Current Trends in Data Storage Backup and Restoration

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Outline

- Storage Demand Drivers
- Backup and Recovery Trends
- Major Trends in Backup
  - Storage Hierarchy and Data Lifecycle
  - Tape Storage
  - Enhanced Backup
  - Disk Drive for Backup/Recovery
  - Form Factor Changes
  - Electrical Interface Development
Information Details

- Roughly 8 EB of digital data produced in 2002.
- 90% of data on disk is never or seldom accessed after 90 days+
- 90% of digital data is on removable storage*
- 80% of digital data is replicated data*
- Disk utilization is often as low at 35-45% ^
- Disk storage is the most expensive component in the data center

+Horison Information Services
*UC Berkeley
^Gartner/Credit Suisse
Need for Storage Administration

According to Giga: One storage administrator can manage 500 GB-2TB

Implies 1.25 million or more administrators by 2006

Source: Strategic Resource
Data Protection

 PROVIDE BUSINESS CONTINUITY EVEN IF DATA IS:

- Accidentally Erased or Modified
- Maliciously or Accidentally Modified
- Corrupted
- Catastrophically Lost

 MAINTAIN AN ACCURATE, UP-TO-DATE COPY OF THE DATA

 DO NOT ALLOW THIS COPY TO GET MODIFIED, CORRUPTED, OR LOST

 USE THIS COPY TO GET BACK IN BUSINESS QUICKLY
Disaster recovery Depends upon effective backup and rapid data recovery.
Costs of Site Downtime

Brokerage $5.6M - $7.3M  
Credit Card Authorization $2.2M - $3.1M  
Home Shopping $87k - $140k     
Airline Reservations $67k - $112k  
Subway Ticket Sales $56k - $82k  
Parcel Shipping $24k - $32k        
ATM $12k - $17k  

This is why rapid recovery is critical!

Gartner Group / Dataquest
Many Backups are through Networks

SANs connect:
- Storage to Servers in the data center

IP connects:
- Users to Servers on the LAN or Internet
# The Storage Hierarchy

## Positioning Parameters

<table>
<thead>
<tr>
<th>Cost/MB</th>
<th>Capacity Limit</th>
<th>Access Time/Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>$250-500</td>
<td>32 GB</td>
<td>24 GB/Sec</td>
</tr>
<tr>
<td>&lt;$250</td>
<td>16 GB</td>
<td>40 ns</td>
</tr>
<tr>
<td>$10-15</td>
<td>25 GB</td>
<td>&lt;.1 ms</td>
</tr>
<tr>
<td>$.10-.15</td>
<td>N x GB/TB</td>
<td>4-10 ms</td>
</tr>
<tr>
<td>&lt;$.10</td>
<td>NGB-40TB</td>
<td>10-25 ms</td>
</tr>
<tr>
<td>$.10-.50</td>
<td>N x GB</td>
<td>5-10 secs</td>
</tr>
<tr>
<td>$.10-.30</td>
<td>TB-PB</td>
<td>5-10 secs</td>
</tr>
<tr>
<td>&lt;$.005*</td>
<td>TB-PB</td>
<td>5-10 secs</td>
</tr>
<tr>
<td>&lt;$.001*</td>
<td>TB/PB</td>
<td>min, hr, day</td>
</tr>
<tr>
<td>+$20</td>
<td>PB/EB</td>
<td>min, hrs, days</td>
</tr>
</tbody>
</table>

* Based on recording technology

Source: Horison
Data Lifecycle
(modified from StorageTek)
Recovery Time vs. Cost
(from StorageTek)
Tape Applications

- Largest single application is in back-up (>75%). Remainder is archive
- About half of average system price is for the autoloader systems and half is for the drives themselves
- Most backup using Veritas or Legato backup software, little NT or Unix.
- Biggest growth area is libraries for NAS or SAN systems
StorageTek Tape Library
Major Backup Tape Formats

- AIT
- LTO
- DLT
Tape Benefits

🌞 Good Archival Medium
  - Shock Resistance
  - Packing Density
  - Transportability

 (~(Cheap Media Cost)
Tape Challenges

- Sequential Access
  - Slow data restoration

- Degradation During Long Term Storage
  - Re-tensioning, bleed through, …

- Lack of Scalability with Data Growth
  - Capacity
  - Throughput

- Periodic Verification Difficult
  - Especially if Offline
Tape Capacity Growth Trend vs. Technology


Tape Capacity (GB)

- AIT (GB)
- DDS (GB)
- DLT
- LTO
- 30% CAGR
- 60% CAGR
- 100% CAGR
- 120% CAGR
Tape Market Observations

- Tape prices tend to be very stable, <5% price erosion on systems per year
- Average drive price is about $5k (S-DLT)
- Average tape price is about $50 (S-DLT)
- Technology changes such as areal density growth and data rate improvements much slower than disk drives (<60% CAGR in Areal Density growth)
Enhanced Backup

More than 80% of the cost of backup is operational costs, mostly manpower, to support backup.

Since the core rate of tape technology development is different than disk backup, solutions with tape alone are scaling more slowly than the primary storage.

This leads to a “backup crisis!”

By enhancing traditional tape backup with disk based solutions we can help customers avoid a “backup crisis” and provide enhanced performance improvements as well.
Enhanced Backup: A New Spin on Data Protection

Value Proposition
- Enhanced Backup Helps Tame the E-Mail Beast
- Fighting the High Cost of Business Continuity
- The ABCs of Enhanced Backup

White Papers
- Driving for Dollars: ROI and Disk-Based Backup
  - The Gap Information Group determined the real-world economic impact of enhanced backup by studying six companies that had deployed or were about to deploy NetApp's NetApp Store. GIG also offers a technical model that can be used by any company that needs to run the numbers before deploying an application.

Data At Risk: Can ESBS Help?
- Despite vendor claims about deduplication benefits, improved media efficiency, enhanced mining, and other IT managers are struggling to develop, implement, and maintain effective data protection strategies. Meanwhile, a substantial percentage of interviewees said data remains at risk, and the potential for outage levels is staggering. What are the most successful ESBS deduplication trials? What are the limitations? Can ESBS deduplication efforts show the benefits of any individual vendor help?

Case Study
Enhanced Backup Restores Health to Hospital Storage
- NetApp's, a provider of enterprise storage systems, implemented a storage solution for a hospital's imaging department.

Products
- NetApp NetBackup
- NetApp Data ONTAP

Enhanced Stack
- Enhance the Data ONTAP 7.3.3 based on NetApp's NetBackup 6.2.6
- The benefits of enhanced backup can be leveraged by organizations looking to reduce costs and improve data protection.

Contact Us
- For more information, please visit EnhancedBackup.com or contact us at info@EnhancedBackup.com.
Enhanced Backup

Exploit the Advantages of Disks to Protect Data

- Random Access
  - Fast Data Restoration
- Reliable
- Scalable
- Online Reliability Verification
Backup Paradigm Shift

Tape

Backup

Offsite Archive

Immediate Business Continuance

Disk

Backup

Offsite Archive

Immediate Business Continuance
Several Levels of Enhanced Backup

**Level 1:** Backup to Disk as Tape Image

**Level 2:** Changed-Block Backup with Read Access

**Level 3:** Continuous Backup with Read-Write Access
Enhanced Backup - Level 1

Backup to Disk as Tape Image

- Data on Primary Storage Is Backed up to Nearline Disk Storage Using Traditional Backup Software
- Data on Nearline Storage Is in Proprietary Format
- Nearline Storage Is Backed up to Tape for Archiving
Enhanced Backup - Level 1

- File-level transfers
- Network Backup
- Server
- Tape Library
- Disk Based Storage
- Fast Data Access
- Weekly / Monthly Full
- Daily Incremental

UNIX Server
Windows Server
Backup Server
Enhanced Backup - Level 1

 Benefits

- Faster Restores From Random-access Disk Storage
- Eliminates the Need for Daily Incremental Backups to Tape
- Integrates Into Your Existing Infrastructure

 Challenges

- Lots of Disk is Required for Full and Incremental Backups
  - One Byte Changed Causes Entire File to be Backed up
- Restore Process Still Requires Human Intervention
  - Backup Copy Cannot Be Directly Accessed
- Backing up Remote Offices Is Not Practical Using This Approach
  - Requires a Robust WAN Network
Enhanced Backup - Level 2

Changed-Block Backup with Read Access

- Data Is Backed up to Nearline Disk Storage
  - Only the Initial Backup to Nearline Storage Is a Full Backup
  - All Subsequent Backups Transfer Changed Data Only
    - Only Changed Blocks Are Stored

- Backup Data on Nearline Storage Is in File Format
  - Can Be Browsed By Users
Enhanced Backup (Level 2)

- NetApp Storage
- Solaris Server
- Network
- Only Changed Blocks Stored
- Windows Server
- Hourly/Daily Incrementals
- Backup Server
- Weekly / Monthly Full
- Tape Library
- Remote Data Center
- Disk Storage System
- SnapVault
- SnapMirror
- Only Changed Blocks Stored
- Backup Server
- SnapMlTar
- WAN
Enhanced Backup (Level 2)

Benefits

- **Superior Data Protection**
  - More frequent backups can be done and kept online
  - Immediate verification of backup data

- **Fast Backups and Restores**
  - Shrinks/eliminates the backup window

- **Lower Backup Infrastructure costs**
  - Less storage utilized to store backup copies
  - User initiated file restores

Challenges

- **Files Need to Be Restored Before Use**
  - Restore Is Delayed Until a New System or Free Disk Space Can Be Located

- **Doesn’t Solve Immediate Business Continuance**
  - Separate Solution Required
Enhanced Backup (Level 3)

- Continuous Backup with Read-Write Access
  - Backup Data on Nearline Storage Can Be Made Write-able in the Event of a Disaster
  - Once the Primary Storage Is Available, the Data on the Nearline Storage Can Be Re-synced With the Primary Storage
Enhanced Backup (Level 3)

1. Level 2 Backup / Replication

Source
Volume (Read/Write)

Target
Volume (Read)

Replication

2. Primary Storage down; Target made read/write

Source
Volume (Read/Write)

Target
Volume (Read)

X

3. Primary Storage available

Source
Volume (Read)

Target
Volume (Read/Write)

Re-Sync

4. Level 2 Backup / Replication Reinitiated

Source
Volume (Read/Write)

Target
Volume (Read/Write)

Replication

Target
Volume (Read)
Enhanced Backup (Level 3)

Benefits

- Superior Data Protection
  - More Frequent Backups Can Be Done and Kept Online
  - Immediate Verification of Backup Data

- Lower Backup Infrastructure Costs
  - Less Storage Utilized to Store Backup Copies
  - User Initiated File Restores

- Solves Backup and Business Continuance Issues
  - One Solution

Challenges

- New Paradigm
## Addressing Traditional Backup Pain Points

<table>
<thead>
<tr>
<th>Traditional Backup Pain Points</th>
<th>Backup to Tape</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary Storage impact during backup</td>
<td>X</td>
<td>⊗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Backup window shrinking is an issue</td>
<td>X</td>
<td>⊗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Restoring data takes a long time</td>
<td>X</td>
<td>⊗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Takes a long time to verify backup data</td>
<td>X</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Backups consume a lot of tape media</td>
<td>X</td>
<td>⊗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Backups consume a lot of network bandwidth</td>
<td>X</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Backup &amp; restore process fails thereby requiring constant monitoring</td>
<td>X</td>
<td>⊗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Restores normally require administrator involvement</td>
<td>X</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Remote backups are not dependable and costly to manage and administer</td>
<td>X</td>
<td>X</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

- **X** Does not address
- **⊗** Helps address
- **✓** Fully addresses
Nearline and Enterprise Drives

Seagate Cheetah Product
73.4 GB, 15,000 RPM, FC/SCSI

Maxtor MaxLine Product
320 GB, 5,400 RPM, SATA

Western Digital Caviar Product
200 GB, 7,200 RPM, PATA

Western Digital Raptor Product
36.7 GB, 10,000 RPM, SATA
ATA-Based Storage Systems

Quantum DX30
The DX30 separates backup functions from archive functions to optimize the data protection process.

Nexsan ATABeast
Nexsan's 14 TB for 7 cents a MB

STK Bladestore product uses 5-3.5 inch drives on blade acting as one drive to a fibre channel output.
Nearline Storage

- NearLine storage is most often a rack of HDD storage shelves and is used for low latency backup (caching for tape archives)
  - Sits between tape archives and primary storage arrays
  - Parallel ATA-based today (low cost drives are a must)
  - FC SAN connections

- NearLine storage requires reasonable reliability and reasonable performance (cost is more important)
  - Focus is on cost and capacity (cost/Mbyte)
Disk Drive Trends

- Increasing storage and lower $/GB
  - Currently 60 and 80 GB/3.5 inch disk
    - Maxtor 320 GB, 4 disk, 5400 RPM
    - Maxtor, WD 200+ GB 7200 RPM
  - Next year 120-160 GB/3.5 inch disk
  - Within 2-3 years 1 TB 4-disk drive will happen!

- New serial interfaces
  - Serial ATA (SATA)
  - Serial SCSI (SAS)

- Growing use of external drive boxes with USB or 1394 interfaces

- New small form factor drives for mobile devices
  - 1.8 inch 20+ GB drives and small drive developments
External Drives (USB or Firewire) or with small NAS devices on a LAN

Maxtor PS5000 with one-touch backup

SNAP Storage Appliances
iVDR
Information Versatile Disk for Removable usage

✧ Common HDD platform for PC and Consumer AV usage regardless of products and manufactures
✧ Compact and Removable
✧ Large Capacity and High-Speed Access
✧ Content/Data Protection
✧ Open Standard
Possible Backup NAS Device using iVDR drives
Estimated ASP Trends
AREAL DENSITY PROGRESSION
(Source: PRC, 2002)
<table>
<thead>
<tr>
<th>Year</th>
<th>Areal Density CAGR</th>
<th>95mm Avg. Capacity Per Platter</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>120%</td>
<td>15</td>
</tr>
<tr>
<td>2001</td>
<td>100%</td>
<td>30</td>
</tr>
<tr>
<td>2002</td>
<td>90%</td>
<td>60</td>
</tr>
<tr>
<td>2003</td>
<td>80%</td>
<td>108</td>
</tr>
<tr>
<td>2004</td>
<td>70%</td>
<td>184</td>
</tr>
<tr>
<td>2005+</td>
<td>60%</td>
<td>294</td>
</tr>
</tbody>
</table>
Disk Cost Trends

Average Price of Storage

- HDD
- DRAM
- Flash
- Paper/Film

Range of Paper/Film

IBM

Ed Grochowski at Almaden
3.5 Inch ATA Network Storage
Drive Capacity and Price/GB

Drive Capacity (G)

$/GB

2001 2002 2003 2004 2005
As low cost disk drive storage decreases in price it offers greater economy to disk to disk backup and the use of disk drives for backup cache.
Comparison of Straw Man DLT Tape vs. IDE Disk Backup System
(Note that Tape has 2:1 Compressed capacity vs. disk drive native capacity)

<table>
<thead>
<tr>
<th>Attribute</th>
<th>DLT Tape Libray</th>
<th>IDE Drive Drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access Time</td>
<td>60 sec</td>
<td>&lt;15 ms</td>
</tr>
<tr>
<td></td>
<td>(&gt;4000 X faster)</td>
<td></td>
</tr>
<tr>
<td>Data Rate</td>
<td>6 MB/s</td>
<td>&gt;46 MB/s</td>
</tr>
<tr>
<td></td>
<td>(&gt;7 X faster)</td>
<td></td>
</tr>
<tr>
<td>Removability</td>
<td>Yes (Cartridges)</td>
<td>Could be (drive carriers)</td>
</tr>
<tr>
<td>A. D. CAGR</td>
<td>&lt;60%</td>
<td>&gt;80%</td>
</tr>
<tr>
<td>Sequential Access</td>
<td></td>
<td>Random Access</td>
</tr>
</tbody>
</table>
DATA PROTECTION MARKET OPPORTUNITY

- Backup Arrays include
  - Virtual Tape, D2D Backup, Point-in-time Backup, Snapshot Backup
- Backup Array revenue grows to $5.1B in 2005 offsetting the Tape Library Market
- Tape Library growth reaches $3.1B in 2005
- Disk usage expands as a secondary data protection device relegateing tape to an archive role
- Tape libraries are the central automated archive repository
- 60%+ of mainframe data is now protected by disk – Virtual Tape

Strategic Research Corp., Nov. 2002
Transition to Smaller Form Factors

- 2.5 inch most popular mobile computer drive form factor.
- 1.8 inch mobile computers now appearing, smaller size drives???
- 60-65-mm disks used in 15k RPM enterprise disk drives (although not yet in 2.5 inch form factor box). Cooling issues
- For new consumer products size and volume will become important.
- Dense server and storage environments favor many more smaller drives. This also gives better performance since the time to data is faster for smaller form factors
- New consumer electronics initiatives using smaller form factor disk drives such as the Japanese iVDR consortium.
- In volume 2.5 inch drives should be as inexpensive or less expensive per box compared to 3.5 inch disk drives.
Capacity vs. Form Factor
(Same Areal Density, 4 Disks)
Volumetric Density Comparison

0.0  2.0  4.0  6.0  8.0  10.0  12.0  14.0  16.0  18.0

2002  2003  2004  2005  2006  2007  2008

Volumetric Density (MB/sq. mm)

65 mm, Enterprise
- 95 mm, Nearline
- 95 mm, Enterprise

65 mm Enterprise
2 disk, mobile form factor

95 mm Nearline
4 disks

95 mm Enterprise
6 disks
Disk Drive Form Factor Changes

Percentage (%)

2000 2001 2002 2003 2004 2005 2006

<1.8 inch 2.5 inch 3.5 inch 5.25 inch
Today’s Hard Disk Drive Interfaces

**Typical Configuration**

- **Fibre Channel**
  - Serial (low pin count)
  - Point to point
  - Looped
  - Switched
  - SCSI commands

- **SCSI**
  - Bus architecture
  - SCSI Cmd. Protocol
  - Reliability
  - Expansion

- **Parallel ATA**
  - Low cost (thin protocol)
  - Point to point interface
Enterprise Storage Challenges

- **Key HDD requirements**
  - Reliability
  - Performance
  - Expansion
  - Hot Swapability
  - Back Plane drive capability (interface)
  - Cost

- **Parallel SCSI challenges**
  - Bus architecture is a bottle neck
  - Date Rate beyond 320 MB/s a huge challenge
  - 5V tolerance in < .15 micron silicon

- **Fibre channel solves all the issues but...**
  - Both host side and drive side solutions come at a cost penalty

- **SATA addresses many of the Enterprise Storage requirements**

  *Will SCSI really get replaced?*
Drive Interface Migrations

Parallel ATA → Serial ATA
ATA is cost-optimized for non-mission critical applications

Parallel SCSI → Serial Attached SCSI
Serial Attached SCSI addresses the performance and reliability needs of enterprise environments

Fibre Channel → Serial Attached SCSI & Fibre Channel
Fibre Channel continues to pursue long-distance and connectivity solutions associated with SANs

2001 Overall HDD Market
- 10%

2001 Enterprise HDD Market
- 9%
Fibre Channel Speeds and Feeds

1 Gigabit per second (100 MB) since 1996
- Physical layer adopted by Gigabit Ethernet

2 Gigabit per second (200 MB) since 1999
- Gigabit Ethernet won’t go there

4 Gigabit per second (400 MB) in 2003
- Only a disk drive interface – not fabrics

10 Gigabit per second (1200 MB) in 2003
- Physical Layer adopted from 10 Gig Ethernet
# Interface Technology Comparison

<table>
<thead>
<tr>
<th>Performance</th>
<th>Serial ATA</th>
<th>Serial Attached SCSI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Half-duplex</td>
<td>Full-duplex with Link Aggregation</td>
</tr>
<tr>
<td></td>
<td>1.5 Gb/sec (3.0 Gb/sec announced)</td>
<td>3.0 Gb/sec</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Connectivity</th>
<th>Serial ATA</th>
<th>Serial Attached SCSI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Internal only</td>
<td>6m external cable</td>
</tr>
<tr>
<td></td>
<td>One device</td>
<td>&gt;128 devices</td>
</tr>
<tr>
<td></td>
<td>No peer-to-peer</td>
<td>Peer-to-peer</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Availability</th>
<th>Serial ATA</th>
<th>Serial Attached SCSI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single-port HDDs</td>
<td>Dual-port HDDs</td>
</tr>
<tr>
<td></td>
<td>Single-host</td>
<td>Multi-initiator</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Driver Model</th>
<th>Serial ATA</th>
<th>Serial Attached SCSI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Software transparent with Parallel ATA</td>
<td>Software transparent with Parallel SCSI</td>
</tr>
</tbody>
</table>
## CE Interface Speed Comparison

<table>
<thead>
<tr>
<th>Interface</th>
<th>USB 2.0</th>
<th>1394</th>
<th>Serial ATA</th>
<th>Serial ATA Gen 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interface speed</strong></td>
<td>480 Mbps</td>
<td>400 Mbps</td>
<td>1500 Mbps</td>
<td>3000 Mbps</td>
</tr>
<tr>
<td><strong>Time to Copy 2GB File</strong></td>
<td>40 sec</td>
<td>33 sec</td>
<td>11 sec</td>
<td>5 sec</td>
</tr>
<tr>
<td><strong>Download 16 GB HD Movie</strong></td>
<td>360 sec (6 min)</td>
<td>300 sec (5 min)</td>
<td>97 sec (1.6 min)</td>
<td>48 sec (0.8 min)</td>
</tr>
<tr>
<td><strong>Back-up 80GB drive</strong></td>
<td>1600 sec (27 min)</td>
<td>1333 sec (22 min)</td>
<td>427 sec (7.1 min)</td>
<td>213 sec (3.6 min)</td>
</tr>
</tbody>
</table>
General SATA & SAS Timelines

2002 2003 2004 2005
1H 2H 1H 2H 1H 2H 1H 2H

SATA Controllers

Bridge Demos

SATA 1.0
- 1.5 Gb/s @1m cabling
- P-ATA Features
- Hot-plug enabled

SATA 2.0
- SATA 1.0, plus
- 3.0 Gb/s @1m cabling
- SATA Command Queuing
- Additional features

Dual Mode SATA/SAS Controllers

Spec Proposal to ANSI T10

SAS 1.0
- 3.0 Gb/s
- >9m cabling
- Parallel SCSI Features
- 128 device addressing
- Dual port

SAS Controllers

NAS/Nearline ⇒ Desktop

SAS

Demo Units

SAS FCS

Server ⇒ Subsystems

SAS FCS

Qual Units

⇒

Desktop

⇒

Subsystems

⇒

NAS/Nearline

⇒

Server
Enabling Choices For Customers

- OR -

- A “properly designed” backplane can accommodate either SAS or SATA disk drives
  - SATA/High-Capacity disk drives can be used to enable “near-line” or tape augmentation applications
  - SAS/High-Performance disk drives can be used to enable “on-line” and performance-oriented applications
- Enables OEMs, VARs & Integrators the ability to re-use designs and more easily broaden their product offerings
Enabling Choices for Customers:
**SATA-SAS Subsystem Example**

*When drives can share a common controller & backplane, system designers & integrators are given more opportunities…*

- **Dual port SAS drives** for main stream server applications
- **SATA drives** integrate disk to disk backup in the server to shorten backup and restore times
- **Add-on JBOD or RAID storage with mixed drive classes**
- **SATA drives** with dual port, switched carriers for networked file storage
Enterprise Storage Interface Forecast

![Graph showing trends in different storage interfaces from 2001 to 2005.]

Source: IDC 3/02
HDD Unit Shipment Forecast by Segment

Source: Dataquest
Conclusions

- Data storage continues to grow. More things made digital.
- Greater need than ever to preserve our digital assets through backup and archive.
- Tremendous financial incentives tied to rapid recovery.
- Disk based backup will displace tape in many backup and restoration applications to create Enhanced Backup Storage.
- Three phases of Enhanced Backup Storage discussed, each leading to greater automation of backup and restore operations.
- Changes in disk areal density and interfaces will lead to higher performance and less costly backup storage.
- Digital backup and archive remain a major component in data storage growth.