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MANAGEMENT BRIEF

VALUE PROPOSITION FOR ENTERPRISE STORAGE
Cost/Benefit Case for IBM TotalStorage Solutions



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EXECUTIVE SUMMARY

A new model for enterprise storage is emerging. By exploiting consolidation, virtualization and new management tools and practices, it is becoming possible to create enterprise-level storage infrastructures. Opportunities are created for breakthrough gains in information transparency and accessibility, in quality of service, and in cost-effectiveness.

Realizing these opportunities will require new initiatives. Not least of these is that organizations must develop new approaches to storage procurement, integration and management that treat storage as a unified enterprise-level resource. It is no longer sufficient to deal with storage as an ad hoc collection of hardware, software and networks supporting specific servers and applications.

This report deals with the cost implications of enterprise storage infrastructures. Specifically, it compares five-year costs for hardware, software, maintenance, personnel and facilities for infrastructures built around solutions from EMC, Hitachi Data Systems (HDS) and IBM.

Comparisons are based on composite profiles of three large companies. Results may be summarized as follows:

1. **Financial services company** is a diversified business with interests in retail and commercial banking, brokerage, insurance and other areas, with assets of approximately \$300 billion. For this company, five-year IT costs for an IBM-based enterprise storage infrastructure supporting a broad range of systems are 38.7 percent and 29.2 percent less than for equivalent EMC- and HDS-based infrastructures respectively.
2. **Manufacturing company** is a global consumer packaged goods manufacturer with revenues of approximately \$13 billion. Five-year IT costs for an IBM-based enterprise storage infrastructure supporting enterprise resource planning (ERP) systems are 48.6 percent and 39.3 percent less than for equivalent EMC- and HDS-based infrastructures respectively.
3. **Retail company** is a grocery and drug chain with approximately \$33 billion in revenues. Five-year IT costs for an IBM-based enterprise storage infrastructure supporting core retail, supply chain, business intelligence, departmental and other systems are 41.6 percent and 32.2 percent less than for equivalent EMC- and HDS-based infrastructures respectively.

Lower costs for IBM-based infrastructures are due to a number of factors. These include the effects of virtualization through deployment of IBM SAN Volume Controller (SVC), along with more aggressive pricing – particularly compared to EMC – for software, maintenance and support, and lower storage administration staffing levels.

Cost disparities are significant. But they are only part of the picture. Storage resources are the backbone infrastructure for an organization's information.

The critical new enablers of competitiveness in the 21st century are information-dependent. Flexibility and responsiveness, integration of processes, reduction of cycle times, collaboration and cooperation, cost-effectiveness and profitability, and processes of relationship-building with customers and partners are affected by quality, availability and timeliness of information.

Enterprise storage infrastructures magnify – or impair – the impact of all of these variables. Their significance increases as organizations move toward real-time strategies.

Which means that storage decisions are no longer tactical matters to be resolved within IT organizations. Today's choices of strategy, and of solutions will materially affect the corporate bottom line for a long time to come.

INFRASTRUCTURES

Overview

At the end of 2003, the typical Fortune 500 corporation contained more than 64 terabytes (TB) of server-based disk storage. On current trends, it will increase to more than 260 terabytes by the end of 2008. Simply keeping up with this growth poses critical challenges.

Escalating costs for storage capacity and administration must be contained. Performance and service quality must be maintained or improved. Mainframe-class availability must be extended to all business-critical systems. Immediate, comprehensive recovery of systems and data must be ensured in the event of a serious outage. New compliance and retention issues must be dealt with. Pressing demands for effective, managed security and auditability must be met.

The portfolio of technologies and techniques that may be used to meet these challenges is changing. The potential value of consolidation, latest-generation storage systems and software, storage networking, virtualization, unified file systems, and new management tools and practices has been demonstrated in a wide range of environments.

But there is a larger opportunity. Each of these may yield significant advantage. Their combined impact is, however, cumulative; i.e. the whole is a great deal more than the sum of the parts. If enterprise-wide storage infrastructures are created in a manner that exploits the potential of all of these technologies and techniques in an aggressive and coordinated manner, it is possible to achieve gains far exceeding those that have been realized to date.

One major implication is that organizational storage strategies must be developed that extend beyond common procurement policies and technical standards. New levels of functionality and cost-effectiveness must be required of storage vendors.

Capabilities that are adequate for application-specific deployments may be less effective for large-scale infrastructures. The impact of differences in operating efficiency, pricing and vendor practices may be minor, or at least acceptable for small and mid-sized procurements. At the enterprise level, however, they may translate into major disparities in overall costs.

The impact of such differences is illustrated in this report by composite profiles of three large companies. A two-phase approach was employed:

1. Profiles were developed from the experiences of 49 organizations worldwide. Storage infrastructures were then constructed using a best practices approach – e.g., gains realized by one company through virtualization were combined with those realized by others in storage area network (SAN) deployment, service-level management and other areas.
2. For each profile, configurations and five-year IT costs were determined for scenarios employing equivalent EMC, HDS and IBM offerings. It was assumed that vendor hardware pricing on a dollars per gigabyte (\$/GB) basis is identical. Common discounts are applied to maintenance, software and support, and the same assumptions are employed for personnel and facilities costs.

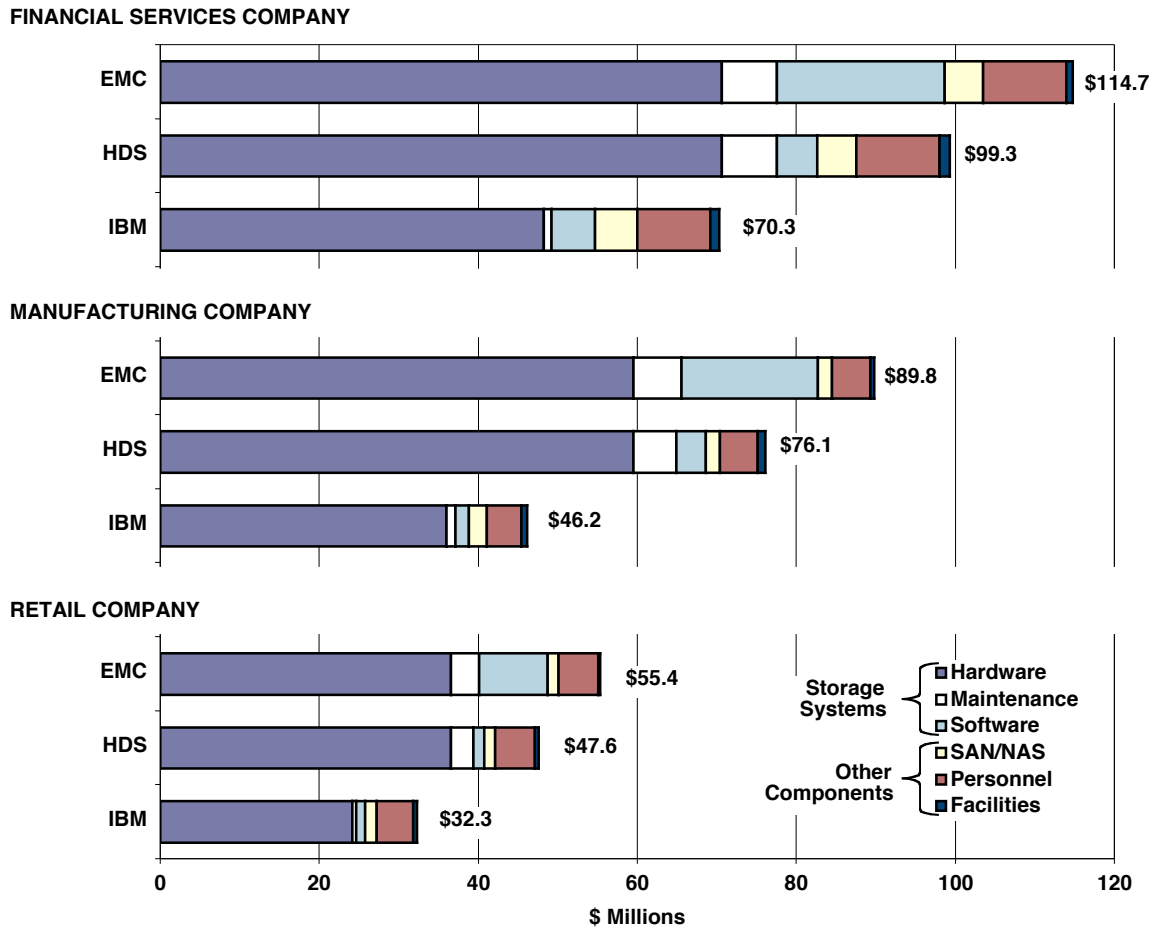
Details of business models, applications, storage organization, and vendor configurations and cost breakdowns may be found in Company Profiles. Methodology and assumptions are detailed in the Methodology section.

Summary of Results

General Picture

Five-year costs for IBM scenarios were, as figure 1 shows, significantly less for IBM than for EMC and HDS scenarios. HDS costs were lower than for EMC scenarios.

Figure 1
Five-year Costs for Vendor Scenarios



Costs for all three companies include latest-generation EMC DMX-2, Hitachi Lightning and IBM Enterprise Storage Server (ESS) 800 high-end storage systems, remote and local replication software, and related tools. Also included are costs of Fibre Channel (FC) SANs, storage administration personnel and data center facilities. IBM scenario costs include SVC hardware and software.

The financial services company profile includes specialized data retention systems, and the manufacturing company profile includes network attached storage (NAS) and midrange platforms. Storage resources in the financial services and retail company profiles support mainframes as well as a broad range of UNIX- and Windows-based systems. In the manufacturing company profile, only UNIX- and Windows-based systems are supported.

Costs are calculated based on rates of capacity growth over a five-year period (yearend 2003 to yearend 2008). Capacity growth rates vary between companies and types of storage, but are consistent for all vendor scenarios. Figures 2 and 3 show the beginning and end points of this process.

Figure 2

Storage Capacity Summary: Yearend 2003 (Terabytes)

Storage Type	EMC & HDS			IBM		
	Financial Services Company	Manufacturing Company	Retail Company	Financial Services Company	Manufacturing Company	Retail Company
High-end						
Mainframe	56	–	19	56	–	19
UNIX & Windows	217	215	97	136	127	68
Data Retention	16 ⁽¹⁾	–	–	11	–	–
NAS & Midrange	–	18	–	–	18	–
TOTAL	289 ⁽²⁾	233	116	203	145	87

(1) EMC capacity. HDS is 10 TB.

(2) EMC total. HDS is 283 TB.

Figure 3

Storage Capacity Summary: Yearend 2008 (Terabytes)

Storage Type	EMC & HDS			IBM		
	Financial Services Company	Manufacturing Company	Retail Company	Financial Services Company	Manufacturing Company	Retail Company
High-end						
Mainframe	164	–	36	164	–	36
UNIX & Windows	820	832	508	499	486	360
Data Retention	38	–	–	39	–	–
NAS & Midrange	–	62	–	–	62	–
TOTAL	1,022	894	544	702	548	396

There are minor variations in yearend 2003 EMC and HDS totals for the financial services company profile due to differences in document retention configurations.

Cost Variations

Cost variations between vendor scenarios are due to two main factors:

1. **Virtualization.** In IBM scenarios, SVC virtualization results in significant reductions in capacity and corresponding hardware, maintenance and software costs for storage supporting UNIX- and Windows-based applications. There is no comparable effect for EMC and HDS scenarios. EMC is not expected to deliver effective storage virtualization solutions before late 2005, while Hitachi's schedule for delivering equivalent capability is unclear.

EMC and HDS configurations are based on capacity utilization of 40 percent to 60 percent, depending on applications, for the financial services company; 35 percent to 45 percent for the manufacturing company; and 45 percent to 55 percent for the retail company. Virtualized IBM configurations are based on average capacity utilization levels of 80 percent, 70 percent and 75 percent for the financial services, manufacturing and retail companies respectively.

SVC is not supported by IBM for mainframe storage systems, and is not employed for data retention, NAS and midrange platforms in profiles. Except for minor variations in data retention configurations, capacities for these are thus the same for all three vendors.

The larger overall capacity and cost disparities between IBM and competitive scenarios for the manufacturing company compared to the financial services and retail companies should be noted. This is primarily because the manufacturing company does not employ mainframes. A higher proportion of overall capacity thus benefits from SVC efficiencies.

It is unlikely that extension of SVC to the mainframe environment would materially affect the overall capacity or cost picture for the financial services and retail companies. Capacity utilization for mainframe storage is already in the 70 percent to 85 percent range in these organizations. Virtualization gains would thus be at best incremental.

- 2. Pricing.** EMC software license and support fees are significantly higher than for HDS and IBM equivalent configurations, and IBM maintenance costs and warranty terms are more favorable than for EMC and HDS.

HDS software costs are marginally lower than for IBM for the financial services company. This reflects comparatively aggressive HDS pricing for mainframe software tools compared to IBM system-based prices. SVC-deployed IBM software is, however, less expensive for UNIX- and Windows-based environments in all three companies.

Although not allowed for in the results presented here, differences between EMC and IBM software ownership policies affect comparative costs. EMC regards licenses for its software as customer-specific; i.e. ownership may not be automatically transferred to another party if the system it runs on is sold. A “re-licensing fee” is required, which must be negotiated with EMC on a case-by-case basis. No such fee is imposed by IBM, which may result in higher residual values.

These factors highlight the importance of adopting a broad approach to comparing the costs of different vendor solutions. Although storage systems hardware represents the largest single cost for all vendor scenarios, other components represent an average of 35.9 percent, 25.3 percent and 27.2 percent of overall costs for EMC, HDS and IBM scenarios respectively. There would, for most organizations, be obvious advantages in measuring overall costs over time.

Enterprise Strategies

Vendor Strategies

Enterprise storage challenges require qualitatively new forms of strategy. Many companies now coordinate storage procurement and technical standards at the corporate level. Few have, however, defined organizational storage architectures, or put mechanisms in place that allow for policy-driven management of diverse resources across large segments of their installed bases.

It can be expected that vendors will play in an important role in addressing these challenges. The strategies of leading players such as EMC, HDS and IBM will have a particularly significant impact. Their ability to execute these strategies will have an equally, if not more, critical impact.

Vendor strategies may be summarized as follows:

- **EMC** has adopted Information Lifecycle Management (ILM) as its main strategic concept. ILM incorporates highly relevant themes. It would clearly be desirable to manage storage resources on an organization-wide, policy-driven basis, across all media and applications, while maintaining high levels of service quality.

The company has certain obvious strengths, including a strong, long-established presence in high-end and midrange disk storage systems, and a successful document retention platform, Centera. The company's software portfolio, however, contains a mix of tools developed internally, as well as obtained through its acquisitions of Documentum, Legato Systems, VMware and others. Management admits that it will take years to integrate these.

EMC was late to focus on storage virtualization, and its plans to deliver virtualization solutions are at least 18 months behind IBM. Similarly, after years of regarding tape as an inconsequential part of the enterprise storage scene, the company has recently begun to target this area. Its first major tape system offerings – OEM versions of automated tape libraries supplied by Advanced Digital Information Corporation (ADIC) – appeared in June 2004.

In these and in other areas of its ILM strategy, the challenges facing EMC are in execution rather than vision.

- **HDS** tends to focus on its core disk systems business. The company has a strong line of high-end systems and software and supports industry standards and a wide range of third-party applications. Its HiCommand framework is positioned for integration of heterogeneous storage environments.

Generally, however, HDS does not play at the level of enterprise storage infrastructure. Recent initiatives, such as its Application-Optimized Storage, deal primarily with system-level capabilities. The company has committed to future implementation of IBM virtualization technologies.

- **IBM** strategic themes are substantively similar to those of EMC, although the company has not to date used ILM terminology extensively in describing these. IBM storage strategy also includes components of the company's broader "On Demand" scheme, such as virtualization, autonomic capability (meaning the application of artificial intelligence technology to system management tasks), provisioning and Grid architecture.

IBM has strong, long-established positions in high-end and midrange disk solutions, as well as in tape systems and software. It has targeted the document retention market through its Data Retention 450 (DR450) platform. The company has moved into a leadership position in storage virtualization, and is a major player in SAN file solutions with its SAN File System.

IBM also has major businesses, and leverageable market and technology strengths in such areas as database, content management, system management and application development software. The company is, in this respect, better equipped than EMC to address higher levels of enterprise architecture that deal with information rather than storage management.

IBM Global Services (IGS) capabilities are also significantly broader than those of EMC and HDS service organizations. IGS addresses planning, implementation, data migration, managed operations and other requirements for storage systems and software in depth. Its capabilities also extend to higher-level storage resource management (SRM) and system integration solutions that are critical to enterprise-level infrastructure optimization.

Compared to EMC and HDS, the IGS pool of qualified staff is also significantly larger, and the organization is better equipped to provide global support to large enterprises.

There are merits to all of these strategies. In terms of ability to address requirements to create, manage and exploit the potential of enterprise storage infrastructures, IBM must, however, be regarded as the leading candidate. The company's broader architectural perspective, the technical consistency of its different solutions, and its greater organizational and technical resources are obvious differentiators.

Business Value

An effective enterprise storage infrastructure delivers multiple levels of value to a business. One of these is lowering storage costs. Others include:

- ***Service quality.*** Key variables such as availability, performance, security and recoverability may be materially improved by an effective storage infrastructure. Maintenance of continuity for business-critical systems and data; faster response times, application throughput, and data location and retrieval cycles; as well as effective protection of organizational records have significant bottom-line impacts for any business.
- ***IT productivity.*** There is a direct correlation between the organization of storage resources and the productivity of the IT organization as a whole. An effective storage infrastructure improves the efficiency of a wide range of IT functions. By increasing across-the-board IT efficiency, application delivery processes may be accelerated, server and networks management tasks simplified, and quality of end-user support increased.

Personnel, funds and attention may be better focused on the delivery of high-impact business solutions, rather than on the minutiae of administering underlying platforms. The overall contribution of IT to the realization of business goals may be significantly improved.

- ***Use of information.*** There is a direct correlation between storage and business performance. Storage resources are the backbone infrastructure for an organization's information. They contribute materially to the effectiveness with which this information is used. Their significance increases as organizations move toward real-time strategies.

The ability to collect, organize, distribute and exploit information transparently, in real time, across the entire enterprise offers powerful new opportunities for competitive differentiation in a wide range of industries. The implication is simple: real-time competitiveness mandates effective cross-organizational storage infrastructures.

Avoiding outages or data loss for a particular system, reducing the time taken to deploy a single application, or improving the quality and timeliness of a specific source information may deliver useful benefits. But efficient, enterprise-wide infrastructures offer the potential to realize such gains across entire server bases and application portfolios, and across the full spectrum of organizational information resources.

The benefit of an efficient storage infrastructure represents the cumulative impact of hundreds, or even thousands of individual gains in cost-effectiveness, flexibility, responsiveness and quality of decision-making across and beyond the enterprise. The potential emerges for transformative gains that extend across all areas of IT implementation and expenditure, and across all of the business activities that IT supports. This potential exists now.

COMPANY PROFILES

Financial Services Company

Business View

This is a full-service retail bank that has expanded aggressively into other areas of financial services. The company reported yearend 2003 assets of approximately \$300 billion, and more than 72,000 employees. Figure 4 summarizes key business statistics.

Figure 4

Financial Services Company: Key Business Statistics

10 million retail banking customers	2,200 branches
4 million credit card accounts	4,200 ATMs
3 million brokerage account	500 financial centers
2 million home mortgages	375 brokerage offices
850,000 small business customers	7,500 brokerage representatives
25,000 commercial customers	3,000 financial advisors
4.2 million online accounts	10 call centers

There are four main lines of business: Retail Banking; Commercial Banking; Capital Management (including brokerage, insurance, trust, 401(k), and other wealth and asset management businesses); and Capital Markets (including investment and corporate banking).

A wide range of online services has been introduced, and the company has more than four million online accounts of all types.

IT Infrastructure

The company has undertaken major data center, server and storage consolidation initiatives following a series of acquisitions in the mid- and late 1990s.

The company's principal servers and storage systems are located in two hardened data centers, which are fully duplexed for disaster recovery purposes. These currently house 10 large-scale mainframes with combined processing capacity of more than 18,000 millions of instructions per second (MIPS), along with 253 UNIX and 122 Windows servers.

Consolidation of Windows servers has been pursued in a particularly aggressive manner. New 8- and 16-way platforms have been widely deployed for company-wide e-mail, groupware and intranet networks; Citrix serving; e-commerce applications; and end-user file/print services. Numerous departmental systems have also been consolidated using VMware technology.

At yearend 2003, installed disk capacity at the company's data centers totaled 289 TB for the EMC scenario, 283 TB for the HDS scenario, and 203 TB for the IBM scenario. By yearend 2008, totals increase to 1,022 TB for the EMC and HDS scenarios, and 702 TB for the IBM scenario.

There are 21 SAN and storage administration full time equivalent (FTE) personnel for the EMC and HDS scenarios, and 18 for the IBM scenario. These numbers remain stable between yearend 2003 and yearend 2008.

Storage Infrastructure

A storage infrastructure based on the following tiers has been implemented in each data center:

- **Mainframe systems** include core banking and electronic funds transfer (EFT) systems; host support for automated teller machine (ATM), point of sale (POS) and branch banking networks; reporting databases; a range of less critical applications; and development systems.

Mainframe systems are integrated into Parallel Sysplex clusters. Storage systems are mirrored, and configured with 73 GB disk drives operating at 15,000 rotations per minute (15K RPM). High-speed remote data replication is employed to maintain currency of data between the company's principal data centers for availability and recovery purposes. Local data replication is employed for backup, development and other applications.

- **Critical open systems** include UNIX- and Windows-based call center and Internet banking systems; major line of business and divisional systems; corporate finance and human resources management systems (HRMS); e-mail and intranet backbones; and other applications sensitive to downtime.

Servers are clustered. Storage systems are mirrored and equipped with 73 GB 15K RPM disk drives, and remote as well as local data replication is employed.

- **Secondary systems** include the remaining UNIX- and Windows-based production business systems; departmental systems; end-user file and print services; Citrix services; non-critical intranet and Internet applications; and development, test and support systems for these and critical open systems.

Secondary systems are supported by RAID 5 storage systems equipped with 73 GB 10K RPM drives. Local data replication is employed.

- **Business intelligence** includes production, development and test systems for the corporate data warehouse, data marts, and other analytical applications. The corporate data warehouse is located in Data Center 1, while other systems are divided between both data centers.

These are supported by RAID 5 configurations equipped with local replication capability. Because applications are less I/O-intensive than for critical and secondary systems, 146 GB 10K RPM drives are employed.

- **Data retention** includes storage for sensitive corporate records (Data Center 1) and for the company's retail brokerage operations (Data Center 2). Specialized systems equipped with Serial ATA (SATA) drives are employed for these applications.

All storage systems and servers are interconnected by FC SANs, which are duplexed for fault tolerance. Storage system and software configurations are summarized in figures 5, 6 and 7. Detailed cost breakdowns are provided in figure 8.

IBM configurations shown in figure 7 include clustered SVC engines supporting UNIX- and Windows-based applications. In this presentation, "1 x 2" means that a single clustered pair is employed, "2 x 2" refers to two clustered pairs, and so on.

Direct-attached storage devices are employed in the company's branch and remote office locations, and at regional administrative centers. These are not included in calculations.

Figure 5
Financial Services Company: EMC Configurations

SYSTEM	PLATFORM	2003	2004	2005	2006	2007	2008
DATA CENTER 1							
Mainframe Systems	Symmetrix DMX-2 – RAID 10 73 GB 15K RPM SRDF, TimeFinder, PowerPath Enterprise, COMPAV	2 x 14 TB	2 x 14 TB 1 x 6 TB	3 x 14 TB	3 x 14 TB 1 x 10 TB	4 x 14 TB 1 x 8 TB	5 x 14 TB 1 x 10 TB
Critical Open Systems	Symmetrix DMX-2 – RAID 10 73 GB 15K RPM SRDF, TimeFinder, PowerPath Enterprise	1 x 12 TB	1 x 14 TB	1 x 14 TB 1 x 6 TB	2 x 14 TB	2 x 14 TB 1 x 12 TB	3 x 14 TB 1 x 12 TB
Secondary Systems	Symmetrix DMX-2 – RAID 5 73 GB 10K RPM TimeFinder, PowerPath Enterprise	2 x 14 TB 1 x 7 TB	2 x 14 TB 1 x 13 TB	4 x 14 TB	5 x 14 TB 1 x 3 TB	7 x 14 TB 1 x 2 TB	9 x 14 TB 1 x 6 TB
Business Intelligence	Symmetrix DMX-2 – RAID 5 146 GB 10K RPM TimeFinder, PowerPath Enterprise	2 x 28 TB 1 x 25 TB	3 x 28 TB 1 x 15 TB	4 x 28 TB 1 x 9 TB	5 x 28 TB 1 x 9 TB	6 x 28 TB 1 x 16 TB	8 x 28 TB
Data Retention	Centera	1 x 8 TB	1 x 8 TB	1 x 8 TB	1 x 8 TB	1 x 15 TB	1 x 15 TB
DATA CENTER 2							
Mainframe Systems	Symmetrix DMX-2 – RAID 10 73 GB 15K RPM SRDF, TimeFinder, PowerPath Enterprise, COMPAV	2 x 14 TB	2 x 14 TB 1 x 8 TB	3 x 14 TB 1 x 2 TB	4 x 14 TB	4 x 14 TB 1 x 12 TB	6 x 14 TB
Critical Open Systems	Symmetrix DMX-2 – RAID 10 73 GB 15K RPM SRDF, TimeFinder, PowerPath Enterprise	1 x 14 TB	1 x 14 TB 1 x 4 TB	1 x 14 TB 1 x 10 TB	2 x 14 TB 1 x 6 TB	3 x 14 TB 1 x 6 TB	4 x 14 TB 1 x 10 TB
Secondary Systems	Symmetrix DMX-2 – RAID 5 73 GB 10K RPM TimeFinder, PowerPath Enterprise	4 x 14 TB 1 x 5 TB	5 x 14 TB 1 x 12 TB	8 x 14 TB	10 x 14 TB 1 x 10 TB	14 x 14 TB 1 x 9 TB	20 x 14 TB 1 x 8 TB
Business Intelligence	Symmetrix DMX-2 – RAID 5 146 GB 10K RPM TimeFinder, PowerPath Enterprise	1 x 14 TB	1 x 19 TB	1 x 25 TB	1 x 28 TB	1 x 28 TB 1 x 16 TB	2 x 28 TB
Data Retention	Centera	1 x 8 TB	1 x 8 TB	1 x 8 TB	1 x 15 TB	1 x 15 TB	1 x 23 TB

Figure 6
Financial Services Company: HDS Configurations

SYSTEM	PLATFORM	2003	2004	2005	2006	2007	2008
DATA CENTER 1							
Mainframe Systems	9980V – RAID 10 73 GB 15K RPM TrueCopy, ShadowImage HPAV	2 x 14 TB	2 x 14 TB 1 x 6 TB	3 x 14 TB	3 x 14 TB 1 x 10 TB	4 x 14 TB 1 x 8 TB	5 x 14 TB 1 x 10 TB
Critical Open Systems	9980V – RAID 10 73 GB 15K RPM TrueCopy, ShadowImage	1 x 12 TB	1 x 14 TB	1 x 14 TB 1 x 6 TB	2 x 14 TB	2 x 14 TB 1 x 12 TB	3 x 14 TB 1 x 12 TB
Secondary Systems	9980V – RAID 5 73 GB 10K RPM ShadowImage	2 x 14 TB 1 x 7 TB	2 x 14 TB 1 x 13 TB	4 x 14 TB	5 x 14 TB 1 x 3 TB	7 x 14 TB 1 x 2 TB	9 x 14 TB 1 x 6 TB
Business Intelligence	9980V – RAID 5 146 GB 10K RPM ShadowImage	2 x 28 TB 1 x 25 TB	3 x 28 TB 1 x 15 TB	4 x 28 TB 1 x 9 TB	5 x 28 TB 1 x 9 TB	6 x 28 TB 1 x 15 TB	8 x 28 TB
Data Retention	9570V*, Data Retention Manager	1 x 3 TB	1 x 7 TB	1 x 7 TB	1 x 7 TB	1 x 10 TB	1 x 14 TB
DATA CENTER 2							
Mainframe Systems	9980V – RAID 10 73 GB 15K RPM TrueCopy, ShadowImage HPAV	2 x 14 TB	2 x 14 TB 1 x 8 TB	3 x 14 TB 1 x 2 TB	4 x 14 TB	4 x 14 TB 1 x 12 TB	6 x 14 TB
Critical Open Systems	9980V – RAID 10 73 GB 15K RPM TrueCopy, ShadowImage	1 x 14 TB	1 x 14 TB 1 x 4 TB	1 x 14 TB 1 x 10 TB	2 x 14 TB 1 x 6 TB	3 x 14 TB 1 x 6 TB	4 x 14 TB 1 x 10 TB
Secondary Systems	9980V – RAID 5 73 GB 10K RPM ShadowImage	4 x 14 TB 1 x 5 TB	5 x 14 TB 1 x 12 TB	8 x 14 TB	10 x 14 TB 1 x 10 TB	14 x 14 TB 1 x 9 TB	20 x 14 TB 1 x 8 TB
Business Intelligence	9980V – RAID 5 146 GB 10K RPM ShadowImage	1 x 14 TB	1 x 19 TB	1 x 25 TB	1 x 28 TB	1 x 28 TB 1 x 15 TB	2 x 28 TB
Data Retention	9585V*, Data Retention Manager	1 x 7 TB	1 x 7 TB	1 x 10 TB	1 x 14 TB	1 x 17 TB	1 x 24 TB

*Serial ATA Intermix

Figure 7
Financial Services Company: IBM Configurations

SYSTEM	PLATFORM	2003	2004	2005	2006	2007	2008
DATA CENTER 1							
Mainframe Systems	ESS 800 – RAID 10 73 GB 15K RPM PPRC, FlashCopy, PAV	2 x 14 TB	2 x 14 TB 1 x 6 TB	3 x 14 TB	3 x 14 TB 1 x 10 TB	4 x 14 TB 1 x 8 TB	5 x 14 TB 1 x 10 TB
Critical Open Systems	ESS 800 – RAID 10 73 GB 15K RPM SVC Base, PPRC, FlashCopy	1 x 8 TB 1 x 2	1 x 10 TB 2 x 2	1 x 12 TB 2 x 2	1 x 14 TB 1 x 2 TB 3 x 2	1 x 14 TB 1 x 10 TB 4 x 2	2 x 14 TB 1 x 4 TB 5 x 2
Secondary Systems	ESS 800 – RAID 5 73 GB 10K RPM SVC Base, FlashCopy	1 x 14 TB 1 x 4 TB 2 x 2	1 x 14 TB 1 x 9 TB 2 x 2	2 x 14 TB 1 x 3 TB 2 x 2	2 x 14 TB 1 x 12 TB 3 x 2	3 x 14 TB 1 x 12 TB 5 x 2	5 x 14 TB 1 x 2 TB 6 x 2
Business Intelligence	ESS 800 – RAID 5 146 GB 10K RPM SVC Base, FlashCopy	2 x 28 TB 3 x 2	2 x 28 TB 1 x 12 TB 3 x 2	3 x 28 TB 4 x 2	3 x 28 TB 1 x 20 TB 5 x 2	4 x 28 TB 1 x 14 TB 6 x 2	5 x 28 TB 1 x 16 TB 7 x 2
Data Retention	DR450	1 x 4 TB	1 x 7 TB	1 x 7 TB	1 x 7 TB	1 x 14 TB	1 x 14 TB
DATA CENTER 2							
Mainframe Systems	ESS 800 – RAID 10 73 GB 15K RPM PPRC, FlashCopy, PAV	2 x 14 TB	2 x 14 TB 1 x 8 TB	3 x 14 TB 1 x 2 TB	4 x 14 TB	4 x 14 TB 1 x 12 TB	6 x 14 TB
Critical Open Systems	ESS 800 – RAID 10 73 GB 15K RPM SVC Base, PPRC, FlashCopy	1 x 10 TB 2 x 2	1 x 12 TB 2 x 2	1 x 14 TB 1 x 2 TB 3 x 2	1 x 14 TB 1 x 10 TB 4 x 2	2 x 14 TB 1 x 4 TB 5 x 2	3 x 14 TB 7 x 2
Secondary Systems	ESS 800 – RAID 5 73 GB 10K RPM SVC Base, FlashCopy	2 x 14 TB 1 x 6 TB 3 x 2	3 x 14 TB 1 x 3 TB 4 x 2	4 x 14 TB 1 x 5 TB 5 x 2	5 x 14 TB 1 x 12 TB 7 x 2	8 x 14 TB 9 x 2	11 x 14 TB 1 x 3 TB 12 x 2
Business Intelligence	ESS 800 – RAID 5 146 GB 15K RPM SVC Base, FlashCopy	1 x 10 TB 1 x 2	1 x 14 TB 1 x 2	1 x 16 TB 1 x 2	1 x 22 TB 1 x 2	1 x 28 TB 1 x 2 TB 2 x 2	1 x 28 TB 1 x 12 TB 2 x 2
Data Retention	DR450	1 x 7 TB	1 x 7 TB	1 x 14 TB	1 x 14 TB	1 x 24.5 TB	1 x 25 TB

Figure 8
Financial Services Company: IT Costs Detail

IT COST CATEGORIES	2003	2004	2005	2006	2007	2008	TOTAL
EMC							
Storage Systems							
Hardware	26,723	6,436	6,702	8,429	9,926	12,398	70,614
Maintenance	–	–	–	1,871	2,321	2,790	6,982
Software licenses	4,339	1,292	1,461	1,880	2,790	3,154	14,916
Software support	–	490	797	1,300	1,567	1,952	6,106
Total (\$000)	31,062	8,218	8,960	13,480	16,604	20,294	98,618
SAN Infrastructure							
Hardware/software	2,683	223	301	376	422	540	4,545
Maintenance/support	–	–	–	107	111	122	340
Total (\$000)	2,683	223	301	483	533	662	4,885
Personnel	–	2,093	2,093	2,093	2,093	2,093	10,465
Facilities	–	108	125	148	181	211	773
TOTAL (\$000)	33,745	10,642	11,479	16,204	19,411	23,260	114,741
HDS							
Storage Systems							
Hardware	26,723	6,436	6,702	8,429	9,926	12,400	70,616
Maintenance	–	–	–	–	3,005	3,963	6,968
Software licenses	1,193	497	301	545	755	990	4,281
Software support	–	–	119	157	201	252	729
Total (\$000)	27,916	6,933	7,122	9,131	13,887	17,605	82,594
SAN Infrastructure							
Hardware/software	2,683	223	301	376	422	540	4,545
Maintenance/support	–	–	98	102	113	118	431
Total (\$000)	2,683	223	399	478	535	658	4,976
Personnel	–	2,093	2,093	2,093	2,093	2,093	10,465
Facilities	–	167	200	245	305	366	1,283
TOTAL (\$000)	30,599	9,416	9,814	11,947	16,820	20,722	99,318
IBM							
Storage Systems							
Hardware	19,347	4,461	4,607	5,215	6,948	7,687	48,265
Maintenance	–	–	31	36	375	478	920
Software licenses	1,986	644	131	529	661	766	4,717
Software support	–	–	113	119	217	308	757
Total (\$000)	21,333	5,105	4,882	5,899	8,201	9,239	54,659
SAN Infrastructure							
Hardware/software	2,689	276	379	441	523	636	4,944
Maintenance/support	–	–	98	102	113	118	431
Total (\$000)	2,689	276	477	543	636	754	5,375
Personnel	–	1,829	1,829	1,829	1,829	1,829	9,145
Facilities	–	148	184	214	270	333	1,149
TOTAL (\$000)	24,022	7,358	7,372	8,485	10,936	12,155	70,328

Manufacturing Company

Business View

This is a global manufacturer of branded consumer packaged goods with approximately \$13 billion in revenues and 40,000 employees. It currently operates approximately 120 manufacturing plants and 200 distribution centers, along with 15 research, development and engineering centers and more than 400 administrative and sales facilities. The profile focuses on the use of SAP AG systems.

During the 1990s, the company deployed SAP systems in a decentralized manner across 18 regional and national business units. These have since been replaced by unified systems supporting business operations in four geographies: North America; Latin America; Europe, Middle East and Africa; and the Asia/Pacific region.

The company employs the SAP applications shown in figure 9.

Figure 9
Manufacturing Company: SAP Applications

R/3 Systems	Other Systems
Controlling	Advanced Planning & Optimization (APO)
Financial Accounting	Product Lifecycle Management (PLM)
Human Resources	Enterprise Buyer Professional (EBP)
Materials Management	Complementary applications
Plant Maintenance	EDI server
Production Planning & Control	E-commerce
Quality Management	Customer Relationship Management (CRM)
Sales & Distribution	– North America
Warehouse Management	Enterprise Portal
	Employee Self Service
	Various
Business Intelligence	
Corporate data warehouse (BW)	Data marts (BW)
Corporate Finance Management (CFM)	• Finance (profitability analysis)
Strategic Enterprise Management (SEM)	• Human resources
	• Market research

There are approximately 21,000 named and 3,000 peak concurrent users of the principal R/3 system, and an additional 6,500 named and 1,500 peak concurrent users of other SAP applications.

In an increasingly competitive global environment, the company is moving toward a real time business model. The ability to assemble information from all stages of the supply chain, and to interpret and exploit it in real time, is becoming increasingly central to the company's competitive performance. New gains are enabled in operational efficiency, in organizational flexibility, and in responsiveness to changing customer demands and market conditions.

The company's storage infrastructure plays a critical role in achieving this transition. Effective, enterprise-wide organization of storage resources is mandated to ensure the delivery of actionable information in real time to hundreds of high-impact applications across the entire supply chain.

IT Infrastructure

The company has consolidated servers and storage supporting most SAP systems in two hardened data centers located in the United States. High-speed replication and failover mechanisms ensure that continuity of service can be maintained if the primary data center is disabled.

Data centers contain 78 UNIX servers and 179 Windows servers. At yearend 2003, installed disk capacity at the company's data centers totaled 219 TB for the EMC and HDS scenarios, and 131 TB for the IBM scenario. By yearend 2008, totals increase to 849 TB and 503 TB respectively.

Smaller data centers with UNIX and Windows servers are maintained in Europe, Latin America and Asia to support regional CRM systems. IBM virtualization is not employed for these, and capacity figures are the same for all three vendors.

Storage Infrastructure

The storage infrastructure implemented at the company's primary data centers consists of the following classes of system:

- **R/3 production systems** located in Data Center 1 are supported by mirrored configurations of high-end storage systems equipped with 73 GB 15K RPM disk drives, and remote and local replication tools.
- **Other production systems** also located in Data Center 1 are supported by RAID 5 configurations of high-end storage systems equipped with similar 73 GB 15K RPM drives, along with remote and local replication tools.

These include SAP APO, PLM, EBP, Enterprise Portal, Employee Self Service and e-commerce applications; complementary software for electronic data interchange (EDI) forms, fax, R/F device and scanner support, and other functions; and the SAP CRM system supporting the company's North American operations.

- **Business intelligence systems** are located in Data Center 1, and are supported by high-end RAID 5 storage systems equipped with 146 GB 10K RPM drives and local replication tools. Systems include production and non-production instances of the corporate data warehouse and data marts based on SAP BW, along with CFM and SEM applications.
- **Non-production systems** are located in Data Center 2 and are supported by high-end RAID 5 storage systems equipped with 73 GB 10K RPM drives and local replication tools. Systems include instances for development, testing, sandbox, quality assurance, staging, integration, training and other support functions for SAP and complementary applications

NAS applications are divided between the two data centers. Midrange systems are employed to support CRM systems at regional data centers. For both sets of applications, EMC Clariion, HDS 9570V and IBM FAStT systems are employed. All are configured with RAID 5 capability, 73 GB 10K RPM drives and local replication tools.

All storage systems and servers at central data centers are interconnected by duplexed FC SANs. Storage system, software and (in the case of IBM configurations) clustered SVC engine pair configurations, and detailed cost breakdowns are provided in figures 10 through 15.

There are nine SAN and storage administration FTEs for the EMC and HDS scenarios, and eight for the IBM scenario. These numbers remain stable between yearend 2003 and yearend 2008.

Figure 10
Manufacturing Company: EMC Configurations

	PLATFORM	2003	2004	2005	2006	2007	2008
DATA CENTER 1							
R/3 Production Systems	Symmetrix DMX-2 – RAID 10 73 GB 15K RPM SRDF, TimeFinder, PowerPath Enterprise	4 x 14 TB 1 x 4 TB	5 x 14 TB 1 x 8 TB	7 x 14 TB 1 x 6 TB	9 x 14 TB 1 x 6 TB	12 x 14 TB 1 x 6 TB	16 x 14 TB
Other Production Systems	Symmetrix DMX-2 – RAID 5 73 GB 15K RPM SRDF, TimeFinder, PowerPath Enterprise	1 x 14 TB 1 x 2 TB	1 x 14 TB 1 x 6 TB	2 x 14 TB	2 x 14 TB 1 x 6 TB	3 x 14 TB 1 x 2 TB	4 x 14 TB
Business Intelligence Systems	ESS 800 – RAID 5 146 GB 10K RPM TimeFinder, PowerPath Enterprise	2 x 28 TB 1 x 4 TB	2 x 28 TB 1 x 23 TB	3 x 28 TB 1 x 21 TB	4 x 28 TB 1 x 28 TB	6 x 28 TB 1 x 16 TB	8 x 28 TB 1 x 20 TB
NAS	Celerra NS700G Clariion CX500, SnapView	1 x 3 TB	1 x 4 TB	1 x 5 TB	1 x 6 TB	1 x 8 TB	1 x 10 TB
DATA CENTER 2							
Support Systems	Symmetrix DMX-2 – RAID 5 73 GB 10K RPM TimeFinder, PowerPath Enterprise	5 x 14 TB 1 x 9 TB	7 x 14 TB 1 x 7 TB	9 x 14 TB 1 x 12 TB	12 x 14 TB 1 x 10 TB	16 x 14 TB 1 x 8 TB	22 x 14 TB
NAS	Celerra NS700G Clariion CX500, SnapView	1 x 1 TB	1 x 2 TB	1 x 3 TB	1 x 4 TB	1 x 5 TB	1 x 7 TB
REMOTE							
Latin America	Clariion CX700 Access Logix, SnapView	1 x 4 TB	1 x 5 TB	1 x 6 TB	1 x 8 TB	1 x 10 TB	1 x 12 TB
EMEA	Clariion CX700 Access Logix, SnapView	1 x 6 TB	1 x 8 TB	1 x 10 TB	1 x 12 TB	1 x 15 TB	1 x 18 TB
Asia/Pacific	Clariion CX700 Access Logix, SnapView	1 x 4 TB	1 x 5 TB	1 x 8 TB	1 x 10 TB	1 x 12 TB	1 x 15 TB

Figure 11
Manufacturing Company: EMC IT Costs Detail

IT COST CATEGORIES	2003	2004	2005	2006	2007	2008	TOTAL
Storage Systems							
Hardware	23,021	5,438	6,409	6,767	8,449	9,423	59,507
Maintenance	–	–	–	1,611	1,992	2,441	6,044
Software licenses	3,625	912	1,395	1,587	2,385	2,899	12,803
Software support	–	410	647	838	1,069	1,397	4,361
Total (\$000)	26,646	6,760	8,451	10,803	13,895	16,160	82,715
SAN Infrastructure							
Hardware/software	1,053	86	117	93	131	162	1,642
Maintenance/support	–	–	–	47	49	52	148
Total (\$000)	1,053	86	117	140	180	214	1,790
Personnel	–	955	955	955	955	955	4,775
Facilities	–	65	80	94	119	142	500
TOTAL (\$000)	27,699	7,866	9,603	11,992	15,149	17,471	89,780

Figure 12

Manufacturing Company: HDS Configurations

	PLATFORM	2003	2004	2005	2006	2007	2008
DATA CENTER 1							
R/3 Production Systems	9980V – RAID 10 73 GB 15K RPM TrueCopy, ShadowImage	4 x 14 TB 1 x 4 TB	5 x 14 TB 1 x 8 TB	7 x 14 TB 1 x 6 TB	9 x 14 TB 1 x 6 TB	12 x 14 TB 1 x 6 TB	16 x 14 TB
Other Production Systems	9980V – RAID 5 73 GB 15K RPM TrueCopy, ShadowImage	1 x 14 TB 1 x 2 TB	1 x 14 TB 1 x 6 TB	2 x 14 TB	2 x 14 TB 1 x 6 TB	3 x 14 TB 1 x 2 TB	4 x 14 TB
Business Intelligence Systems	ESS 800 – RAID 5 146 GB 10K RPM ShadowImage	2 x 28 TB 1 x 4 TB	2 x 28 TB 1 x 23 TB	3 x 28 TB 1 x 21 TB	4 x 28 TB 1 x 27 TB	6 x 28 TB 1 x 15 TB	8 x 28 TB 1 x 20 TB
NAS	Enterprise NAS Gateway, 9570V, ShadowImage	1 x 3 TB	1 x 4 TB	1 x 5 TB	1 x 6 TB	1 x 8 TB	1 x 10 TB
DATA CENTER 2							
Support Systems	9980V – RAID 5 73 GB 10K RPM ShadowImage	5 x 14 TB 1 x 9 TB	7 x 14 TB 1 x 7 TB	9 x 14 TB 1 x 12 TB	12 x 14 TB 1 x 10 TB	16 x 14 TB 1 x 8 TB	22 x 14 TB
NAS	Enterprise NAS Gateway, 9570V, ShadowImage	1 x 1 TB	1 x 2 TB	1 x 3 TB	1 x 4 TB	1 x 5 TB	1 x 7 TB
REMOTE							
Latin America	9570V, ShadowImage	1 x 4 TB	1 x 5 TB	1 x 6 TB	1 x 8 TB	1 x 10 TB	1 x 12 TB
EMEA	9570V, ShadowImage	1 x 6 TB	1 x 8 TB	1 x 10 TB	1 x 12 TB	1 x 15 TB	1 x 18 TB
Asia/Pacific	9570V, ShadowImage	1 x 4 TB	1 x 5 TB	1 x 8 TB	1 x 10 TB	1 x 12 TB	1 x 15 TB

Figure 13

Manufacturing Company: HDS IT Costs Detail

IT COST CATEGORIES	2003	2004	2005	2006	2007	2008	TOTAL
Storage Systems							
Hardware	23,021	5,438	6,409	6,767	8,449	9,423	59,507
Maintenance	–	–	–	–	2,364	3,066	5,430
Software licenses	976	208	313	434	599	602	3,132
Software support	–	–	89	108	139	182	518
Total (\$000)	23,997	5,646	6,811	7,309	11,551	13,273	68,587
SAN/NAS Infrastructure							
Hardware/software	1,032	86	117	93	131	162	1,621
Maintenance/support	–	–	43	46	49	50	188
Total (\$000)	1,032	86	160	139	180	212	1,809
Personnel	–	955	955	955	955	955	4775
Facilities	–	114	125	173	223	272	907
TOTAL (\$000)	25,029	6,801	8,051	8,576	12,909	14,712	76,078

Figure 14
Manufacturing Company: IBM Configurations

	PLATFORM	2003	2004	2005	2006	2007	2008
DATA CENTER 1							
R/3 Production Systems	ESS 800 – RAID 10 73 GB 15K RPM SVC Base, FlashCopy, PPRC	2 x 14 TB 1 x 10 TB 5 x 2	3 x 14 TB 1 x 7 TB 7 x 2	4 x 14 TB 1 x 9 TB 9 x 2	6 x 14 TB 12 x 2	7 x 14 TB 1 x 11 TB 15 x 2	10 x 14 TB 19 x 2
Other Production Systems	ESS 800 – RAID 5 73 GB 15K RPM SVC Base, FlashCopy, PPRC	1 x 8 TB 1 x 2	1 x 11 TB 2 x 2	1 x 14 TB 2 x 2	1 x 14 TB 1 x 4 TB 2 x 2	1 x 14 TB 1 x 9 TB 3 x 2	2 x 14 TB 1 x 2 TB 3 x 2
Business Intelligence Systems	ESS 800 – RAID 5 146 GB 10K RPM SVC Base, FlashCopy	1 x 28 TB 1 x 8 TB 2 x 2	1 x 28 TB 1 x 20 TB 2 x 2	2 x 28 TB 1 x 6 TB 3 x 2	2 x 28 TB 1 x 26 TB 4 x 2	3 x 28 TB 1 x 26 TB 5 x 2	5 x 28 TB 6 x 2
NAS	NAS Gateway 500 FASTT 600, FlashCopy	1 x 3 TB	1 x 4 TB	1 x 5 TB	1 x 6 TB	1 x 8 TB	1 x 10 TB
DATA CENTER 2							
Support Systems	ESS 800 – RAID 5 73 GB 10K RPM SVC Base, FlashCopy	3 x 14 TB 1 x 3 TB 3 x 2	4 x 14 TB 1 x 4 TB 4 x 2	5 x 14 TB 1 x 9 TB 6 x 2	7 x 14 TB 1 x 4 TB 7 x 2	9 x 14 TB 1 x 6 TB 9 x 2	12 x 14 TB 1 x 8 TB 12 x 2
NAS	NAS Gateway 500 FASTT 600, FlashCopy	1 x 1 TB	1 x 2 TB	1 x 3 TB	1 x 4 TB	1 x 5 TB	1 x 7 TB
REMOTE							
Latin America	FASTT 900, FlashCopy	1 x 4 TB	1 x 5 TB	1 x 6 TB	1 x 8 TB	1 x 10 TB	1 x 12 TB
EMEA	FASTT 900, FlashCopy	1 x 6 TB	1 x 8 TB	1 x 10 TB	1 x 12 TB	1 x 15 TB	1 x 18 TB
Asia/Pacific	FASTT 900, FlashCopy	1 x 4 TB	1 x 5 TB	1 x 8 TB	1 x 10 TB	1 x 12 TB	1 x 15 TB

Figure 15
Manufacturing Company: IBM IT Costs Detail

IT COST CATEGORIES	2003	2004	2005	2006	2007	2008	TOTAL
Storage Systems							
Hardware	14,170	3,278	3,672	4,113	4,937	5,812	35,982
Maintenance	–	–	18	22	496	627	1163
Software licenses	781	–	–	70	–	219	1070
Software support	–	–	142	142	142	152	578
Total (\$000)	14,951	3,278	3,832	4,347	5,575	6,810	38,793
SAN/NAS Infrastructure							
Hardware/software	1,192	56	162	221	175	199	2,005
Maintenance/support	–	–	58	58	66	74	256
Total (\$000)	1,192	56	220	279	241	273	2,261
Personnel	–	866	866	866	866	866	4,330
Facilities	–	101	122	151	188	230	792
TOTAL (\$000)	16,143	4,301	5,040	5,643	6,870	8,179	46,176

Retail Company

Business View

This company is a grocery and drug retailer with approximately \$33 billion in revenues, 180,000 employees and 1,700 stores. These include 1,200 supermarkets, of which 850 contain in-store pharmacies, along with 200 superstores and 300 standalone drug stores. Outlets average more than 35,000 stock keeping units (SKUs) each. The company also operates an Internet store.

The company grew rapidly during the 1990s through a major series of mergers and acquisitions. More recently, however, it has focused on acquiring smaller regional chains and groups of stores from competitors. To eliminate inefficiencies created by these acquisitions, the company has moved aggressively to rationalize division structures, store networks and distribution operations.

The company is transitioning to a real-time competitive model. Aggressive targets have been set for the delivery of timely, high-quality information for a wide range of decision-making applications throughout the organization. Benefits are expected to include faster procurement and logistics cycles, reduced inventory and logistics costs, and improvements in the speed and accuracy of forecasting, planning and replenishment processes.

As for the manufacturing company, better use of information requires better enterprise-wide organization and management of storage resources. An effective enterprise storage infrastructure is again the critical enabler of real-time competitive strategy.

IT Infrastructure

As part of its broader rationalization program, the company has standardized key systems. A single set of mainframe-based core retail applications is employed company-wide. Other corporate standards include PeopleSoft financial and human resources applications, i2 Technologies online procurement, and Retek merchandising, inventory optimization and supply chain management solutions.

The company's principal systems are concentrated in a single data center containing three mainframes representing approximately 2,000 MIPS, along with 80 UNIX and 145 Windows servers. At yearend 2003, installed disk capacity at this center totaled 116 TB for the EMC and HDS scenarios, and 87 TB for the IBM scenario. By yearend 2008, totals increase to 544 and 396 TB respectively.

Disaster recovery coverage is provided through a third-party arrangement. Data is replicated on a continuous basis to a secure offsite location.

Storage Infrastructure

This includes the following:

- ***Mainframe systems.*** Business-critical core merchandising and sales consolidation systems are supported by mirrored storage system configurations equipped with 73 GB 15K RPM disk drives. Non-critical (including development) systems are supported by RAID 5 configurations with 73 GB 10K RPM drives.
- ***Open business systems.*** Business-critical procurement, supply chain management, finance and HR systems, along with the company's online store, are supported by storage system configurations equipped with 73 GB 15K RPM disk drives. Non-critical systems are supported by RAID 5 configurations with 73 GB 10K RPM drives.

- **Business intelligence systems.** The company's data warehouse and smaller data marts for marketing, sales, procurement, financial and supply chain analysis are supported by RAID 5 storage system configurations equipped with 146 GB 10K RPM drives.

All systems are equipped with local replication tools, and are interconnected by duplexed FC SANs. Storage system, software and (in the case of IBM configurations) clustered SVC engine pairs, and detailed cost breakdowns are provided in figures 16 through 21.

Direct-attached storage devices and small systems are employed at the company's retail outlets and distribution centers. These are not included in calculations.

Figure 16

Retail Company: EMC Configurations

PLATFORM	2003	2004	2005	2006	2007	2008
MAINFRAME SYSTEMS						
Symmetrix DMX-2 – RAID 10 73 GB 15K RPM	1 x 12 TB	1 x 14 TB	1 x 14 TB 1 x 2 TB	1 x 14 TB 1 x 4 TB	1 x 14 TB 1 x 6 TB	1 x 14 TB 1 x 9 TB
Symmetrix DMX-2 – RAID 5 73 GB 10K RPM TimeFinder, PowerPath Enterprise	1 x 7 TB	1 x 8 TB	1 x 9 TB	1 x 10 TB	1 x 11 TB	1 x 13 TB
OPEN BUSINESS SYSTEMS						
Symmetrix DMX-2 – RAID 10 73 GB 15K RPM	1 x 14 TB 1 x 12 TB	2 x 14 TB 1 x 8 TB	3 x 14 TB	4 x 14 TB	5 x 14 TB 1 x 2 TB	6 x 14 TB 1 x 12 TB
Symmetrix DMX-2 – RAID 5 73 GB 10K RPM TimeFinder, PowerPath Enterprise	1 x 14 TB 1 x 8 TB	2 x 14 TB	2 x 14 TB 1 x 8 TB	3 x 14 TB 1 x 4 TB	4 x 14 TB 1 x 2 TB	5 x 14 TB 1 x 6 TB
BUSINESS INTELLIGENCE						
Symmetrix DMX-2 – RAID 5 146 GB 10K RPM TimeFinder, PowerPath Enterprise	1 x 28 TB 1 x 21 TB	3 x 28 TB	4 x 28 TB 1 x 26 TB	7 x 28 TB	9 x 28 TB 1 x 16 TB	12 x 28 TB

Figure 17

Retail Company: EMC IT Costs Detail

IT COST CATEGORIES	2003	2004	2005	2006	2007	2008	TOTAL
Storage Systems							
Hardware	12,866	3,594	4,609	4,592	5,620	5,279	36,560
Maintenance	–	–	–	901	1,152	1,475	3,528
Software licenses	1,802	565	677	908	1,394	1,027	6,373
Software support	–	204	334	432	559	750	2,279
Total (\$000)	14,668	4,363	5,620	6,833	8,725	8,531	48,740
SAN Infrastructure							
Hardware/software	790	76	45	74	149	128	1,262
Maintenance/support	–	–	–	32	34	34	100
Total (\$000)	790	76	45	106	183	162	1,362
Personnel	–	1,002	1,002	1,002	1,002	1,002	5,010
Facilities	–	29	40	48	58	69	244
TOTAL (\$000)	15,458	5,470	6,707	7,989	9,968	9,764	55,356

Figure 18
Retail Company: HDS Configurations

PLATFORM	2003	2004	2005	2006	2007	2008
MAINFRAME SYSTEMS						
9980V – RAID 10 73 GB 15K RPM	1 x 12 TB	1 x 14 TB	1 x 14 TB 1 x 2 TB	1 x 14 TB 1 x 4 TB	1 x 14 TB 1 x 6 TB	1 x 14 TB 1 x 9 TB
9980V – RAID 5 73 GB 10K RPM	1 x 7 TB	1 x 8 TB	1 x 9 TB	1 x 10 TB	1 x 11 TB	1 x 13 TB
ShadowImage						
OPEN BUSINESS SYSTEMS						
9980V – RAID 10 73 GB 15K RPM	1 x 14 TB 1 x 12 TB	2 x 14 TB 1 x 8 TB	3 x 14 TB	4 x 14 TB	5 x 14 TB 1 x 2 TB	6 x 14 TB 1 x 12 TB
9980V – RAID 5 73 GB 10K RPM	1 x 14 TB 1 x 8 TB	2 x 14 TB	2 x 14 TB 1 x 8 TB	3 x 14 TB 1 x 4 TB	4 x 14 TB 1 x 2 TB	5 x 14 TB 1 x 6 TB
ShadowImage						
BUSINESS INTELLIGENCE						
9980V – RAID 5 146 GB 10K RPM	1 x 28 TB 1 x 21 TB	2 x 28 TB 1 x 27 TB	4 x 28 TB 1 x 26 TB	7 x 28 TB	9 x 28 TB 1 x 16 TB	12 x 28 TB
ShadowImage						

Figure 19
Retail Company: HDS IT Costs Detail

IT COST CATEGORIES	2003	2004	2005	2006	2007	2008	TOTAL
Storage Systems							
Hardware	12,866	3,594	4,609	4,592	5,620	5,279	36,560
Maintenance	–	–	–	–	1,184	1,607	2,791
Software licenses	330	88	159	173	243	184	1,177
Software support	–	–	25	41	57	74	197
Total (\$000)	13,196	3,682	4,793	4,806	7,104	7,144	40,725
SAN Infrastructure							
Hardware/software	790	76	45	74	149	128	1,262
Maintenance/support	–	–	33	34	34	35	136
Total (\$000)	790	76	78	108	183	163	1,398
Personnel	–	1,002	1,002	1,002	1,002	1,002	5,010
Facilities	–	53	77	96	118	143	487
TOTAL (\$000)	13,986	4,813	5,950	6,012	8,407	8,452	47,620

Figure 20
Retail Company: IBM Configurations

PLATFORM	2003	2004	2005	2006	2007	2008
MAINFRAME SYSTEMS						
ESS 800 – RAID 10 73 GB 15K RPM	1 x 12 TB	1 x 14 TB	1 x 14 TB 1 x 2 TB	1 x 14 TB 1 x 4 TB	1 x 14 TB 1 x 6 TB	1 x 14 TB 1 x 9 TB
ESS 800 – RAID 5 73 GB 10K RPM FlashCopy	1 x 7 TB	1 x 8 TB	1 x 9 TB	1 x 10 TB	1 x 11 TB	1 x 13 TB
OPEN BUSINESS SYSTEMS						
ESS 800 – RAID 10 73 GB 15K RPM	1 x 14 TB 1 x 2 TB	1 x 14 TB 1 x 6 TB	1 x 14 TB 1 x 12 TB	2 x 14 TB 1 x 6 TB	3 x 14 TB 1 x 3 TB	4 x 14 TB 1 x 3 TB
ESS 800 – RAID 5 73 GB 10K RPM SVC Base, FlashCopy	1 x 14 TB 4 x 2	1 x 14 TB 1 x 4 TB 5 x 2	1 x 14 TB 1 x 9 TB 5 x 2	2 x 14 TB 1 x 2 TB 7 x 2	2 x 14 TB 1 x 10 TB 9 x 2	3 x 14 TB 1 x 7 TB 11 x 2
BUSINESS INTELLIGENCE						
ESS 800 – RAID 5 146 GB 10K RPM SVC Base, FlashCopy	2 x 19 TB 2 x 2	2 x 28 TB 1 x 6 TB 3 x 2	3 x 28 TB 1 x 20 TB 4 x 2	5 x 28 TB 1 x 8 TB 6 x 2	7 x 28 TB 1 x 6 TB 8 x 2	9 x 28 TB 9 x 2

Figure 21
Retail Company: IBM IT Costs Detail

IT COST CATEGORIES	2003	2004	2005	2006	2007	2008	TOTAL
Storage Systems							
Hardware	8,764	2,494	3,299	3,272	3,265	3,058	24,152
Maintenance	–	–	28	37	192	258	515
Software licenses	565	40	40	100	50	–	795
Software support	–	–	51	57	85	91	284
Total (\$000)	9,329	2,534	3,418	3,466	3,592	3,407	25,746
SAN Infrastructure							
Hardware/software	823	87	51	96	171	145	1,373
Maintenance/support	–	–	33	34	34	35	136
Total (\$000)	823	87	84	130	205	180	1,509
Personnel	–	914	914	914	914	914	4,570
Facilities	–	63	73	97	118	136	487
TOTAL (\$000)	10,152	3,598	4,489	4,607	4,829	4,637	32,312

METHODOLOGY

Composite Profiles

Profiles are based on actual company business models, strategies and experiences, organization structures, application portfolios, server and storage bases, workloads, service quality levels and IT staffing. The profiles are composites drawn from a number of different companies as follows:

- ***Financial services company*** profile is based primarily on data from nine North American diversified banks with yearend fiscal 2003 assets of from \$200 billion to \$800 billion.
- ***Manufacturing company*** profile is based primarily on data from 10 global consumer products manufacturers employing SAP systems with 2003 revenues of between \$8 billion and \$50 billion.
- ***Retail company profile*** is based primarily on data from five North American and two European grocery and drug retailers with 2003 revenues of \$12 billion to \$60 billion.

Data from an additional 23 North American and European companies was employed to develop specialized configurations (e.g., data warehouses, compliance-related databases, network-attached storage) and for specific calculations of capacity utilization, effects of consolidation, SAN deployment and virtualization, and other values.

Basis of Configurations

General Approach

Figures for installed capacity at yearend 2003 – along with projected growth rates between yearend 2003 and 2008, capacity figures – are based on data supplied by users for categories of storage and (where appropriate) individual configurations detailed for each profile.

Figures are for “raw” rather than used capacity. Since comparisons are for the same applications, workloads and service levels, and configurations are based on equivalent system sizes and technology levels, used capacity levels would – except where virtualization is employed – be generally similar.

The objective of the report was to demonstrate configuration and cost structures for enterprise storage infrastructures in which all of the potential variables of efficiency – including consolidation, SAN deployment, management tools and practices, and (in IBM scenarios) virtualization – were exploited to achieve high levels of cost-effectiveness, service quality and performance optimization.

Few organizations have realized all of the potential efficiency benefits of these technologies and techniques across entire bases of enterprise storage. A best practices approach was thus adopted. A specific profile might, for example, draw upon the gains realized by one company through consolidation of storage systems, a second through deployment of FC SANs, a third through upgrades to latest-generation storage system technology, and a fourth through use of virtualization.

The scenarios results presented in this report reflect the potential of current technology efficiently employed. They do not necessarily reflect actual configurations and cost structures in any specific company.

Older platforms employed in user organizations were converted to current technology EMC, HDS and IBM models based on installed total capacity in gigabytes or terabytes. During this conversion process, and in calculations based on annual growth rates, configurations were rounded to the next largest increment of capacity offered by each vendor. Results were similar for all platforms.

All three vendors' high-end systems can in principle be configured with higher capacities than shown in profiles. Users tend, however, to be reluctant to employ very large single-frame configurations for performance reasons, as well as to reduce vulnerability to outages affecting any single system.

It was thus decided that systems would not be configured with more than 24 x 8 drives. For systems equipped with 73 GB or 146 GB drives, this limit translates into maximum configurations of approximately 14 TB and 28 TB of "raw" capacity respectively. The limit was applied uniformly to all applications, workloads, types of storage, and storage systems.

Effects of Virtualization

Values for the effects of virtualization in IBM scenarios are based on experiences with IBM SAN Volume Controller as well as solutions offered by competitive vendors. Calculations of these effects were based on a set of baseline average utilization levels, shown in figures 22 through 24, for major categories of high-end UNIX and Windows storage for each profile.

Figure 22

Baseline Capacity Utilization Levels: Financial Services Company

System	Data Center 1 Utilization Level	Data Center 2 Utilization Level
Critical Systems	45%	45%
Secondary Systems	45%	40%
Business Intelligence	60%	48%

Figure 23

Baseline Capacity Utilization Levels: Manufacturing Company

System	Data Center Utilization Level
R/3 Production Systems	45%
Other Production Systems	35%
Non-production Systems	40%
Business Intelligence	40%

Figure 24

Baseline Capacity Utilization Levels: Retail Company

System	Data Center Utilization Level
Critical Systems	50%
Secondary Systems	45%
Business Intelligence	55%

Configurations for EMC and HDS systems were determined using these baseline levels. Virtualized configurations in IBM scenarios were determined assuming infrastructure-wide utilization levels of 80 percent for the financial services company, 70 percent for the manufacturing company, and 75 percent for the retail company.

For IBM SVC engines, values were assigned to each storage category in each profile for I/O intensity and other workload characteristics, and configurations were determined for these based on IBM published guidelines based on these. All configurations of SVC engines were clustered.

Virtualization was not applied to IBM systems supporting mainframes in the financial services and retail company profiles; to DR450 configurations in the financial services company profile; or to NAS and remote midrange storage in the manufacturing company profile.

Hardware and Software Products

Comparisons are based on configurations of the EMC, HDS and IBM products shown in figure 25.

Figure 25

Vendor Hardware and Software Products

	EMC	HDS	IBM
PLATFORMS			
High-end Systems	Symmetrix DMX-2 (1000/2000/3000)	Lightning 9980V	Enterprise Storage Server (ESS) 800
Midrange Systems	Clariion CX500/700	Thunder 9970V	FAST 600/900
Data Retention	Centera	Thunder 9570V & 9585V with Data Retention Manager	DR450
NAS	Celerra NS700G	Enterprise NAS Gateway	NAS Gateway 500
SAN	Connectrix ED-24000	Brocade Silkworm 24000	IBM SAN Switch M14
SOFTWARE			
Remote Replication	Symmetrix Remote Data Facility (SRDF)	TrueCopy	Peer to Peer Remote Copy (PPRC)
Local Replication	TimeFinder (Symmetrix) SnapView (Clariion)	ShadowImage	FlashCopy
Parallel Access Volumes	COMPAV	HPAV	PAV

In the financial services company profile, HDS 9570V and 9585V systems employed for data retention are equipped with the company's Serial ATA Intermix Option, and configured with 250 GB Serial ATA as well as standard 146 GB drives.

The versions of EMC SRDF, HDS TrueCopy and IBM PPRC configured for business-critical systems in the financial services and manufacturing company are for remote asynchronous replication. Tools supporting parallel access volume capability are employed only for mainframe configurations in the financial services company profile.

EMC systems are also configured with the company's path management tools: PowerPath Enterprise for Symmetrix systems, and Access Logix for Clariion systems.

Cost Calculations

Cost Components

Costs include hardware acquisition (including disk storage systems, NAS gateways and, in IBM scenarios, SVC engines) and maintenance; license and support costs for software as indicated for each profile; FTE storage administration (including SAN administration) personnel; and facilities, including real estate, environmental and other data center costs.

SAN infrastructure costs are divided into two categories: (1) acquisition (including hardware and software license fees); and (2) maintenance and support. This reflects the practice of bundling hardware and software components for pricing purposes.

Cost figures do not include servers, peripherals or networking solutions other than SAN and NAS; software other than as indicated above; other IT personnel; migration, conversion, installation and other services costs other than maintenance and software support; or other components.

Hardware and Software Acquisition

Costs for acquisition of high-end storage systems hardware were based on “street” (i.e. discounted) prices which are the same on a \$/GB basis for all vendors. Prices are for loaded configurations, including base systems, processor engines, memory, adapters and other hardware components that would normally be employed to support the workloads described in profiles.

For acquisitions that form yearend 2003 installed bases, street prices used in calculations ranged from approximately \$120 to \$226 per gigabyte for loaded configurations employing 73 GB 15K RPM drives, \$109 to \$215 per gigabyte for loaded configurations employing 73 GB 10K RPM drives, and \$67 to \$197 per gigabyte for loaded configurations employing 146 GB 10K RPM drives depending on configuration size.

Between yearend 2003 and yearend 2008, it is assumed that prices for disk storage units decline by 30 percent per gigabyte per year for all types of drive, while costs for base systems and other components remain consistent over this period.

These assumptions are applied to EMC Symmetrix DMX-2, HDS Lightning 9980V and IBM ESS 800 systems. Acquisition costs for data retention and midrange systems, SAN and NAS hardware and software, and IBM SVC hardware are based on vendor list prices discounted by 50 percent.

Software acquisition costs for all platforms are based on vendor list prices discounted by 50 percent.

Maintenance and Software Support

Maintenance and software support costs are for a five-year period starting at yearend 2003, and are net of the warranty periods shown in figure 26.

Costs for HDS and IBM systems are based on vendor list prices for hardware and software configurations shown in profiles, discounted by 50 percent. EMC maintenance and software support costs are calculated as 7 percent and 20 percent respectively per year of initial acquisition costs.

Figure 26
Vendor Warranty Periods

COMPANY	PRODUCT	TIME PERIOD
EMC	Celerra, Centera, Clariion, Connectrix, Symmetrix hardware & core software	Two years
	COMPAV, PowerPath Enterprise, SnapView, SRDF, TimeFinder	90 days
HDS	9980V, 9585V, 9970 V hardware & core software	Three years
	Brocade 24000, Enterprise NAS Gateway hardware & software	One year
	Data Retention Manager, HPAV, ShadowImage, TrueCopy	One year
IBM	ESS 800, FASt hardware & core software, DR450 hardware	One year
	NAS Gateway 500, SAN Switch, SAN Volume Controller hardware & core software	One year
	FlashCopy & PPRC licensed via SAN Volume Controller, DR450 software	One year
	FlashCopy & PPRC direct license, PAV	Three years

Other Costs

Personnel costs are based on annual average salaries per FTE of \$99,512 for SAN administrators and \$68,272 for other storage administration specialists. Salaries are increased by 29.1 percent to allow for benefits, bonuses and other non-salary compensation, along with training, development and related items. It is assumed that costs per FTE remain stable from 2004 through 2008.

Facilities costs were calculated based on square footage occupied by storage systems, NAS gateways, SAN switches and related equipment, and (in IBM scenarios) SVC engines in raised floor environments. A norm of \$50 per square foot per year was employed. It is again assumed that this remains consistent over the projection period.

In all scenarios, data centers are fully equipped with FC SANs, and all devices are SAN-attached at yearend 2003. Subsequent acquisition costs are for new attachments and switch upgrades.

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