Magnetic Tape Data Storage Trends and Products

Mike Leonhardt
Storage Technology Corporation
2270 S 88th St
Louisville CO 80028-6100
Phone: +1-303-673-5627; FAX: +1-303-673-7967
e-mail: mikel@adtek.stortek.com
Outline

• Technology Overview
• Storage Trends
• Architecture
• StorageTek’s “Building Blocks”
  – Drives
  – Automation
• Enabling Events
• Magnetic Tape Outlook
Storage Hierarchy
Areal Density Trends

- Optical Disk
- Magnetic Disk
- Helical Scan Tape
- Narrow Track Longitudinal Tape
- Parallel Track Longitudinal Tape
- RedWood™
- 3590
- TimberLine™
- New Tape Development

Holographic (Volumetric Optical)
Data Rate vs. Capacity

- 18 Trk, 1/2" (3480)
- 36 Trk-1/2" (performance) (3490E)
- 128 Trk-1/2" (3590)

High Performance Helical Tape ‘96-’00
General Purpose Tape ‘96-’00
OnLine and NearLine® Systems

Capacity Utilization: 100%

Solid State Disk Based Systems
'96-'01 (StorageTek)

Disk Based Systems '96-'01 (StorageTek)

Performance Disk *
'01 '96

Capacity Disk *
'01 '96

5 1/4” Optical Disk
'01 '96

SD-R Optical Disk
'01 '96

TimberLine™ '96 '98

Tape Based Systems '96-'01

RedWood™ '96 '96

(10 GB) (50 GB)

* Device Only

StorageTek
Storage Trends -- 5 years

- Magnetic disk fuels the technology pace of data storage.
- Holographic storage has very high data density potential but many technological challenges to overcome.
- Magnetic tape based systems continue to remain the primary technology for storage at < $0.1/MB, > 30 second access time.
- Magnetic tape technology is on track to support storage at <$0.001/MB, > 15 second access time over the next 5 years.
- A large “access gap” remains between tape and disk based systems.
- Optical based systems could reach into this “gap”.
  “Super CD” recordable optical disk technology (SD-R) will provide low cost, low data rate storage.
- Magnetic disk based systems will typically remain 10 - 100 X magnetic tape system costs (for total user storage capacity).
  But...very low end disk arrays add only 20% to the cost of commodity disk and could challenge some tape based systems.
Array Tape (RAIT)

Concept
- First described by Prof. R. Katz, UCB, October ‘91 at IEEE Mass Storage Conference
- Borrowed from disk’s redundant array of independent disks (RAID)
- Array levels include -- tape drive, tape automation and networks

Function
- Capacity multiplying
- Data rate multiplying
  - Cost-performance benefits
- Fault tolerance (media and drive)
  - Enhanced archive data integrity
- Data reconstruction
Challenge

• Data Management
  Multiple tape sets
  Integrate processes with non array tape
  Use of automation

• Application Compatibility
Automation Scenarios

3+1 RAIT

Data Rate = n MB/s
Performance = exchanges per hour (EPH)/(n+m)
Granularity = 1 library

Example

Date Rate = n MB/s
Performance ≈ EPH
Granularity = (n+m) libraries

(n+m) RAIT

(n+m) RAIT
**Drive and Automation Products**

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9704</td>
<td>TimberWolf™ Family</td>
</tr>
<tr>
<td>9714</td>
<td>TimberWolf™</td>
</tr>
<tr>
<td>9710</td>
<td>WolfCreek™</td>
</tr>
<tr>
<td>9360</td>
<td>PowderHorn™</td>
</tr>
<tr>
<td>9310</td>
<td></td>
</tr>
<tr>
<td>4890</td>
<td>TwinPeaks™™</td>
</tr>
<tr>
<td>4480</td>
<td></td>
</tr>
<tr>
<td>4490</td>
<td>Silverton™™</td>
</tr>
<tr>
<td>9490</td>
<td>TimberLine™™</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SD-3 RedWood™™</td>
</tr>
</tbody>
</table>
# Drives

<table>
<thead>
<tr>
<th>Type</th>
<th>SD-3 RedWood™</th>
<th>9490 TimberLine™</th>
<th>4490 Silverton™</th>
</tr>
</thead>
<tbody>
<tr>
<td>Format</td>
<td>1/2” helical</td>
<td>1/2” 36 track</td>
<td>1/2” 36 track</td>
</tr>
<tr>
<td>Media</td>
<td>“3480 form factor”, MP</td>
<td>3480/3490E</td>
<td>3480/3490E</td>
</tr>
<tr>
<td>Capacity (GBytes)</td>
<td>10, 25, 50</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>Data Rate (MBytes/sec)</td>
<td>11.2</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Average Access Time (sec)</td>
<td>44-85</td>
<td>26</td>
<td>51</td>
</tr>
<tr>
<td>Interface</td>
<td>ESCON, SCSI-2</td>
<td>ESCON, SCSI-2</td>
<td>ESCON, FIPS</td>
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</table>

ILLUSTRATIONS OMITTED IN THIS VERSION
## Drives

<table>
<thead>
<tr>
<th></th>
<th>4890</th>
<th>4480</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>TwinPeaks™</td>
<td></td>
</tr>
<tr>
<td><strong>Format</strong></td>
<td>1/2” 36 track</td>
<td>1/2” 36 track</td>
</tr>
<tr>
<td><strong>Media</strong></td>
<td>3490E/3480</td>
<td>3490E/3480</td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
<td>0.8</td>
<td>0.8</td>
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<tr>
<td><strong>Data Rate</strong></td>
<td>3</td>
<td>3</td>
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<tr>
<td><strong>Average Access Time</strong></td>
<td>49</td>
<td>29</td>
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<tr>
<td><strong>Interface</strong></td>
<td>SCSI-2, FIPS</td>
<td>SCSI-2, FIPS</td>
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</tbody>
</table>

ILLUSTRATIONS OMITTED IN THIS VERSION
Data Rate vs. Capacity

Data Rate (MB/s)

Capacity (GB)

SD-3 ('96)

High Performance Helical Tape ‘96–’00

General Purpose Tape ‘96–’00

4480, 4890
# Automation

ILLUSTRATIONS OMITTED IN THIS VERSION

<table>
<thead>
<tr>
<th>Library</th>
<th>9310 PowderHorn™</th>
<th>9360 WolfCreek™</th>
<th>9710 TimberWolf™</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity (# cartridges)</td>
<td>2000-6000</td>
<td>500-750-1000</td>
<td>250-420-588</td>
</tr>
<tr>
<td>Performance (exchanges/hour)</td>
<td>190, 350</td>
<td>90, 190, 350</td>
<td>180</td>
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<tr>
<td>Drives (max. # - type)</td>
<td>16 - 4480, 4490, 9490, SD-3 (includes mix)</td>
<td>8 - 4480, 4490, 9490, SD-3 (includes mix)</td>
<td>6 - 4890, 10 - DLT 4000/7000 (includes mix)</td>
</tr>
<tr>
<td>Cartridge Access Port (# cartridges)</td>
<td>21, 80</td>
<td>20, 50</td>
<td>14</td>
</tr>
<tr>
<td>Typical Footprint (ft²)</td>
<td>103</td>
<td>24 - 35</td>
<td>12 - 16</td>
</tr>
<tr>
<td>Other Features</td>
<td>pass thru to 16</td>
<td>pass thru to 16</td>
<td>office environment</td>
</tr>
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</table>
# Automation

## Specifications

<table>
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<tr>
<th>Feature</th>
<th>9714</th>
<th>9704</th>
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</thead>
<tbody>
<tr>
<td><strong>Library</strong></td>
<td>TimberWolf™ Family</td>
<td></td>
</tr>
<tr>
<td><strong>Capacity</strong></td>
<td>40-60-80-100</td>
<td>25</td>
</tr>
<tr>
<td>(# cartridges)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Performance</strong></td>
<td>240</td>
<td>180</td>
</tr>
<tr>
<td>(exchanges/hour)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Drives</strong></td>
<td>6 - DLT 4000/7000</td>
<td>2 - DAT</td>
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<tr>
<td>(max. # - type)</td>
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<tr>
<td><strong>Cartridge Access</strong></td>
<td>1</td>
<td>1, 25 (carousel)</td>
</tr>
<tr>
<td><strong>Port (# cartridges)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Typical Footprint</strong></td>
<td>6.5</td>
<td>1/2 rack</td>
</tr>
<tr>
<td>(# ft²)</td>
<td></td>
<td></td>
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<tr>
<td><strong>Other Features</strong></td>
<td>office environment</td>
<td>office environment</td>
</tr>
<tr>
<td></td>
<td>unannounced product,</td>
<td>carousel access via “door”</td>
</tr>
<tr>
<td></td>
<td>some #’s preliminary</td>
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</tr>
</tbody>
</table>

*ILLUSTRATIONS OMITTED IN THIS VERSION*
Enabling Events -- Magnetic Tape

- New tape magnetic, backside coatings; thinner, more stable substrate materials
- First track following servo system introduced into product -- others expected
- Key tape product line advances -- 4 mm through 1/2” -- but several delays
- Strong consumer driven product technologies and data services
  
  High density, low cost digital storage:
  
  PC tape backup, data exchange
  Digital VCR/camcorders -- Digital Video Cassette (DVC)
  Competing optical technology:
  
  CD movies -- Digital Video Disk (DVD), recordable
  CD’s (SD-R)

New requirements for low cost mass data storage:

Video-on-demand
Internet databases
Magnetic Tape Outlook

• Tape continues to offer the lowest cost data storage for the 5 year outlook period with capacity and data rate making significant gains
• Tape’s areal density continues to increase but magnetic disk is outpacing all storage technologies in rate of advancement
  Tape utilizes disk’s technology advancements
• Media and servo technologies are poised to support continued product advancements.
• Tape development will be increasingly pushed by consumer driven products and services
• Alternate system architectures (e.g. tape array) will have an expanding role -- offering unique levels of performance and data reliability