Gen 6 Fibre Channel Evaluation of Products from Emulex and Brocade

Gen 6 Fibre Channel provides new speeds and features for enterprise datacenters.

Executive Summary

Large enterprises choose Fibre Channel storage networking because of its proven performance, reliability and scalability for mission-critical workloads. Fibre Channel is seeing renewed interest from customers who have deployed other storage technologies. This comes as no surprise since Fibre Channel was purpose-built for storage – it delivers consistently high performance, does not drop packets, and has deep ecosystem support from all of the major operating system (OS) and hypervisor vendors.

Enterprise datacenters are increasingly turning to solid-state (flash) storage to improve storage performance, and they most frequently select Fibre Channel as the host interface to meet their flash storage requirements. In many cases, however, deploying solid-state storage moves the performance bottleneck to the storage network. This situation often drives users to push for higher performance from their storage network infrastructure.

The sixth generation of Fibre Channel is aimed at satisfying the needs of growing deployments of flash storage, hyper-scale virtualization, and new high-speed data center architectures such as NVMe.

Demartek gained early access to the newest Gen 6 products from Emulex and Brocade**®**, and subjected them to a series of SQL Server data warehousing application tests. We found that the new Emulex Gen 6 HBAs and Brocade Gen 6 switches provide the performance needed to alleviate network bottlenecks that can be caused by all-flash arrays and dramatically improve data warehousing application performance. New features boost reliability and deliver a suite of diagnostic, troubleshooting and deployment features.

Key Findings

Demartek found the following regarding the new Emulex LPe32002 32GFC HBAs:
- ◆ Gen 6 products from Emulex and Brocade provide the powerful combination that can be used today to accelerate applications even with existing 8GFC and 16GFC storage arrays.

◆ The Emulex LPe32002 (32GFC) HBA reduced Microsoft SQL Server 2014 data warehouse workload query time by almost half compared to 16GFC and reduced it to a quarter compared to 8GFC connected servers.

◆ Reduced latency for both target and initiator by half when compared to the LPe16002 (Gen5) HBA.

◆ The Emulex ExpressLane feature offers a prioritized write path through application servers and SAN fabrics for critical applications to more effectively use high performance tiered storage assets.

◆ Advanced features developed in conjunction with Brocade accelerate deployment and simplify support that integrates with Brocade Fabric Vision™.

◆ Easy-to-upgrade from previous generations of Fibre Channel (4GFC/8GFC) with forward/backward compatibility– using the same connectors, management, and cabling.

We believe that the results of this benchmark illustrate why flash storage arrays should be combined with Gen 6 Fibre Channel HBAs and switches.

Emulex Gen 6 HBAs

Emulex Gen 6 HBAs deliver 2x greater bandwidth than the previous generation – 12,800MBps (2 ports, 32G, full duplex) – as well as less than half the latency and over 1.6 million IOPS on a single port [the highest FC per port performance seen thus far]. Improvements in the Emulex Gen 6 Fibre Channel adapter technology include operating at faster clock rates and an increased number of hardware offloads that reduce the number of firmware "touch points" required for Fibre Channel connection initialization functions.
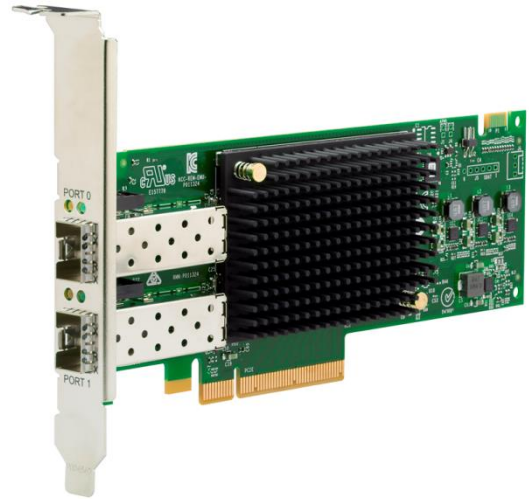
One of the design goals of the new Emulex Gen 6 products was to lower latency in order to complement the growing all-flash storage array market. We visited Emulex labs and validated on specialized laboratory equipment that both the initiator and target latency was cut in half when compared to the previous generation products.

Emulex Gen 6 Fibre Channel Adapter Models

Model	Ports	32GFC	16GFC	8GFC	4GFC
LPe32000-M2	1	✔	✔	✔	
LPe32002-M2	2	✔	✔	✔	
LPe31000-M6	1	*	✔	✔	✔
LPe31002-M6	2	*	✔	✔	✔
LPe31004-M6	4		✔	✔	✔

* Upgradeable to 32GFC with Emulex-branded transceiver kit

LPe32000-series is available in single and dual-port models with 32GFC optics. The Emulex LPe31000–series is available in single, dual and quad-port models with 16GFC optics. The single and dual-port are 32GFC-ready. Optics can be upgraded to 32GFC, enabling data centers to scale-up when needed. The quad-port model is a low-profile board with fixed optics. In order to accommodate a quad-port low-profile form-factor, the transceivers are not upgradeable.

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NVMe over Fabrics Ready

NVM Express (NVMe) is a relatively new protocol for solid-state storage devices built with non-volatile memory technologies. NVMe provides substantially lower latency for storage I/O operations and significantly higher IOPS per device. NVMe will scale up the number of devices it can address by adopting "NVMe over Fabrics" technology. Fibre Channel is one of the fabric technologies that will be supported by NVMe over Fabrics, and the Emulex Gen 6 Fibre Channel adapters are "NVMe over Fabrics Ready."

Dynamic Multi-Core Architecture

Emulex's unique Dynamic Multi-Core Architecture enables Emulex HBAs to apply all ASIC resources to any port that needs it. LPe32000/31000 HBAs are able to provide full IOPS performance – 1.6 million IOPS – to a single-port, which is critical when using dual-port HBAs in an active-standby configuration. In fact, an estimated 80% of HBAs sold are dual-port and configured for active-standby fail-over mode.
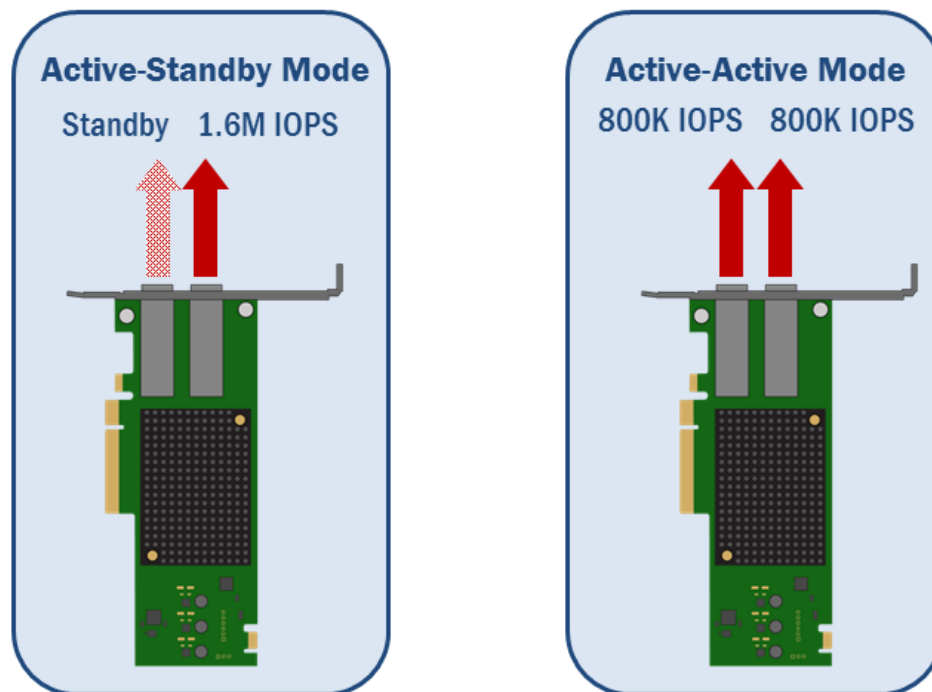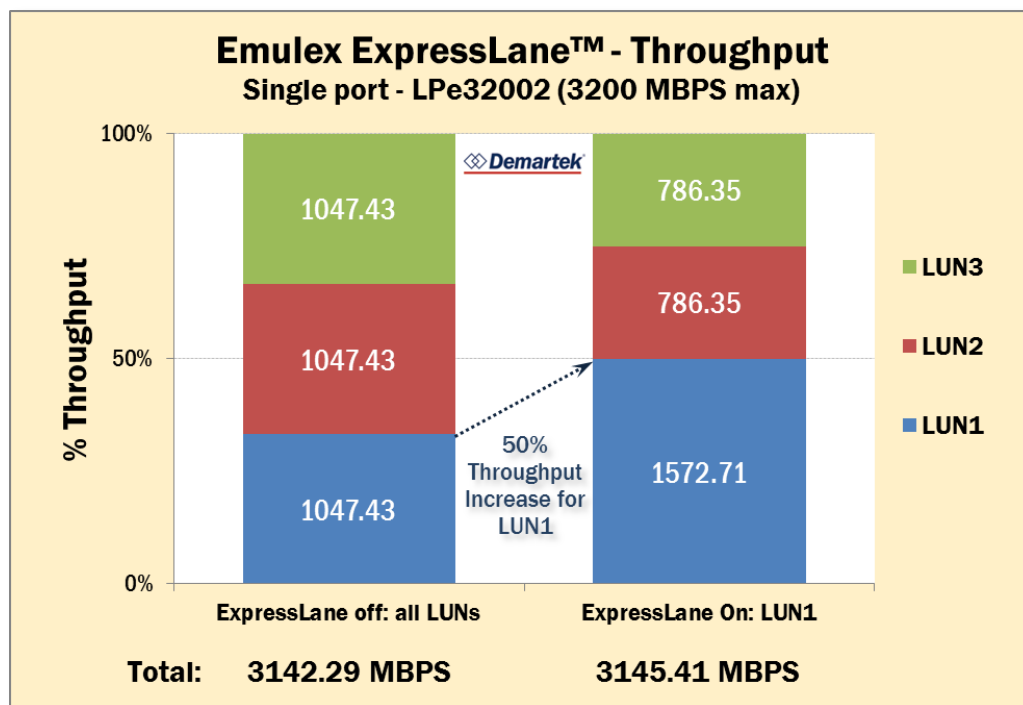

ExpressLane™

In high-density virtual environments with mixed storage, scaling to meet business needs can be complex and often results in performance reduction. Emulex ExpressLane provides Quality of Service (QoS) and application performance between servers and across the fabric by tackling congestion in storage environments. Emulex ExpressLane assigns traffic priorities on the host application's storage path. This priority allows Fibre Channel frames

to get to targets quickly, much like a highway express lane. The Emulex Gen 6 HBA provides a fully compatible prioritized frame to a Brocade switch, creating a virtual insurance policy for critical I/O during peak times in a scaled-out environment. ExpressLane is easily enabled from Emulex OneCommand® Manager extending into Brocade's fabric QoS.

To test ExpressLane, we configured three LUNs on the storage system and connected them all via the same Fibre Channel connection using one port of the Emulex LPe32002 adapter. We ran a workload that consumed approximately one-third of the available bandwidth for each of the three LUNs for the duration of the run. We enabled ExpressLane on one of the LUNs using the Emulex OneCommand Manager and repeated the test. With ExpressLane enabled we found that the ExpressLane enabled LUN achieved a higher throughput than the other two LUNs, without modifying the workload or its settings. This feature allows one LUN to be given higher priority than the other LUNs on the same connection.

ExpressLane is easily enabled and disabled with a right-mouse click on the desired LUN in the Emulex OneCommand Manager, as shown in the screen shot below.

ExpressLane enabled LUN

Right-mouse click enables/disables feature
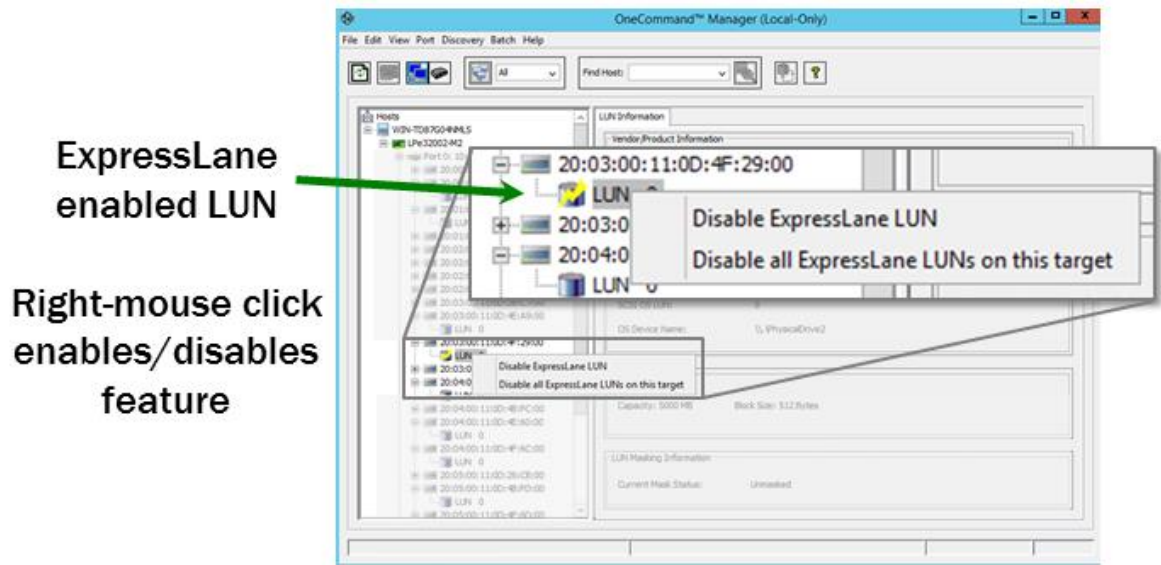
Secure Firmware Update

The new Secure Firmware update feature protects the integrity of firmware with compliance to NIST—SP800-147B standards. Secure Firmware is a feature whereby the Fibre Channel adapter firmware is digitally signed by Emulex. The signature is verified at the time of a firmware update, only allowing authentic firmware images to be loaded on the adapter. This eliminates the possibility of loading firmware that has been tampered with, making security attacks more difficult for hackers.

Forward Error Correction (FEC)

Forward Error Correction (FEC) is a new Gen 6 Fibre Channel standard feature for HBAs and switches that provides enhanced data reliability and performance by automatically detecting and recovering from bit errors. It is especially useful in diverse and complex user environments such as blade system implementations. FEC is a digital signal processing technique that introduces redundant data, called an error correcting code, prior to data transmission or storage. FEC then provides the receiver with the ability to correct errors without a reverse channel to request the retransmission of data, thereby improving performance.

Brocade Gen 6 Fibre Channel Switches

The LPe32000/LPe31000-series of adapters support Brocade I/O Insight for Gen 6 FC which proactively and non-intrusively monitors device and application-level I/O to gain insights into performance and availability, ensuring predictable performance and operational stability. SAN administrators have traditionally had poor visibility into the

performance of storage I/O workloads between host and storage devices, and this inability to locate IOPS and latency issues can create storage related performance problems. The Brocade I/O Insight feature solves this problem by obtaining I/O latency and IOPS metrics for a storage device to diagnose I/O operational issues, including the ability to:

◆ Identify I/Os that deviate from expected behavior to facilitate fault isolation

◆ Locate source of resource contention, congestion and errant storage devices with proactive I/O monitoring of the following:

　◆ Total I/Os

　◆ First response max/avg

　◆ I/O latency (ECT) max/avg

　◆ Outstanding I/O max/avg

The following advanced features and functionality are supported by Emulex Gen 6 HBAs, when connected to a Brocade Gen 5 or Gen 6 switch, providing a complete end-to-end solution:

◆ ClearLink™ (D_Port) – automated end-to-end signal integrity checks help identify any cabling, optics or port issues in minutes versus hours.

◆ Link Cable Beaconing – locates a connection on either the Brocade switch port or the Emulex HBA port by making the LED port glow for easy end-to-end identification.

◆ Host Name Registration – automated capture of information from Emulex HBA ports eliminates the need to manually associate worldwide port names with servers.

◆ Read Diagnostic Parameters – Brocade switches and Emulex HBA ports will self-report diagnostic information, including port speed, link errors, and SFP information (temperature, Tx and Rx power, etc.).

Test Results

The primary workload used for these tests was a data warehousing application workload running on Microsoft SQL Server 2014. This read-intensive data warehousing workload is also known as a decision support application because it gives answers to critical business questions. It consists of a fixed set of 22 queries of relatively high complexity of a large database that examines large volumes of data.

Because this is a fixed set of work, any improvements in infrastructure such as faster Fibre Channel host bus adapters (HBAs) will result in completion of the work in a smaller amount of time.

We compared the performance of this data warehousing workload with three Emulex adapters. The same operating system (Windows Server 2012 R2), the same database software (Microsoft SQL Server 2014) and the same application workload settings were used for all three tests.

- ◆ Emulex LPe12002 – 8GFC
- ◆ Emulex LPe16002 – 16GFC
- ◆ Emulex LPe32002 – 32GFC

When using real database workloads, the I/O rate varies as the workload progresses because the application is not only issuing I/O requests but is also consuming varying amounts of host CPU and memory resources. In our tests, we achieved full line rate for each of the adapters, but the amount of time to complete the workload was much faster for the LPe32002 (32GFC) adapter than the other adapters, as shown in the chart.
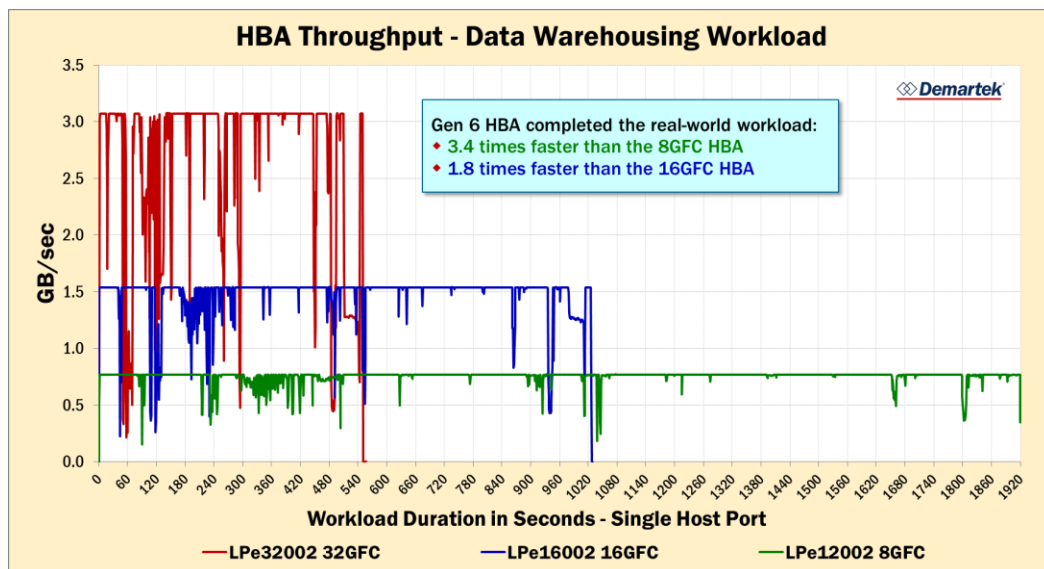
In the following chart, the time to complete each of the individual 22 queries is shown for each of the three adapters. Using the LPe12002 (8GFC) completion time as a baseline, we observed that the LPe32002 (32GFC) adapter achieved a 71% reduction in the time to complete the workload, from approximately 32 minutes to approximately 9 minutes. We believe that this same rate of reduction in time to complete the work would scale to much larger databases.
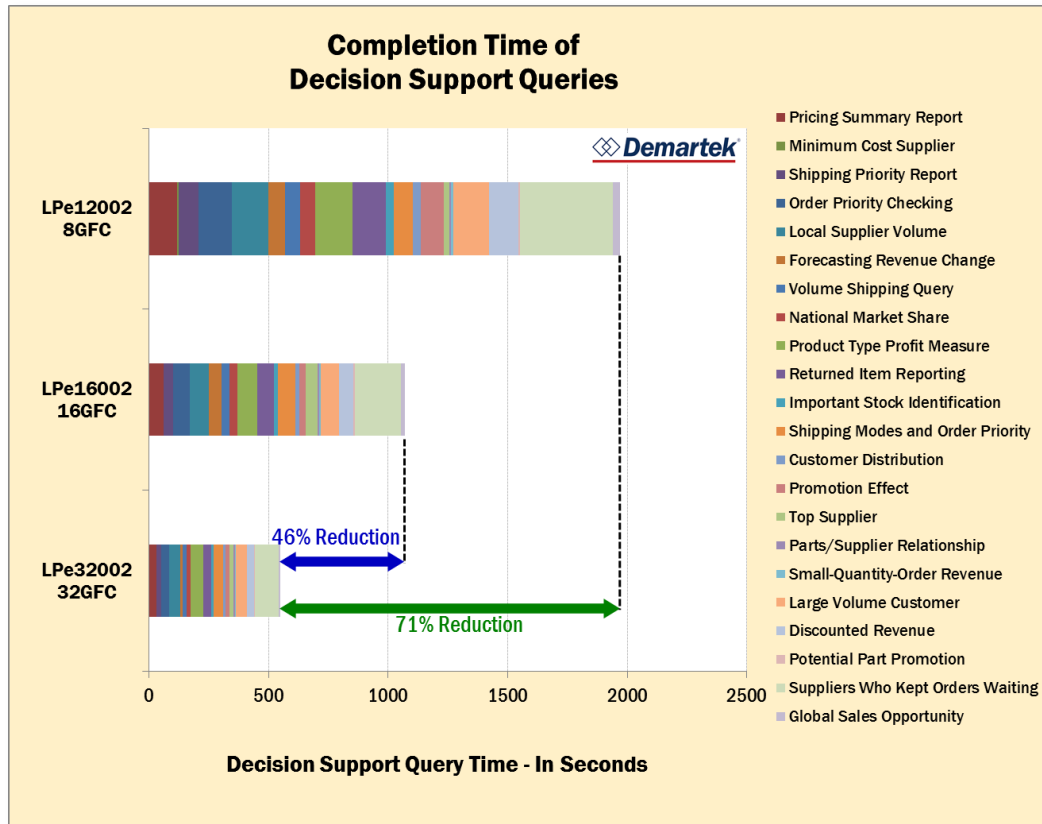

Storage Array Speeds

These tests show that even with all-flash arrays that have 8GFC target ports, substantial improvements in performance can be achieved by upgrading the host adapters and switches to the 32GFC technology without changes on the target storage system.

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A Brief Commentary on Response Time

In our testing of all-flash arrays, we have found that application response time, or latency, is heavily dependent on the application workload. At one end of the spectrum, some workloads such as online transaction processing (OLTP) have very low latencies because they request small amounts of data. On the other hand, large data warehousing applications have much higher latencies because of the large volume of data that is usually requested. Other applications typically fall in between these two extremes.

In a separate test of the Emulex adapters, we observed substantial reductions in response time as measured by the host server for the various application workloads, based on their block sizes. The Emulex LPe32002 (32GFC) adapter provided approximately 70% lower application response time than the 8GFC adapter across four different types of workloads. The 32GFC adapter achieved approximately 50% lower response time for three of the workloads and 40% lower response times for the OLTP workload.
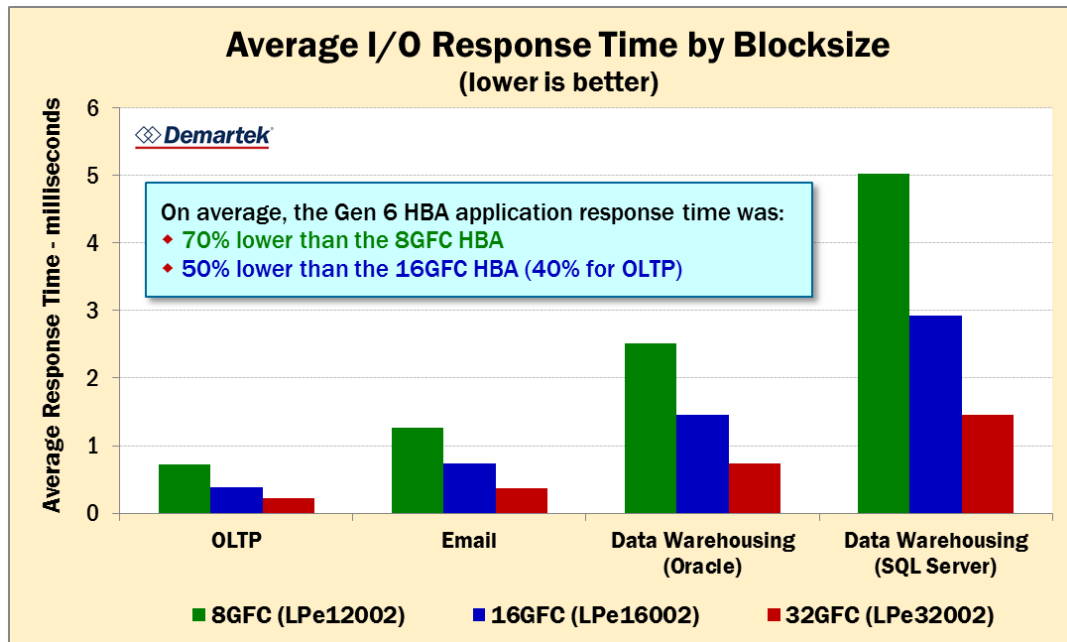
Test Environment
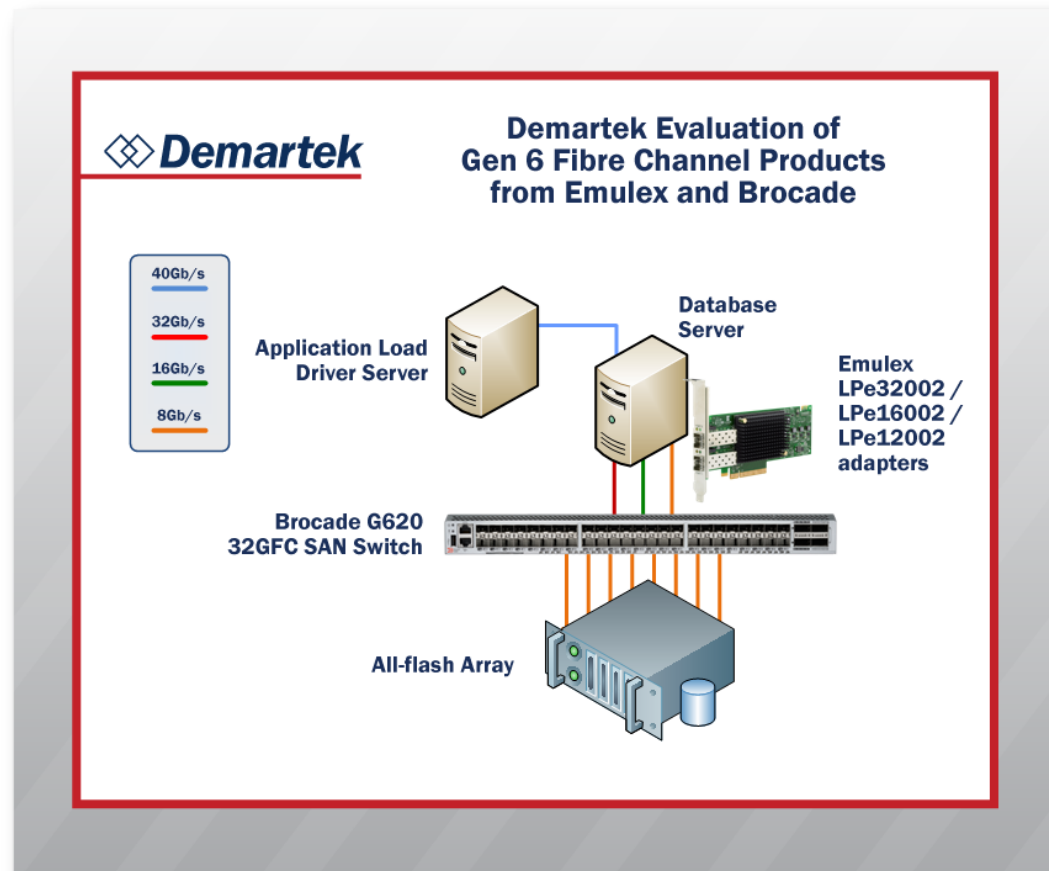
Servers (application and database servers)

◆ 2x Intel Xeon E5-2643v3, 3.4 GHz, 12 total cores, 24 total threads
◆ 256 GB RAM
◆ 40 Gb Ethernet NIC (Emulex OCe14401)
◆ Windows Server 2012 R2
◆ SQL Server 2014 (database server only)

Fibre Channel Adapters

◆ Emulex LPe12002 (8GFC)
◆ Emulex LPe16002 (16GFC)
◆ Emulex LPe32002 (32GFC)

Fibre Channel Switch

◆ Brocade G620 32GFC Switch

Storage System

◆ All-flash array
◆ 8x 8GFC target ports

Summary and Conclusion

The Gen 6 Fibre Channel products from Emulex and Brocade provide new performance and feature capabilities ideally suited to connecting to high-speed flash-based storage systems. We found the following benefits and advantages to deploying these products together:

◆ Accelerates applications even with existing 8GFC and 16GFC storage arrays
  ◆ Up to 4x faster for data warehousing workloads
  ◆ Cuts down data warehousing query time by 71%, from 32 minutes to 9 minutes in one example, enabling faster decision making and offering substantial business value

◆ Unique features such as Emulex ExpressLane more effectively use high performance tiered storage assets

◆ Advanced features developed in conjunction with Brocade accelerate deployment and simplify support that integrates with Brocade Fabric Vision

◆ Easy-to-upgrade from previous generations of Fibre Channel (4GFC/8GFC) with forward/backward compatibility– using the same connectors, management, and cabling

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Appendix – Fibre Channel Technology Overview

History

Fibre Channel is an industry standard storage solution. Development began in 1988, receiving ANSI standard approval in 1994. Fibre Channel technology was introduced to the market in 1997 at 1 gigabit per second (Gbps) and its single-lane speed has doubled every three to five years. With Gen 6 Fibre Channel, there is a single-lane (32GFC) and quad-lane (128GFC) specification.

Fibre Channel Speed History
Gbps
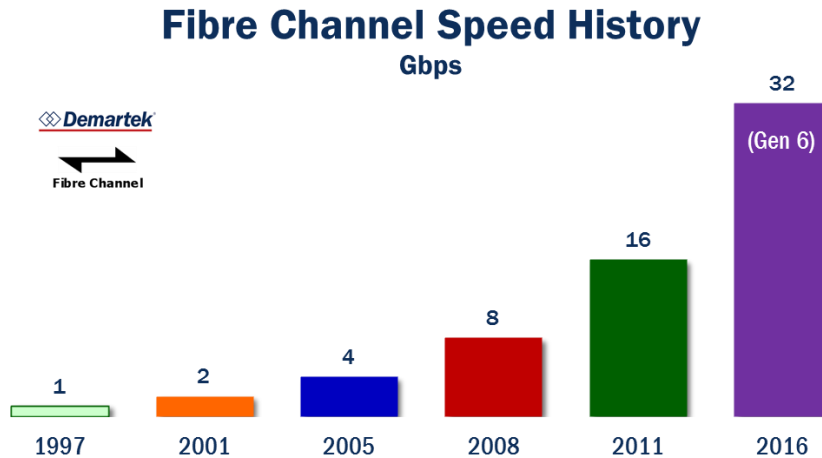
Source: Fibre Channel Industry Association (FCIA)

Backward Compatibility

Fibre Channel technology is backward compatible with the two previous generations. This means that Gen 6 (32GFC) Fibre Channel switches, host bus adapters (HBAs) and optics (transceivers) are backward compatible with 16GFC and 8GFC equipment. This provides a smooth upgrade path for enterprises.

Fiber-Optic Cable Types and Lengths

Demartek recommends that customers purchase OM3 or OM4 multi-mode fiber-optic cables for Fibre Channel deployments within datacenters. The orange-colored OM1 and OM2 fiber-optic cables are considered obsolete for new deployments.

Fiber Optic Cable Lengths by Speed and Distance

◇◇ Demartek	OM1	OM2	OM3	OM4
Cable Color	Orange	Orange	Aqua	Aqua
4GFC	70m	150m	380m	400m
8GFC	21m	50m	150m	190m
16GFC	15m	35m	100m	125m
32GFC	–	20m	70m	100m

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http://www.demartek.com/Demartek_Emulex_LPe32000_Gen6_FC_Evaluation_2016-03.html on the Demartek
website.