Storage Extension Network Solutions Between Data Centers

Simplified, Low Cost, Networks for Storage Replication, Business Continuity and Disaster Recovery

TODAY'S OPERATING CLIMATE DEMANDS HIGH AVAILABILITY OF SYSTEMS AND CONTINUOUS ACCESS to mission critical information. IT organizations are challenged to protect against disruptions in service and loss of data. With recent threats of disruption that include widespread power losses, natural disasters, malicious activity, and terrorism, CIOs must deploy an infrastructure to secure both mission critical and general day-to-day data. Often these plans include interconnection of data centers across regions, separated by tens, hundreds or even thousands of miles.

ENTERPRISE AND GOVERNMENT AGENCIES ARE ALSO INTERCONNECTING DATA CENTERS for consolidation of data between geographically separate data center locations to drive higher efficiency—resulting in data migrations from one data center to another and forcing requirements for high bandwidth connectivity.

In support of these requirements, long distance storage replication between data centers, as shown in Figure 1, has become a central focus of many enterprise and government IT departments. Applications such as disk mirroring, remote tape backup, clustering, Storage Area Network (SAN) extension, Local Area Network (LAN) extension, and Mainframe extension are being leveraged in support of Continuity Of Operations Plans (COOP), Business Continuity (BC), Disaster Recovery (DR), and data center consolidation and replication. It is now becoming common for an organization to locate some of its storage devices, such as disk arrays and tape libraries, at a remote location far from the primary data center location. In these implementations, either a second enterprise or government owned data center is used, or space is leased in dedicated, third-party DR sites. Regardless of where the remote equipment is located, there are a number of challenges in implementing the connectivity between locations. The data center protocols used, such as Fibre Channel (FC), ESCON®, FICON™, and Gigabit Ethernet (GbE) were designed primarily for use within a data center, and have traditionally required complex, costly engineering to connect equipment located tens, hundreds, or even thousands of miles apart.

The net result is that the availability of robust, secure, resilient and high capacity networked storage replication solutions are a critical business imperative. The right solutions must provide reliable, timely and accurate application-layer replication over a network that cost effectively delivers high performance connectivity to fit application requirements.

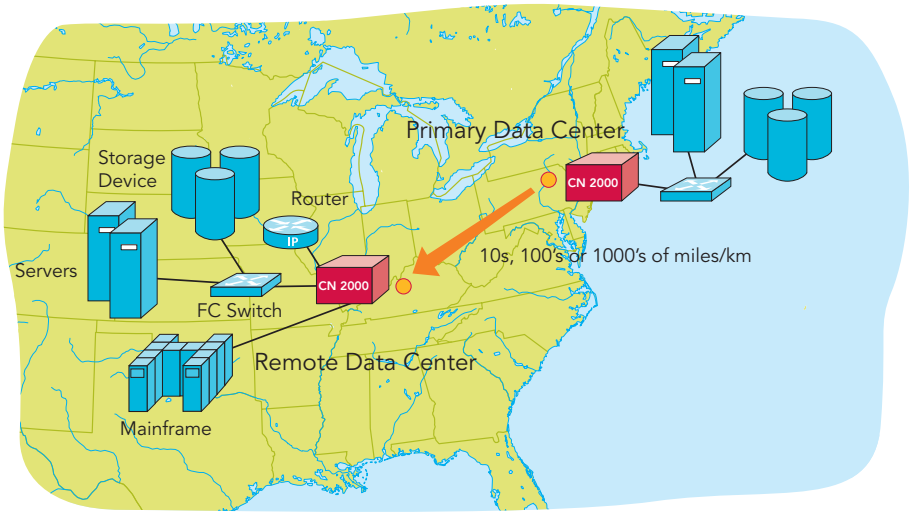

Figure 1: Long distance storage replication between data centers

Storage Replication Application Requirements

Because they deal with management of large amounts of data, long distance storage replication applications place the following requirements on network connectivity, as shown in Table 1.

» **High Throughput:** Storage applications are the largest drivers of traffic across a network.

» **Low Latency**: Storage applications require quick response times or performance can suffer.

» **Zero or Minimal Data Loss:** Depending on application requirements, data loss may be unacceptable in a storage environment, and minimal data loss is always an imperative. Retransmissions to replace lost data significantly affect application performance.

Application	Typical Throughput	Latency Requirement	Loss Tolerance
Synchronous Disk Mirroring	10 to 40 MB/s	Low, fixed latency	Zero loss
Asynchronous Disk Mirroring	10 to 40 MB/s	Low latency	Zero loss
Remote Backup	10 to 40 MB/s	Low latency	Low loss
Clustering	5 to 20 MB/s	Low, fixed latency	Zero loss
SAN extension	10 to 40 MB/s	Low latency	Zero loss

Table 1: Storage Application Requirements

Enterprise and government organizations need connectivity options that can leverage their existing data center infrastructure and scale economically as their storage needs grow.

Connectivity Options

WITHIN THE METROPOLITAN AREA NETWORK (MAN) AND WIDE AREA NETWORK (WAN), there are several network choices for connecting data centers:

» **IP Virtual Private Networks (VPNs):** Service providers sometimes offer IP VPN data services to address storage extension requirements. However, IP VPNs are delivered across a shared infrastructure, and their performance (loss, latency), although suitable for web and email access, may be too low to be effective for use as a storage extension technology.

» **Asynchronous Transmission Mode (ATM):** ATM is a data service provided by carriers and service providers that is designed to carry voice and data simultaneously. For storage extension, ATM services are generally used by legacy channel extension devices. These devices have a large footprint, are costly, and rely on application emulation to accomplish storage extension.

» **SONET/SDH:** A widely available, dedicated connectivity service that delivers high performance, low latency, zero loss, and private line security. There are a wide variety of service options when leasing SONET/SDH services from carriers or service providers.

» **Wavelength Division Multiplexing (WDM):** Coarse WDM (CWDM) and Dense WDM (DWDM) are similar technologies that allow many high bandwidth optical channels over a single pair of dark fibers between data centers. An organization must have access to dark fiber in order to use WDM, and WDM may not cost-effectively support distance connectivity outside of the MAN.

IP Networked Remote Storage Solutions

TODAY, IP NETWORKING IS BEING UTILIZED AS TRANSPORT for storage extension for replication applications with low bandwidth requirements and relatively lenient network performance requirements. Typically available at lower bandwidths, (e.g.1.5 Mb/s) at price points below high bandwidth services, IP services are widely available and support storage applications where throughput, data loss, and latency are secondary considerations to low cost. End users should be aware of costs of additional router systems and interfaces when deploying storage extension solutions over IP networking.

IP storage extension solutions rely on industry standards such as FC over IP (FCIP). FCIP solutions inherit the performance limitations of Transmission Control Protocol/IP (TCP/IP). TCP/IP was developed in the 1980s, when bandwidth across the MAN/WAN was measured in Kb/s, not Mb/s. Today's storage applications often require sustained throughputs of many Mb/s and very low latencies. Service level agreements provided with

IP VPNs do not guarantee a level of service adequate to meet these demands, often with latencies in the 10's of milliseconds and throughputs variable, subject to network congestion. This is primarily due to TCP/IP's reliance on retransmission when a packet is lost in the network. The typical performance of these solutions is less than 10 Mb/s, as shown in Figure 2.

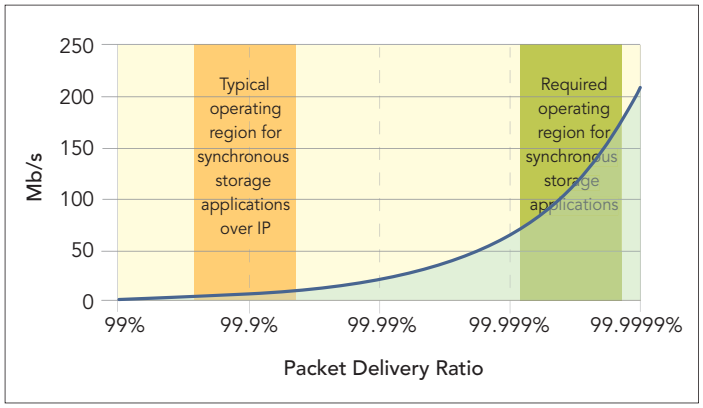

Figure 2: IP Throughput diminishes at high bandwidths

Based upon key criteria for networking long distance replication, IP has the following attributes:

» **Throughput:** As a service with best effort performance, IP throughput is subject to overall congestion on the service provider network, and throughput can vary depending on traffic levels on the network. Generally storage extension over IP is utilized for applications that do not have high performance requirements.

» **Latency:** IP services usually have latencies in the many 10's of milliseconds due to the need for packet processing over multiple router hops normally involved with interconnecting data centers. Many times this can impact the ability for operation of synchronous storage applications and for storage extension at long distances over 100's of miles.

» **Packet Loss:** IP services may drops data due to contention in the network though this is usually a function of network capacity engineering to provide adequate bandwidth for customer traffic requirements. While SLA's may be available for throughput from service providers, there is always a risk for data loss on the network due to congestion.

» **Multiple Bandwidth Levels:** IP services are available in multiple bandwidths from 1.5 Mb/s through 2500 Mb/s, allowing an end user to pick the service that best meets their individual application requirements.

» **Manageability:** IP networks generally have solid management capabilities, though there is increased complexity in managing and monitoring multiple protocol layers in storage extension solutions leveraging IP connectivity, as shown in Figure 3.

In order to support storage applications over distance, IP based storage extension solutions may require a dedicated IP network. Typically, these IP networks are built by leasing SONET/SDH services, such as a DS3 or OC-3, and then using routers to encapsulate the IP traffic into Packet over SONET. These implementations can be very inefficient and costly, as multiple platforms must be deployed and managed. In addition, the largest benefit of IP is its ability to send traffic to multiple destinations. Creating a point-to-point IP network limits the effectiveness of IP in the WAN and is therefore inefficient. Also, IP based storage extension devices do not support protocols, such as ESCON, which are still widely used in data centers, so IT organizations using IP networking must budget for additional systems to handle ESCON channel extension as well.

Figure 3: Protocol Stacks for Long Distance Replication over the WAN (Fibre Channel Example)

ATM-based Networked Remote Storage Solutions

LEGACY CHANNEL EXTENSION SOLUTIONS TRANSPORT STORAGE PROTOCOLS OVER ATM. ATM is a Layer 2 switched data service that utilizes fixed length cells over "virtual circuits" that interconnect two end user interface ports. With the addition of ATM, storage extension solutions rely on a multi-layer protocol stack which can introduce cost and complexity to network operation and management. Costs can also be increased by the processing overhead associated with encapsulating FC into ATM, and with decreased efficiency due to the fact that 15% of network bandwidth is typically lost to this encapsulation process. ATM services generally are provided by service providers but at bandwidth rates not commonly available for data rates required by storage extension applications. Additionally network latency is longer than SONET/SDH or wavelength solutions due to the cell processing required by ATM network switches in end user and network service provider networks.

ATM has the following attributes, based on key criteria for networks supporting long distance storage replication:

» **Throughput:** ATM generally provides higher throughput than IP services but lower throughput versus SONET/SDH or wavelength connections. It is possible that throughput can diminish during periods of high congestion on service provider ATM networks.

» **Latency:** ATM services have lower latency than IP services but due to packet processing, latencies do range in the realm of many tens of milliseconds, depending on distance. Many times this can impact the ability for operation of synchronous storage applications and for storage extension at long distances over 100's of miles.

» **Packet Loss:** ATM services may drop data due to contention in the network, though this is usually a function of network capacity engineering by the network service provider to provide adequate bandwidth for customer traffic requirements.

» **Multiple Bandwidth Levels:** ATM services are available in multiple bandwidths from 45 Mb/s through 2500 Mb/s, allowing an end user to pick the service that best meets their individual application requirements. ATM services costs at higher levels of bandwidth could surpass those of SONET/SDH solutions.

» **Manageability:** ATM systems and switches generally have solid management capabilities, though there is increased complexity in managing and monitoring multiple protocol layers in storage extension solutions leveraging ATM connectivity.

SONET/SDH Solutions for Higher Performance, Greater Distances

SONET/SDH IS A SOUND CHOICE FOR STORAGE EXTENSION because it meets the needs of storage applications that require synchronous operations over regional distances and low latency high bandwidth performance over distances in the range of 10s, 100's or 1000's of miles.

SONET/SDH, widely available as the foundation for numerous service provider networks, offers reliability as carrier "private line" services, providing the following:

» **Throughput:** SONET/SDH provides contention-free, guaranteed bandwidth —ensuring consistent, high performance connectivity.

» **Latency:** SONET/SDH services have low, fixed latency, ensuring maximum application performance that does not vary based on other traffic in the network.

» **Packet Loss:** SONET/SDH never drops data due to contention in the network.

» **Multiple Bandwidth Levels:** SONET/SDH services are available in multiple bandwidths from 45 Mb/s through 10 Gb/s—allowing an end user to pick the service that best meets their individual application requirements.

» **Manageability:** SONET/SDH was designed from the start to be a MAN/WAN protocol with built-in management capabilities that ensure full visibility of the health of the MAN/WAN.

WDM Solutions for Highest Bandwidth and Low Latency over Fiber Networks

WDM SOLUTIONS PROVIDE HIGH PERFORMANCE, high throughput, low latency connectivity for storage extension and data center interconnection by providing native-protocol transport. These protocols: FC, FICON, ESCON and GbE are transported over 2.5G and 10G optical channels called wavelengths. Usually WDM solutions are utilized in regional

networks (where they are more cost effective) and when bandwidth requirements meet or surpass traditional SONET speeds of up to 2.5 Gb/s. Multiple wavelengths may be utilized by organizations who have requirements to transport high bandwidth voice and data traffic in addition to high volume storage traffic on a single, consolidated network.

WDM provides the following characteristics:

» **Throughput:** WDM provides native rate bandwidth for storage traffic of 1 Gb/s and 2 Gb/s over wavelengths that can be sized at 2.5G or 10G depending on network requirements.

» **Latency:** WDM connectivity has low latency, with transparent transport of storage traffic over dedicated bandwidth, and with no packet processing that would add latency.

» **Packet Loss:** WDM never drops data due to contention in the network, providing dedicated bandwidth to storage applications.

» **Bandwidth Efficiency:** WDM connectivity is used for full native rate bandwidth transport of storage protocols. Sophisticated WDM systems employ multiplexing techniques that enable transport of multiple ESCON, FICON, Fibre Channel and GbE channels over a common wavelength, enabling highest wavelength utilization.

» **Manageability:** While legacy WDM systems deployed only minimal protocol monitoring, sophisticated systems allow visibility into storage protocol monitoring to enable faster troubleshooting and problem resolution.

Choosing the Right Networked Remote Storage Solution

THE RIGHT TECHNOLOGY CHOICE FOR NETWORKING SOLUTIONS FOR REMOTE STORAGE is based on the amount of data that needs to be moved between data centers, the performance requirements of the applications, and the cost involved in implementing the solution. It is critical to understand business and application requirements to ensure the appropriate technology and bandwidth are selected. For synchronous copy applications, highest levels of bandwidth and throughput with minimal latency is required. Storage extension over SONET/SDH or WDM is recommended for synchronous applications. Other technology choices do not support the

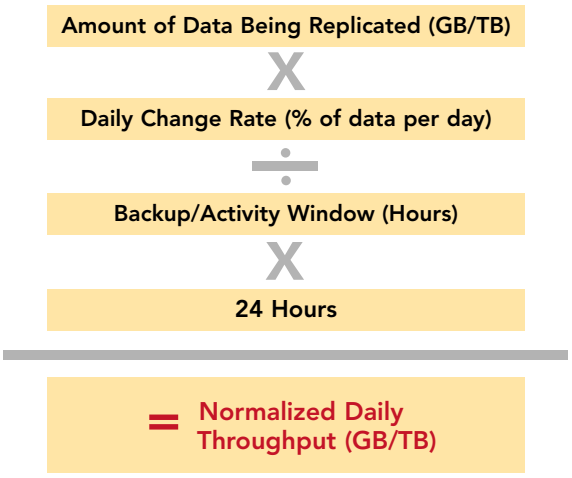

Figure 4: Normalized Daily Throughput Formula

Normalized Daily Throughput	Optimum Technology Solution
0 to 100 GB	IP solutions, if high latency is not an issue
100 GB to 500 GB	CN 2000 over DS3 or GbE
500 GB to 1.5 TB	CN 2000 over OC-3/STM-1 or GbE
1.5 TB to 6 TB	CN 2000 over OC-12/STM-4 or GbE
6 TB+	CN 2000 over OC-48/STM-16 or GbE or CN 2600 or ONLINE Metro over Dark Fiber

Table 2: Optimum Technology Solution Comparison

throughput, latency or performance required for synchronous applications. For asynchronous copy applications, the technology choice is mainly driven by the amount of bandwidth required. See Figure 4 to calculate estimated normalized daily throughput. Nomalized daily throughput can be used to determine an optimum technology solution, as shown in Table 2.

Ciena's Complete Solution Portfolio

CIENA BREAKS DOWN THE DISTANCE BARRIER FOR HIGH PERFORMANCE STORAGE EXTENSION with its best-in-class storage extension solution portfolio. Ciena provides systems, software and services that dramatically lower the cost of long distance storage replication over distances from 10s to 1000s of miles. At the same, assured network performance is provided that ensures zero to near zero data loss.

Ciena's CN 2000™ Storage Extension Platform

CIENA IS AN INDUSTRY LEADER in network solutions for storage extension. Ciena's CN 2000 Storage Extension Platform is a cost-effective, high performance storage extension device that:

» Leverages widely available DS3, OC-3/12/48, and STM-1/4/16, wavelength, and Gigabit Ethernet carrier services.

» Aggregates up to 16 physically isolated FC, FICON, ESCON, and GbE-based applications onto the same WAN link.

» Provides dedicated hardware compression on each client port to deliver maximum compression ratios and minimize latency—reducing the amount of WAN bandwidth required, and the associated recurring bandwidth charges.

» Delivers high efficiency, due to native mapping of storage protocols directly into SONET/SDH, bypassing intermediate encapsulation protocols, such as IP and ATM (See Figure 3).

» Provides plug-and-play deployment and point-and-click management for simplified, easy to manage storage extension.

» Allows end users to change supported protocols on each port through a simple software command, providing easy migration from one protocol to another—eliminating the need for additional hardware.

The CN 2000 Solution has significant advantages over other storage extension platforms in the market, including:

» Lowest cost, up to 80% less expensive than traditional channel extenders.

» Dramatically lowers network services costs with per-port hardware-based compression.

» Features Dynamic Bandwidth Assignment (DBA) which enables flexible, dynamic multiplexing of multiple channels of application traffic, allowing them to dynamically share network bandwidth, further reducing network services costs.

» Concurrent support of FC, FICON, ESCON, and GbE with software selectable protocols on each client port.

» Ability to independently scale the number of client ports and the WAN connection as data center needs change.

» Point-and-click management interface that provides true end-to-end visibility of extended storage applications.

WDM for Dark Fiber Solutions and High Bandwidth Requirements

CIENA HAS INDUSTRY-LEADING WDM PLATFORMS that cost-effectively deliver high bandwidth connectivity. Ciena's CN 4200™ FlexSelect Advanced Services Platform is capable of supporting any transport protocol including TDM, Ethernet, storage or video on any port, with any mix on the same line card. It is the first in the industry to offer user programmable line ports allowing services, up to 10 Gb/s, to be provisioned, upgraded or changed with point-and-click ease and without introducing new modules. The CN 2600™ Multiservice Edge Aggregator concurrently supports FC, FICON, ESCON, GbE, D1 Video, OC-3/12, and DS-1 and DS-3 client services on the same Dark Fiber. Ciena's ONLINE Metro™ Multiservice DWDM Platform supports a similar set of services with up to four times higher service density. As standalone solutions or when combined with the capabilities of the CN 2000 Solution, the CN 2600 and ONLINE Metro provide very cost-effective options for high bandwidth data center connectivity over wavelength-based WAN topologies.

Ciena WDM systems provide remote networked storage connectivity with the following benefits:

» **Unprecedented Flexibility:** Ciena's systemss are enabled by software-configurable modules that support any mix of services. Designed to meet the changing needs of end user applications, ports can be remotely programmed for any of the supported service types and data rates so services can be provisioned and upgraded at any time. Ciena platforms support a multitude of functionalities that include multiplexing, ADM or cross connection.

» **Optimal Cost Efficiency:** Ciena's products are enabled by innovative technology including advanced switching and grooming, remote programmability and savings of engineering, operations and sparing costs from fewer hardware elements. Sub-wavelength grooming and a Fixed OADM provide greater efficiency than competing solutions.

» **Highest Reliability:** Ciena's WDM platforms have been hardened from extensive testing and years of deployment in the most demanding carrier, government and enterprise networks around the world. By comparison, the optical platforms of leading data networking companies are only enterprise class.

» **Manageability:** Ciena's ON-Center® sets the benchmark for management. This sophisticated, integrated design, planning and operational tool in its sixth generation saves end users by minimizing downtime and streamlining management activities. In addition, Ciena provides the highest level of performance monitoring in the industry, available at both the SONET and Protocol layers.

» **Maximum Utilization of Bandwidth:** Ciena has the highest concentration capability of any optical product in the industry, so end users can obtain the highest possible concentration of connectivity over individual wavelengths. With Ciena platforms, you can leverage highest density multiplexing of GbE, Storage (FC, FICON, ESCON), and SONET/SDH available on the market today.

» **Scalability:** Ciena's Metro platforms scale to over 330G protected, providing the ability to meet bandwidrequirements of today's applications and those in the future.

Summary

WHETHER REPLICATING A 1 TB DATABASE ACROSS A CITY OR MOVING 50 TB TO A NEW DATA CENTER, Ciena's products deliver the price, performance, and manageability required for a successful storage extension network.

» **Ciena's CN 4200 FlexSelect:** Advanced services platform that supports any transport protocol including TDM, Ethernet, storage or video on any port, with any mix on the same line card. It is the first in the industry to offer user programmable line ports allowing services, up to 10Gb/s, to be provisioned, upgraded or changed with point-and-click ease and without introducing new modules.

» **Ciena's CN 2000:** Industry-leading Storage Extension Platform, designed for low cost, high performance network solutions for long distance replication.

» **Ciena's CN 2600:** Low cost CWDM multiservice platform with support for storage and non-storage traffic, such as D1 video, TDM, and OC-3/12 services.

» **Ciena's ONLINE Metro:** High density DWDM platform for organizations requiring very large amounts of inter-data-center bandwidth in support for storage, LAN, and voice and video connectivity.

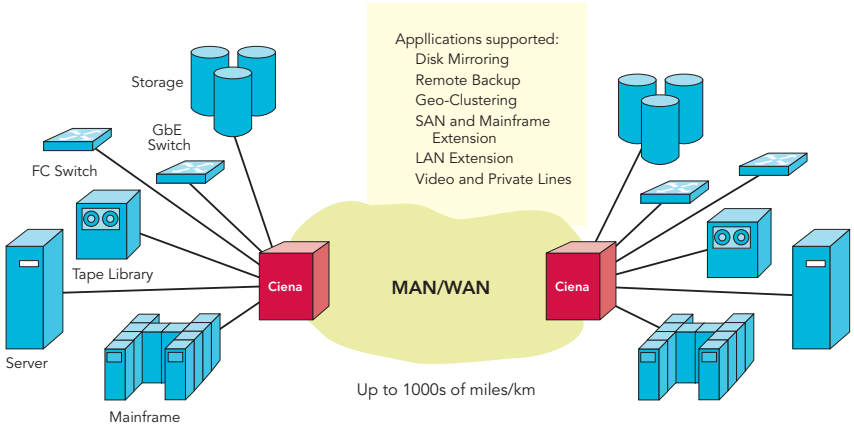

Figure 4: Ciena's Complete Solution Portfolio for Storage Extension

Benefits of these systems to storage and networking end users include:

» **Low Capital Cost:** Ciena's solutions are up to 80% less expensive than alternative solutions.

» **Low Operating Costs:** The efficiency of Ciena's solutions provide up to 70% operational savings by providing per-port compression, Dynamic Bandwidth Assignment and by enabling the consolidation of multiple channel and network connections on a common WAN connection.

» **Simplicity:** Ciena allows true plug-and-play storage extension deployment.

» **End User Control:** Point-and-click provisioning provides full control of the storage extension network through an easy to understand interface.

» **Complete Visibility:** Ciena's solutions enable proactive management and rapid fault isolation.

» **Security:** Ciena's storage extension solutions extend multiple storage applications, while retaining physical isolation, ensuring the strongest levels of security.

» **High Performance:** The low latency and high throughput of Ciena's solutions shrink backup windows.

» **Flexibility:** Ciena's solutions support concurrent extension of multiple applications and multiple protocols, and support the complete range of Wide Area Network (WAN) infrastructures.

» **Scalability:** Ciena's solutions grow seamlessly with enterprise and government organizations, as their storage extension requirements evolve.

» **Reliability:** Carrier class reliability is built into all Ciena solutions, with full system redundancy and in-service upgrades.

» **Proven:** Ciena's solutions are qualified by all major storage vendors and have a strong global customer base.

About Ciena: Ciena Corporation, the network specialist, supplies application-focused network systems, software and services to customers worldwide. The company leverages core competencies in optical networking, data networking and broadband access to solve its customers' most critical networking challenges so they can best exploit the applications that are driving their businesses forward.
For more information about Ciena, please call 1-800-207-3714 (US) or 1-410-865-8671 (outside US), or visit **www.ciena.com**

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