# Data-Center iSCSI

## Building next generation storage networks

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Evaluator Group

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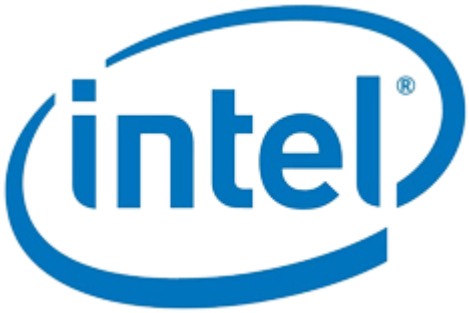


## Executive Summary

Information Technology has moved into an exciting new phase that allows the Data Center to separate application workloads from the underlying hardware, delivering better utilization, faster application deployment and workload balancing. Data centers have a mix of applications; some require dedicated systems, although a growing number of applications are able to leverage dynamic next generation infrastructure.

Despite the emergence of new IT technologies, administrators continue to see increased demand for resources, higher availability requirements and lower budgets. In order to solve these challenges, IT organizations should adopt infrastructure that supports several objectives, which include:

- Open – supported by multiple vendors dedicated to compatibility and innovation
- Flexible – an architecture that scales from small to large environments
- Efficient – delivering high performance without compromising on cost or power needs

Many companies looking to leverage the new virtual infrastructure while still accommodating the legacy deployments are turning to iSCSI storage and Ethernet SAN infrastructure to meet these requirements. This paper outlines the most important developments in storage networks, along with considerations for executives and IT staffs tasked with creating, and implementing architectures that require SAN connectivity.

## Virtualization – the new "Killer App"

In order to build the next generation data-center, IT infrastructure must support dynamic configuration, and provide the ability to transparently migrate workloads without physical limitations. IT users and applications demand a dynamic infrastructure, while IT administrators require the ability to manage multiple components as one virtual system. All of these goals must be met while the number of business applications is increasing, their availability demands are increasing and budgets remain flat.

These seemingly impossible goals are now possible due to several new developments. Virtualization technology is now able to allow administrators and users to view IT resources as a virtual system. This provides better utilization of the computing, networking and storage resources. As a result, administrators and businesses are able to simplify the management while improving performance and lowering costs.

### The new Virtual Infrastructure

The new virtual IT data-center must support multiple application and data workloads, efficiently. IT administrators are looking to deliver only the resources necessary, without over-provisioning equipment or experiencing performance bottlenecks.

The same trends that have been driving server consolidation are now placing demands on storage networks and storage subsystems. Just as standardization on X86 server hardware allows consolidation, standardization on IP networks will enable similar gains through storage network consolidation onto Ethernet based infrastructure.

Current server technology supports multi-core processors, each capable of running 10 or more virtual systems simultaneously. This can result in over 1,000 virtual systems running in one rack, driving a massive increase on the network interfaces in virtual environments.

Along with a converged infrastructure, comes the requirement for storage networking technologies that are able to support massive scale-out virtual server farms, and facilitate rapid provisioning and dynamic movement of workloads between systems. In order to reap the benefits of virtualization, it is imperative that networks and storage systems are able to support dynamic workloads.

## A Scalable SAN for Virtual Environments

iSCSI is one of the few storage networking technologies able to deliver flexible scalability along with high performance and availability while retaining ease of management. The use of iSCSI is increasing without regard to industry or company size due to its ability to deliver on these capabilities.

One of the primary benefits of iSCSI is its unique ability to grow from small, inexpensive workgroup deployments to large, enterprise-grade SAN environments. The multiple options for providing high-availability also provide choices for IT departments looking to deliver high-availability connectivity and fail-over capabilities.

Additionally, iSCSI supports the use of both software initiators running over standard Ethernet for low cost connectivity, and specialized server adapters for the highest performance. Adapters leverage hardware assistance to provide performance gains for highly virtualized environments and systems running critical applications.

The standard OS initiators used by iSCSI allow IT administrators to utilize embedded Ethernet links, or add high performance 10 Gb connections. As a result, administrators can avoid deploying complex, single purpose, adapters and the inherent compatibility challenges with proprietary initiators.

> ***Evaluator Group Comment: iSCSI provides unmatched scalability, by inexpensively supporting small networks and scaling up to thousands of dedicated SAN ports for large enterprises who require the highest performance and availability.***

For highly virtualized environments, server adapters off-load processing to dedicated hardware that works with the operating systems to accelerate native OS protocols such as TCP/IP and iSCSI. These adapters can also provide I/O virtualization to scale I/O across multi-core servers. By standardizing on scalable protocols and connectors, iSCSI supports moving from low-cost built in adapters to specialized adapters when needed, all while using the same protocols and management tools. As a result, iSCSI delivers the performance and flexibility required for virtualized, dynamic data centers.

## I/O technologies for Virtualization

Another benefit is iSCSI's ability to deliver features that virtual server workloads demand, such as the ability to move applications and data transparently, without re-provisioning the SAN network.

With a new generation of Ethernet available as a converged data transport, IT users are now able to deploy one transport and then choose which protocols provide the best match for an application.

Virtualized applications often impose different I/O workloads than more traditional compute stacks. The new virtualized environment requires a dynamic networking infrastructure that is flexible and cost effective, while providing high performance and availability.

All too often debates have centered on the merits of one technology or protocol compared to another. The real questions IT professionals should be asking revolve around delivering results, easily and cost effectively:

- How do I manage ports and I/O across servers?
- How do I deploy and manage redundant I/O?
- Can I move or add LAN and SAN I/O without reconfiguring servers?
- How do I converge connectivity while preserving quality and security?
- Will these features work equally well in virtual server, network and storage environments?

The answer to these questions will have a significant impact on day-to-day IT operations.

## The Enterprise Storage Network

When data center architects consider how to answer these questions, it is apparent that Ethernet is the best network transport choice. With Ethernet in place, iSCSI is a natural fit for applications and deployments that require block storage.

New server or storage deployments are good candidates for iSCSI, in particular deployments that utilize virtual servers and scale-out designs. By leveraging the Ethernet ports embedded in all servers, iSCSI access is ubiquitous.

> ***Evaluator Group Comment: Large organizations looking to provide wide-scale block storage access should strongly consider iSCSI due to its flexibility, and ability to dramatically lower infrastructure costs. Smaller organizations should consider an Ethernet SAN infrastructure and iSCSI for all block storage requirements.***

Investments in new Fibre Channel SAN's will become increasingly rare, in particular for smaller organizations and those without significant existing investments in FC SAN equipment. Unlike FCoE, which requires a new enhanced version of Ethernet known as DCB Ethernet, iSCSI can run on existing Ethernet networks without requiring DCB enhancements. IT administrators have the option of deploying iSCSI on dedicated links or converging traffic on the same physical links. As I/O rates increase, 10 GbE links can be deployed, along with DCB Ethernet to guarantee minimal bandwidth and avoid retransmission of data.

The emergence of FCoE and 10 Gb Ethernet will ultimately help the adoption of iSCSI by breaking down the barriers that have existed in adopting a common data transport. By moving all enterprise traffic onto Ethernet, all protocols including iSCSI, FCoE and NAS will benefit from a shared infrastructure.

# Industry Trends Driving iSCSI Adoption

## iSCSI Today

The current level of maturity allows iSCSI to compete for new data-center storage build-outs, while industry trends are driving increased interest. Due to the ability to deploy an iSCSI SAN without dedicated hardware equipment, its growth has been particularly strong with small and mid-sized businesses. However, this has led to the misconception that iSCSI is not suitable for enterprise deployments.

Today, iSCSI SANs offer the best of both worlds; the capability to use shared switched Ethernet networks in smaller IT centers, with the ability to segment LAN and SAN traffic on Ethernet for large IT data-centers. Ethernet is able to deliver a consolidated SAN and LAN transport today, and with the emergence of new Ethernet technologies, offers enhanced SAN capabilities.

One of the biggest advantages iSCSI has over alternative block storage protocols is the use of Ethernet and TCP/IP networks. The maturity of these technologies, combined with the ability to dynamically segment data, provides the ability to separate traffic, while sharing infrastructure.

The breadth of support for Ethernet and IP networking, coupled with the depth of technical features available provide one of the best foundations for data transport available. By leveraging these technologies, iSCSI is able to simplify management by providing synergy and consistency with other data-center networks already in place.

> ***Evaluator Group Comment: Reducing overhead and gaining flexibility are key factors for over-burdened IT administrators tasked with managing virtual server and storage environments. iSCSI is able to leverage network features such as virtual IP addressing, dynamic routing, and long distance WAN capabilities to provide flexibility while simplifying management.***

There are numerous options for achieving both high performance and high availability with iSCSI SAN's. The iSCSI protocol itself supports multiple connection sessions (MCS) to enhance both performance and availability. The IP layer provides multiple network paths between hosts and targets, and the Ethernet layer allows for teaming or grouping connections for both performance and availability. Additionally, most iSCSI initiators support high availability configurations through device drivers that allow multiple paths and failover capabilities, often known as MPIO.

Modern, best of breed iSCSI deployments have many of the same characteristics as other SAN deployments. These include dedicated networks that are correctly sized, along with a staff of professionals who are tasked with managing the availability and performance of the network.

All of these options provide a multitude of choices for IT architects looking to implement highly performing and reliable iSCSI SANs. The current generation of iSCSI products includes a broad portfolio of server optimized adapter cards at both 1 and 10 Gb, an extremely mature Ethernet switch market along with an extensive set of iSCSI capable storage products.

## I/O Consolidation

There are several trends driving the need for faster networking, including multi-core CPU's, server virtualization and an increased use of networked storage. Today's multi-core processors allow data center designers to consolidate logical infrastructure onto fewer physical systems through server virtualization. This has driven a corresponding requirement for greater I/O along with the move to virtual servers. Compounding this is the increased I/O connectivity between servers and storage.

All of these factors are driving the adoption of 10 Gb Ethernet, which is pushing down the cost of high-speed ports. Until recently, 10 Gb Ethernet ports were more expensive than 4 and 8 Gb FC ports. In 2009, pricing parity was reached, and with the adoption of low cost 10 GbE LAN on Mother (LOM) controllers 10 Gb Ethernet is now out shipping 8G FC ports, and is expected to increase its lead.

One issue plaguing system deployments has been that a single high speed, low cost network that can support processing and storage requirements has not been available. What is needed is a network, able to support both LAN and SAN requirements at significantly higher data rates, cost effectively.

## Enhanced Ethernet – The Future of Networking

Recently, storage and networking vendors have create a converged, multi-protocol network using an enhanced version of Ethernet. The newly improved version of Ethernet is on track to become a standard, delivering 10 Gb Ethernet for use as a transport for SAN protocols. The name for this enhanced version is Ethernet DCB (for Data Center Bridging). The implications are far-reaching; all storage protocols using the new DCB Ethernet will see a benefit.

To some, the thought of using converged Ethernet means moving storage protocols to a LAN. This is not the case, as the new DCB Ethernet has the characteristics of storage networks, including virtual channels, priority and quality, guaranteed delivery, redundant connections and transparent failover. The Ethernet DCB standards transform Ethernet into a network transport that provides reliable delivery of data, along with predictable performance, congestion management and flow control, much like Fibre Channel.

## Network Convergence

There are an increasing number of alternatives for connecting servers and storage, including iSCSI, Fibre Channel over Ethernet (FCoE) and Fibre Channel. These choices allow companies to have more flexibility when creating specific solutions, choosing file protocols for applications that work with unstructured data, and block protocols such as iSCSI or FCoE for applications requiring access to structured data, such as databases or file-systems.

With the emergence of converged Ethernet, even large organizations with heavy reliance on FC SAN infrastructures are beginning to rethink their long-term strategy and roadmaps for new storage and SAN deployments.

> ***Evaluator Group Comment: A converged, flexible network infrastructure will allow IT administrators to choose which storage protocols to utilize, rather than being forced to use a protocol specific network. Ethernet is becoming the logical choice as the best network technology for protocols in both large and small enterprises.***

Over the next few years, new FC SAN deployments will continue, in particular for large server and storage installations. However, new FC SAN deployments will become more difficult to justify each year. FC storage will remain a significant part of many environments for over a decade, but are likely to diminish as networks converge on Ethernet, and protocols such as iSCSI, NFS, CIFS and FCoE are all able to utilize a converged Ethernet network.

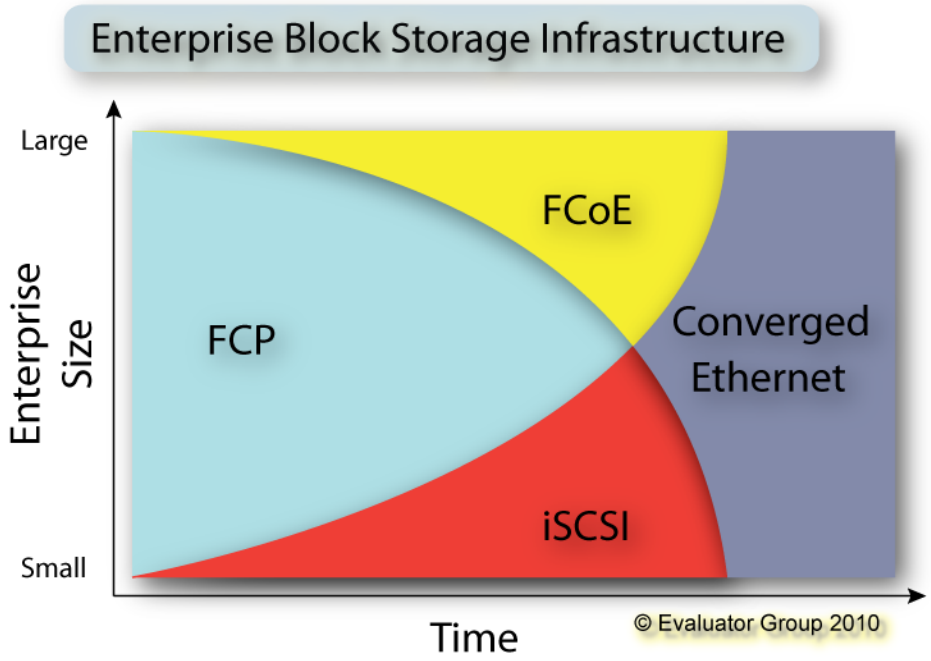


**Figure 1: The Convergence of Storage Infrastructure**

## Who Wins with Convergence

Nearly everyone gains from the use of a single transport technology. With the convergence on Ethernet for both LAN and SAN traffic, both large and small organizations are able to standardize on Ethernet today, with the knowledge that they can upgrade to DCB Ethernet in the future to increase performance. By moving to a standard infrastructure, companies are able to future proof their SAN and storage investments.

Large organizations will benefit by having a way to consolidate server I/O traffic onto a flexible, virtual data transport with less space, heat and cabling. Additionally, these organizations will be moving to a higher speed connections in the future for increased bandwidth.

For small and large business, companies will no longer be forced to choose which transport technology they will need in the future. The answer is "Ethernet." With an Ethernet infrastructure in place, organizations can deploy NAS and iSCSI storage over standard Ethernet today.

# Intel Ethernet 10 Gigabit Server Adapters

Intel Ethernet Server Adapters are a single family of multi-application Enterprise Class products based on 25 years of trusted Ethernet deployments. Intel Ethernet uses the trusted, native iSCSI initiator

integrated into the operating system. This removes the need for proprietary software that can add complexity to the OS driver and management tools utilized. Intel Ethernet Server Adapters also include a number of hardware features that accelerate iSCSI traffic and improve data processing on multicore processor-based servers. Intelligent hardware offloading delivers iSCSI performance that exceeds other iSCSI interface alternatives.

Intel's portfolio of 10 GbE server adapters is among the broadest in the industry with single and dual port versions available for both copper and fiber networks supporting iSCSI. Some key features of the Intel Ethernet 10 GbE family include:

| Feature | Benefit |
|---|---|
| **10 Gb connectivity** | High speed connectivity for I/O intensive or virtualized systems |
| **Native iSCSI Driver Support** | Flexibility for OS drivers support & low cost connectivity |
| **iSCSI boot support** | Supports diskless servers and improves system availability |
| **Native OS TCP / UDP and iSCSI Hardware Acceleration** | Reduces CPU utilization, and improves performance |
| **DCB & FCoE support** | Supports emerging standards for future flexibility |
| **Send/Receive Coalescing** | Combines multiple operations to reduce system overhead |
| **VTc support** | Provides virtualization I/O enhancement |
| **128 queues (64 VMDq)** | Offloads data copying for enhanced I/O virtualization performance |
| **AES encryption with IPSec support** | Ensures security with iSCSI storage |
| **PCI IO Virtualization** | Supports sharing of I/O devices by multiple virtual OS – delivering near native performance via dedicated I/O channels |

**Table 1: Intel 10 Gb Server Feature – Benefit Overview**

Intel Ethernet Server Adapters also implement the hardware assists provided by Intel Virtualization Technology for Connectivity (Intel VT-c) to accelerate I/O in virtualized servers, for greater iSCSI scalability, and performance.

The latest Intel 10 Gigabit Ethernet Controllers include support for Virtual Machine Device queue (VMDq) technology and I/O virtualization (PCI-SIG SR-IOV). Intel lab tests have shown Intel Ethernet Server Adapters with VMDq achieving near line-rate 10 GbE performance in both VMware ESX 3.5 and later and Microsoft Hyper-V R2.

## NetApp iSCSI Products

NetApp's iSCSI capabilities span their entire product line of primary storage products. NetApp has offered iSCSI storage access on the FAS and V-Series systems since iSCSI has been a standard, and first introduced 10 Gb Ethernet support in 2006.

A NetApp technical report examining the relative performance of multiple protocols including NFS, FC and iSCSI with VMware ESX 3.5 environments shows that iSCSI's performance is nearly identical to alternatives under multiple workloads. Additionally, continual iSCSI performance improvements are being made in products such as Hyper-V, VMware vSphere and general-purpose operating systems.

Support for iSCSI has been included in NetApp products for more than six years. NetApp has consistently led the industry in support for new storage connectivity and protocol options. This broad support for protocols, coupled with the consistent manner in which protocols and connectivity are managed has helped to reduce the management burden imposed by some competing iSCSI vendors.

NetApp has several unique advantages over other iSCSI competitors, including the following:

| Feature | Benefit |
|---|---|
| **Primary storage deduplication** | Unique space savings for use with primary storage |
| **Space efficient PIT copies and clones** | Near zero performance impact permits more granular protection |
| **Unified storage** | Supports all Ethernet protocols, (iSCSI, FCoE and NAS) |
| **Consistent data protection tools** | Cross platform support includes all FAS and V-Series models |
| **Application integrated data protection** | Delivers critical application level HA through simplified interfaces |
| **Management support of iSCSI** | Management tools support consistent use of multiple protocols |
| **Interface connectivity options** | Allows the use of multiple 1 and 10 Gb Ethernet ports |
| **Remote replication via iSCSI** | Supports native use of IP transport of LAN/WAN connectivity |

**Table 2: NetApp iSCSI Feature – Benefit Overview**

## Customer Proof Point

A major customer was looking to leverage their investment in server virtualization. Despite having invested previously in a fibre channel SAN, they chose to move their storage to an IP SAN. Their new infrastructure consisted of servers from multiple vendors, running VMware ESX for virtualization, connected to Cisco Nexus networking, with NetApp storage. By leveraging an IP SAN environment, the customer was able to continue using block storage via iSCSI to support their Exchange, SQL Server, SharePoint, Oracle and DB2 database applications.

They were able to utilize the same Ethernet and IP network infrastructure to support applications requiring access to unstructured data, along with access to structured data. All of this became possible by deploying a converged Ethernet network. This environment utilized NetApp storage, Intel Ethernet Server Adapters along with VMware and Cisco equipment. The customer now processes the majority of their IT on this consolidated converged stack.

As a result, the time to provision storage moved from over 10 weeks, down to less than a week with their new IP based storage infrastructure. Through consolidation, the customer was able to reduce their total IT costs by 40%, which included reductions obtained through standardization and consolidation on virtualized servers, converged IP based networks, and NetApp storage.

Additionally, service levels have improved through the deployment of application data-protection services such as SnapManager for Exchange, SQL Server, SharePoint, and others.

## Summary

The current generation of iSCSI products has evolved significantly since the iSCSI standard was ratified over six years ago. During that time, performance, efficiency and security concerns have all been addressed. The current generation of Ethernet infrastructure can deliver results for both small and large companies alike.

- Small to mid-sized business should continue to invest in Ethernet and iSCSI storage – however, the use of DCB Ethernet will typically not be needed in the near-term
- Larger organizations should look to implement converged Ethernet and iSCSI with server virtualization and consolidation projects
- The benefits of iSCSI over alternatives will be apparent in many environments when organizations are able to choose any protocol for their converged network

New investment in scale out server technology utilizing virtualization and high I/O density are the best candidates for new iSCSI deployments. With the advent of 10 Gb Ethernet, along with the new DCB enhancements to Ethernet, the converged network supporting iSCSI will see significant performance and availability enhancements in the future.

***Evaluator Group Comment: NetApp and Intel together provide many unique advantages for the new, converged IT data-center of tomorrow. The advantages delivered by Intel and NetApp, coupled with the features inherent in iSCSI make it an excellent choice of organizations looking to move beyond the initial gains made through server virtualization.***

The future is coming and the answers are clear – Ethernet is the new SAN, and iSCSI will be the block storage protocol of choice for many organizations.