Why SAS NL?

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Acquisition, Flood Recovery, Industry Conditions

Thailand Flood Recovery Effort

- Re-started production of hard drives in one of its buildings in Bang Pa-in (BPI), Thailand on November 30th, one week ahead of internal schedules.
- Started production of WD internal sliders on January 30th at it's Bang Pa-in facilities.
- WD's new Penang, Malaysia, slider operation will begin to output later in CQ1, with HDDs shipping from this supply line by CQ2 '12.
- The company's other Thailand hard drive facilities at Navanakorn are dry and plan to begin producing drives in the March quarter.
- Based on a pre-flood output of 58 million units per quarter, WD expects to recover 60%, 80%, and 100% of pre-flood capacity in CQ1, CQ2, and CQ3'12, respectively.

HGST Acquisition

- The company announced on March 8th, 2012 that it completed the acquisition of Hitachi Global Storage Technologies.
- WD reached an agreement with Toshiba to divest certain 3.5" HDD assets, including manufacturing equipment and intellectual property.
- WD to purchase Toshiba Storage Device (Thailand) Co. Ltd. The principal assets of TSDT are its Thailand property, facilities and employees.
  - TSDT manufactured hard drives but has not resumed operations after the recent Thailand flooding
  - Subject to completion of the transaction, WD plans to integrate these facilities and employees into its Thailand operations

Industry Conditions

- Company believes that significant industry supply constraints will continue in the March quarter and through calendar year 2012 into early CY13.

What Is SAS?

SAS (Serial-Attached SCSI) is an evolution of SCSI technology

- First introduced in 2004
- Serial-based, versus parallel
  - **Advantages:** Higher-speed interconnect, less intrusive cabling
- Supports the full SCSI protocol
  - **Advantages:** Backward compatibility with rich installed-based of legacy SCSI middleware
- Point-to-point, multi-channel, dual-port full-duplex connectivity
  - **Advantages:** Reliability, availability, and scalability designed for enterprise
- Connector is a derivative of the SATA connector
  - **Advantages:** Allows flexible system backplane design to support either type of device, and deliver customized solutions tailored to customers' specific needs

SAS is designed for mid-range to high-end enterprise applications and workloads

What is SATA?

- **SATA (Serial ATA)**
  - First introduced in 2003
  - Replaces Parallel ATA (PATA)
    - **Advantages:** Higher-speed interconnect, can scale to higher speeds, longer & less intrusive cabling
  - Supports the full ATA command set
    - **Advantages:** Backward compatibility with client-based OS/controller software stack
- **Design is extremely cost-sensitive**
  - Architected to overcome PATA performance limits
  - Low-cost design driven by need to facilitate desktop market adoption
  - ATA command set does not support the robustness required in high-end enterprise

SATA is designed for desktop, but provides a low-cost entry-level enterprise interconnect option

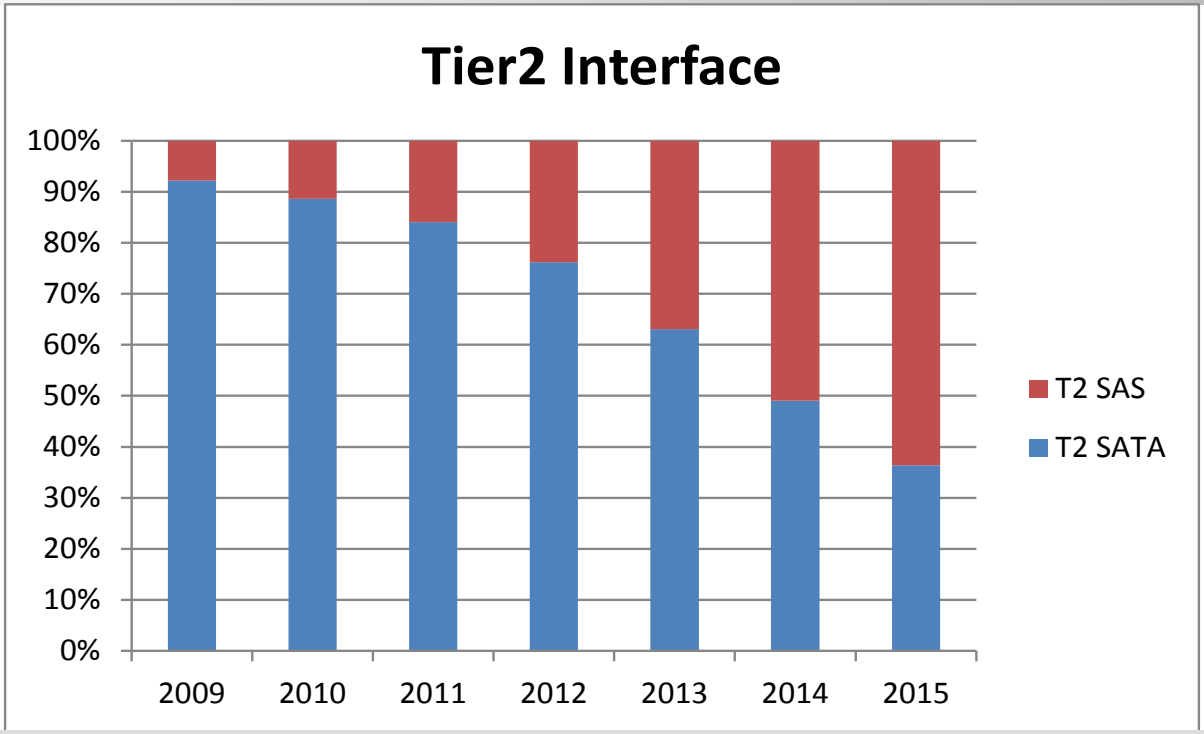
SAS Advantages Versus SATA

- **SAS has strong features and benefits for Enterprise applications**
  - **Reliability:** Point-to-point, backplane-enabled, higher-voltage signaling
  - **Availability:** Fail-over mechanism via dual-port capability and multi-initiator support
  - **Scalability:** Use of expanders allows scaling to up to 65,535 total devices
- **SAS performance advantages extend beyond theoretical bandwidth**
  - Unique ability to aggregate bandwidth of multiple ports in a "wide port" that can scale in width to meet the application demands
  - Scalability **+** bandwidth aggregation **+** higher density (via 2.5" form factor) **=** densest and best performing storage interconnect available today

	SAS	SATA
Maximum Throughput	300 MB/s (3.0 Gb/s SAS) **600 MB/s** (6.0 Gb/s SAS)	150 MB/s (1.5 Gb/s SATA) 300 MB/s (3.0 Gb/s SATA II) **600 MB/s** (6.0 Gb/s SATA III)
Full Duplex	**Yes**	No
Dual-Ported	**Yes (native)**	No (requires multiplexer)
Multi-Initiator capability	**Yes**	No
Fail-over Capability	**Yes**	No
Max. cable length	**10 m**	1 m

Near-Line Interface Trends

Source: WD Marketing



Excludes 10K SATA

	2009	2010	2011	2012	2013	2014	2015
T2 SATA	92.2%	88.6%	84.0%	76.1%	63.1%	49.0%	36.4%
T2 SAS	7.8%	11.4%	16.0%	23.9%	36.9%	51.0%	63.6%
T2 SATA	13,551	18,551	20,209	19,927	18,989	17,063	15,372
T2 SAS	1,153	2,381	3,840	6,242	11,116	17,747	26,875

The Dynamics Behind the Trends

- **Adoption of SAS is driven by two intertwined characteristics**
  - Economics
  - Ability to realize the SAS value proposition
- **The Economics**
  - In 2007, a 1TB SAS HDD may have cost as much as $75 more than SATA
    - A SATA to SAS interposer may have cost $30
  - In 2013, a 4TB SAS HDD may cost as little as $20 more than SATA
    - A SATA to SAS interposer may now only cost $15
- **The SAS Value Proposition**
  - The acceptance of SAS as a Tier 1 replacement of FCAL is almost complete
  - Leveraging the SAS investment into Tier 2 (Near-line) becomes “free”
  - SAS has a future beyond 6Gb (12Gb, 24Gb…)

6Gb SAS

- **Specification ratified in 2008; first products available in 2009**
- **6Gb SAS delivers enhanced capabilities needed in enterprise storage**
  - 6Gb/s transfer rate:
    - **Advantages:** Highest-speed standardized drive interface available in Enterprise
  - Adds standardized expander zoning – assignment of devices/subsystems to operate with multiple hosts in virtualized server environments
    - **Advantages:** Vastly improved scalability and support of complex topologies
  - Self-discovering Expanders – 6Gb SAS shifts more of the SAS topology discovery and configuration process from the host to the expander
    - **Advantages:** Dramatically reduces SAS messaging traffic and shortens system initialization time, allowing for greater ability to scale with the unrelenting capacity demands that drive tiered-storage solutions
  - Improved Error Management – enhancements made to SAS specification to clarify, improve and provide a consistent means of managing errors.
    - **Advantages:** Streamlines handling of system errors, reducing down-time and performance degradation

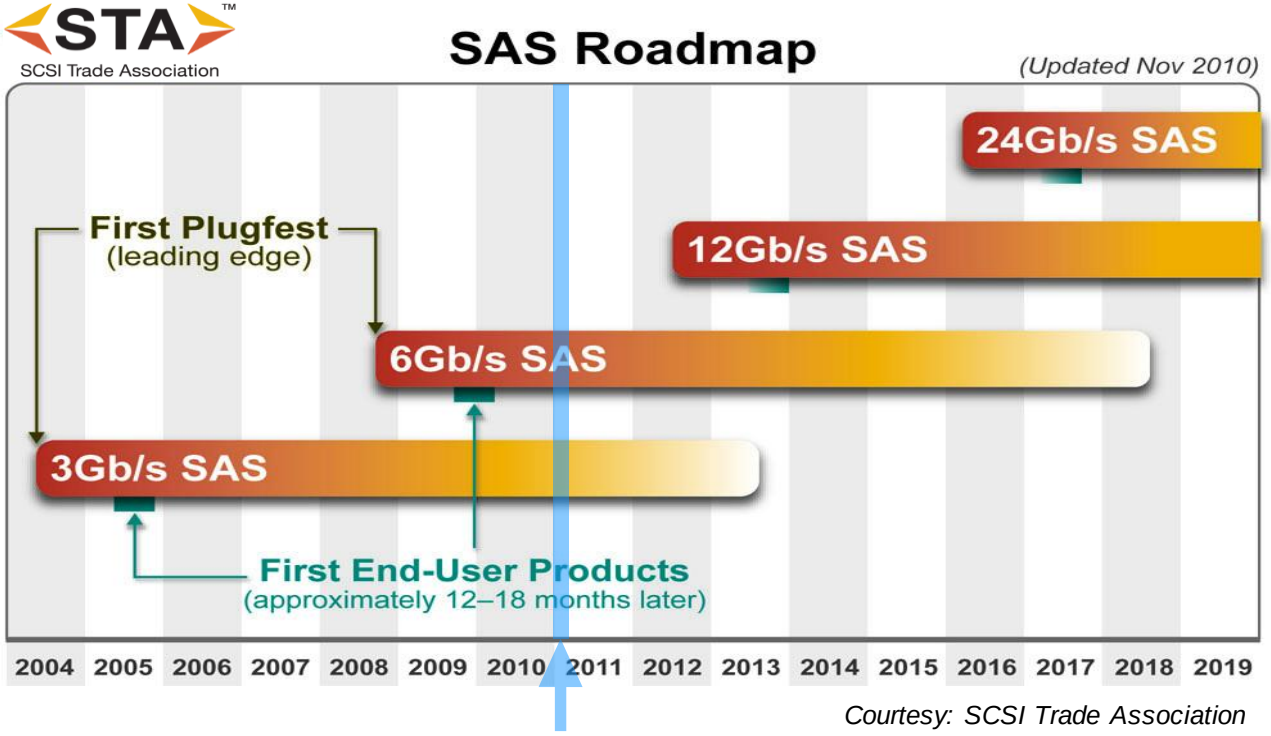
6Gb SAS

6Gb SAS delivers enhanced capabilities needed in enterprise storage (cont'd)

- Multiplexing and Bandwidth Optimization – aggregates 2 slower 3Gb SAS devices to a single 6Gb lane
  - **Advantages:** Improves efficiency of system when mixing 3Gb SAS and 6Gb SAS storage devices and subsystems
- Data Integrity Field (DIF) – protection scheme that allows data and the commands to be protected all the way through to the storage system to the disk drive.
  - **Advantages:** Adopts an important capability required in high-end storage systems, providing end-to-end data integrity down to the storage device
- Performance and Scaling – Signaling protocol enhancements improve performance while preserving the cabling distance and compatibility with older SAS 1.0 deployments.
  - **Advantages:** Allows SAS to double its performance, maintain compatibility with first-generation products, and keep up with system-level technology advancements, such as PCI Express 2.0

Future of SAS

SAS feature set and capabilities will continue to evolve to deliver greater value and benefits to enterprise server and storage systems



Courtesy: SCSI Trade Association

SSDs in Enterprise

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The Role of SSDs in the Enterprise Hierarchy

- **Over the last 50+ years, the need for IOPs (IOs/second) has continued to increase with the steady, predictable improvement in processors**
- **HDDs have increased RPM but it has not mitigate the gap between electronic media and magnetic media**
- **Enter Enterprise Solid-State Drives …**
  - Expensive, but very fast relative to HDDs
  - Reliable, but not with finite limitations
  - Appropriate, but not pervasive
- **This has lead to a storage hierarchy and the need for tiering software**
  - To provide a balance between the limitations of budget and the insatiable need for performance

Enterprise Tiers

Requirements		Products
• Extreme performance • Enterprise reliability • Data “accelerator”	Tier 0	SSDs
• Higher performance • Highest reliability • Primary storage for “hot” data	Tier 1	15,000 RPM HDDs 10,000 RPM HDDs
• Higher capacity • Great performance • Primary storage	Tier 2	7200 RPM HDDs
• Highest capacity • Decent performance • Enterprise reliability	Tier 3	< 7200 RPM HDDs Tape

Thank You!