Networked storage can provide several key advantages for organizations, including cost reduction and increased efficiency—but it also presents challenges. Storage area networks (SANs) can add their own complexity, and organizations often require increasing levels of throughput for connecting networked storage to servers as the enterprise grows.

The arrival of 10 Gigabit Ethernet (10GbE) along with the Data Center Bridging (DCB) and Fibre Channel over Ethernet (FCoE) specifications holds the promise of a truly converged network fabric. These technologies offer IT administrators a clear path for unifying Internet SCSI (iSCSI) and Fibre Channel SANs while providing enhanced levels of storage efficiency, increased throughput, and cost-effective network storage deployment in their data centers.

SAN GROWTH IN NETWORKED STORAGE ENVIRONMENTS
SANs are essential elements of the move to data center virtualization. In virtualized environments, images and data are stored on a shared SAN to facilitate live migration of virtual machines. SANs are also growing because they deliver value in key areas including storage consolidation, enhanced disk utilization, disaster recovery, and centralized data protection.

Deploying SANs introduces a number of challenges for IT administrators. As the virtualized environment scales, for example, SANs require multiple networks; each network calls for the addition of ports and cables from each server, which can increase costs and power consumption. Servers and storage require advanced integration and management to realize the full benefits of virtualization, further increasing costs. And a virtualized, consolidated infrastructure also creates increased I/O requirements: running multiple virtual machines means supporting multiple I/O streams, and the aggregate of the streams increases the I/O bandwidth and throughput needs for physical servers and storage arrays.

Still another source of complexity is the fact that many organizations deploy two types of networks: Fibre Channel for storage and Ethernet for data. Organizations typically maintain both types because each protocol has its own advantages and disadvantages. The latest Fibre Channel storage devices provide relatively high throughput—hardware is currently available for 8 Gbps Fibre Channel, and is expected to become available for 16 Gbps Fibre Channel—but Fibre Channel can also have high acquisition and administration costs. Ethernet is typically more cost-efficient than Fibre Channel and connects with IP networks to help overcome long distances, but the Gigabit Ethernet (GbE) networking prevalent in
today’s data centers typically has less throughput and higher latency compared with Fibre Channel.

With dual networks, managing growth and optimizing utilization can become increasingly difficult, costly, and complex. The two network types require separate IT resources, including different hardware and technical expertise, increasing the costs of infrastructure and management. The emergence of iSCSI has allowed cost-effective Ethernet infrastructure to be used as a SAN fabric, and has fueled increasing adoption of iSCSI SANs such as Dell™ EqualLogic™ PS Series arrays.

EMERGENCE OF 10GbE
10GbE is expected to emerge as the future of data center networking because it retains the advantages of Ethernet while opening up new possibilities. For example, new 10GbE components becoming available are expected to preserve the existing Ethernet cost advantage over Fibre Channel, and cost-efficient 10GbE interfaces can help reduce management complexity.

10GbE offers an effective way to expand bandwidth for virtualized environments—providing highly scalable and simplified connectivity by enabling multiple virtual networks to be streamed onto the same physical connection. Using 10GbE connectivity is also generally more power efficient and more cost-effective than using multiple GbE network interface cards.

10GbE also offers a clear path for unifying iSCSI and Fibre Channel storage on a single network fabric. It enables the increased throughput required to unify communications and allow network consistency while building on the familiar, cost-effective Ethernet and IP technology generally already in place in the enterprise. Original equipment manufacturers (OEMs) are readying products supporting the emergence of 10GbE; Dell has introduced a 10GbE iSCSI I/O module for Dell/EMC CX4 Series storage, and plans to add 10GbE capability to its comprehensive range of storage arrays.

UNIFIED NETWORK FABRIC FOR A CONVERGENCE PARADIGM
Organizations are looking for ways to combine their storage and data networks into a single converged fabric to help reduce the total cost of ownership of the data center infrastructure, connect multiple storage islands, and enhance storage scalability. 10GbE offers the necessary throughput to help accomplish this goal, and the DCB specification is the last piece of the convergence paradigm that is falling into place (see the “Enhancing Ethernet bridging” sidebar in this article). The DCB specification provides a set of standards-based extensions to traditional Ethernet, offering a lossless data center transport layer that allows the convergence of LANs and SANs onto a single unified network fabric.

DCB provides advantages for both iSCSI and Fibre Channel storage. Organizations can use the FCoE specification—which depends on DCB capabilities, and is supported by a large number of network and storage vendors—to connect legacy infrastructures to the 10GbE and DCB Ethernet network. FCoE maps Fibre Channel frames over Ethernet while preserving the Fibre Channel protocol, and the DCB specification is designed to maintain the assured-delivery characteristics of the Fibre Channel physical and link layers. The DCB specification also helps ensure delivery for iSCSI storage by providing enhanced congestion management and end-to-end high bandwidth for Ethernet traffic, including iSCSI traffic.

NETWORK FABRIC OPTIONS WITH 10GbE AND DCB
Together, 10GbE and DCB can help provide a single efficient network fabric that offers organizations strategic choices in planning data center networking.

ENHANCING ETHERNET BRIDGING
Cisco Systems originally created the term Data Center Ethernet for a set of enhancements to Ethernet bridge standards designed to boost Ethernet Layer 2 congestion management and enable convergence of different traffic types—including not only storage area network (SAN) traffic, but also LAN, management, and Interprocess Communication (IPC) traffic—on the same network. These enhancements led to the IEEE 802.1 Data Center Bridging (DCB) working group, and Cisco now refers directly to the DCB specification, which is expected to soon be formally adopted and compliant with the following standards:

- Priority-based flow control (IEEE 802.1Qbb) at the link level helps ensure no packets are lost under congestion in DCB networks.
- Enhanced transmission selection (IEEE 802.1Qaz) enables administrators to reserve a specific amount of bandwidth for each traffic type to help ensure high quality of service.
- Congestion notification (IEEE 802.1Qau) helps enhance end-to-end congestion management and avoid recurring congestion and frame loss.
- The DCB Exchange (DCBX) protocol helps ensure consistent configuration across the network.

Together with other IEEE 802.1 standards, the DCB specification is expected to help IT organizations take advantage of enhanced communication quality for converged networking.

For information on using DCB in mixed GbE and 10GbE environments, see “Mixing Gigabit Ethernet and 10 Gigabit Ethernet in a Dedicated SAN Infrastructure,” by Tony Ansley, in Dell Power Solutions, September 2009, DELL.COM/Downloads/Global/Power/ps3q09-20090916-Ansley.pdf.
are expected to be able to take advantage of the ongoing evolution of FCoE (see Figure 1). The first generation of FCoE-enabled devices is expected to focus on I/O convergence on the server using an Ethernet switch. In the second phase of this evolution, large FCoE networks supported with DCB-enabled switches are expected to provide assured-delivery characteristics over Ethernet that are equivalent to Fibre Channel switches. Finally, the third phase is expected to provide availability of native FCoE storage for connectivity to the FCoE network, which requires FCoE services to run on the DCB network.

**CONVERGENCE TO CONSOLIDATED NETWORK STORAGE**

Network convergence allows organizations to consolidate storage, providing enhanced levels of efficiency and cost reduction. Multiple networks can share one 10GbE host connection, helping to minimize server adapters, cabling, and power consumption (see Figure 2). Furthermore, combining SAN and LAN traffic on the same network helps significantly reduce the number of adapters, cables, and switches. SAN traffic on the converged network can use either iSCSI or FCoE.

The additional bandwidth availability provided by the unified 10GbE fabric helps to address I/O challenges presented by virtualization of servers and storage. Networks that deploy 10GbE and DCB are expected to support bandwidth up to 20 Gbps using two 10GbE adapters for redundancy. Other benefits include the following:

- **Low support costs:** Convergence can reduce management complexity, and resources no longer need to be divided between Ethernet and Fibre Channel.
- **Expanded high-performance computing (HPC) bandwidth:** 10GbE is designed to expand bandwidth for connecting HPC clusters to the network.
- **Energy savings:** Using fewer adapters, cables, and switches in a unified network fabric than in a legacy data center network helps reduce physical infrastructure, which enhances power and cooling efficiency.
- **Security:** The Ethernet features of virtual LANs and Ethernet bridge access control lists can be used to provide traffic isolation and security for various traffic flows. Security remains robust because storage traffic (iSCSI or FCoE) is simply carried in Ethernet frames.

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**Figure 1.** FCoE offers a bridge to legacy Fibre Channel SANs in support of evolving network consolidation

**Figure 2.** A unified network fabric helps reduce the number of adapters, cables, and switches

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FLEXIBILITY FOR MIGRATING TO UNIFIED NETWORK STORAGE

Organizations have considerable flexibility as they prepare to unify network storage. FCoE can be used to connect FCoE servers to legacy Fibre Channel SANs through Ethernet, preserving the Fibre Channel user experience as the organization migrates to 10GbE, while iSCSI offers the ability to run storage in native Ethernet environments and to route traffic across both LANs and wide area networks (WANs). As the organization migrates from GbE to 10GbE, iSCSI can work in a mixed GbE and 10GbE network environment, and the iSCSI traffic can take advantage of enhanced network features when the infrastructure is upgraded to the DCB specification.

Many enterprises can ultimately benefit by migrating to either iSCSI or FCoE connectivity. Now is a good time for organizations to conduct an extensive review of storage strategy. Enterprises can continue to consolidate operations without anxiety over stranded investments, because the DCB specification for Ethernet can equally benefit both iSCSI and FCoE networked storage.

Achmad Chadran is a storage solution marketing manager in the Dell Large Enterprise Business Unit. Before joining Dell, Achmad held positions including industry analyst, market consultant, and product marketing manager in IT and telecommunications. He has a bachelor’s degree from the University of Virginia and a master’s degree from Ohio University.

Gaurav Chawla is a technology strategist in the Enterprise Storage Architecture and Technology Group in the Dell Office of the CTO. In this role, he leads the technology initiatives for networked storage and also participates in associated industry standards organizations. He has a B.S. in Computer Engineering from Manipal Institute of Technology, Manipal, and an M.S. in Computer Engineering from Santa Clara University.

Ujjwal Rajbhandari is a product marketing consultant for Dell storage solutions. He has a B.E. in Electrical Engineering from the Indian Institute of Technology, Roorkee, and an M.S. in Electrical Engineering from Texas A&M University.