INTERFACE DECISIONS: SAS, FC, OR iSCSI?

POWERVAULT™ MD3000 AND MD3000i

Dell | Product Group

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SECTION 1
INTRODUCTION

Interface Options

A typical shared or networked storage environment consists of application servers, storage arrays, external hardware interfaces within the application servers, cabling, and in the case of a storage area network (SAN), a storage fabric between the servers and the arrays.

The external interface technologies, as components of these environments, are the foundation of the overall storage framework's performance, scalability, reliability, technical complexity, and cost. Several interface options have been developed to support environments such as these:

- Serial Attached SCSI (SAS)
- Fibre Channel (FC) protocol
- Internet Protocol SCSI (iSCSI)

With this range of interface options, each with its own distinct features and characteristics, it is important to examine the strengths, position, and special considerations of each one.

As with any technology, one size will never fit all. Each interface option is likely to be more complementary to one organization than another based on the needs of the business and its data storage requirements. This document provides the information required to effectively evaluate each of these technologies and to choose the optimal interface for your specific environment.

One inherent benefit of these interface technologies is the ability to share storage by way of a shared storage configuration or a network fabric. In order to better appreciate this advantage, it is important to understand direct-attached storage (DAS) and the challenges of unconsolidated storage.

Challenges of DAS

For many organizations, a large portion of their storage is directly attached to individual servers. This type of storage architecture typically accounts for approximately 60-80 percent of all servers in any given organization. A DAS device can be either internally housed within the server or externally attached. DAS, at first glance, is often the configuration of choice due to its low initial cost investment and simplicity.

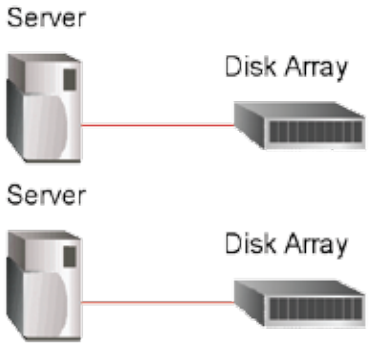

Figure 1: Single DAS Configuration

As organizations grow and additional servers are added, more storage is directly attached and isolated to each server. By building a storage framework in this manner, many businesses find themselves inefficiently managing isolated islands of storage across the organization. In addition, DAS typically results in lower storage utilization and complex data protection schemes.

Without the consolidation of data, the duplication of data management efforts at each DAS installment results in the wasteful use of the administrator's time, which could otherwise be dedicated to other IT projects. Wasted capacity and expense is another consequence, with over-utilization of capacity on some storage devices and under-utilization on others. In addition, the availability of data is vulnerable because each DAS is reliant on the server to which it is attached, creating data protection inconsistencies across the organization.

With these inherent challenges, sharing or networking of storage as an alternative to DAS can enable substantially higher scalability, availability, and manageability. SANs, in fact, have become the defacto standard as the solution to centralizing dispersed storage across an organization's infrastructure as global commerce and need for 24/7 information becomes more prevalent, and data must be available on demand.

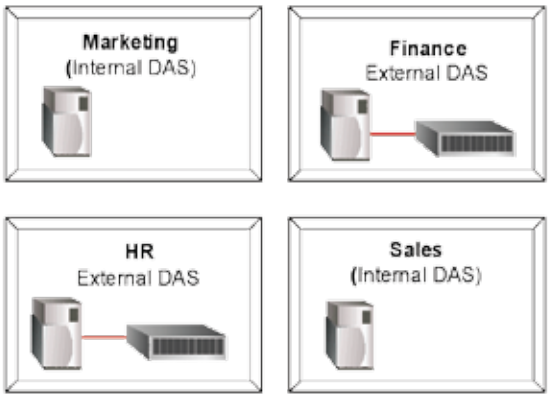

Figure 2: Unshared DAS Configurations across an Organization

Benefits of Networked or Shared Storage

Networked or shared storage solves many of the problems that organizations might experience with unconsolidated DAS, while offering other numerous benefits:

- CONSOLIDATION—With the traditional dedicated connection between server and storage eliminated, the consolidation of islands of DAS removes the restrictions to the amount of data that a server can access. Consolidating storage assets into a single centrally managed pool can deliver improved performance and availability while driving down the cost of storage hardware. This sharing of storage supports overall lower total cost of ownership (TCO), balanced utilization, and increased flexibility and control.
- INCREASED DATA AVAILABILITY AND PROTECTION—A highly available SAN ensures that storage is accessible and can be shared by multiple servers. With SANs, redundant data paths can be created between servers and the storage array, which help guarantee application uptime in the event of a connection failure. Clustering with a highly available SAN can also greatly enhance IT service levels. By allowing multiple servers to share access to data stored on a storage array, application availability is assured in the event that one of the servers is taken offline.

- BETTER USE OF IT RESOURCES—By managing data from a single location, the time it might have taken previously to manage dispersed DAS configurations is reduced. In addition, IT administrators spend less cycles recovering from downtime because the SAN can utilize redundant data paths and components to quickly recover if any part of the network becomes unavailable.
- DATA SHARING AND IMPROVED ASSET USAGE—With DAS, some capacity is typically over-utilized while other capacity is underutilized. This unbalanced workload creates inefficient use of available capacity as data cannot be shared across the servers. By consolidating storage, servers can leverage the same pool of data, allowing administrators to dictate how much capacity can be allocated and accessible to each server.

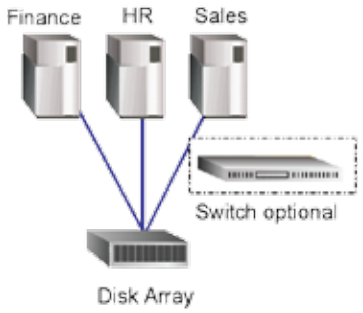

Figure 3: Shared Storage – All Servers Share the Same Storage System

- IMPROVED BACKUP AND RECOVERY—By combining network or shared storage with replication features, such as snapshot, data can be written to and read from disk to tape without using server cycles to significantly reduce the overall backup time. Administrators can instantaneously create a snapshot virtual disk of the data, and then mount the snapshot to a separate backup server which effectively eliminates the backup window and reduces any impact on the applications that are running.

SECTION 2
SAS INTERFACE

With a solid roadmap and industry acceptance behind it, SAS technology is the follow-on of parallel SCSI technology. SAS satisfies businesses interface requirements of scalability, performance, reliability, and manageability at an affordable price-point.

SAS provides a physical connection between a storage array and a number of servers. Because SAS has the capability to directly attach to more than a single server, it has made headway as a shared storage interface technology.

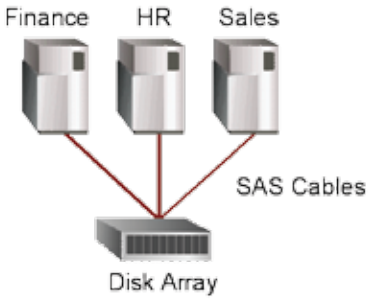

Figure 4: Shared Storage Configuration with SAS

Positioning

SAS interface technology offers the following value propositions:

- AFFORDABLE PRICE—When designing SAS technology, a key element was to keep its cost in-line with its SCSI predecessor. This cost objective was successfully achieved and SAS storage arrays are an affordable entry-level array for all types and sizes of organizations.
- SIMPLE STORAGE CONSOLIDATION—Although SAS cannot connect to as many server interfaces as a SAN configuration that uses FC or iSCSI, SAS does not require the additional complexity of switches for a shared storage solution. Thus, SAS provides comparable ease-of-use as a DAS configuration, while still offering shared storage for multiple servers.
- PERFORMANCE—SAS technology supports faster data throughput with link aggregation using x4-wide links. Each individual link operates at 3 GB/s (within the x4), which provides a maximum cumulative bandwidth of 1200 MB/s.

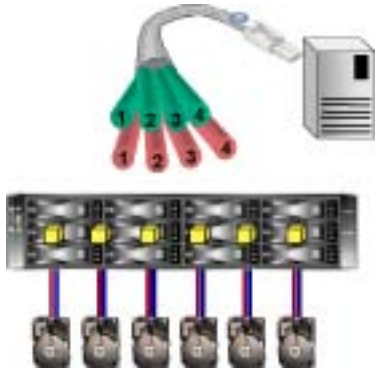

Figure 5: SAS x4 Wide Links and Full Duplex

Special Considerations

While the benefits of SAS technology far outweigh its limitations, it is important to be aware of its limits and understand if they could have any impact on its overall effectiveness of your environment.

- PERCEIVED COMPLEXITY—As a new technology introduced in recent years, the SAS interface might be perceived as complex. Regardless of its actual ease-of-use, this perception is typical with newly introduced technologies due to limited awareness and education.
- LIMITED REACH—Limited by practical cable lengths of about eight meters between discrete devices, an SAS environment cannot support configurations that go beyond a single local site. SAS technology can be an optimal solution when the array and servers are located in a single rack or room.
- NUMBER OF SERVER CONNECTIONS—Currently, the number of servers that can be attached to an SAS-based storage array is limited by the physical number of SAS host ports on the disk array, typically ranging from two to four SAS host ports per array.

Target Markets and Applications

Target Markets

The target market for the SAS interface option includes both small to medium business (SMB) and enterprise departments. These markets will benefit specifically when their storage requires either shared storage or one-room storage:

- SHARED STORAGE — Shared storage capabilities cost-effectively take an overburdened DAS infrastructure to the next level. SAS storage can remove wasted capacity, duplicated functions, inefficiencies, and data protection inconsistencies across an organization that is typically associated with DAS.
- ONE-ROOM STORAGE — One-room storage configurations consolidate several co-located servers. A one-room storage configuration offers outstanding performance and exceptional scalability on a local level and maintains simplicity because networking expertise is not necessary.

Applications

SAS technology is especially useful in the following environments:

- MICROSOFT® EXCHANGE — The growing adoption of Microsoft Exchange, and the benefit of sharing this application beyond a single DAS configuration for high availability, has made shared SAS storage implementations for Exchange highly desirable. The brief latency of SAS protocol also makes it well-suited for this transactional application.
- CLUSTERED TOPOLOGIES — SAS-based shared storage is ideal for two-node cluster solutions like MSCS and Oracle RAC.
- DISK-TO-DISK BACKUP AND VIDEO STREAMING – Because SAS technology offers solid throughput, SMBs can take advantage of SAS for high-bandwidth applications such as backup and streaming.

SECTION 3
FC INTERFACE

FC offers increased flexibility for array configurations with true network operation and increased scalability.

FC is currently the most commonly deployed SAN technology. While the benefits of SAN have been long apparent, it was only with the advent of FC that massive adoption of SANs (shared and networked storage) became feasible.

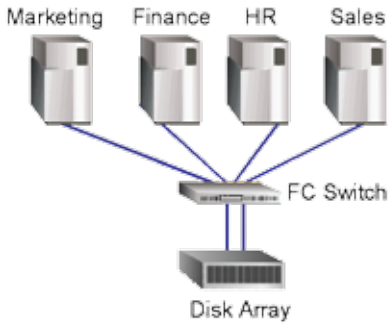

Figure 6: FC SAN Non-redundant Switch Configuration

Positioning

FC interface technology retains dominance in the enterprise and high-compute environments in these significant areas:

- SCALABILITY—FC is a highly addressable interface capable of supporting up to a maximum of 16 million addresses. From single point-to-point gigabit links to integrated organizations with hundreds of servers, FC delivers unmatched configuration scalability.
- PERFORMANCE—With current 4 GB/s throughput and a solid performance roadmap, FC supports the relentless growth of data and the ever-increasing need for quick access to it. FC is specifically designed for high performance operations with a congestion-free and credit-based flow control that is capable of delivering data as fast as the destination device is able to receive it.
- MATURE AND PROVEN TECHNOLOGY—With development going back to 1988, FC is a long-standing, highly-trusted interface technology. With its time-proven designs, FC has become a standard technology for the high performance enterprise data center.
- INVESTMENT PROTECTION WITH AUTO-NEGOTIATING LINK SPEEDS—Auto-negotiable FC link speeds allow for seamless integration into an existing 1 GB/s or 2 GB/s environment and allow organizations to immediately benefit from the performance improvements when the rest of the configuration is upgraded.
- CABLING DISTANCE—FC can reach up to 50,000 meters maximum cabling length between discrete devices.

Special Considerations

It is essential to consider some potential confines as to the overall effectiveness and investment of implementing an FC SAN:

- STEEP LEARNING CURVE—FC SANs can be a complex undertaking for businesses that lack the budget and dedicated IT expertise to design, deploy, and manage it.
- FINANCIAL INVESTMENT—The total cost of ownership (TCO) of an FC SAN initially can be quite high. This is not only based on the cost of FC equipment, but the expense of administration, maintenance, and staff training.
- LOW-COST SERVERS WILL TYPICALLY NOT BE INCLUDED—As the price for additional FC cabling and HBAs typically outweighs the price tag of low-cost and blade servers, it is often not cost-effective to deploy an FC SAN to these servers.

Target Markets and Applications

Target Markets

The target market for the FC interface option is primarily the **enterprise data center** based on:

- CURRENT MARKET DOMINANCE—FC SANs currently dominate enterprise storage markets and are expected to retain dominance with the continual investment in FC equipment. This investment is good for complex SANs with a large number of addresses and long cabling distances.
- HIGH PERFORMANCE—With 24/7 information on-demand environments, the enterprise has come to rely on FC to deliver high performance.
- MATURE AND TIME-PROVEN DESIGNS—FC delivers the most reliable and robust configurations, which this technology has succeeded in for well over a decade. This success has created a strong and loyal following of FC technology.

- HIGH ADDRESSABILITY—FC can support thousands of servers, which is typical of a growing enterprise environment.

Another market where FC technology is prevalent is at **college and university campuses**. This is primarily due to high bandwidth. With its high throughput and ability to achieve distances of up to 50,000 meters between devices, FC is ideally suited for campuses.

Applications

The FC interface option is highly versatile and can be used in a number of beneficial ways:

- MICROSOFT EXCHANGE—Exchange is an IOPS-driven application. As FC excels in IOPS, FC can meet the performance requirements for this transactional application.
- SQL—SQL can use FC arrays for databases, log files, and other SQL-related files in much the same way that SQL can use other storage technologies. High throughput with FC can be obtained by using multiple network adapters with MPIO. SQL also benefits from the inherent advantages of consolidating its data to a centralized location.
- HIGH CLUSTER COMPUTING—FC takes the full advantage of server clustering and can support up to 100 or more servers as needed.
- MISSION-CRITICAL AND TRANSACTION-BASED DATABASES—FC supports large, heterogeneous block data transfers reliably and will benefit from applications, such as online transaction processing (OLTP), by ensuring high availability and continuous access to data.
- VIRTUALIZATION—FC works well in VMware environments because VMware features rely on the shared storage benefits of a SAN so virtual server images, applications, and data can be consolidated.
- STREAMING VIDEO—Large-block I/O applications, such as world-class broadcasting, rich media storage networks, content creation, modeling, and publishing, will benefit from the additional bandwidth that 4 GB/s offers.
- DATA MINING—With FC, companies can accelerate and scale simulation, visualization, modeling, and rendering applications simply and easily to accelerate large dataset I/O rates, as well as cost-effectively scale and share information across the organization for high-level collaboration.
- DATABASE IN MEMORY—High throughput and IOPS are necessary to run very large datasets in memory. Loading or refreshing hard disk drives becomes a time-critical effort. FC speeds of 4 GB/s can be used effectively for this application because data can be loaded from the disk array to the server quickly.
- DATA WAREHOUSING—To be effective, data warehousing must achieve both high bandwidth and random performance. Offering the highest levels of performance in both throughput and IOPS, FC is ideally suited for this application, delivering the information that data warehouse users need when they need it.
- BACKUP AND RESTORE—With the ability to rapidly transfer data from disk array to server or restore data from online backup media, FC supports short backup windows and recovery time for high productivity.
- CAMPUS AREA REPLICATION—When replicating data across a high-speed SAN, data can be mirrored synchronously, ensuring that remote sites have the exact same data as the local site at all times.

SECTION 4

iSCSI INTERFACE

The iSCSI interface combines the proven advantages of SCSI as a storage communication protocol and TCP/IP networking capabilities. The iSCSI protocol allows SANs to be configured using TCP/IP connectivity using low-cost, readily available Ethernet switches, IP routers, and cables.

Over the last two years, such iSCSI-networked storage solutions (commonly called IP SANs) have rapidly entered the IT mainstream, offering a secure, reliable, and flexible network array solution. With the introduction of IP SANs, a wide range of organizations, from entry to the enterprise have the opportunity to maximize their existing IT investment while deploying effective and efficient networked data storage solutions.

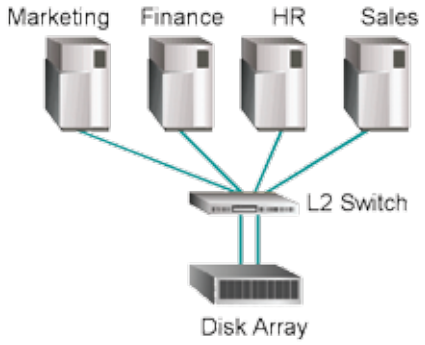

Figure 7: IP SAN Configuration

Positioning

IP SANs offer not only the inherent benefits that come with consolidating data, but additional iSCSI attributes can play well into an organization's overall data storage strategy:

- PERVASIVE AND WELL-UNDERSTOOD TECHNOLOGY — Companies, from SMBs to the largest enterprise, use IP technology. As a simple and familiar technology, IP SANs can be easily deployed and managed by administrators with LAN experience.
- LOW CAPITAL INVESTMENT — The equipment necessary for an IP SAN is equivalent in concept to that found in an FC SAN, but it is less expensive. This cost savings allows businesses to control their storage expenses without completely retro-fitting their existing network or investing in a completely new technology.
- REACH — As a routable transport with no distance limitations, IP SANs can to be located almost anywhere. The reach of other interfaces in an organization are most often limited by the distance restriction of the fabric. iSCSI removes these distance limitations and extends its scope well beyond the corporate data center.

  IMPORTANT: The majority of applications and operating systems do not work well with the latencies that occur as the distance between devices over an IP network increases. Therefore, you must determine an acceptable response time for the storage system before you consider implementing a configuration across long distances.
- IN-HOUSE IT RESOURCES — With in-house networking expertise common throughout most companies today, organizations can capitalize on their existing IT skill sets. Administrators will not find themselves having to learn a new networking protocol that could include extensive and sometimes expensive training.

Special Considerations

As an emerging technology in data storage, organizations considering an IP network should carefully evaluate all facets of the technology to ensure that a sound overall data storage investment is made. iSCSI does have its share of behaviors and functionality to consider:

- PERFORMANCE — At 1 GB/s, iSCSI might not meet bandwidth requirements for an application needing high throughput. Careful planning of your network, choosing the appropriate software, hardware, and adjusting network attributes can result in some improvements in performance:
  - INITIATORS AND ADAPTERS — A software iSCSI initiator works in combination with a network adapter. The most fundamental (and cost-effective) combination includes an iSCSI initiator and a standard network card. However, several other adapters are available to provide varying degrees of performance:
    - An advanced network card offers features such as Receive-side Scaling (RSS) and TCP/IP Segmentation Offload (TSO). RSS balances the network load across multiple CPUs and TSO breaks down data into smaller segments that pass through the network connection and reduces CPU overhead.
    - A TCP/IP Offload Engine (TOE) network card improves performance by offloading the TCP/IP processing workload.
    - A hardware iSCSI HBA provides both the software iSCSI initiator functions and hardware processes that the CPU would perform, and therefore, offers the highest performance in many instances.
  - JUMBO FRAMES — A large Ethernet frame, jumbo frames, can be increased in size from 1,500 bytes to 9,000 bytes.
- SECURITY — The implementation of an IP SAN within an existing network can lead to security vulnerabilities. By running mission-critical data over an IP network, which is also handling other traffic, the IP network can become very susceptible to security breaches and data loss.

  It is critical that this issue is addressed when implementing IP SANs. A best practice for an IP SAN is to separate data traffic from the normal LAN traffic through the use of virtual LAN technology or by deploying IP data traffic to a physically separate network. Greater security in a shared network is provided by implementing a VPN (Virtual Private Network) to move iSCSI traffic. A VPN maintains privacy through security procedures and tunneling protocols. The transferred data is secured by encrypting the data when it is sent and decrypting when it is received.

  In addition to maintaining an IP SAN separate from the rest of network, iSCSI inherently provides its own protection. This security is implemented by the Challenge Handshake Authentication Protocol (CHAP). CHAP verifies the identity of iSCSI servers in which the iSCSI server and the iSCSI array share a predefined secret. If the secret values match, the iSCSI server is authenticated and the transfer of data can occur.

Target Markets and Applications

Target Markets

iSCSI can be deployed across the full spectrum and sizes of organizations. Some specific organizations will experience immediate benefits:

- SMB — iSCSI removes the cost and complexity barrier of entry into a SAN environment based on the minimal investment per server to connect to an IP SAN. These organizations can justify the addition of all servers in an organization to an IP SAN, including environments dominated by mid-range and low-end servers.

- DEPARTMENTAL AND SATELLITE OFFICES—With iSCSI able to maintain long distances between devices, remote site's data storage needs can be handled through the corporate data center and thus have back-ups managed by IT-experienced in-house staff.
- ENTERPRISE AND CORPORATE DATA CENTERS—With the affordability of iSCSI equipment, an organization can now validate the cost of adding its low-cost and virtual servers to networked storage, removing the barriers of entry into networked storage.
- GOVERNMENT—When competing on price, low-cost iSCSI can effectively compete against other interface technologies. In addition to cost, IP SAN's flexibility makes it suitable for distributed environments and standards-based security environments.
- HEALTHCARE—IP SAN's performance is adequate for healthcare organizations to manage medical records and image retention. With iSCSI, the healthcare industry gains the benefits of distributed access at a modest cost.

Applications

Based on its cost, simplicity and networking capabilities, the iSCSI interface option can be used in a number of beneficial ways:

- MICROSOFT EXCHANGE—iSCSI works well with Exchange Server 2007 and its performance enhancements. Exchange Server 2007 takes more advantage of cache memory on the server might not require as much throughput to perform many functions, such as the back-and-forth communication between the server and iSCSI storage array.
- SQL—IP SANs are ideally suited for databases, log files and other SQL-related files in much the same way that they can use other interface technologies. SQL benefits from the inherent advantages of consolidating its data to a centralized location.
- LINUX® OPERATING SYSTEMS—As part of the cost-reduction strategy for many data centers, iSCSI complements the Linux operating system, which provides a similar strategy. An iSCSI storage array plus a Linux operating system are a natural combination for efficient, adequate storage infrastructures. In addition, iSCSI complements the common and value-oriented Oracle® solutions.
- VMWARE®—Virtual servers rely on the shared storage benefits of network storage in order for all virtual server images, applications and data to be centralized and accessible. This consolidation of servers drives the need for low-cost networked storage.
- CLUSTERING—Clustering supports the use of iSCSI-connected disk arrays. Clustering greatly enhances IT service levels by allowing multiple servers to share access to the data stored on a storage array. Application availability is then ensured in the event that one of the servers becomes unavailable. Additional benefits include planned maintenance without downtime and increased performance levels with the workload spread across servers.
- SECONDARY STORAGE—Affordable with adequate performance, iSCSI is the optimal choice for secondary storage for departmental and remote offices, disk-based storage for regulated, archived, or rapidly growing data.
- ORACLE—iSCSI provides connections to multiple servers when the Oracle grid version is specified for the application.

SECTION 5
RECAP AND FINAL RECOMMENDATIONS

Choosing the interface that is optimal for your environment is a matter of considering a variety of IT factors, such as performance, scalability, and distance. It is also important to consider various aspects of the business environment as well, including utilized applications, budget, staff skill sets, and staff availability.

Summary

This document has outlined the strengths and weaknesses and the relative positioning of these options to provide you the background and tools to effectively evaluate and choose the optimal interface for your environment. The key characteristics and positioning of the three interface options, SAS, FC, and iSCSI, were described.

SAS

SAS is well-suited for the entry-level user who is transitioning from DAS in hopes of transitioning unconsolidated and dispersed storage into a shared environment. The impact and adoption of SAS in networked/shared environments will likely take hold in the coming years.

- STRENGTHS — Cost, performance and simplicity
- WEAKNESSES — Distance, direct-attach support only, and unfamiliarity based on relative newness in the market
- OPTIMAL ENVIRONMENT — Direct-attach shared storage within a single-room environment and performance-sensitive applications

FC

The well-established FC interface currently dominates the enterprise SAN architecture, providing the performance, distance, and connectivity required for these demanding environments. FC will continue to be the leading interconnect for large SANs due to its robustness, performance, and scalability advantages.

- STRENGTHS — Performance, scalability, reliability, and availability
- WEAKNESSES — Cost and complexity
- OPTIMAL ENVIRONMENT — Large-scale data networks and performance-sensitive applications

iSCSI

This prevalent IP technology has been introduced into network storage within the past several years. iSCSI has recently received more awareness and acceptance in the market as an attractive option for organizations where cost and simple management is key.

- STRENGTHS — Cost, simplicity distance, and pervasiveness
- WEAKNESSES — Performance for high throughput applications
- OPTIMAL ENVIRONMENT — Low-cost storage networking environments where performance is not critical, but consolidation is

Final Recommendations

It is not only important to look at your current environment to determine the appropriate technology, but to also consider your company's future growth. Will you be adding remote office sites? Do you expect your performance requirements to grow in the upcoming years? What applications do you plan on introducing? These requirements are just a few of many future considerations to be taken when investing in your storage infrastructure.

While a variety of interface options is good, making a sound investment in the right interface for your organization is even better. By choosing the appropriate technology based on the information offered in this document and by understanding your environment's unique requirements, you can ensure that you can meet your organization's data needs today and in the future.

SECTION 5

INTERFACE QUICK REFERENCE

	iSCSI	SAS	FC
Description	Interconnect technology built on SCSI and TCP/IP	Serial protocol for data transfer incorporating SCSI command	Transporting SCSI command sets, in the case of disk arrays.
Architecture	IP-based standard — SCSI commands send in TCP/IP packets over Ethernet	Serial, point-to-point with discrete signal paths	Switched — multiple concurrent transactions
Distance between disk array to a node (server or switch)	Unlimited, however, latencies increase as distances increase	8 meters between devices	50,000 meters
Scalability	No limits to the number of devices	32 devices	256 devices 16 million devices with the use of switched fabric
Performance	1 GB/s	3 GB/s with x4 wide ports for theoretical bandwidth up to 12 GB/s	Up to 4 GB/s
Investment	Low – use an existing IP network	Medium	High
IT Expertise	Medium – Requires some storage and IP cross-training	Low	High
Best for	SMBs and enterprise departmental and remote offices • Business applications running on top of smaller Oracle or IBM DB2 databases • Messaging, web, and eCommerce	Infrastructures within close proximity to all devices • Transaction-sensitive databases • High-performance computing • Data streaming • Internet and eCommerce	Complex SANs: high number of addresses and read/write applications • Non-stop corporate backbone • OLTP • CAD/CAE network • Quick response network for imaging and data warehousing

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