

# The Enlightened Storage Area Network

CIENA's solutions for extending high-availability storage networks across geographies

***Transport is now key for extended SAN applications. Main factors required in SAN interconnect transport solutions are:***

- **Native support for all SAN protocols including ESCON, Fibre Channel and Gigabit Ethernet.**
- **SAN protocol full bandwidth throughput up to 2 Gb/s Fibre Channel and 10 Gb/s Ethernet.**
- **Fast optical reliability with carrier class (< 50msec) recovery for fiber cuts.**

Data loss within any company is extremely costly. Losing mission-critical data can put a company's success at risk. When disruptions occur, an airline reservation center may lose tens of thousands of dollars per hour. A financial institution or brokerage may lose millions per hour. Simply put, enterprises requiring high levels of data availability cannot afford to be without a resilient, high-speed internetworked storage solution.

Historically, it has not been technologically or economically feasible to transport gigabit storage protocols across metro (10-60 km) and regional (60-200+ km) networks. As a result, most enterprises have been forced to rely on archaic disaster recovery processes involving manual tape vaulting, in which limited data recovery could take days or even weeks. A few very large enterprises with substantial IT budgets were able to implement remote data replication strategies, but they came at a high cost.

Now, with new telecommunications technologies that are able to cost-efficiently transport "storage protocols" across the metro area, managing an interconnected storage area network (SAN) is no longer an unobtainable desire. This paper will explain how enterprises can now economically interconnect their SANs across the metropolitan area and region by using optical networking over the wide area network (WAN). By interconnecting their different "SAN island" data centers using high-bandwidth, high-reliability and low-latency connections, enterprises can easily implement a variety of storage applications across extended SANs.

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**Simply Smarter Light**

## Enterprise Storage Applications

There are three primary applications for enterprise storage. Each takes a different approach based on the unique needs of the enterprise, but all rely on a high-reliability, high-bandwidth, cost-effective means of interconnecting the SANs.

**Business continuity** is a disaster protection scheme that copies stored data in off-site locations using remote mirroring software. This technique enables a redundant remote system that can access the mirrored data immediately in the event of an emergency. The scheme facilitates an effective disaster recovery plan, because mirrored systems are physically separated. Disaster protection is increased as the distance between sites increase. Many financial and government mirrored sites are located in different cities, states, and even regions over the long-haul network.

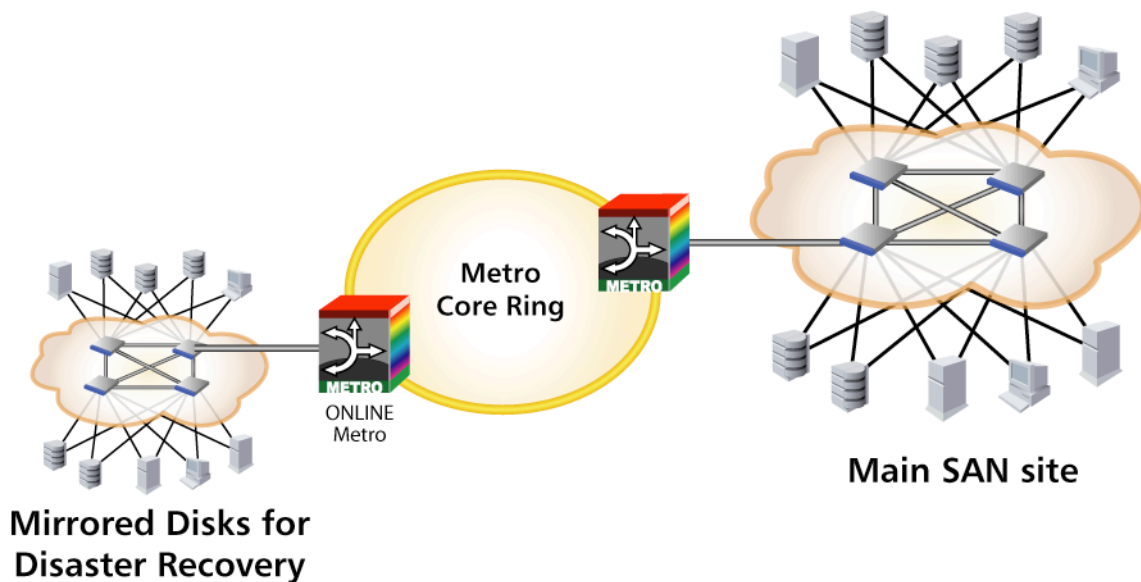


Figure 1: Mirrored SAN will take over immediately if Main SAN becomes inoperable

**Centralized backup**, as the name implies, uses software to provide a remote, centralized, heterogeneous data backup capability allowing companies in a campus or multi-site environment to optimize tape library utilization and reduce backup administration. Centralized backup also enables a streamlined disaster-protection solution by providing electronic vaulting of tape backups at a disaster recovery site. Centralized backup eliminates the manual effort of writing and delivering physical tapes from multiple server sites by remotely locating the backup storage equipment to a centralized and safe location.

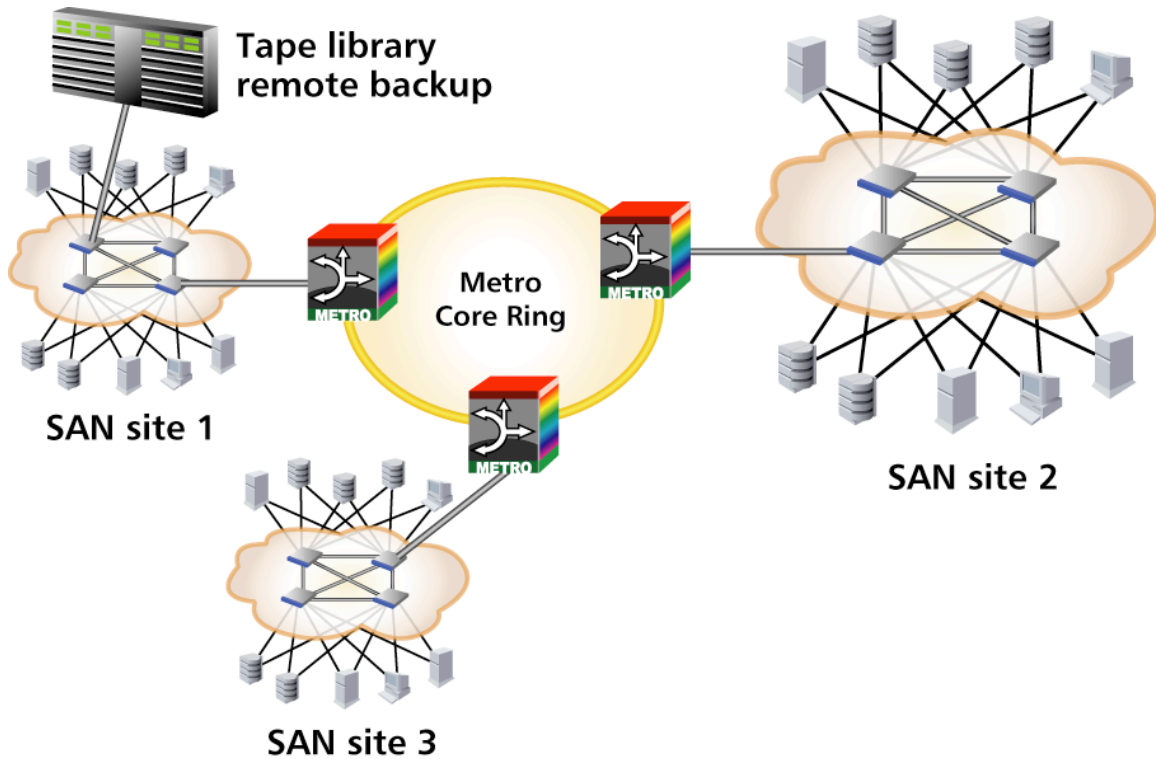


Figure 2: One site performs tape backup for many SAN sites

**Storage consolidation** provides a remote storage infrastructure over the metropolitan area. It offers any-to-any server and storage connectivity over metro and regional distances, and enables consolidation of storage resources that are shared by servers residing at other locations. Storage consolidation disaggregates servers and storage over distance, allowing the servers to access remote storage resources. This increases system flexibility and optimizes use of resources, simplifying storage management. With this approach, companies can save capital through maximum utilization of storage resources. They can also save operational costs by centralizing IT staff at a single storage location.

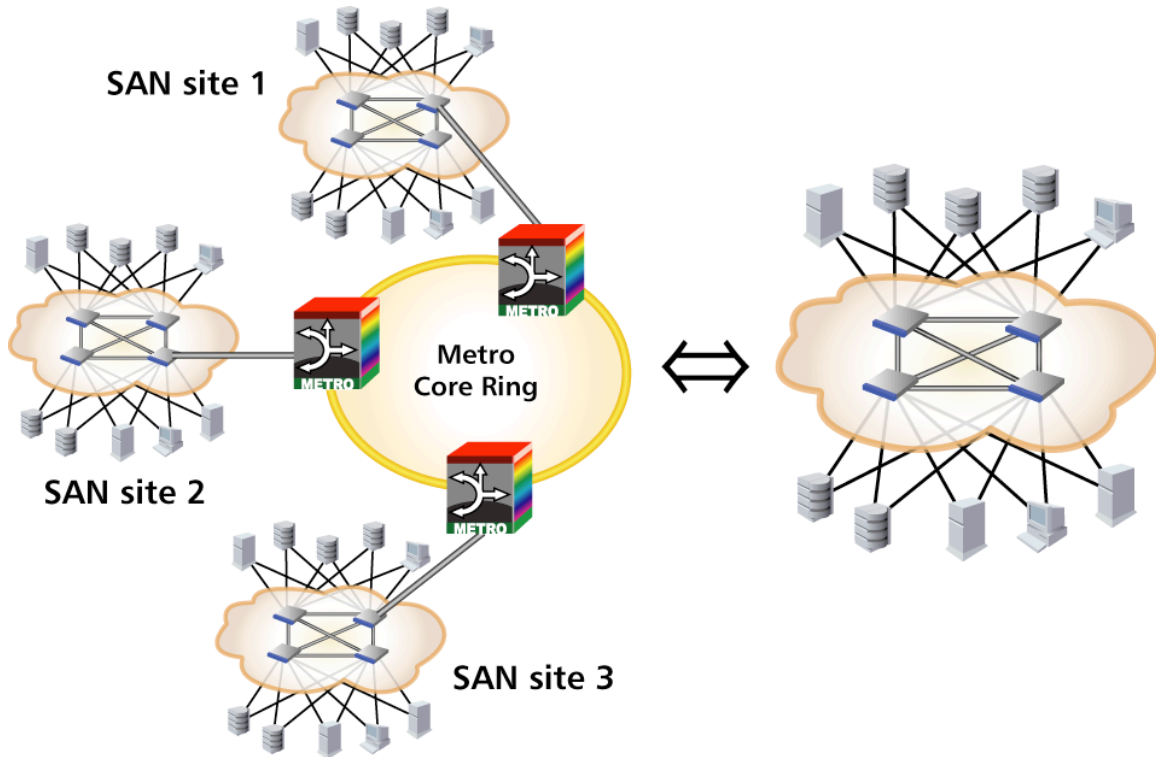


Figure 3: Storage consolidation interconnect SAN "islands"

In each of these applications, the common theme is efficient, reliable and high-bandwidth transport between SANs over metro and wide area distances. Today, this can be accomplished with proven technologies that are engineered to ideally fit the requirements of storage networking – made economically feasible by leveraging existing carrier-class optical networks.

## SAN Protocols

SANs may be implemented utilizing a variety of protocols. IBM servers and storage devices typically use Enterprise Systems Connection (ESCON®). Each connection operates at 200Mbps requiring many connections at each site for high-bandwidth throughput. ESCON has evolved to 1 Gb/s with Fibre Connection (FICON™) based on the existing Fibre Channel technology. Disk arrays and servers support the Fibre Channel protocol running at 1 or 2 Gb/s and SAN switches also utilize Fibre Channel. Advancements in the use of IP for storage have recently emerged with Fibre Channel over IP (FCIP) and iSCSI communication protocols over a Gigabit Ethernet connection. Fibre Channel standards have evolved from a 1 Gb/s to current 2 Gb/s with plans to reach 10 Gb/s. It is clear that storage area networking will continue to evolve with high-bandwidth Fibre Channel technology at its core.

## Legacy Network Infrastructure Challenges

The legacy telecom networks using SONET/SDH infrastructure, with their rigid signaling hierarchy including T1, T3 and OC-3, were originally designed to carry voice traffic. Traditionally, there have been no efficient mechanisms to enable the transparent transport of high-speed SAN protocols outside of a campus network using legacy infrastructure.

This inflexibility drove up costs, which restricted storage traffic over the metro optical network, requiring enterprises to perform manual tape vaulting or to use expensive protocol conversion gateways that encapsulated Fibre Channel into ATM cells that SONET/SDH could frame and carry. Besides being expensive and complex, these gateways did not fully support native Fibre Channel, which stifled throughput to a fraction of its native gigabit capacity.

## Wave Division Multiplexing for Extending Storage Networks

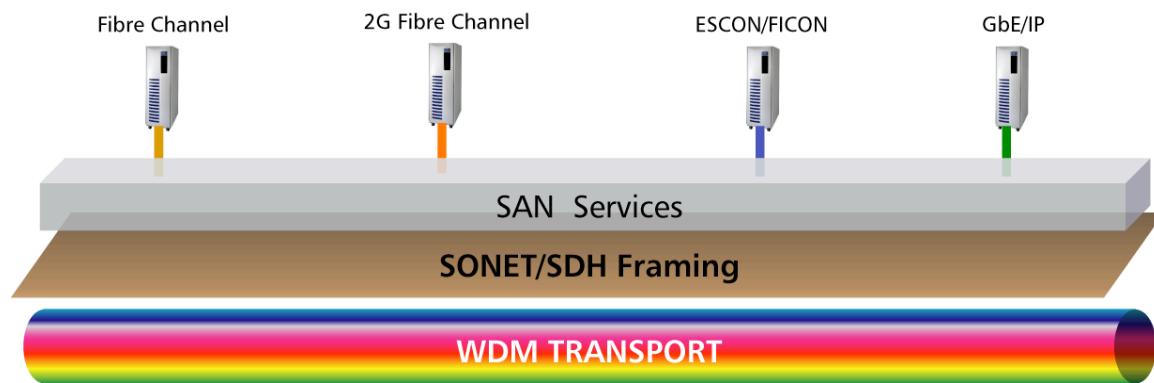


Figure 4: Multiple SAN protocols converged on a single WDM optical transport layer

Wave division multiplexing enables numerous network efficiencies by allowing a single fiber pair to transmit multiple independent signals by dividing the light into individual wavelengths or colors that carry one signal each. Each wavelength can be added, dropped, or passed through the many WDM nodes in a network. This allows multiple high-speed protocols to be multiplexed and transported over the same fiber, without the need for protocol conversion or compression. Multiple SANs in the same city can be connected over a single WDM network. Service changes are made to the WDM nodes without manipulating the fiber, and Fibre Channel signals from the SAN equipment (such as a Fibre Channel switch) traverse the WDM network at full-rate natively.

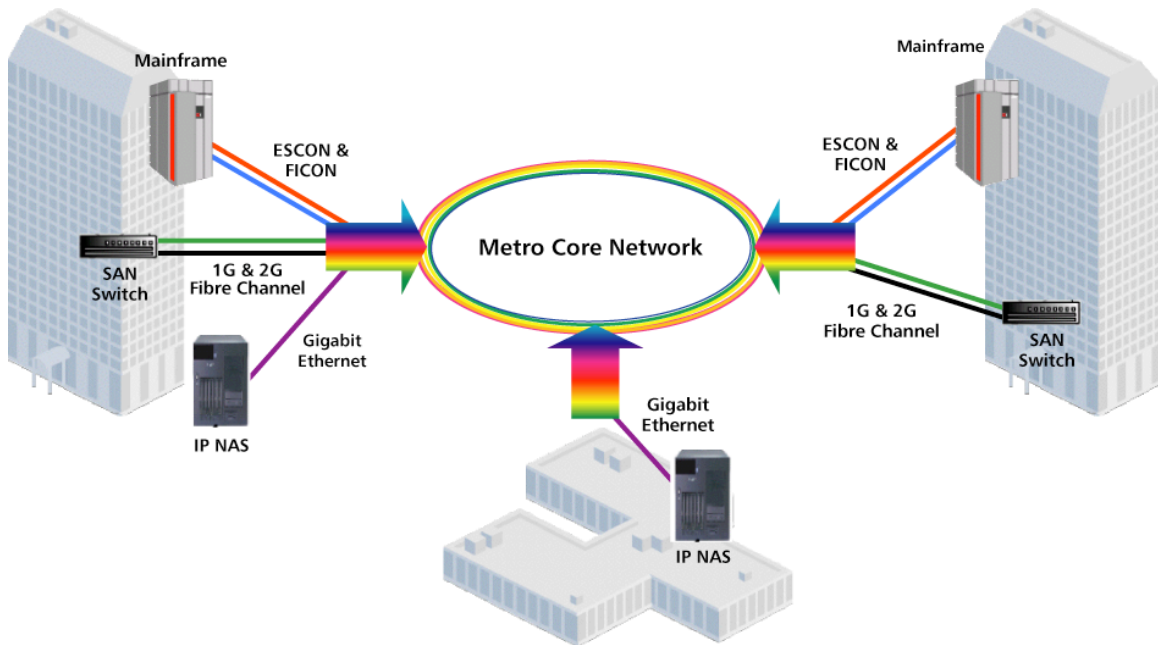


Figure 5: WDM enables multiple full-rate protocols over wavelengths on a single fiber ring across the metro core

Internetworking SANs across longer distances, for example between cities, used to require buying or leasing expensive, dedicated optical fiber links for each service connection. Leveraging the existing SONET/SDH infrastructure is a more logical approach. WDM solutions with built-in SONET framing allow use of the existing SONET/SDH infrastructure, which dramatically improves storage economics across the network.

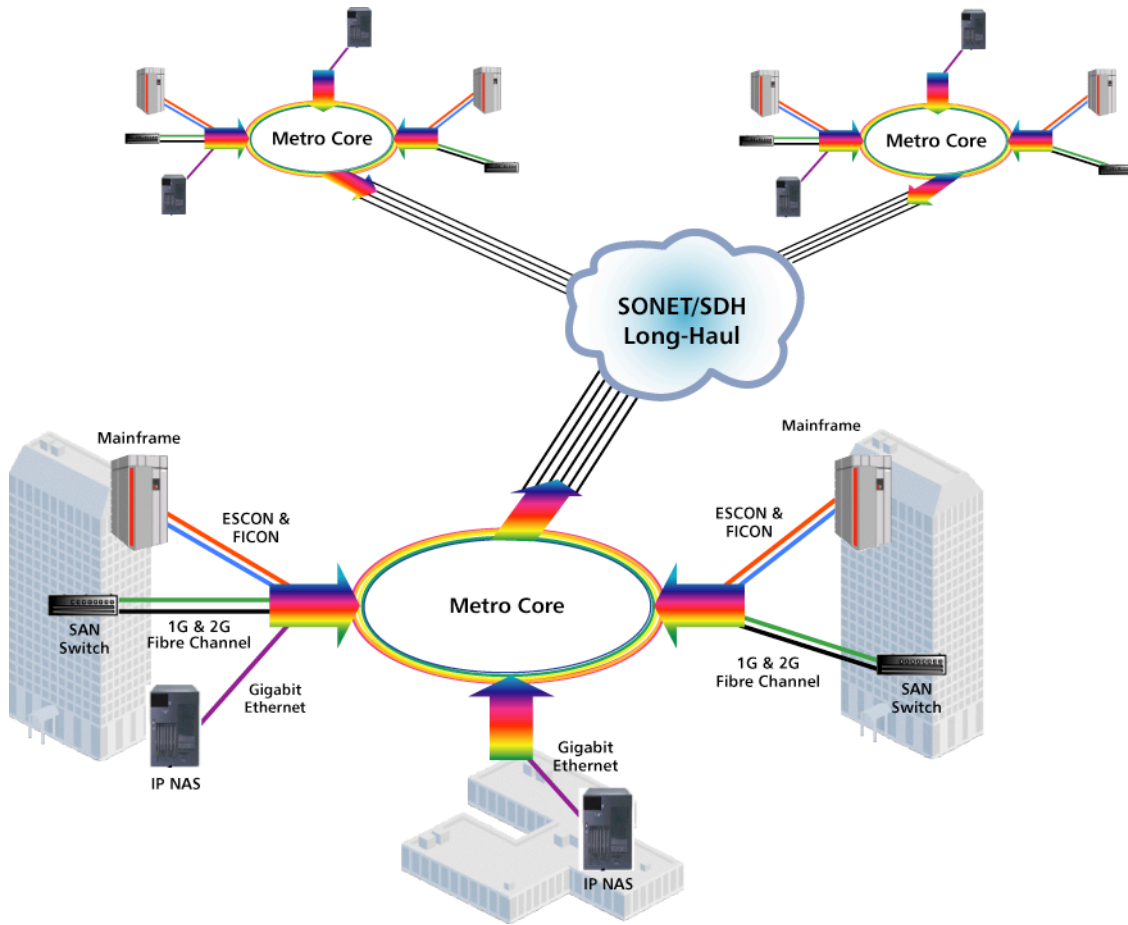


Figure 6: Multiple protocols framed over SONET/SDH provide regional reach

While WDM and SONET/SDH transport will support storage over long distances Fibre Channel's flow control methodology based on buffer credits can limit throughput over long distances due to transport delay. Products that compensate for buffer credit delays feature intelligent buffer credit controls that enable Fibre Channel transport at full speed over distances up to thousands of kilometers.

## The Enlightened SAN

RHK forecasts that by 2005 the North American market for WDM equipment will reach \$2 billion. Over half of all WDM deployments will be used for internetworking storage applications. Clearly the protocol, reliability and bandwidth requirements of storage applications require the attributes of a WDM solution. Certified multi-vendor solutions that leverage WDM are available now from CIENA that extend SANs up to thousands of miles and transport native protocols including Fibre Channel at its full 2 Gb/s potential. These solutions also allow operators to run their network using advanced software that seamlessly integrates operational processes including design, turn-up and management.



## CIENA LightWorks™ Solution for Storage Internetworking

There is no doubt that storage is a mission-critical investment for businesses today, and the need to extend storage networks across geographic bounds is increasingly apparent as enterprises continue to optimize storage architectures for cost and reliability. That's why CIENA's LightWorks portfolio offers an array of industry leading and tested WDM transport platforms that are certified to interoperate with products from the world's leading storage vendors. Solutions featuring full-rate native storage interfaces include the ONLINE™ Edge for lower density coarse WDM (CWDM) deployments and the ONLINE™ Metro for higher density dense WDM (DWDM) applications. These products, as well as the rest of CIENA's leading LightWorks portfolio of optical transport and switching platforms, enable virtually any type of business continuity, centralized backup or storage consolidation application for the continuing expansion of storage area networks.

***Storage vendor interoperability is key to an end-to-end solution. CIENA has jointly deployed with the following leading SAN solution providers:***

- Brocade
- EMC
- HP
- McDATA
- CNT
- HDS
- IBM

## ONLINE Platforms

The key advantage of the ONLINE platforms is the flexible aggregation of multiple protocol services at full native bandwidths with fast optical protection. ONLINE supports a family of ESCON, FICON, and Fibre Channel, as well as TDM and Ethernet multiplexing cards that efficiently aggregate any mix and scale of services over WDM wavelengths or the SONET/SDH network. This full-rate native protocol transport eliminates latencies caused by the complexities of buffering, conversion, and routing. Transport service protection is provided at carrier grade restoration times (<50 msec) through optical unidirectional path switched rings (O-UPSR) or optical bi-directional path switched rings (O-BLSR) as well as application protection schemes such as redundant SAN switch fabrics or standard SONET/SDH protection.



## ONLINE Edge—Multi-services CWDM



The ONLINE Edge brings wavelength services to the edge with a modular, stackable and compact form utilizing low-cost coarse wave division multiplexing technologies. Up to eight protected or 16 unprotected wavelengths can be supported on a

single fiber pair. Each Data ADM service card supports two ports of Fibre Channel, FICON or Gigabit Ethernet in an add, drop or multiplexing transport path on a single wavelength framed over 2.5 Gb/s SONET/SDH. At maximum capacity, the ONLINE Access can provide 16 protected or 32 unprotected services on a single fiber. Storage distances of thousands of kilometers are achieved through buffer credit extension technology that compensates for transmission delay impacts on Fibre Channel's flow control methodology.

## ONLINE Metro—Multi-services DWDM



The ONLINE supports 33 protected or 66 unprotected dense wave division multiplexed wavelengths. Service multiplexing cards groom multiple services onto individual wavelengths. Cascading storage grooming cards with ONLINE's OC-192 10 Gb/s card results in dramatic scalability from a few services up to hundreds of Fibre Channel, ESCON and Gigabit Ethernet services per fiber pair. Optical protection options include O-UPSR for hubbed traffic or O-BLSR for distributed traffic patterns. The ONLINE Metro expands metro connectivity over the long haul with long-reach optics.

## CoreDirector<sup>®</sup>—Intelligent Optical Core Switch



The CoreDirector switch provides 640 Gb/s of non-blocking, bi-directional switching in a single rack, with the ability to upgrade to 38 terabits. It supports 256, individually serviceable, OC-48/STM-16 or 64 OC-192/STM-64 interfaces, and up to 512 OC-12/STM-4 and OC-3/STM-1 optical interfaces for lower speed access. In addition, all optical interfaces can be configured as concatenated for wavelength switching, with transparent service options, or channelized for grooming and switching at STS-1 granularity for maximum flexibility. Because of its scalability, range of optical interfaces, and configurable switching granularity, the CoreDirector switch incorporates the functionality of SONET/SDH add/drop multiplexers (ADM), digital cross-connects, and optical cross-connects in a single unit.

## LightWorks ON-Center<sup>®</sup> Management Suite

The LightWorks ON-Center Management Suite provides a sophisticated array of element, network and service management capabilities across the intelligent optical network. ON-Center is designed for easy interoperability based on a flexible range of open, standards-based interfaces to support the wide diversity of Network Management System / Operation Support System (NMS/OSS) implementation options in the marketplace. Through the use of optical and protocol-specific performance metrics, service providers and enterprises are able to provision and monitor internetworked storage transport, as well as application service level agreements.

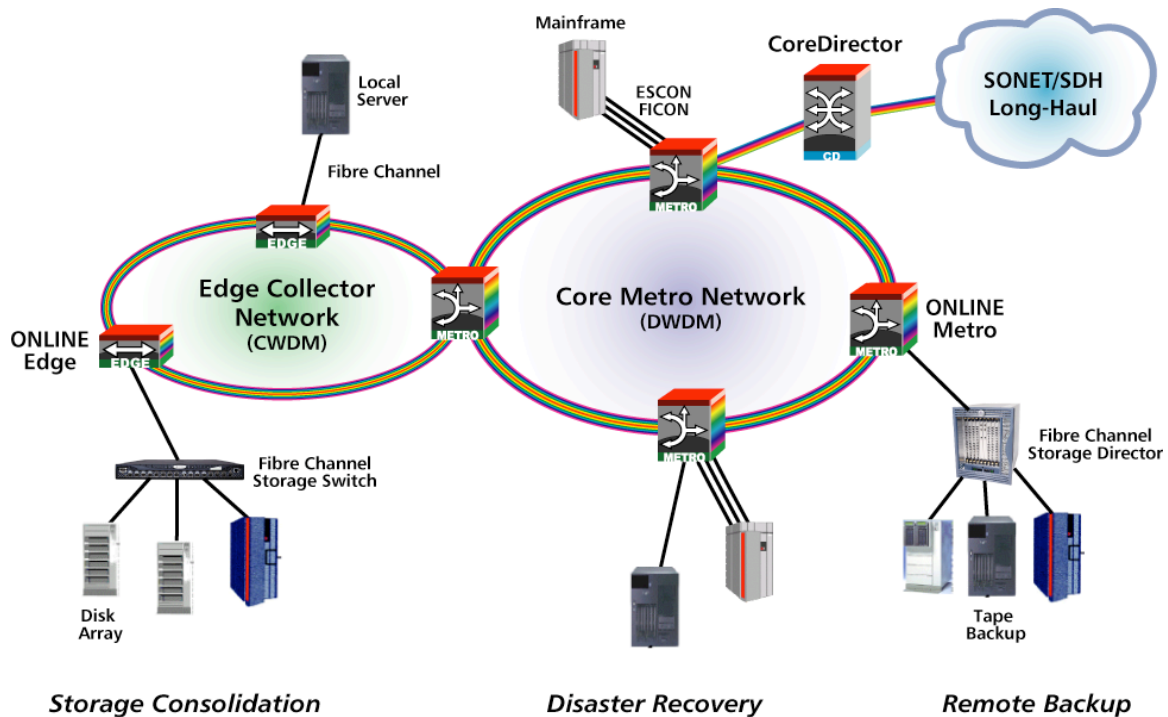


Figure 7: CIENA's LightWorks portfolio provides storage transport solutions over the metro, regional and long haul networks

Storage applications have evolved from server-attached dedicated storage within the building, to storage area networks over the campus, and now to internetworked storage across the metro, regional and into the long haul networks. Internetworked storage is driven by business continuity, centralized backup, and storage consolidation applications. Economically feasible, resilient and high-speed transport has become a critical element in the implementation of these applications. Today, carriers already have the fiber, DWDM and SONET infrastructure to deploy internetworked storage services to enterprises. This paper has described the drivers for internetworked storage applications and demonstrated the flexible WDM and SONET/SDH solutions through CIENA's LightWorks metropolitan transport and core switching portfolios providing the services, features and management for the continued evolution of storage networking.