NVMe Protocol Impact on CPU Utilization

AUGUST 2015

OVERVIEW

NVMe (Non-Volatile Memory Express) is an interface protocol developed specially for solid-state storage drives (SSDs). Since it's early development, one of the technical promises of the NVMe protocol was the ability to improve system level CPU utilization. NVMe allows for lower levels of protocol overhead by utilizing a streamlined command set that is not built on a legacy software stack. By moving to NVMe as the native interface for storage devices, the expected net result is higher levels of performance and reduced overall CPU utilization. This white paper attempts to quantify the benefits of SSDs supporting NVMe protocol and their impact on overall performance and system-level CPU utilization

BACKGROUND

As the use of flash SSDs becomes more prevalent in today's data center, the industry is predicting that NVMe will be the next generation storage protocol, eventually replacing legacy interfaces such as SATA/AHCI. This trend is due to an increasing need for higher performance and lower latency in the data center, which NVMe protocol fully supports. However, limited data is available comparing the overall effects of legacy and NVMe protocols on performance and utilization.

NVMe PERFORMANCE & UTILIZATION

The primary goal of this white paper is to study performance differences when comparing AHCI- vs. NVMe-based PCIe SSDs. Specifically, what are the potential effects of each protocol when comparing CPU profiles, and how does each protocol effect performance.

Table 1: IOPS and CPU Utilization by SSD Type

	AHCI SSD	NVMe SSD	Delta
IOPS	~160,000	~275,000	~1.7x
CPU Utilization	~18%	~11%	~1.7x
IOPS / CPU-Utilization	~9K IOPS per 1%	~25K IOPS per 1%	~3x

Based on testing, two important findings surfaced:

1) NVMe enables up to ~70% higher performance with up to a 40% drop in CPU utilization
2) NVMe enables up to ~300% improvement in IOPS/CPU-Utilization compared to AHCI
3) Note: CPU utilization varied for AHCI from 13%~20% and for NVMe from 8~12%

TEST SETUP

Windows edition

Windows Server 2012 R2 Datacenter

Windows Server 2012 R2

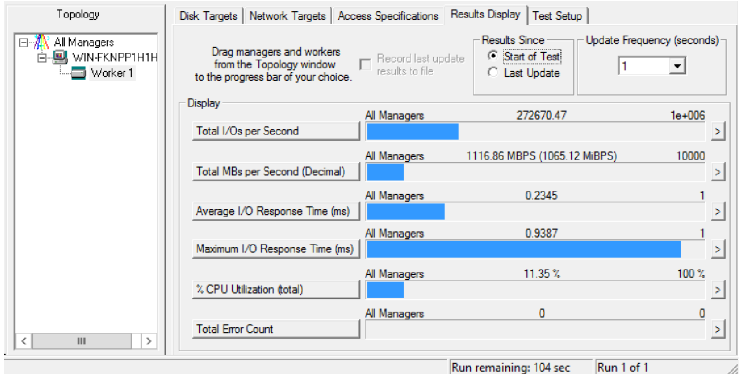
System

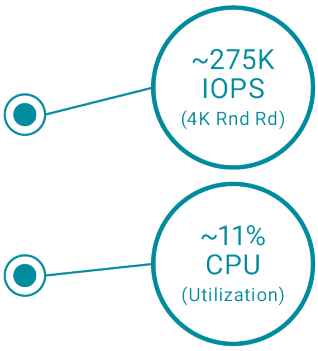
Processor:	Intel(R) Core(TM) i7-4700EQ CPU @ 2.40GHz 2.40 GHz
Installed memory (RAM):	16.0 GB (15.8 GB usable)
System type:	64-bit Operating System, x64-based processor
Pen and Touch:	No Pen or Touch Input is available for this Display

Application: IOMeter, Rev 1.1.0 (Access Pattern Tested: 4KB Rnd Rd)

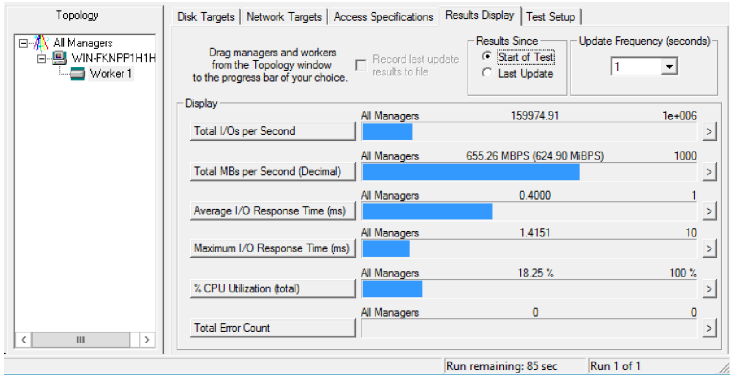
AHCI Drives:	NVMe Drives:
Vendor A AHCI SSD Gen2x4 ~160K IOPS	Toshiba XG3 NVMe SSD Gen3x4 ~275K IOPS

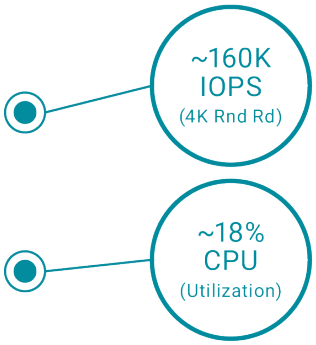
Toshiba XG3 NVMe SSD:





Vendor A AHCI SSD:





CPU SELECTION

There are several end user net benefits enabled by NVMe – as less CPU cycles are utilized for the same amount of data transfer, excess CPU resources are available for other system level applications. Less demand is placed on the CPU for storage services, and more of the CPU cycles can be used to increase application performance. Additional benefits are related to the CPU selection per workload, NVMe can enable lower power and lower cost CPUs to service workloads previously reserved only for higher end processors. The NVMe protocol enable system designers to select CPUs with lower power and reduced cost and still deliver increased levels of application performance.

SUMMARY

Testing revealed a clear differentiation in the NVMe protocol resulting in higher performance while maintain lower CPU utilization and lowering latency when compared to AHCI. The benefits of NVMe on performance are clear, illustrating up to a 1.7x improvement in IOPS and a 40% reduction in CPU utilization rates at the system level. As the performance benefits to NVMe become more well-known, there will be a greater migration away from legacy protocols. NVMe will enable higher levels of efficiency for next generation data centers.

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