Accelerating Workload Performance with Cisco 16Gb Fibre Channel Deployments

16GFC provides performance boost for Oracle data warehousing workloads.

Executive Summary

The computing industry is experiencing increasing demand for storage performance, including greater bandwidth and IOPs along with reduced latency due to demands for increased application performance and continual data growth. Fibre Channel storage area networks (SANs) carry the bulk of storage traffic in the enterprise data center and are being continually improved to meet these increased demands.

As they implement flash storage, enterprises may find themselves constrained by the available bandwidth between the servers and storage, or foresee a constraint as they observe their growing data consumption patterns. The Emulex LPe16002 16Gb Fibre Channel (16GFC) host bus adapter (HBA) addresses these increasing demands on storage performance by providing double the bandwidth of previous generation Fibre Channel HBAs.

Emulex commissioned Demartek to evaluate their 16GFC and 8GFC Fibre Channel adapters in an Oracle database data warehousing environment running on Cisco servers and Fibre Channel switches.

Key Findings

Demartek confirmed that, for the database workload tested, the 16GFC infrastructure with the Emulex LPe16002 HBA installed in a Cisco UCS C240 M4 server connected to a Cisco MDS 9148S Fibre Channel switch, exceeded the performance of the same workload in an 8GFC environment:

◆ The Cisco and Emulex solution completed the workload in approximately half the time

◆ Peak throughput was 2x higher

◆ Maximum I/O transactions were up to 6x greater

◆ LPe16002 supports PCIe Gen 3 and matches the I/O slots of the Cisco UCS C240 server

◆ Backward compatibility to 4GFC / 8GFC infrastructure provided a streamlined performance upgrade

◆ Emulex OneCommand Manager provides efficient deployment and management

The Need for More Bandwidth and Lower Latency

Today's datacenters face a variety of challenges brought on by seemingly insatiable demands on server and storage infrastructure. At the same time, new technologies are being introduced that contribute to new hurdles while also offering opportunities to meet these growing challenges.

The following is a summary of factors that Demartek has identified as driving the need for greater storage networking performance as provided by 16GFC Fibre Channel devices including HBAs such as the Emulex LPe16002 16GFC HBA and switching, as provided by the Cisco MDS 9148S FC switch.

8Gb Fibre Channel Saturation

When speaking with end-users about saturation of Fibre Channel links, we're hearing from a growing number of users who indicate that they have saturated their 8GFC legacy networks and need something faster. The applications that are consistently identified as needing this higher bandwidth are database applications, regardless of the brand of database. These include single database instances running on physical hardware, multiple database instances running on physical hardware and multiple database instances running in virtual machines (VMs). These users are generally looking for compatibility with their existing infrastructure and higher bandwidth to meet their growing demands.

All-flash Storage Technology

Solid-state storage technology is a strong driver of bandwidth growth. Enterprises that deploy any form of solid-state drive (SSD) technology have experienced significant storage performance improvements. Many of these all-flash array (AFA) deployments are in SAN environments, which drive up storage networking bandwidth consumption. Based on comments from users and many of the tests we have performed in our own lab, we have concluded that faster storage networking technology such as 16GFC Fibre Channel—including the Emulex LPe16002 16GFC HBA and Cisco MDS 9148S switch—is well-suited to all-flash storage technology.

Standard Deployment of PCIe 3.x in Servers

Current and recent generation servers include PCIe 3.x technology, which doubles the maximum possible I/O rates to 1 GBps (gigabyte per second) per lane from the previous PCIe generation. PCIe 3.x also doubles the maximum number of lanes available, allowing up to 40 PCIe lanes per processor as compared to the previous generation. As a result, the total I/O bandwidth available in one of these servers is approximately quadruple that of

the earlier generations of PCIe 2.x servers. The Emulex LPe16002 16GFC adapter takes advantage of the PCIe 3.0 slots available in the latest Cisco UCS C-Series servers.

Bandwidth Growth Summary

When we discuss storage networks with enterprise users, we find that Fibre Channel remains the dominant storage interface in large-scale data centers and is expected to remain dominant as a SAN interface for the foreseeable future.

When using storage-intensive applications like backup/restore, database transactions, virtualization, and rich media, there is clearly a need for higher storage networking bandwidth and performance. The improved I/O performance of 16GFC enables faster storage and retrieval of data.

Customers are rapidly migrating to 16GFC technology according to market research firm, Crehan Research. In reports released in 2016, data showed that 16GFC has become the solid majority of total Fibre Channel switch shipments. Additionally, reports showed host bus adapter total addressable market (TAM) growth that was attributed to an increasing number of flash-based external storage array deployments connected with 16GFC. 16GFC shipments are expected to continue to grow as customers upgrade their server networking capabilities to faster speeds to take advantage of the higher bandwidth capabilities of the most recent server platforms and storage arrays.

For those enterprises that don't believe they need this higher performance yet, now is the time to start planning for these eventualities, making Emulex LPe16002 16GFC HBAs a solid choice for host-side upgrades, and Cisco C-Series servers with Cisco MDS 9148S switches a worthy consideration for the compute and FC backbone of the data center.

Emulex 16GFC HBAs

Technology advances, including the Emulex LPe16002 16GFC HBAs, can help address growing constraints on current server and storage infrastructure.

Whether the environment includes mission-critical standalone database workloads or increasing numbers of VMs running on a single server, Emulex LPe16002 16GFC HBAs enable higher workloads and more applications and VMs to run on a single server and port, resulting in reduced cabling and higher return on IT investment.

The Emulex LPe16002 Fibre Channel adapters provide several features designed for supporting growing enterprise I/O workloads:

◆ Twice the performance of 8GFC adapters
◆ Backward compatibility with 4GFC and 8GFC infrastructure
◆ Support for Microsoft Windows Server (with and without Hyper-V), VMware, Red Hat Linux and SUSE Linux Enterprise Server (SLES)
◆ In-box drivers for all major operating environments
◆ NPIV support standard

Emulex OneCommand Manager

Emulex adapters feature OneCommand Manager, an easy-to-use management application that is designed for efficient deployment and management of all current and older Emulex-branded adapters in an enterprise. It includes a simple installation package that installs the management software and operating system drivers. The OneCommand Manager provides a topology view showing all the Emulex adapters installed in all visible hosts, with a summary of the total number of discovered fabrics, hosts, adapters, adapter ports and target ports. Firmware and driver parameter updates can be applied to a single adapter or to all adapters of the same type in a "batch" mode. OneCommand Manager also includes a full suite of adapter diagnostics.

ExpressLane™

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, allowing one LUN to be given higher priority than the other LUNs on the same connection, improving performance and lowering latency for the prioritized traffic.

Dynamic Multi-Core Architecture

Emulex's unique Dynamic Multi-Core Architecture enables Emulex FC HBAs to apply all ASIC resources to any port that needs it. Beginning with the Emulex LPe16002 FC HBA, these HBAs are able to provide full IOPS performance 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.

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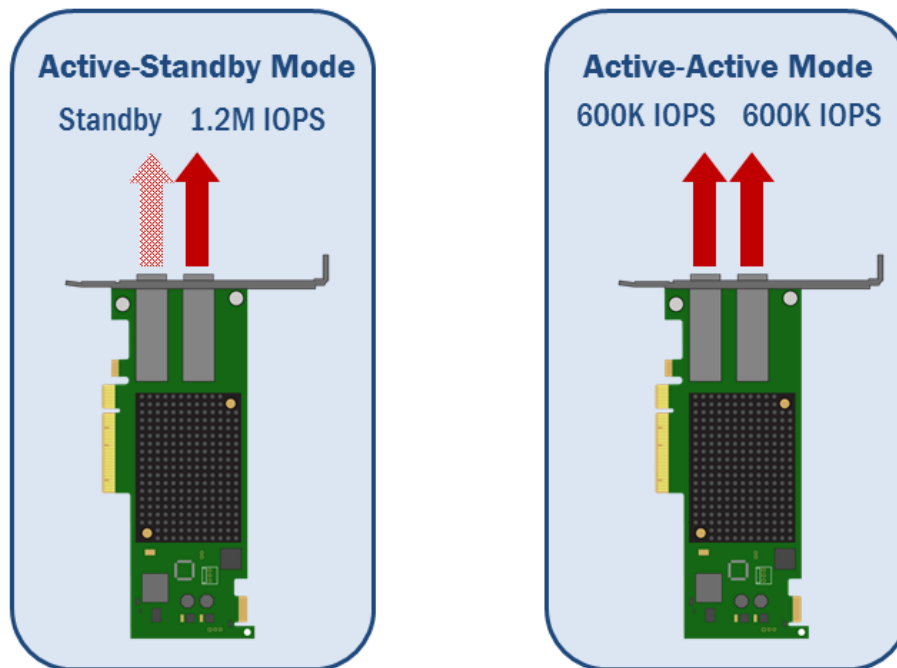
Cisco UCS C240 M4 Server

The Cisco UCS C240 M4 server is an enterprise-class 2-socket, 2-rack-unit (2RU) server.

It includes:

◆ One or two Intel®
Xeon® E5-2600 v3
or v4 processors

Courtesy of Cisco Systems, Inc. Unauthorized use not permitted.

◆ Up to 24 DDR4 DIMMs at speeds up to 2400 MHz
◆ Up to 6 PCI Express (PCIe) 3.0 slots (4 full-height, full-length)
◆ Available with up to 24 small form factor (SFF) or 12 large form factor (LFF) drives, plus two optional internal SATA boot drives
◆ 12 Gbps SAS support
◆ Cisco UCS virtual interface card (VIC) support in PCIe or modular LAN-on-motherboard (mLOM) form factor
◆ Supports up to two double-wide NVIDIA graphics processing units (GPUs), providing a graphics-rich experience to more virtual users
◆ The Cisco UCS C240 M4 server can be deployed standalone or as part of the Cisco Unified Computing System (UCS).

Cisco MDS 9148S 16Gb Fibre Channel Switch

Introduced in July 2014, the Cisco MDS 9148S 16GFC switch is a compact, 1 rack-unit (1RU) switch that includes up to 48 auto-sensing line-rate 16GFC ports.

Courtesy of Cisco Systems, Inc. Unauthorized use not permitted.

Its features include:

◆ Available in a base configuration of 12 ports, with increases in 12-port increments up to 48 ports, or available in a full 48-port configuration.
◆ Compatibility with 2, 4, 8 and 16 Gbps speeds.
◆ Role-based authentication, authorization, and accounting services to support regulatory requirements
◆ High-performance interswitch links with multipath load balancing
◆ Dual redundant hot-swappable power supplies
◆ Cisco NX-OS software can be upgraded while the Fibre Channel ports carry traffic
◆ Industry leading Data Integrity checks – Dropping corrupted CRC frames, protecting storage arrays
◆ Intelligent diagnostics and hardware-based slow port detection
◆ Powered by Cisco NX-OS and Cisco Prime™ Data Center Network Manager (DCNM) software

Cisco UCS SmartPlays

Cisco UCS SmartPlays are limited-time, special-priced promotional offers for Cisco UCS servers and are designed to help lower TCO. They deliver the exceptional performance, agility, and scale that have made Cisco UCS the fastest-growing x86 server lines in the industry. Cisco SmartPlays can reduce data center costs through competitively priced, preconfigured bundles.

The Emulex HBA is configurable in UCS SmartPlay and non-SmartPlay configurations using the following part number:

- UCSC-PCIE-E16002
    - Emulex Dual-port 16GFC HBA

Cisco UCS SmartPlays are available from Cisco and Cisco Partners.

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Test Results – Data Warehousing Workload

The primary workload used for these tests was a data warehousing application workload running on Oracle 12c. This read-intensive data warehousing workload is also known as a decision support application because it gives answers to critical business questions. The workload 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, 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 the following two Emulex adapters.

◆ Emulex LPe12002 – 8GFC dual-port PCIe 2.0 HBA
◆ Emulex LPe16002 – 16GFC dual-port PCIe 3.0 HBA

The same operating system (Red Hat Enterprise Linux 6.6), the same database software (Oracle 12c) and the same application workload settings were used for all tests.

Oracle Settings
The Oracle database used a 16GB cache for its data, with a cache-to-data ratio of 1:12.5. A "round robin" setting was used for the multi-path I/O for the eight paths to the all-flash storage array.
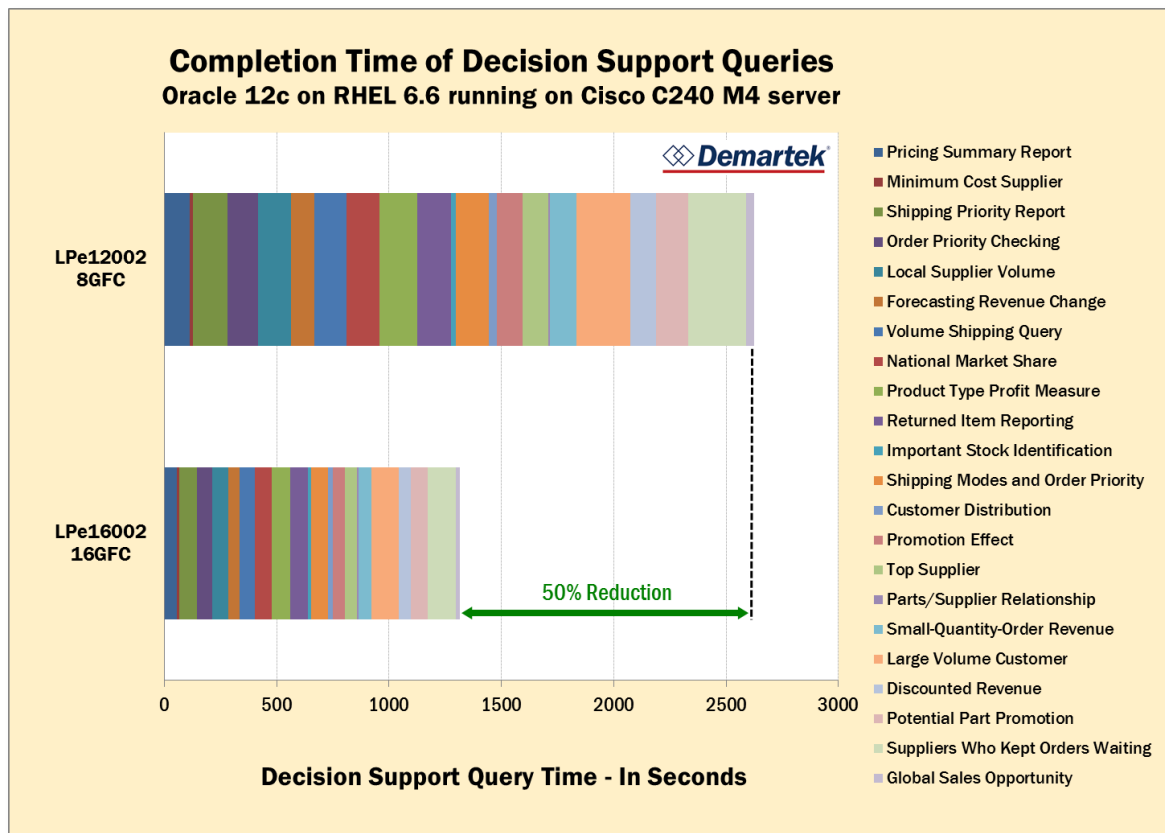
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Throughput

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 nearly full line rate for each of the adapters, but the 16GFC adapter allowed the workload to be completed in approximately half the time of the 8GFC adapter, as shown in the chart.
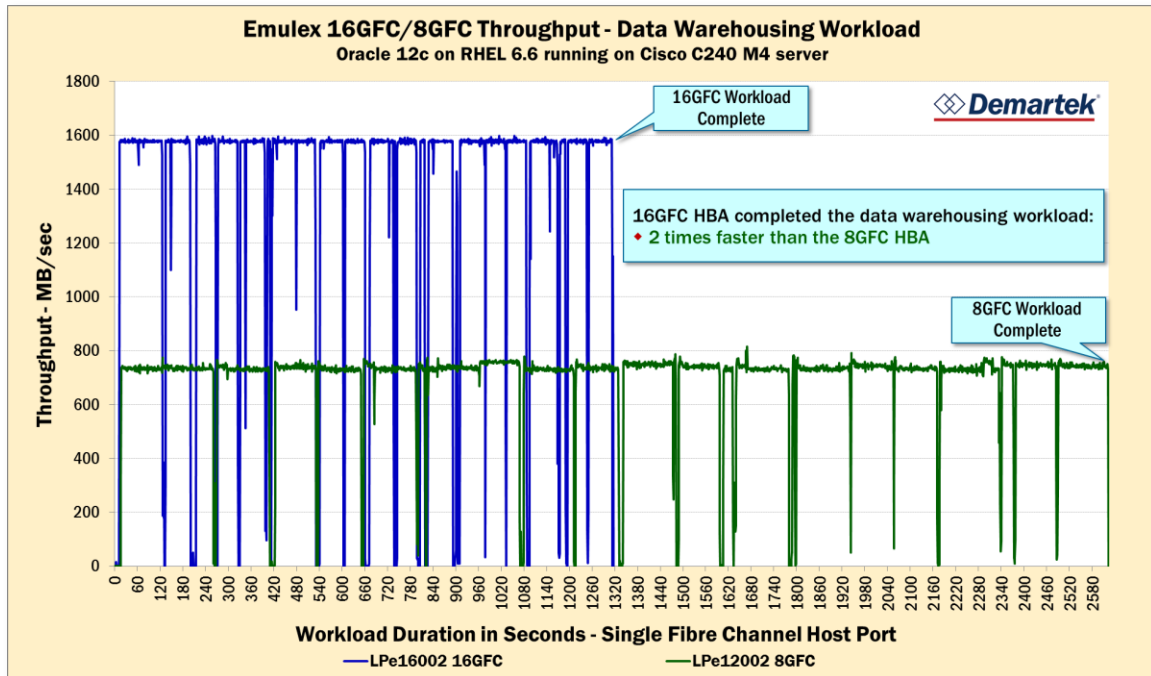
Query Response Time

In the following chart, the time to complete each of the individual 22 queries is shown for each of the adapters. Using the LPe12002 (8GFC) completion time as a baseline, we observed that the LPe16002 (16GFC) adapter achieved a 50% reduction in the time to complete the workload, from more than 43 minutes to approximately 22 minutes. We believe that this same rate of reduction in time to complete the work would scale to much larger databases.


Storage Array Speeds

The testing in this report was conducted using an 8GFC all-flash array. This configuration was chosen because of the volume of 8GFC arrays that are in production environments today. Demartek has tested 16GFC all-flash arrays and found that in addition to higher available bandwidth, these arrays also provide lower latency.

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 16GFC technology without changes on the target storage system.

Test Results – Synthetic Workload

A synthetic workload, using Iometer, an open-source workload generator, was used to test the Emulex Dynamic Multi-Core Architecture that was introduced with the Emulex 16GFC adapters. When only one port of a dual-port adapter is configured, the dynamic multi-core architecture applies all resources to a single port in order to achieve maximum performance.

As shown in the chart below, the 16GFC adapter significantly outperformed the 8GFC adapter when a single-port of each adapter was active.
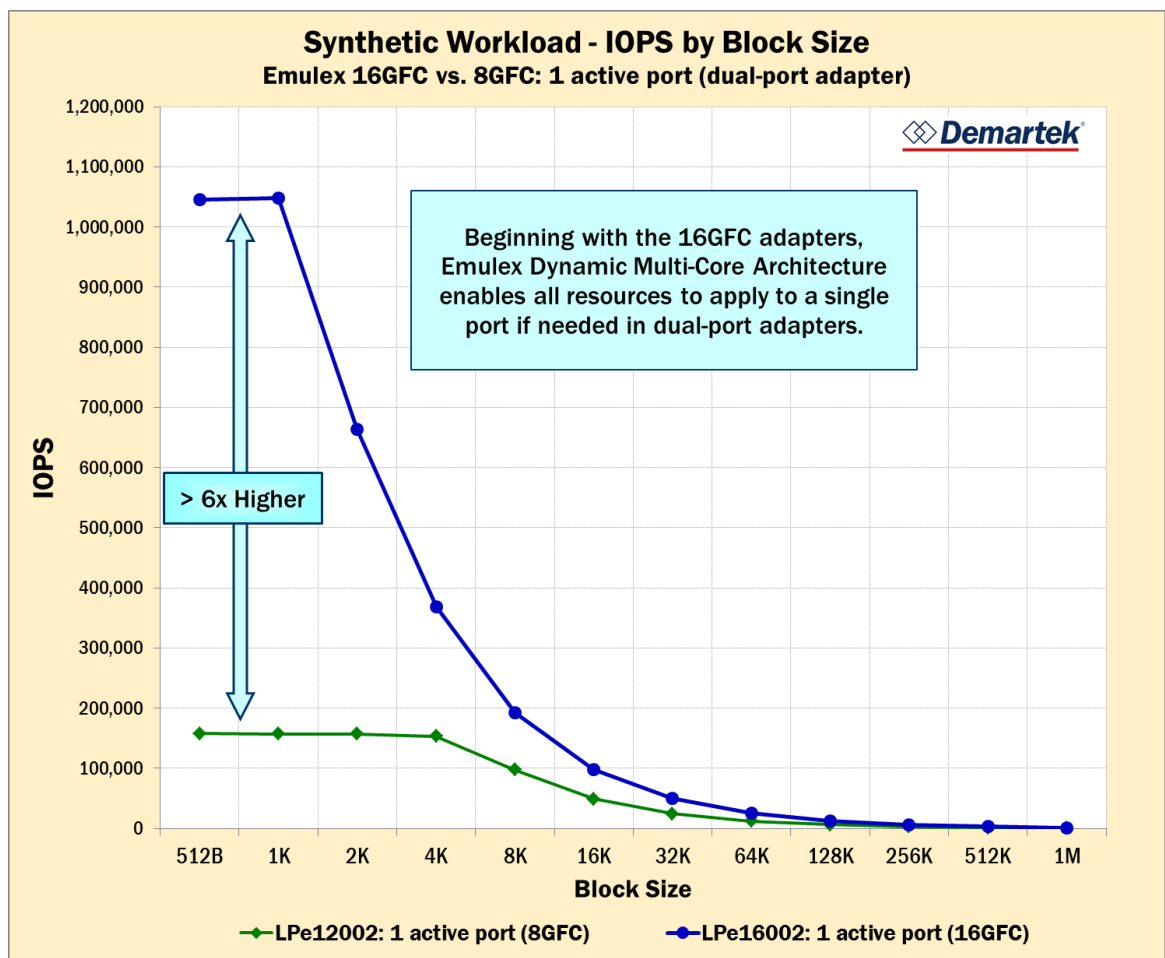
Test Environment

Servers (application and database servers)

◆ 2x Intel Xeon E5-2660 v3, 2.6 GHz, 20 total cores, 40 total threads
◆ 256 GB RAM (both servers)
◆ 40 Gb Ethernet NIC (Emulex OCe14401)
◆ Red Hat Enterprise Linux 6.6
◆ Oracle 12c (database server only)

Fibre Channel Adapters

◆ Emulex LPe12002 (8GFC), firmware 2.02.A0
◆ Emulex LPe16002 (16GFC), firmware 11.0.235.14

Fibre Channel Switch

◆ Cisco MDS 9148S 16GFC Switch

Storage System

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

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Summary and Conclusion

Fibre Channel is purpose-built for storage and was designed to address the performance, reliability and scalability requirements of all-flash arrays, new data center architectures and hyper-scale virtualization. The result of database workload testing with 16GFC components was the achievement of higher performance than the same server and storage configuration using the same workload in an all 8GFC environment. The results of this Cisco and Emulex solution include:

- ◆ A doubling of available bandwidth
- ◆ Peak throughput was 2x higher
- ◆ Maximum I/O transactions were up to 6x greater
- ◆ Completed the workload in approximately half the time
- ◆ The latest Emulex LPe16002 adapters take advantage of PCIe 3.0 slots in the Cisco UCS C-Series servers

The 16GFC infrastructure provides performance horsepower for both new environments and existing environments that demand higher performance than are available today with older technologies. For existing environments with 4GFC or 8GFC infrastructure, installing 16GFC adapters and switching provides a simple plug-and-play performance upgrade.

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 with the release of every generation.

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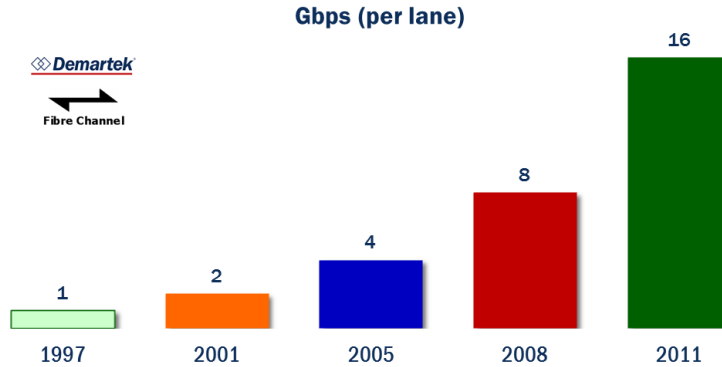
Source: Fibre Channel Industry Association (FCIA)

Backward Compatibility

Fibre Channel technology is backward compatible with the two previous generations. This means that 16GFC Fibre Channel switches, host bus adapters (HBAs) and optics (transceivers) are backward compatible with 8GFC and 4GFC equipment. This provides a smooth upgrade path for enterprises.
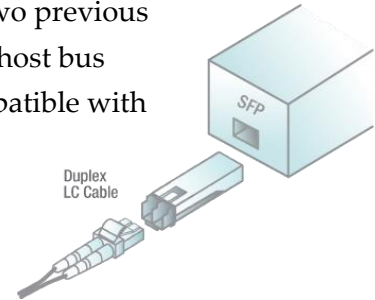
Fiber-Optic Cable Types and Lengths

Demartek recommends that customers purchase OM3 or OM4 multi-mode fiber-optic cables for Fibre Channel deployments within datacenters for existing and planned future speeds of Fibre Channel. 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

The most current version of this report is available at
http://www.demartek.com/Demartek_Emulex_16GFC_Cisco_Accelerating_Workload_Performance_Evaluation_2016-06.html on the Demartek website.

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