Data Storage Systems for E-Business

by

Ms. Sasina Taengtard

A Final Report of the Six-Credit Course
IC 6998 E-Commerce Practicum

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
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The Graduate School of Assumption University has approved this final report of the six-credit course, IC 6998 E-Commerce Practicum, submitted in partial fulfillment of the requirements for the degree of Master of Science in Internet and E-Commerce Technology.

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ABSTRACT

E-commerce has become the most talked about topic in Thailand during the past few years. Many businesses have adopted the successful online store models from the United States such as "Amazon.com" which started itself off by selling books and "Yahoo.com" a well-known search engine.

While there is a lot businesses doing electronically, in essence e-business connects people directly with information. The information that makes e-business connects people directly with information. The information that makes e-business work is largely represented as electronic data stored and managed by computer systems.

This project is about data storage management for e-business, focusing on the following factors

(1) Computer Environment Today

(2) IT industry facts and trends

(3) Industry challenge face by CIO's

(4) Storage Solution Alternatives

(5) Managing data that is information asset for every companies

(6) Enable the growth of business

(7) Study of what kind of storage that is suitable to your company

ACKNOWLEDGEMENTS

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

I. INTRODUCTION

1.1 Background of the Project

Analysts agree that business is heading for the Internet. Forrester, For example, estimated in late 1999 that online business would grow from $43 billion in 1998 to $1.3 Trillion in 2003. By the end of 1999, a sixth of U.S. households were making online purchases.

The reasons for going online are obvious. Being online makes a business more responsive, reduces costs, improves access to customers, shortens supply lines, improves cash flow and helps manage inventory. If you are not doing business online today, you would better be planning to, because your competitors are.

Today, many people have been on the consumer side of an "amazon.com", "etrade.com", or similar electronic consumer experience, and this tends to shape their perception of e-business. But e-business is a lot more than doing business online eliminates intermediaries and creates direct customer relationships.

Electronic document interchange enables real time supply chain management. Orders can be placed, status verified and invoices paid electronically, dramatically reducing turnaround time and errors. Intranets give employees instant access to up-to-date company information that they need to function effectively. Electronic presence enables a business to establish a strong brand with a wise following at a very low cost.

Going on-line can streamline the way business is done today. For the future, it offers virtually limitless possibilities for new ways of doing business. It's a phenomenon that no organization can afford to ignore.

While there is a lot of reason to do business electronically, in essence e-business connects people directly with information. The information that made e-business work is largely represented as electronic data stores and managed by computer systems.

The partners that make up an e-business (employees, suppliers and customers) need accessed to this information that is:

(1) Reliable: The fastest way to destroy customer confidence is to be non-responsive. Even if disks fail, applications halt or systems must be reconfigured, information has to be available to respond to partner needs.

(2) Fast: With e-business, competition is a click away. When customers or business partners ask for information, they expect instant answers; no excuses accepted.

(3) Manageable: Information must be protected from equipment failures, human error and malice. Online data must be protected and moved to where it is needed, often while it is being accessed by applications.

(4) Scalable: E-business growth opportunities are truly staggering. By one analyst's estimate, a company can increase its revenues by as much as 50% just by going online. If a growing e-business can't grow its ability to deliver information, success can turn into failure.

(5) Disaster proof: Going online streamlines operations, reduces costs and improves profitability. Once online, however, there's no turning back. Electronic data and applications must remain available, even it there's a fire, flood or massive power grid failure. An e-business must be able to get back "on the air" quickly when disaster strikes.

Regarding to the reasons, data is an important thing for e-business which the management has to consider on it, not only stores it but they have to manage it as well.

All collected data will be processed to be "Information". And "Information" was analyzed to be "Knowledge" which finally turned to be "Business Value" as shown in Figure 1.1. below.

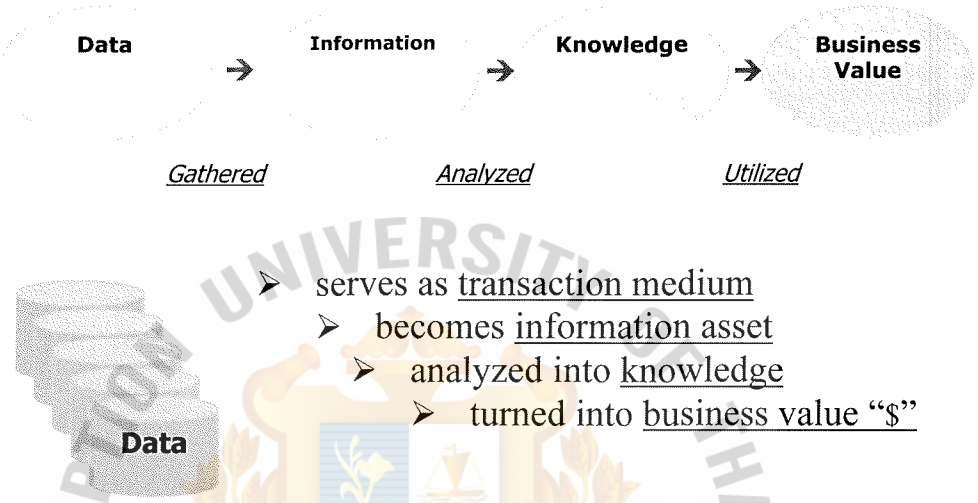


Figure 1.1. How Data Is Processed to Be Business Value?

So the management needs the solution which can support them in storing and managing data especially for e-business market which data has to be available for 24 hours a day seven days a week. At this point, "Storage Solution" is proposed to solve the problems.

"Storage Solution" is about data storage management for e-business: on keeping electronic data available, providing fast access to it, managing it, enabling it to grow with the business and making it disaster proof. Because of the increased dependence on information, the storage needs of companies are growing exponentially. Research shows that storage needs for companies are doubling every year. This growth raises new concerns for the maintenance and protection of valuable data resources.

1.2 Objectives of the Project

(1) To study the kinds of storages that exists in the current market today.

(2) To find the advantages of each Storage Solution Alternatives.

(3) To evaluate the right solution for storage need.

1.3 Scope of the Project

It will study each type of storage solution in details (such as specifications, features, advantage and etc), and the difference of each type of storage. The project will cover the details of the external storage of IBM hardware which is one of the leading storage companies. Finally, after gathering all information of IBM storages and find the advantages of each type of storage or solution which will be analyzed and made to which type of storage or what solution suitable to your business.

1.4 Deliverables

A final report in details covers the scope mentioned earlier.

1.5 Project Plan

Table 1.1 shows the project plan of Study on the "Storage Solution" and schedule management for this project. There are 4 mainly periods of time such as project proposal, progress report, "Storage Solution" research and analysis, and oral examination. In conclusion, it takes 6 months to complete this project.

Table 1.1. Project Plan.

Phase	Task Name	July				August				September				October				November				December			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
I	Project Proposal	←	—	—	→																				
II	Progress Report					←	—	—	—	—	—	—	—	—	—	—	—	—	—	—	→				
	Information Gathering																								
	Periodic Report Drafting																								
	Periodic Report Review																								
	Report Correction																								
III	Storage solution Research & Analysis									←	—	—	—	—	—	—	—	—	—	—	→				
	Analyzing what problems and difficulties																								
	Improvement for the existing systems																								
	Find the right solution for your storage																								
	Solution and cost analysis																								
IV	Oral Examination																					←	—	—	→
	Preparing presentation slides																								
	Presentation practicing																								
	Oral Examination																								

II. THE EXISTING SYSTEM

2.1. Background of the Project

Today's storage environments have become a maze of complexity, spanning multiple platforms, storage media and applications. Organizations find themselves purchasing platform-specific solutions to protect data, control usage, address Storage Area Network (SAN) and Network-Attached Storage (NAS) environments and manage offline storage. In the end, they are left with islands of storage solutions, not an integrated set. Managing today's complex storage environments requires enterprise-class solutions that cross platform, network and application boundaries for end-to-end storage management. The storage growth and comprehensive management are key in delivering high-performance and high available business services.

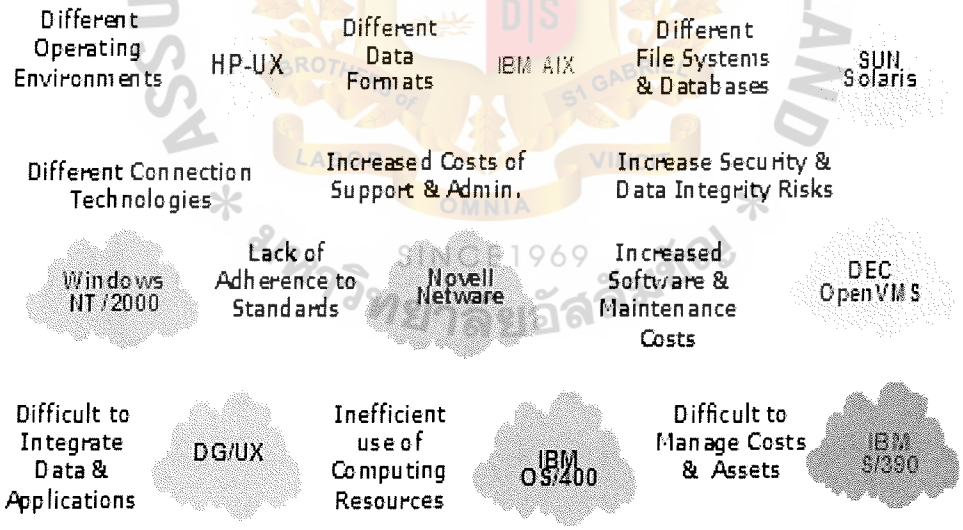


Figure 2.1. Computing Environment Today.

Storage management solutions integrate today's disparate offerings and provides the solid infrastructure for tomorrow with end-to-end storage management, operations

and Best Practices. IBM storage solution makes **"Managing Storage without Boundaries"** possible with automated, self-learning, policy-based enterprise capabilities.

E-business Data and Databases

Rational database technology is an obvious answer to getting an e-business online fast and efficiently. Database technology is mature and robust. Most of today's mission-critical applications are based on databases. Database management systems maintain transactional integrity, even when multiple applications access data simultaneously.

Databases also protect data integrity. Properly designed, a database stores each data item once, on matter how many applications use the item. Built-in filters prevent invalid values from entering the database. Redo logs help re-establish data consistency after the system or application failure.

Finally, databases help get applications up and running quickly. Major business applications, such as SAP R3, Baan, and PeopleSoft, are all based on database technology. Database companies (e.g., Oracle) offer complete business application suites that exploit their underlying database management technology.

Database Management Systems for E-Business

E-business has some of computing most challenging requirements. On the one hand, 24x7 availability requirements mean that e-business data processing has to be at least as robust as the most mature applications in the enterprise data center. On the other hand, the explosive growth of this young area fields frequent reconfigurations as hardware is added and redeployed, data are moved and restructured and applications evolve with business needs and practices. The challenge for e-business data processing in the midst of all this chaos is to provide customers, suppliers and employees with

reliable access to the information they need at performance levels that won't leave them frustrated.

Database management systems clearly help bring order to e-business environments. The fundamental concept of database management is to separate the structure and organization of data from applications. Databases provide the stability, integrity guarantees, transactional semantics and recovery capabilities that "keep data whole" as applications and information processing infrastructures grow, change and are replaced.

Online Storage for Database Management Systems.

Database Management systems are an obvious way to meet demanding e-business requirements. But they don't exist in a vacuum. The higher the quality of it underlying storage, the better the job a database management system can do. Database management systems require three fundamental qualities from their data storage:

(1) **Reliability:** Database management systems organize the contents of huge numbers of disk blocks into interrelated tables of user data and metadata that collectively represent the state of an e-business. They excel at maintaining data's logical integrity, but they need the support of a solid foundation to maintain data's physical integrity.

(2) **High Performance:** Faster access to data translates directly into improved application responsiveness. While database management systems attempt to minimize physical I/O through extensive use of cache, disks ultimately have to be read and written.

(3) **Ability to grow non-disruptive:** Database management systems generally handle growth very well. Most support the addition of storage capacity to database while they are online. In order to exploit databases' ability to grow,

however, their underlying storage must be able to grow dynamically as well. Growth doesn't just mean adding storage. It also requires rebalancing I/O workloads across storage resources to avoid hot spot that saturate some disks and I/O buses while others remain idle.

2.2 Trends and Directions of Storage Management.

In this e-commerce economy, it is no secret that data is business. Because of the increased dependence on information, the storage needs of companies are growing exponentially. For a database to perform optimally under the all unpredictable circumstances that are a part of doing business online, it needs an underlying infrastructure that:

(1) Provides robust

(2) high-performance

(3) flexible online storage

Enable execution of backup and other management tasks while the database is operating, Support database growth over a wide range of storage capacities and Maximize data availability, including protecting against disasters.

STORAGE	TODAY	TOMORROW
Architecture	Direct-Attached	Networked
Storage Location	Decentralized	Centralized
Utilization	Poor: 40%-60%	High: 70%-90%
Management Tools	Many, Complex	Few (Integrated), Simple
Management	In-house	Mix of in-house and external
Connection Technology	Mostly SCSI, some Fibre Channel	Mostly Ethernet (File/SCSI), Fibre Channel

Source: Forrester Research, Inc

Figure 2.2. Storage Trend.

Total storage management for e-business databases integrates storage and data management technologies that span the enterprise data storage spectrum. Research shows that storage needs for companies are doubling every year. This growth raises new concerns for the maintenance and protection of valuable data resources. There are 4 key critical points that CIO must be aware when considering their storage need.

Data Protection

It could have been a power surge or just and accidental delete, but any way you look at it, lost data costs your company in many ways. In today's non-stop business environment, developing a stable plan for protecting data through backup and recovery is critical to on-going success. A good backup and recovery strategy not only protects vital data but can also reduce the backup window, provide faster, more efficient recovery.

Companies recognize the value of their data, losing it is not an option. If they did, they could lose a lot more than their data. A reliable backup and recovery strategy address the following needs.

(1) Protecting vital data

(2) Reducing the backup windows

(3) Providing more efficient storage

(4) Reducing server cycles

(5) Providing faster, more effective recovery

(6) Storage Consolidation

Data is doubling every eight months, to stay competitive. Companies need to increase their operational efficiency and data cost effectiveness. Storage consolidation helps reduce storage cost of ownership, maximize efficient use of capacity and enables capacity growth simply and without disruption.

Most complex organizations function in distributed computing environments with fragmented storage resources. As a result, storage capacity is often underutilized but reallocating storage resources often causes disruptions or network downtime.

Consolidation is the answer. Consolidating data means that stored data is centralized, rather than dispersed (resulting in reduce manpower needs, optimized storage capacity, and more efficient storage management.

Disaster Tolerance

The unpredictable can happen due to its mother nature, outside forces, or the ability to continue operating and recover quickly from a disaster is critical. Companies need storage which can provide high data availability from no single point of failure automatic failure capabilities and remote vaulting or mirroring over long distance.

No one likes to think that a disaster could strike their business, but planning for that off chance can save your business. High data availability and quick recovery are essential to maintaining business continuance in the event of disaster, whether it is an earthquake or a system failure.

Your company's dependence on it data requires storage with on single point of failure, automatic failover capabilities, and the ability to do remote vaulting or mirroring over long distances. Being able to endure a disaster and to recover quickly is a key to business survival.

Data Sharing and Access.

Few companies boast a totally heterogeneous, vender-neutral computing environment. For this reason, cross platform data sharing have become like the holy grail of distributed computing. Cross-platform data sharing allows any-to-any access across the organization, resulting in greater operational efficiency and cost effectiveness.

Only storage products that conform to open standards permit this degree of universal access. Sharing data across your global organization can make the difference between quick action and missed opportunity. Gaining a competitive edge means able to leverage your data to maximum potential. True data sharing enables any-to-any access, load balancing, reduce data duplication and improved data currency. Important applications such as e-business, Enterprise Resource Planning, Business Intelligence, Messaging, and more all require an optimized infrastructure that can handle data across these applications.

2.3 Basic Types of Storage

There are 3 basic data types of storage subsystems.

(1) Tape Storage

Tape Storage characteristics.

Tape is most frequently used for the following purposes:

(a) Low cost archive of data

(b) Backup and disaster recovery

(c) Interchange of data between systems

Tape is available in different forms and with different characteristics:

(a) 4 mm

(b) 8 mm

(c) one-half inch cartridge

(d) quarter-inch cartridge (QIC)

Table 2.1. Tape Technology in the Current Market.

Compressed Comparison	LTO Ultrium	DLT 8000	SuperDLT	Mammoth II	AIT-2
Capacity	200 GB	80 GB	220 GB	120 GB	100 GB
Data rate	30 MB/s	12 MB/s	22 MB/s	24 MB/s	12 MB/s
Servo Tracks	Yes	No	Yes	No	No
Format	Longitudinal	Longitudinal	Longitudinal	Helical	Helical

(2) Disk Storage

Disk Storage is used to transfer a large amount of data to and from to computer processor at high rate of speed. Disk Storage is most frequently used for the following purposes.

(a) Fast Access to Data

(b) Random and sequential read and write data

Table 2.2. Disk Technology.

Feature	IDE	ATA	SCSI	Fibre Channel
Connectivity • Max Devices • Cable Length	 2 18	 2 18"	 16 25 m	 126 / Millions 10 km
Performance • Bandwidth • Bandwidth / drive • Multi-threaded I/O	 16 mb/s 8 mb/s No	 66 mb/s 33 mb/s Yes	 160 mb/s 10 mb/s Yes	 200 mb/s 1.6 mb/s Yes
Max Initiators	1	1	< 16	125 / Millions
Topologies	Bussed	Bussed	Bussed	Loop / Fabric
Error Detection	None	Yes	Yes	Yes
Protocol "Weight"	Very Light	Light	Med-Heavy	Heavy
Cost • Interface • Drives	 N/A N/A	 Lowest Lowest	 Med-High Med-High	 Highest Med-High
Manageability	None	Low-Medium	Medium	Medium+

(3) Optical Storage

While tape and disk storage primary used magnetic material in the media surface optical technology uses laser technology to read data to or from a surface.

Optical storage is available in these different forms:

(a) Permanent

(b) Write-Once, Read-Many (WORM)

(c) Rewritable

(d) Continuous Composite Write-Once (CCW)

(e) Permanent and Rewritable

Optical Media is a suitable media when the following data requirements are met;

(a) Large volume

For example: Sales data of high-volume company

(b) Infrequently accessed

For example: A company needs to retain legacy data but not use it very often.

(c) Long retention period

For example; When the data which needs to be protected for many years.

Summary of Media Characteristics

Table 2.3. Summarizes the Advantages of Each Device Types.

Feature	Disk	Optical	Tape
High Speed Random Access	X	X	X
Low Cost Random Access	X	X	X
Sequential Access Only	X	X	X
Low Cost High Capacity	X	X	X
Removable Media	X	X	X
Permanent Recording	X	X	X

2.4 Current Problems/ Difficulties and Areas of Improvement

2.4.1 Current Problems and Difficulties

There are many platforms in the current computing environment such as Windows NT/200, Novell Netware, IBM OS/400, UNIX, SUN Solaris and etc.

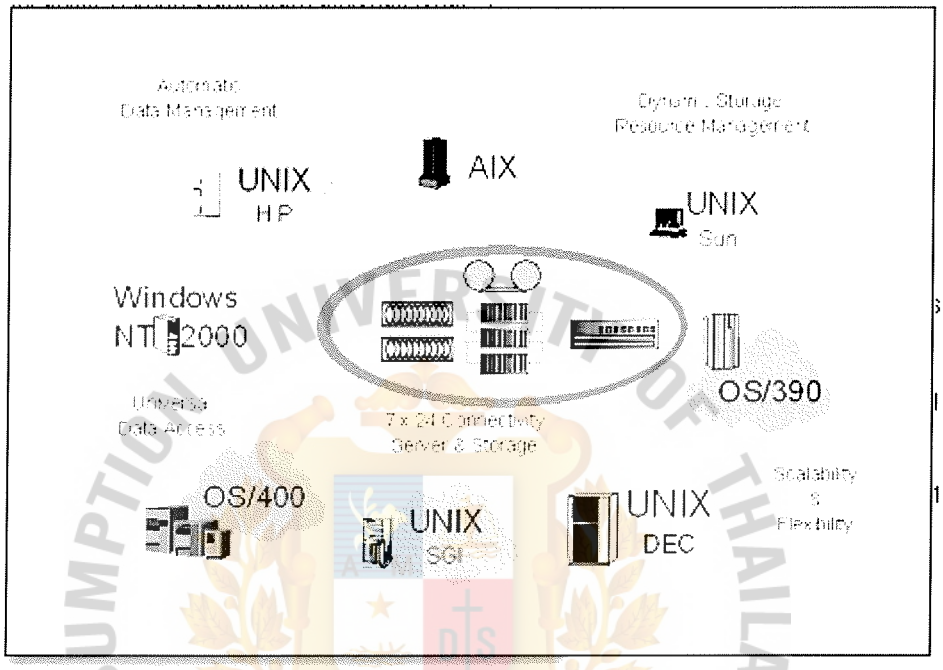


Figure 2.3. Current Plat Form in the Market.

There are different data format, different connection technology, different file system and database format therefore there are many problems and difficulties such as:

(1) Need for different skills of system support

(2) Poor data sharing between different operating environments and lack of adherence to standards

(3) Difficulty to manage

(4) Increase security & data integrity risk

(5) Increase costs of Support and Administrator

(6) Different connection technologies

(7) Difficult to integrate data and application

(8) Inefficient use of computing resources

(9) Increase software and maintenance costs

All these problems are directly affect the systems performance and the working process.

2.4.2 Areas of Improvement

The right management solution should provide comprehensive IT management tailored to the system, including fast and easy installation, a short learning curve, and immediate productive gains. It should further be enabled to manage application, proactively solve problems, and automate routine task. For the project, we focus on three main aspects:

(1) **Control over IT resources**, with fully interrogated view of the whole environment. Accountability through powerful technology that is affordable, easy-to-install, and east-to-use. The area of improvements which are focused on improving the existing systems.

(2) **Centralized control of IT management**, by comprehensive management all of the critical IT resources (hardware, application, and networks) and help support staff to manage key software application by monitoring resources, managing events, automating routine tasks, tracking inventory, and deploying software components across the system.

(3) **Anticipate potential problems and automate correct actions**, and prevent crisis before they emerge. This can help support staff to concentrate on improving the business applications than solving the preventable problems.

To increase speed of working process and response time with a standard solution if repeated problems occur, and reduce time consumption for defining the solution of

each problem occurring in the system. Provide report and information of the system. This will be used by support staff for daily operations and the management level (MIS/EDP) for decision-making.

III. PROPOSED SYSTEMS

3.1 Proposed Solutions

Since the advent of mainframes, computer scientists have constantly wrestled with various architectures to speed the I/O performance with increasing processor performance. Earlier efforts to improve data access involved tight coupling file systems and I/O with its operating systems. The rise of networked distributed computing brought the challenge of sharing files amongst heterogeneous computers running different operating systems. This gave rise to network-attached-storage servers to be independent of applications servers and dedicated to only serving files to users while offloading data management tasks from the over burdened application servers.

Faced with the lack of a practical technology that would interconnect these servers, the industry gave birth to a high speed fibre-channel technology which in turn provided the impetus for a third generation storage architecture called "SAN" (or Storage Area Networks) to emerge.

SANs create a dedicated network, focused on creating a universal any-to-any connectivity between storage and server nodes - a network that combines the best of mainframe bus and channel's high speed and data integrity benefits with networks' distance benefits, a network that frees the main LAN network from backup duties that consume valuable bandwidth, a network that is scalable allowing increments in capacity without disruptions while leveraging the existing investments in legacy platforms and existing data, a network that provides centralized control while providing remote data vaulting for disaster recovery, a network that offloads storage management tasks from application servers and speeds up the entire network, thus allowing users the benefit of fast data access. SANs will eventually be at the core of every enterprise's data center,

allowing companies to design centrally-managed data centers that embrace and interconnect farflung global SANs and provide service to all of their servers, no matter how far or no matter what operating systems they are running on.

This new focus on data storage, as a key asset to manage, is obvious given the rise in dollars being spent on storage to the tune of 40-50% of total IT dollars in 1998. The rise in storage requirements is being fueled by the birth of incessantly newer internet, data warehousing and ERP applications and further stoked by the lure of cheap disk drives at 5 cents per MB at the end-user level today.

Options for connecting computers to storage have increased dramatically in a short time. Variations (and associated acronyms) for storage networking seem to be materializing out of thin air faster than they can be tracked. Storage networking offers significant capabilities and flexibilities not previously available, and understanding the technology basics is essential to making the best choices. This project provides an easy-to-understand comparison of the storage attachment alternatives. Information is presented beginning at a high level and slowly adding increasing detail. The focus is on connectivity options for midrange platforms such as IBM AS/400, NetWare, Microsoft Windows NT, Microsoft Windows 2000 and UNIX.1 Storage management and storage network management, while important topics, are not discussed in detail. We'll start with a brief description of the major storage networking variations.

Let's step back and introduce the concepts that will lead to understanding the storage attachment alternatives. There are just three key concepts to be understood:

(1) Connectivity: how processors and storage are physically connected. Think of this as how the connections would be drawn in a picture.

(2) Media: the type of cabling and associated protocol that provides the connection.

(3) I/O protocol: how I/O requests are communicated over the media. It is how these three items are combined in practice that differentiates the various ways processors (hosts) and storage can be connected together. Essentially, storage is attached to processors over a direct or network connection, and they communicate by the way of an I/O protocol that runs "on top of" the media protocol.

Let's examine the three concepts one at a time.

Connectivity

The pictures below illustrate the two basic ways to physically connect storage to processors.

Direct Attached Storage (DAS):

DAS: a single storage device is connected to a single processor (host). Storage (usually disk or tape) is directly attached by a cable to the computer processor. (The hard disk drive inside a PC or a tape drive attached to a single server is simple types of DAS.) I/O requests (also called protocols or commands) access devices directly.

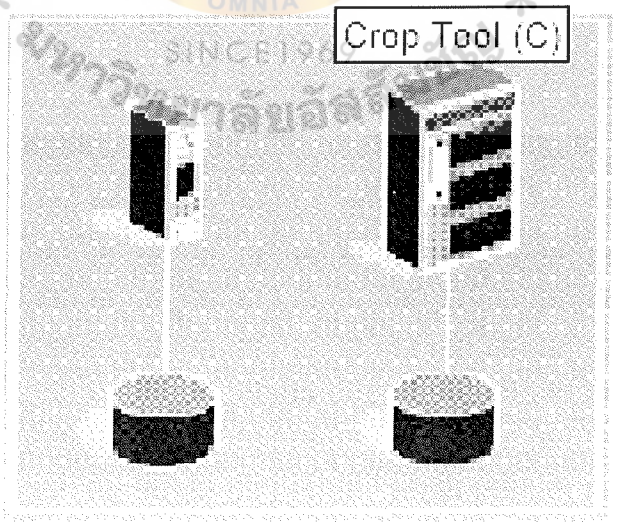


Figure 3.1. Direct Attach Network.

Network Attached Storage (NAS):

A NAS device ("appliance"), usually an integrated processor plus disk storage, is attached to a TCP/IP-based network (LAN or WAN), and accessed using specialized file access/file sharing protocols. File requests received by a NAS are translated by the internal processor to device requests.

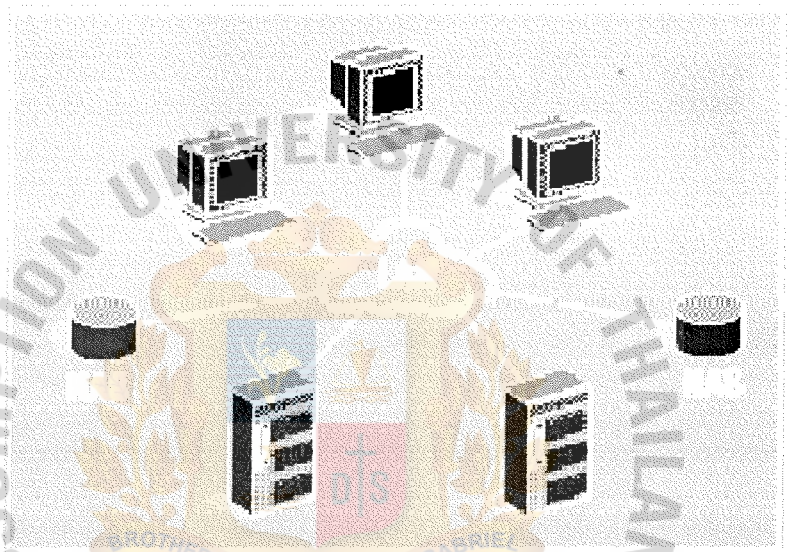


Figure 3.2. NAS Network.

"SAN": Storage Area Network

Storage resides on a dedicated network. Like DAS, I/O requests access devices directly. Today, most SANs use Fibre Channel media, providing any-to-any connection for processors and storage on that network.

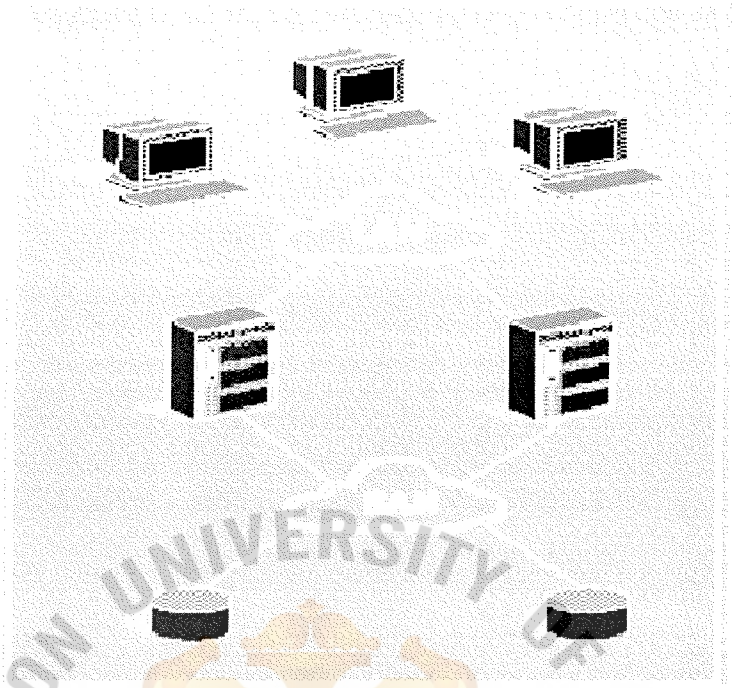


Figure 3.3. SAN Networking.

The simplest form of direct attached storage (DAS) is a single disk drive or single tape drive connected to a single processor. Some disk systems allow the aggregate disk capacity to be "carved" into partitions (subsets) of capacity where each partition can be assigned to a different processor. Further, the subsystem may allow partitions to be manually reassigned from one processor to another. This is essentially still a DAS approach to storage.

For simplicity, Direct Attach is common in the industry, this paper will sometimes refer to storage networking alternatives without explicitly mentioning direct attach, but it should be considered as one such alternative.

Following industry convention, a cloud is used to indicate a network without showing the inner details of how cables, and devices such as hubs and switches, may be connected to form a particular implementation. Such implementations will vary from

organization to organization and do not need to be understood in order to explain storage connectivity alternatives. The idea is that all objects connected to the same cloud can potentially communicate with each other. (Such any-to-any flexibility can be managed in practice to prevent undesired communications.

Media

The media is the physical wiring and cabling that connects storage and processors. Media is always managed by a low-level protocol unique to that media regardless of the attached devices. A protocol is the rules for exchanging information between two objects. In computers, this specifies the format and sequence of electronic messages. In storage-to-processor connections, the following media and associated protocols are prominent. All are open industry standards.

(1) Ethernet: Ethernet began as a media for building LANs in the 1980s. Typical bandwidths are 10Mbps, 100Mbps, and 1Gbps.3 Ethernet is a media and its protocol. IP-based protocols such as TCP/IP generally run on top of Ethernet.

(2) Fibre Channel: Fibre Channel is a technology developed in the 1990s that has become increasingly popular as a storage-to-processor media (for both SANs and DAS). Bandwidth is generally 100MBps, with 200MBps expected in 2001.

(3) Parallel SCSI: (Small Computer Systems Interface): (Pronounced "scuzzy"). Parallel SCSI is an evolving technology with origins in the 1980s. Typical bandwidths are 40MBps (also called UltraSCSI), 80MBps (also called Ultra2 SCSI), and 160MBps (also called Ultra160 SCSI). Parallel SCSI is limited to relatively short distances (25 meters or less, maximum) and so is

appropriate for direct attach, especially when storage and processors are in the same cabinet, but is not well-suited for networking.

(4) SSA: (Serial Storage Architecture): SSA is a media technology optimized for high-performance and used to connect disks together inside some disk systems. Bandwidth is 160MBps.

I/O Protocols

I/O processing uses specific protocols that run "on top of" the underlying media protocols. (In the case of Ethernet, I/O protocols generally run at some level on an IP protocol stack.) The following are the most common I/O protocols supported on midrange platforms.

(1) SCSI (Small Computer Systems Interface): The I/O protocol most prevalent in the midrange world. A SCSI I/O command might tell a disk device to return data from a specific location on a disk drive, or it might tell a tape library to mount a specific cartridge. SCSI is often called a "block level" protocol, or block-I/O, because SCSI commands specify particular block (sector) locations on a specific disk. Originally, SCSI I/O commands could only be sent over media called "parallel SCSI". Today, SCSI commands can be issued over different types of media such as Fibre Channel, SSA, and Ethernet, as well as over parallel SCSI.

(2) NFS (Network File System): A file-level (also called file-I/O) protocol for accessing and potentially sharing data. This protocol is device-independent in that an NFS command might just request reading the first 80 characters from a file, without knowing the location of the data on the device. NFS has its origins in the UNIX world.

(3) CIFS (Common Internet File System, often pronounced "siffs"): It is a file-level protocol for accessing and potentially sharing data. This protocol is device-independent in that a CIFS command, like NFS, might just request reading the first 80 characters from a file, without knowing the location of the data on the device. CIFS has its origins in the Microsoft Windows NT world. With SCSI (block-I/O), disk volumes are visible to the servers attached to them. With NFS and CIFS (file-I/O), only files are visible to the attached processors, but the disk volumes on which those files reside are not visible to those processors.

The Storage Networking

Storage networking such as DAS and NAS can be viewed as various combinations of the three key concepts discussed above: connectivity, media and I/O protocol. Not every possible combination is implemented today, or may be implemented in the future.

(1) DAS (Direct Attached Storage): Storage is directly attached by a cable to the processor. The media could be any (i.e., Fibre Channel, SCSI, SSA, Ethernet). The I/O protocol is SCSI.

(2) SAN (Storage Area Network): Storage resides on a dedicated network, providing an any-to-any connection for processors and storage on that network. The most common media is Fibre Channel, but Ethernet-based SANs are emerging. (See iSCSI below). The I/O protocol is SCSI.

(3) NAS (Network Attached Storage): A NAS device is attached to a TCP/IP-based network (LAN or WAN), and accessed using CIFS and NFS - specialized I/O protocols for file access and file sharing. A NAS device is sometimes also called a file server, or "filer" or "NAS appliance". It

receives an NFS or CIFS request over a network and has an internal processor which translates that request to the SCSI block-I/O commands to access the appropriate device only visible to the NAS product itself.

(4) NAS gateway: Instead, the NAS device connects to storage by direct attachment or by a SAN. This term is most meaningful when there is a choice of the disk storage to attach to the gateway.

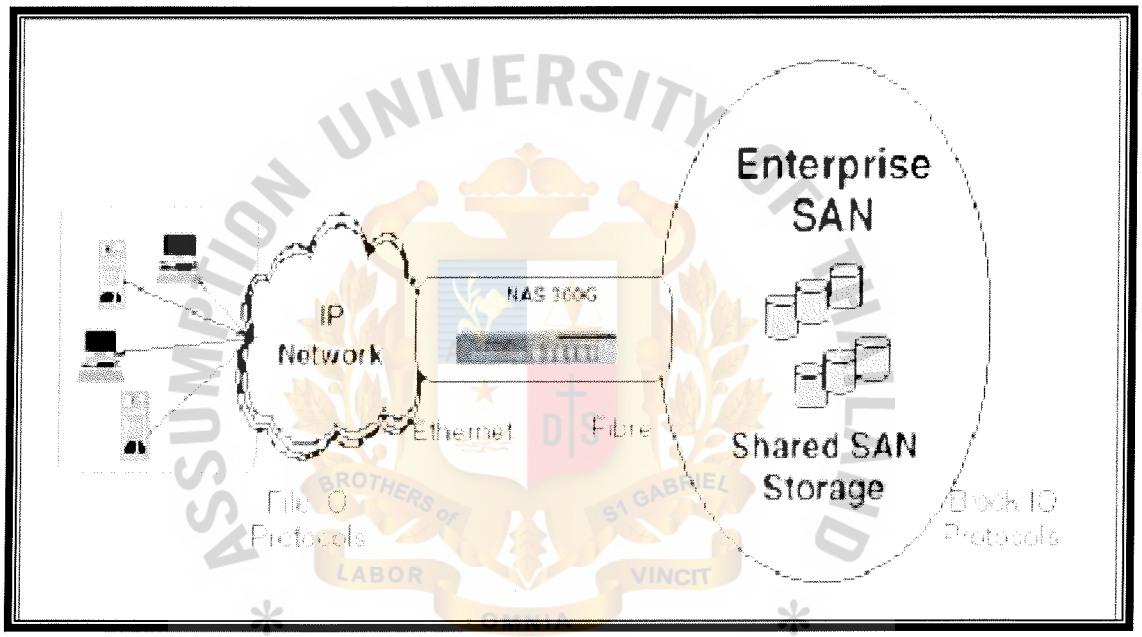


Figure 3.4. NAS Gateway.

(5) iSCSI: Storage is attached to a TCP/IP-based network, and is accessed by block-I/O SCSI commands. iSCSI could be direct attached or network attached (i.e., DAS or SAN).

The various storage networking alternatives are summarized in the following

Table 3.1. Storage Networking Comparison.

A Tabular Comparison						
Processor-storage connection	Network	Media	I/O Protocol	Bandwidth	Capacity Sharing	Data Sharing
DAS	No	"Under the processor covers" wiring, parallel SCSI, Fibre Channel, or SSA	SCSI	40MBps up to 160MBps, depending on media	Manual or no	No
SAN	Yes	Fibre Channel is most common, with Ethernet emerging	SCSI	100MBps Fibre Channel, with 200MBps expected during 2001	Yes	Requires specialized software such as SANergy
NAS	Yes	Ethernet	NFS, CIFS	10Mbps to 1Gbps	Yes	Yes
NAS gateway	Yes	Ethernet	NFS, CIFS	10Mbps to 1Gbps	Yes	Yes
iSCSI	Yes	Ethernet	SCSI	10Mbps to 1Gbps	Yes	Requires specialized software such as SANergy
Tivoli SANergy	Yes	SAN media	NFS, CIFS, SCSI	SAN speeds	Yes	Yes

Note that while the terms NAS and SAN seem similar, SAN refers to a dedicated storage network and NAS is a device on a LAN/WAN network (whether the network is

shared or dedicated to storage). Occasionally, the industry uses the term "SAS" to refer to SAN Attached Storage. As you may realize, storage networking terminology is not intuitive, and isn't standardized; you may want to take care that you and others are talking about the same thing when using a given term.

Direct Attached Storage or Server Attached Storage

Early mainframe storage designs took the premise that disk storage which was cheaper than main memory, could be treated as a extended virtual memory to swap memory-pages. To achieve the fast data access, the data paths (or channels) between storage and processor were widened, the storage bus kept adjacent to the processor bus for data/signal integrity while boosting the channel speeds. Server attached storage architectures dominated the scene for several years from mainframe processor channels to PC Server bus slots and adapters.

One of the handicaps of the traditional server attached storage comes from the tight coupling between storage and the operating system. A general purpose SAS server performed a variety of tasks concurrently from running applications, manipulating databases, file/print serving, providing communications, and checking data-integrity to many housekeeping functions.

This meant that all data access requests from a client must continuously compete with these tasks continuously. As the number of users accessing the common centralized data storage increases, the file access takes a back seat to other tasks leading to slow response time for queries. For years one of the major jobs of MIS administrators was to keep the storage performance fine tuned to achieve a certain minimum level of user query response time.

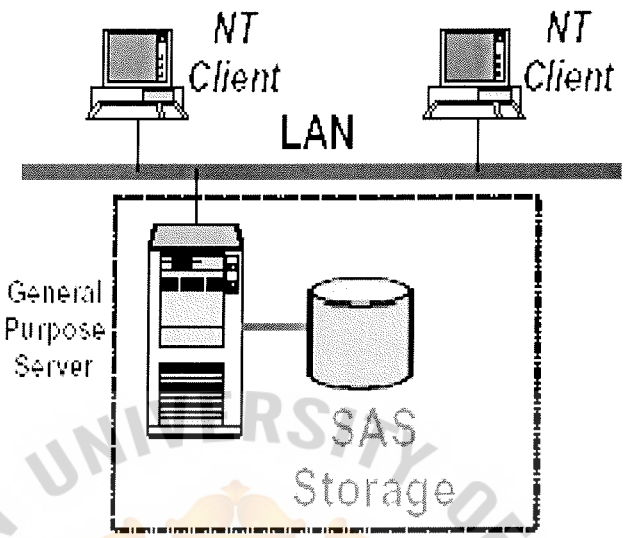


Figure 3.5. Server Attached Storage Configuration.

Another limitation imposed by the Server Attached Storage architecture was that of limited distance imposed by the interface - the OEMI wide parallel connections in mainframes and wide differential parallel SCSI connections in servers were limiting the distance between computers and servers to a few meters. This led to the creation of raised-floor data centers but posed a severe constraint and limitation on interconnectivity in multi-site operations. One of the major benefits of fibre channel connectivity that is not fully emphasized is the removal of spaghetti of OEMI/SCSI wires interconnecting storage to servers and the associated improvement in reliability. This is over and above the advantage of allowing high speed connectivity and increased distance between centrally managed data repositories and dispersed LAN servers.

NAS – Network Attached Storage

In NAS, you can add storage at random without disrupting the network. When the storage was on the server as in SAS, the administrator had to take down the system, install or upgrade the drives and bring the system back up again, that create a lot of unacceptable downtime.

Server Attached Storage, NAS is making inroads into the marketplace at different price, performance and size levels. As business operations become more global and around the clock, more and more applications become mission critical that demanding 24x7 uptime. Feeding this frenzy of 24x7 uptime are the obliquities to the Internet using email messaging and around the clock customer information browsing demanding richer and richer content from text to images to audio/video clips, virtual private nets for e-commerce and data warehousing and ERP applications on the intranet.

NAS architectures generally sport a light proprietary OS kernel and file system able to operate autonomous of other applications and are thus devoid of all overhead from extraneous drivers prevalent in SAS architecture. The NAS operating system is fully compatible with server operating systems such as NT, UNIX, Netware and etc. Generally called a Network Appliance, NAS devices are relatively easy to set up turning painful storage upgrades into simple plug-and-play devices requiring no server downtime to set up. After plugging a NAS server onto a network and assigning an IP address, setting up control lists and user permissions and voila, all is done. This is because the NAS server boards integrate the Ethernet connection, the SCSI (or Fibre Channel) controller-to-disk connections, the operating system and boot up software all on one simple card. Much as NAS devices have built-in security features, administrators generally choose to rely on existing robust security features of their networks. One of

the main benefits of NAS is that it allows clients to directly access data without burdening the application servers.

Network Attached Storage, compared to server attached storage on the other hand is a dedicated file server optimized to do just one function only and do it well - file serving. NAS is a system independent, shareable storage that is connected directly to the network and it is accessible directly by any number of heterogeneous clients or other servers. NAS file servers are essentially stripped down servers specifically designed for file serving and offloading file management services from the more expensive application servers.

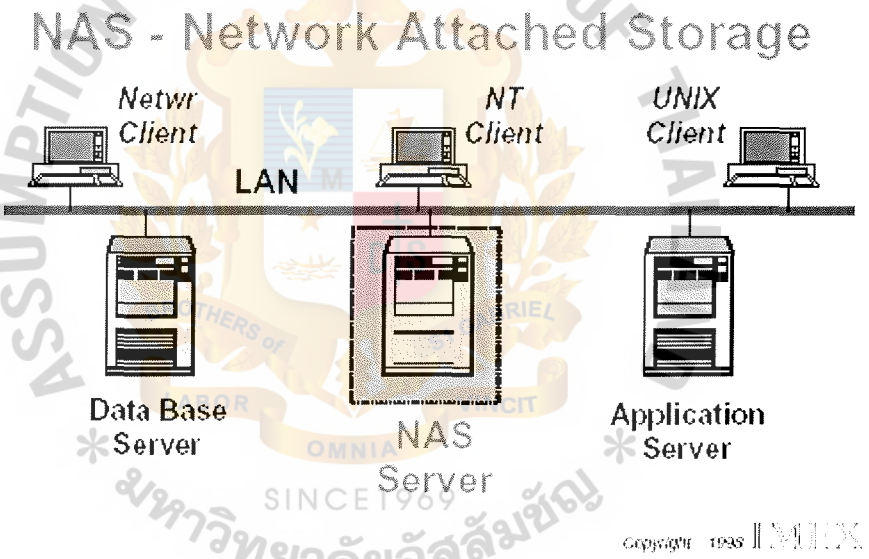


Figure 3.6. Network Attached Storage Configuration.

Factors Motivating Rise of NAS Servers Include:

Performance

Stored data supplied directly to clients without server intervention Performance enhancements of a site can be achieved by dedicating each NAS server for its specific needs (e.g. Publishing/Prepress department can have its own file server dedicated to video/imaging graphics data using RAID-3 while the e-commerce sales/order

processing/ shipping/customer service groups could be running OLTP applications on its own dedicated server, running RAID-5 or RAID-1 attached to the same net).

Availability

(1) Fault Resiliency -Majority of data has become a mission critical to run a business and so must be made secure and reliable.

(2) Need for 99.9% availability (8 Hours per year of downtime). Some applications require even higher data availability such as 99.99% (1 hour of downtime per year) and recovery from failure from hardware, software and application switchover within 30 seconds.

(3) Ease of remote vaulting for data recovery

New architectures such as Wolf pack, the Windows NT 2-node Clustering provide high availability via server failover using MSCS software acting in an active/active mode. Thus when a server fails, the application is switched to the surviving server and so is the storage.

Cost

HSM: migration to low cost tape for infrequently used data.

Scalability

Other benefits accruing to NAS architecture include modular scalability by direct attachment of add-on file servers directly to the net without bringing down any application running already.

Interoperability

NAS is very capable of supporting heterogeneous clients (such as NT and UNIX workstations) to share same data from network attached server. Majority of mainframe storage today acts as a physical repository to store different types of file data such as UNIX/NFS or MVS or NT/SMB in different physical locations of the storage system.

Some UNIX companies emulate the NT client data into UNIX NFS format and store as NFS data on NAS file server. Others notably, Net Appliance has a data format conversion facility to store NT or UNIX data in a common format, allowing faster data retrievals, data sharing and interoperability to serve heterogeneous clients.

Manageability

NAS lends itself to dedicated storage management resident on the NAS servers itself to ensure efficient backups.

Challenges

One of the major shortcomings of NAS storage architecture is that the network on which NAS runs is also used for data access by clients to retrieve data from the file server or communicate with application servers. The data movement between the disk and tape servers also goes over the same LAN. This creates a major network bottleneck when the number of user increases. Further the overhead of network stack contributes to higher data latency during server or client to storage communications.

While NAS works well for documents, file manipulations and transaction based applications, it is not necessarily most advantageous for database applications because it is file-oriented. Also for high bandwidth video applications, NAS slows down since the shared network on NAS gets clogged fast with multiple large files and starts to become a bottleneck.

Storage Area Network (SAN)

A storage area network (SAN) is a dedicated, centrally managed, secure information infrastructure, which enables any-to-any interconnection of servers and storage systems.

A SAN:

(1) Facilitates universal access and sharing of resources.

(2) Supports unpredictable, explosive information technology (IT) growth.

(3) Provides affordable 24 x 365 availability.

(4) Simplifies and centralizes resource management.

(5) Improves information protection and disaster tolerance.

(6) Enhances security and data integrity of new computing architectures.

SAN is based on a systematic approach to data storage management pioneered by IBM in the S/390 environment almost 30 years ago. Now SANs are rapidly being integrated into distributed network environments using Fibre Channel technology For detailed information about SANs, including standards bodies and industry organizations active in the field.

What Business Challenges Have Inspired the Move to SANs?

The move to storage area networks has been motivated by the need to manage the dramatically increasing volume of business data, and to mitigate its effect on network performance.

Key factors include:

(1) E-business -- securely transforming internal business processes and improving business relationships to expedite the buying and selling of goods, services and information via the internet.

(2) Globalization -- the extension of IT systems across international boundaries.

(3) 'Zero latency' -- the need to exchange information immediately for competitive advantage.

(4) Transformation -- the ability to continually adapt, while immediately accessing and processing information to drive successful business decisions.

Distributed computing, client/server applications, and open systems give today's enterprises the power to fully integrate hardware and software from different vendors to

create systems tailored to their specific needs. These systems can be fast, efficient, and capable of providing a competitive edge. Unfortunately, many enterprises have taken a far less proactive approach with their storage systems. Storage, unlike a web application server or a database system, is rarely viewed as a strategic tool for the enterprise. This view, however, is beginning to change.

With the explosive growth of e-business, information technology (IT) managers are working intensely to keep pace with managing the significant growth of data (multiple terabytes per year.) They are installing high-performance storage systems to meet the demands for smaller backup windows and greater application availability. However, these systems are sometimes complex and expensive to manage. In addition, they are often single platform, restricting access to data across the network. To improve data access and reduce costs, IT managers are now seeking innovative ways to simplify storage management. The storage area network (SAN) is a promising solution.

What Are the Benefits of a SAN?

Storage area networks remove data traffic, like backup processes, from the production network giving IT managers a strategic way to improve system performance and application availability. Storage area networks improve data access. Using Fibre Channel connections, SANs provide the high-speed network communications and distance needed by remote workstations and servers to easily access shared data storage pools.

IT managers can more easily centralize management of their storage systems and consolidate backups, increasing overall system efficiency. The increased distances provided by Fibre Channel technology make it easier to deploy remote disaster recovery sites. Fibre Channel and switched fabric technology eliminate single points of failure on the network.

With a SAN, virtually unlimited expansion is possible with hubs and switches. Nodes can be removed or added with minimal disruption to the network. By implementing a SAN to support your business you can realize the following:

(1) Improved administration: Consolidation and centralized management and control can result in cost savings. Any-to-any connectivity, advanced load balancing systems and storage management infrastructures can significantly improve resource utilization.

(2) Improved Availability: With a SAN, high availability can be provided at lower cost.

(3) Increased Business Flexibility: Data sharing is increased while the need to transform data is reduced.

A SAN (Storage Area Network) is a dedicated high performance network to move data between heterogeneous servers and storage resources. Being a separate dedicated network, it avoids any traffic conflict between clients and servers. A fibre channel based SAN combines the high performance of an I/O channel (IOPS and bandwidth) and the connectivity (distance) of a network.

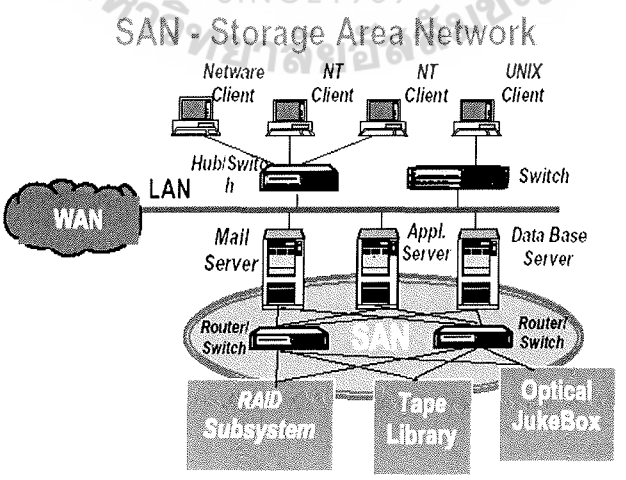


Figure 3.7. SAN Dedicate Storage Area Network Dedicate to Data Movement between Servers and Storage or between Diverse Storage Devices or between Any Nodes Attached to the SAN.

To interconnect distributed systems over distance, IT system administrators have been forced to use Fast Ethernet links which are terribly inefficient because of large packet overhead (associated with small 1500 byte transmission packets) and high latency. In smaller computer room environments, short, thick and unwieldy spaghetti of SCSI wires or OEMI copper cables in mainframe environments to connect storage to servers are commonplace.

Adopting SAN technology through the use of Fibre Channel and hubs and switches allows high speed server to storage, storage to storage or server to server connectivity using a separate network infrastructure mitigates problems associated with existing network connectivity. SAN have also the potential to allow cable lengths up to 500 meters today and up to 10 km in future so servers in different buildings can share external storage devices. And because the new emerging SAN/VIA (virtual interface architecture) interconnects have low latency and lesser overhead as compared to traditional LAN/WAN networks, they are ideally suited for clustering and mirroring/replication applications. The capability of connecting existing SCSI devices to SAN using SCSI to Fibre Channel bridges also preserves investments made in existing storage devices. This will help fuel growth of SAN infrastructures.

Performance

SAN enables concurrent access of disk or tape arrays by two or more servers at high speeds across fibre channel(1GB/ Sec, 2GB/ Sec), providing much enhanced system performance.

Availability

SAN has disaster tolerance built in since data can be mirrored using FC SAN up to 10 km. away.

Cost

Since SAN is an independent network, initial costs to set up the infrastructure would be higher but the potential exists for rapid cost erosion as SAN installed base increases.

Scalability

Scalability is natural to SAN architecture, depending on the SAN network management tools used.

Interoperability

Like a LAN/WAN it can use a variety of technologies such as serial SCSI, ESCON, FICON, SSA, ATM, SONET etc. This allows easy relocation of backup data, restore operations, file migration and data replication between heterogeneous environments.

Manageability

(1) Data centric

(2) Part of Server cluster

(3) Thin protocol for low latency

(4) DMA to server RAM - direct communication to Data

Future of SAN

(1) Embedded and Distributed File System

(2) Intelligent SAN-smart File System where portion of File System is in SAN

(3) Data routing

(4) Storage network management

(5) Concurrent processing and manipulation of intelligent data streams

(6) Server Independent Storage Tasks

(7) Peer to Peer copying

(8) Peer to Peer backup

(9) Automatic back up using Fibre Channel

(10) Data Sharing, Data Formatting

(11) Security - Authorization, Authentication, Access Control

SAN technology, in future, may also interconnect worldwide with other SAN intranet sites to provide instantaneous replication of corporate data to these remote sites to create a global information system. This would allow local access to fast while being up-to-date.

Challenges

As with all new technologies, SAN developments must rapidly happen in areas of data management, security features, interoperability test suites, availability of VI adapters to improve latency between interconnected servers and the availability of SCSI/Fibre Channel bridges.

The ability to manage SAN is as vital as having the speed and distance benefits of SAN. Unless the storage management features are built into the operating systems, customers end up buying them from server vendors or third parties who in turn license them to the server vendors. To simplify management, SAN vendors need to adopt SNMP and WBEM type standards to monitor, alert and manage data on SAN networks, also the need for dynamic logical partitioning of different network operating systems being managed by the centralized console. Since there are a number of different devices from different vendors, the big challenge facing system administrators end up to make sure that they are interoperable and have one centralized management tools (such as HP Open View) and with which other management software packages are compatible with.

The lack of SAN optimized applications, management utilities, fault-tolerance features and full plug-and-play interoperability at this time are the caveats and cautions for administrators to use before plunging into adopting SAN.

I/O Performance – SAS vs. NAS vs. SAN

In a distributed and networked environment, NAS allows better performance as measured by the response time of user queries, as the number of user increases. This is based on the independence of NAS from burdening other application servers and sporting a dedicated light OS to move files.

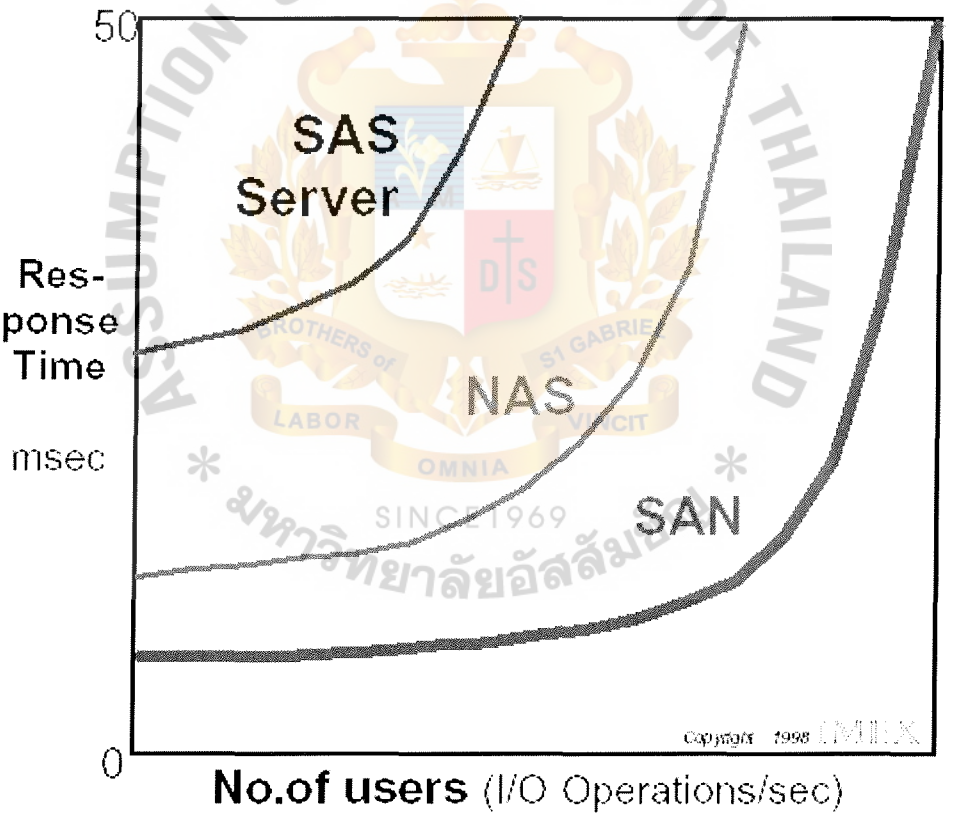


Figure 3.8. Performance of SAS vs. NAS with Increasing Number of Users.

The SAN related curve shown in the graph relates to the potential benefit the SAN/Fibre Channel architectures will bring in the future.

The figure bellow summarizes the comparisons between SAS, NAS and SANs. There is a wide proliferation of low cost NAS products to serve the exploding Web Server market. Additional benefits of NAS for Web Servers accrue when using load balancing and web caching technologies.

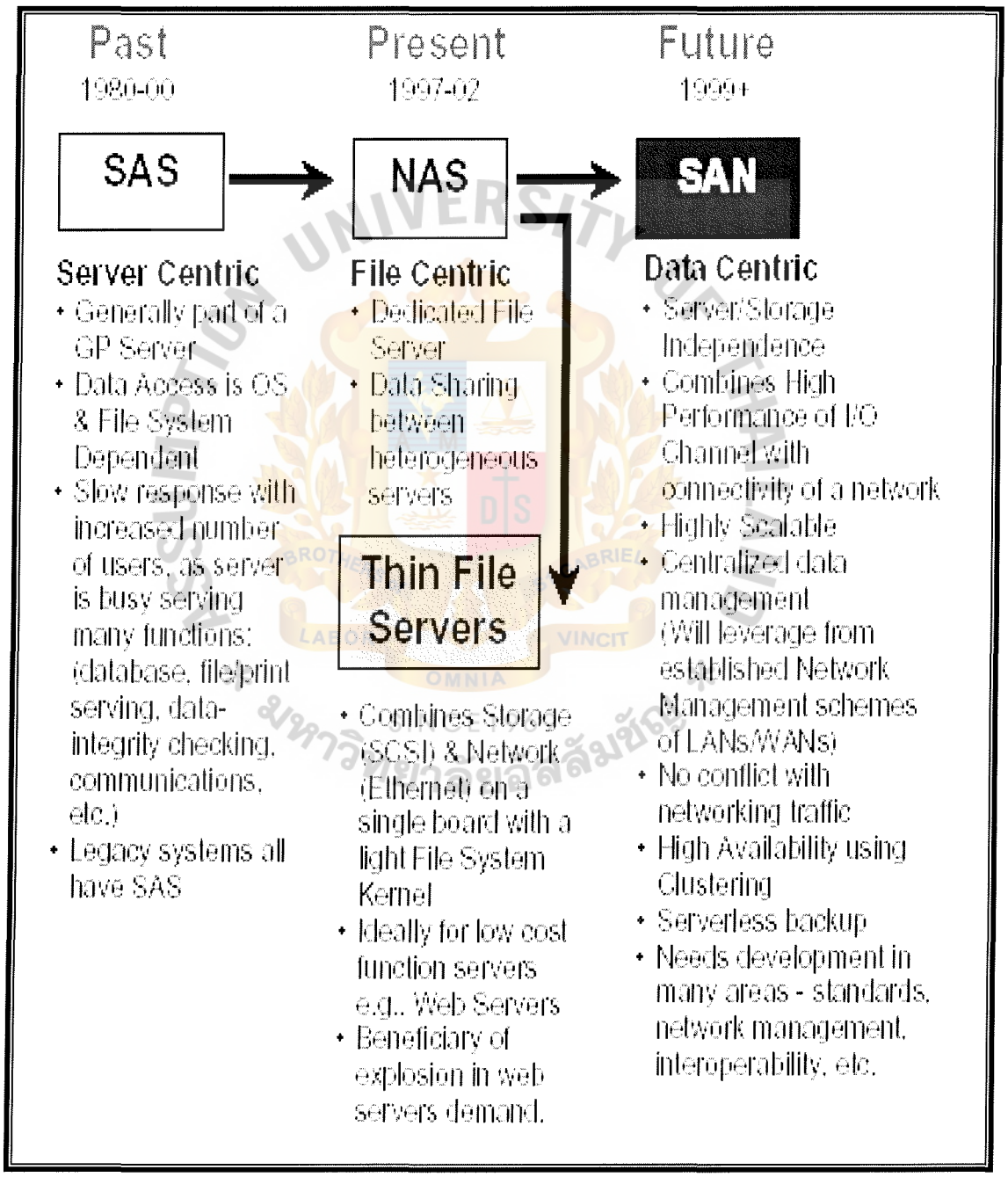


Figure 3.9. SAS vs. NAS vs. SAN – The Past, Present and Future of Storage Servers.

Market Outlook for Storage Subsystems, SAS, NAS and SAN

The market for Storage Subsystems is concentrated in top 10 players.

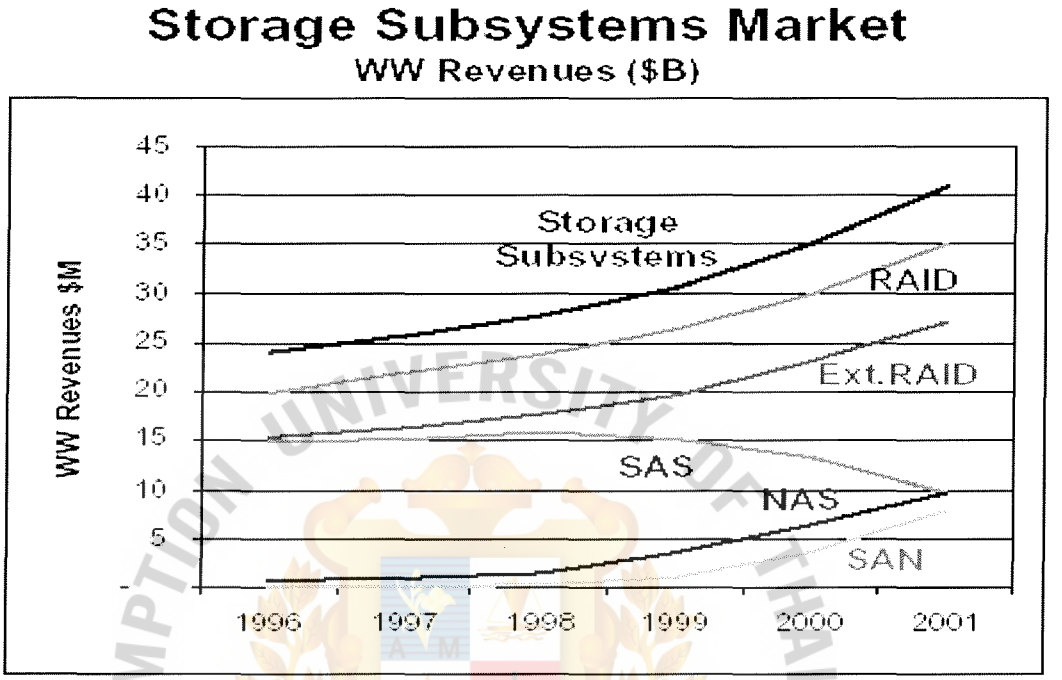


Figure 3.10. The Future Trend of SAS, NAS and SAN.

The top 3 players includes Compaq (including DEC acquisition), IBM and EMC alone control 50% of the market. Internal RAID is being led by Compaq, HP and Dell servers.

Network attached storage has started to materialize led by Network Appliance at the High end and Meridian Data/Snap products at the lower end. SAN fibre channel products are increasingly being introduced in the market including fibre-channel adapters, hubs, switches and routers, SCSI/FC bridges, disk drives and testers from multiple sources.

The advantages and popularity of FC/SAN the leading data networking vendors like 3COM have jumped in to embrace the technology. Not far behind would be major players like CISCO, Lucent and Nortel/Bay Networks eyeing the convergence of voice and data networks and associated centralized database servers for interactive voice response and e-commerce applications for the global marketplace.

3.2 Simulation

Case Study of an ABC Company in Implementing Network Attached Storage

An ABC company is doing e-business online. They have got some problems about explosion of data in web server (Unix platform using Linux). Now they have data about 100 GB and their data will increase about 30% each year. They have many platforms using in their business such as Linux, NT and Sun Solaris in their business. Regarding to their problems they have 2 solutions to solve this problem.

1st Solution: Consider for purchasing New Server and hiring an administrator to take care the Unix platform.

2nd Solution: Consider for purchasing External Storage to keep their data

The following graph will show you the comparison between investments of 2 choices.

Table 3.2. Comparing between NAS 200 and X Series Accumulate Cost.

Year	NAS 200 Accumulate Cost	Accumulate cost of buying new server (3+4)	Buying new Server (3)	Accumulate cost of buying new server and hiring and admin. (4)	Amount of Data increase about 30% each year (GB)	No of Disk using (36.4 GB)
1	400,000	350,000	350,000	0	100	3
2	430,000	350,000	350,000	0	130	4
3	460,000	494,000	350,000	144,000	169	5
4	520,000	914,000	770,000	144,000	220	7
5	550,000	914,000	770,000	144,000	286	8
6	580,000	914,000	770,000	144,000	372	11
7	680,000	1,418,000	1,274,000	144,000	484	14

Suppose that the company will hire the systems administrator at year three due to increasing of data. And the monthly income that they will pay is 12,000 per month so the total expense that will be increase for the company will be 144,000 per year.

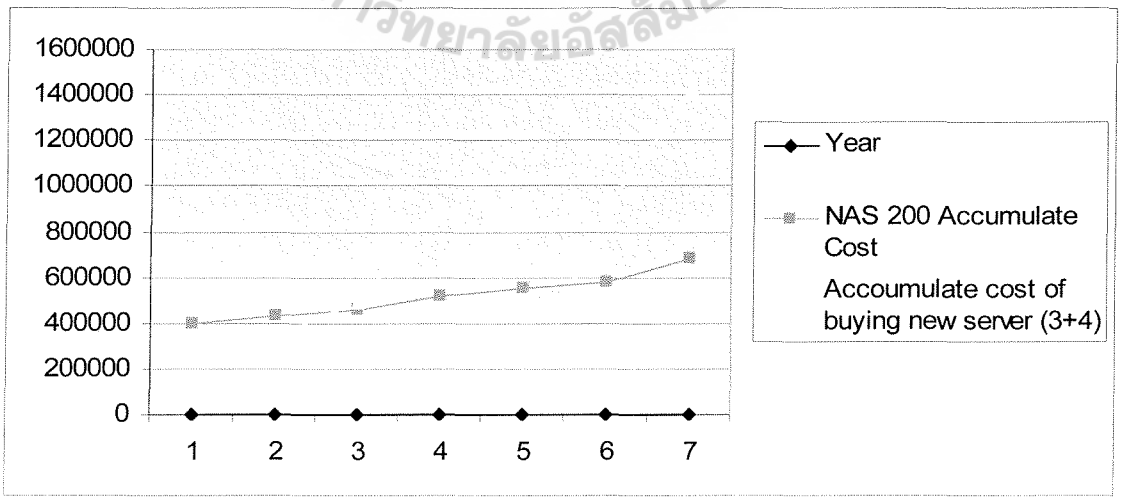


Figure 3.11. Comparing between NAS 200 and X Series Accumulate Cost.

From the graph it will show that you will get return of the investment after year three. Due to comparing the investment cost I would recommend ABC Company to purchase external storage. The Network Attached Storage consists of network attached storage appliances that come standard with CIFS and NFS support for use in heterogeneous environments. With IBM NAS 200 Series can be one of your external network attached storage choice.

The Solution can help you to:

(1) Achieve economies of scale

(2) Efficient resources management

(3) Increase flexibility for multiple platforms

(4) Enhance scale ability to easy accommodate growth

The IBM NAS 200 tower, with its tuned Windows Powered OS, is designed to provide a high performance solution for Windows (CIFS) as well as mixed Windows and Unix environments in workgroups and branch office environments. With a maximum raw disk capacity of 1.69 TB, the tower version of NAS 200 provides investment protection for those who require a scalable workgroup storage solution.

The following graphs illustrate the performance capabilities of NAS 200 tower model for CIFS environments. The graph below shows that the CIFS performance (throughput) continues to increase as more clients make requests until the maximum performance of 43 Mbytes/sec is reached at 8 clients. As more than 8 clients are added the performance stabilizes between 35 – 40 Mb/sec.

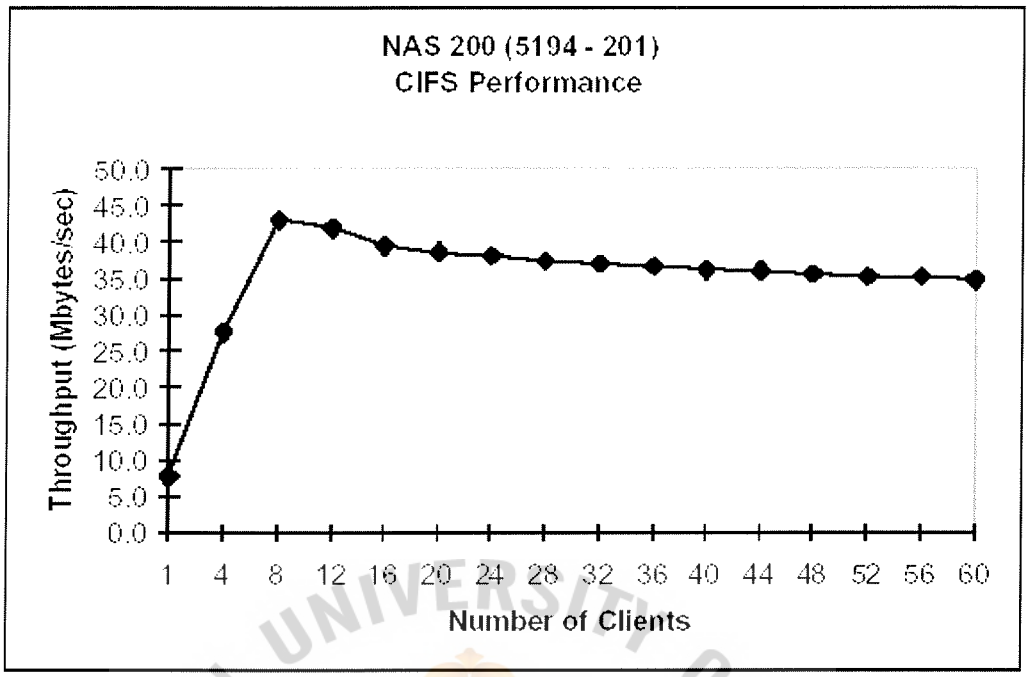


Figure 3.12. NAS Performance (Throughput) due to the No. of Clients Makes Requests.

The graph below show the CIFS Average response Time, which starts at less then 0.5 milliseconds for one client and increases to only 3.5 milliseconds for 60 clients.

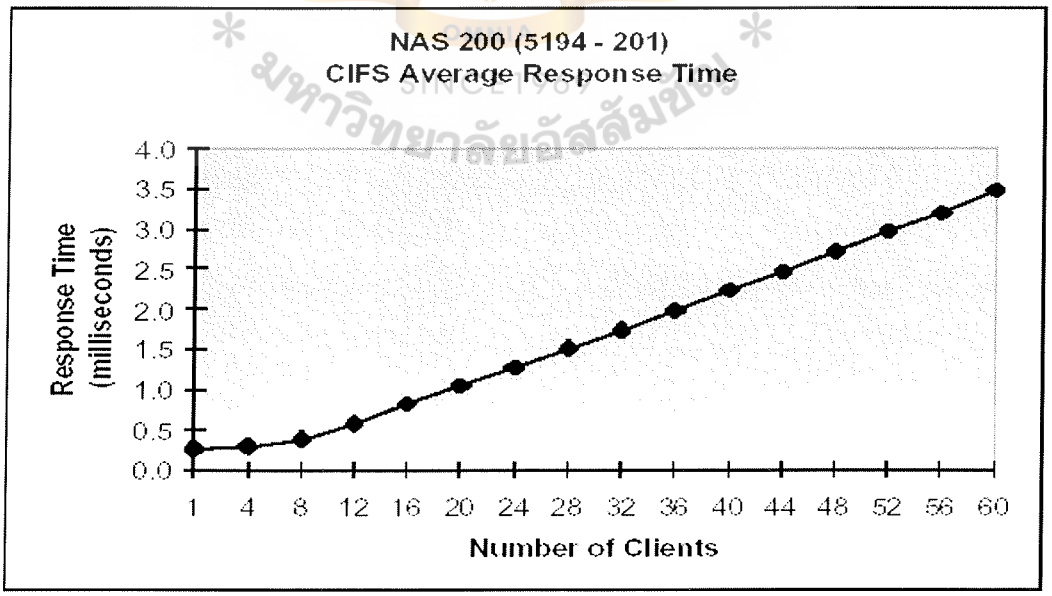


Figure 3.13. Throughput Response Time Depend on Number of Clients.

The throughput and response time of NAS 200 Model 201 illustrate its capability to provide excellent performance for users accessing a network drive in a workgroup environment. More than 60 clients can access NAS at one time.

High Availability, the Next Frontier for Computing Systems

One of the key factors necessary for open systems to succeed in enterprise environments, despite inroads made in price/ performance areas, is high availability. Given the ever increasing mission critical nature of almost every computing task, high availability ranks at the top of the list today for enterprise data center administrators.

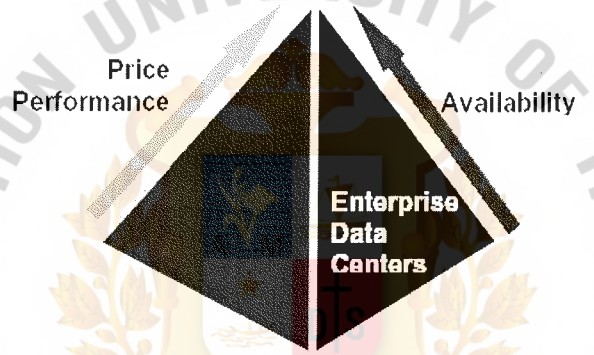


Figure 3.14. The Relation of Price Performance and Availability.

ROI on High Availability

Achieving continuous availability has been the main mission of mainframe s/390 and proprietary computers. While the price/performance/availability afforded by UNIX computers have achieved remarkable success, NT clustering is being adopted by at least 20 major server manufacturers. Given their expertise in mainframe and UNIX type computing, it would not be long before the clustered NT solutions not only provide the performance but the cascaded high availability from cluster of multimode servers.

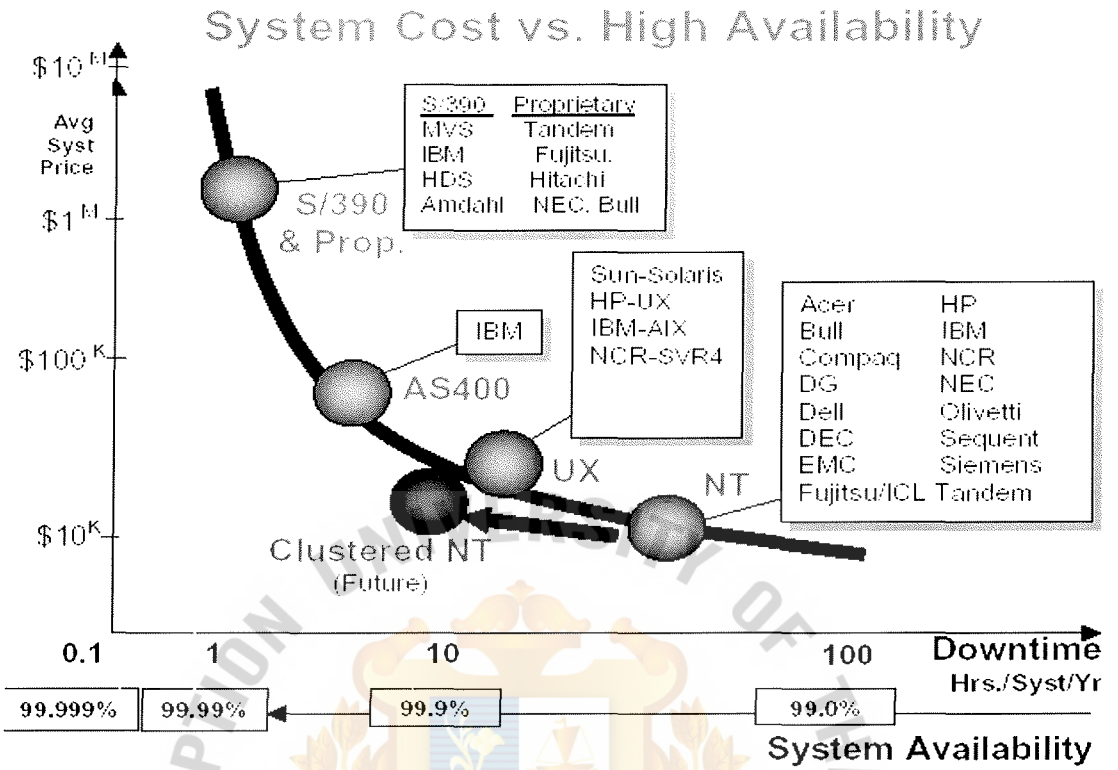


Figure 3.15. Cost of Systems VS High Availability.

While NAS will succeed more in the low end dedicated to providing plug and play solutions, SANs would be embraced strongly by the enterprise starting with multimode clusters running Oracle OPS and SQL type of parallel databases. It would proliferate to initially coexist and then displace SAS and NAS architectures. Its real strengths will come from centralized SAN connected to remote SANs in Global 2000 and Fortune 1000 enterprises doing global electronic commerce.

IV. CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

For one, new technologies emerge and evolve but don't replace the investment in previous technologies overnight. And no single storage networking approach solves all problems or optimizes all variables. There are tradeoffs in cost, ease-of management, performance, distance and maturity, to name a few of these variables. For the foreseeable future, multiple storage network alternatives will coexist—often within the same organization.

The benefits of the major types of processor-to-storage connectivity can be briefly summarized as:

(1) "DAS" (Direct Attached Storage): DAS is optimized for single, isolated processors and low initial cost.

(2) "SAN" (Storage Area Network): SAN is optimized for performance and scalability. Some of the major potential benefits include support for high-speed Fibre Channel media which is optimized for storage traffic, managing multiple disk and tape devices as a shared pool with a single point of control, specialized backup facilities that can reduce server and LAN utilization and wide industry support.

(3) "NAS" (Network Attached Storage): NAS is optimized for ease-of-management and file sharing using lower-cost Ethernet-based networks. Installation is relatively quick, and storage capacity is automatically assigned to users on demand.

Now you can decided on the components and the topology in your SAN you can pull them together. You may decide to implement a very simple solution until you have become used to the SAN infrastructure.

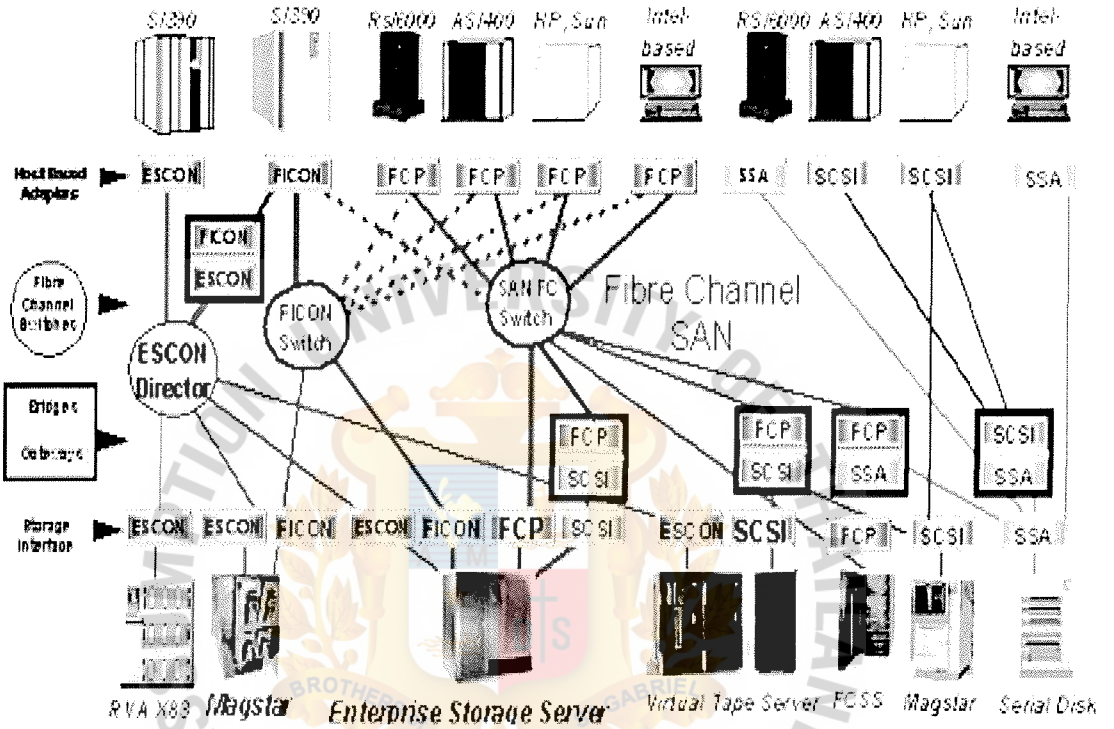


Figure 4.1. Illustrate Complex Diagram of SAN.

4.2 Recommendations

Nowadays, SME are using information technology to create competitive advantage among their competitors. The proposed systems can improve High Availability of the system and protecting your data, better performance, interoperability with multi-platform, scalability with the reasonable investment.

Storage management is a factor that is very critical for your business, it is Asset Information of any company which can turn to business value to your company as a result the EDP/CIO should set up a long term plan for the company for IT direction to

enhance the entire system and storage management to protect critical asset of your company that is "Database". Choosing Storage you have to consider Storage life time and also performance such as high speed access disk.

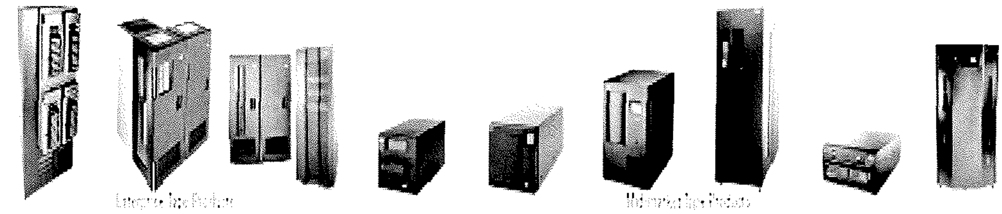
Storage Resource Management provides centralized management of storage resources for multiplatform. This leading cross platform solution centrally analyzes, manage, reports, schedules and centralized environments in the enterprise. Comprehensive support exists for leading applications, databases, devices and systems to enable complete end-to-end resource management.

Storage networking offers significant capabilities and flexibilities not previously available, and understanding the technology basics is essential to making the best choices.

APPENDIX A

STORAGE PRODUCTS

Table A.1. IBM Removable Media Storage Products.



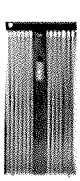
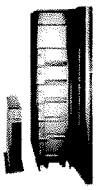
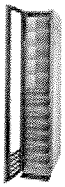
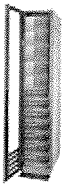
	3590	3494	3494-VTS	3580	3581	3583	3584	3570	3575
Description	1/2" Enterprise Tape Drive	1/2" Cartridge Tape Library	Virtual Tape Server	LTO Ultrium Tape Drive	LTO Ultrium Tape Autoloader	LTO Ultrium Scalable Library	LTO Ultrium Ultra Scalable Tape Library	Magstar MP Tape Subsystem	Magstar MP Tape Library Dataserver
Machine Model	**3590** B1A/E1A/H1A Library B11/E11/H11 Rack	**3494 (frames)** L10, L14 Library D10, D14 Library Frame S10 Storage HA1 High Availability	**3494** B10, B20	**3580** H11 L11	**3581** H17 L17	**3583** L18-18 Carts L36-36 Carts L72-72 Carts	**3584** L32 Base Frame D32 Expansion Frame	**3570** C00 Drive only C01 Desktop C02 Desktop C11 Rack mount C12 Rack mount	**3575** L06-60 Carts L12-120 Carts L18-180 Carts L24-240 Carts L32-324 Carts
Product Strengths	Capacity performance reliability	Modular cartridge automation for high-volume storage	Virtual tape and peer-to-peer copy	Open systems attach high capacity streaming data rate	Open systems attach high capacity streaming data rate	Open systems attach scalable, high capacity streaming data rate	Open systems attach, multiplatform ultra-scalable, high capacity	Automation designed for fast data access	Multiplatform multipath and multihomed
Technology	Longitudinal Serpentine		Disk Emulated Tape Tape 3590	Longitudinal Serpentine	Longitudinal Serpentine	Longitudinal Serpentine	Longitudinal Serpentine	Longitudinal Serpentine	Longitudinal Serpentine
# Heads/Tracks	B: 16/128 E: 16/256 H: 16/384	Drive Dependent	N/A	8/384 Yes	8/384 Yes	8/384 Yes	8/384 Yes	8/128 Yes	8/128 Yes
Number of Drives	1	1-32 SCSI FC 1-76 ESCON/FICON or 3590 Fibre mix	64-256 (virtual)	1	1	1-6	1-72	C00/C01/C11 1 C02/C12 1-2	L06: 1-2 L12: 1-4 L18/L32: 1-6
Max Number of Cartridges	10 per autoloader	6,240	500,000 (virtual volumes)	1	7	72	2,481	20	60-324
Cartridge Capacity Native/Compressed	B: 10/30GB BX: 20/60GB E: 20/60GB EX: 40/120GB H: 30/90GB HX: 60/180GB	Drive Dependent	400/1200MB 800/2400MB	100/200GB	100/200GB	100/200GB	100/200GB	CXL: 7/21GB C: 5/15GB	CXL: 7/21GB C: 5/15GB
Max System Capacity Compressed	B11: 300/900GB E11: 600/1200GB H11: 900/1800GB	H: 561TB HX: 1122TB	Disk up to 5.2TB Tape 748TB	200GB	1.4TB	14.4TB	496TB	CXL: 420GB	CXL: 6.8TB
Max Drive Data Rate/Sec Native/Compressed	B: 9/27MB E: 14/42MB H: 14/42MB	Drive Dependent	VTS up to 280MB/s	15/30MB	15/30MB	15/30MB	15/30MB	7/15MB	7/15MB
Time to Data	Model Dependent	Drive Dependent	VTS 1-5 seconds if data in VTS Cache	95 sec	95 sec	95 sec	95 sec	19 sec	29 sec
Interface	SCSI-2 F/W, Diff PCI, Ultra SCSI FC, ESCON, FICON	SCSI-2 F/W, Diff PCI, Ultra SCSI FC, ESCON, FICON	Ultra SCSI, ESCON FICON	LVD-LVD HVD-HVD	LVD-LVD HVD-HVD	LVD-HVD	LVD-HVD	SCSI-2 F/W Diff PCI	SCSI-2 F/W Diff PCI, Multiport Logical Lib Capability
SAN-Ready	pSeries, iSeries, RS/6000, Sun, HP, Windows NT, Linux, Windows 2000, Tru64 UNIX	pSeries, iSeries, RS/6000, Sun, HP, Windows NT, Linux, Windows 2000, Tru64 UNIX	pSeries, RS/6000, Windows NT, Windows 2000, Sun	pSeries, RS/6000, Windows NT, Sun	pSeries, RS/6000, Windows NT, Sun	pSeries, RS/6000, Windows NT, Sun	pSeries, RS/6000, Windows NT, Sun	pSeries, RS/6000, Windows NT, Sun	pSeries, RS/6000, Windows NT, Sun
Supported Platforms	iSeries, AS/400, pSeries, RS/6000, zSeries, S/390, Tru64 UNIX, Linux, Windows NT, Windows 2000, Sun, HP	iSeries, AS/400, pSeries, RS/6000, zSeries, S/390, Linux, Windows NT, Windows 2000, Sun, HP	pSeries, RS/6000, zSeries, S/390, Windows NT, Windows 2000, Sun, HP	xSeries, Netfinity, iSeries, AS/400, pSeries, RS/6000, Windows NT, Windows 2000, Sun, HP, Linux	xSeries, Netfinity, iSeries, AS/400, pSeries, RS/6000, Windows NT, Windows 2000, Sun, HP, Linux	xSeries, Netfinity, iSeries, AS/400, pSeries, RS/6000, Windows NT, Windows 2000, Sun, HP, Linux	xSeries, Netfinity, iSeries, AS/400, pSeries, RS/6000, Windows 2000, Sun, HP, Linux	xSeries, Netfinity, iSeries, AS/400, pSeries, RS/6000, Windows NT, Windows 2000, NetWare, Sun, HP	xSeries, Netfinity, iSeries, AS/400, pSeries, RS/6000, Windows NT, Windows 2000, NetWare, Sun, HP
ISV-Independent Software Vendor	Model Dependent	A B D E F G H I J K L M		A C D E F G H I J L N	A C D E F G H I J L N	A C D E F G H I J L N	A C D E F G H I J L N	A B C D E F G H I J K L M	A B C D E F G H I J K L
Media Part number 1-800-IBM-Media	05H4434 X: 05H3188	05H4434 X: 05H3188	05H4434 X: 05H3188	08L9120	08L9120	08L9120	08L9120	08L6187-5GB 08L6663-7GB	08L6187-5GB 08L6663-7GB
Warranty	IBM On-Site Repair One Year, 24x7	IBM On-Site Repair One Year, 24x7	IBM On-Site Repair One Year, 24x7	IBM On-Site Exchange One Year, 9-5	IBM On-Site Exchange One Year, 9-5	IBM On-Site Repair One Year, 24x7	IBM On-Site Repair One Year, 24x7	IBM On-Site Repair Three Years, 24x7	IBM On-Site Repair One Year, 24x7

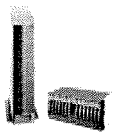
Table A.1. IBM Removable Media Storage Products. (Continued)

Complementary Storage Products

	7204	7206	7206-VX2	7332	7208	7334	7205	7337	7329	7207	7212
Description	External Disk Drive	4mm DDS 2,3,4 Tape Drive	4mm DDS 2,3,4 Tape Drive	4mm DDS 3,4 Tape Autoloader	8mm Mammoth Tape Drive	8mm Mammoth 2 Tape Library	Digital Linear Tape (DLT) Drive	Digital Linear Tape (DLT) Library	SLR100 Autoloader	QIC compatibility	Storage Device Enclosure
Machine Model	7204 409: 9.1GB 419: 18.2GB 512: 18GB 536: 36GB	7206 110: DDS3 220: DDS4	7206 VX2	7332 110: DDS3 220: DDS4	7208 341: Mammoth 1 342: Mammoth 1 345: Mammoth 2	7334 410	7205 440	7337 360 Desktop or Rack mount	7329 308	7207 122	7212 102
Product Strengths	External deskside disk storage	Cost effective streaming tape drive	Cost effective high capacity DDS 4 drive	Autoload tape cartridges into DDS 4 drive	High performance 8mm technology	High performance 8mm technology	Cost effective save restore archive solution	Large capacity library offers flexibility and scalability	Compatible with QIC	Backward read write	Rack mountable 2 drive enclosure utilizes only 1U (1.75") of space
Technology	N/A	Helical Scan		Helical Scan	Helical Scan	Mammoth 2 Helical Scan	Longitudinal Serpentine	Longitudinal Serpentine	SLR	QIC	DDS 4, DVD RAM, CD ROM
# Heads Tracks Servo Tracking?	N/A	Rotating Drum No	N/A	Rotating Drum No	Rotating Drum No	Rotating Drum No	4 208 No	4 208 No	4 192 Yes	1 1 No	Rotating Drum DDS 4 No
Number of Drives	1	1	1	1	1	1-4	1	1 up to 6	1	1	1-2
Max Number of Cartridges	N/A	1	1	110: 1 220: 6	1	30	1	60	8	1	2
Cartridge Capacity Native Compressed	N/A	110: 12/24GB 220: 20/40GB	20GB (non compressed) 40GB (compressed) on 23M tape	110: 12/24GB 220: 20/40GB	341: 20/40GB 342: 20/40GB 345: 60/150GB	60/150GB	440: 40/80GB	40/80GB	50GB/100GB	4GB/8GB	20/40GB DDS 4
Max System Capacity Compressed	409: 9.1GB 419: 18.2GB 512: 18GB 536: 36GB	110: 24GB 220: 40GB	system adapter dependent for max number of devices	110: 36GB 220: 240GB	341: 40GB 342: 40GB 345: 150GB	4.5TB	440: 80GB	4.8TB	100GB/800GB	4GB/8GB	40/80GB (with 2 DDS 4 drives)
Max Drive Data Rate/Sec[1] Native Compressed	320MB	110: 1/2MB 220: 3/6MB		110: 1/2MB 220: 3/6MB	341: 3/6MB 342: 3/6MB 345: 12/30MB	12/30MB	440: 6/12MB	6/12MB	5MB/10MB	.38MB/.76MB	3/6MB DDS 4
Time to Data[2]	7ms	N/A	TBD	60 sec.	341: 87 sec. 342: 87 sec. 345: 93 sec.	93 sec.	440: 100 sec.	115 sec.	80 sec.	65 sec.	N/A
Interface	SCSI 2, SCSI-3 LVDSE	SCSI 2 F/W SE, SCSI Ultra2 SCSI LVD SE		SCSI 2 F/W SE, LVD SE	341: SCSI 2 F/W Diff 342: SCSI FC 6534 or 2729 345: SCSI 2 Ultra2 LVD	SCSI 2 Ultra2 LVD	SCSI 2 F/W Diff PCI Ultra2 SCSI LVD	Ultra2 SCSI LVD	Ultra SCSI 2, single ended	SCSI 2, SE	SE Ultra SCSI Ultra2 SCSI, Ultra3 SCSI
SAN Ready[3]			No					pSeries, RS/6000	No	No	
Supported Platforms[4]	pSeries, RS/6000	pSeries, RS/6000 Sun, HP, DEC	pSeries	pSeries, RS/6000 Sun, HP	341: pSeries, RS/6000 342: iSeries, AS/400 345: pSeries, RS/6000, iSeries, AS/400	pSeries, RS/6000	pSeries, RS/6000	pSeries, RS/6000, Windows NT or [illegible]	iSeries, AS/400	iSeries, AS/400 pSeries, RS/6000	pSeries, RS/6000
ISV Independent Software Vendor[5]		A,B,C,E	N/A	A,B,C,E	A,B,C,E,J	A,B,C,D	A,B,C,E	A,B,D,E,F,G,H	A,B,C,D	A,B,C,D	Varies

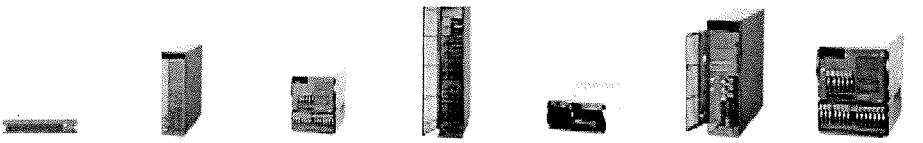
Table A.2. IBM Disk Storage Products.



	2105	7133	1742	3552	3542	2104
Description	Enterprise Storage Server	Serial Disk System	FASTT700 Storage Server	FASTT500 Storage Server	FASTT200 Storage Server	EXP Plus
Model	800	D40, T40	1RU	1RU	1RU, 2RU	E10, 1U3
Platform Support	6S/400™, AIX™, Solaris™, HP-UX™, Digital, DG/UX™, OpenVMS™, Intel™, Windows NT®, Windows 2000, NetWare®, Linux® for S/390, z/OS™, AIX, OS/390™, VM/ESA®, VSE/ESA™, MVS/ESA™, IBM, Linux commercial distributions	AIX, Windows NT, Windows 2000, Solaris, HP-UX and many others	Windows NT, Windows 2000, NetWare, Linux, AIX, HP-UX, Solaris supported	AIX, Windows NT, Windows 2000, NetWare, Linux, HP-UX, Solaris	AIX, Windows NT, Windows 2000, Digital, HP-UX, Linux, NetWare, Solaris	AIX
Host Connectivity	ESCON®, FICON®, 2Gbit FC-AL, Fibre Channel, SCSI	SSA, Fibre Channel, SCSI	Fibre Channel	Fibre Channel	Fibre Channel	Ultra3 SCSI
SAN Support	Direct, FC-AL, Switched Fabric	FC-AL, Switched Fabric	Direct, FC-AL, Switched Fabric	Direct, FC-AL, Switched Fabric	Direct, FC-AL, Switched Fabric	N/A
Copy Services	Remote Copy (PPRC & XRC), FlashCopy, Concurrent Copy	Remote Copy up to 160km, 3-way copy, Instant Copy	Remote Copy, FlashCopy	Remote Copy, FlashCopy	Remote Copy, Snapshot via FlashCopy	N/A
Availability Features	Fault tolerant, RAID, redundant power cooling, hot-swap drives, dual controllers, concurrent microcode update, dual pathing driver	Fault tolerant, RAID, redundant power cooling, hot-swap drives, dual adapters, enclosure services, dual pathing driver	Fault tolerant, RAID, redundant power cooling, hot-swap drives, dual controllers, concurrent microcode update capability, dual pathing driver	Fault tolerant, RAID, redundant power cooling, hot-swap drives, dual controllers, concurrent microcode update capability, dual pathing driver	Fault tolerant, RAID, redundant power cooling, hot-swap drives, dual controllers, concurrent microcode update capability, dual pathing driver	RAID, redundant power cooling, hot-swap drives, enclosure services
Controller	SMP, dual active	Single, Multiple active adapters	Dual active	Dual active	Single, Dual active	Adapters in server
Cache: min, max	8GB, 64GB	0, 32MB write and 16MB read	2GB, 2GB	512MB, 1GB	128MB, 256MB	N/A
RAID Support	5, 10	0, 1, 5, 10 using adapters; 1, 10	0, 1, 3, 5, 10	0, 1, 3, 5, 10	0, 1, 3, 5, 10	0, 1, 5 using server-based adapters
Capacity: min, max	580GB, 27.9TB (physical capacity)	36GB, 7TB	36GB, 16.4TB Both w/in EXP700	36GB, 16.4TB Both w/in EXP500	18GB, 4.3TB w/in EXP500	9GB, 1TB
Drive Interface	SSA, SCSI	SSA	FC-AL	FC-AL	FC-AL	Ultra3 SCSI
Drive Support	18GB, 36GB, 72.8GB	9GB, 18GB, 36GB and 72.8GB 10,000 rpm disk drives	36.4GB and 73.4GB 10,000 rpm (2Gbps FC) 18.2GB and 36.4GB 15,000 rpm (2Gbps FC)	18GB, 36GB, 73GB	18GB, 36GB, 73GB	9GB, 18GB, 36GB and 73GB 10,000 rpm disk drives
Certifications	Microsoft® RAID, Cluster and Data Center, HACMP, Novell NetWare®, Linux	Microsoft RAID and Cluster, HACMP	Microsoft RAID, Cluster and Data Center	Microsoft RAID, Cluster and Data Center	Microsoft RAID, Cluster	HACMP

Table A.3. IBM Network Attached Storages.



	IBM NAS 100	IBM NAS 200-201	IBM NAS 200-226	IBM NAS 300	IBM NAS 300G	IBM IP 200i-110	IBM IP 200i-210
Model	5194-1RZ (10)	5194-201 (tower)	5194-226 (rack)	5195-326 (rack)	5195-G01 (326)	4125-110 (tower)	4125-210 (rack)
Scalability	480GB	1.69TB	3.52TB	109.2GB—6.0TB	1.1TB-22TB	109.2GB—440.4GB	109.2GB—3.52TB
Engines	1 nonclustered	1 nonclustered	1 nonclustered	2 clustered	1-2 clustered	1 nonclustered	1 nonclustered
Processors	One 1.26GHz Pentium III with 133MHz front-side bus	Up to two 1.13GHz Pentium III with 133MHz front-side bus	Two 1.13GHz Pentium III with 133MHz front-side bus	Dual 1.13GHz Pentium III per engine with 133MHz front-side bus	Dual 1.13GHz Pentium III per engine with 133MHz front-side bus	one 1.13GHz Pentium III with 133MHz front-side bus	two 1.13GHz Pentium III with 133MHz front-side bus
I/O	File I/O Windows clients: CIFS UNIX clients: HTTP, FTP, Apple File Protocol and NetWare	File I/O Windows clients: CIFS UNIX clients: HTTP, FTP, Apple File Protocol and NetWare	File I/O Windows clients: CIFS UNIX clients: HTTP, FTP, Apple File Protocol and NetWare	File I/O Windows clients: CIFS UNIX clients: HTTP, FTP, Apple File Protocol and NetWare	File I/O Windows clients: CIFS UNIX clients: HTTP, FTP, Apple File Protocol and NetWare	Block I/O	Block I/O
Operating System	Windows OS	Windows OS	Windows OS	Windows OS	Windows OS	Linux kernel	Linux kernel
Performance (as of 8-10-02)	43MB/sec CIFS	15MB/sec CIFS 2552 ops/sec NFS	50MB/sec CIFS 5660 ops/sec NFS	110MB/sec CIFS 8076 ops/sec NFS 65,540 ops/sec UNIX	601.59MB/sec CIFS; 5759 ops/sec NFS 626. 112MB/sec CIFS; 10671 ops/sec NFS		
PCI slots available	1	4	4	4/engine	5/engine	1	1
Network connectivity (default, single 10/100 Base-T Ethernet port)	2 (std)	1 (std), 7 (opt)	1 (std), 7 (opt)	0 (std), 4/engine (opt)	1 (std) nonclustered; 0 clustered; 4/engine (opt)	1	1
Quad 10/100 Base-T Ethernet ports		1 (opt)	1 (opt)	1 (opt)/engine	1-2 (opt)	1*	1*
Gigabit Ethernet ports	2 (std)	2 (opt)	2 (opt)	2 (opt)/engine	2-4 (opt)	1*	1*
ECC SDRAM memory (max)	512MB	Up to 2.5GB	Up to 3GB	Up to 2GB/engine (4GB total)	Up to 2GB/engine	Up to 1.5GB max	Up to 2GB max
Protocol attachment to HDD	ATA	SCSI	SCSI	Fibre Channel	Fibre Channel	SCSI	SCSI
Data protection	256 Persistent Image Data Views, instant volume restoration	256 Persistent Image Data Views, instant volume restoration and data mirroring	256 Persistent Image Data Views, instant volume restoration and data mirroring	256 Persistent Image Data Views, instant volume restoration and data mirroring	256 Persistent Image Data Views, instant volume restoration and data mirroring	RAID 0, 1, 1E, 5, 5E 2-channel	RAID 0, 1, 1E, 5, 5E 4-channel
Redundancy; high availability	Hot swap, redundant disk drives, two fail-over Gigabit Ethernet controllers, OS fail-over/OS mirroring	Hot swap, redundant power supplies and disk drives, Advanced Systems Management, Lightpath diagnostics, predictive failure analysis, remote connect automated paging	Hot swap, redundant power supplies and disk drives, Advanced Systems Management, Lightpath diagnostics, predictive failure analysis, remote connect automated paging	Dual engines, hot swap, redundant power supplies and disk drives, Advanced Systems Management, Lightpath diagnostics, predictive failure analysis, remote connect auto-mated paging, dual OS hard drives	Dual engines clustered model), hot swap, redundant power supplies and disk drives, Advanced Systems Management, Lightpath diagnostics, predictive failure analysis, remote connect auto-mated paging, dual OS with RAID level 1	Hot swap, redundant power supplies, hot swap fans, hot swap disk, Lightpath diagnostics	Hot swap, redundant power supplies, hot swap fans, hot swap disk, Lightpath diagnostics
Backup	Optional through Ultra2 SCSI PCI Adapter	Internal or External Tape (SCSI or FC)	Internal or External Tape (SCSI or FC)	External Tape (SCSI or FC)	External Tape (SCSI or FC)	Standard server procedures	Standard server procedures
RAID levels	0, 1, 5	0, 1, 1E, 5, 5E, 00, 10, 1E0, 50	0, 1, 1E, 5, 5E, 00, 10, 1E0, 50	0, 1, 3, 5	SAN disk dependent	0, 1, 1E, 5, 5E	0, 1, 1E, 5, 5E
Systems management	IBM Director Agent, ISM client, UAM, SNMP	IBM Director Agent, ISM client, UAM, SNMP	IBM Director Agent, ISM client, UAM, SNMP	IBM Director Agent, ISM client, UAM, SNMP	IBM Director Agent, ISM client, UAM, SNMP	SNMP	SNMP

APPENDIX B

STORAGE COMPARISON

Table B.1. Disk Storage Systems Comparison (Reliability and Availability).

	IBM ESS 2105-F20	EMC S000 Family	HDS 9910 9960	Amdahl Platinum 400	STK SVA 9500
RAID Level Supported	5,0	1,0	1+0,5	1	5
Parity Group	6D + 1P + 1S 7D + 1P	1D + 1P 3D + 1P	2D + 2D 3D + 1P	1D + 1P	11D + 2P + 1S
Spared Disk Pairs	4+	32	32	1	1
All disks can internally transfer data concurrently	Yes	No	No	No	Yes
Back plan disk technology	SSA	SCSI	FC-AL	SCSI	SSA
Number of disk per raidset group (more is better)	Up to 8	4	4	7	7
Redundancy					
Major Components	Yes	Yes	Yes	Yes	Yes
Dual AC Power	Yes	Yes	Yes	Yes	Yes
Dual DC Power	Yes	Yes	Yes	Yes	Yes
Cooling Fan	Yes	Yes	Yes	Yes	Yes
Cache					
Duplex Writes	Yes	No	Yes	Yes	Yes
Battery Backup	Yes	Yes	Yes	Yes	Yes
• Full System Cache Only	Both	Full System	Cache Only	Cache Only	Cache Only
• Battery Life	5 minutes+ 7 days	30 minutes	48 hours	4 days	4 days
Config Changes					
Dynamic by User	Yes	Limited	Yes	Yes	Yes
Non-Disruptive	Yes	Yes	Yes	Yes	Yes
Non-Disruptive					
Component Replacement	Yes	Yes	Yes	Yes	Yes
Hot-pluggable HDA	Yes	Yes	Yes	Yes	Yes
Microcode Updates	Yes	Yes	Yes	Limited	Limited
Pro-Active Maintenances					
Service Processors	2	1	1	1	2
Hot Spare Disks	2 per loop est. Max 16 volumes	Optional 2-8	1 per device est. Option up to 4 16	Optional 1-32	Standard 1 per RAID array
Remote Maintenances					
Call Home Function	Yes	Yes	Yes	Yes	Yes
Password Protected	Yes	Yes	Yes	Yes	Yes
Software	Standard No Charge	None	Hi-Track	Expert System Facility	?
Warranty					
Hardware	3 years	3 years	3 years	24 months	3 years
Software	3 years	90 days	3 months	?	90 days

Table B.2. Disk Storage Systems Comparison (Configurations and Scalability).

	IBM ESS 2105-F20	EMC 8430	EMC 8730	HDS 9910	HDS 9960	Amdahl Platinum 400	STK SVA 9500
Usable Capacity							172GB – 1.8TB (5)
• DDM 9GB (Min Max (RAID))	420GB – 840GB (5)	Not Supported	Not Supported	Not Supported	Not Supported	112GB – 755GB (1)	
• DDM 18GB (Min Max (RAID))	420GB – 5.6TB (5)	143GB – 1.7TB (1) 117GB – 1.2TB (S)	572GB – 6.8TB (1) 286GB – 3.4TB (1) 409GB – 5.1TB (S)	51GB – 552GB (1) 34GB – 374GB (1) 51GB – 552GB (5)	54GB – 6.4TB (1) 34GB – 4.2TB (1) 51GB – 6.4TB (5)	112GB – 1.4TB (1)	
• DDM 36GB (Min Max (RAID))	840GB – 11.2TB (5)	286GB – 3.4TB (1) 13GB – 1.7 TB (1) 214GB – 2.5TB (S)	1.1TB – 13TB (0) 572GB – 6.8TB (1) 859GB – 6.8TB (S)	Not Supported	Not Supported	112GB – 2.8TB (1)	
• DDM 73GB (Min Max (RAID))	4Q2001	286GB – 3.4TB (1) 143GB – 1.7TB (1) 214GB – 2.5TB (S)	2.3TB – 28TB (0) 1.1TB – 13.8TB (1)	136GB – 1.5TB (1) 204GB – 2.3TB (5)	136GB – 17TB (1) 204GB – 25TB (5)	Not Supported	
Cache							
Min-Max	8GB – 32GB	4GB – 32GB	4GB – 32GB	1GB – 16GB	2GB – 32GB	1GB – 12GB	4GB – 6GB
Separate NVS	384MB	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	64MB
Connectivity							
Total Host Connections	4 – 32	4 – 24	4 – 32	8 – 24	8 – 32	4 – 16	8 – 16
• ESCON Channel	4 – 32	8 – 24	8 – 32	8 – 24	0 – 32	4 – 16	8 or 16
• Parallel Channel	Not Available	Not Supported	Not Supported	Not Supported	Not Supported	4 – 16	Not Available
• SCSI Channel	4 – 32	8 – 24	8 – 32	0 – 24 via bridge	0 – 32 via bridge	2 – 12	4 – 16
• Fibre Channel	2 – 16	4 – 12	4 – 64	0 – 24	0 – 32	2 – 12	4 – 16
• FICON Channel	2 – 16	Not Supported	Not Supported	Not Supported	Not Supported	Not Supported	Not Supported
Performance							
Multipath (failover, load balancing) server software	IBM SDD (Free of Charge)			Hitachi Path Manager	Hitachi Path Manager	?	?
Parallel Access	PAV	No	No	No	No	No	No
SCSI Command Tag Queuing Support	Yes	No	No	No	No	No	No
Instant Copy feature	FlashCopy with Nocopy Function	TimeFinder	TimeFinder	ShadowImage	ShadowImage	No	SnapShot
DRC Solution in Synchronous mode (Synchronous Remote Copy)	PPRC	SRDF	SRDF	HRC	HRC	TDMF	PPRC
DRC Solution in Asynchronous mode (Asynchronous Remote Copy)	XRC	No	No	HXRC	HXRC	Yes	No
Configuration and Management							
Customer can re-config	Yes	No	No	?	?	?	?
Monitor and Configuration tools	StorWatch Specialist (Free), StorWatch Expert	ControlCenter	ControlCenter	Graph-Track LUN Manager	Graph-Track LUN Manager	No	IXFP, SVAA

Table B.3. Comparing FAStT (IBM) and StorageAge (HP).

	Without StorAge SVM			With StorAge SVM		
	FAStT 200	FAStT 600	FAStT 700	FAStT 200	FAStT 600	FAStT 700
Creates instant snapshot images?	Read only	Read only	Read only	Read/Write	Read/Write	Read/Write
Creates instant data copies (FlashCopy) on AIX, Solaris and HP-UX?	No	No	No	Yes	Yes	Yes
Copy or migrate data between IBM and non-IBM storage devices?	No	No	No	Yes	Yes	Yes
Can stripe data across multiple FAStT units for improved performance?	No	No	No	Yes	Yes	Yes
Supports large numbers of clustered servers on each FAStT?	No	No	No	Yes	Yes	Yes
Multi-path failover solution supports:						
FAStT and ESS simultaneously?	No	No	No	Yes	Yes	Yes
IBM and non-IBM storage devices?	No	No	No	Yes	Yes	Yes
Centrally manages data:						
Across multiple storage devices?	No	No	No	Yes	Yes	Yes
Across IBM and non-IBM devices?	No	No	No	Yes	Yes	Yes
Clustering support:						
Microsoft Cluster Services	✓	✓	✓	✓	✓	✓
Novell Cluster Services	✓	✓	✓	✓	✓	✓
IBM HACMP	—	✓	✓	✓	✓	✓
HP MC Service Guard	✓	✓	—	✓	✓	✓
Solaris 8 & Veritas Cluster Server	✓	✓	—	✓	✓	✓

Information subject to change without notice

Table B.4. IBM ESS VS EMC CLARiiON Family (Configuration and Scalability).

	IBM ESS 2105	EMC CLARiiON FC4700	EMC CLARiiON FC4500	EMC CLARiiON Model FC5700	EMC CLARiiON Model FC5300
Usable Capacity					
GB Min-Max	420GB - 11.2TB	36 GB - 4.32TB	36 GB - 4.32TB	36 GB - 4.32TB	36 GB - 1.08TB
RAID-0	Not Support	1-15 drives	1-15 drives	1-15 drives	1-15 drives
RAID-1	Not Yet	18GB - 2.12TB	18GB - 2.12TB	18GB - 2.12TB	18GB - 536MB
RAID-3	Not Support	4+1,...8+1	4+1,...8+1	4+1,...8+1	4+1,...8+1
RAID-5	420GB-11.2TB	2+1,...15+1	2+1,...15+1	2+1,...15+1	2+1,...15+1
Cache/controller					
MB Min-Max	8GB - 32GB	128MB - 512MB	128MB - 512MB	128MB - 512MB	128MB - 512MB
MB Increment	8GB, 16GB, 32GB	128MB	128MB	128MB	128MB
MB Separate NVS	384MB	-	-	-	-
Connectivity					
Total host connections	4-32				
Serial (ESCON)	4-32	-	-	-	-
FICON	1-16	-	-	-	-
Ultra SCSI	4-32	-	-	-	-
Fibre Channel	1-16	4	4 (internal hub)	4 (internal hub)	4 (internal hub)
Platform Support	OS/390, VM ESA, VSE ESA, ACP TPF, OS 400, AIX, Solaris, HP-UX, Windows NT, Windows 2000, Linux, Novel Netware, NUMA-Q, Data General	AIX, HP-UX, Solaris, Windows NT, NCR, DG AViiON	AIX, HP-UX, Solaris, Windows NT, NCR, DG AViiON	AIX, HP-UX, Solaris, Windows NT, NCR, DG AViiON	AIX, HP-UX, Solaris, Windows NT, NCR, DG AViiON
Management Tools					
Configuration Management	ESS Specialist, Expert	Navisphere	Navisphere	Navisphere	Navisphere
Browser Support	Yes	Yes	Yes	Yes	Yes
Hardware Special Function					
Parallel Access Volume	Yes (PAV)	No	No	No	No
Synchronous Remote Copy	Yes (PPRC)	?	?	?	?
Asynchronous Remote Copy	Yes (XRC)	?	?	?	?
T0 Copy Function	Yes (FlashCopy)	?	?	?	?

Table B.5. IBM ESS VS EMC CLARiiON Family (Reliability and Availability).

	IBM ESS 2105	EMC CLARiiON FC4700	EMC CLARiiON FC4500	EMC CLARiiON Model FC5300	EMC CLARiiON Model FC5300
RAID Level Supported					
Level Supported	RAID-5	0, 1, 0+1, 3, 5	0, 1, 0+1, 3, 5	0, 1, 0+1, 3, 5	0, 1, 0+1, 3, 5
Parity Group	6D+1P+1S 7D+1P	2+1,...,15+1	2+1,...,15+1	2+1,...,15+1	2+1,...,15+1
XOR Location	SSA Device Adapter	Controller	Controller	Controller	Controller
Redundancy					
Dual AC Power	Yes	Optional	Optional	Optional	Optional
Dual DC Power	Yes	Yes	Yes	Yes	Yes
Cooling Fans	Yes	Yes - N+1	Yes - N+1	Yes - N+1	Yes - N+1
Cache					
Duplexed Writes	Yes	Yes	Yes	Yes	Yes
Single Bit Correction	Yes	Yes	Yes	Yes	Yes
Double Bit Correction	Yes	Double bit detection	Double bit detection	Double bit detection	Double bit detection
Triple Bit Detection	Yes	No	No	No	No
ECC Checking	Yes	Yes	Yes	Yes	Yes
LRC Checking	Yes	Yes	Yes	Yes	Yes
Battery Backup	Yes	Yes	Yes	Yes	Yes
Battery Life	5 minutes - 7 Days	120 hours	120 hours	120 hours	120 hours
Config Changes					
Dynamic Upgrade	Yes	Limited	Limited	Limited	Limited
Non-Disruptive	Yes	Yes	Yes	Yes	Yes
Non-Disruptive					
Component Replacement	Yes	Major FRU	Major FRU	Major FRU	Major FRU
Hot-pluggable HDA	Yes	Yes	Yes	Yes	Yes
Microcode Updates	Yes	Yes	No	No	No
Pro-Active Maint					
Cache Scrubbing	Yes	Yes	Yes	Yes	Yes
Disk Scrubbing	Yes	Yes	Yes	Yes	Yes
Hot Spare Disks	2 per loop std.	Global 1-30	Global 1-30	Global 1-30	Global 1-30
Remote Maint					
Call Home	Yes	Yes	Yes	Yes	Yes
Password Protected	Yes	Yes	Yes	Yes	Yes
Software	Standard	CLARalert Control Center	CLARalert Control Center	CLARalert	CLARalert
Warranty					
Hardware	3 years	?	?	?	?
Software	3 years	?	?	?	?

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