WHITE PAPER

THE ESSENTIAL ELEMENTS OF A STORAGE NETWORKING ARCHITECTURE

The Brocade Intelligent Fabric Services Architecture provides a flexible framework for continued SAN growth

BROCADE
The intelligent platform for networking storage

As organizations increasingly need to process and store ever-growing amounts of data, they are looking for new ways to simplify management and reduce the overall cost of their networked storage environments. As a result, these organizations need powerful yet flexible tools to manage a wide variety of tasks within the storage environment.

To provide the essential framework for deploying, scaling, and managing networked storage environments, Brocade® has recently developed the Intelligent Fabric Services Architecture. This architecture provides the advanced fabric services and functions that give organizations new options for building enterprise Storage Area Networks (SANs). Beginning with the new Brocade SilkWorm® 12000 Core Fabric Switch, organizations will be able to fully leverage this framework to effectively grow and manage their SAN fabrics in a cost-efficient manner. As new SAN protocols and technologies emerge, Brocade will continue building on this architecture to provide the widest range of SAN solutions available.

The Challenges of Rapid Data Growth

Regardless of their industry, size, or geographical location, today's organizations share a common trait: they face the enormous challenge of efficiently managing an ever-increasing amount of business data. The rapid growth of the Internet and the proliferation of e-business applications have generated a tremendous amount of transaction and collaborative data. In turn, this data has fueled data-intensive analysis applications that produce even more information to be stored. On top of this influx of information, new forms of data—such as images, audio, and video—are increasingly stored and integrated with applications, further accelerating the demand for storage capacity.

A recent study at the University of California at Berkeley concluded that the total amount of stored information in the world today would double in the next 2.5 years. Moreover, some industry analysts have estimated that the number of terabytes shipped each year would grow from 2,000 today to over 150,000 by 2003. Regardless of the estimate or prediction, one thing is clear: storage growth is a major challenge for organizations that want to remain competitive in a highly dynamic business world.

The Storage Networking Imperative

The rapid pace of storage growth has required organizations to re-evaluate how they design and manage their IT infrastructures. The traditional model of deploying application servers with directly attached storage is no longer a cost-effective or efficient way to store, manage, and protect critical data. The direct-attach storage model impedes efficient use of storage resources and reduces overall application availability when servers must be taken offline to add or remove storage capacity. In addition, the direct-attach storage model does not scale easily and is an expensive drain on critical staffing resources.

In contrast, the networked model of storage, where servers and storage are connected by a network of intelligent switches, is a proven solution that provides superior scalability, higher availability, and simplified management—all of which greatly reduces costs. Today, organizations around the globe are implementing SANs to solve a variety of technical and business requirements. As such, SANs are beginning to play a more vital role within the overall IT infrastructure for enterprises of all sizes.

For instance, SANs enable more efficient use of storage capacity by consolidating widely distributed disk space onto fewer storage arrays accessible by heterogeneous servers across the SAN. This practice improves storage resource utilization by allowing excess storage capacity from one application to be used for another. In addition, many organizations are reducing backup windows more than 50 percent by moving the data directly between disk and tape over the SAN rather than the already-overworked production LAN. Other impressive SAN benefits include a better return on capital expenditure for storage and servers, greater configuration flexibility, and reduced management costs through centralization.

Many first-generation SANs have been deployed to solve specific application requirements. In general, these SANs have typically connected servers and storage from a single vendor and have been somewhat limited in their scope (see Figure 1). In addition, many of these SANs have not yet been considered a strategic component of the IT infrastructure. However, the growing success of SANs in terms of scalability, availability, and manageability has caused many organizations to begin viewing SANs as essential parts of the corporate IT infrastructure.

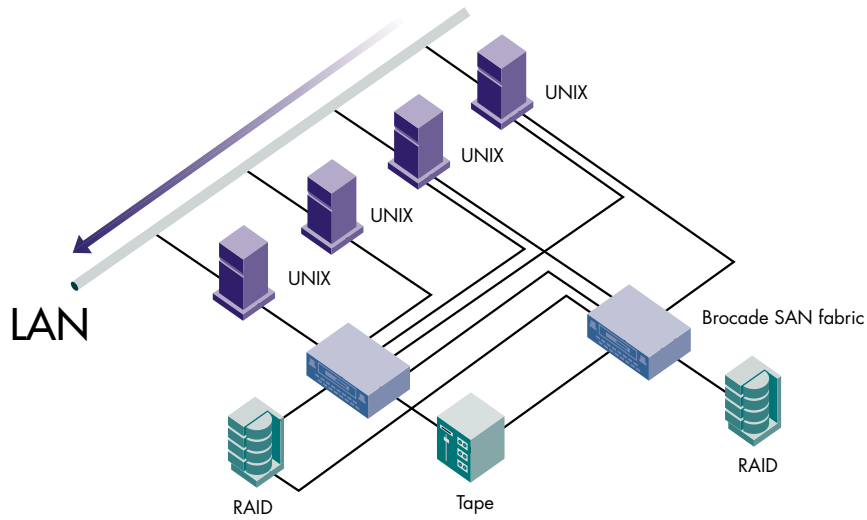

Figure 1.
A simple homogeneous SAN for server and storage consolidation

The Basic Requirements for Storage Networks

As SANs begin to play a more prominent role in the IT infrastructure, organizations need to evaluate how the SANs will interact with the overall environment. As part of this process, organizations need to ask several crucial questions:

- **Is it a proven solution?** A SAN solution should be field-proven in a wide range of industries and application environments, and supported by a variety of server and storage vendors. It must also deliver the throughput and latency performance required by the server-to-storage connections.

- **Is it scalable?** A SAN configuration should be able to scale independent of storage and server capacity—without disrupting applications' ability to access data. Likewise, a SAN must provide excellent configuration flexibility and extended distance connectivity.
- **Is it manageable at a reasonable cost?** A SAN provides a centralized point of management for many storage functions, and the consolidation of independent storage devices helps reduce management expenses. However, a SAN also represents an additional entity to be managed, and therefore must require a minimum of direct management or ideally be manageable by existing tools that manage applications, storage, or servers.
- **Is it highly available?** Today's most demanding enterprise applications require continuous availability, with downtime limited to seconds or minutes per year. Built-in redundancy, and the high-availability characteristics of a networked storage approach are critical.
- **Is it secure?** As SANs grow in size, or are used to support multiple customer environments, they must provide auditable security mechanisms that prevent unauthorized access to data. This requires specific mechanisms to secure access to SAN management functions, reliable authentication of devices, and prevention of network intrusion.
- **Is it heterogeneous?** No single storage or server vendor can meet the entire range of application requirements for all possible business needs. A SAN should be designed with interoperability and support for the widest range of devices, and it should be based on open industry standards.
- **Can it accommodate future technologies?** A SAN should be based on an architecture that can grow and adapt to new requirements and technologies. In addition, the SAN should be controlled by a set of management services that can be extended to accommodate new storage protocols.

The Brocade Intelligent Fabric Services Architecture

To provide a powerful yet flexible framework for addressing critical SAN requirements, Brocade has developed the Intelligent Fabric Services Architecture. Brocade has led the industry in pioneering the widespread deployment of storage networks. The key components of this leadership—the SilkWorm family of Fibre Channel fabric switches and the associated Fabric OS™ software platform—are at the heart of networks ranging from a few switches to thousands of ports.

To build on this success, the Brocade Intelligent Fabric Services Architecture delivers both the basic switching functions and the advanced services that improve manageability, availability, security, and scalability while enabling new types of applications (see Figure 2). These services help transform the *network* into an *intelligent SAN fabric*—a more robust form of interconnectivity solution that integrates data transport with application services.

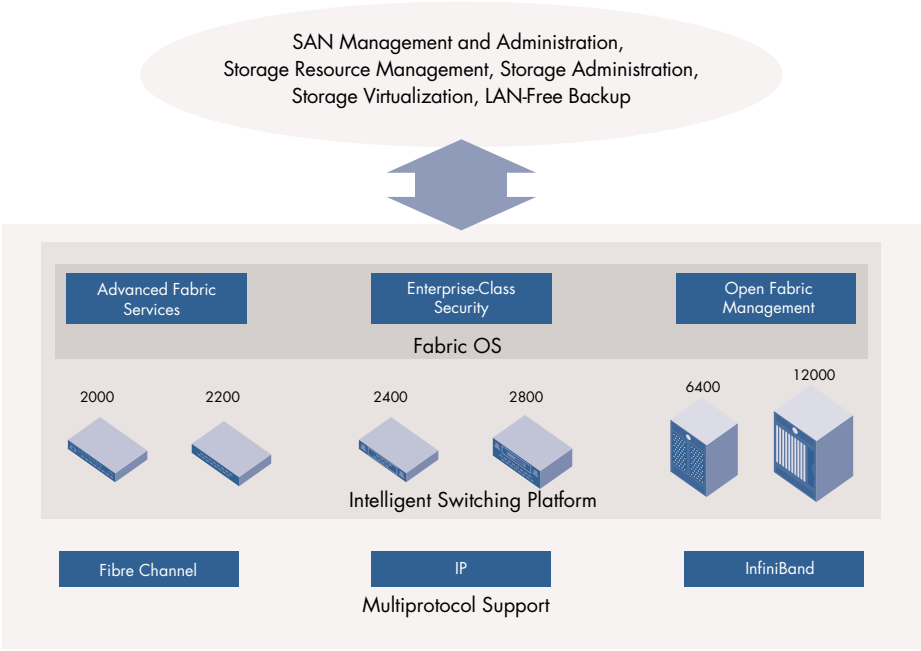

Figure 2.
The Brocade Intelligent Fabric Services Architecture

The Brocade Intelligent Fabric Services Architecture consists of the following building blocks:

- The SilkWorm family of fabric switches
- Advanced Fabric Services
- Open Fabric Management tools
- Enterprise-class security products

The SilkWorm 12000: An Advanced Platform for Networking Storage

The SilkWorm family of fabric switches ranges from entry 8-port switches to the SilkWorm 12000 Core Fabric Switch, which provides up to 128 ports of connectivity in a single enclosure. The SilkWorm 2000 series of products is built upon a second-generation ASIC that supports the ANSI-standard Fibre Channel protocol at 1 Gbit/sec. The new SilkWorm 12000 is the first model based on a third-generation ASIC that provides link speeds of 1 and 2 Gbit/sec. The SilkWorm 12000 features a protocol-independent backplane that supports 2 Gbit/sec Fibre Channel blades today, as well as emerging storage protocols such as 10 Gbit/sec Fibre Channel blades, InfiniBand fabric blades, and IP/Ethernet blades in the future.

In addition to Fibre Channel, InfiniBand, and IP, the SilkWorm 12000 also supports an optional Application Platform blade that enables the deployment of high-performance fabric services such as storage virtualization and third-party copy. With the Application Platform integrated into the switch, higher data rates are possible and management between switches and applications is much easier.

In addition, the Fabric OS provides powerful software functions without the overhead of a traditional operating system. The hardware and software combine to enable networks that support robust topologies with multiple paths between devices. As new switches are added to accommodate growth in server or storage capacity, existing older switches can continue to interoperate with the new equipment. In this way, organizations can

interconnect SilkWorm switches to grow their networks to thousands of devices in a modular, cost-effective, and non-disruptive manner.

Advanced Fabric Services

The Fabric OS used in every SilkWorm switch contains a set of essential fabric services that improve manageability, availability, and scalability. These critical services enable organizations to create a fabric that spans all of the switches and ensures that directory or status information is immediately available when servers and storage send requests to a local switch.

For instance, path routing services based on the industry-standard Fabric Shortest Path First (FSPF) protocol identify possible routes through the fabric and manage sub-second path rerouting in the event of a link or node failure. In addition, the Brocade Extended Fabric feature manages buffer allocation to enable full-bandwidth transfers of 120 km over Dense Wave Division Multiplex (DWDM)-based Metropolitan Area Networks (MANs) and even longer distance transfers using existing WAN infrastructures and the TCP/IP protocol.

Operating at a higher level than the essential services of Fabric OS is the optional Application Platform within the SilkWorm 12000. This platform provides a high-performance open processing environment for new SAN applications such as storage virtualization, cluster services, and third-party copy. Brocade will deliver this platform with a multi-CPU processor complex, large amounts of memory, multiple high-speed PCI buses with multiple connections to the fabric, and an integrated fabric switch. Brocade is actively engaged with several of its partners to develop advanced applications for this platform.

Beginning with the SilkWorm 12000 and its third-generation ASIC technology, the Brocade Intelligent Fabric Services Architecture enables an even wider range of advanced switch fabric services:

- **Brocade Inter-Switch Link (ISL) Trunking™:** Enables as many as four Fibre Channel links between switches to be combined to form a single logical ISL with an aggregate speed of up to 8 Gbit/sec. These high-speed trunks simplify network design, optimize bandwidth utilization, and ensure that server-to-storage performance remains balanced under heavy network loads (see Figure 3).
- **Brocade Frame Filtering™:** Enables more secure and available fabrics that are easier to manage. Wire-speed filtering of each frame based on the content of several

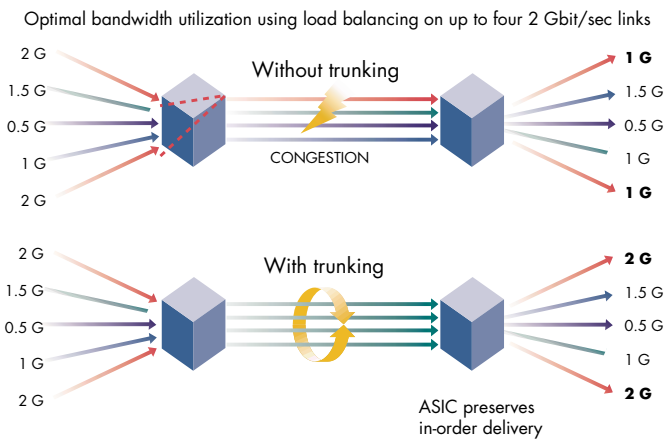

Figure 3.
Brocade ISL Trunking relieves congestion and enables high-speed data traffic

fields in both the header and the payload enables fabric zoning based on Logical Unit Number (LUN), network protocol, or I/O request type. This approach enables fabric-wide heterogeneous LUN masking managed from a central point.

- **Hardware-enforced zoning by World Wide Name (WWN), port ID, or Arbitrated Loop-Physical Address (AL-PA):** Simplifies administration while providing the highest level of secure control over data access. This new capability provides administrators with much more flexibility in how they partition storage and servers to secure the overall fabric.
- **Enhanced end-to-end performance analysis:** Enables more effective tracking of resource utilization on a fabric-wide basis. Administrators can capture I/O performance levels associated with specific initiator and target device IDs anywhere in the fabric, independent of fabric topology. In addition to reducing management cost through more proactive capacity planning, this capability enables reporting at a level required to demonstrate adherence to service level agreements.

As storage networks grow to include protocols beyond Fibre Channel, Brocade will expand the Fabric OS advanced services layer to provide similar name server, routing services, filtering, and performance analysis services for InfiniBand and IP fabrics. In the case where standard protocols already exist to provide these types of functions, Brocade will incorporate those standards under a common administration and operational framework within Fabric OS.

For more information about Brocade advanced fabric services such as ISL Trunking and Frame Filtering, refer to the Brocade white paper *Increasing Intelligence within the SAN Fabric* at **www.brocade.com/san.**

Open Fabric Management

The Fabric OS management framework is designed to support the widest range of solutions—from very small SANs, where rapid deployment and plug-and-play simplicity are required, up to multi-thousand node SANs composed of multiple fabrics where centralized management and automated administration are the only economical solutions. Brocade Fabric Watch™ threshold monitoring tracks the health of switches and the fabric, and sends reports to any SNMP-enabled application such as HP OpenView, CA Unicenter, and Tivoli. The supported set of SNMP MIBs includes Fibre Element, Fibre Alliance, and others.

At the center of Fabric OS open management is the Brocade Fabric Access™ Layer, an XML-based API that facilitates the integration of SAN management with broader third-party applications that are already a part of the IT infrastructure. Integrating SAN management with widely used applications reduces IT staff training and expense while reducing the requirement for administrators to learn a new SAN management console application.

Today, the Fabric Access layer accesses API server agents on each switch from a set of host libraries. Only a single connection to the fabric is required to access any switch or fabric-wide resource. Brocade intends to extend this API to offer multiple-fabric management capabilities and persistence of information such as configuration, event history, and performance statistics. A Fabric Service agent residing on a fabric-attached host server would provide this extension. The extension would be the foundation for

managing multiple independent fabrics, using multiple protocols managed under a common set of policies and procedures. The Fabric Access Layer also supports integration with Common Information Model (CIM) management tools.

Enterprise-Class Security

As fabrics grow larger, or are used by multiple independent customers or "tenants," it is increasingly difficult to depend on physical security to prevent unauthorized access to data. In particular, outsourced storage providers must be able to guarantee that one customer's data cannot be viewed or accessed by another customer supported on the same service provider SAN. In addition, more restrictive audit compliance and service level agreements make SAN security a higher priority.

Within the Intelligent Fabric Services Architecture, Brocade provides Secure Fabric OS™, the most comprehensive SAN security architecture available. Based on state-of-the-art networking security technology, Secure Fabric OS addresses vulnerabilities in the SAN fabric and supports authentication methods at the following access points:

- User access to the management interface
- Management console access to the fabric
- Server access to the fabric
- Switch access to an existing fabric

Each of these points carries a risk of unauthorized access attempts (see Figure 4). To prevent unauthorized configuration or management changes, Fabric OS employs policies with multilevel passwords, extensive use of Access Control Lists (ACLs), and centralization of fabric configuration changes on "trusted" switches. Fabric OS prevents WWN "spoofing"—the practice of assuming the WWN of another server to gain access to storage in its zone—at both the Host Bus Adapter (HBA) and server level by locking certain WWNs to certain ports. With Secure Fabric OS, new switches are assigned digital certificates, enabling an existing fabric to authenticate any switch that joins the fabric.

Secure Fabric OS builds upon the hardware-enforced Brocade Zoning™ capabilities in Fabric OS. While Secure Fabric OS prevents unauthorized access to the fabric from the outside, zoning ensures that devices can access only their authorized storage resources. As additional fabric protocols emerge in the data center, Brocade intends to extend the capabilities of Secure Fabric OS to cover these new solutions as well.

An Intelligent Architecture to Meet Key SAN Requirements

The multiprotocol SilkWorm 12000 and the Brocade Intelligent Fabric Services Architecture provide a solid foundation for meeting the most critical storage networking requirements facing organizations today:

- Flexible scalability
- Multiprotocol support
- Low cost of management
- High availability
- Advanced security
- Heterogeneous compatibility
- Investment protection

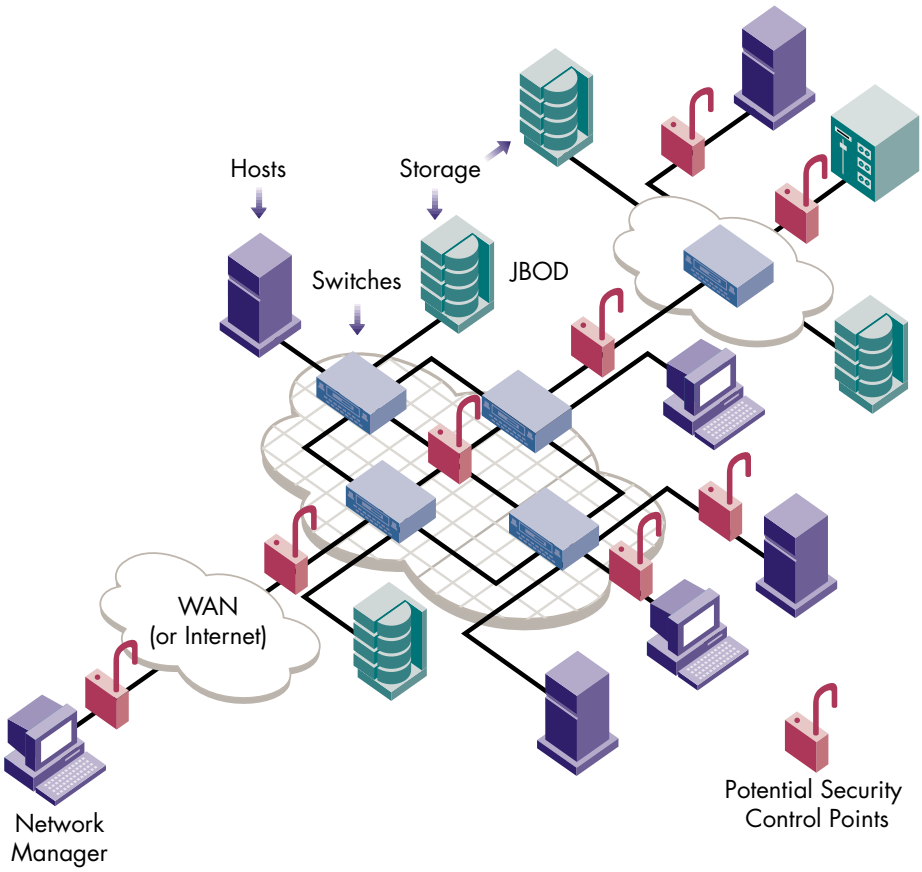

Figure 4.
Secure Fabric OS addresses points of vulnerability in the SAN fabric

Flexible Scalability

To scale efficiently, SANs must be capable of interconnecting large numbers of servers with large amounts of storage without disrupting application processing. The highest levels of scalability are possible only through networks of modular components that provide switching functions and services for attached servers and storage. Ranging from 8 ports to 128 ports of connectivity, SilkWorm switches enable networks to start small and grow in cost-effective increments. Support for 1 Gbit/sec, 2 Gbit/sec, and 10 Gbit/sec Fibre Channel enables the creation of a "core-to-edge" network in which edge switches attach to devices at whatever speed the devices require, and traffic from the edge switches is routed through higher speed core switches.

The core-to-edge network enables near-infinite scalability at very low incremental cost, and organizations can also use high-speed links to connect large storage arrays at the core for storage resource sharing. In addition to scaling a SAN within a data center, these connections can extend across an optical metropolitan network or long-distance WAN links over TCP/IP.

Multiprotocol Support

Today's organizations demand strategic SAN management services that accommodate a variety of storage protocols. A strategic software platform should provide a common set of services and management facilities that support protocols such as Fibre Channel, IP, and InfiniBand. Although the dominant storage networking protocol today is Fibre Channel, these other protocols might also be used to transfer block I/O storage traffic in some environments in the future.

Brocade switches, fabric services, and management tools are designed to integrate these and other protocols under a common architecture. Initial support for InfiniBand and IP storage protocols—including iSCSI and FCIP—will be provided by the SilkWorm 12000, which employs a protocol-independent backplane for maximum flexibility. Additional offerings based on the newer protocols will follow.

Low Cost of Management

The Brocade architecture greatly simplifies SAN management while enabling a modular, pay-as-you-grow approach. Because management costs for storage-intensive environments already exceed capital costs, organizations must be able to grow their businesses without increasing the costs associated with additional staffing resources. Brocade SilkWorm switches can automatically detect configuration information from other switches or from a central location—reducing or eliminating the need to manage individual switches. This centralized management and administration of a network of distributed switches allows organizations to manage more devices with less staff in less time.

The switches maintain extensive statistics and fabric health information, allowing both self-monitoring and the ability to automate many management tasks through higher level management applications. Configuration information and management functions can be accessed through the Fabric Access Layer API by external third-party SAN management applications.

High Availability

Many enterprise applications require continuous availability, where unplanned outages must be limited to seconds or minutes per year—and all maintenance can be accomplished without application outages. To address this need, the Brocade Intelligent Fabric Services Architecture supports levels of availability that scale with application requirements.

Individual switches provide redundant power and cooling—providing resiliency against failure with minimal investment. The SilkWorm12000 features a highly available chassis that exceeds all of the availability features associated with director-class switches, including no single point of failure, redundant and hot-swappable components, and non-disruptive software updates. However, true continuous availability requires a redundant network design that utilizes dual-independent fabrics with dual attachment for servers and storage. To address this need, Brocade SAN infrastructures are capable of delivering redundant fabrics with overall system availability greater than 99.999 percent—the "five nines" of availability.

Advanced Security

Advanced security features in Secure Fabric OS give administrators powerful tools for securing SAN access and supporting multiple customer environments such as those deployed by Storage Service Providers. In addition, software- and hardware-enforced zoning helps administrators secure data by preventing unauthorized access in a variety of ways.

Heterogeneous Compatibility

To optimize storage and server capital assets, organizations must be able to choose best-of-breed solutions from a wide variety of vendors. To ensure cost effectiveness, these solutions should be available for purchase from multiple sources. The Brocade Intelligent Fabric Services Architecture is built upon a platform of open industry-standard protocols, ensuring the broadest possible compatibility with equipment from other vendors. Brocade has verified compatible SilkWorm switch operation with equipment from more than 40 vendors (representing virtually 100 percent of the world's server and storage providers). Moreover, Brocade has invested more than $20 million in equipment and infrastructure to perform ongoing heterogeneous test certification.

Investment Protection

To maintain a competitive edge, organizations must protect their current server, storage, and network infrastructure investments by ensuring that these components can support continued expansion. Brocade technology helps ensure that products installed today will be able to interoperate with future platforms to enable a non-disruptive, cost-effective expansion of the fabric. This expansion includes the migration to faster link speeds, where organizations can combine 1 Gbit/sec and 2 Gbit/sec switches to build networks with high-speed links at the core and a range of link speeds at the edge. As 10 Gbit/sec Fibre Channel links—or storage networking capabilities based on 10 Gbit/sec Ethernet or InfiniBand—emerge, those capabilities can be integrated into the SilkWorm 12000 and the Brocade Intelligent Fabric Services Architecture.

A Flexible Architecture Designed for Continued SAN Growth

As rapid data growth continues to challenge organizations around the globe, they are increasingly implementing high-performance storage networks. These networks have proven their value by increasing application scalability and availability while reducing overall storage management costs. Current implementations have demonstrated measurable ROI through such benefits as improved resource utilization, reduced backup times, and cost-effective business growth.

As storage networks become a more integral part of the strategic IT infrastructure, organizations must carefully examine the past, present, and future of storage networking architectures. Because storage networks are strategic decisions, organizations must also select a network architecture that solves today's requirements while providing the flexibility to meet future needs. Having delivered the vast majority of the world's installed storage networks, Brocade provides exactly this type of flexible solution with its Intelligent Fabric Services Architecture. Moreover, Brocade plans to continue providing the innovation, performance, quality, and solutions that can transform a storage network into a vital competitive advantage well into the future.

For more information about the Brocade Intelligent Fabric Services Architecture and the SilkWorm 12000 Core Fabric Switch, visit the Brocade SAN Solution Center at **www.brocade.com/san.** The SAN Solution Center also includes customer case studies, white papers, and a variety of certified Brocade SOLUTIONware™ SAN configurations.

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