

Impact of HBA Performance on Server Virtualization

QLogic HBAs Reduce Datacenter Costs Through Higher Performance Scalability in VMware® Environments



Executive Summary

Server consolidation is the primary driver for enterprise datacenters to deploy server virtualization technologies. Server consolidation helps to improve server/processor utilization and lower datacenter capital and operational costs. As more virtual servers get consolidated onto a single physical server, there is an increased demand on the scalability and performance of the server CPU, memory, host bus interfaces, and I/O sub-systems like storage networking. IT managers should ensure that none of these sub-systems become a bottleneck for successful deployment of a virtualized and consolidated datacenter.

Introduction of 64-bit, multi-core processors, PCI Express host bus and improved memory architectures have greatly benefited server consolidation and its rapid adoption in the virtualized datacenter. In the storage networking space, the evolution of consolidated server deployments and the move to 4Gb Fibre Channel switches and storage arrays is demanding a need for higher scalability in server connectivity to storage. To meet these ever-growing demands in consolidated and virtualized environments, it is imperative that enterprise IT managers deploy a scalable, high performance HBA architecture; an HBA architecture that can address the demands placed by multiple virtual machines (VMs) or guest Oses, and applications in virtualized environments running simultaneously on a single physical server.

To help IT decision makers make an informed HBA choice for virtualized environments using VMware® ESX Server, QLogic has performed a series of head-to-head performance benchmarks for I/O performance and scalability of the QLogic SANblade™ 2400 series HBAs versus Emulex® LightPulse® 11000 series HBAs while running scalability tests with multiple VMs, Oracle (OLTP)/Microsoft Exchange workloads, in VMware ESX Server 3.0.1 environments.

Key Findings

For [datacenters deploying virtualization](#) for server consolidation with VMware, [QLogic 4Gb FC HBAs](#) enable [28% higher efficiency \(lowering capital and operational costs\)](#) by providing [38% higher HBA performance scalability](#) in multi-virtual machine environments.

QLogic 4Gb HBAs delivered higher performance in comparison to Emulex 4Gb HBAs:

- **38%** higher in HBA performance scalability testing in VMware.
 - **QLogic HBAs scaled higher with multiple VMs** compared to **Emulex HBA performance which peaked at 2 VMs.**
- **35%** higher performance using Oracle workloads in VMware.
- **39%** higher performance using Microsoft Exchange workloads in VMware.

Introduction

The objective of the performance testing was to test and compare the I/O performance of QLogic and Emulex 4Gb Fibre Channel HBAs in a representative selection of real world enterprise applications like Oracle and Microsoft Exchange while running in VMware ESX Server environments. HBA performance scalability testing was also performed to measure the ability of the HBA to scale across multiple VMs deployed on a single physical server deploying VMware ESX Server 3.0.1.

The three test environments that were used are:

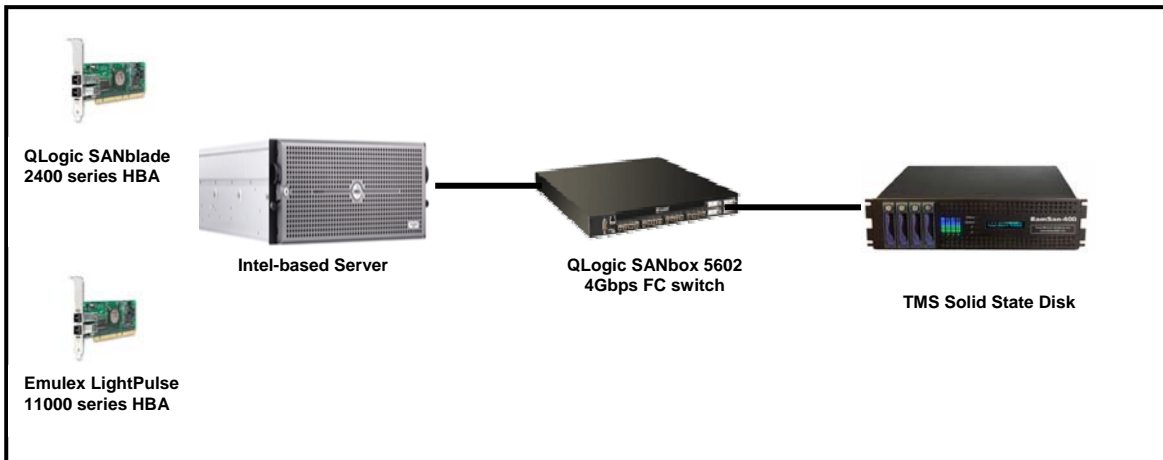
- **HBA Performance Scalability Testing in VMware Environments**
 - Measured IOPs and throughput for HBAs for 1, 2, and 4 VMs installed on the same physical server.
- **HBA Performance using Oracle Workloads in VMware Environments**
 - Simulated database I/O workloads (OLTP) using Oracle's ORION software tool.
- **HBA Performance using Microsoft Exchange-Workloads in VMware Environments**
 - Simulated I/O workloads for a heavily utilized server running Microsoft Exchange that accounted for message traffic and transaction log traffic.

Test Setup

The test setup consisted of the latest QLogic SANblade™ 2400 series and Emulex® LightPulse® 11000 series HBAs running with the latest commercially available drivers, installed in a Intel-based server running VMware ESX Server 3.0.1. The server was connected to a Texas Memory Systems solid state disk through a QLogic® SANbox™ 5602 4Gbps fibre channel switch. The solid state disk was used to minimize rotational latency of the storage system and concentrate on saturating the HBA bandwidth. All tests were run using the HBA default settings from both companies.

A Windows Server™ 2003 operating system was installed on the VMware ESX Server 3.0.1 as the guest OS on all VMs using one virtual CPU, 2GB RAM, and 500MB LUN capacity.

3 QLogic HBA Reduce Datacenter Costs Through Performance Scalability in VMware Environments



HBA Performance Scalability Testing in VMware Environments

Test Overview

To meet the ever-growing demands on the SAN, it is imperative that enterprise SAN users deploy a scalable HBA architecture that can address a full spectrum of concerns including cost, performance, backward compatibility, and most importantly scalability in virtualized environments.

As virtualization and server consolidation deployments increase, enterprise IT managers need to be aware of how performance benefits in non-virtualized OS environments translate to virtual server OS environments (for example, VMware ESX Server).

Tests were performed to compare I/O performance of QLogic and Emulex 4Gb FC HBAs in a VMware ESX Server 3.0.1 virtualized environment with Windows Server 2003 as a guest OS. IOMeter was used to measure the IOPs and throughput values across a range of block sizes. The IOMeter tests were run to measure how HBA performance would scale across instances of 1, 2, and 4 VMs for:

- Sequential Reads
- Sequential Writes
- Sequential Read/Write (full duplex)

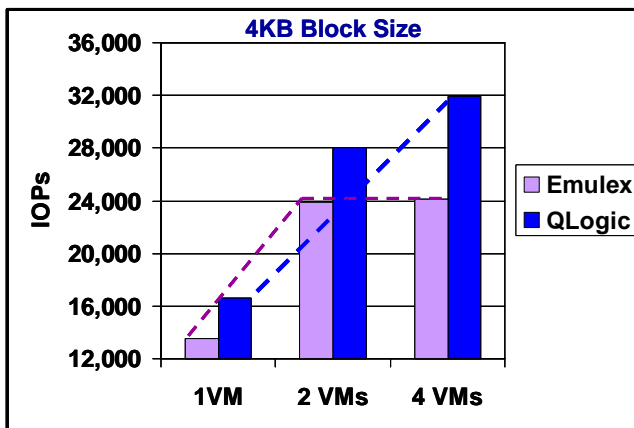
Windows Server 2003 was the guest OS used in all three test cases. I/O was run in a physical compatibility mode on a mapped raw LUN per VM.

4 QLogic HBA Reduce Datacenter Costs Through Performance Scalability in VMware Environments

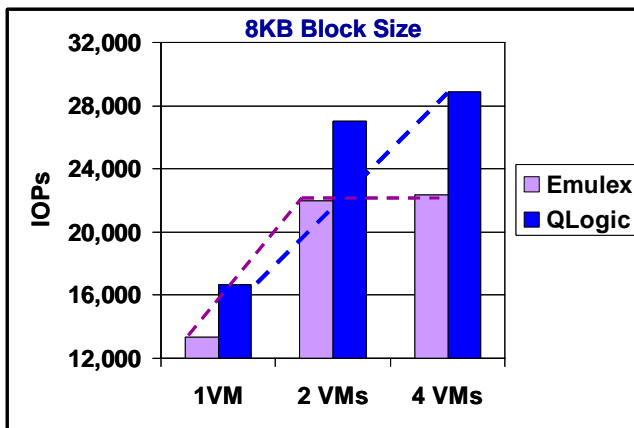
Test Results

QLogic HBAs outperformed Emulex in all three test scenarios. The charts for the test results can be found in Appendix B at the end of this paper. For more specific details on the testing results, please contact your QLogic sales representative.

Most enterprise applications including Oracle and Microsoft Exchange operate in block sizes ranging from 4KB to 8KB. Below are two charts that clearly demonstrate how **QLogic FC HBA performance scales higher as the number of VMs increase from one to four**. In contrast, the Emulex HBA performance peaked at 2 VMs and did not scale higher with the addition of more VMs.



HBA Performance Scalability Testing Comparison



HBA Performance Scalability Testing Comparison

QLogic scales 42% higher with increase in VMs

5 QLogic HBA Reduce Datacenter Costs Through Performance Scalability in VMware Environments

HBA Performance Using Oracle Workloads in VMware Environments

Test Overview

Today's mission-critical Oracle applications demand the highest levels of performance from their database servers and storage infrastructure. The objective of the Oracle workload testing was to test and compare the I/O performance of QLogic and Emulex 4Gb Fibre Channel HBAs in a VMware ESX Server 3.0.1 virtualized environment with a single Windows Server 2003 guest OS.

In order to make the benchmarks relevant to today's businesses, we selected the market-leading **Oracle® RDBMS** running on Microsoft® Windows 2003™ Enterprise Edition with Service Pack 1. Selecting Oracle enabled us to use ORION (v10.2), a tool from Oracle used for predicting the performance of the Oracle database under load.

For this test the following workload was used:

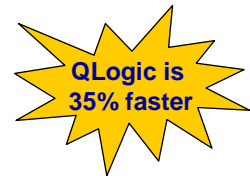
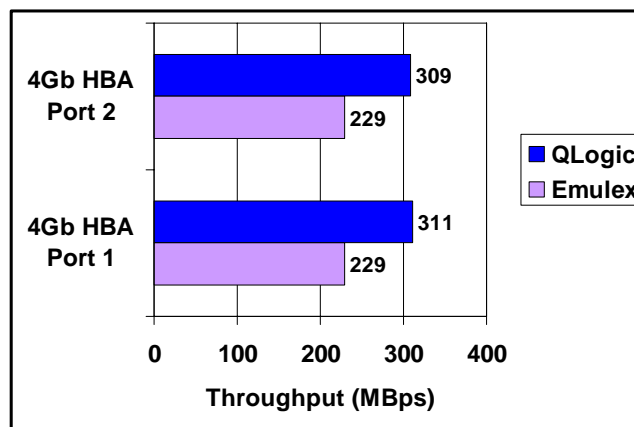
- An **OLTP workload** with a read: write ratio of 70:30. OLTP applications are high throughput, insert/update-intensive and typical for companies having large transaction processing applications, such as airline ticketing, large order-entry, and banking applications.

For our tests, the key measure of HBA I/O performance, especially when used in a database application was the ability of the HBA to handle the volume of data or throughput as measured in megabytes per second (MBps), and the ability of the HBA to scale across multiple ports.

Test Results

The performance was measured against an increasing load on the HBAs determined by number of outstanding Input-Output (I/Os) requests. All tests used a standard block size of 1MB (default recommended setting) and ORION num_disks parameter set at 16.

In large random I/O workloads with DUAL port 4Gb FC HBAs (with both ports at maximum load). QLogic 4Gb HBA delivered a 35% higher throughput in database applications (Oracle) workloads running in VMware environments.



Oracle Workload Comparison

HBA Performance Using Microsoft Exchange Workloads in VMware Environments

Test Overview

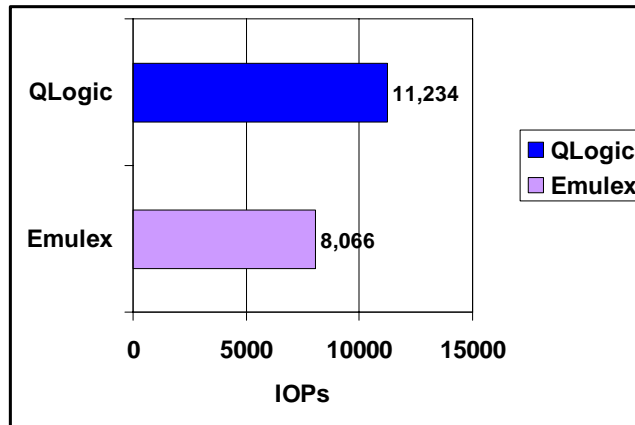
Microsoft Exchange is the #1 business critical email application in small, medium and large enterprises. Scalability and performance is a major factor for deciding on an enterprise class FC HBA. The objective of the Microsoft Exchange workload testing was to test and compare the I/O performance of QLogic and Emulex 4Gb Fibre Channel HBAs in a VMware ESX Server 3.0.1 virtualized environment with Windows Server 2003 as the guest OS.

The tests performed were based on generation of a complex set of data streams in a pattern that simulate I/O for a virtualized server running Microsoft Exchange. The I/O model had two components: message traffic (90%) and transaction log traffic (10%). In heavy message traffic environments, the read-to-write ratio goes up to 67% reads and 33% writes.

To represent above I/O patterns, IOmeter was structured around 18 processes. To represent message I/O, we launched 12 processes, to read 4KB blocks and 4 processes to write 4KB blocks. To represent transaction log I/O, we launched 2 processes to write data in 64KB blocks.

Test Results

QLogic achieved 39% higher IOPs and processed over 3000 more transactions running Microsoft Exchange Workloads in VMware environments.



MS Exchange Workload Comparison

Business Benefits of Superior HBA Performance Scalability

The testing results demonstrated that QLogic 4Gb SANblade 2400 series FC HBAs significantly outperform Emulex 4Gb LightPulse 11000 series FC HBAs in virtualized server environments using VMware ESX Server 3.0.1.

As stated earlier in this paper, with architecture advances such as multi-core CPUs, high performance host-bus architecture (PCIe 2.0), and server virtualization initiatives, the I/O interconnect could potentially become the bottleneck to achieving high performance. The importance of FC HBA performance and scalability is even more pronounced in virtualized environments. The ability to scale with multiple-VMs has a direct correlation to the degree of server consolidation that can be achieved in enterprise datacenters.

A high performance and scalable HBA enables IT managers to:

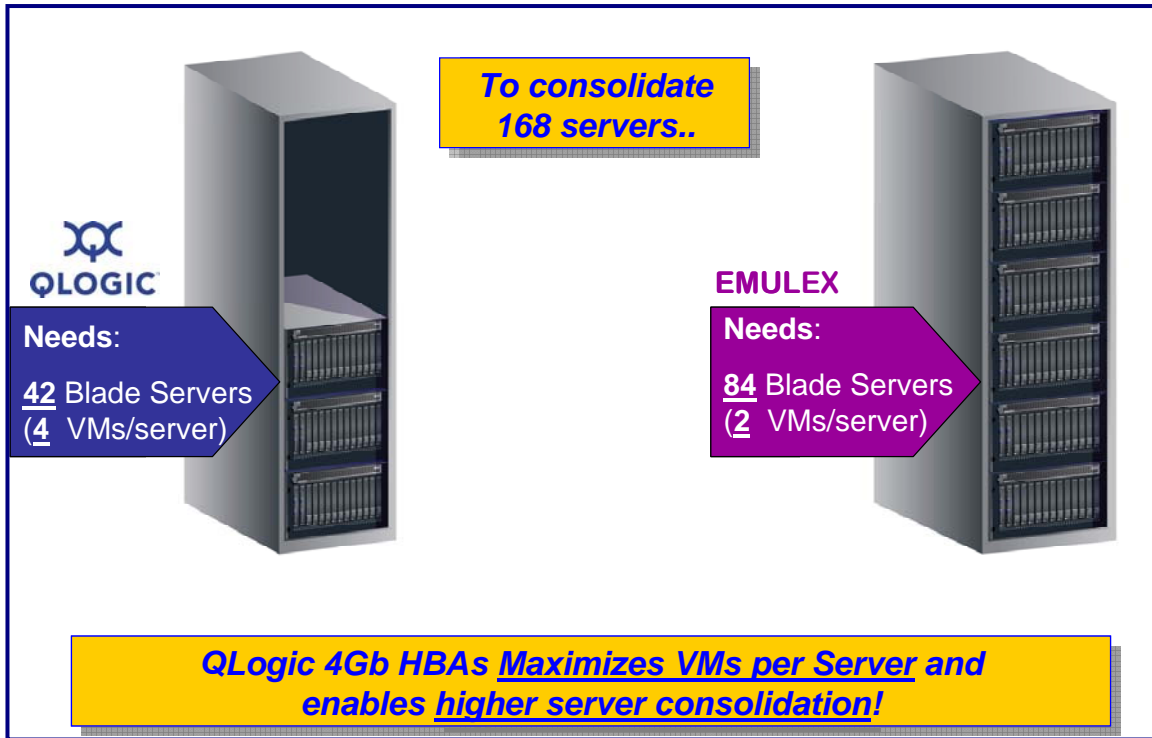
- Ensure HBAs are not an I/O bottleneck as they deploy more VMs on a single server.
- Reduce number of additional servers that are necessary to accommodate additional VMs, and hence reduce associated hardware acquisition costs.
- Lower operational costs (power, cooling, and space) through savings generated by reduced number of servers.
- Lower software licensing, provisioning, and maintenance costs associated with each additional server.

8 | QLogic HBA Reduce Datacenter Costs Through Performance Scalability in VMware Environments

Business Case 1: Consolidating Servers in a Mid-sized Datacenter

An IT Administrator of a mid-sized datacenter would like to deploy VMware ESX Server 3.x environments with a primary motivation to consolidate the number of servers being deployed. Currently the datacenter has 168 servers that they are planning to consolidate.

Maximizing Number of VMs/Server with QLogic HBAs



As demonstrated earlier, QLogic HBAs continue to scale as more VMs are deployed where as Emulex HBA performance peaks at 2VMs. **As illustrated in the above figure, a datacenter consolidating 168 Servers with QLogic HBAs can deliver the same level of performance scalability with 50% less hardware compared to the leading competitor's solution.**


9 QLogic HBA Reduce Datacenter Costs Through Performance Scalability in VMware Environments

Business Case 2: Deploying Additional Servers in a Virtualized Enterprise Datacenter

An IT Administrator of an enterprise datacenter is planning to deploy 1000 additional servers in a VMware ESX Server 3.x environment to host database applications (Oracle), email applications (Exchange) and backup applications (sequential read/writes).

An enterprise datacenter which was planning to deploy a thousand server environment using Emulex 4Gb FC HBAs would now deliver higher level of performance using QLogic 4Gb FC HBAs with only 724 servers. **QLogic HBAs process 38% more transactions (based on average performance advantage across the three test scenarios presented earlier) with the same underlying server hardware.** The following table provides a summary of the business value generated by deploying the highly scalable QLogic 4Gb FC HBAs in a virtualized server environment.

Maximizing Datacenter Cost Savings with QLogic FC HBAs

	EMULEX	 QLOGIC™
# of Blade servers	1,000	724
# of Chassis	71	52
# of Racks	12	9
Hardware acquisition costs ¹	\$6.02M	\$4.36M
3-year cost for power, space, and cooling ²	\$2.67M	\$1.93M
3-year OS Licensing Costs ¹	\$9.20M	\$6.66M
3-year Server Administrator Costs ³	\$5.40M	\$3.90M
Total Costs⁴	\$23.29M	\$16.85M

As demonstrated above, each high performance 4Gb QLogic HBA saves ~\$9,000 in datacenter costs over a comparable 4Gb Emulex HBA.

QLogic 4Gb HBAs reduce datacenter costs and deliver 28% higher cost efficiency in Server-virtualized environments!

Notes:

1. Hardware acquisition and OS licensing costs are based on list prices.
2. Power, space, and cooling costs based on industry estimates.
3. Estimated one server administrator per 50 servers.
4. Total costs exclude software provisioning, management, and maintenance/support costs.
5. Additional infrastructure costs (for example, FC Switches, cabling etc.) are not included.

10 | QLogic HBA Reduce Datacenter Costs Through Performance Scalability in VMware Environments

Conclusion

With the increase in virtual server deployments in datacenters, it is imperative to understand how FC HBAs perform in virtualized environments.

By testing the same enterprise applications and performing scalability testing in virtualized environments deploying VMware ESX Server software, QLogic 4GB FC HBAs again demonstrated superior performance scalability against Emulex 4Gb FC HBAs.

For [datacenters deploying virtualization](#) for server consolidation with VMware ESX Server, [QLogic 4Gb FC HBAs](#) enable [28% higher cost efficiency \(lowering capital and operational costs\)](#) by providing [38% higher HBA performance scalability](#) in multi-virtual machine environments.

QLogic 4Gb HBAs delivered higher performance in comparison to Emulex 4Gb HBAs:

- **38%** higher in HBA performance scalability testing in VMware environments
 - QLogic HBAs scaled higher with multiple VMs compared to Emulex HBA performance which peaked at 2 VMs.
- **35%** higher performance using Oracle workloads in VMware environments
- **39%** higher performance using Microsoft Exchange workloads in VMware environments

Standardizing on and deploying QLogic 4Gb FC HBAs in virtualized environments translates to a clear performance benefit, enabling enterprises to do more with less and drive more value from SAN infrastructure investments through enhanced levels of server consolidation.

11 QLogic HBA Reduce Datacenter Costs Through Performance Scalability in VMware Environments

Appendix A

Server Configuration

Intel Server	
Type and Speed of Processor	Dell 6850 w/ 4 Intel Xeons @ 3.66 GHz
Memory	8GB SDRAM
Operating System (OS)	VMware ESX Server 3.0.1 and MS Windows Server 2003 Enterprise Server SP1 (guest OS)
System Model	Dell Power Edge 6850

FC HBA Hardware

FC HBAs	
QLogic	QLE2462
Emulex	LPe11002

Drivers

VMware ESX Server	
VMware ESX Server 3.0.1 Drivers (Inbox) for QLogic and Emulex 4Gb FC HBAs	

VM Configuration

Windows Server 2003 Virtual Machine	
Operating System (OS)	Windows Server 2003 Enterprise Server SP1
CPU	1 virtual CPU
Memory	2GB SDRAM
LUN Capacity	500MB

Switch Configuration

Switch Configuration	
Switch	SANbox 5602
Vendor	QLogic
Total Number/Speed of Ports	16 4Gb
Firmware Version	V5.0.1.10

Storage Configuration

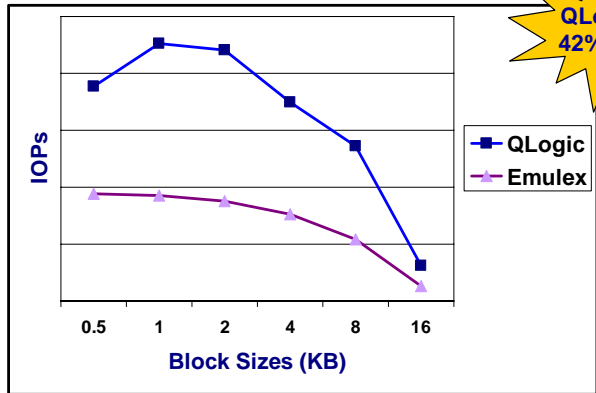
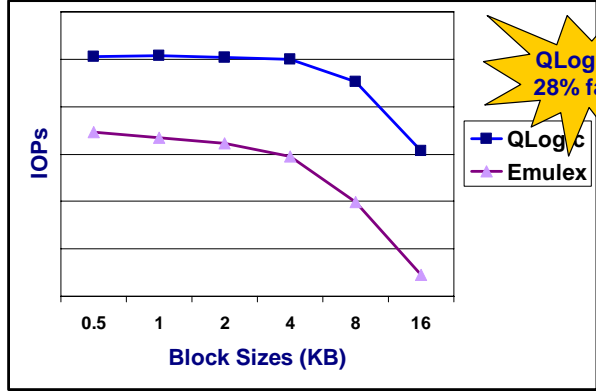
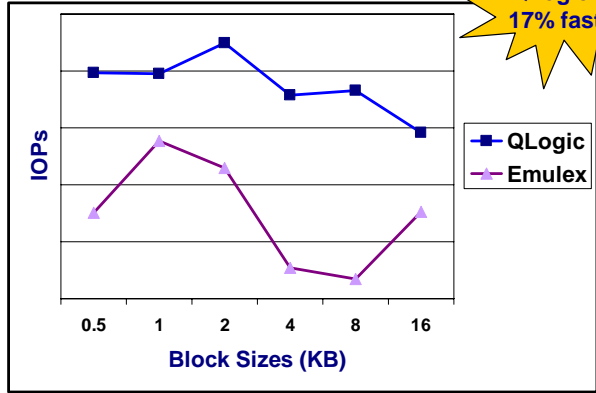
RamSan Storage	
Model	RamSan 400
Total Storage Capacity	16 GB
Number of Ports Used	1/2/4 Ports

Appendix B

Testing Results for Sequential Reads

Most enterprise applications including Oracle and Microsoft Exchange operate in block sizes ranging from 4KB to 16KB and hence this was the focus of the HBA performance scalability tests.

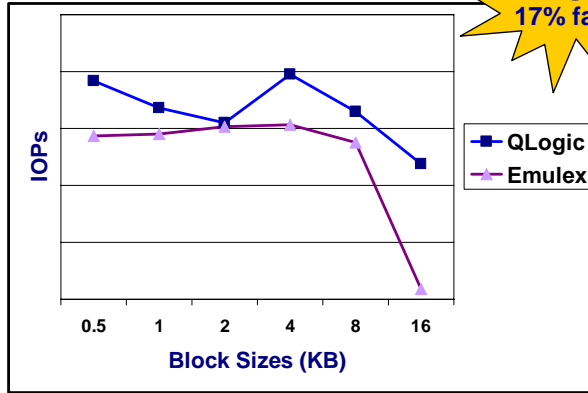
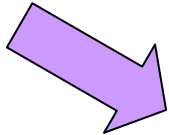
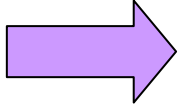
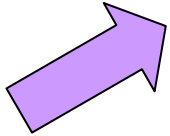
Emulex HBA IOPs peaks at 2 VMs and does not scale as more VMs are added.



13 | QLogic HBA Reduce Datacenter Costs Through Performance Scalability in VMware Environments

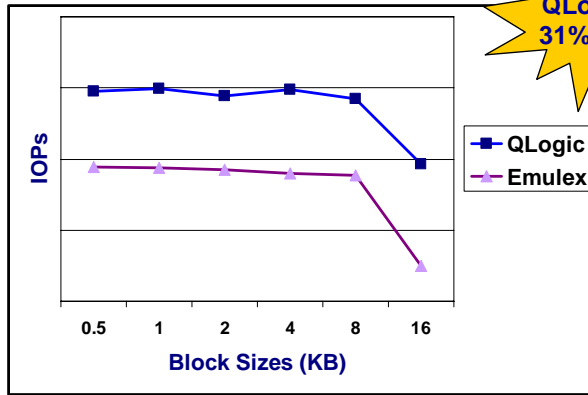
Testing Results for Sequential Writes

Emulex HBA IOPs peaks at 2 VMs and does not scale as more VMs are added.



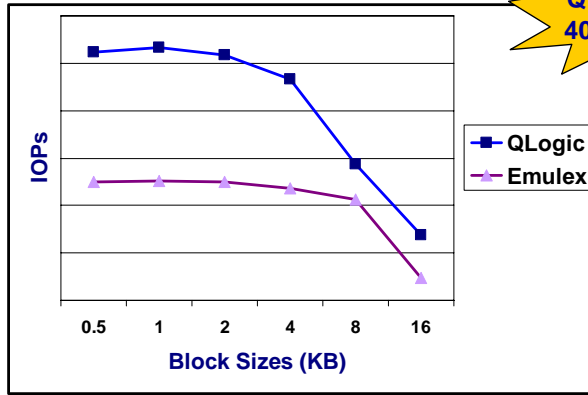
QLogic is 17% faster

IOPs Comparison Running One VM



QLogic is 31% faster

IOPs Comparison Running Two VMs



QLogic is 40% faster

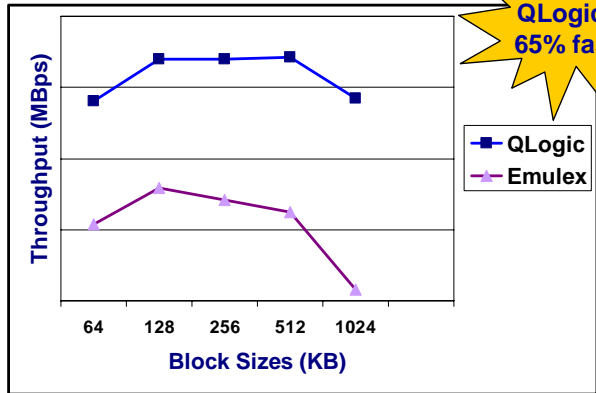
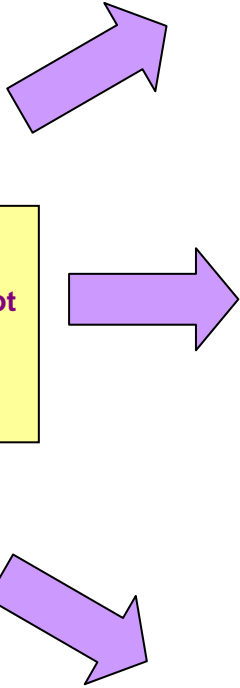
IOPs Comparison Running Four VMs

14 | QLogic HBA Reduce Datacenter Costs Through Performance Scalability in VMware Environments

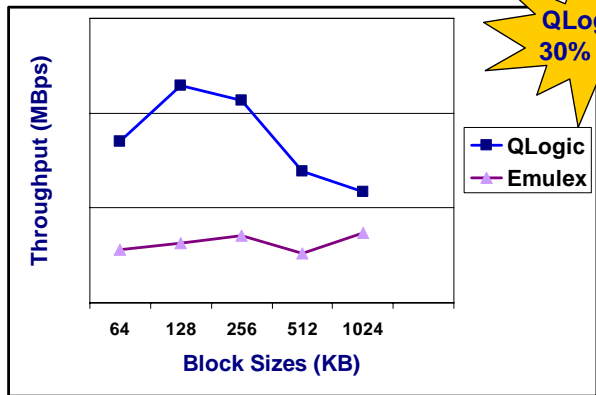
Testing Results for Full Duplex Throughput (Sequential Read/Write)

For bandwidth demanding applications like backup and video streaming, large block size throughput is more valuable than small block size IOPs. Full duplex throughput is a good measure to test.

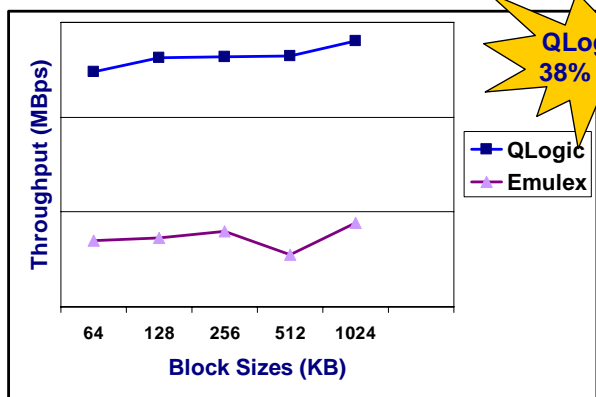
Emulex HBA maximum throughput does not come close to achieving wire speed (800MBps)



Throughput Comparison Running One VM



Throughput Comparison Running Two VMs



Throughput Comparison Running Four VMs

QLogic is 65% faster

QLogic is 30% faster

QLogic is 38% faster

15 | QLogic HBA Reduce Datacenter Costs Through Performance Scalability in VMware Environments

Disclaimer

Reasonable efforts have been made to ensure the validity and accuracy of these comparative performance tests. QLogic Corporation is not liable for any error in this published white paper or the results thereof. Variation in results may be a result of change in configuration or in the environment. QLogic specifically disclaims any warranty, expressed or implied, relating to the test results and their accuracy, analysis, completeness or quality. All brand and product names are trademarks or registered trademarks of their respective companies.