High-Performance and Large-Capacity Storage: A Winning Combination for Future Data Centers

Phil Brace | August 12, 2015
Data is Changing…

**Bigger**

- Explosive growth in data
- Shift in use and store model
- Modest growth in IT budgets

**Different**

- Location SHIFTING dramatically to the CLOUD
- Demand GROWING at Exponential RATE

**$ Constrained**

- Stable but SLOW growth

Exciting Time to be in the Storage Industry!

Need innovation in architecture and media within economic constraints

We have a collective opportunity
## Storage Architecture
Leveraging tiers to meet workload and economic demands

<table>
<thead>
<tr>
<th>Management Layer</th>
<th>End Customer</th>
<th>Applications</th>
<th>SDS / SDN</th>
<th>Key Criteria</th>
</tr>
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<tbody>
<tr>
<td>Systems</td>
<td>Compute</td>
<td>Networking</td>
<td>Storage</td>
<td>Flexibility</td>
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<td>Devices</td>
<td>HDD</td>
<td>Hybrid</td>
<td>SSD</td>
<td>Partnership of Choice</td>
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<td>Media</td>
<td>Magnetics</td>
<td>Flash</td>
<td>Next-NVM</td>
<td>Functionality</td>
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<td>Accelerator</td>
<td>User-friendliness</td>
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<td>Scalability</td>
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<td>Ease of Use</td>
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<td>Optimization for Workload</td>
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<td>CapEx, OpEx</td>
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<td>Media management</td>
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<td>Data Integrity</td>
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<td>Performance, Power</td>
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Existing Media Technology

Enabled phenomenal bit-density scaling thus far

**Magnetic Media**

Both media have seen approx. 10,000 fold increase in areal density from 1990 until now

If the HDD HEAD was scaled to a 747, then the 747:

- Would be flying at 6 times the speed of sound
- Less than 1 centimeter off the ground
- Counting every blade of grass as it rocketed past, making an…
- Irretrievable error <10 blades of grass in lawn the size of Minnesota

**Solid-State Media**

Physical scaling has moved from 120nm to 15nm

- Use of advanced manufacturing

Logical scaling has moved from SLC to MLC to TLC

- Program / Erase Cycles have gone from 100K to <1K
- Error correction has risen from nearly 4 bits/KB to ~60 bits/KB

New Media Technology Driving Density Further
Innovations are almost defying Physics – rapidly increasing noise to signal

<table>
<thead>
<tr>
<th>Magnetic Media</th>
<th>Solid-State Media</th>
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<tbody>
<tr>
<td><strong>Shingled Magnetic Recording (SMR)</strong></td>
<td>2D scaling attempting to go to 12/10nm</td>
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<td>- Focus on reducing track pitch</td>
<td>- Storing charge with handful of electrons</td>
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<tr>
<td>- Areal Density ~1.2 Tb/in²</td>
<td>- Manufacturing complexity due to geometry</td>
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<tr>
<td>- 20% Areal Density Increase</td>
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<tr>
<td><strong>Two Dimensional Magnetic Recording (TDMR)</strong></td>
<td>3D-NAND</td>
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<tr>
<td>- Focus on reducing track pitch</td>
<td>- Exploits the Z-dimension to increase density</td>
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<td>- Improved Signal - to - Noise Ratio</td>
<td>- Projected to go 64-layers and above</td>
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<td>- 15% Areal Density Increase</td>
<td>- Complex deposition and etch – new tools</td>
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<tr>
<td><strong>Heat Assisted Magnetic Recording (HAMR)</strong></td>
<td>Re-RAM, PCM, 3D-XPoint and STT-RAM are future contenders</td>
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<tr>
<td>- Focus on reducing grain size</td>
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<tr>
<td>- Areal Density ~1.2 - 5.0 Tb/in²</td>
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Media Management Innovations

Enable reliable signal extraction in increasingly high noise environments

**Magnetic Media**
- Algorithms for SMR, MSMR, HAMR
- Fly-Height Control
- Hybrid Tiering IP
- Significant Analog/Mixed-Signal IP
- Large Block/Track Codes
- Drive Mechanics

**Solid-State Media**
- Recycling/Garbage-Collection
- Flash Translation Layer
- Compression
- Mostly Digital IP
- Page/Block/Chip Failure Tolerance

**Significant commonality in Magnetic and Solid-State Media-Management**

SMR = Shingled Magnetic Recording; MSMR = Multi-Sensor Magnetic Recording, HAMR = Heat Assisted Magnetic Recording
Requirement for Both Flash and Magnetics

$/GB differential projected to continue into 2020

Data Demand, Workload Variation and $/GB differential will require HDD and SSD

5x – 10x Differential based on Application

Source: Seagate Strategic Marketing and Research 2014
Seagate – Spanning Performance and Capacity

Servicing diverse workloads in integrated manner
Summary

- Data is changing – bigger, different and $ constrained
- New applications driving different workloads/economics – need tiered solutions
- Innovations in storage architecture and media required – access and density
- MIPS commoditized, storage needs to be tailored – seek integrated solutions
- Exciting time to in the Storage industry – we have a collective opportunity!
Thank You