

The Strategic and Financial Justification of Storage Area Networks

Executive Summary

The intent of this white paper is to assist senior managers in defining the IT vision of their companies, and to provide the necessary strategic and financial justification to make effective decisions regarding their storage networking initiatives.

In an effort to continue to improve business productivity and customer service, most organizations are deploying data intensive enterprise applications like customer relationship management (CRM), enterprise resource planning (ERP), and e-mail. This has resulted in an explosion of information and data that has become the lifeblood of these organizations, greatly elevating the importance of a sound storage strategy. Selecting a unified architecture that integrates the appropriate technologies to meet user requirements across a range of applications is central to ensuring storage support for mission critical applications. Matching technologies to user demands allows for an optimized storage architecture, providing the best use of capital and IT resources.

Storage Area Networks (SANs) have emerged as the best solution for advanced storage requirements. Often, SANs can alleviate many if not all of the pain points of IT managers, since they allow for more manageable, scalable and efficient deployment of mission critical data. Not only do SANs provide advanced functionality, but they also lower an organization's Total Cost of Ownership (TCO) and provide significant positive Return on Investment (ROI) vs. a Direct Attached Storage (DAS) environment.

Not all SAN technology is the same, however. In order to realize the positive benefits of SAN deployment, the choice of vendor and SAN implementation partner is just as critical as the SAN equipment itself. Centralized, efficient management, intelligent SAN services, a truly robust and flexible platform and global, 365 x 24 x 7 service and support are requisites for next-generation SAN technology. Any solution that closes off heterogeneous options, whether it is protocol, vendor, or equipment specific, will only be a transient solution with limited strategic and ROI justification. The optimal SAN solution will have a robust, high performance architecture that creates new opportunities and alternatives while protecting resource investments from unexpected turns in the economic environment and changes in market adoption of new technology.

I. An IT Manager's Dilemma

In April 2002, Cisco Systems conducted a series of focus groups across three major cities within the United States. The IT managers in these focus groups identified the following five major "pain points" when asked about their storage under management:



- Difficulty of managing large, disparate islands of storage from multiple physical and virtual locations
- Complexity of maintaining scheduled backups for multiple systems and difficulty in preparing for unscheduled system outages
- Inability to share storage resources and achieve efficient levels of subsystem utilization
- Shortage of qualified storage professionals to manage storage resources effectively
- Confusion over the justification of the plethora of storage technology alternatives, including appropriate deployment of Fibre Channel, Internet Small Computer Systems Interface (iSCSI), Fibre Channel over IP (FCIP), and Infiniband

To add to these technical dilemmas, IT managers are facing restricted budgets during this time of economic uncertainty and increasing costs of deploying and maintaining both DAS and SANs, despite decreasing prices for physical storage in terms of Average Street Price (ASP) per terabyte. The result is that IT projects are now faced with a greater degree of scrutiny than ever before.

However, regardless of the economic environment and the abundance of new technologies, organizations must continue to invest in IT projects that support specific business goals and that can produce quick ROIs. A well-planned, well-justified storage strategy will allow a business to emerge from adverse market conditions in a better position to take advantage of new opportunities. In effect, the choice of storage investment can actually result in a sustainable competitive advantage versus the competition. For example, a brokerage firm that loses the ability to commit transactions during trading hours will suffer significant losses relative to a competitor. A large consumer goods retailer that can't determine its inventory in real-time because of insufficient storage capacity will suffer higher costs than a competitor that has implemented sophisticated storage provisioning and management tools that can track inventory flows and store all relevant data in an easy-to-access database.

It is important, therefore, that the decision makers in the storage strategy include not only the technical IT managers, but also business and financial managers who want a greater strategic and financial justification in order to invest the organization's capital.

Cisco aims to help IT managers evaluate the costs and benefits of different storage solutions, and then to work with them on extending these benefits to all areas of their enterprise. Recognizing that no single transport technology is ideal in all environments, Cisco explores the application of various transport protocols to illustrate how they can work in a complementary fashion to create an optimized and efficient storage architecture.

II. Evolution and Benefits of Networked Storage

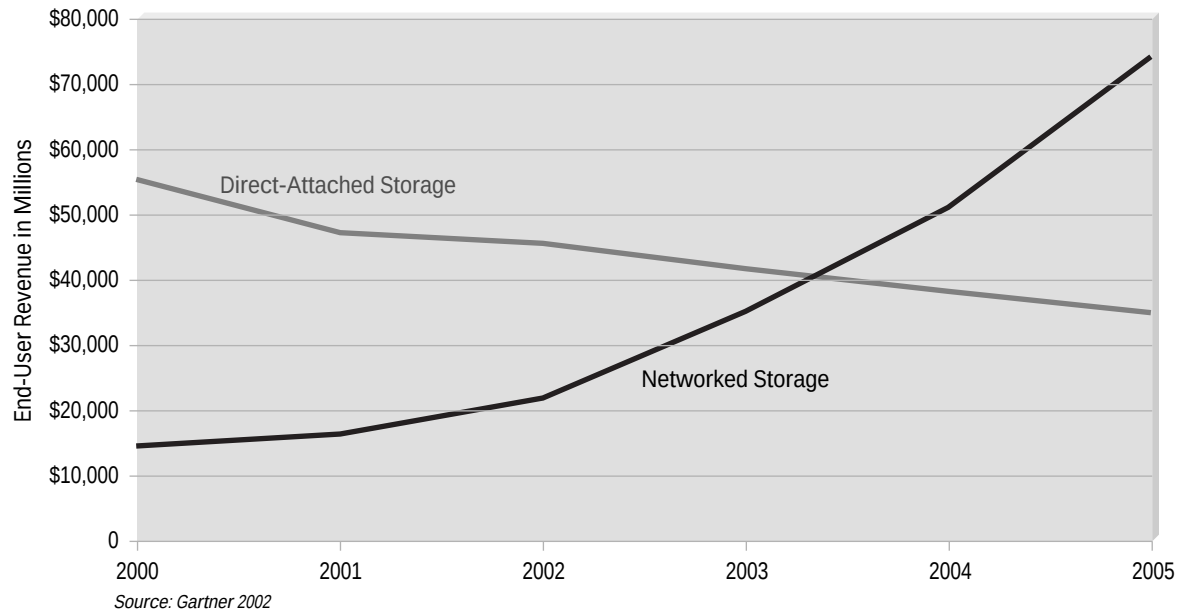
The evolution of SANs has progressed to the point where all organizations should seriously evaluate their role in the future of their storage environment. According to a recent report from Gartner Dataquest, the market for SAN-attached external storage in 2005 will exceed \$22 billion, representing almost three *million* terabytes of data.

¹ Figure 1, which includes all storage-related revenue (disk, software, services, networking equipment, etc.), illustrates the increasing transition from DAS to SAN environments and shows clearly that SANs should be considered by all IT managers as a possible storage strategy.

1. "2001 Disk Storage Systems Worldwide", Gartner 2002



Figure 1
Migration to Networked Storage



The main reason SANs have emerged as the leading advanced storage option is because they often can alleviate many if not all of the pain points of IT managers. They allow for more manageable, scalable, and efficient deployment of mission critical data.

A large number of enterprises have already tested or implemented production SANs and many industry analysts have researched the actual benefits of these implementations. A recent study of large enterprise data center managers by Gartner and WitSoundview show that 64% of those surveyed were either running or deploying SANs. Another study by the Aberdeen Group cites that nearly 60% of organizations that have a SAN installed have two or more separate SANs. The study also states that 80% of those surveyed felt that they had satisfactorily achieved their main goals for implementing a SAN.

Across the board, all vendor case studies and all industry analyst investigations have found the following benefits of SAN implementation when compared to a DAS environment: Ease of management, increased subsystem utilization, reduction in backup expense, and lower TCO. Table 1 lists some of the perceived major advantages of SANs and notes which of the current major SAN studies circulating today report evidence of such a result.



Table 1 Main Benefits of SAN Implementation

	McKinsey/ Merrill Lynch ¹	Aberdeen ²	Salomon Smith Barney ³	IDC ⁴	Forrester ⁵	HDS ⁶	Wit Soundview ⁷
Sharing of Resources	X		X	X			X
Centralized Backup	X	X	X	X	X	X	X
Storage Consolidation	X	X	X	X	X	X	X
Reduced TCO	X	X	X	X	X	X	X
Improved Scalability	X	X	X	X		X	
Improved Manageability	X	X	X	X	X	X	X
Better Disaster Recovery	X		X	X		X	
Improved Application Performance	X	X		X		X	
Improved Availability		X	X	X	X	X	

1. "The Storage Report—Customer Perspectives & Industry Evolution"; McKinsey & Co. and Merrill Lynch; June 2001

2. "The State of the Storage Area Network (SAN): 2001"; Aberdeen Group; January 2002

3. "The SAN Book 3.0"; Salomon Smith Barney; October 2001

4. "EMC Information Storage Infrastructure Reduces Cost, Drives Business Value: A summary of Case Studies"; IDC; October 2001

5. "Slaying the Storage Beast"; Forrester Research; March 2001

6. "Developing Return on Investment and Business Case Support for Storage Area Networks"; Hitachi Data Systems

7. "WitSoundview/Gartner Storage'01 Conference User Survey"; WitSoundview; July 2001

III. Business Impact of Current SANs

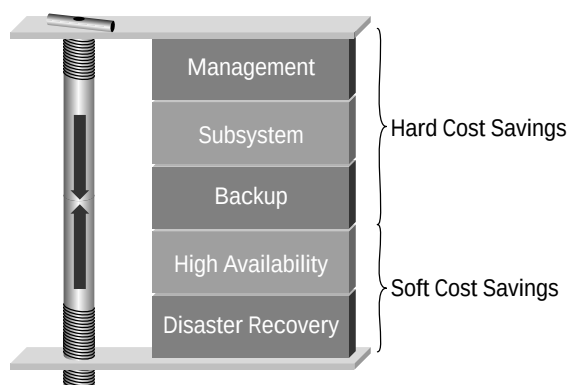
With the exception of lowering TCO, all of the benefits of SANs presented in Table 1 are technical in nature. For example, IT managers perceive the benefit of a centralized point of management since it makes the everyday work of storage administrators easier. But, to truly justify the SAN investment from *both* a technical and a business perspective, it is necessary to attach a concrete dollar savings to the benefit or to define a concrete source of competitive advantage. While the hard cost savings are usually enough to justify migrating to a SAN, the less easily quantifiable "soft benefits" may provide the most compelling argument.

A good IT investment (and, therefore, a good networked storage architecture) should lead to a lower TCO and a higher ROI. In this paper, TCO refers to the full cost of a project including upfront capital costs and recurring costs over the period of the project (2 years, 3 years, etc.), and ROI is the average expected cash flow over the period of the project divided by the initial investment outlay.



There are three major quantifiable savings associated with SANs that lower TCO and result in a large positive ROI versus DAS environment: reduced management costs, reduced subsystem costs, and reduced backup costs. There are also two more strategic benefits of SANs that, though difficult to quantify, may be even more important justification for SAN implementation: high availability and disaster recovery.

Figure 2
Hard and Soft Benefits of Current SANs



Management Costs

A recent study by McKinsey and Merrill Lynch shows that the TCO of SAN solutions typically are less than half those of DAS solutions primarily because of huge savings in management costs. The study found that SANs were able to lower the budget for storage administrators from 47% of total cost to less than 10%.

The main reason for the cost savings is that SANs are *easier to manage* than DAS because of the existence of a simplified, central point of control for monitoring, backup, replication and provisioning. This results in an increased amount of TB of data that a single storage administrator can manage by himself/herself. This frees up time for administrators to devote to more value-added activities. This time savings results in slower staff growth and ultimately decreases the required rate of hiring.

Table 2 lists the average increase in TB/administrator in a SAN environment reported in several major studies.

Subsystem Costs

SANs allow any-to-any access and connectivity between storage and servers. Therefore, servers can be better matched with underutilized subsystems and overall *capacity utilization can increase*. This leads to savings on future subsystem purchases as less disk needs to be added each year. For example, in DAS environments, it is usually possible to achieve 50% capacity utilization of usable data storage space. So, if an organization has 20 TB of data to store, it will actually have to purchase 40 TB of disk. Current SANs can increase utilization to about 70% to 85%. The same organization would only need 24-29 TB of disk in this scenario. The difference in storage utilization can add up quickly in a fast-growing organization.

Table 2 lists the average capacity utilization in a SAN environment reported in several major studies.



Backup Costs

Backup and recovery applications can be much easier to run in a SAN environment. *Centralizing and consolidating backup* functions can cut the number of tape drives that need to be bought in the future (similar to the way subsystem purchases can be reduced) and can decrease the time it takes to perform backup.

Table 2 lists the average decrease in required tape drives in a SAN environment reported in several major studies.

Table 2 Average SAN Cost Savings

	McKinsey/ Merrill Lynch	Salomon Smith Barney	HDS	Forrester	IDC	Average
Achievable Subsystem Capacity Utilization (vs. 50% in DAS)	85%	85-90%	90%	70-90%	85-90%	86%
TB/ FTE¹ (vs. DAS)	2-13x	5-10x	5-19x	NA	9x	9x
Tape Drive reduction (vs. DAS)	50% fewer drives	NA	NA	75% fewer drives	NA	62.5%

1. "Full Time Equivalent"

High Availability

SANs allow for easier implementation of High Availability (HA) or greater than 99.999% uptime. This is absolutely crucial to ensure business continuance in the event of planned or unplanned system outage. Redundant, multiple paths from servers to storage allow for automated failover across all storage in an easily scalable manner. Servers can connect to remote storage even over vast geographical distances, bypassing traditional SCSI cable limitations.

The HA features of Fibre Channel DAS implementations with enterprise-class storage can be improved by networking, achieving more robust HA features in a highly scalable architecture. The HA network is not just limited to a campus environment, but can be easily extended to WAN implementations that would be difficult or even impossible to achieve with Fibre Channel DAS.

High Availability is important since every minute of system downtime costs a business money. For enterprises that rely on e-commerce for any part of their revenue, the opportunity cost of an enterprise system interruption due to storage failure is directly linked to lost revenue. This number can range in the millions of dollars depending on the type of enterprise or application. Table 3 lists some averages by industry and by company of the cost of system failures.



Table 3 The Cost of Downtime

Cost per hour	
Financial brokerage	\$6.5 M
Credit card authorization	\$2.6 M
Home shopping	\$0.1 M
Catalog sales	\$0.09 M
Airline reservations	\$0.09 M
Tele-ticket	\$0.07 M

Source: Fibre Channel Industry Association²

Even for non-e-commerce transactions, the ability to access relevant customer information, like reservation schedules for an airline, is a 24 x 7 x 365 requirement. Customer satisfaction and brand image can be damaged if information is unavailable and transactions have to be delayed. Employee productivity can decrease significantly, resulting in not only wasted time as systems are unusable but also in the extra time and resources required to get the system up and running again. IT is no longer a support function. It is a critical business function and must be a core competitive competency.

Disaster Recovery and Business Continuity

SANs allow for greater flexibility in and more robust disaster recovery (DR) planning. By bypassing the geographical limitations of direct-attached environments, SANs enable remote replication of not just one storage subsystem, but, potentially, entire data centers. High availability with SANs does not just mean the system is always up, but also means that required bandwidth is available on-demand.

The most recent annual IT spending survey from Network World reported that 36% of respondents plan to increase spending for disaster recovery planning in 2002. Many firms plan to maintain separate completely redundant networks. For example, a large number of Wall Street investment firms have one datacenter in their Manhattan headquarters and a back-up datacenter in a remote location such as Brooklyn or New Jersey. The fail-over time between primary and backup networks can be done in just a few hours, even in the event of a complete loss of the primary network. Such a quick recovery to a fully available network would be impossible without networked storage capabilities.

IV. Increasing ROI with Advanced Intelligence

Clearly, there seems to be ample justification for those with DAS environments to migrate towards SAN implementation. However, most analyst figures show that less than 30% of all storage has migrated to SANs to date. Many of the studies mentioned in this paper surveyed large enterprise data center managers, i.e. those with the biggest and most mission-critical storage requirements and the biggest storage budgets, and, therefore, those

2. "Business Continuity When Disaster Strikes"; Fibre Channel Industry Association; <http://www.fibrechannel.com/technology/index.master.html>



most likely to try cutting edge storage technologies. Even with these “early adopters,” WitSoundview reported that 49% responded that they had greater than expected difficulty in getting their SAN components to work together (i.e. interoperability) and 49% stated that the SAN implementation took longer than expected. Still, even with these obstacles, not a single manager surveyed regretted the decision to implement a SAN.

The main take-away from these studies seems to be that current SAN technology has produced vast benefits for organizations that have deployed them, and is the best existing storage option for organizations with advanced storage requirements. However, there still is much room for improvement. Indeed, not all SANs are the same and the choice of vendor and SAN implementation partner remains just as critical as the SAN equipment itself. Centralized, efficient management, intelligent SAN services, a truly robust and flexible platform and global, 24 x 7 x 365 service and support are requisites for next-generation SAN technology. Any solution that closes off heterogeneous options, whether they be protocol, vendor, or equipment specific, will only be a transient solution with limited strategic and ROI justification. The optimal SAN solution will have a robust, high performance architecture that creates new opportunities and alternatives while protecting resource investments from unexpected turns in the adoption of new technology.

Currently, much of the SAN ROI potential is not being achieved, especially as one starts to scale. There are four major reasons why customers are not achieving full ROI benefits from large SAN deployments today:

- *Limited scalability:* Most switches and Directors have low throughput architectures and relatively low port density. For example, 128 port fabrics are typically achieved with several chassis meshed together. Up to 20% of switch ports end up being “wasted” on Inter-Switch Links (ISLs) and meshing together enough switches for even a 200-port SAN ends up becoming a connectivity nightmare. Also, there is no way to isolate processes or traffic to stabilize and manage a truly large SAN.
- *Lack of truly useful management tools:* The gains in administrator efficiency discussed in this paper apply mainly to small-scale SAN deployments. As TB managed increases, deploying and monitoring SANs can become overwhelmingly complex. The sophisticated management tools used in large data networks simply do not exist in the storage world. Therefore, building and managing a large SAN is quite difficult and providing seamless SAN to MAN or WAN integration is almost impossible.
- *Monolithic Transport:* Almost all SANs today run over one transport: Fibre Channel. This limits the amount of storage that can be consolidated since the cost of connectivity precludes the consolidation of many mid-range hosts.
- *Limited Interoperability:* All SAN switch products today provide low, if any, functionality across heterogeneous devices. This lack of flexibility locks customers into one vendor, increasing costs and limiting functionality.

The new Cisco MDS 9000 Family of Multilayer Directors and Fabric Switches is designed to address the limitations of current SAN technology and to enable customers to respond easily to future technology shifts. The Cisco MDS 9000 can help customers build small or large SANs that meet their technical requirements and that make sense to the bottom line.

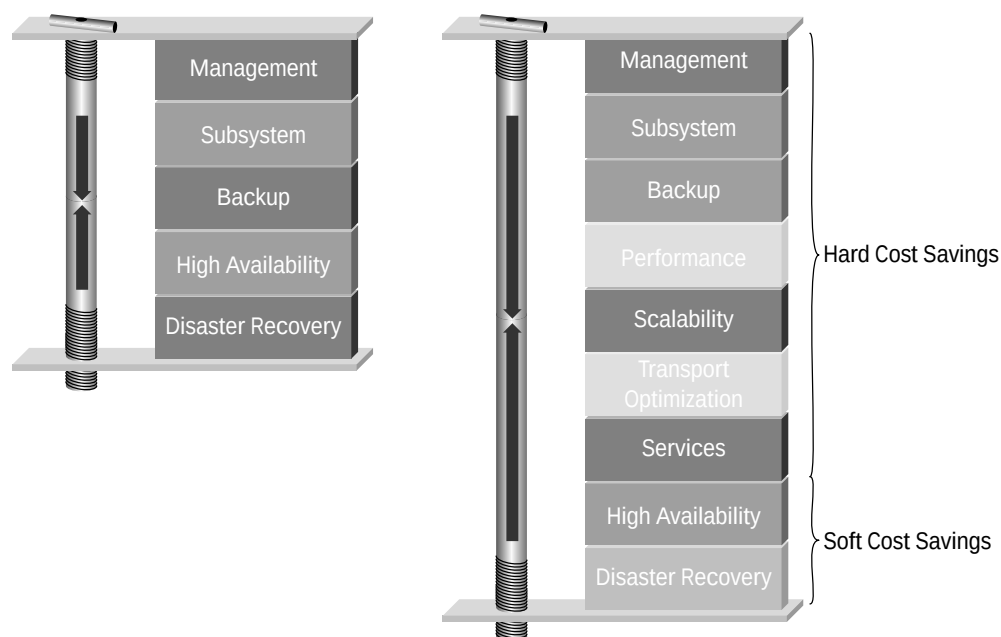
Consisting of the Cisco MDS 9500 Series of multilayer Directors and the Cisco MDS 9216 multilayer Fabric Switch, the Cisco MDS 9000 Family provides a full line of products to meet requirements across storage networks of all sizes and architectures.

For more information on the Cisco MDS 9000 Family, please refer to: www.cisco.com



Figure 3 illustrates that not only does the Cisco MDS 9000 Family give you all the benefits of current SANs, but also, the solution can lower TCO and improve ROI beyond the levels achieved with current SAN technology:

Figure 3
Incremental Value of the Cisco MDS 9000 Family



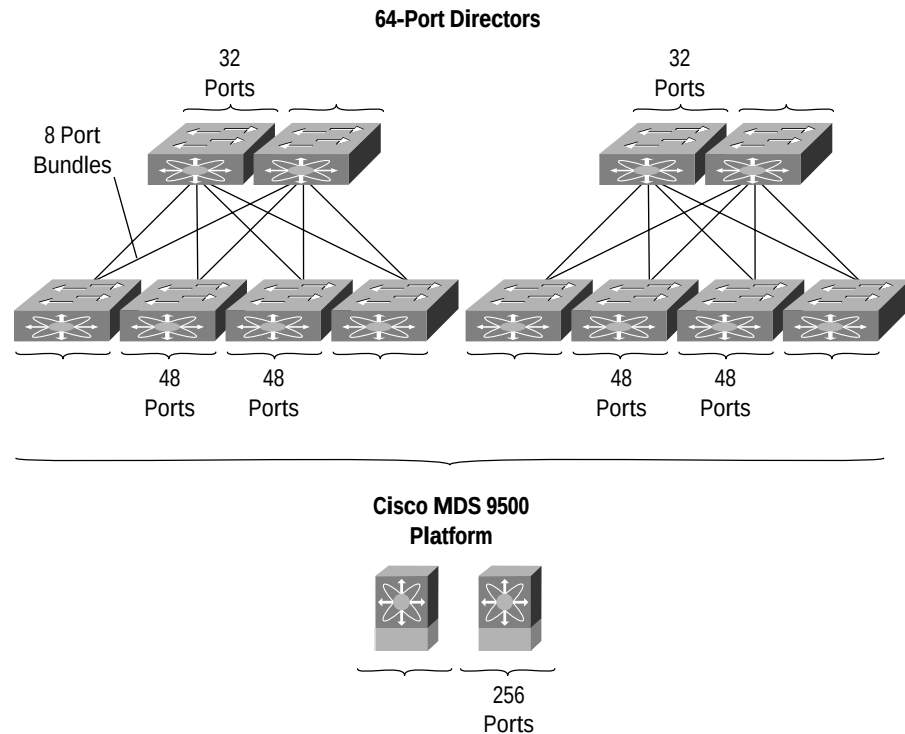
Scalability

With its modular architecture, high port density potential, and innovative management features for large SANs, the Cisco MDS 9000 Family offers the most easily scalable platform on the market. Available in 2-slot, 6-slot, 9-slot and 13-slot chassis configurations, the Cisco MDS 9000 Family can scale up to 768 Fibre Channel ports per rack. Moreover, there is full flexibility to “fine-tune” port counts so that the maximum number of ports can be used in the smallest amount of real estate.

This flexible and high port density is critical when deploying a large SAN. Fewer switches are ultimately needed, resulting in two major cost savings: fewer ISLs are required (at \$2700 per port, this can really add up) and management is infinitely simpler. Figure 4 illustrates the difference high port density switches make in building large SANs. Twelve standard 64-port Directors must be deployed to enable the same port count as two Cisco MDS 9500 platforms.



Figure 4
Building a Dual-Redundant 256-Port SAN Fabric with the Cisco MDS 9000



The Cisco MDS 9000 modules also can be used in any Cisco MDS 9000 chassis so that as customer needs change, only chassis need to be upgraded or purchased. Alternately, as new services modules come out, only those modules need to be purchased and the chassis and supervisor investment remains protected.

Simplified, Automated Management

The Cisco MDS 9000 Family is the first storage-networking platform to provide management access to all switch functionality through all management interfaces. The suite of policy-based management tools of the Cisco MDS 9000 coupled with seamless integration with Cisco and leading 3rd party network management platforms makes the Cisco MDS 9000 the most manageable SAN platform in the industry.

In addition, Cisco builds on its expertise in the management of large data networks by bringing a new set of Intelligent Network Services to SANs. Specifically, Cisco's solution introduces new features in the areas of Large SAN Management, Advanced Security, and Analysis/Debug. These features are enabled by Cisco advanced application-specific integrated circuit (ASIC) technology embedded on every Cisco MDS 9000 module. Some of the most salient features are as follows:

Virtual SANs

Cisco enables more efficient and secure management of large SANs by the introduction of Virtual SANs (VSANs). VSANs are a mechanism for achieving higher security and greater scalability in Fibre Channel fabrics. VSANs provide isolation among devices that are physically connected to the same fabric, in effect creating multiple logical SANs over a common physical infrastructure.



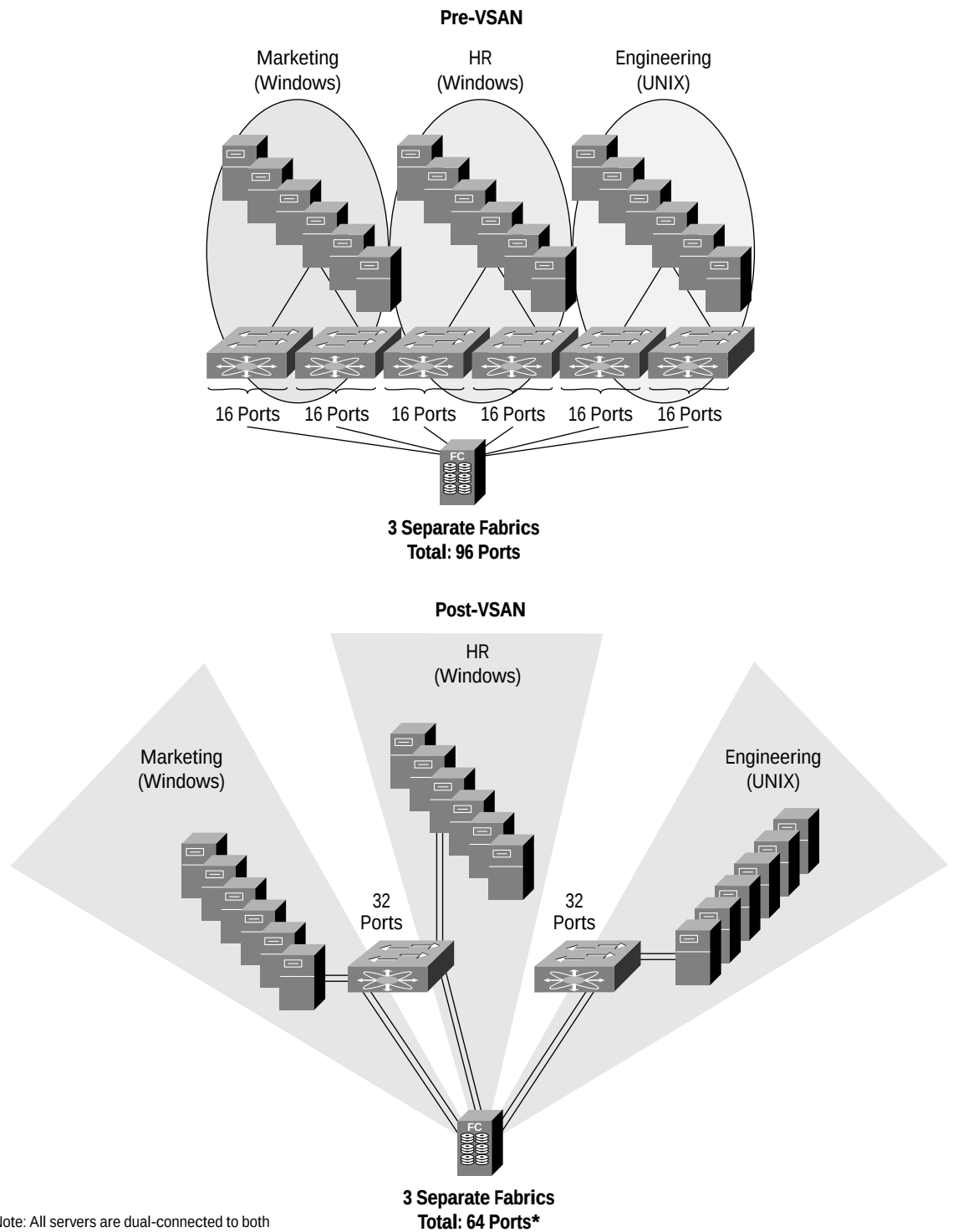
Compared to physically separated SANs, VSANs offer much greater flexibility. Moving a device from one VSAN to another requires only configuration at the port level, rather than a physical move. Compared to zoning, VSANs provide a more complete mechanism for traffic isolation by enforcing control of frames at every step along the way, rather than only at the edge of the fabric.

This partitioning of fabric services greatly reduces network instability by containing fabric reconfigurations and error conditions within an individual VSAN. Should a fabric function such as Fabric Shortest Path First (FSPF) have a failure, the failure is contained to the VSAN and has no effect on the rest of the switch. VSANs also provide the same isolation between individual VSANs as would exist between physically separated SANs. Traffic cannot cross VSAN boundaries and devices may not reside in more than one VSAN. This attribute of VSANs is of great value in service provider environments where absolute separation must be maintained between customers. Since VSANs each run separate instances of fabric services, each VSAN has its own Zone Server, Name Server, and FSPF and can be zoned in exactly the same way SANs without VSAN capability are zoned.

VSANs save customers money by enabling them to consolidate physically separate switch infrastructures that may not have optimal port utilization into one physical infrastructure that can be managed as a single logical entity. Not only is this one infrastructure easier to manage, but in general it will have fewer ports. Figure 5 illustrates how VSANs can consolidate network infrastructure. On the left, we see that currently, three different fabrics must be housed on three different sets of switches, resulting in unused ports on each switch (because of inflexible switch port counts) and more subsystem ports than would be necessary with fewer switches. On the right we see three different fabrics on the same set of switches, enabled by VSANs. Using the optimal switch port-count for all the hosts results in 32 fewer ports being purchased.



Figure 5
Consolidating Network Infrastructure with VSANs





Advanced Security

The following features automatically provide full network security at all times, freeing up monitoring time for SAN administrators and guaranteeing 24x7 availability:

- *Roles-based Access*: provides secure SAN management with 64 customizable roles that apply to command-line interface (CLI), Simple Network Management Protocol (SNMP), and Cisco Fabric Manager access
- *Secure management protocols*: support Secure Shell Protocol (SSH), secure File Transfer Protocol (SFTP), and SNMPv3 and support secure switch control protocols leveraging IP Security Encapsulating Security Protocol (ESP) to yield Fibre Channel ESP (FC-ESP)
- *Full Remote Access Dial-In User Service (RADIUS) support*: enables switch and iSCSI host authentication

Analysis and Debug

The following features enable SAN administrators to monitor SANs more easily and to automatically identify and address failures in the network:

- *FC Traceroute*: enables administrators to verify the path, and per hop latency to a specified destination
- *SPAN (Switched Port ANalyzer)*: allows traffic from a source port to be mirrored to a SPAN destination port for analysis; SPAN enables service organizations to analyze switch traffic without disrupting service on the port being analyzed
- *Cisco Fabric Analyzer*: enables service organizations to perform sophisticated protocol analysis without the need for an expensive hardware protocol analyzer; Administrators can quickly diagnose protocol-level problems remotely and send trace remotely to a receiving workstation over IP
- *Call Home*: provides proactive notification of switch issues to a designated service contact; All switches are constantly monitored by the Call Home feature, which detects failures and sends alerts along with relevant failure information; Contacts may be the Cisco Technical Assistance Center, a third party service organization of the customer's choice or even an internal IT contact

All of these features free up valuable time for SAN administrators, increasing the TB of storage they can handle from three to five times. That is, if an administrator could maintain 10 TB of storage on a daily basis with current SAN technology, he or she could manage 30 to 50 TB on a daily basis with the Cisco MDS 9000 platform. This translates directly into management cost savings as it takes fewer people to maintain the network. The shortage of qualified Fibre Channel SAN experts that most IT organizations have to deal with disappears, and the incremental time savings results in slower staff growth and ultimately decreases the required rate of hiring.

Network-Hosted Storage Applications

The Cisco MDS 9000 Family offers a robust platform to host network-based advanced storage applications. For example, Cisco has enabled the Cisco MDS 9000 platform with best-in-breed network-based volume management solutions from storage industry leaders—ensuring compatibility with a customer's existing storage strategy. Network-based volume management applications are highly integrated and specifically tuned for the Cisco MDS 9000 architecture to deliver optimal performance.

Cisco's storage network-based volume management consolidates all available storage across connectivity, disk array enclosure and operating system boundaries, and masks the physical limits of the underlying storage while leveraging specified performance and availability characteristics of the underlying storage. With network-based volume management, storage administrators can provision the class of storage that meets the needs of the enterprise



applications. Network-based volume management enables a single virtual logical unit number (VLUN) to be made up of complex Redundant Array of Independent Disks (RAID) layouts and even span across heterogeneous storage. Services such as remote replication and snapshot copies provide the highest level of business continuity and disaster recovery.

Cisco's network-based volume management provides uniform consolidated management of heterogeneous storage from a central console using either a simple graphical user interface (GUI) or a robust CLI. Policy-based storage services allow a storage administrator to automate the provisioning of storage based on the business application, location, department, or other business characteristic. A storage administrator has the ability to assign individual system administrators privileges to manage specific domains, allowing multiple system administrators to perform daily storage management tasks only for his or her assigned domain. This allows the system administrators unrestricted control for day-to-day storage manipulation, while giving the storage administrator the tools for planning and capacity management.

Cisco's network-based network based volume management enables administrators to more efficiently manage and allocate heterogeneous storage resources. In addition, it can improve storage utilization levels since underutilized physical disk can now be allocated to any server in the network quickly and easily.

High performance

The Cisco MDS 9500 Series is the highest performance Fibre Channel switching platform on the market. It has a total available switching bandwidth of 1.44 Tbps and a routing capacity of 1000 Mpps. On a per-rack basis, the Cisco MDS 9000 provides up to 8.4 Tbps of switching bandwidth versus the next nearest competitor's 3.6 Tbps—a better than 2x performance advantage!

In terms of ROI, higher throughput and performance protects a customer's SAN investment as technology changes and bandwidth needs increase. For example, the Cisco MDS 9500 Series products will be easy to upgrade when Fibre Channel goes to 10 Gbps, since the Cisco MDS 9000 crossbar can already support this requirement. Most competitors' products will need forklift upgrades with each major bandwidth increase, resulting in more capital equipment costs, and, more importantly, major system disruption.

In addition, in today's storage networks very few 1 Gb Fibre Channel links are fully utilized. Commonly, links connected to an application server are only at 20%-30% utilization. This is a highly inefficient use of expensive Fibre Channel switch ports. Storage subsystems, on the other hand, require more bandwidth. Typically four to eight applications servers will be connected to a single storage interface. This ratio of connectivity could push a 1Gb link to 80%-90% utilization.

The Cisco MDS 9000 platform makes available two line card modules with different price/performance tradeoffs to optimize bandwidth utilization. The DS-X9016 module has 16 ports, where each port has a dedicated 2Gbps bandwidth to the crossbar. This allows for fully non-blocking performance. This card is specifically designed for high bandwidth links such as storage subsystem interfaces, high bandwidth application server interfaces, and ISLs. The DS-X9032 has 32 ports, which are divided in 4-port 'Port Groups'. Each port group shares 2Gbps of bandwidth to the crossbar. This bandwidth optimization creates a cost-effective way to connect lower bandwidth devices such as typical application servers or tape drives.



High Availability

The Cisco MDS 9000 is the most robust high availability platform in the industry. Through many innovative hardware and software features, Cisco ensures that maximum bandwidth availability is always possible.

There is no single point of failure in the Cisco MDS 9000 platform and all of the following components are hot-swappable:

- Modular Line Cards
- Dual Power Supplies
- Dual Supervisors
- Dual Cross-Bars
- Dual Out-of-Band (OOB) Management Channels
- Dual System Clocks
- Fan Tray with 9 Independent Fans

In terms of software, numerous features allow quick and seamless recovery from any type of failure:

- *Stateful failover between Supervisor modules*: allows the standby Supervisor Engine, which is constantly monitoring the state information, to take over seamlessly when the active Supervisor fails
- *Restartable software processes*: allows the Supervisor Module, which is continually monitoring all software processes, to restart a failed process without disrupting the flow of traffic in the switch.
- *Non-disruptive software upgrades*: allows customer to load and activate new software on the switch without disrupting the traffic across the SAN
- *Virtual Router Redundancy Protocol (VRRP) on Ethernet interfaces*: protects against the failure of the principal switch used for inband management
- *PortChannel*: allows up to 16 independent physical links to be combined to create one logical ISL. The physical links can be located on any port on any linecard in the switch, so not only is protection provided for link failures, such as cable breaks and failed small form-factor pluggables (SFPs), but also from ASIC or linecard failures

The Cisco MDS 9000 Family, delivers the industry's most comprehensive suite of high availability features for non-stop access to mission critical data.

Protocol and Transport Optimization

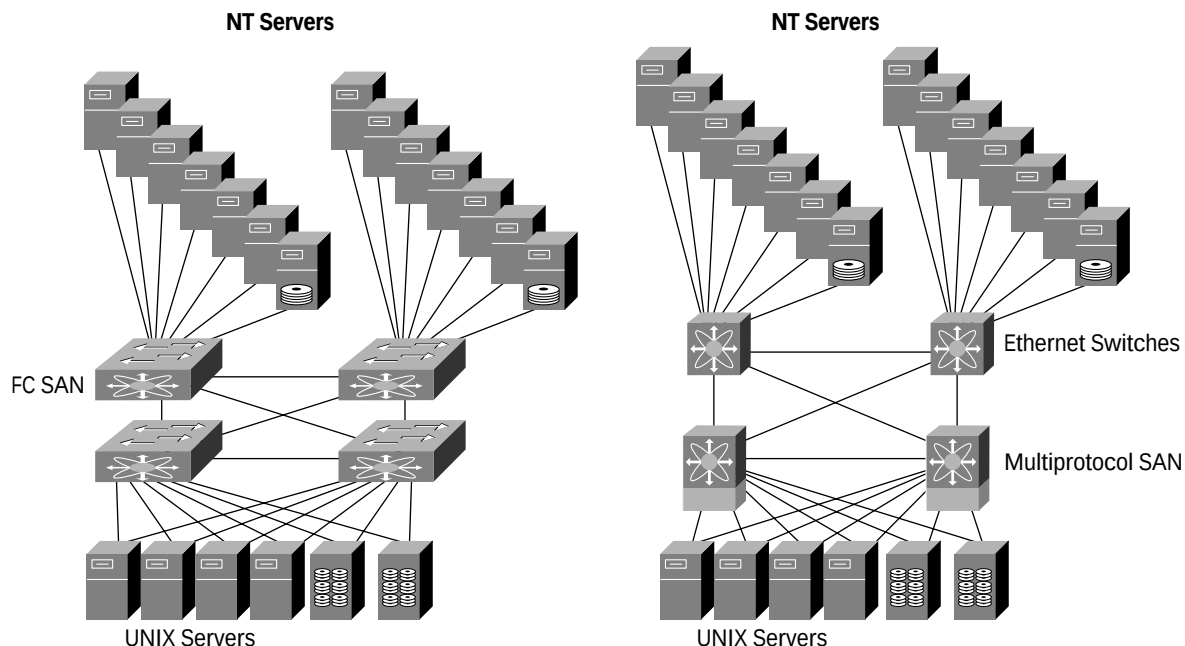
The Cisco MDS 9000 has the ability to support multiple network transports. The two network transports currently supported are Fibre Channel and Ethernet. The Cisco MDS 9000 also has the ability to support multiple storage and storage networking protocols such as SCSI, Fibre Channel, Internet Protocol over Fibre Channel (IPFC), FCIP, and iSCSI.

There are two major benefits to having multiple transports on one flexible platform. First, regardless of which way a customer's needs shift—whether it be for Fibre Channel, IP—the Cisco MDS 9000 protects a customer's major infrastructure investment. The chassis, supervisors, power supplies, etc. will remain the same and the only modification required would be to upgrade line card modules. This enables Cisco to respond to technology trends or changes in a customer's environment in less time than any other vendor in the market, saving the customer both time and money.



The second major benefit is protocol/transport optimization. For instance, from one platform, a customer can connect high-end, mission critical servers to storage via Fibre Channel and can connect mid-range NT servers to storage via cost-effective iSCSI. Since many of these servers do not require the advanced performance and functionality of Fibre Channel, they can be connected via iSCSI much more economically. iSCSI can extend the benefits of SANs to servers for less than half the cost of Fibre Channel. Figure 6 shows how using Fast Ethernet switches to fan out from the IP services module of the Cisco MDS 9000 can connect hosts into a Fibre Channel SAN. However, the two physically separate environments (IP and FC) can still be managed as one common management infrastructure.

Figure 6
Fibre Channel vs. iSCSI connectivity for NT servers



Service and Support

With the Cisco MDS 9000 platform, Cisco offers support services across the entire life cycle of a customer's SAN, from initial design, through extended hour implementation support, development of "best practice" operating standards, and planning for future network growth to accommodate the growth in storage demand. Cisco offers a full suite of consulting services to help customers make the most of their network and optimize their investment. In addition to the "best in class" break/fix support available within the Cisco SMARTnet™ offerings, Cisco Advanced Services for SAN offers the SAN client access to the Cisco experts that are helping build some of the world's largest and most "mission critical" SAN capabilities. Services are available in a full life-cycle package in which Cisco experts provide key technical inputs during the design, implementation, operation, and planning of your network under an annual contract. Individual services are also available to help clients bridge resource or knowledge gaps in specifically defined areas.



These services, listed in Table 4, lead to a reduction in planning and design cycle time, operations costs and maintenance windows, and an increase in operational efficiency. Most importantly, because of the proactive upfront consulting and monitoring time, Cisco's services shorten the time it takes for customers to deploy their SAN, in turn enabling them to realize all of the benefits discussed in this paper much *sooner than with other vendors' offerings*.

Table 4 Cisco Advanced Support Services

Service Components	Activity
SAN Customer Requirements & Performance Assessment	SAN Customer Requirements and Performance Assessment
SAN Migration Plan Review	Review and recommendations on the fit, readiness, and gaps with respect to migration of the current storage network infrastructure to the new design, or developing a roadmap to assure that the network scales with increasing storage demands
SAN Design Review	Design review and assistance
SAN Design Validation	Assistance in the development of a test plan to validate the key features of the proposed design in the customer's lab; Remote assistance with the execution of the test plan
SAN Implementation Roadmap	Review of the customer's implementation plan and M&Ps; advice on configurations, and access to Cisco "best practices"
SAN Remote Deployment Support	Remote support for faster problem resolution during deployment of SAN LANs/WANs
SAN Hardware & Software Recommendations	Application software recommendations for ongoing network moves, expansions, etc.
SAN Ongoing Performance Optimization & Escalation Support	Preventive analysis and solutions to address operational problems; Cisco engineers help customer address the root causes of ongoing network problems and continually improve network application performance and utilization
SAN Scheduled Maintenance Support	Standby support during pre identified maintenance activities
SAN Knowledge Transfer	Provide TOI (Transfer of Information) sessions for key staff in areas defined by the client

Summary and Conclusions

IT decision makers are faced with the task of creating a vision for the future of the network and of their storage architecture that will help their organizations achieve their business objectives. Increasingly, the choice of technology for one area of the IT infrastructure cannot be made in isolation. End-to-end effects must be considered with each new segment of the architecture so that seamless performance, interoperability, support, and service are ensured. This would lead many managers to the decision to not invest in a new technology until it has been proven and commoditized. However, if an IT infrastructure truly is to be a source of competitive advantage, organizations must identify the appropriate time in the life cycle of the technology at which the maximum benefits can be achieved with the least risk. Reducing risk to zero will not lead to the optimal strategic investment. Rather, competitive advantage will only be realized if the technology is adopted and integrated faster and better than the competition.

With storage needs increasing at an accelerating annual rate, with the proliferation of voice, video, and data running over the network, and with tightening IT budgets forcing optimal technology investment decisions, now is the time to implement advanced, next-generation SAN technology. Cisco has had the advantage of learning the shortcomings of first-generation SANs, and has incorporated intelligent network services into a protocol agnostic, flexible

platform designed to seamlessly integrate SAN, LAN, MAN and WAN connectivity for a complete, end-to-end storage networking solution.

For more information about the benefits of next-generation SANs and about calculating concrete ROI for a SAN implementation, contact Cisco or an authorized Cisco sales partner, or visit: www.cisco.com



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