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Data Storage Futures

August 2014

Dr. Robert M. Raymond
Director, Tape Systems Development
Storage Trends
Oracle StorageTek Tape – A Look Back 16 years

**10 TB in 1998**

- ~ 6000 carts
- TimberLine 9490EE – 1.6 GB ea
- 357 sq ft
- 8200 lbs

**10 TB in 2014**

- < 2 carts
- T10000D – 8.5 TB ea
- 0.3 sq ft
- 1.2 lbs
Oracle StorageTek Tape – A Look Back 16 years

10 PB in 1998

~ 6,000,000 carts
~ 8 acres
~ 4,100 tons

10 PB in 2014

1,177 carts
StorageTek SL3000 with T10000D
37 sq. feet
~1.5 tons
Storage Technologies Areal Density Trends
Tape Storage Projections - Recent Technology Demos

• INSIC tape roadmap shows technology path to 128 TB on a cartridge
• Sony sputtered media demo
  – Areal density of 148 GB/in\(^2\)
  – ‘185 TB’ cartridge
• Fujifilm advanced BaFe demo
  – Areal density of 85.9 GB/in\(^2\)
  – ‘154 TB’ cartridge
• Demos show we’ve got solid technology to achieve roadmap goals
Demos vs Products

• Technology demos show the potential for product
• Product cartridge capacities and areal densities are always lower
  – Demos done with HDD heads; not tape cartridge running in tape drive
• Oracle does not publicize internal tech demos. The focus is on first to market
• IBM’s 29.5 GB/in$^2$ demo in 2010
  – Gen 1 BaFe media demo
  – Advertised as ‘35 TB cartridge’ demo
  – T10000 T2 cartridge was first product launched using this media (5 TB T10000C drive)
Chart courtesy of INSIC
Tape Data Rate Trend

INSIC 2012 Roadmap
23% per year

StorageTek Tape
23% per year

Data Rate (MB/sec)

Year

Tape Management Trends
Maximize Performance and Capacity
Simplify Management
T10000D Leads the Industry in Capacity

More than 2X the Capacity of TS1140

More than 3X the Capacity of LTO-6
T10000D Leads the Industry in Throughput

Throughput (MB/sec)

<table>
<thead>
<tr>
<th></th>
<th>Throughput (MB/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>StorageTek T10000D</td>
<td>252</td>
</tr>
<tr>
<td>IBM TS1140</td>
<td>250</td>
</tr>
<tr>
<td>LTO-6</td>
<td>160</td>
</tr>
</tbody>
</table>

More than 1.5X the Data Rate of LTO-6
NEW! File Sync Accelerator’s Large File Mode

Write Performance with 1 GB Files

<table>
<thead>
<tr>
<th>Drive Data Rate (MB/sec)</th>
<th>Host Data Rate (MB/sec)</th>
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</thead>
<tbody>
<tr>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>50</td>
<td>80</td>
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<tr>
<td>100</td>
<td>120</td>
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<td>150</td>
<td>160</td>
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<tr>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>250</td>
<td>240</td>
</tr>
<tr>
<td>300</td>
<td>280</td>
</tr>
</tbody>
</table>

- **T10000D**
- **LTO-6**

Large File Example (>50 MB)

Write 1GB Files

3.3X Faster Than LTO-6
File Sync Accelerator’s *Small File Mode*

<table>
<thead>
<tr>
<th>Time to Write 25 GB of 13 MB Files (256 KB blocks)</th>
<th>1:03:26</th>
</tr>
</thead>
<tbody>
<tr>
<td>StorageTek T10000D File Sync Accelerator</td>
<td>0:08:07</td>
</tr>
<tr>
<td>IBM TS1140 Virtual Back Hitch</td>
<td>0:11:18</td>
</tr>
<tr>
<td>LTO-6</td>
<td></td>
</tr>
</tbody>
</table>

Small File Example (<50MB)
Write 13 MB Files **8X Faster** than LTO-6
...with 0.01% of the backhitches

<table>
<thead>
<tr>
<th>Backhitches</th>
</tr>
</thead>
<tbody>
<tr>
<td>StorageTek T10000D File Sync Accelerator</td>
</tr>
<tr>
<td>IBM TS1140 Virtual Back Hitch</td>
</tr>
<tr>
<td>LTO-6</td>
</tr>
</tbody>
</table>
NEW! StorageTek File Access Accelerator

Step 1: Generate Read Access Order (GRAO)*

Step 2: Request Read Access Order (RRAO)*

Step 3: Send Reordered File List

Read Files A thru U without File Access Accelerator

00:33:21

Read Files A thru U with File Access Accelerator

00:21:47

35% Faster Access!

*Supports T10 ANSI Standard 13-266r4
Intelligently Manage Your Storage

- Can We Leverage Software to Monitor for Us?
- Where are We Seeing Bottlenecks?
- Are Our Drives and Media Optimally Configured?

StorageTek Tape Analytics 2.0 is Your Answer

- Reports on How Efficiently Your Applications are Using the Library
- Customized Dashboards So Your Administrators Can Focus on the Resources They Are Managing
- Browser and Mobile Access to Tape Analytics
- Customized Email Alerts for Unique Users

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Expanded Monitoring
Go Beyond Just Drives and Media

Tape Analytics 1.0
- Drives
- Media
- Library Indicator

NEW with Tape Analytics 2.0
- Robots
- Cartridge Access Ports
- Pass-Through Ports
- Elevators
Library Media Validation
Supporting StorageTek T10000 Data Integrity Validation

• Validate Media Health
  – Initiate media validations through StorageTek Library Console or StorageTek Tape Analytics
    • Perform Basic, Standard, and Complete Verifications with CRC checks
    • Supports StorageTek T10000 media and T10000C/D tape drives
• Data Security
  – Validation kept inside the StorageTek T10000C/D tape drives
    • No extra fibre, No extra servers, No key management
  – Cartridges stay secure within the library
• Fastest Performance
  – StorageTek T10000C/D offers the FASTEST data validation speeds
  – No speed limit with compressed data
Four Media Verify Options Maximize Flexibility

Choose the Type of Validation that Fits Your Needs

1. Basic Verify (~1 minute)
   - Validate the cartridge Media Information Region (MIR)

2. Standard Verify (~15-30 minutes)
   - Validate two upper and two lower data wraps on tape

3. Complete Verify (~1 hour/TB)
   - Validate entire contents of tape cartridge

4. Complete Verify Plus (1+ hours/TB)
   - Validate entire contents of tape cartridge, including any DIV CRCs, and decrypts* and decompresses all data

* Complete Verify Plus requires OKM connection for any encrypted tapes
Automated Policies for Media Validation

Policy Based Automated Scanning

StorageTek Tape Analytics can automatically select media to verify based on policy and logically group media.
Advanced Email Alerts
Instant Notifications to Get the Job Done

- High level alerts to monitor growth rates and system trends
- Unique Alerts for Each Datacenter
- Notification When Media is Removed
- Alerts When Upgrades Occur

Executive
Storage Administrator
Operator
Go Mobile
Proactively Monitor Your Storage
From Anywhere

Executive, Storage Administrator & Customized Mobile Information

Mobile Browser Access

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## Enterprise Tape Technology Roadmap

<table>
<thead>
<tr>
<th>Date</th>
<th>SL3000 Modular Library System</th>
<th>SL8500 Modular Library System</th>
<th>T10000C Enterprise Tape Drive</th>
<th>SL3000 Modular Library System</th>
<th>SL8500 Modular Library System</th>
<th>T10000E Enterprise Tape Drive</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>5,925 Slot Capacity</td>
<td>3,200,000 Slot Capacity</td>
<td>5 TB Capacity</td>
<td>50 PB Capacity</td>
<td>27 EB Capacity</td>
<td>12 to 18 TB Capacity</td>
</tr>
<tr>
<td>2013</td>
<td>56 Drive Capacity</td>
<td>20,480 Drive Capacity</td>
<td>252 MB/s throughput</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>SL3000 Modular Library System</td>
<td>SL8500 Modular Library System</td>
<td>T10000D Enterprise Tape Drive</td>
<td>SL3000 Modular Library System</td>
<td>SL8500 Modular Library System</td>
<td>T10000E Enterprise Tape Drive</td>
</tr>
<tr>
<td></td>
<td>27 EB Capacity</td>
<td>27 EB Capacity</td>
<td>8.5 TB Capacity</td>
<td>27 EB Capacity</td>
<td>38 to 58 Exabyte Capacity</td>
<td>12 to 18 TB Capacity</td>
</tr>
<tr>
<td>2015</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2016</td>
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<tr>
<td>2017</td>
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</tr>
</tbody>
</table>

**Delivered**
- SL3000 Modular Library System 5,925 Slot Capacity
- SL8500 Modular Library System 3,200,000 Slot Capacity
- T10000C Enterprise Tape Drive 5 TB Capacity

**Planned**
- SL3000 Modular Library System 50 PB Capacity
- SL8500 Modular Library System 27 EB Capacity
- T10000D Enterprise Tape Drive 8.5 TB Capacity
- SL3000 Modular Library System 71 to 106 PB Capacity
- SL8500 Modular Library System 38 to 58 Exabyte Capacity
- T10000E Enterprise Tape Drive 12 to 18 TB Capacity
Hardware and Software
Engineered to Work Together