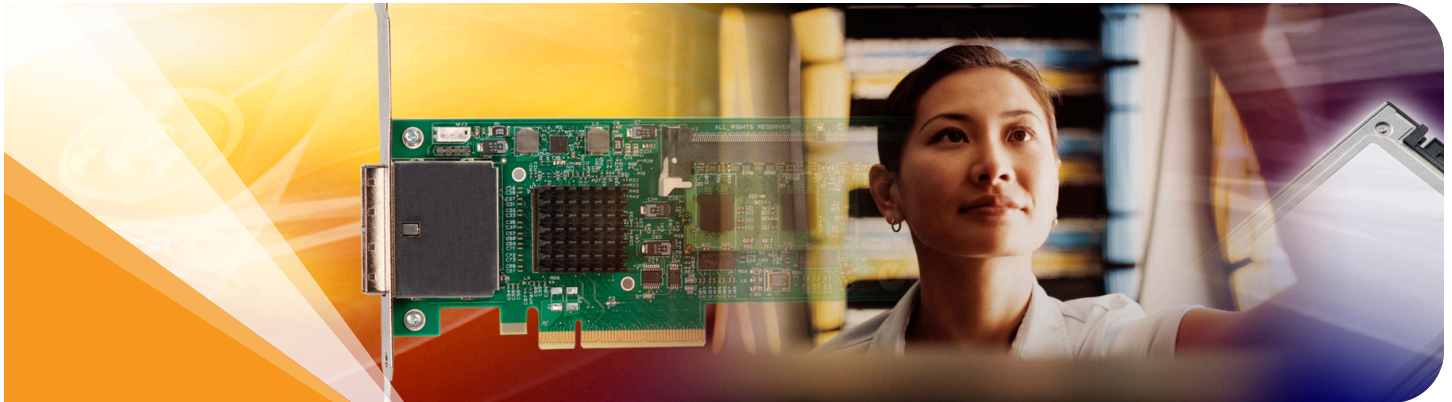


Hard Disk Drives vs. Solid State Drives

A performance evaluation



This is an informational paper that has been assembled to help users understand the performance characteristics of Solid State Drives (SSDs) and their potential uses. It is not a formal benchmark report.

LSI SAS/SATA Storage Adapters and Solid State Drives

LSI SAS Host Bus Adapters and MegaRAID SAS 87XX and 88XX series adapters now support Solid State Drives, which are high-performance plug-and-play data storage devices that contain no moving parts. Some advantages of using SSDs compared to Hard Disk Drives (HDDs) are a faster start-up, extremely low latency, near zero noise pollution, greater temperature range, higher reliability, and faster seek times. SSDs provide excellent performance benefits for applications comprised primarily of random access patterns, such as online transaction processing, databases, and web servers.

MegaRAID management applications are able to identify and manage SSD devices with ease. In fact, MegaRAID Storage Manager (MSM) is a comprehensive set of management tools with the ability to control solid state drives just as it does with hard drives. MSM monitors for proper usage of SSD devices and allows for any combination of SAS HDDs, SATA HDDs, SAS SSDs, and SATA SSDs to be used in the same system.

The combination of LSI SAS/SATA adapters and SSDs are most effective for server applications and server systems where I/O response time is crucial. MegaRAID SAS 87XX and 88XX series adapters also offer a unique data protection feature when used with SSDs. SSD Guard™ increases the reliability of SSDs by automatically copying data from a drive with potential to fail to a designated spare or newly inserted drive. A predictive failure event notification, or S.M.A.R.T command, automatically initiates this rebuild to preserve the data on an SSD whose health or performance falls below par. This new feature provides added data protection, particularly benefitting those users employing a RAID 0 configuration.

Summary of Results

The purpose of this report is to provide an analysis of the performance benefits of SSDs and to illustrate how they differ from traditional HDD rotational media. The following table outlines the performance characteristics for common applications.

MEASUREMENT	IO CHARACTERISTIC	TYPICAL APPLICATIONS
Online Transaction Processing	Small transfer sizes (2KB-16KB), random in nature with two reads for every write. Large number of concurrent requests	Databases (SAP, Oracle, SQL), Email, Decision support.
File Server	Requests fall between 4-64KB in size, primarily random, as multiple users are being serviced with a fair amount of concurrency	File Servers, Print Servers
Web Server	Generally random IO, which varies widely in size and is applied with a high number of concurrent accesses	Web Services, Search Engines, RSS Feeds, Blogs etc.
Workstation	Primarily small to medium requests with a 4:1 read to write ratio, with 80% of the requests being sequential with 20% random IO interspersed.	Business Productivity, CAD/CAM, Scientific and Engineering Applications

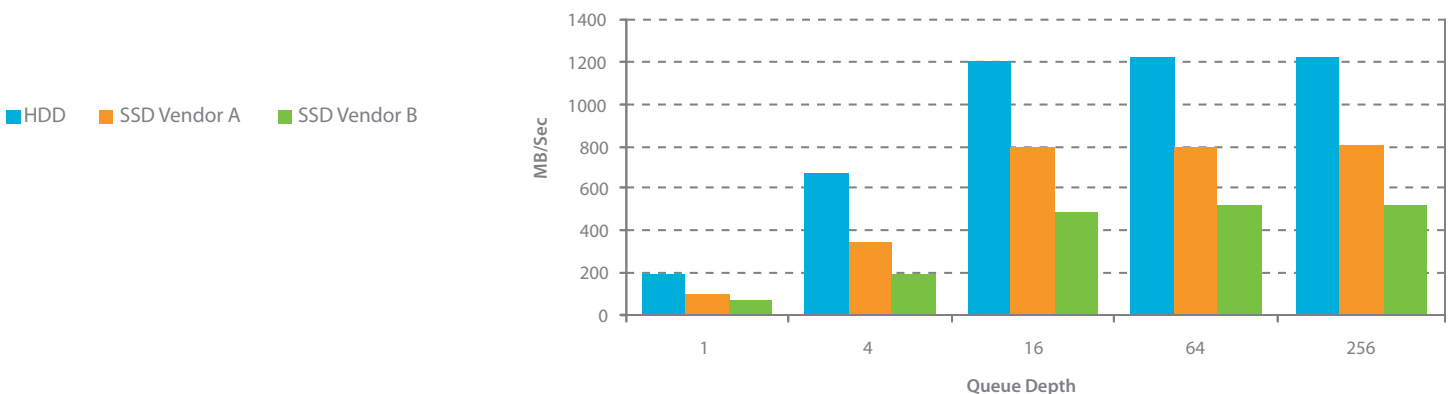
SSDs provide additional performance benefits for access patterns that are primarily random. SSDs have "access" times over 100 times faster than HDDs (5-7ms for 15K RPM HDDs vs 20us for SSDs). As a result of wear leveling, write performance is generally significantly lower than read performance, and because of limited write cycles, SSDs are more suitable for read intensive workloads. The following table shows common usages for each disk type, taking into account the performance characteristics and inherent differences between them.

SATA WORKLOADS	SAS HDD WORKLOADS	SSD WORKLOADS
Video Servers	Online Transaction Processing	Online Transaction Processing
Video Editing	Databases	High Transaction Databases
Virtual Tape Libraries	Enterprise E-mail Servers	Level 4 cache
Backup Servers	Web Servers	High Bandwidth Web Servers
SoHo Business Systems	File Server	OS Paging
Medical Imaging	Application Servers	Workstations
Archiving		

The following charts outline performance comparisons for the different pure access types: sequential reads, sequential writes, random reads, and random writes. In addition, performance is measured in five real world applications: web server, email server, online transaction/database processing, file server and workstation. The RAID levels tested are RAID 0, 5, 6, and 10.

RAID 0

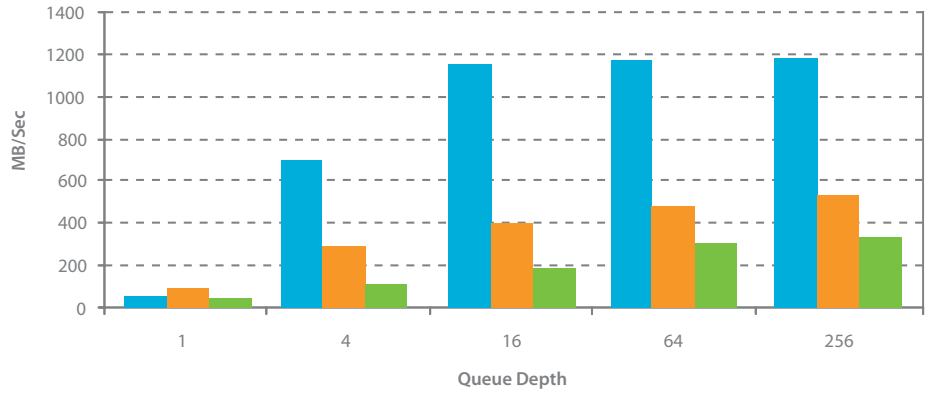
64KB Sequential Reads



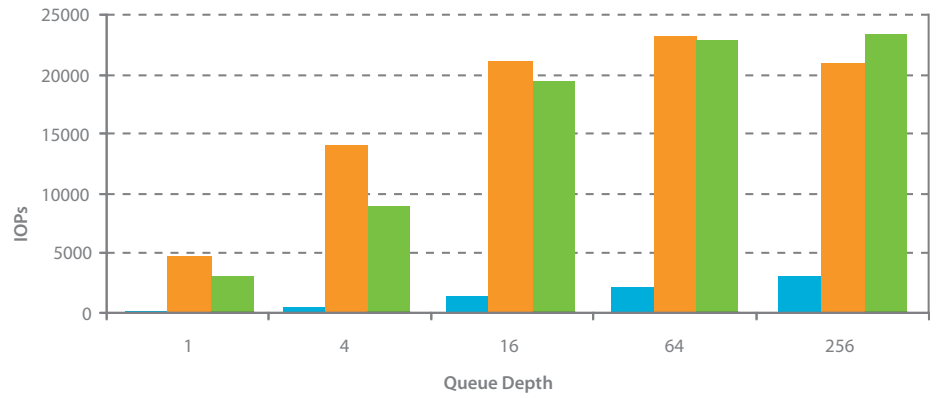
RAID 0

■ HDD ■ SSD Vendor A ■ SSD Vendor B

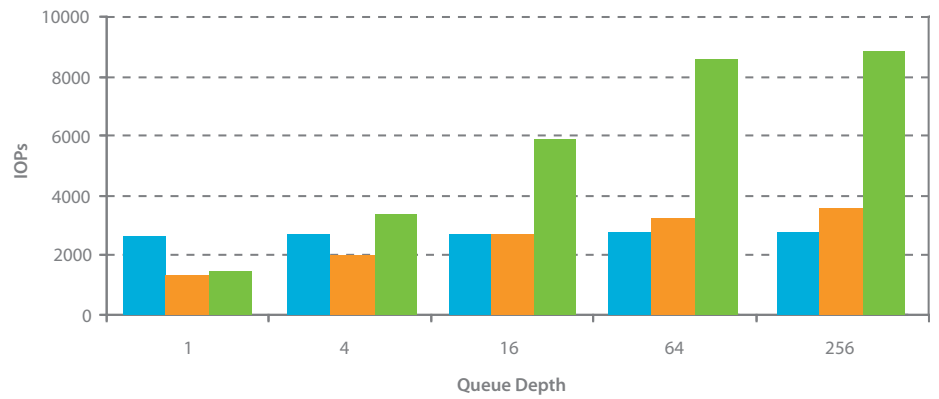
64KB Sequential Writes



4KB Random Reads



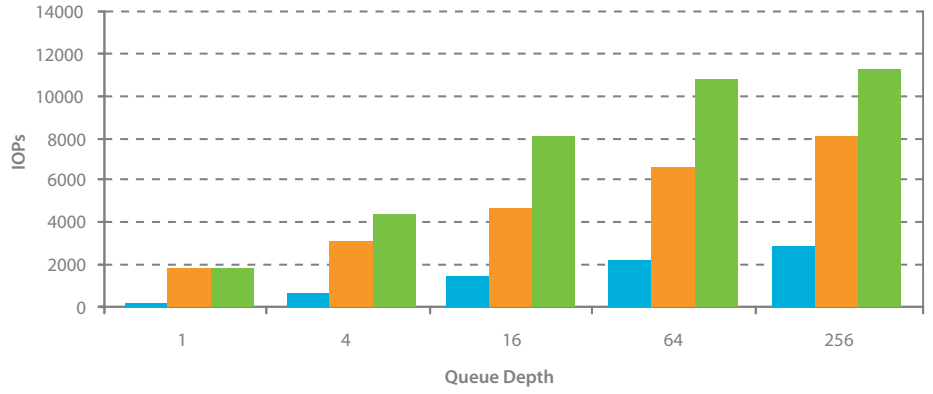
4KB Random Writes



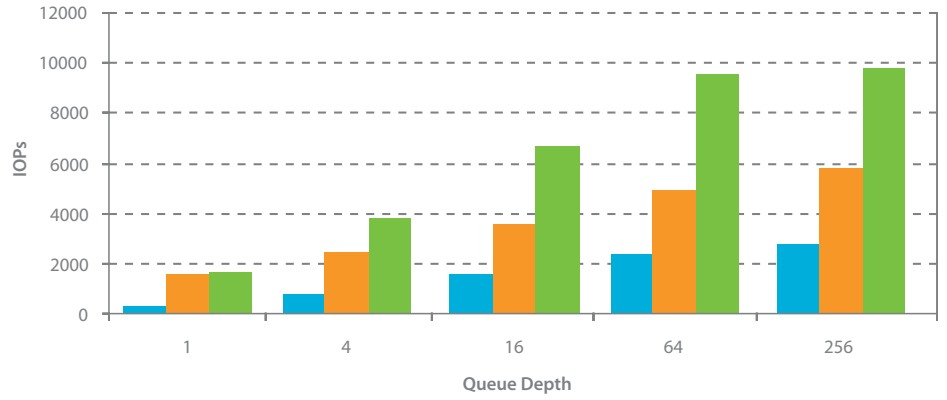
RAID 0

■ HDD ■ SSD Vendor A ■ SSD Vendor B

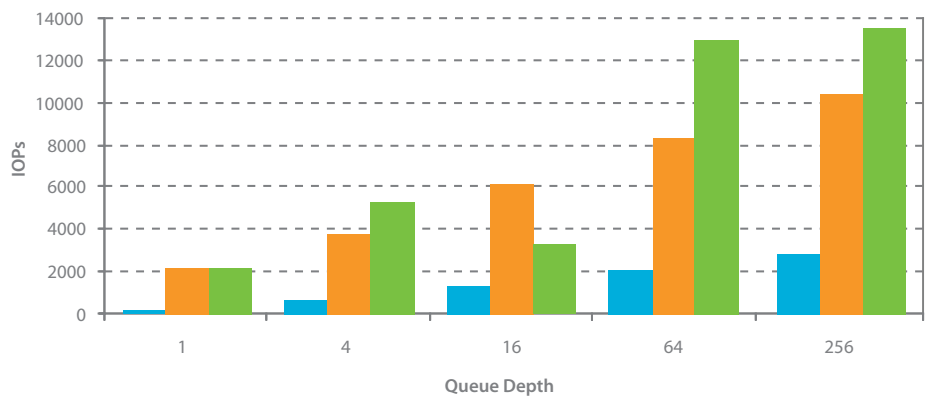
8KB OLTP



E-Mail Server

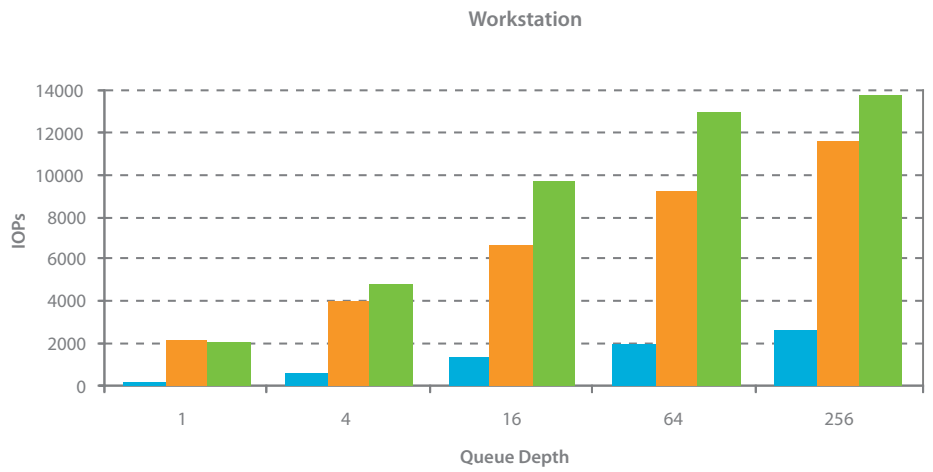
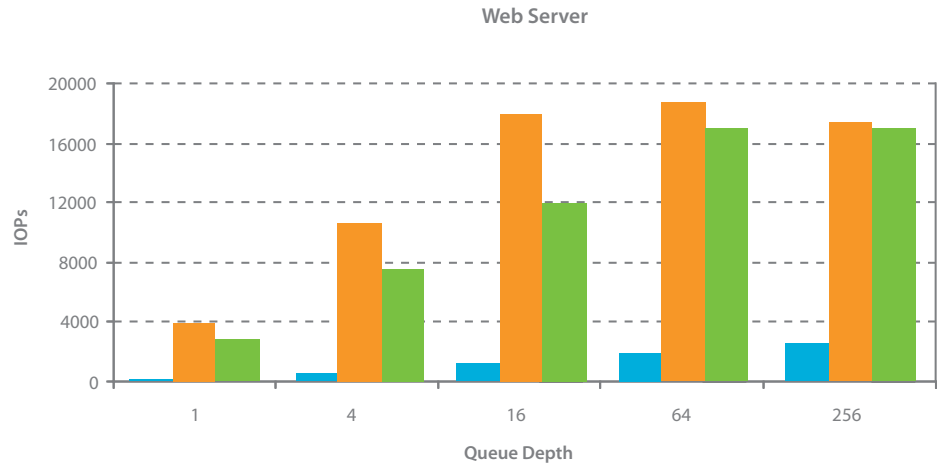


File Server



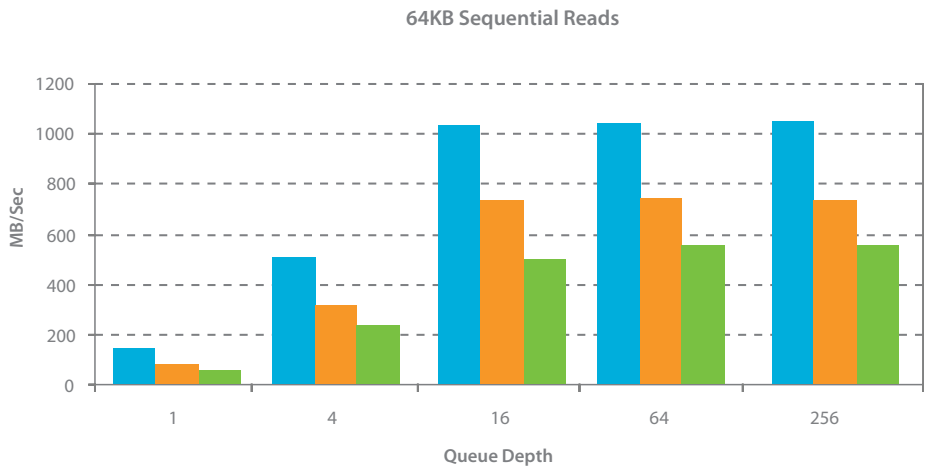
RAID 0

■ HDD ■ SSD Vendor A ■ SSD Vendor B



RAID 5

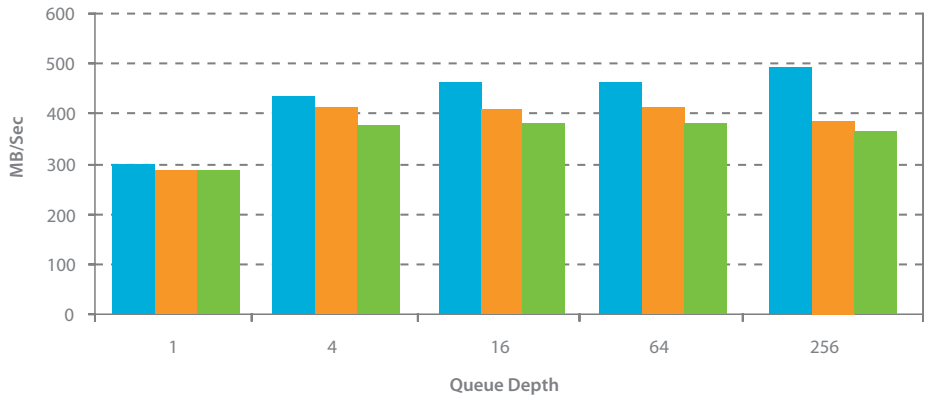
■ HDD ■ SSD Vendor A ■ SSD Vendor B



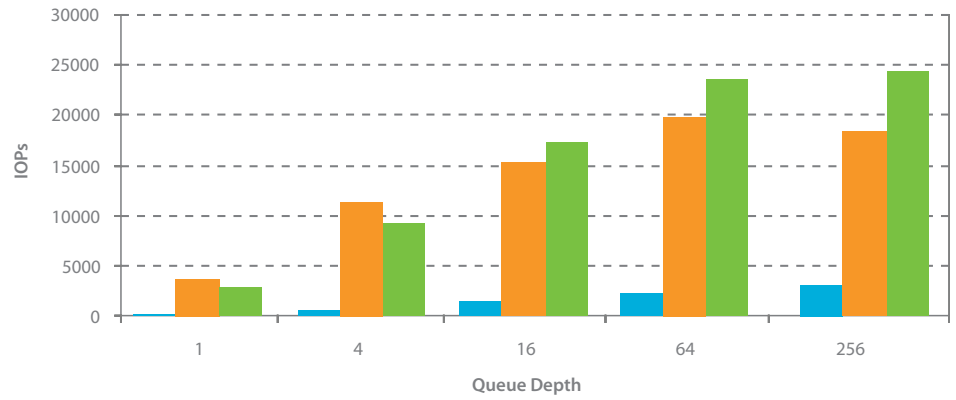
RAID 5

■ HDD ■ SSD Vendor A ■ SSD Vendor B

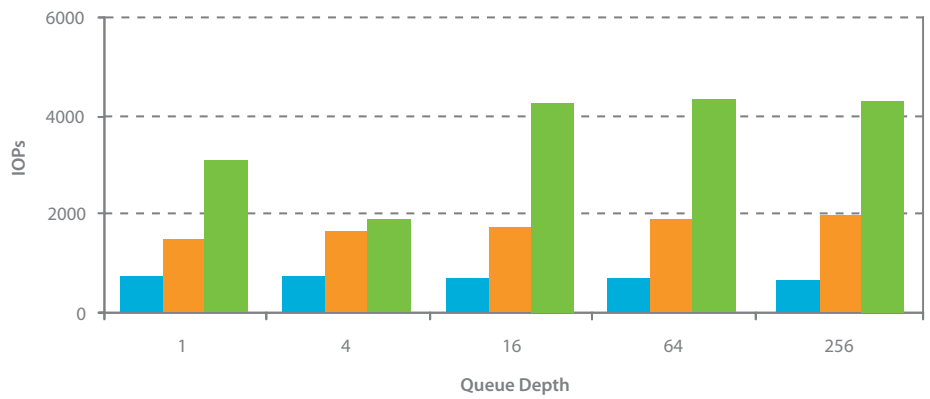
64KB Sequential Writes



4KB Random Reads

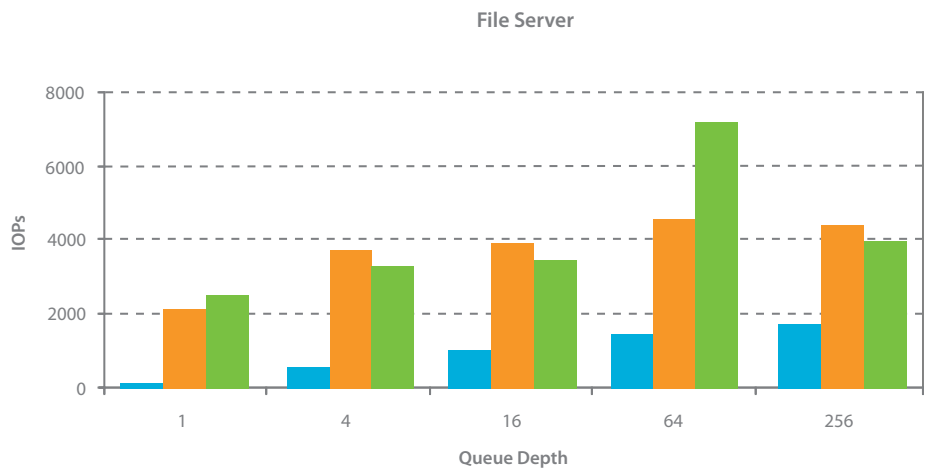
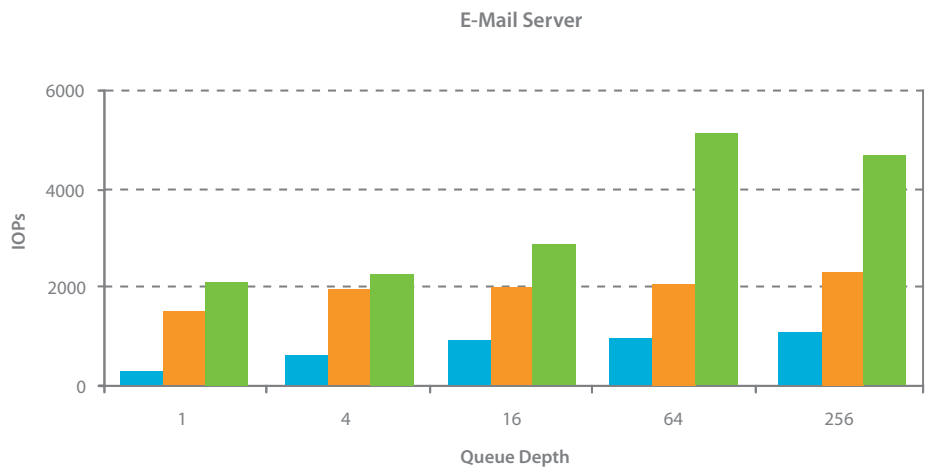
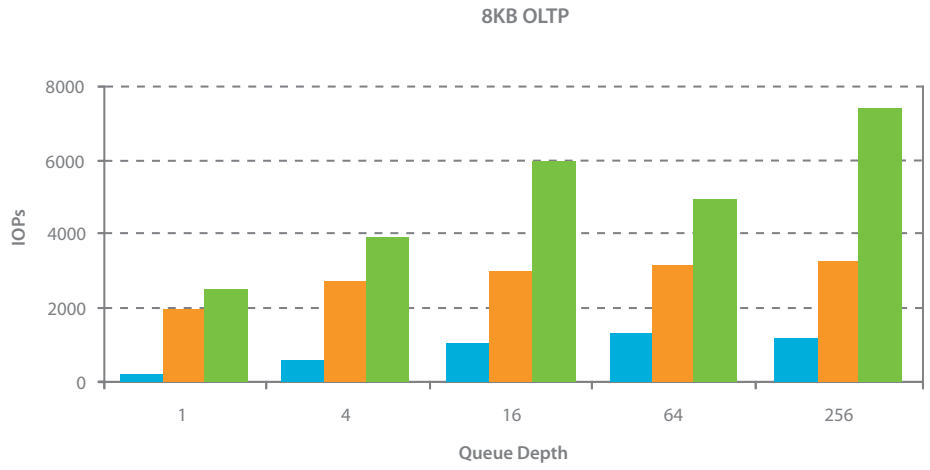


4KB Random Writes



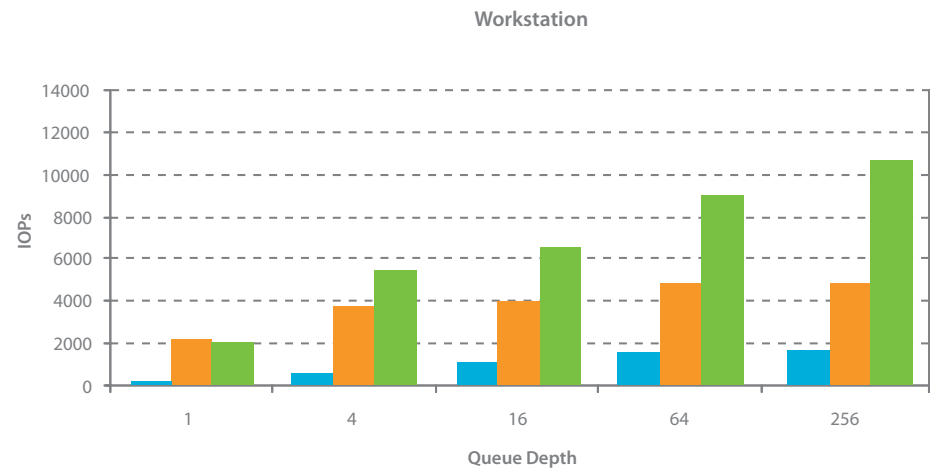
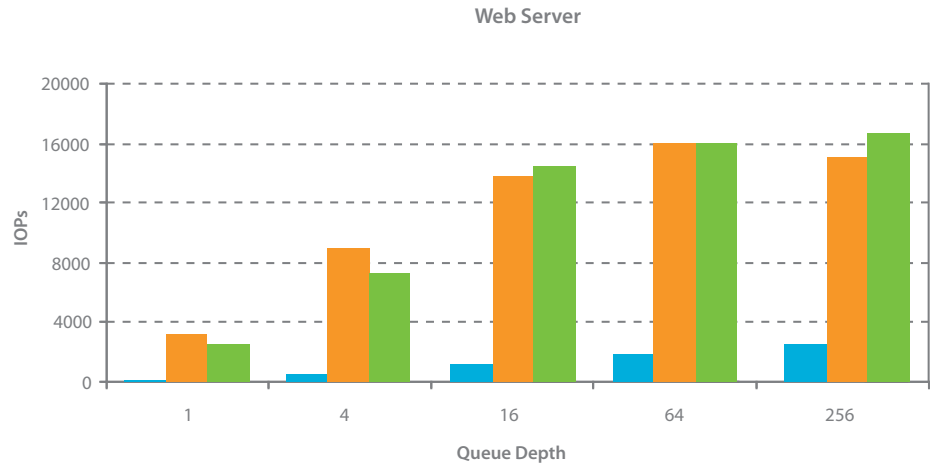
RAID 5

■ HDD ■ SSD Vendor A ■ SSD Vendor B



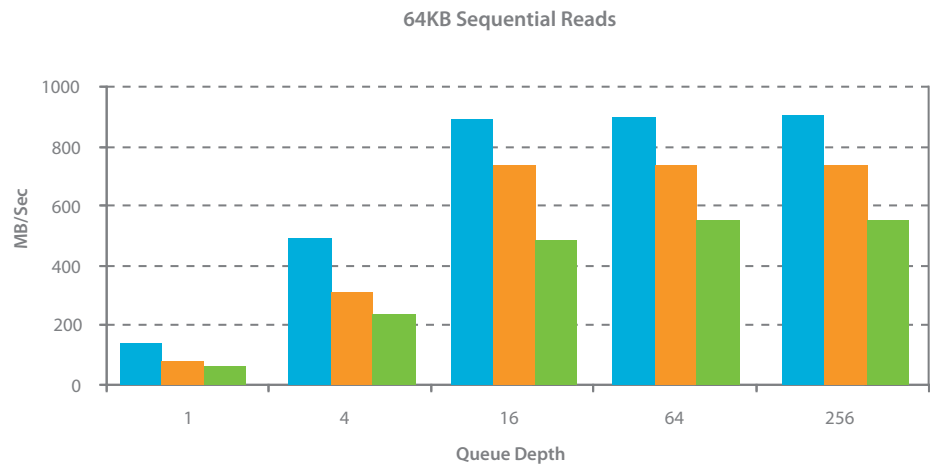
RAID 5

■ HDD ■ SSD Vendor A ■ SSD Vendor B



RAID 6

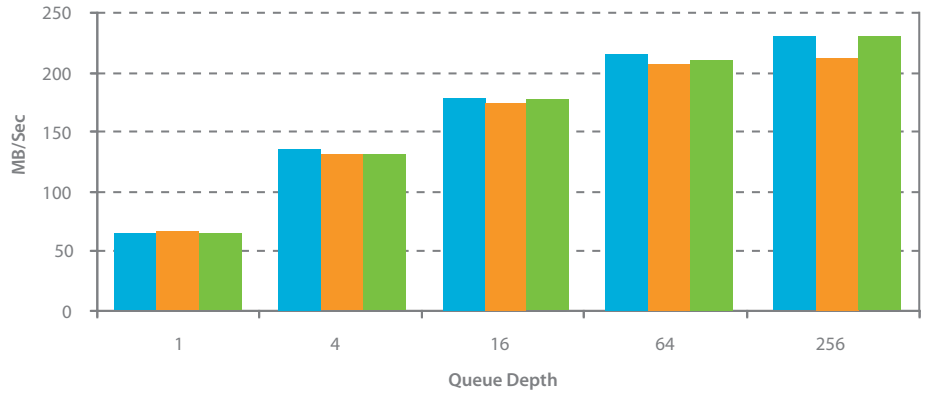
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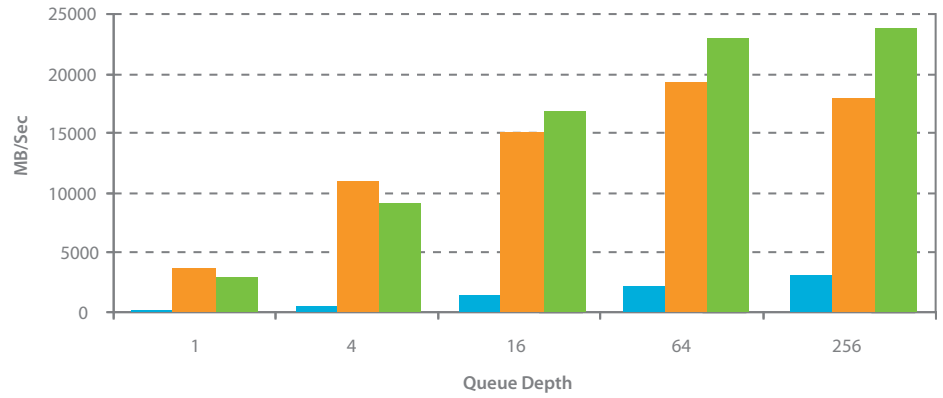
RAID 6

■ HDD ■ SSD Vendor A ■ SSD Vendor B

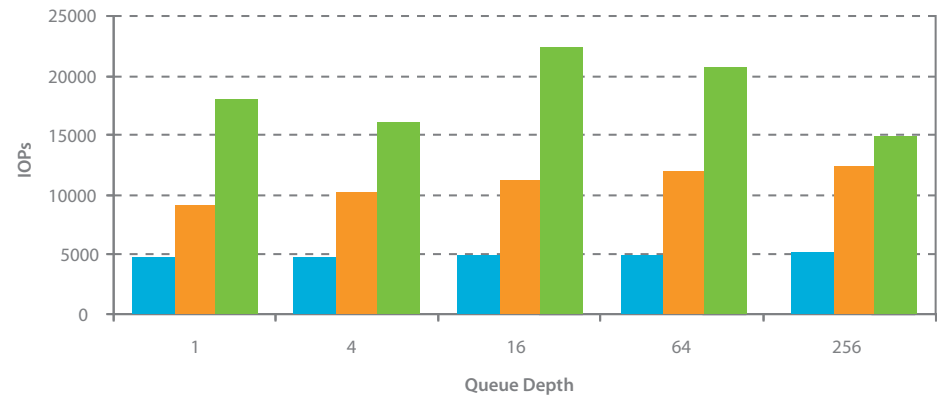
64KB Sequential Writes



4KB Random Reads



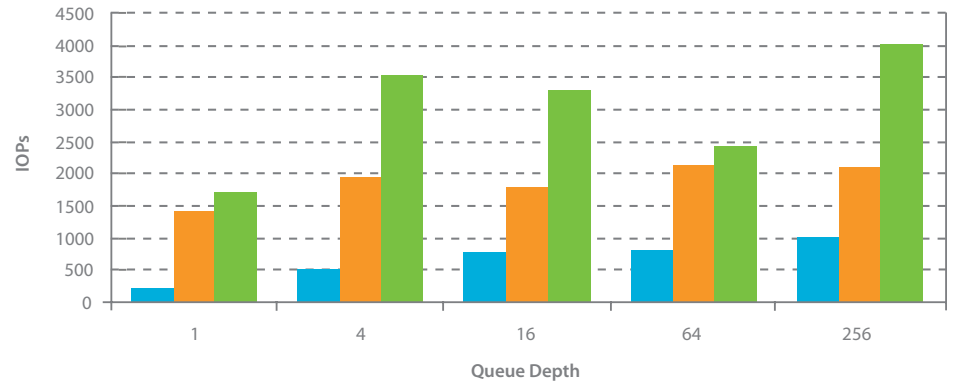
4KB Random Writes



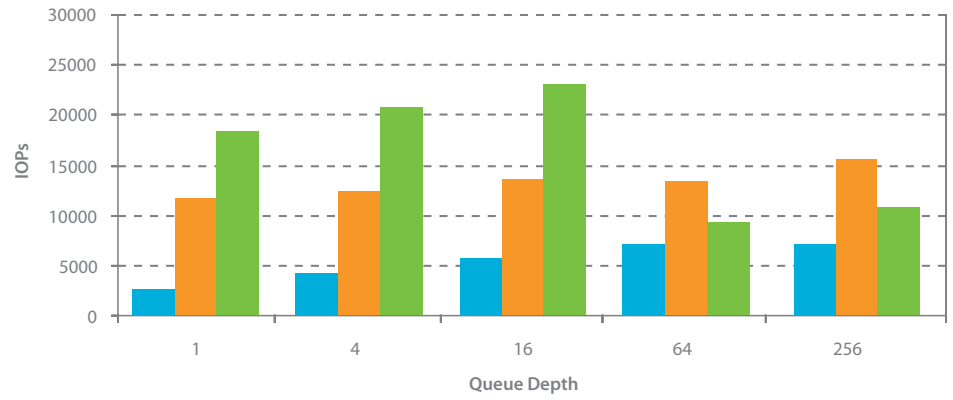
RAID 6

■ HDD ■ SSD Vendor A ■ SSD Vendor B

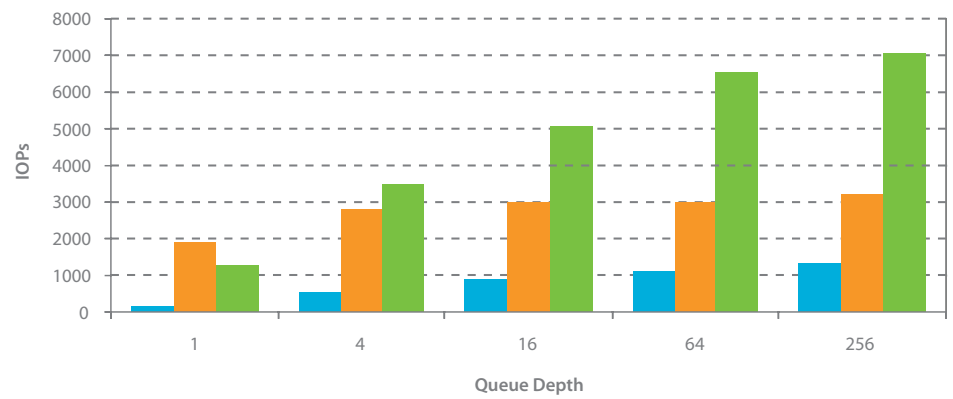
8KB OLTP



E-Mail Server

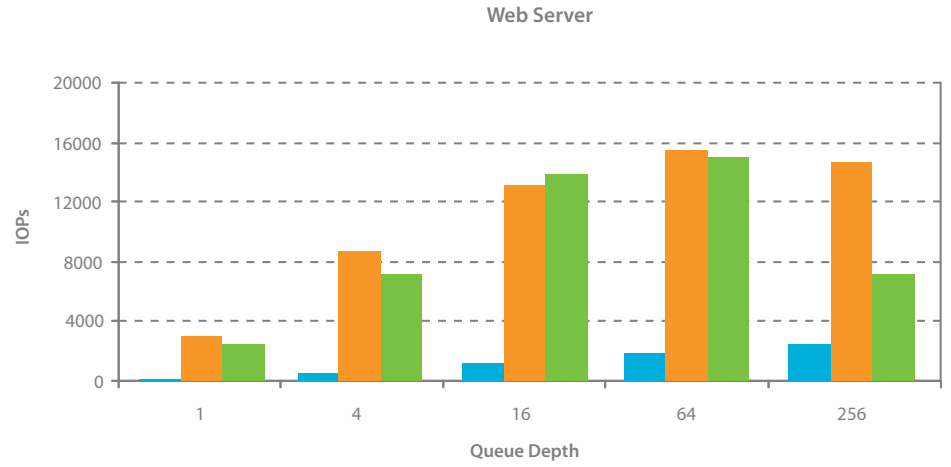


File Server



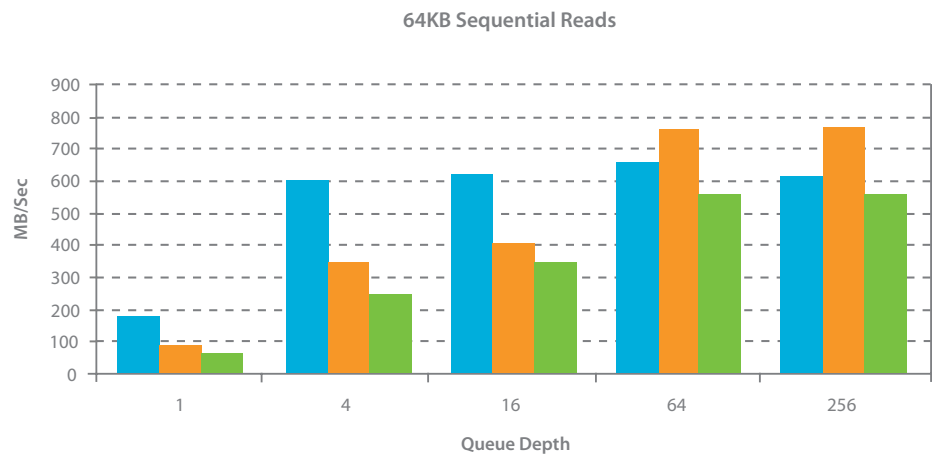
RAID 6

■ HDD ■ SSD Vendor A ■ SSD Vendor B



RAID 10

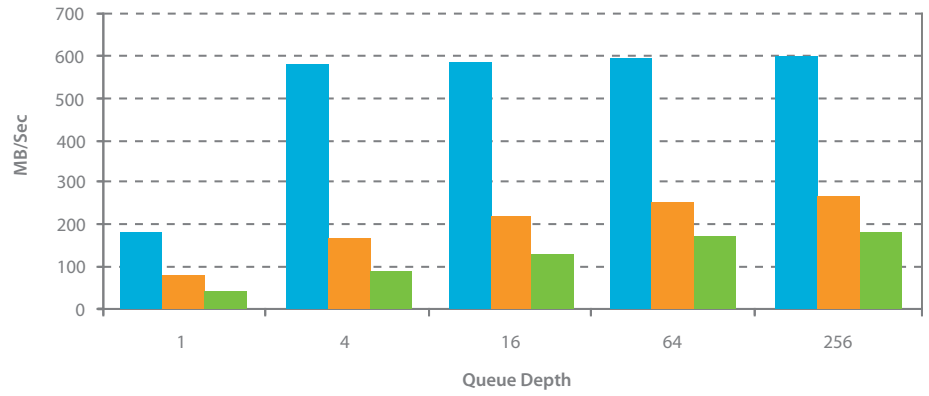
■ HDD ■ SSD Vendor A ■ SSD Vendor B



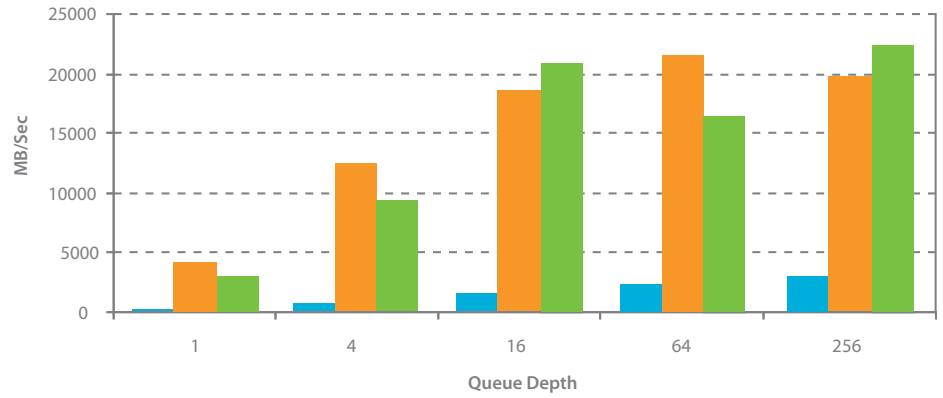
RAID 10

■ HDD ■ SSD Vendor A ■ SSD Vendor B

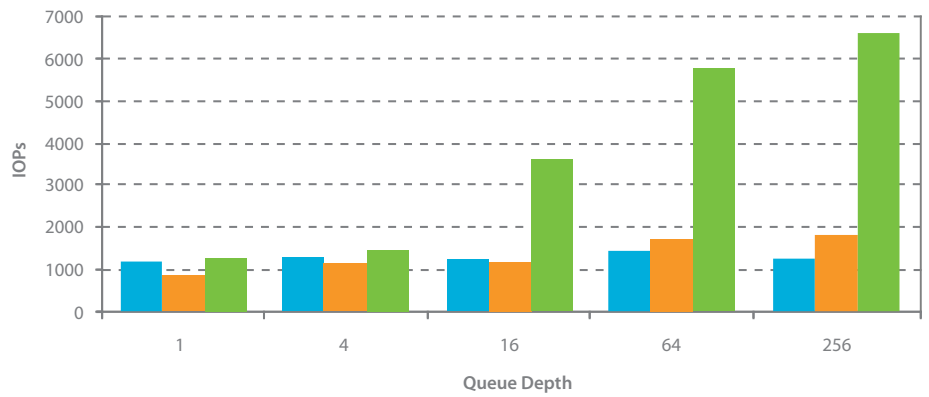
64KB Sequential Writes



4KB Random Reads



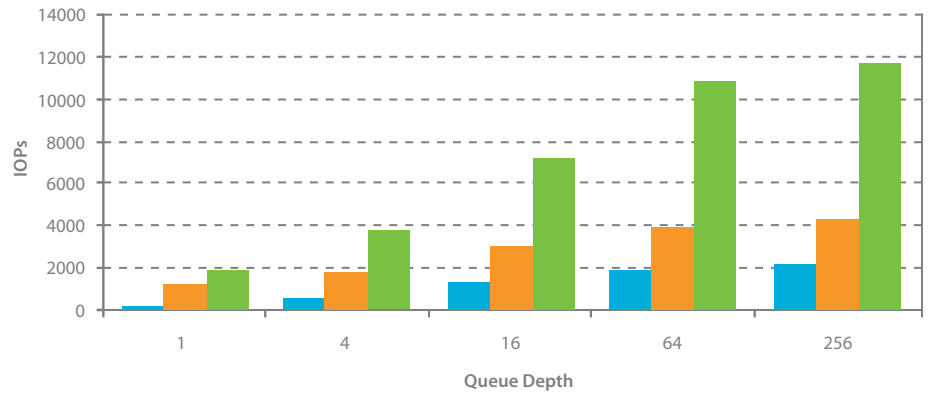
4KB Random Writes



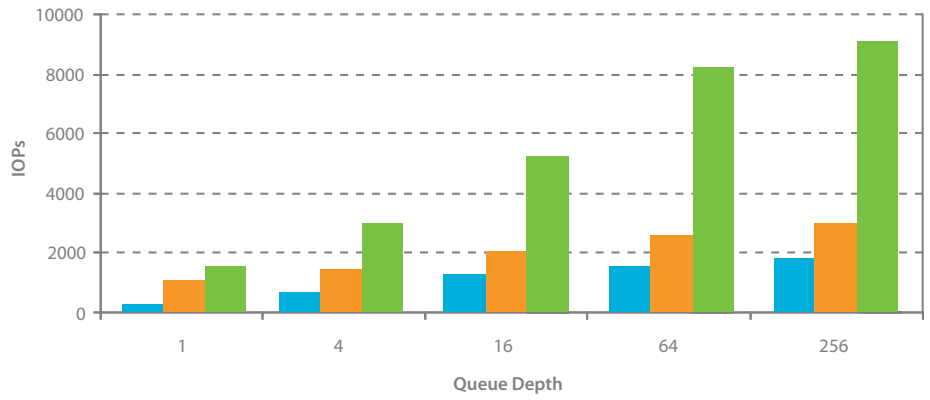
RAID 10

■ HDD ■ SSD Vendor A ■ SSD Vendor B

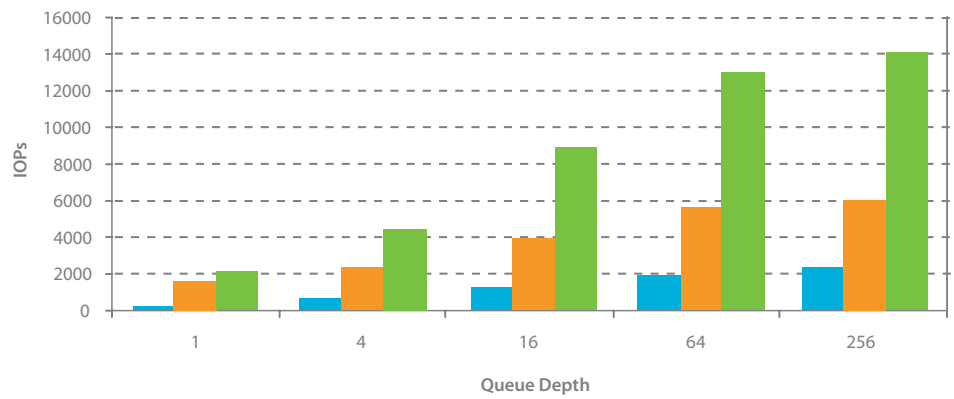
8KB OLTP



E-Mail Server

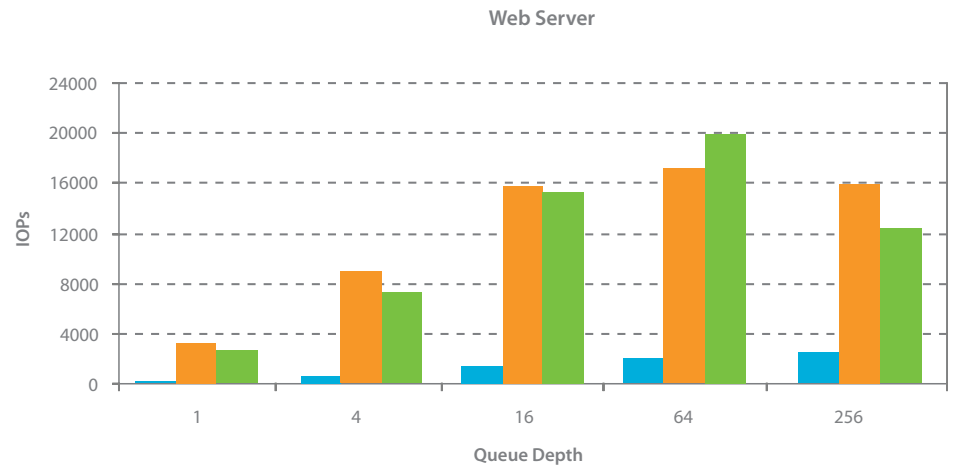


File Server



RAID 10

■ HDD ■ SSD Vendor A ■ SSD Vendor B



Summary

From a performance perspective, SSDs provide much better performance for workloads that are primarily random. However the SSDs fail to scale as well as the HDDs in sequential throughput. The LSI MegaRAID® SAS/SATA adapter was able to produce up to nearly 30,000 random IOPs.

Test Description

IOmeter is useful for identifying the performance of a wide spectrum of transfer sizes and queue depths to identify trends and/or anomalies. These tests were measured by using the IOmeter benchmark 2006.07.26 and a standard script developed by LSI. The script measures several performance metrics while ramping queue depth from 1 outstanding command up to 256 commands incrementing in powers of 2 for each access type. For each test, the drives were configured with the following settings: write through, disk cache enabled, direct IO, and no read ahead.

Test Configuration

System	Type	Intel X86-based PC	Intel X86-based PC	Intel X86-based PC
	CPU	1xIntel Xeon DP 5080 3.73GHz	1xIntel Xeon DP 5080 3.73GHz	1xIntel Xeon DP 5080 3.73GHz
	System Board	S5000XSL	S5000XSL	S5000XSL
	Memory	4GB	4GB	4GB
	Slot	PCIE X8	PCIE X8	PCIE X8
Card	Model	8888ELP	8888ELP	8888ELP
	Cache Memory	512MB	512MB	512MB
	Firmware	1.40.02-0514	1.40.02-0514	1.40.02-0514
	Driver	3.8.0.64	3.8.0.64	3.8.0.64
Topology	Connection	External Ports	External Ports	External Ports
	Ports Used	8	8	8
Enclosure	Number of Enclosures	2	2	2
	Vendor	LSI	LSI	LSI
	Enclosure Model	SYM3600-SAS	SYM3600-SAS	SYM3600-SAS
	Enclosure FW	193	193	193
	Number of Drive Slots	12	12	12
Drives	Type	SAS HDD	SATA SSD	SATA SSD
	Drive Size	146GB	50GB	25GB
	Number of Drives	8	8	8
Logical Drives	RAID Level	0, 10, 5, 6	0, 10, 5, 6	0, 10, 5, 6
	Policy	WT/NOR/DIO/DCE WT/RAE/DIO/DCD WB/ARA/DIO/DCE WB/NOR/DIO/DCD	WT/NOR/DIO/DCE WT/RAE/DIO/DCD WB/ARA/DIO/DCE WB/NOR/DIO/DCD	WT/NOR/DIO/DCE WT/RAE/DIO/DCD WB/ARA/DIO/DCE WB/NOR/DIO/DCD
	Stripe Size	64K	64K	64K
	Logical Drive Size	100%	100%	100%
	IO Meter	Version	7.26.2006	7.26.2006
	Outstanding IO's	1-256 powers of 4	1-256 powers of 4	1-256 powers of 4
Operating System	OS	Windows	Windows	Windows
	Version	2003 SP1	2003 SP1	2003 SP1
	Type	32-bit	32-bit	32-bit

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