

NetApp Ethernet Storage Evaluation

Performance evaluation sponsored by NetApp, Inc.

Introduction

Ethernet storage is advancing towards a converged storage network, supporting the traditional NFS, CIFS and iSCSI storage protocols and adding Fibre Channel over Ethernet (FCoE), all running over a single connection between the host server and the target storage.

NetApp introduced general availability in August 2009 of native FCoE/Data Center Bridging (DCB) connectivity with its FAS and V-Series storage systems. Via the same 10GbE unified target adapter (UTA), NetApp also began demonstrating publicly support of FCoE, iSCSI, NFS and CIFS over a single port, with general availability planned in 2010. Demartek evaluated this storage solution for its flexibility and performance in satisfying all these storage protocols.

NetApp, working closely with its partners, has provided a unified, end-to-end solution that supports Fibre Channel, FCoE, iSCSI, NFS and CIFS at the same time all from the same storage solution.

Evaluation Summary

The NetApp FAS3170 storage system proved to be a versatile storage system, handling multiple file and block protocols simultaneously, including FCoE, iSCSI, NFS and CIFS on the same 10Gb converged networking connection. The NetApp storage system also serves traditional Fibre Channel data access on separate Fibre Channel connections within the same storage controller. We found that we were able to drive FCoE connections at nearly their maximum rated speed.

Managing the FCoE connection in the NetApp storage system was exactly equivalent to managing a traditional Fibre Channel connection. This makes adopting FCoE technology as seamless as possible and we believe is encouraging for IT shops considering FCoE as a technology.

NetApp is the first storage vendor to provide general availability for an FCoE storage target and the NetApp storage system is an excellent system for handling combined Fibre Channel, FCoE, iSCSI, NFS and CIFS protocols in a single solution.

What is Unified Storage and Why is it Important?

Modern datacenters currently deploy multiple network interfaces running at different speeds and carrying different protocols and types of traffic over these networks. The two most common networking technologies deployed in commercial datacenters today are Ethernet and Fibre Channel. These two separate networks exist today because they each meet needs that the other does not. Each of these networks require their own adapters, switches and cables.

Ethernet, commonly run at 1 Gigabit per second, carries a variety of traditional TCP/IP and UDP traffic and often is used for file serving functions using the NFS and CIFS protocols. In addition, Ethernet can also carry “block” storage traffic by using the iSCSI protocol. Ethernet networks also support 10 Gigabit per second technology and this higher-speed Ethernet equipment is typically deployed in the core of the Ethernet network, but is not yet commonly found in edge devices.

Fibre Channel, commonly run at 4 Gigabits per second, carries “block” storage traffic using the SCSI protocol within Fibre Channel frames. Fibre Channel networks also support 8 Gigabit per second technology today and this higher speed Fibre Channel equipment is beginning to be deployed in datacenters, with vendors such as NetApp being early with support of this higher speed today.

As computing requirements increase, especially with the popularity of server virtualization and multi-core processors, the existing Ethernet and Fibre Channel networks must add connections and ports to keep pace. With the added concern of electric power consumption and the large numbers of cables required for each network in the datacenter, CIOs are facing challenges in scaling up the current technologies to meet the expected demands of future datacenters.

As new racks in existing datacenters are deployed, or as new datacenters are built, one way to handle the increased requirements is to use one network that provides the best of Ethernet and Fibre Channel, supporting all the protocols over a single cable, single host adapter technology and single network switch technology. This simplifies the infrastructure by reducing the number of host adapters, cables and equipment required, while continuing to support today’s protocols and applications.

A new lossless Ethernet known as Data Center Bridging (DCB), also sometimes known as Converged Enhanced Ethernet (CEE), running at 10 Gigabits per second, supports a new standard known as Fibre Channel over Ethernet (FCoE). FCoE and DCB provide the lossless transport that storage protocols such as Fibre Channel require, while maintaining compatibility with all the existing Ethernet-based protocols.

Overview of the FCoE technology

Fibre Channel over Ethernet (FCoE) is a standard that has been approved by the T11 Technical Committee and works with Data Center Bridging. This new form of Ethernet includes enhancements that make it a viable transport for storage traffic and storage fabrics without requiring TCP/IP. These enhancements include Priority-based Flow Control (PFC), Enhanced Transmission Selection (ETS), and Congestion Notification (CN).

These enhancements to Ethernet are defined in the following IEEE specifications:

- ◆ 802.1Qbb: **Priority Flow Control (PFC)**
 - Ability to control a flow (pause) based on a priority
 - Allows lossless FCoE traffic without affecting classical Ethernet traffic
 - Establishes priority groups using 802.1Q tags
- ◆ 802.1Qaz: **Enhanced Transmission Selection (ETS)**
 - Allows bandwidth allocation based on Priority Groups
 - Allows Strict Priority for low bandwidth / low latency traffic
- ◆ 802.1Qau: **Congestion Notification (CN)**
 - Allows for throttling of traffic at the edge of the network when congestion occurs within the network

FCoE is designed to use the same operational model as native Fibre Channel technology. Services such as discovery, world-wide name (WWN) addressing, zoning and LUN masking all operate the same way in FCoE as they do in native Fibre Channel.

FCoE hosted on 10 Gbps Enhanced Ethernet extends the reach of Fibre Channel (FC) storage networks, allowing FC storage networks to connect virtually every datacenter server to a centralized pool of storage. Using the FCoE protocol, FC traffic can now be mapped directly onto Enhanced Ethernet. FCoE allows storage and network traffic to be converged onto one set of cables, switches and adapters, reducing cable clutter, power consumption and heat generation. Storage management using an FCoE interface has the same look and feel as storage management with traditional FC interfaces.

Evaluation Environment

The evaluation was conducted at the NetApp facility in Research Triangle Park, North Carolina and the Demartek lab in Arvada, Colorado.

For this evaluation, Demartek deployed host servers running Windows Server 2008, 10GbE converged network adapters (CNAs), 10GbE DCB-capable switches with FCoE and a NetApp FAS storage system configured with the 10GbE unified target adapter.

The components in the NetApp lab included:

- ◆ NetApp FAS3170 storage system
 - One NetApp FAS3170 controller
 - Two disk shelves each containing 14 144GB FC 10K RPM disk drives
 - One 10GbE unified target adapter
- ◆ Cisco Nexus 5010 10GbE, FCoE Enhanced Ethernet Switch
- ◆ IBM x3550 server
 - One Intel Xeon E5345 processor (2.33 GHz), 4 total cores, 4 logical processors
 - 8 GB RAM
 - Onboard IBM ServeRAID 8k-1 SAS RAIDcontroller
 - One 73GB 10K RPM SAS disk for boot
 - One QLogic QLE8152 dual-port 10Gb CNA configured as a host adapter
 - Windows Server 2008 Enterprise x64 edition with Service Pack 2, with Microsoft MPIO enabled

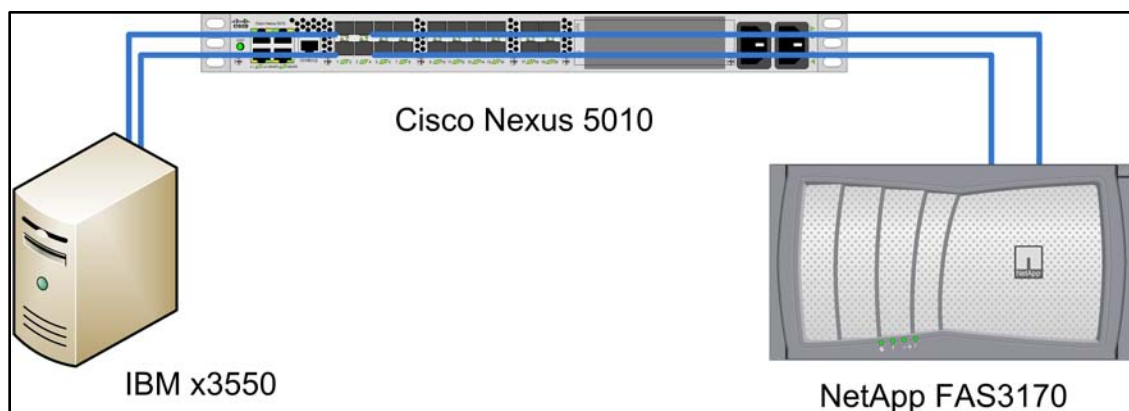


Figure 1 – NetApp Ethernet Storage Configuration

Test Process

One objective of the tests was to run multiple protocols concurrently between the host server and the NetApp FAS3170 storage system. Another of the objectives of these tests

was to measure the performance of the unified network while running a mix of types of traffic.

While the focus of this paper is on FCoE, we took the opportunity to configure multiple protocols (FCoE, iSCSI, CIFS and NFS) to see how easy it is to configure and manage a mixed environment. It proved to be simple and straightforward using the single 10Gb unified target adapter (UTA), and would be familiar to anybody who has configured similar NetApp storage systems. For FCoE traffic, the UTA appeared to the NetApp system as a traditional Fibre Channel adapter and was managed exactly the same way as a traditional FC adapter. The LUNs assigned to the UTA ports were managed as traditional FC LUNs.

A series of tests were run using IOmeter, an open-source I/O workload generator. IOmeter is a flexible I/O workload generator that can perform read and write operations of any block size and any number of simultaneous operations. IOmeter performs these I/O operations without regard to the underlying interface technology.

A series of IOmeter tests were run over various types of connections, with selected data shown in the following graphs. The number of sectors read and written to each of the LUNs was limited so that I/O would fit into the cache of the FAS3170 storage system. This was configured so that the speed of the connection could be tested, and not the speed of the disk drives in the storage system.

All the Ethernet and FCoE traffic (using all the protocols) went through the QLogic CNA in the host server through the Cisco Nexus switch and the 10GbE UTA in the NetApp FAS3170 Storage system. The server and storage were connected to four 10GbE ports on the Cisco Nexus switch. The systems were connected with OM-3 multi-mode 62.5 micron fiber optic cables with SFP+ connectors, certified for 10Gb line rate.

Several LUNs and volumes were created on the NetApp FAS3170 storage system. Four LUNs were created for Fibre Channel protocol, two LUNs were created for iSCSI protocol and two volumes were created for NFS and CIFS access.

Test Results

The results shown below focus on the FCoE and mixed FCoE/iSCSI interface performance. As a reminder, the IOMeter tests were configured to read and write primarily to the cache of the NetApp FAS3170 storage system. As a result, the sequential and random I/O results are very similar.

The graphs below show the results of IOMeter tests performing random and sequential reads and writes to LUNs in three relatively simple configurations. All tests used formatted LUNs with the NTFS file system so that they would be equivalent to regular file system access.

1. FCoE only: one FCoE (FC) LUN
2. Mixed FCoE and iSCSI: one FCoE LUN and one iSCSI LUN.

We noted the following characteristics of the FCoE traffic to the NetApp FAS3170 storage system:

- The NetApp FAS3170 treated the FCoE traffic the same way that it treats traditional Fibre Channel traffic. The FCoE ports were regarded as “FCP” ports.
- We achieved a maximum of 1099 MBPS across one host port while running 100% FCoE traffic to one LUN. This is 92% of the theoretical line rate of a 10Gb connection.
- The host CPU utilization was best (lower and more efficient) when 100% FCoE workloads were performed, especially for the larger block sizes. This is not surprising because FCoE is handled the same way as traditional Fibre Channel traffic, which is largely offloaded onto the adapter.

We noted the following characteristics of the iSCSI traffic to the NetApp FAS3170 storage system:

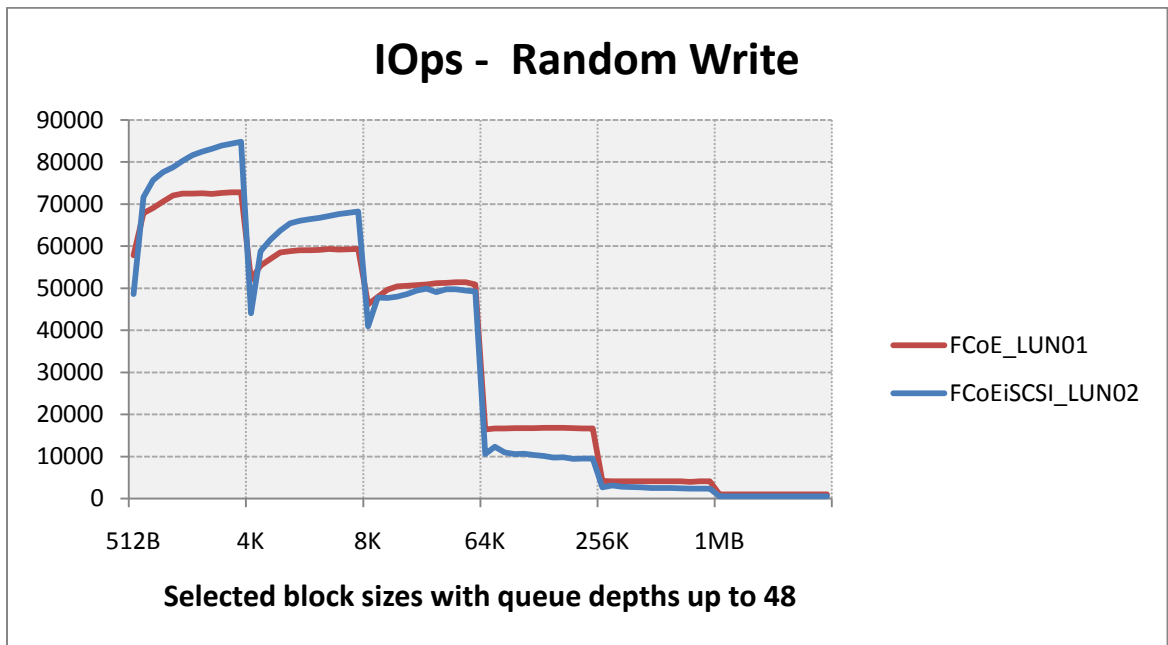
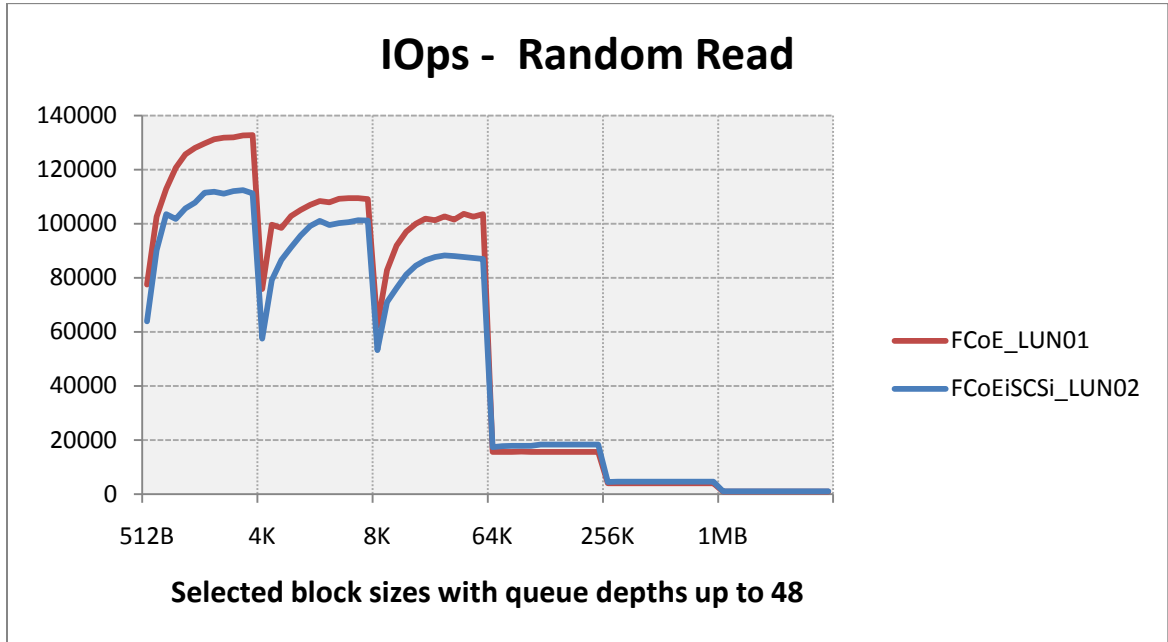
- The iSCSI traffic was sensitive to various Ethernet settings in the Cisco Nexus switch. Under most conditions where we ran FCoE and iSCSI traffic concurrently, the FCoE traffic seemed to have priority over Ethernet (iSCSI) traffic. It is our understanding that the Cisco Nexus switch always reserves some bandwidth for FCoE traffic even under large Ethernet (including iSCSI) traffic loads.
- iSCSI performance is also sensitive to the features of the adapter. There are numerous settings in most server-class Ethernet adapters, and we did not attempt to optimize or test every possible combination of Ethernet adapter settings. The only setting we changed was to enable jumbo frames. If different adapters were used in the host server, we would expect different iSCSI performance results.

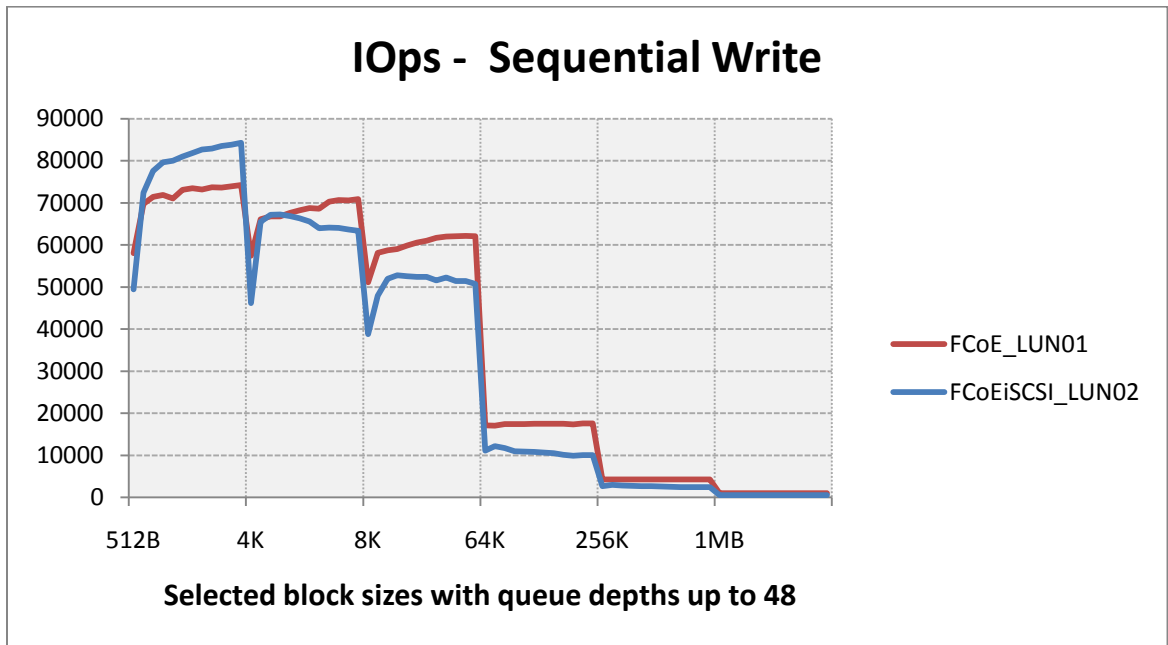
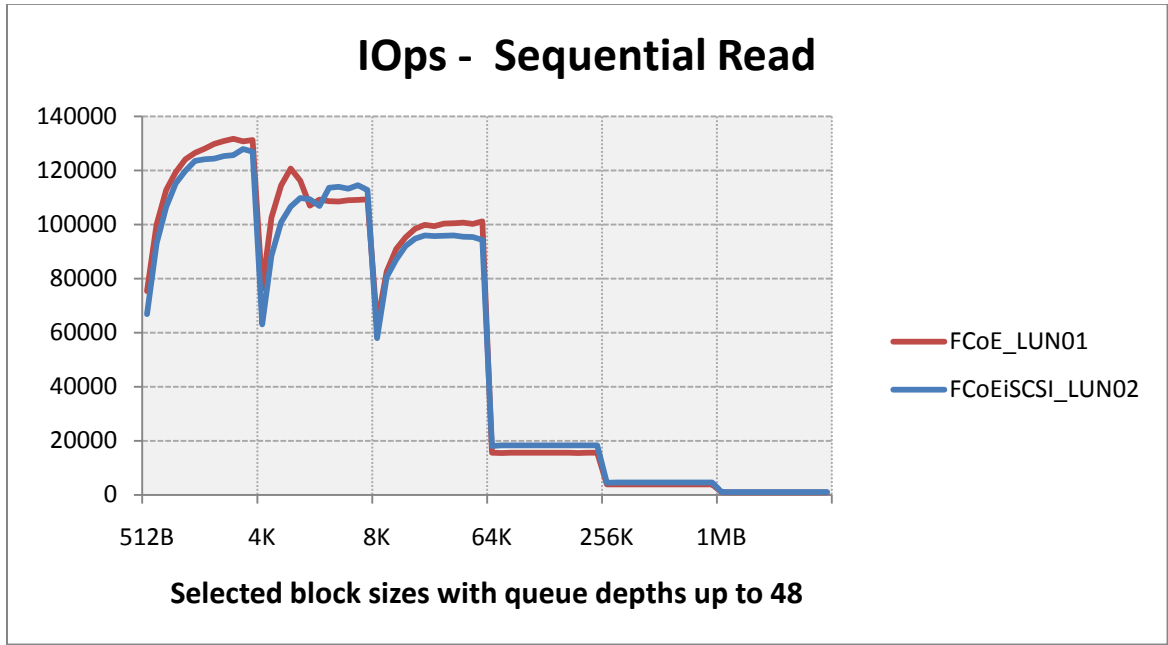
IOmeter Queue Depth Description

For each block size tested, we ran a set of incrementing queue depths beginning at queue-depth = 4 and ending at queue-depth = 48, incrementing by 4. The queue depth indicates the number of simultaneous I/Os issued. This resulted in twelve data points for each block size. This data appears as a curve in the graphs for each block size. In some cases, this curve is flat because the through-put had achieved its maximum.

It should be noted that in some cases, the mixed FCoE/iSCSI throughput was higher than the pure FCoE throughput. This is due, in part to having two connections, one for FCoE and one for iSCSI. However, refer back to the comments on the previous page regarding iSCSI traffic characteristics.

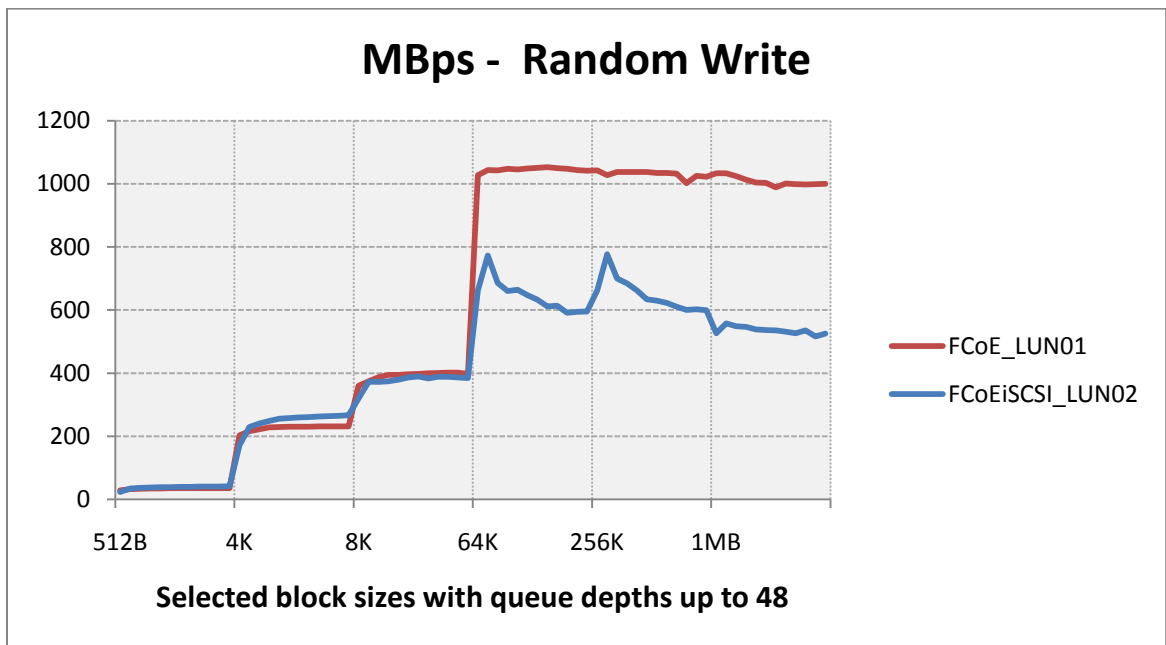
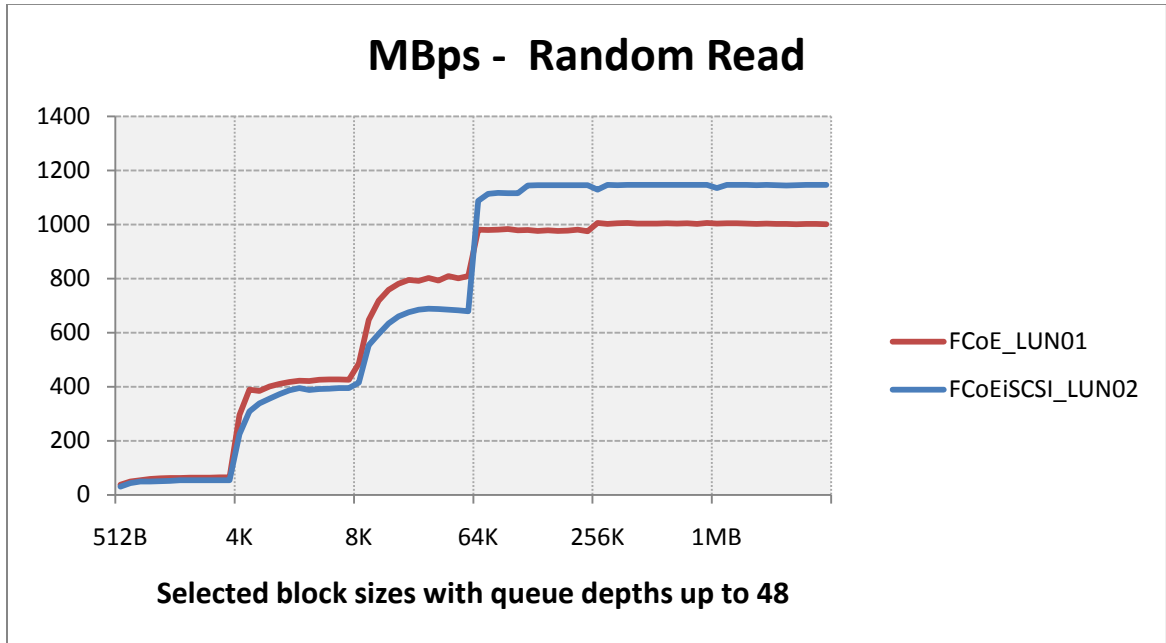
IOPS – I/O's per second

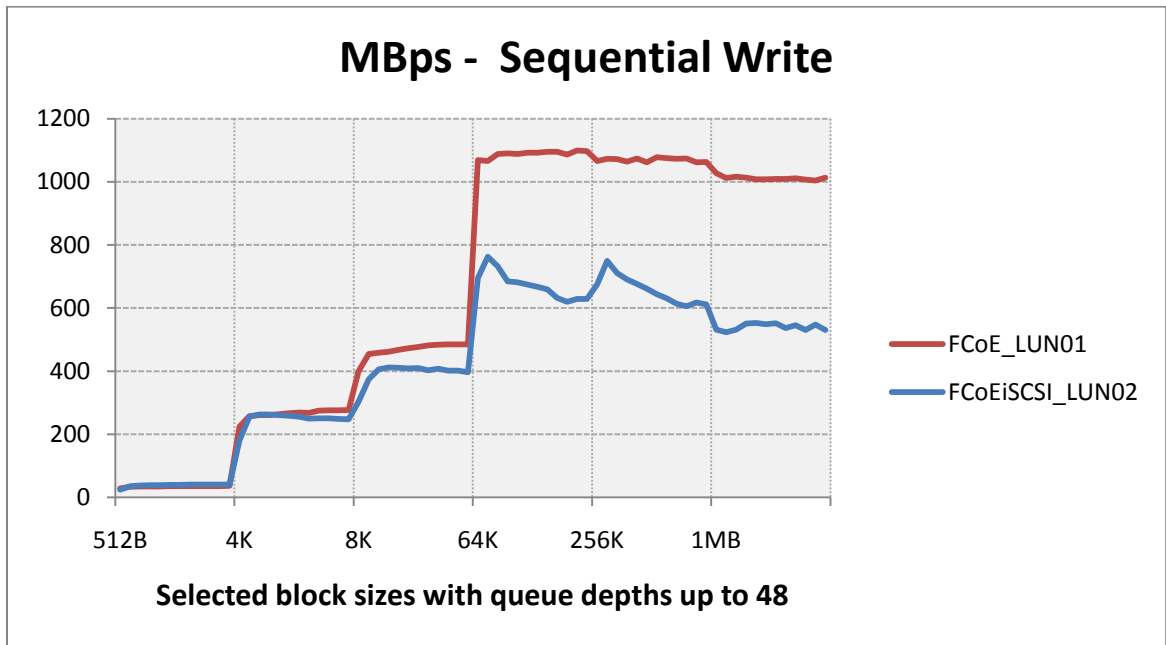
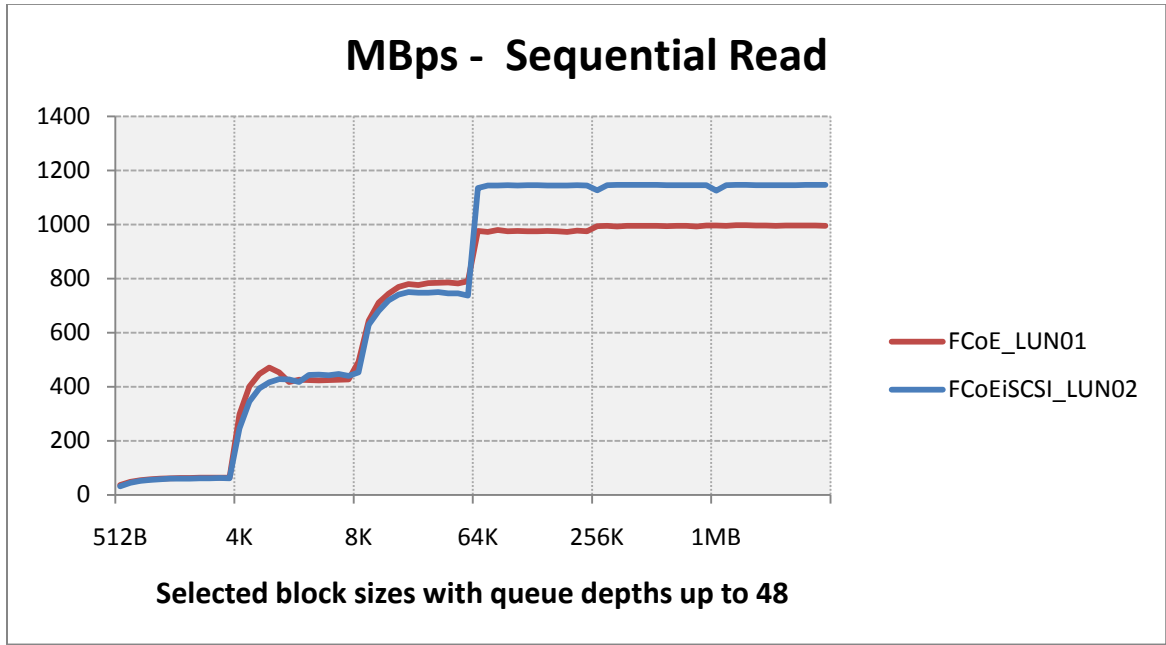




MBPS – MegaBytes per second

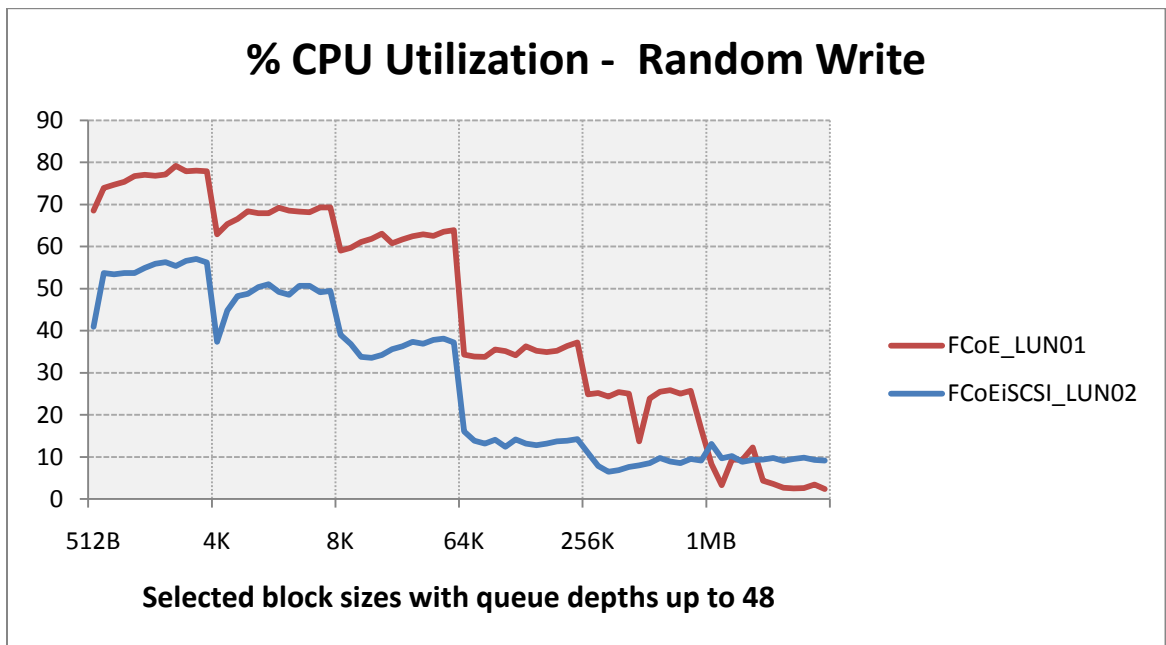
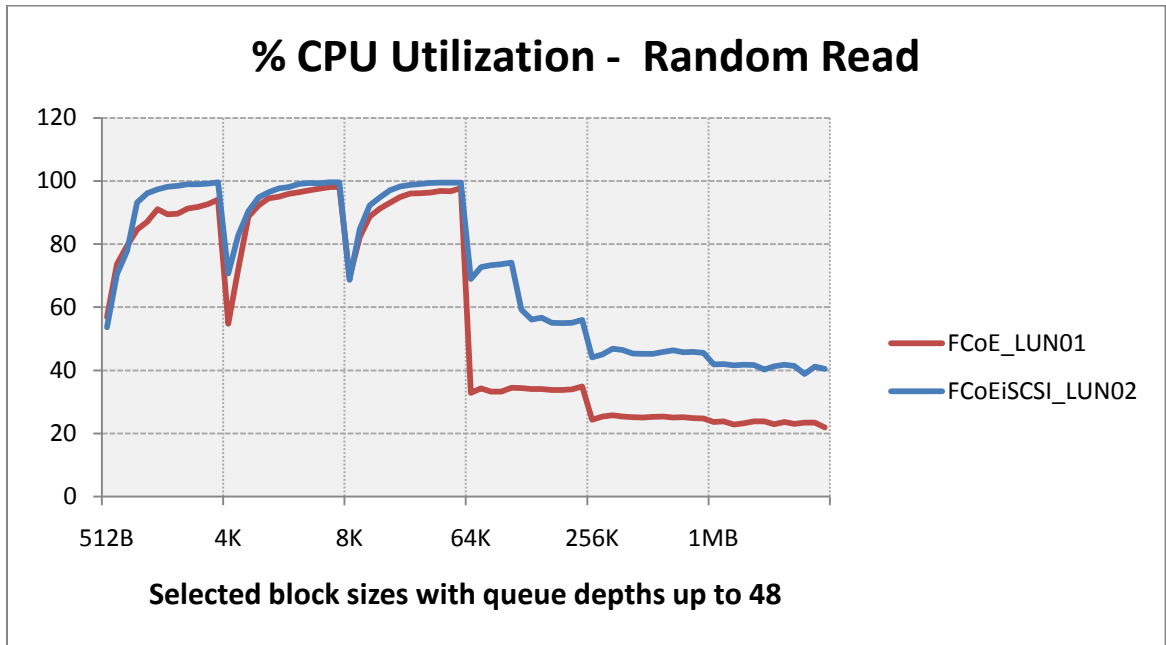
At block sizes 64K and above, we observed nearly full line rate for FCoE traffic, especially sequential writes.

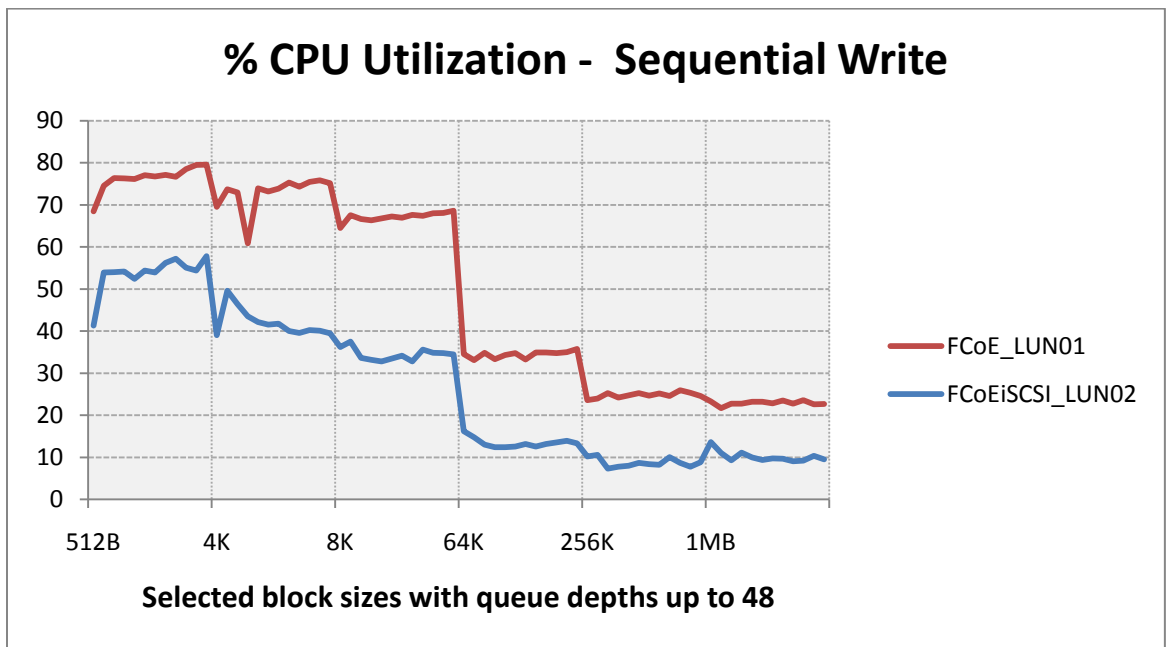
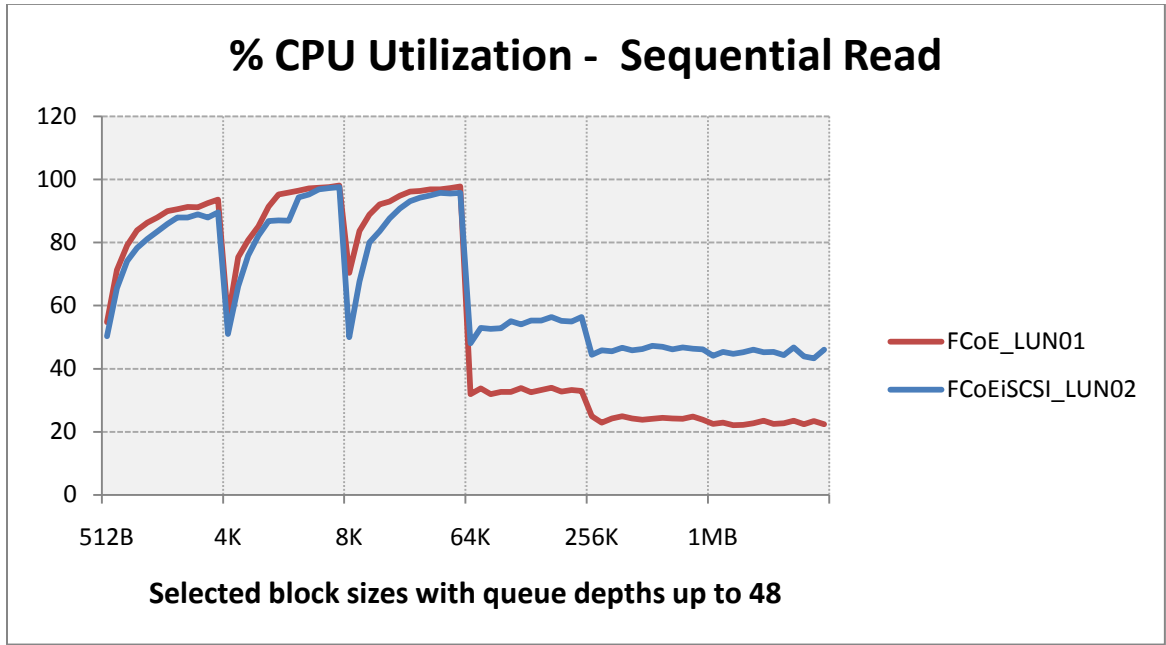




Percent CPU Utilization

For host CPU Utilization, lower is better and more efficient.





Conclusion

NetApp is the first storage vendor to support traditional Fibre Channel, FCoE, iSCSI, NFS and CIFS in a single storage controller and high-availability system. Now storage administrators, datacenter managers and CIOs can deploy a storage product that supports all of today's needs, is compatible with today's technology, and will support the needs of future "converged" networks that support shared infrastructure architectures.

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