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Improving Business Outcomes with HPE DL380 Gen9 Server, 3PAR StoreServ 8450 All-Flash Storage, StoreFabric SN6600B Switch and SN1600E HBA Gen6 32Gb FC Technology

32Gb FC delivers faster time to insight for SQL Server 2016 data warehousing workloads.

Executive Summary

Large enterprises choose two-socket servers to power their most demanding workloads, including big data analytics and dense virtualization deployments. The latest HPE DL380 Gen9 two-socket server leverages the current Intel® Xeon® E5 v4 processor family to deliver the highest levels of performance.

Concurrently, datacenters are pairing their high-performance HPE dual-socket servers with Fibre Channel solid-state (flash) storage systems to improve storage performance so that it matches the performance of the new servers. In many cases, however, deploying solid-state storage often moves the performance bottleneck to the storage network, driving users to seek higher performance from their storage network infrastructure.

HPE commissioned Demartek to evaluate its DL380 Gen9 Server connected to an HPE 3PAR StoreServ 8450 All-Flash Storage with 48 SSDs using two different generations of HPE StoreFabric SN1200E/SN1600E Fibre Channel Host Bus Adapters (16Gb FC and 32Gb FC) from Broadcom/Emulex and HPE StoreFabric B-series SN6600B Fibre Channel Switch (32Gb FC) from Brocade. These were run in a native O.S. SQL Server 2016 database data warehousing environment and in a VMware environment with two different SQL Server 2016 workloads running simultaneously.

We found that the combination of the new HPE DL380 Gen9 Server, HPE 3PAR StoreServ 8450 All-Flash Storage and HPE StoreFabric SN1600E 32Gb Fibre Channel Host Bus Adapter and StoreFabric B-series SN6600B Fibre Channel Switch supporting Gen6 32Gb FC technology provided the performance needed to alleviate network bottlenecks that can be caused by all-flash arrays in slower speed FC SANs to dramatically improve data warehousing application performance.

Key Findings

> **37% increased read throughput with 32Gb FC for MS SQL and VMware:** MS SQL Server 2016 Data Warehousing workload completed in 37% less time than with the 16Gb FC (native O.S), 6.0 hrs. to 3.7 hrs., and 36% less time in VMware.

> **54% of I/O completed with less than 2 milliseconds latency for MS SQL and VMware with 32Gb FC:** >54% of the large block I/Os for the data warehousing workload completed in less than two milliseconds, compared to only 3% of the large block I/Os using the 16Gb FC (native O.S). In VMware, latencies were even lower.

> **49% more SQL transactions processed with 32Gb FC:** The OLTP workload achieved an average of 49% higher SQL transactions per second.

> **Achieve immediate results with HPE StoreFabric 32Gb FC SAN**: Any improvements in HPE SAN infrastructure by adding Gen6 32Gb FC host and switches result in faster job completions without performance tuning.

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HPE DL380 Gen9 Server

The DL380 Gen9 Server with Microsoft SQL Server 2016, as well as its built-in high performing data warehouse, has the processing power required for virtualization and memory-intensive application workloads for databases. In order to scale performance to meet the demands of almost any workload, the DL380 Gen9 Server supports the following:

- Intel® Xeon® E5 v4 processor family with up to 22 cores per processor, totaling 44 processing cores with two processors
- 24 DDR4 2400 MHz DIMM slots supporting standard DIMM and up to 16 NVDIMM
- Up to six PCIe 3.0 slots, including up to two x16 slots
- Two 96 percent efficient (Titanium) power supplies

HPE 3PAR StoreServ 8450 All-Flash Storage

The HPE 3PAR StoreServ 8450 All-Flash Storage supports high-end workloads through its quad-controller design and scale-up capabilities. The 3PAR 8450 includes the following:

- Up to 480 SSDs and up to 1843 TB raw capacity
- Up to 24 16Gb Fibre Channel host ports
- Up to 8 10GbE iSCSI host ports
- Integration with VMware VAAI, VASA and Microsoft Offload Data Transfer (ODX)
- Federation with other models in the HPE 3PAR 8000 family
- Synchronous/Asynchronous replication
- Unconditional 5-year SSD warranty
- Optional FIPS-certified self-encrypting SSDs

HPE StoreFabric SN1600E 32Gb Fibre Channel Host Bus Adapter from Broadcom/Emulex

The HPE SN1600E 32Gb HBA from Broadcom/Emulex delivers the ultimate in high bandwidth, up to 12,800 MB/sec (2 ports, 32Gb FC, full duplex), and low latency (50% lower on-chip latency compared to the previous generation HPE StoreFabric SN1100E 16Gb HBA) performance.

The Broadcom/Emulex 32Gb FC and 16Gb FC adapters feature the Emulex Dynamic Multi-core Architecture that delivers optimum IO performance, up to 1.6 million IOPS, by dynamically applying ASIC resources to either a single active port or across both active ports, as demanded by the workload. This ensures that performance is delivered when and where needed, to meet service level agreements (SLAs).

The new HPE SN1200E 16Gb FC HBA, built on the same platform as the new SN1600E 32Gb FC HBA, delivers many of the same features for portfolio consistency and interoperability.

Supported Features

- NVMe over Fibre Channel enablement
- Secure firmware update
- ExpressLane LUN prioritization for write operations
- 10 million hour Mean Time Between Failure (MTBF) reliability
- HPE Smart SAN for 3PAR software for simplified and error-free target driven SAN deployment for All-Flash Storage

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HPE StoreFabric B-series SN6600B Fibre Channel Switch from Brocade

Gen6 32Gb FC Fibre Channel connectivity maximizes the performance of flash storage, even when connecting at speeds less than 32 Gbps. In addition to faster throughput speeds and increased Inputs/Outputs per Second (IOPS), Gen6 Fibre Channel provides enhanced monitoring and diagnostics capabilities that provide visibility into network latency levels and IOPS from the storage level all the way up to the Virtual Machine (VM) level.

HPE StoreFabric Fibre Channel solutions from Brocade provide the following benefits:

- Increased Performance for demanding workloads across 32Gb FC links
- Simplified end-to-end management of large-scale environments with automated monitoring and diagnostics
- Automatic detection of degraded application or device performance through network sensors
- Forward Error Correction (FEC) for increased data resiliency
- Significantly reduced latency in high-transaction applications compared with other offerings
- Seamless integration with emerging NVMe over Fabrics (NVMe-oF) technology without a disruptive “rip and replace”

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Test Results – Native O.S. Environment

The primary workload used for these tests was a data warehousing application workload running on SQL Server 2016. 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 presented to 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) and/or Fibre Channel switches will result in completion of the work in a smaller amount of time even if the storage target is supporting slower FC speeds.

The business benefit of this is demonstrated in a faster time to extract business insights from the decision support application.

We compared the performance of this data warehousing workload with two generations of StoreFabric B-series Fibre Channel Switch technology.

The same operating system (Windows Server 2016), the same database software (SQL Server 2016) and the same application workload settings were used for these tests.

Fibre Channel switches:

> HPE SN6000B – 16Gb FC

> HPE SN6600B – 32Gb FC

Fibre Channel host bus adapters (HBAs):

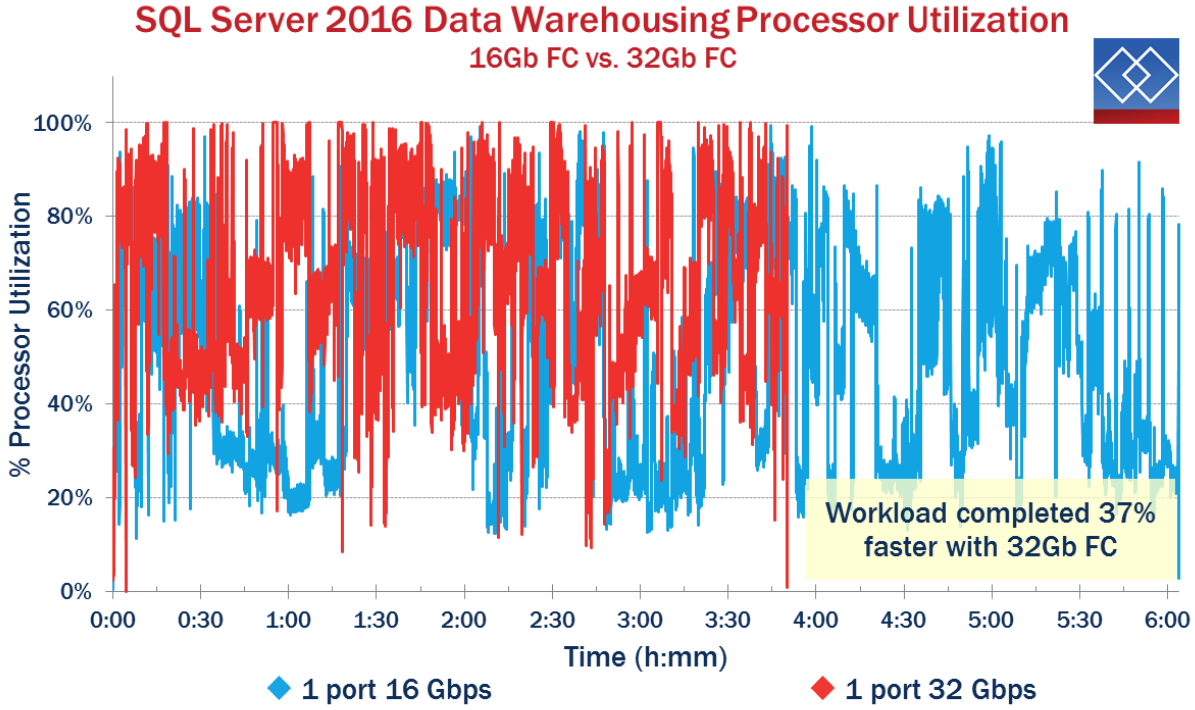
> HPE SN1200E – 16Gb FC

> HPE SN1600E – 32Gb FC

The results shown in this report used a single host Fibre Channel port for connectivity to the SAN fabric for each generation of technology.

Host CPU Utilization

The 32Gb FC technology allowed the host server to achieve a higher utilization rate, enabling it to complete the work in 37% less time, delivering better ROI on host CPU investment.



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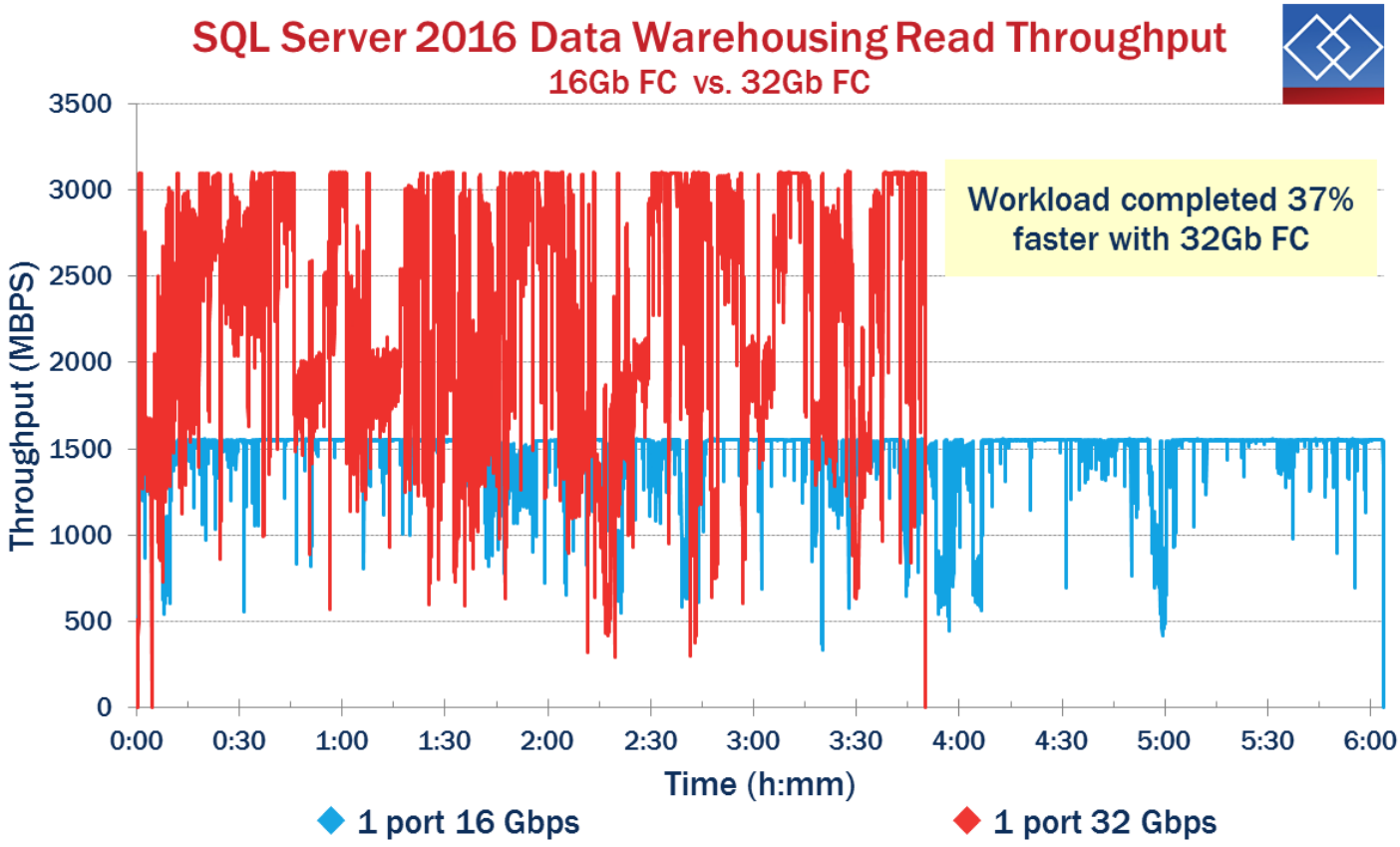
Higher Throughput

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 faster for the SN1600E (32Gb FC) adapter than the other adapter, as shown in the chart.



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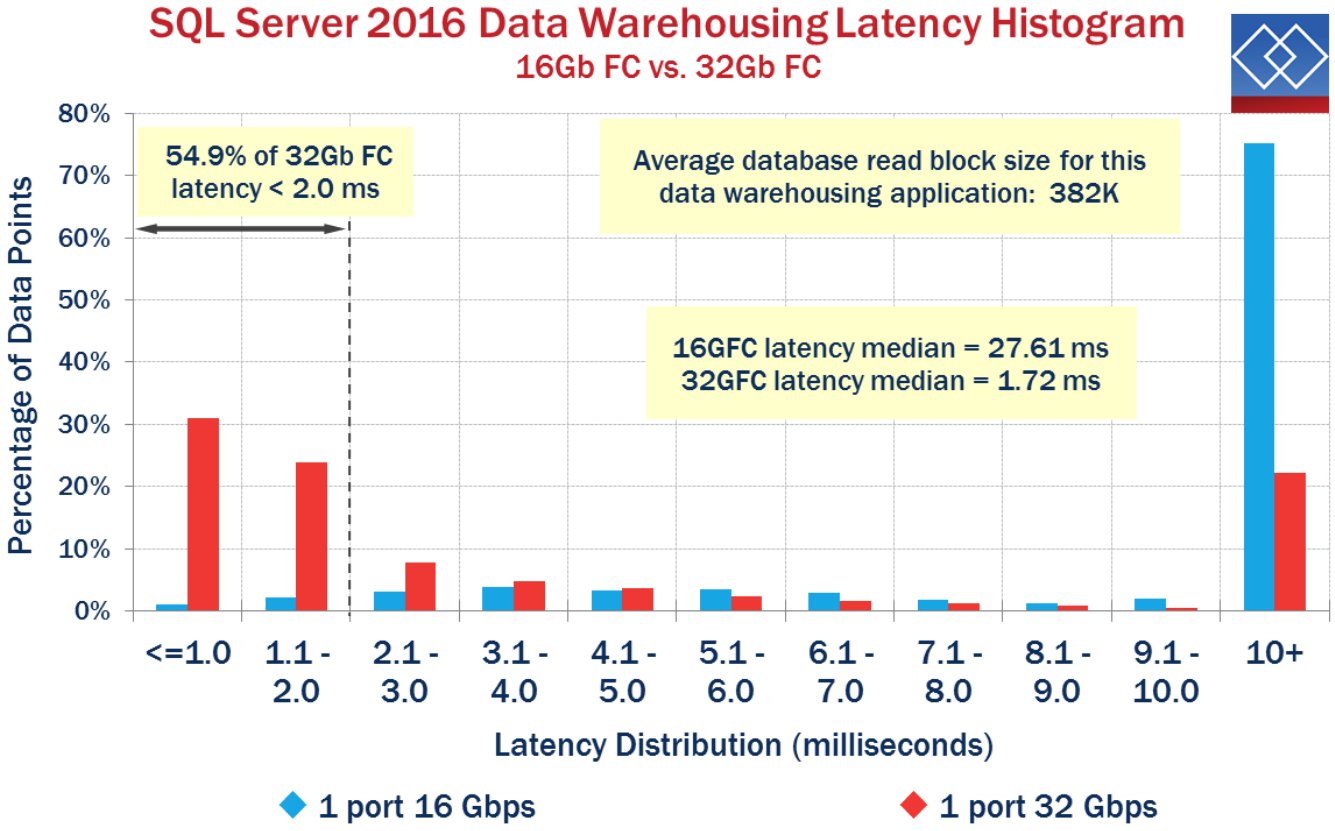
Faster Query Response Time

In the following chart, the time to complete each of the individual 22 queries is shown for each of the generations of adapters. Using the StoreFabric 16Gb FC technology completion time as a baseline, we observed that the StoreFabric 32Gb FC switch and adapter achieved a 37% reduction in the time to complete the workload, from approximately 363 minutes to approximately 230 minutes.

This particular data warehousing workload used large block sizes for its database read operations, averaging 382K, and reaching a peak of 512K.

The combination of 32Gb FC switch and adapter technology completed more than 54% of the I/O requests in less than two milliseconds, compared to only 3% of the I/O requests using the 16Gb FC technology. This shows the much improved latency capability of the 32Gb FC technology.



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Test Results – VMware Environment

A VMware environment was deployed with the same server, adapter and storage hardware as the native O.S. environment described previously, but with two virtual machines running simultaneously, each with SQL Server 2016. The two workloads used for these tests included one VM running an OLTP workload similar to TPC-E and a separate VM running a data warehousing workload similar to TPC-H and similar to the test run in the native O.S. environment described previously.

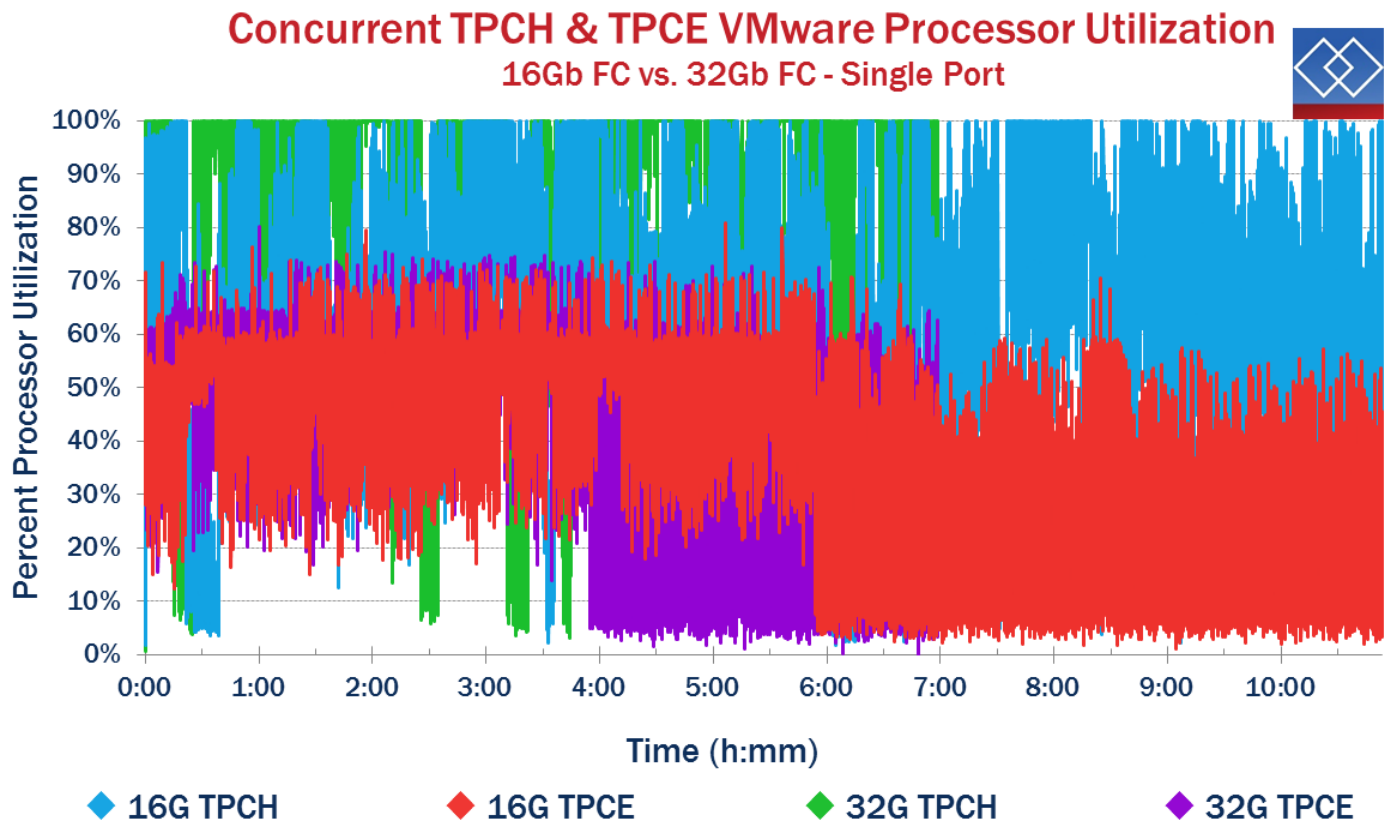
The OLTP workload emphasizes IOPS and latency and runs until it is stopped. The data warehousing workload emphasizes throughput and is a fixed set of work, completing in less time when faster storage networking infrastructure is deployed.

We compared the performance of both workloads running together with two generations of StoreFabric B-series Fibre Channel Switch technology.

The results shown in this report used a single host Fibre Channel port from the physical server for connectivity to the SAN fabric for each generation of technology.

Host CPU Utilization

The 32Gb FC technology enabled the virtual machine running the data warehousing workload to complete the work in 36% less time, delivering better ROI on host CPU investment.



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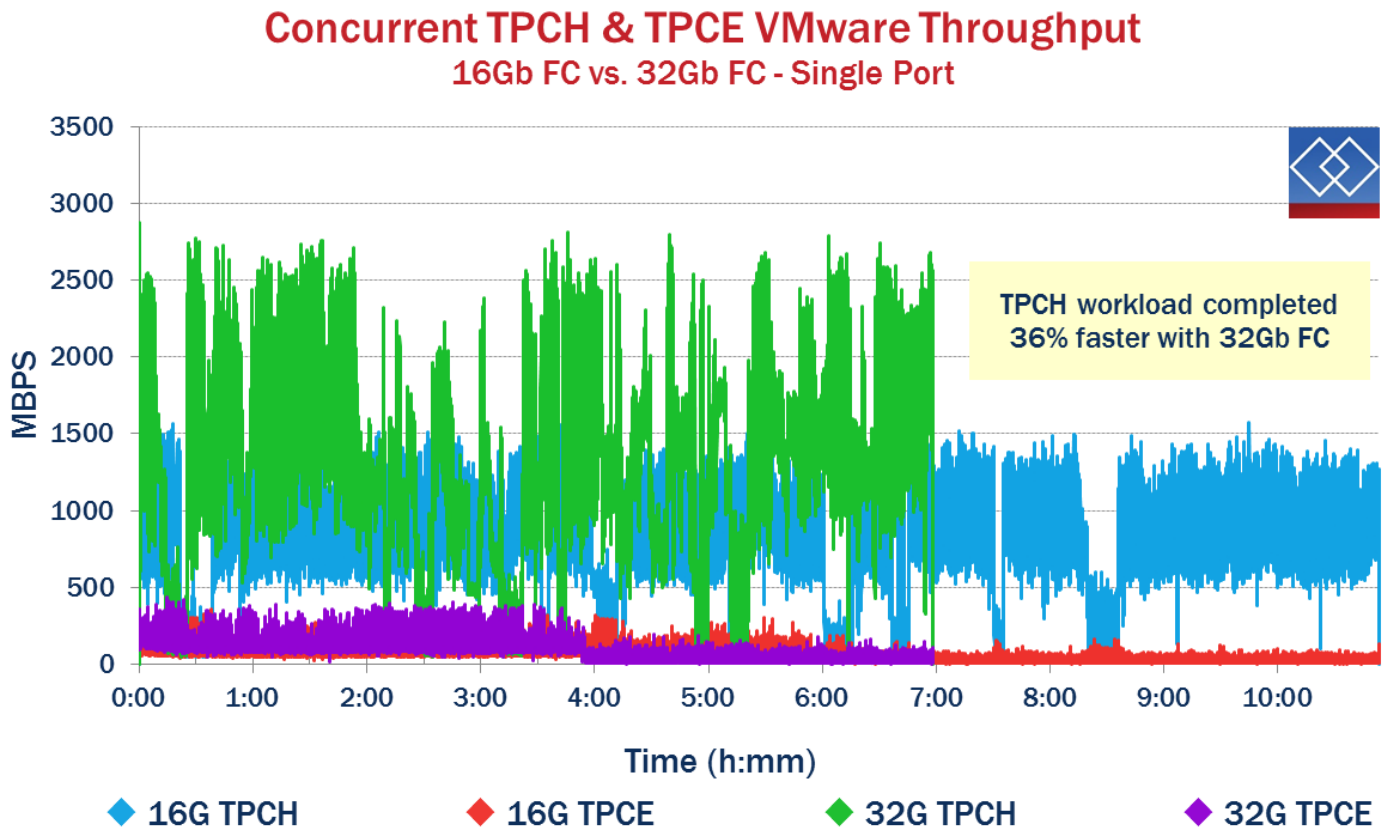
Higher Throughput

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.

With these two VMs running, we did not maintain full line rate for the duration of the test using either technology. Using the 32Gb FC technology, both workloads combined approached 90% of the full line rate during certain periods. Using the 16Gb FC technology, both workloads combined only occasionally reached full line rate.



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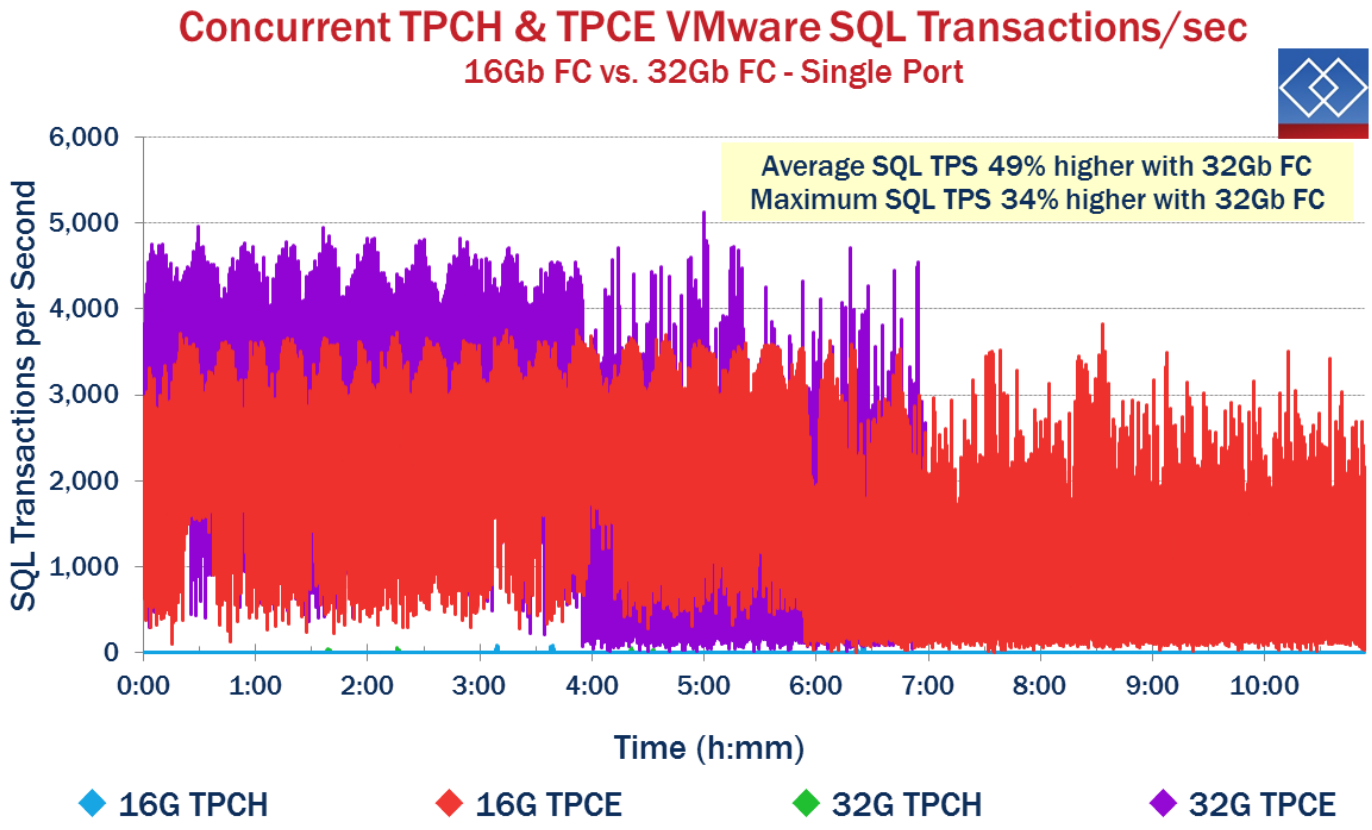
SQL Transactions per Second (TPS)

For OLTP (TPCE) workloads, SQL Transactions per Second (TPS) are one of the application's ways of measuring performance.

Data warehousing workloads (TPCH) typically perform few transactions per second, as they primarily issue query commands.

In our tests, the OLTP workload running in the VMware environment on average achieved 49% more SQL transactions per second using the 32Gb FC technology. The peak SQL transactions per second were 34% higher with the 32Gb FC technology.

	32Gb FC	16Gb FC
Avg. SQL TPS	2034.83	1357.28
Max. SQL TPS	5135.95	3825.98



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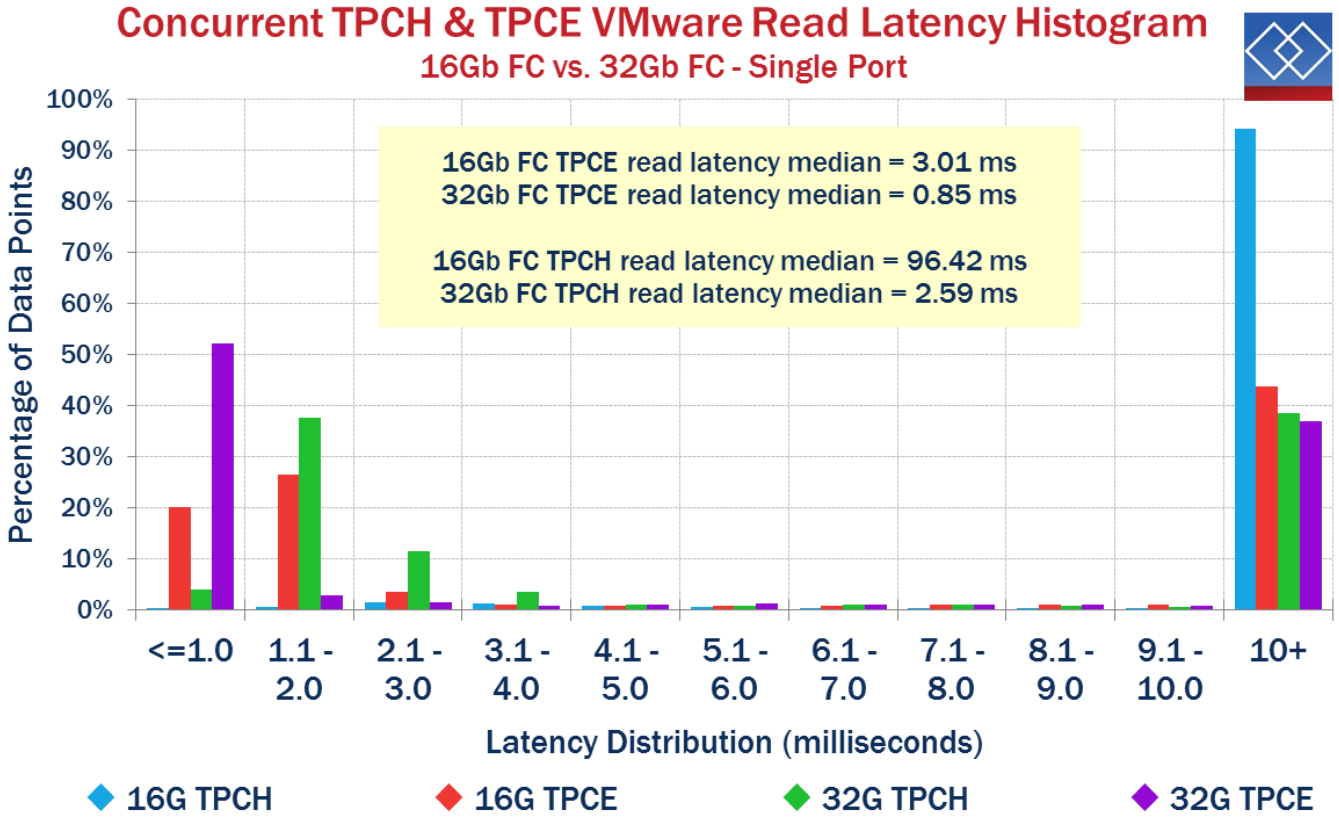
Faster Query Response Time

The following chart is a read latency histogram for both workloads running simultaneously, using both generations of Fibre Channel technology.

These latency results were measured from within the respective virtual machines.

More than 50% of the OLTP workload running with the 32Gb FC technology completed its read requests in less than one millisecond, as measured by the host virtual machine while the same workload running with the 16Gb FC technology took longer.

The majority of the data warehousing workload latency was considerably better (lower) using the 32Gb FC technology than when it was run with the 16Gb FC technology.



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Fibre Channel Technology Overview

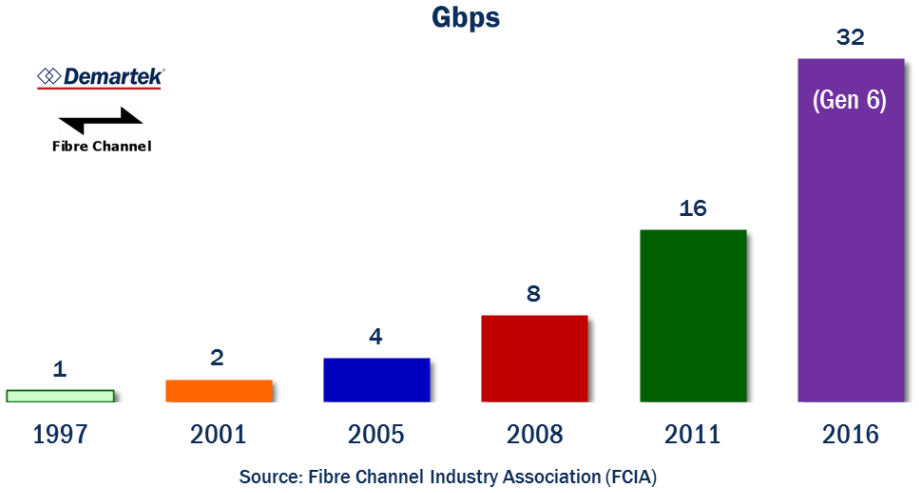
History

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 Gen6 Fibre Channel, there is a single-lane (32Gb FC) and quad-lane (128Gb FC) specification.

Backward Compatibility

Fibre Channel technology is backward compatible with the two previous generations. This means that Gen6 (32Gb FC) Fibre Channel switches, host bus adapters (HBAs) and optics (transceivers) are backward compatible with 16Gb FC and 8Gb FC equipment. This provides a smooth upgrade path for enterprises.

Fibre Channel Speed History



Source: Fibre Channel Industry Association (FCIA)

Fiber Optic Cable Lengths by Speed and Distance

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

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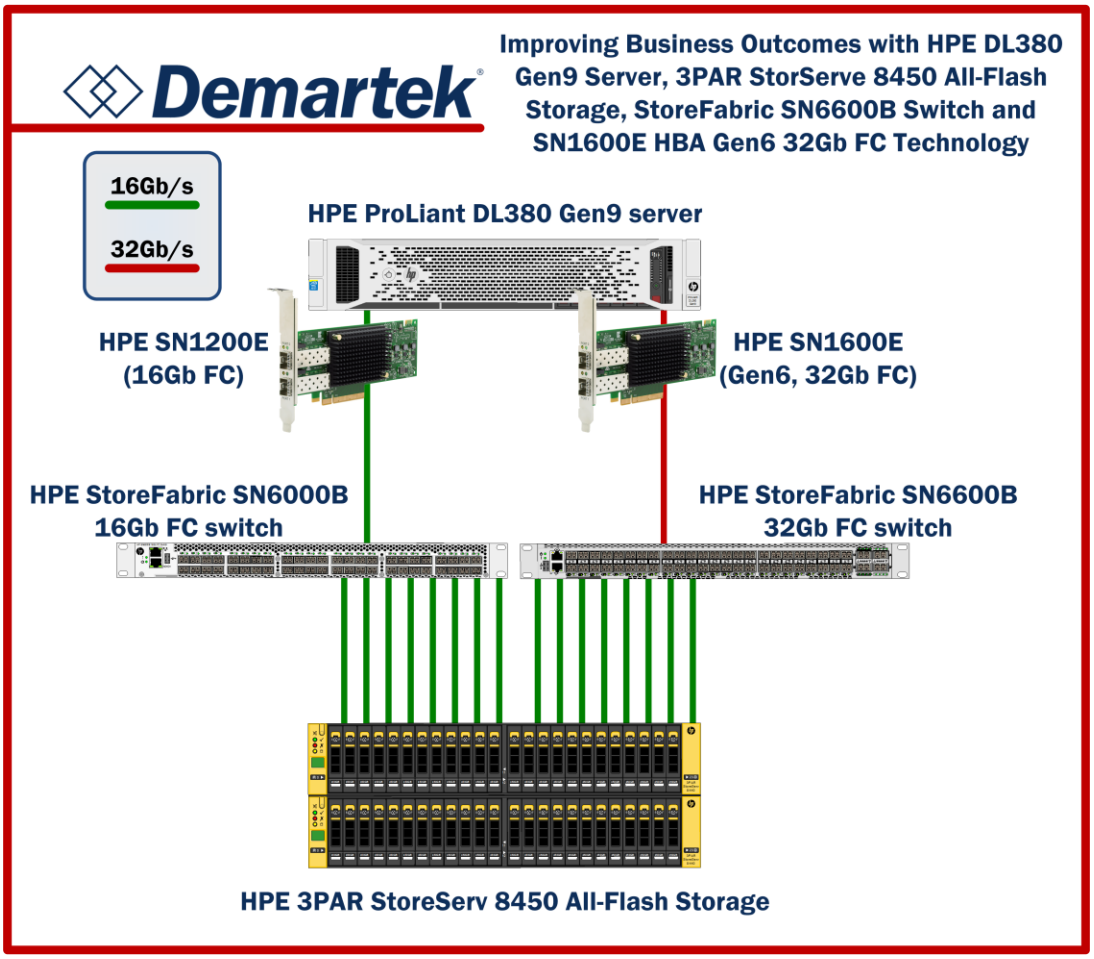
Test Environment



Servers (application and database servers)

- 2x Intel Xeon E5-2690v4, 2.6GHz, 28 total cores, 56 total threads
- 64 GB RAM, 2400 MHz
- 10Gb Ethernet NIC
- VMware vSphere 6.0.0
- Windows Server 2016
- SQL Server 2016 Developer Edition

Storage System

- HPE 3PAR StoreServ 8450 All-Flash Storage
- 48x 480GB SSDs
- 8x 16Gb FC target ports

Fibre Channel Adapters

- HPE SN1200E 16Gb Dual Port Fibre Channel Host Bus Adapter (Broadcom/Emulex)
- HPE SN1600E 32Gb Dual Port Host Bus Adapter (Broadcom/Emulex)

Fibre Channel Switch

- HPE StoreFabric SN6000B 16Gb 48/24 Fibre Channel Switch (Brocade)
- HPE StoreFabric SN6600B 32Gb 48/24 Fibre Channel Switch (Brocade)

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Summary and Conclusion

Combining the new HPE DL380 Gen9 Server, the HPE 3PAR StoreServ 8450 All-Flash Storage and the latest 32Gb FC HBAs and switches from HPE StoreFabric (Storage Networking) utilizing Broadcom/Emulex and Brocade technology provides a powerful solution for today's demanding enterprise workloads that are latency and I/O sensitive. *Workloads such as data warehousing with Microsoft SQL Server 2016, which are taking advantage of storage with All-Flash technology while supporting the latest FC technology for their infrastructure will see immediate performance outcomes even if the entire SAN end-to-end is not all the same FC speeds.*

Gen6 Fibre Channel technology from Brocade and Broadcom/Emulex will help Information Technology to immediately experience the benefits of application performance and I/O insight not seen previously on slower FC technologies, in addition to having access to a broader Gen6 32Gb FC feature-set and investment protection.

- **37% increased read throughput with 32Gb FC for MS SQL and VMware:** MS SQL Server 2016 Data Warehousing workload completed in 37% less time than with the 16Gb FC (native O.S), 6.0 hrs. to 3.7 hrs., and 36% less time in VMware.
- **54% of I/O completed with less than 2 milliseconds latency for MS SQL and VMware with 32Gb FC:** >54% of the large block I/Os for the data warehousing workload completed in less than two milliseconds, compared to only 3% of the large block I/Os using the 16Gb FC (native O.S). In VMware, latencies were even lower.
- **49% more SQL transactions processed with 32Gb FC:** The OLTP workload achieved an average of 49% higher SQL transactions per second.
- **Achieve immediate results with HPE StoreFabric 32Gb FC SAN**: Any improvements in HPE SAN infrastructure by adding 32Gb FC host and switches result in faster job completions without performance tuning.

The most current version of this report is available at www.demartek.com/Demartek_HPEStoreFabric_Gen6 on the Demartek website.