White Paper

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Disk Storage Subsystems: The Economic Challenge

The IBM DS6000/DS8000 Series

A META Group White Paper

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Contents

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Introduction

IBM's recent introduction of its TotalStorage DS6000 and DS8000 disk storage arrays represents a significant new storage generation that both leverages and extends its Enterprise Storage Server (ESS — a.k.a. Shark). Further exploiting IBM's ubiquitous and extensible POWER5 (DS8000) and PowerPC (DS6000) technologies, the DS6000/8000 series promises a more unified storage continuum targeted at easing the major management headache of distinct enterprise-class versus midrange-class storage. (With the DS6000/8000 sharing 97%+ common code, it is clear that IBM understands the cost, support, and time-to-market advantages of a nearly unified storage operating environment.)

The DS6000/8000 series has the potential to deliver not just massive raw capacity but also the scalable performance and logical partitioning required to fully exploit that capacity — as well as the pricing and terms to facilitate its use over a longer and more cost-effective four-year term.

Equally important, we believe the DS6000/8000 series pricing and terms and conditions will challenge the industry to address an increasingly tough impediment to affordable storage growth: the full and cost-effective exploitation of the massive capacities of current and future disk array frames. Indeed, the DS6000/8000 series has the potential to deliver not just massive raw capacity but also the scalable performance and logical partitioning required to fully exploit that capacity — as well as the pricing and terms to facilitate its use over a longer and more cost-effective four-year term.

All users of IT infrastructure — from the large Global 2000 (G2000) enterprise to the small and medium business — face a growing storage infrastructure dilemma: the increasingly large disk storage frame capacities (e.g., IBM's new DS8000 scales to 192TB of raw capacity when stocked with new 300GB drives) make fully exploiting that capacity over the traditional short, three-year life cycle problematic for all but the largest users. Indeed, our research indicates that more than 70% of users inefficiently churn their disk storage infrastructure every three years. Moreover, this is typically not due to the system's premature obsolescence — when most users ask their storage operations staff about retaining a given storage subsystem for a fourth (or even fifth) year, the response is invariably positive from the perspective of both performance and reliability.

Although these three-year-old systems are clearly no longer the "hot box" they were initially, good operations staff can usually find an effective home for such

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"mature" systems in what should be a broad-based storage hierarchy. Indeed, the growing trend toward effective information life-cycle management (ILM) and a consequent tiered storage hierarchy should be expanded to include not just new "mix and match" technologies (e.g., Serial ATA with SCSI Fibre Channel drives), but also more granular use of multiple generations as well.

A Prerequisite to Information Life-Cycle Management: Effective Storage Tiers

> *Information life-cycle management is defined as the movement of data through a continuum of storage media to ensure business-driven service-level delivery at the lowest unit cost, based on the content of the data element.*

Changing business and regulatory compliance requirements are mandating that more data be kept readily and reliably accessible online, forcing the IT organization (ITO) to rethink data requirements, storage technologies/vendors, and traditional monolithic, one-size-fits-all storage infrastructure. Our research indicates that only about 40% of G2000 ITOs distinguish between an enterprise disk-based storage tier for mission/business-critical OLTP-type applications and a midrange "good enough" tier (less than 10% have a disk-based business-unit/archival tier). We project that by 2008, more than 75% of G2000 enterprises will implement multi-tiered disk storage solutions, often mixing storage tiers and generations to deliver increasingly cost-effective services.

This is indeed the basis for information life-cycle management, which is defined as the movement of data through a continuum of storage media to ensure business-driven service-level delivery at the lowest unit cost, based on the content of the data element.

> *The DS6000/8000 series' four-year transferable warranty will enable users to drive a more granular, cost-effective, "aged" storage portfolio.*

Yet with rapidly improving storage management and infrastructure technologies, ITOs will have a much broader range of infrastructure deployment options, enabling them to better match business requirements (e.g., data access, retention, security) with infrastructure choices (e.g., enterprise storage, midrange storage, ATA/SATA, tape). META Group believes the storage

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industry is on the cusp of robust, heterogeneous storage management capabilities that will enable ITOs to select best-of-breed storage systems and management.

We see two DS8000 features as potentially significant aids to facilitating the ILM prerequisite of tiered infrastructure:

- The DS8000 is able to logically segment the traditionally monolithic storage asset into multiple "containers" with different cost, performance, and capacity characteristics.

- The four-year, transferable warranty of the DS8000 will enable users to drive a more granular, cost-effective, "aged" storage portfolio (e.g., in the out years, the older but still reliable DSx000 will migrate down the tiered hierarchy, extending its useful life and ROI — see below). A prerequisite to including this concept of aging storage within a tiered storage portfolio is more efficient exploitation of the very large frame capacities and a concomitant longer useful life of the storage asset.

Impediments to Effective Exploitation: Performance, Economics, and Fear

Our research indicates that there are three primary impediments to full capacity exploitation of increasingly massive disk array subsystems:

I. ***Lack of truly scalable performance:*** A mismatched capacity/performance equation, wherein performance does not scale with capacity to deliver acceptable throughput

II. ***Storage economics:*** Limitation of the storage frame's useful life to the standard three years, which will make exploiting its huge capacity potential increasingly problematic

III. ***Fear:*** A natural reluctance of users to concentrate such huge data capacity in a single operating environment

I. Lack of Truly Scalable Performance

The first issue — that of scalable performance — is rapidly becoming a primary pain point for many large users. As capacity grows, many storage subsystems lack the components (e.g., robust base engine, global cache, access ports, bandwidth) required to scale performance proportionately by delivering adequate access density (see box, "Capacity + Performance = Access Density"). Indeed, the ITO must deliver storage capacity via a granular menu of service (and cost) levels required/defined by the business.

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As enterprise storage evolves to a true utility, users will require a modular menu of capacity, performance, availability, and cost components to configure generic storage service across the enterprise.

The new paradigm for cost-effective and efficient storage utilization will be to deliver not just massive, low-cost, single-frame capacities (200TB+), but the components required to deliver that capacity in granular, "useable" (i.e., with adequate performance, response times), end-user chunks. As enterprise storage evolves to a true utility, users will require a modular menu of capacity, performance, availability, and cost components to configure generic storage service across the enterprise. Indeed, IBM's extension of the POWER5's logical partitioning (LPAR) technology to the DS8300 server (see below) promises to help users solve this intractable problem of efficient intra-frame performance and resource allocation.

Assuming IBM delivers on its stated performance projections for its new DS8000 disk array subsystems (see following section), it will attack the first impediment to cost-effective storage exploitation, targeting the "holistic" scalability required to deliver good performance throughout the DS8000's capacity range.

Capacity + Performance = Access Density

A useful metric that ties storage capacity to performance is access density (AD), expressed in terms of I/Os per second (IOPS) per GB of capacity (IOPS/GB). In relatively small configurations (e.g., ≤10TB), it is common to maintain AD well over 1.0 (e.g., 8K IOPS [K-IOPS] against only 4TBs of data results in an AD of 2.0). However, as capacity rises disproportionately compared to performance, the AD can drop below 1.0. For example, the same 8K-IOPS accessing a 40TB configuration yields a relatively low AD of 0.2.

N.B. Users should not necessarily draw a straight line from low AD to poor user service levels — much depends on the access characteristics of the data (e.g., if a significant portion of the 40TBs is accessed infrequently, the 0.2 AD may still satisfy the end-user's service-level requirements).

Linear Scalability and the Promise of Performance

META Group believes that this new DS6000/8000 series promises to be more than just "Shark IV" (i.e., the fourth in a slowly improving series of array subsystems). While IBM has targeted robust

If IBM can deliver on the performance promises of the DS6000/8000 series, we believe its potential for linear scalability should position the DS6000/8000 series among the leaders in disk storage arrays.

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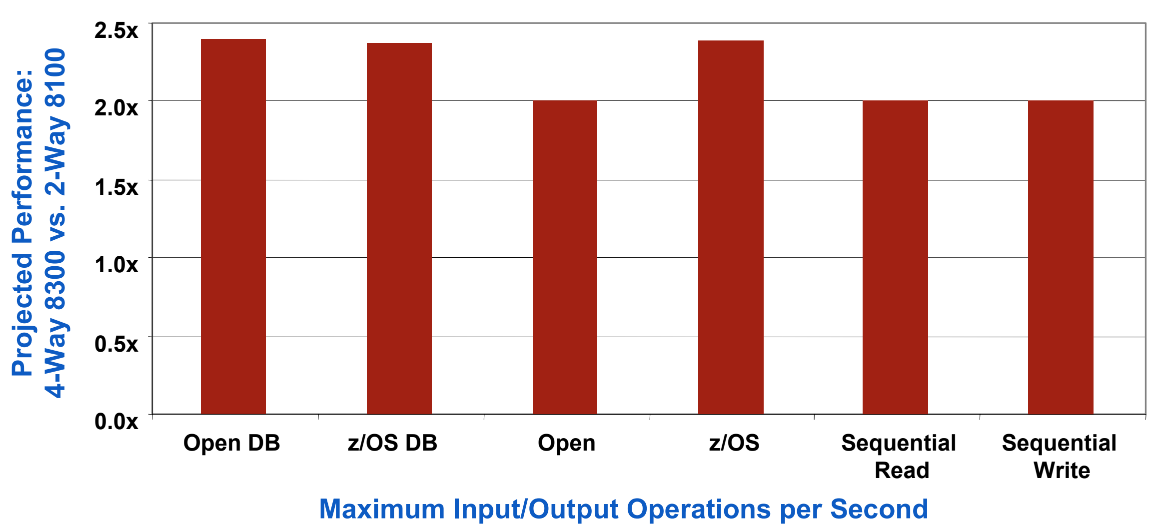
performance goals for the DS6000/8000 series (see below), it is too early to have seen verifiable benchmark results. Moreover, with volume shipments beginning in 1Q05, it will be some time before IBM's claims can be verified in the field under real-world user conditions.

Having said that, if IBM can deliver on the performance promises of the DS6000/8000 series detailed below, we believe its potential for linear scalability (i.e., balanced performance scaling with capacity to yield more truly *usable* capacity — see Figure 1) should position the DS6000/8000 series among the leaders in disk storage arrays.

In most performance metrics, both the DS6000 and DS8000 are expected to significantly outperform the Shark ESS 800 and 800 Turbo (800T). The performance values described below and depicted in the referenced figures are maximum values, and assume that each machine has been optimized to take advantage of its unique features (e.g., configured with maximum channels, cache, and disk drives).

Figure 1 — DS8000's Promise of Linear Scalability: Projected Performance of 4-Way 8300 vs. 2-Way 8100



These charts are based on IBM's estimates and projections of maximum throughputs for the DS8100 and DS8300 for several laboratory benchmarks, using IBM performance models and preliminary measurements in a controlled environment. Final tuning is still in progress, but IBM anticipates that these maximum throughput targets will be met. They do not constitute a performance guarantee. Actual performance may vary and will be dependant on an individual customer's applications and implementation.

Source: IBM

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The DS8000
The TotalStorage DS8000 is based on IBM's POWER5 (P5) processor technology that has been adapted and enhanced as a storage server. The larger model, the DS8300, supports the P5's logical partitioning capability (see below).

The smaller of the two initial DS8000 models, the 2-way DS8100, can have up to:

- 64 x 2Gb fibre channels (or 2Gb FICON channels in a mainframe z/OS environment)
- 128 GB of system memory (cache)
- 384 disk drives

The maximum capacities of the DS8000 are (see Figure 2):

- ***73GB:*** 27.7TB
- ***146GB:*** 55.5TB
- ***300GB:*** 115.2TB

DS8000 data protection levels are RAID 5 and/or RAID 10 (mirrored) — see box, "Do-It-Yourself RAID."

The larger DS8000 storage server, the DS8300, can be configured with up to:

- 128 x 2Gb fibre channels (or 2Gb FICON channels in a mainframe z/OS environment)
- 256 GB of system memory (cache)
- 640 disk drives

The maximum capacities of the DS8300 are (see Figure 2):

- ***73GB:*** 46.2TB
- ***146GB:*** 92.5TB
- ***300GB:*** 192.0TB

D8300 data protection levels are RAID 5 and/or RAID 10 (mirrored) — see box, "Do-It-Yourself RAID."

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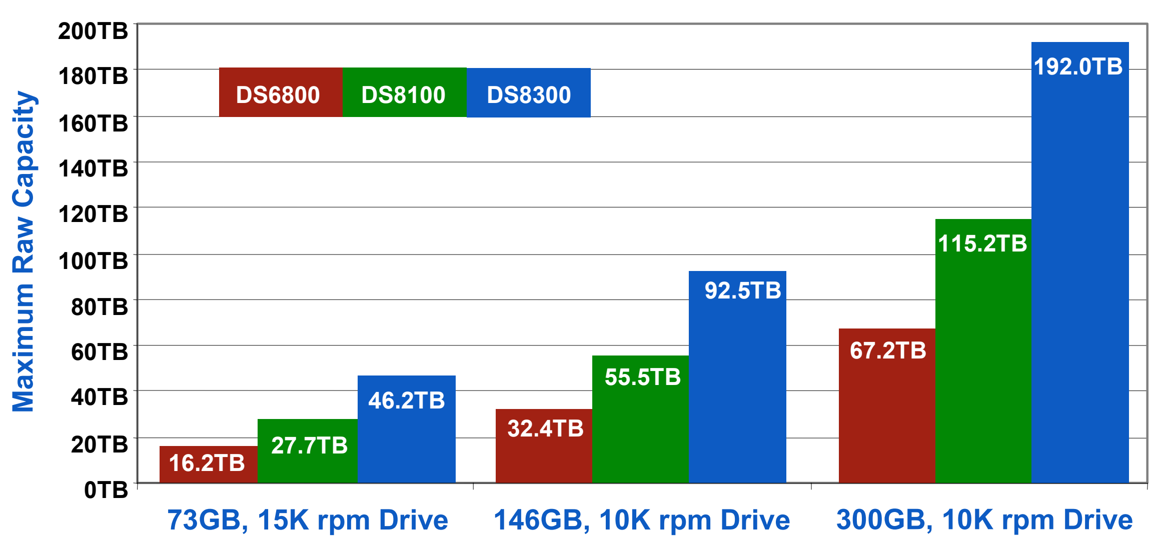
Do-It-Yourself RAID

IBM's DS6000/8000 systems come enabled with intermixable RAID 5 and RAID 10 (mirrored) capacity. Users can reconfigure their arrays at any time on their own, with no requirement (nor cost) to notify or involve IBM to deploy the required RAID implementation. (N.B. Such reconfiguration does require a planned outage for the data on the affected arrays). Given the relatively high reliability of both 73GB and 146GB drives, we project most users will maximize usable capacity by initially deploying a RAID 5 configuration, and then rarely, if ever, changing the RAID type.

Yet given the size and relative immaturity of the new 300GB (10K rpm) drives, we believe most users will limit their use to non-core applications, where price is the primary decision factor, rather than performance or availability. For users considering the new 300GB drives, we believe a mirrored RAID 10 implementation will prove most prudent for availability and performance reasons, with any 300GB RAID 5 configurations largely limited to non-critical, non-core applications.

Figure 2— DS6000/DS8000 Series Capacities



Source: IBM

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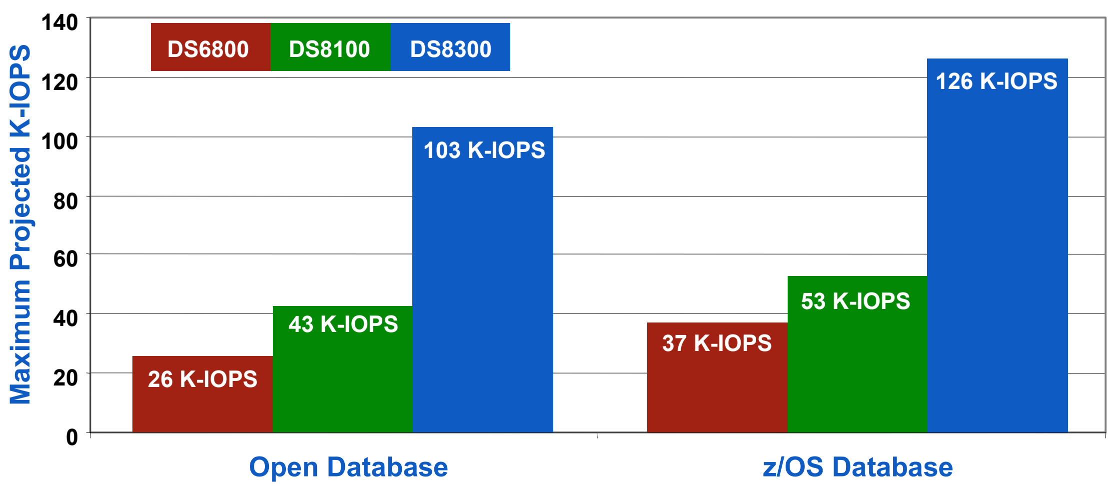
The 2-way DS8100 is expected to achieve up to 43K-IOPS (thousands of I/Os per second), or about 70% more than the ESS 800T on IBM's internal open database (70/30/50) benchmark (see Figure 3). The larger 4-way DS8300 server is expected to drive about 4x the performance of the ESS 800T and 2.4x that of the DS8100 (yielding reasonably balanced, linear scalability), or up to 103,000 K-IOPS. This improvement is due to:

- The enhanced POWER5 server technology
- Significant improvements to the internal connection architecture
- Expanded and enhanced cache capabilities (see below)
- The use of simultaneous multi-threading
- Faster switched fibre channel drives

In the mainframe arena (z/OS Database [Cache Standard] benchmark), the DS8100 and DS8300 are expected to exceed the ESS 800T by 40% (53 K-IOPS) and 3.4x (126 K-IOPS) respectively.

Figure 3 — TotalStorage Database Performance Targets for DS8000 vs. ESS 800 Turbo



These charts are based on IBM's estimates and projections of maximum throughputs for the DS8100 and DS8300 for several laboratory benchmarks, using IBM performance models and preliminary measurements in a controlled environment. Final tuning is still in progress, but IBM anticipates that these maximum throughput targets will be met. They do not constitute a performance guarantee. Actual performance may vary and will be dependant on an individual customer's applications and implementation.

K-IOPS — Thousands of I/Os per second

Source: IBM

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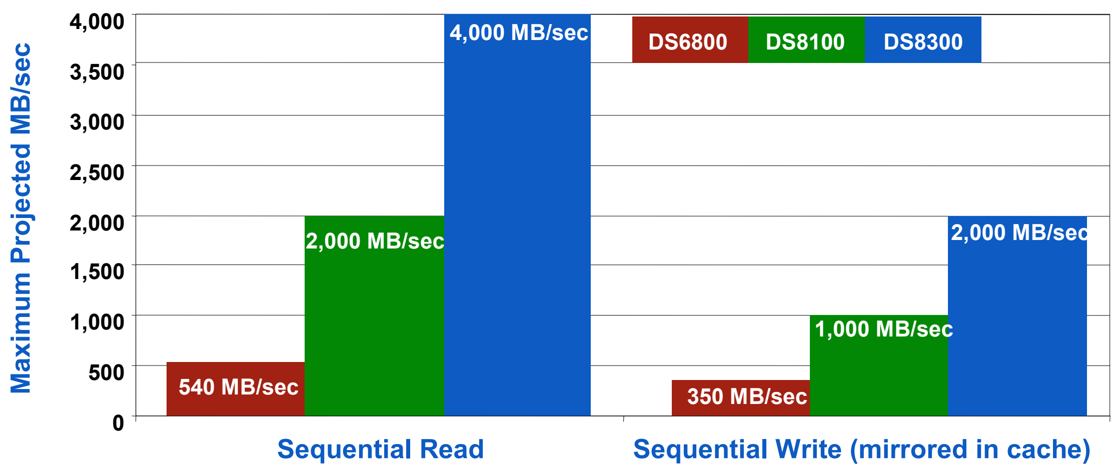
For sequential read and write benchmarks (see Figure 4), the DS8100 is expected to be about 3x faster than the ESS Model 800, and the DS8300's expected linear scalability should deliver up to 6x or more the performance of the ESS Model 800.

Figure 4 — TotalStorage Performance Targets for Sequential Read & Write: DS8000 vs. ESS 800 Turbo



These charts are based on IBM's estimates and projections of maximum throughputs for the DS8100 and DS8300 for several laboratory benchmarks, using IBM performance models and preliminary measurements in a controlled environment. Final tuning is still in progress, but IBM anticipates that these maximum throughput targets will be met. They do not constitute a performance guarantee. Actual performance may vary and will be dependant on an individual customer's applications and implementation.

Source: IBM

The DS6000

The TotalStorage DS6000 is based on IBM's PowerPC technology and a base 3U server with up to 16 disk drives. The DS6800 can be expanded by an additional 13 3U systems for a total of up to 8x2Gb fibre channels (or 2Gb FICON channels in a mainframe z/OS environment). We believe its maximum capacity of 224 drives (67.2TB using 300GB drives — as shown in Figure 1 above) is largely theoretical, since the performance implications of its single 4GB cache limitation will preclude most applications from exceeding 10TB-15TB capacities (nonetheless, its new adaptive replacement cache (ARC)-based caching algorithm promises significantly improved cache efficiency — see below). Although we would have liked to have seen the DS6000's initial instantiation come with the option of low-cost SATA drives and a higher upper limit on cache, its enterprise-class reliability, close affinity with the DS8000 (90%+ common code), and host attachment in a small, modular, low-cost package should prove attractive to a range of users.

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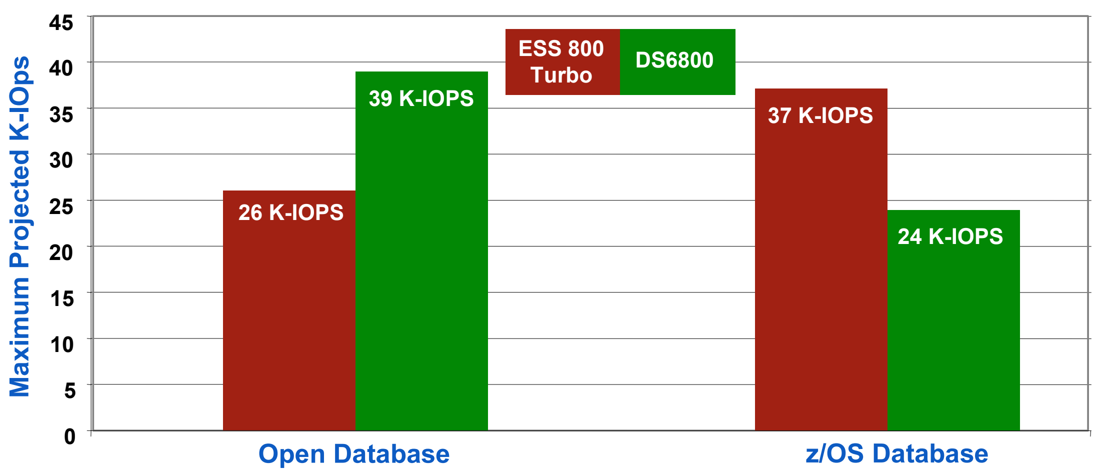
Users can reconfigure their DS6000/8000 arrays at any time on their own, with no requirement (or cost) to notify or involve IBM to deploy the required RAID implementation.

A single DS6800 server with a full complement of 224x73GB SCSI disk drives (16TB raw capacity) is expected to deliver up to 39 K-IOPS on the IBM Open Database (70/30/50) benchmark, which is 50% better than the ESS 800T (see Figure 5). For sequential read benchmarks, the DS6800 is expected to reach up to 1,400 MB/sec, which is more than 2.5x that of the ESS 800T (see Figure 6). For the sequential write (with mirrored cache) benchmark, the DS6800 is projected to achieve up to 530 MB/sec, or 50% more than the ESS 800T.

Figure 5 — TotalStorage Database Performance Targets for DS6000 vs. ESS 800 Turbo



These charts are based on IBM's estimates and projections of maximum throughputs for the DS6000 for several laboratory benchmarks, using IBM performance models and preliminary measurements in a controlled environment. Final tuning is still in progress, but IBM anticipates that these maximum throughput targets will be met. They do not constitute a performance guarantee. Actual performance may vary and will be dependant on an individual customer's applications and implementation.

K-IOPS — Thousands of I/Os per second

Source: IBM

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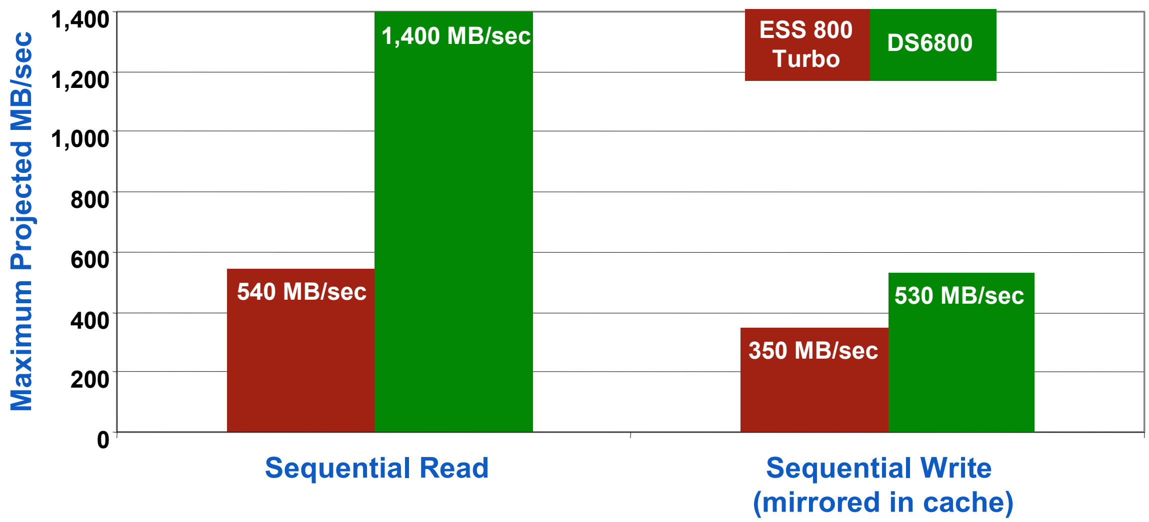
Figure 6 — TotalStorage Performance Targets for Sequential Read and Write: DS6000 vs. ESS 800 Turbo



These charts are based on IBM's estimates and projections of maximum throughputs for the DS8100 and DS8300 for several laboratory benchmarks, using IBM performance models and preliminary measurements in a controlled environment. Final tuning is still in progress, but IBM anticipates that these maximum throughput targets will be met. They do not constitute a performance guarantee. Actual performance may vary and will be dependant on an individual customer's applications and implementation.

Source: IBM

IBM Raises the Cache Bar

The concept of cache — a relatively small quantity of fast, expensive memory in front of lots of slow, cheap memory — is widely used throughout computing systems (e.g., servers, databases, storage systems, middleware, processors, RAID controllers, operating systems). The cache's primary objective is to optimize the system's overall performance by maximizing the "cache hit ratio," which is the percentage of requested pages found in "fast" memory that thus do not require loading from slow memory.

In the DS6000/DS8000 series, IBM is deploying an innovative, homegrown adaptive replacement cache (ARC) algorithm, which combines the strengths of the least recently used (LRU) and least frequently used (LFR) algorithms, without their weaknesses.

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Traditional cache systems have been based on the least recently used (LRU) algorithm, which (as the name implies) maintains cache pages according to how recently they were requested, flushing those least recently used. Although the LRU algorithm's strengths are its simplicity and efficient focus on clustered locality of reference (CLR — common to many workloads), it largely misses the often critical *frequency* characteristics of sequential and onetime-use workloads. An alternative algorithm focuses on replacing the least frequently used (LFU) pages. Although this is good for stable, predictable (e.g., sequential) workloads, the LFU algorithm misses the CLR that is so critical to efficient caching of most commercial transaction workloads.

In the DS6000/DS8000 series, IBM is deploying an innovative, homegrown adaptive replacement cache algorithm, which combines the strengths of LRU and LFU without their weaknesses. In simple terms, ARC dynamically and continually optimizes the cache hit ratio by analyzing the log of flushed pages to tune cache utilization based on its two primary predictive characteristics: how *recently* and *frequently* the pages were used.

The result is a significant improvement in cache efficiency. Our research indicates that DS6000 and DS8000 users may require up to 30%+ less cache to deliver equivalent performance. Indeed, with the DS6000 also exploiting the new ARC caching algorithm, we believe users should be able to stretch its single (and relatively modest) 4GB cache size to drive 10TB+ of active capacity (see "The DS6000" above).

II. Storage Economics 101: Extend the Life Cycle, Deliver the Value

Our research indicates that a more systemic and historically intractable impediment to cost-effective storage exploitation centers on the economics of the standard three-year frame life cycle. Indeed, we find that users rarely add capacity to existing frames after only 12-18 months.

The problem lies in the high real cost of financing upgrades over the frame's diminishing term. For example, the user who adds 2TB to a one-year-old frame must typically write that upgrade off over the remaining two years — a 50% increase in amortized cost versus the original three-year write-off. Moreover, the user who upgrades in the frame's third year must typically absorb the entire cost of the upgrade in that single year — which is often prohibitively expensive despite the expected 35% annual price/capacity improvement.

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The challenge for users going forward will be to achieve the compelling economies of scale of full-frame capacities throughout the frame's life cycle.

Ensuring Affordable Vertical Growth

Our research indicates that most currently installed disk storage frames will complete their (typically three-year) life cycle at less than 50% of total potential capacity. The challenge for users going forward will be to achieve the compelling economies of scale of full-frame capacities throughout the frame's life cycle.

We project that during the next three to five years, more than 50% of large, G2000 users will adopt a more granular, aged approach to IT portfolio asset management, which will drive adoption of a four-year refresh cycle for up to 75% of the storage portfolio. Specifically, recent research indicates that users can realize significant and recurring hard-dollar budget savings (10%-12% of annual storage procurement costs) by targeting some significant portion of their enterprise storage portfolio for an extended four-year refresh life cycle. For example, the user growing net capacity at 65%/year on a 35% annual price/capacity improvement curve pays a 15% *annual* premium to refresh the entire storage inventory on a rolling three-year continuum — see Figure 7). We project that by 2008, the combined pressure of ongoing budget constraints with unrelenting business and compliance/regulatory demands will force most large users to rework typically monolithic IT asset accounting to a more granular blend of three- and four-year life cycles.

The Four-Year Life Cycle: Key to Affordable Storage Economics

The implications of this "rolling" inventory approach to budgeting are significant for planning long-term procurement requirements and optimizing the asset and accounting management of the user portfolio.

Too often, users apply a straight annual price/capacity improvement curve (e.g., 30%/year) to their projected compound annual growth rate (CAGR — e.g., 1.5 or 50%/year) and arrive at a simplistic (and inaccurate) projected budget. The reality of most users' installed storage portfolio is a three-tier or four-tier model (depending on the user's defined refresh cycle) whose ongoing costs (whether lease financed or depreciated purchase) vary with the age and consequent original procurement cost of the storage assets. Indeed, because robust annual growth relegates older installed assets to a diminishing percentage of the total inventory (see box, "The Storage Portfolio: Age Is Relative"), for accurate portfolio capacity planning, management, and budget projections, users must add the cost of replacing old storage assets to net, "on-the-floor" growth.

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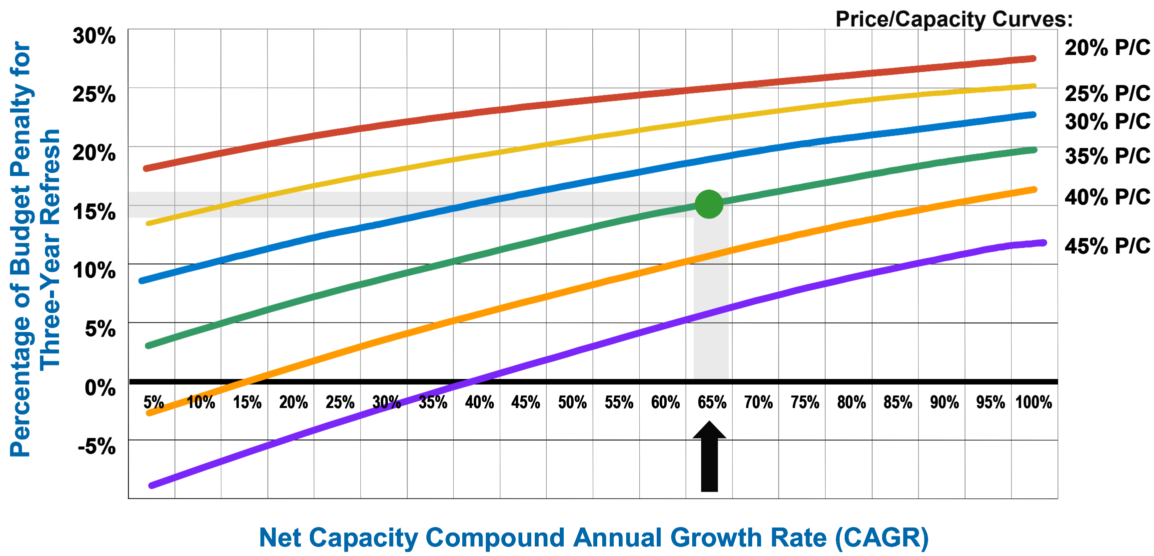
Figure 7 — Percentage of Annual Storage Budget Penalty for Three-Year Refresh Cycle



For example, the user growing net installed capacity at 65%/year and improving price/capacity at 35%/year will pay an annual 15% budget premium or penalty to refresh every three years versus every four.

Source: IBM

The Storage Portfolio: Age Is Relative

The user who refreshes the installed storage portfolio every three years and is growing net storage capacity on average 65% annually will typically have just over half (51%) the total inventory at less than one year old, 30% at two years old, and about 19% approaching three years old. The same user who extends the portfolio's useful life to four years will have a rough asset inventory age breakdown of 46%, 28%, 17%, and 10% for years one to four respectively.

The implications of this "rolling" inventory approach to budgeting are significant for planning long-term procurement requirements and for optimizing the user portfolio's asset and accounting management. Figure 8 (see below) illustrates the difference in total capacity procurement requirements (i.e., for both additional *and* replacement capacity) to deliver a given installed capacity growth rate for three-year versus four-year refresh cycles.

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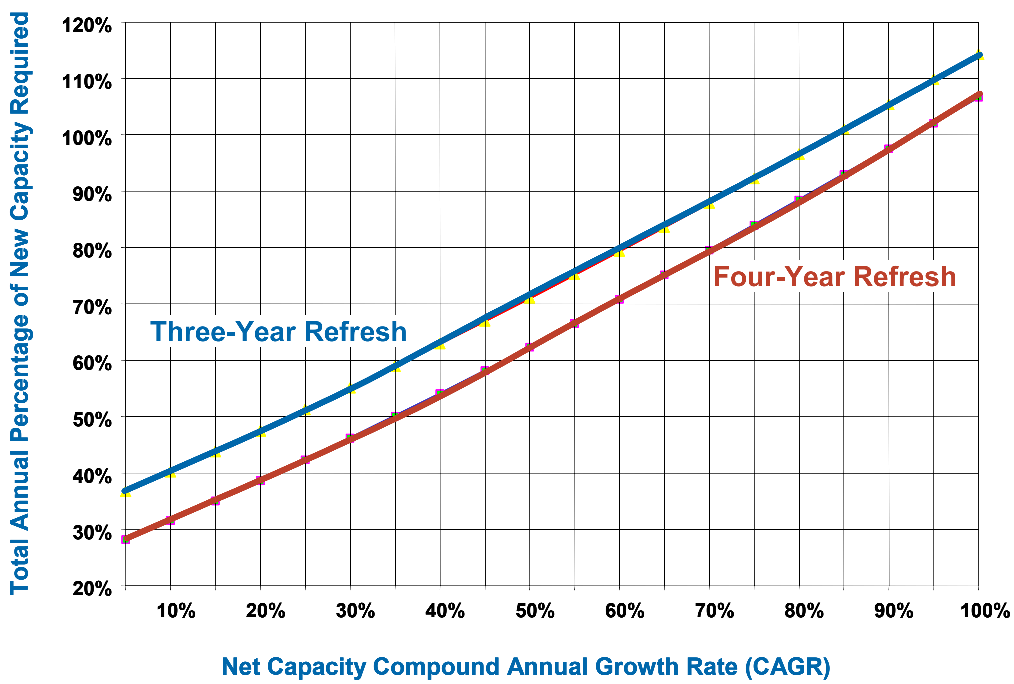
Figure 8 — Three-Year vs. Four-Year Refresh Cycles



Source: IBM

For example, the user who is growing installed storage capacity at 65% per year will actually have to acquire a total of almost 85% new capacity on a three-year refresh cycle versus 75% on a four-year cycle. Although Figure 8 above may make this appear insignificant, Figure 7 shows the sizable penalty the user faces in additional annual capacity procurement when refreshing the storage inventory every three years (versus every four years). Indeed, the three-year refresh premium translates into acquiring 11% more new storage each year than is required in a four-year refresh scenario. (The growth rate determines the premium's relative size — the greater the growth rate, the smaller the replacement component relative to new capacity.)

The importance of IBM's innovative four-year warranties on both the DS8000 and the DS6000 should not be minimized. Users looking to optimize their enterprise storage portfolio and minimize its costs have identified rising storage maintenance costs as a key factor that is severely limiting their efficiency and operational flexibility.

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A Prerequisite to a Cost-Effective Four-Year Life cycle

The importance of IBM's innovative four-year warranties on both the DS8000 (on-site repair, 24x7) and DS6000 (parts only, with labor upgrade available, 8-5/M-F) should not be minimized (nor should the warranties' transferability — see box, "Residual Value Inflation: IBM's Warranty Transfer"). Users seeking to optimize their enterprise storage portfolio and minimize its costs have identified rising storage maintenance costs as a key factor that is severely limiting their efficiency and operational flexibility. Specifically, onerous storage hardware maintenance charges (e.g., >$10/GB/year) are making it simply unaffordable for users to keep still-functional assets past the standard three-year warranty.

Where it is technically feasible to migrate aging storage assets to less-critical and performance-sensitive levels of the storage hierarchy, the cost of the manufacturer's post-warranty maintenance renders such extended useful life cost-prohibitive. Indeed, our research indicates that more than 75% of users refresh their storage portfolio every three years — not for technical, performance, or reliability reasons, but because the maintenance costs exceed even the financed cost of new equipment.

Residual Value Inflation: IBM's Warranty Transfer

An important but little-noticed aspect of IBM's DS6000/8000 announcement is the transferability of its extended four-year warranty. DS6000/8000 users will have the added flexibility and benefit of asset disposition prior to warranty expiration — without losing the remaining warranty's value. Specifically, the user who sells a DS6000/8000 asset after two to three years will likely see its residual value enhanced by the 12-24 month remaining warranty that the second owner will acquire with the used asset. Users should consider such a potential for enhanced residual value in the upfront storage procurement evaluation.

Users seeking to exploit the significant budget and operational advantages of a four-year storage life cycle as detailed above must eliminate the traditional impediment of prohibitively high post-warranty maintenance costs. Specifically, META Group research indicates that the typical cost of post-warranty maintenance (i.e., year four and beyond) is so high that it could fund *twice* the capacity in new, high-performance storage (also with a three-year or more warranty) for the cost the vendor charges to maintain the existing three-year-old storage (see Figure 9). Indeed, we believe IBM's standard four-year warranty on both the DS6000 and the DS8000 will have an impact that transcends the direct savings associated with maintenance costs in the asset's fourth year. It will facilitate a fourth year of utility for the user's storage portfolio, driving the associated hard-dollar cost savings detailed above. Indeed, from a business perspective, more granular accounting views of storage assets will help deliver an improved return on assets and enable the business to better afford its high-growth requirements.

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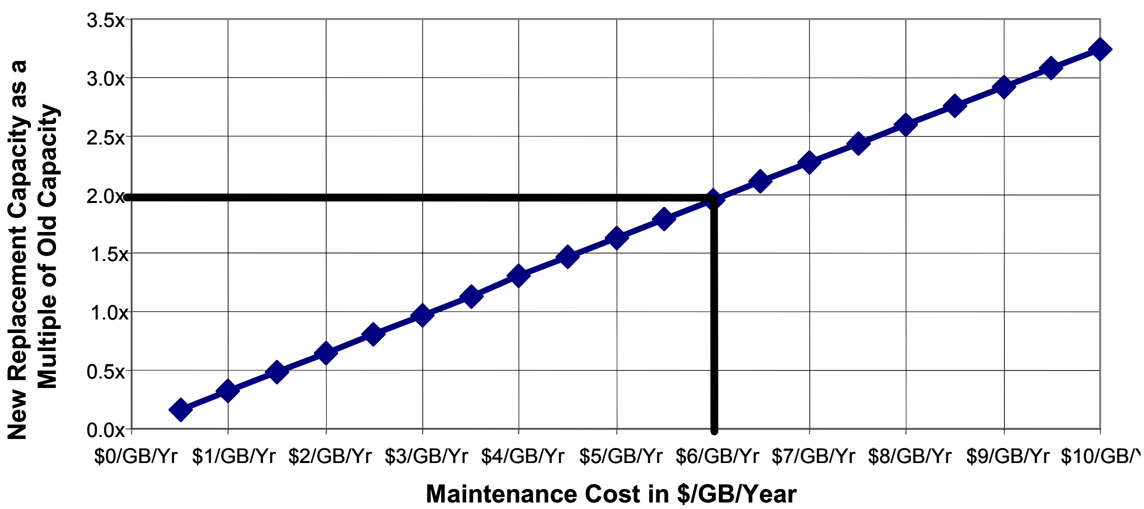
Figure 9 —Using the Cost of Maintaining Post-Warranty Capacity to Finance New Capacity Exorbitant Storage Maintenance Costs



For example, users with a $6/GB/year cap on post-warranty maintenance could finance almost 2x of new, replacement capacity for the same annual cost of maintaining the three-year-old equipment. At $9/GB/year, the user could finance almost triple the old capacity. (Assumes current $20/GB, 25% annual price/capacity improvement, 36-month warranty and financing term, 6% discount factor, and 0% residual value.)

Source IBM

III. Fear: The DS8300 — LPAR Virtualization Comes to Storage

The third impediment to full-frame exploitation is basic fear. We believe one of the most interesting innovations of the DS8000 (specifically the high-end 8300) — its exploitation of the P5's logical partitioning capability — will also contribute to allaying users' "monster box" fears. With its virtualization capability, DS8300 users can have (initially) two distinct "virtual" hardware storage subsystems running the same or different application environments (IBM will expand this initial 2-LPAR limitation in future releases). These completely separate virtual operating environments can be used for distinct production, test, or other unique storage application environments, all operating within a single physical array.

In exploiting the DS8300's LPAR capability, users should be able to better leverage the significant investment potential of these increasingly massive assets … while maintaining a level of data integrity not possible with traditional monolithic storage arrays.

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Exploiting the P5's robust ability to isolate components, the DS8300 should reduce the risk of total system failure by potentially isolating errors to an individual LPAR. We believe this LPAR-based virtualization capability will further aid users in exploiting the full capacity potential of the DS8300, and consequently in driving a higher return on the storage asset investment.

DS8300's Initial LPAR Specs
Initially, the DS8000's dual-LPAR capability will be limited to a 50:50 split of hardware resources (we expect this to be expanded to a 25:75 processor and cache allocation by mid-2005). Following are the initial lower and upper resource allocation bounds for DS8000 LPAR definition, based on the 25:75 allocation capability:

- Smallest virtual image or LPAR:
  - 2 CPUs (1 per CEC)
  - 8 GB memory (4 GB per CEC)
  - 1.2 TB
  - 8 FCP ports

- Largest virtual image or LPAR (when running with another LPAR):
  - 6 CPUs (3 per CEC)
  - 192 GB memory (96 GB per CEC)
  - 96 TB
  - 64 FCP ports

In exploiting the DS8300's LPAR capability, users should be able to better leverage the significant investment potential of these increasingly massive assets, tailoring intra-frame configurations to the specific (and often dynamic) resource requirements of heterogeneous workloads, while maintaining a level of data integrity not possible with traditional monolithic storage arrays. Examples of early DS8300 LPAR exploitation are as many and varied as user environments:

- Production workloads split by operating system, application, business organization, etc.

- Split production workload from application development, change control, test, data mining, etc.

- System resources dedicated to a specific LPAR to better guarantee service-level attainment

- A secondary business continuity LPAR established within the same physical array

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- Deployment of an “information life-cycle management” partition with fewer and lower cost resources dedicated to lower-priority workloads that have less stringent requirements

Indeed, the concept of “application” will be quite broad when applied to virtualized storage servers. To give users an idea of some of the possibilities for storage server virtualization, following are examples of potential storage LPAR-based applications:

- Integrated file systems (e.g., SAN File System, NAS)

- Additional storage protocols and interfaces (e.g., iSCSI gateway, Object Server)

- Database acceleration via offloading (e.g., DB2 health check, multi-level security, database reorganizations, image copies, HSM)

- Business continuity and backup and recovery (e.g., Tivoli Storage Manager, Legato, Veritas, disk-to-tape offload))

- Integrated, domain-specific applications (e.g., reference data, medical imaging)

- Integrated functions (e.g., ESSNet, SAN Volume Controller, delayed RPO [recovery point objective])

DS8000’s LPAR Futures
Users should understand that this initial introduction of P5-based LPAR virtualization on the DS8300 represents the beginning of the potential for logically partitioned storage. Given the P5’s robust performance and architectural characteristics, we project significant and ongoing enhancements to IBM’s initial foray into storage-based partitioning, including:

- More granular I/O allocation (e.g., down to the array level)
- Dynamic processor movement between LPARs (e.g., LPAR granularity from 0.1 to 1.0 of a CPU)
- Dynamic memory movement between LPARs
- Application LPARs — tight integration of storage-centric applications
- Virtual I/O between application LPARs and virtual array images
- Virtualized external application I/O — virtualization of Ethernet and FC ports for application LPARs

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Bottom Line

Although it is still too early to render a comprehensive judgment on IBM's significant introduction of the DS6000 and the DS8000, it clearly indicates a significant step forward for IBM and its overall TotalStorage strategy. The architecture of the DS6000/8000 series is designed as a unified storage continuum with balanced performance that aims to finally put to rest the storage management challenge of distinct enterprise versus midrange storage.

The architecture of the DS6000/8000 series is designed as a unified storage continuum with balanced performance that aims to finally put to rest the storage management challenge of distinct enterprise versus midrange storage.

The high-end DS8000's promised linear scalability and its ability to isolate (initially two) LPAR segments (DS8300 only) is a good first step toward leveraging previously monolithic storage investments into multiple, distinct, productive workloads. The DS6000's compact, low-cost, modular design and its close-to-seamless affinity with the DS8000 promise an attractive choice for the significant low-range and midrange market (the addition of SATA drives in 2H05 will further enhance the DS6000 equation).

While the "marketecture" wars among the Big 4 (EMC, IBM, HP, and HDS) will undoubtedly continue unabated, this announcement should give IBM highly competitive offerings in terms of price, performance, and functionality.

Although pricing will ultimately be market-driven, new (and more complex) pricing models and Ts&Cs (e.g., standard four-year transferable warranty) indicate that IBM intends to "take off the gloves" in its attempt to regain market share lost to competitors (primarily EMC) during the past five years. Assuming solid execution on product rollout, the DS6000/8000 series positions IBM among the leaders in disk storage subsystems. While the "marketecture" wars among the Big 4 (EMC, IBM, HP, and HDS) will undoubtedly continue unabated, this announcement should give IBM highly competitive offerings in terms of price, performance, and functionality.

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