Express (NVMe) over Fibre Channel (FC), including a comparison between applications leveraging storage supporting both NMVe over FC (NVMe/FC) and SCSI over FC (SCSI/FC) storage protocols. We also tested the ease of application migration in VMware vSphere 7.0 environments with Broadcom's Brocade Gen 6 Switches and Emulex's dual protocol LPe35002 32Gb/s host bus adapters.

# **Background**

ESG research has uncovered that 71% of surveyed businesses have already deployed or are planning to deploy NVMe-based flash storage. And the two most often cited objectives for leveraging NVMe were to increase performance of storage infrastructure to "future proof" the environment or support new, more demanding workloads, and to improve performance of existing applications (see Figure 1).<sup>1</sup>

Figure 1. Top Drivers for Using On-premises NVMe-based Flash Storage

Which of the following objectives are driving your organization's use of or interest in onpremises NVMe-based flash storage? (Percent of respondents, N=305, multiple responses accepted)



Source: Enterprise Strategy Group

While organizations note the advantages of NVMe, concerns remain on how to easily leverage this storage type to enable faster data access and improved application performance. They would ideally use NVMe-based storage without incurring additional time or costs on purchasing additional storage network infrastructure or modifying existing administrative processes. Organizations want to reap the advantages of NVMe while not drastically changing how they build or operate their existing application environments, specifically those supported by Fibre Channel (FC) storage area networks (SANs) and VMware vSphere.

<sup>&</sup>lt;sup>1</sup> Source: ESG Master Survey Results, <u>2019 Data Storage Trends</u>, November 2019.



### Broadcom NVMe over Fibre Channel Solutions with VMware vSphere 7.0 Support

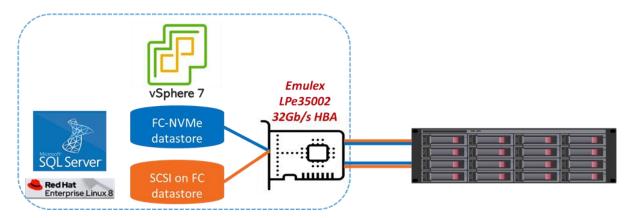
Broadcom's NVMe over Fibre Channel (NVMe/FC) solution enables organizations to leverage NVMe-based storage within FC SANs. This solution is enabled via the Emulex LPe35002 32Gb/s host bus adapter (HBA) with full support for VMware vSphere 7.0. The combination of the Emulex HBA and VMware support enables organizations to increase performance of applications running on VMware ESXi servers while maintaining the existing benefits organizations already derive from FC-based SANs.

Broadcom's Brocade Switches and Emulex HBAs enable organizations to support both SCSI/FC and NVMe/FC protocols concurrently in the same FC SAN without having to rip and replace any storage infrastructure. Organizations can realize application performance improvements on existing FC SANs at the switch, server, and storage levels (front and back of the storage array). The Brocade Gen 5 and higher Switches are NVMe over Fibre Channel-ready so organizations can implement this solution within their existing SAN architecture. At the server level, the Emulex 32Gb/s HBA enables a shorter path through the operating system storage stack, thus lowering overall CPU utilization. At the front of the NVMe/FC-enabled storage array, the HBA also enables a shorter path to the storage target, increasing IOPS. Finally, moving from SCSI/FC to NVMe/FC-based storage decreases latency.

With the Emulex HBA's dual protocol support, organizations can simply present NVMe/FC storage via VMware vCenter 7.0 to existing VMware ESXi hosts. Organizations can migrate virtualized enterprise applications easily in existing VMware environments from SCSI/FC to NVMe/FC-based storage to improve performance. Emulex's support for VMware vSphere 7.0 also helps organizations to use their same VMware environments so that they do not have to learn or implement new administrative procedures. VMware support also helps to enhance the ability of Broadcom's solution to optimize mission-critical application performance.

Figure 2 illustrates a VMware ESXi 7.0 environment with Emulex 32Gb/s HBAs.

Figure 2. Dual SCSI/FC and NVMe/FC support in VMware vSphere 7.0 Environments with Emulex LPe35002 32Gb/s HBAs



#### **ESG Technical Validation**

ESG conducted tests with the Brocade Gen 6 Switch and Emulex LPe35002 32Gb/s at Broadcom's facilities in San Jose, CA. Testing was designed to observe the ease of application migration within a VMware vSphere 7.0 environment from SCSI/FC to NVMe/FC-based storage while improving performance. We also validated that the Emulex 32Gb/s HBA delivered higher transaction rates and application performance for both Microsoft Server SQL 2017 and Oracle 19c workloads.

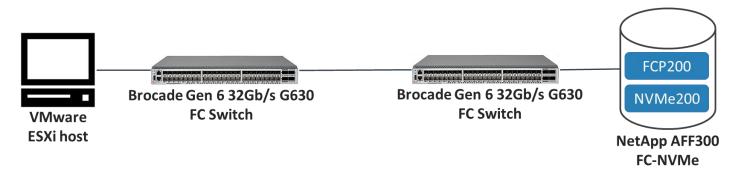


## Ease of Application Migration with VMware vCenter

For organizations that wish to take advantage of NVMe's benefits, the ability to integrate NVMe into existing virtualized application environments cannot be taken for granted. When using the Broadcom NVMe over Fibre Channel solution with VMware vSphere 7.0 Support, administrators can easily migrate applications from SCSI/FC to NVMe/FC-based storage to increase performance without investing in additional storage infrastructure and modifying operational processes.

Our testbed consisted of the following components, as shown in Figure 3. Using VMware vCenter 7.0, we connected an ESXi host containing multiple virtual machines (VMs) to datastores loaded onto the NetApp All-Flash FAS AFF300 via an NVMe fabric supported by two Brocade Gen 6 G630 FC Switches. The Emulex HBA is installed in the ESXi host. The NetApp AFF contains two physical disks—a 10GB SCSI/FC disk (containing the "FCP200" datastore) and a 10GB NVMe/FC disk (containing the "NVMe200" datastore).

Figure 3. Testbed for Evaluating Ease of Application Migration



#### **ESG Testing**

ESG began with viewing the VMware ESXi 7.0 host through vCenter 7.0. Using industry standard tools, we generated an OLTP-like workload on "VM21" (see Figure 4) with a 70/30 read/write ratio, 32 threads, queue depth of two, and 4KB I/O size. We used this simulated workload to characterize performance before and after application migration. VM21 was initially connected to the datastore on "FCP200." Average application I/O response time was recorded slightly above 0.001 seconds, and average speed was measured around 250 MB/sec.

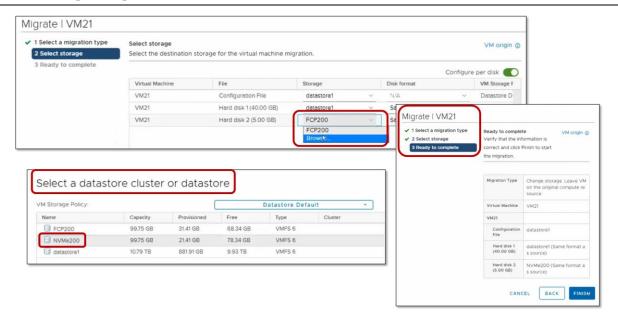


Figure 4. Performance before Application Migration with VMware vCenter 7.0



To migrate the application, ESG initiated a storage vMotion. ESG navigated to the "Migrate VM21" window and chose to only change the storage type (see Figure 5). We selected "FCP200" and chose "Browse..." from the drop-down menu. We then selected the "NVMe200" datastore. Once the system automatically performed compatibility checks, the final window popped up and prompted us to complete the migration by clicking "Finish."

Figure 5. Executing Storage vMotion from FCP200 to NVMe2000



After completing the storage vMotion, ESG observed the change in both the average application I/O response time and MB/s (see Figure 6). We noted the brief drop in performance right after the vMotion to NVME but quickly saw performance increase to slightly under 600 MB/s, more than double than what was observed on the SCSI/FC disk. We also observed that the average application I/O response time trended downward from 0.001 seconds to approximately 0.0007 seconds.

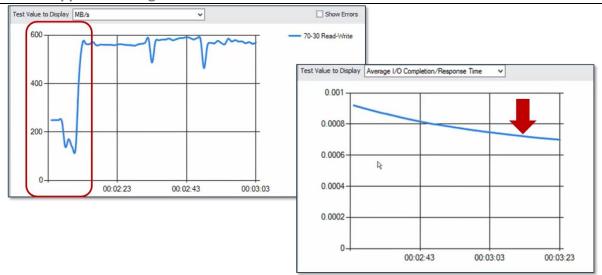


Figure 6. After Application Migration with VMware vCenter 7.0

Based on our testing, ESG found that moving an OLTP-type application from SCSI/FC to NMVe-based storage does not require installing new hardware in an FC SAN or learning new management systems and procedures. Both SAN and VMware administrators can leverage the same tools and SAN infrastructure to provision new storage types for applications, as long as the new storage can be presented as a datastore in VMware vCenter. Thus, organizations can minimize both capital and operational expenses.

ESG also noted that the storage vMotion was completed while the application was still running. Migrating applications typically requires IT to involve the application owners, VMware administrators, SAN administrators, and possibly end-users to determine how and when to perform the migration. They would coordinate when to stop, move, and bring the application back online. This approach consumes time and resources, and is therefore costly to the business. With Emulex's concurrent support for SCSI and NVMe along with VMware vSphere 7.0, application migration is easy and non-disruptive.



# **Why This Matters**

Ease of application migration from SCSI/FC to NVMe/FC enables organizations to accelerate application performance in critical areas such as analytics, OLTP, and other transactional operations. As a result, decisions can be made faster, potentially speeding time to market, improving customer satisfaction, and fast-tracking other initiatives that influence competitive advantage.

ESG validated that support for VMware vSphere 7.0 on the Broadcom NVMe over Fibre Channel solution can help organizations to perform application migrations from SCSI/FC to NVMe/FC-based storage easily. We verified that migrating an application from accessing SCSI/FC to NVMe/FC-based storage can be done using tools that many organizations already use in their virtualized application environments—VMware vSphere. Because the migration happens at the driver level via the Emulex 32Gb/s HBA, no additional storage infrastructure is needed for performing such migrations.

#### **Increase in Application Performance**

Faster access to data helps to increase overall application performance. With NVMe/FC-based storage, application performance can drastically improve, helping organizations to improve their response time to business needs. Applications such as databases can clearly help the business to make faster decisions and improve time to market.

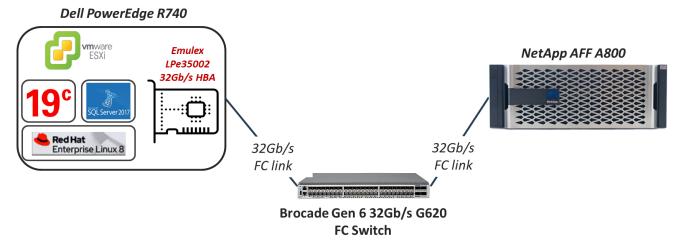


To validate the increased application performance delivered by the Emulex LPe35002 32Gb/s HBAs, we used the testbed shown in Figure 7. This testbed consisted of a Dell PowerEdge R740 server with 24 CPUs, each supporting 2 logical CPUs, for a total of 48 logical CPUs.

VMware ESXi 7.0 was installed on the Dell server. One VM was installed with Red Hat Enterprise (RHEL) v8.0, the operating system on which both Oracle 19c and Microsoft SQL Server 2017 ran. Both database solutions ran on VMs acting as database servers, each with 48 vCPUs and 50 GB of memory. To ensure that we gauged how storage contributed to overall application performance, database configurations for both applications maintained a 1:10 relationship between the amount of database memory allocated and the data set.

The Emulex 32Gb/s HBA was installed in the Dell server and connected with two NetApp AFF A800 nodes via 32 FC links into and out of a Brocade G620 FC Switch. Testing utilized a single port on all equipment. Both an NVMe namespace and SCSI/FC LUN were enabled on the AFF A800.

Figure 7. Testbed for Evaluating OLTP Performance with Oracle 19c and Microsoft SQL Server 2017



#### **ESG Testing**

ESG tested OLTP performance of both Oracle 19c and Microsoft SQL Server 2017 with the goal of benchmarking performance on the Emulex 32Gb/s HBA when accessing both SCSI/FC and NVMe/FC-enabled storage. Using HammerDB 3.2,² we populated the database schema and generated a "TPC-C like" workload for each database application. Each workload simulated 1,000 data warehouses containing a 100GB data set. For each database application, the test had a ramp-up time of five minutes and a runtime of five minutes. Tests were run twice for each database application, and we noted the better result.

For our tests with Microsoft SQL Server 2017, ESG simulated 48 users, each conducting one million transactions. We measured performance using total transactions per minute (TPM).<sup>3</sup> Results of the Microsoft SQL Server 2017 test are shown in Figure 8.

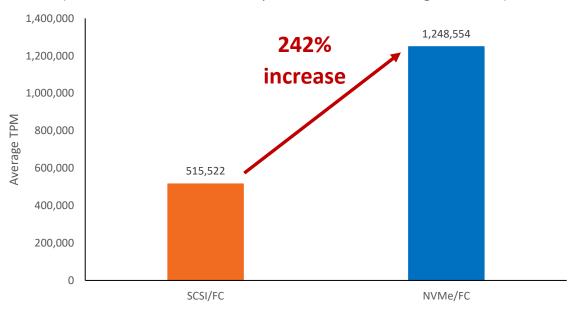
<sup>&</sup>lt;sup>2</sup> HammerDB is an open source load testing and benchmarking application used to test databases running on any operating system. It supports a number of databases such as Oracle Database, Microsoft SQL Server, DB2, PostgreSQL, and Amazon Aurora.

<sup>&</sup>lt;sup>3</sup> TPM is the combined number of user commits (database changes occurring during the transaction) and user rollbacks (restorations on a database when cancelling a transaction).



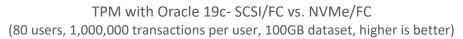
Figure 8. Microsoft SQL Server 2017 Performance – SCSI/FC versus NVMe/FC Storage

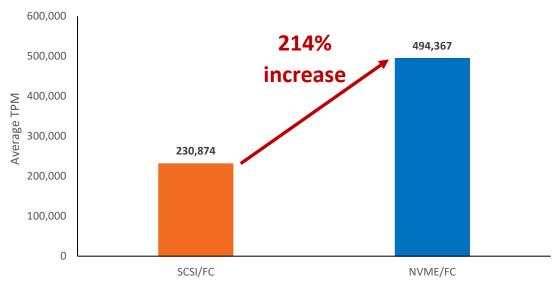
TPM with Microsoft SQI Server 2017 - SCSI/FC vs. NVMe/FC (48 users, 1,000,000 transactions per user, 100GB dataset, higher is better)



ESG ran the same test with Oracle 19c. We increased the number of users from 48 to 80. Results are shown in Figure 9.

Figure 9. Oracle 19c Performance – SCSI/FC versus NVMe/FC Storage





# What the Numbers Mean

• Higher TPM results indicate the database infrastructure for both Microsoft SQL Server 2017 and Oracle 19c can support a larger number of concurrent users who are getting more work done and processing more orders.



- Transaction results captured by the HammerDB utility quantify the benefits of the improved performance of Emulex 32Gb/s FC HBA with end-to-end NVMe.
  - Migrating a Microsoft SQL Server 2017 application from SSCI/FC to FC/NVMe-based storage increased TPM
    2.4x
  - o Migrating an Oracle 19c 2017 application from SSCI/FC to FC/NVMe-based storage increased TPM 2.1x.



# **Why This Matters**

For many large enterprises, response time-sensitive workloads such as OLTP and e-commerce are critical revenue drivers. The faster that OLTP applications, particularly database applications, can be executed, the greater the impact to the business. Faster transactions per minute leads to greater customer satisfaction, which lead to higher revenue.

ESG validated that an end-to-end NVMe solution enabled by Broadcom's Brocade Gen 6 Switch and Emulex's 32Gb/s HBA with VMware ESXi 7.0 support increased database performance when comparing average transactions per minute (TPM) achieved using NVMe/FC-based storage with SCSI/FC-based storage. When testing Microsoft SQL Server 2017, we achieved an average of 240% more TPM when accessing NVMe/FC-based storage. Similarly, when testing Oracle 19c, the average TPM increased by 214% using NVMe-based storage over SCSI/FC-based storage.

# **The Bigger Truth**

Flash has been a game changer for IT and data center environments, but its potential is limited by traditional data networks. With hard drives, the bottleneck in the data path was obvious. With flash and now NVMe, the performance bottleneck is often no longer the storage and moves to the network. NVMe over Fabric technology is poised to remedy that situation with a storage network designed for the low latency of flash media. There is already tremendous interest for NVMe over Fabric technology, because without it, IT infrastructure limits the potential of what flash storage can deliver. To reap these benefits easily, organizations would desire a solution that integrates seamlessly into their existing IT infrastructure and operational processes without requiring additional storge infrastructure or learning new management procedures.

Broadcom's Brocade Gen 6 Switches and Emulex's LPe35002 32Gb/s host bus adapter (HBA) with full support for VMware vSphere 7.0 helps organizations to increase the performance of applications currently running on VMware ESXi servers while maintaining the existing benefits offered by FC SANs. Not only can organizations experience higher performance, but they can also benefit from the dual support for both SCSI/FC and NVMe/FC protocols. Organizations can leverage NVMe storage without ripping and replacing any storage infrastructure or management systems, helping to minimize overall capital expenses. With VMware vSphere 7.0 support, organizations can migrate applications from SCSI/FC to NVME-based storage using existing operational processes with little disruption to application performance.

ESG validated that organizations can easily leverage NVMe storage while continuing to use their existing VMware vSphere application environments and FC SANs. As long as NVMe storage can be presented within VMware vCenter, organizations can migrate applications between datastores with minimal end-user impact, while achieving higher performance. We also tested the difference in the average transactions per minute when using two database applications—Microsoft SQL Server 2017 and Oracle 19c—to access a data set loaded on SCSI/FC and NVMe/FC-based storage. We found that transactions per minute increased 2.4x and 2.14x, respectively, when Microsoft SQL Server 2017 and Oracle 19c accessed data loaded on NVMe/FC-based storage compared with SCSI/FC-based storage.



While Broadcom's solution does not require organizations to make huge changes to either the existing SAN infrastructure or current IT operating procedures, it is always a good idea to gauge exactly what changes may need to occur to achieve the benefits of simplicity in IT daily activities and increased performance simultaneously.

If your organization is looking to accelerate access to data throughout your storage infrastructure and capitalize on its potential to increase value and revenue, then ESG believes that you should consider the potential advantages of leveraging Broadcom's 32Gb/s NVMe/FC solution with VMware vSphere 7.0 support in your existing FC SANs.

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