Increased Reliability of Large HPC Storage Deployments

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Leading Provider of Data Storage Technology to OEMs

- > 4,000 Petabytes of storage shipped in 2011
- Largest OEM Disk Storage System provider

- ~ 50% of w/w disk drives are produced utilizing Xyratex Technology*
- Largest independent supplier of Disk Drive Capital Equipment

Enterprise Data Storage Solutions

HDD Capital Equipment Solutions

*Company estimates
A Lustre Cluster

- Client
- Router
- OSS
- Disk
- Support multiple network types: Elan, Myrinet, IB, GigE

ClusterStor HA-MDS
- CIFS Client
- NFS Client
- Metadata Servers (MDS)
- Metadata Target (MDT)

ClusterStor SSU
- Object Storage Servers (OSS) 1-1,000s
- Object Storage Target (OST)
- Disk arrays & SAN Fabric

Lustre Client 1-100,000

Gateway
### Ultra HD - CS-2584 SSU - OSS

- **5U84 Enclosure** – completely H/A
  - Two (2) trays of 42 HDD’s each
  - Dual-ported 3.5” FatSAS & SSD HDD Support
  - 150MB/s SAS available bandwidth per HDD
- **Pair of H/A Embedded Application Servers**
  - CS-3000: =3.5GB/sec IOR over IB
- **IB QDR or 10GbE Network Link**
- **Data Protection/Integrity (RAID 6, 8+2)**
  - 2 OSS’s per SSU
  - 4 OST’s per OSS
- **2x SSD OSS journal disks for increased performance**
  - 2X Hot Spare HDD’s
- **64 Usable Data Disks per SSU**
  - 1TB x 64 – 64TB usable per SSU
  - 2TB x 64 - 128TB usable per SSU
  - 3TB x 64 - 192TB usable per SSU
  - 4TB x 64 - 256TB usable per SSU
Xyratex ClusterStor (a.k.a. Sonexion) – Breaking new ground

- Up to 1.8 PB/rack
  - Up to 588 disks per rack
  - Supports 1, 2, 3 and 4TB SAS disks

- More than 24 GB/s throughput per rack
  - Lustre file system performance

- Supports full QDR IB or 10 GbE fabrics

- All active components redundant and hot swappable

- Engineered, balanced solution for extreme density and performance

- Dedicated management utility

- Lustre 2.x based solution
  - Active development of new features and fixes
“What do you mean, the file system is down ??”

“Again !!!”
Let’s do the numbers – HAL 9000

Problem: Fly a large space craft to Saturn while preparing to kill all of it’s astronauts and find the monolith ……*

Solution:

- Compute system capable of 10 PFLOPs
- Storage capable of doing 10% of Compute -> 1 000 GB/s
- Energy efficient
- Incredible reliability (well, let’s settle for decent ….)
- Supportable for 3-5 years …

* Thanks goes to A. C. Clarke for inspiration

<table>
<thead>
<tr>
<th>Throughput reqs (GB/s)</th>
<th>1000</th>
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<td>Embedded Server</td>
<td><strong>CS3000</strong></td>
</tr>
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<td>3</td>
</tr>
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<td>Volume requirements (TB)</td>
<td>300</td>
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<td>Disk size (TB)</td>
<td>2</td>
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<tr>
<th></th>
<th># SSUs</th>
<th>Total usable volume</th>
<th>Agg. throughput</th>
<th>IB Uplink ports</th>
<th># Racks</th>
<th># OSTs</th>
<th># HHDs</th>
<th>Power reqs (kW)</th>
<th>Weight (T)</th>
<th>Floor space (m²)</th>
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<tr>
<td>Solution (performance)</td>
<td>334</td>
<td>42 752 TB</td>
<td>1002 GB/s</td>
<td>670</td>
<td>42</td>
<td>2 672</td>
<td>27 388</td>
<td>696,7</td>
<td>48,3</td>
<td>50,4</td>
</tr>
<tr>
<td>Solution (Full racks)</td>
<td>335</td>
<td>42 880 TB</td>
<td>1005 GB/s</td>
<td>672</td>
<td>42</td>
<td>2 680</td>
<td>27 470</td>
<td>698,8</td>
<td>48,3</td>
<td>50,4</td>
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Based on the current ClusterStor 3000 solution featuring:
- Lustre file system delivering 640 GB/s
- Usable volume: 26.8 PB
- 27 racks with a total of 17,280 nearline SAS 2 TB drives

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<tr>
<th>Time period of interest</th>
<th>Number of simulations</th>
<th>Mean Availability (across 720 hours)</th>
<th>Instantaneous Availability (at 720 hours)</th>
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<tbody>
<tr>
<td>30 days (720 hours)</td>
<td>100</td>
<td>99.51%</td>
<td>98.00%</td>
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<tr>
<td></td>
<td>100,000</td>
<td>99.56%</td>
<td>99.55%</td>
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Key Take-Aways from 30-day simulation:
- Monte Carlo analysis using Reliasoft BlockSim software
- Only 11 out of 17,280 would fail (0.0636%)
- Probability of 1 or more OSTs rebuilding within a 5U/84 = 4.9607%
- Probability of 2 or more OSTs rebuilding within a 5U/84 = 0.1097%
So how do we get there??

- Testing of every component and the entire system is key
  - Disk drives
  - Enclosures
  - Embedded server modules
  - All software
    - GEM (General Enclosure Management)
    - Linux/HA/MD-RAID/Software Components
    - Lustre
      - ClusterStor Manager (Scale-Out Management Solution)
  - Rack integration
  - Cabling
  - System Configuration tests
  - File system deployment tests
  - Client based testing
  - Soak testing of complete system
Scalable Storage Unit (SSU) Build / Configuration

- Tested Drives, Embedded Application Servers (EAS) and SSU build is received in the area

- The product is configured into a SSU, with the installation of the tested components and custom bezel
Integrated System Testing (IST) is a patented 3 Stage testing process embedded within manufacturing and designed to remove hidden quality problems.

**Features**

- Optimized 36 Hour Manufacturing & Test
- Adaptable Test Automation
- Standard Across the Globe

**Benefits**

- Reduces solution warranty and service costs
- Reduces Infant Mortality
- Up to 1.5X drive reliability improvement over 3 Yrs.
  - AFR Reduction from ~9% to 2% or less*
  - 67% less disk drive failures in first 3 months
- Accelerates time to market

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*Comparison of Google Study and Xyratex CERT

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Xyratex HDD Reliability: Failure Rate Comparison

Annual Failure Rate (AFR) by drive class

NetApp Study, 1.8M HDDs, 155K systems over 44 months, 99.99% reliability

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<tr>
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<th>XYR ATA FR</th>
<th>XYR Enterprise FR</th>
<th>Google paper Base ~AFR</th>
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<tbody>
<tr>
<td>3 Months</td>
<td>0.92%</td>
<td>0.46%</td>
<td>2.80%</td>
</tr>
<tr>
<td>6 Months</td>
<td>0.98%</td>
<td>0.51%</td>
<td>1.80%</td>
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<tr>
<td>1 Year</td>
<td>1.04%</td>
<td>0.73%</td>
<td>1.75%</td>
</tr>
<tr>
<td>2 Years</td>
<td>1.27%</td>
<td>1.32%</td>
<td>8%</td>
</tr>
<tr>
<td>3 Years</td>
<td>2.19%</td>
<td>0.68%</td>
<td>8.70%</td>
</tr>
<tr>
<td>4 Years</td>
<td></td>
<td></td>
<td>6%</td>
</tr>
<tr>
<td>5 Years</td>
<td></td>
<td></td>
<td>7.40%</td>
</tr>
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</table>
Rack Build / Integration

- All of the rack components are installed and cabled including MDS, SSU’s, Network Switches, Management Switches and PDU’s
- The assembled rack is installed and fastened into its final shipping crate.
- The shipping crate is positioned into its test alcove
Test Alcove Infrastructure

- Each test alcove is powered with 4x 32A 3-phase sockets, internal and external IP access.

- Each alcove has a chilled water rear door attached and a transition frame to mate with the product within its crate.
Product Under Test

- Up to 30-day ‘Soak Test’

Soak test measures:
  - I/O connectivity to (ClusterStor to Lustre clients)
  - I/O performance - read/write/rewrite (ClusterStor)

- Tests a system with significant load extended over a significant period of time

- Includes "adverse" conditions testing (running HA scenarios for ClusterStor systems)
Xyratex delivers a complete ready-to-run ClusterStor solution

- Sizing and Configuration optimization
  - Performance centric
  - Capacity centric
- Factory Integration & Staging
  - Rack integration & Cabling
  - Entire storage software stack factory pre-installed and pre-configured
  - System soak test and benchmark testing area at Xyratex factory
- Drive speed-loader reduces drive insertion time by 85%
Drive Installation / Unloading Process

• The drives are removed from the unit with the use of a speed loader.

• The speed loader allows the user to rapidly remove and install 7 drives at a time.

• The packaging and loader compliment each other, thus significantly reducing the handling time.
Ensuring Quality of Delivery & OOB Experience

Racks are reinforced with an additional 32 rivets to ensure quality!
ClusterStor Summary

- Architected
- Integrated
- Tested
- Optimized
- Qualified
- Supported

- Factory integration
- Component and system testing
- System shipped to site, not built on site
- Single owner of entire stack
- Global Support capability

ClusterStor Manager

- Lustre File System
- Data Protection Layer (RAID)
- Linux OS
- Unified System Management (GEM-USM)
Thank You - Questions?