SAS SSDs – Building Blocks for High-Performance Enterprise Storage

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Cloud Changes Storage Dynamics

50 Billion
Connected Devices

4 Billion
Connected People

1 Zettabyte
Global Traffic

449 Billion Objects — amazon web services

1.5 Million Requests/Sec — YAHOO!

48 Hours Video/Min — YouTube

38,000 Searches/Sec — Google

1 Billion Items/Day

290 Million Tweets/Day

Virtualization

Tiering

Petabyte Growth

Source: HGST Market Research based on publicly available websites, interviews and industry reports.

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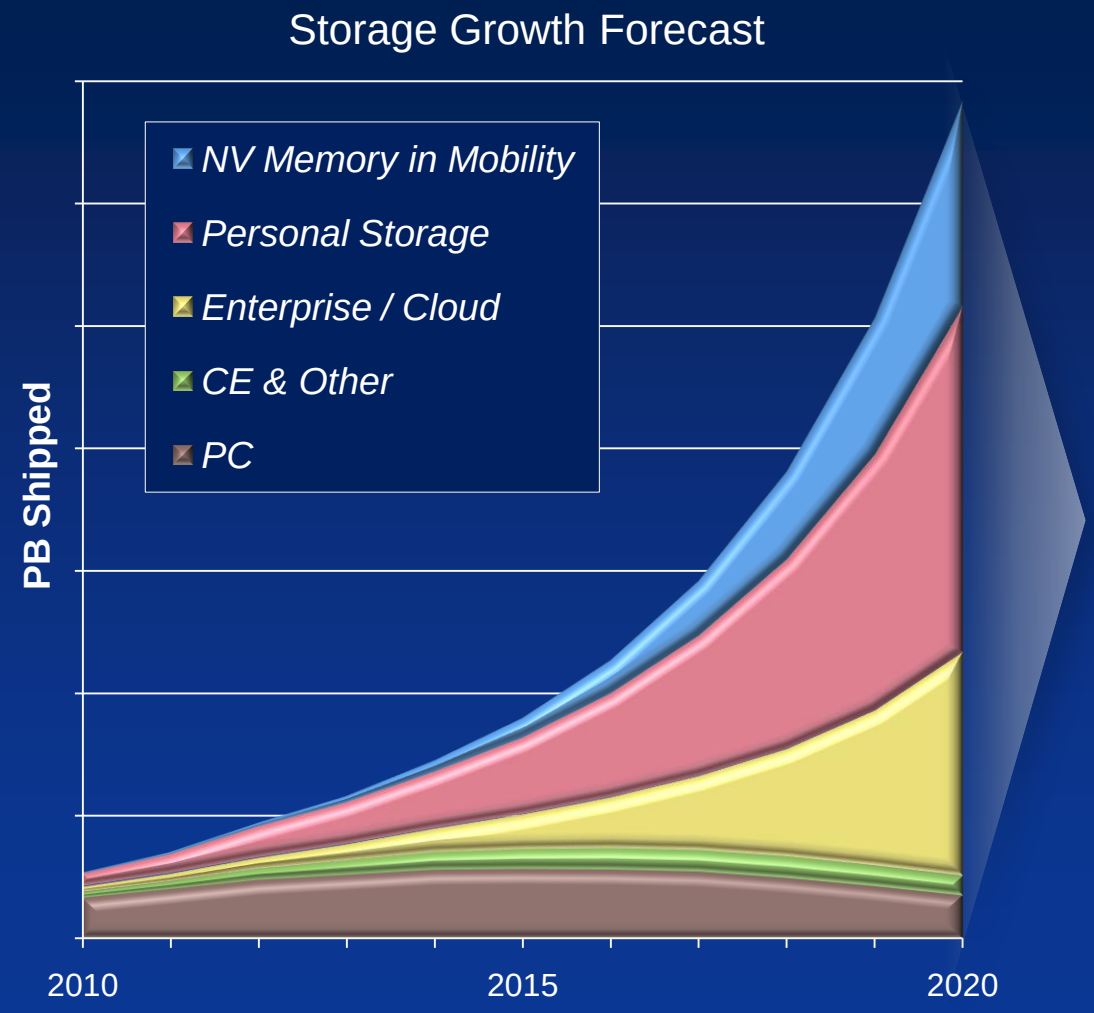
Shifts in the Marketplace



Source: Hitachi GST

Industry Trends

- New architectures: Atom, ARM, Android, IOS
- Internet Bandwidth, Low-Capacity Clients and Privacy Concerns
- Video, M2M, Analytic Data
- "Anywhere, Anytime" access, Mobility and Datacenter Economics
- Flash, SSD, Tablets & Mobile Clients "Good Enough"

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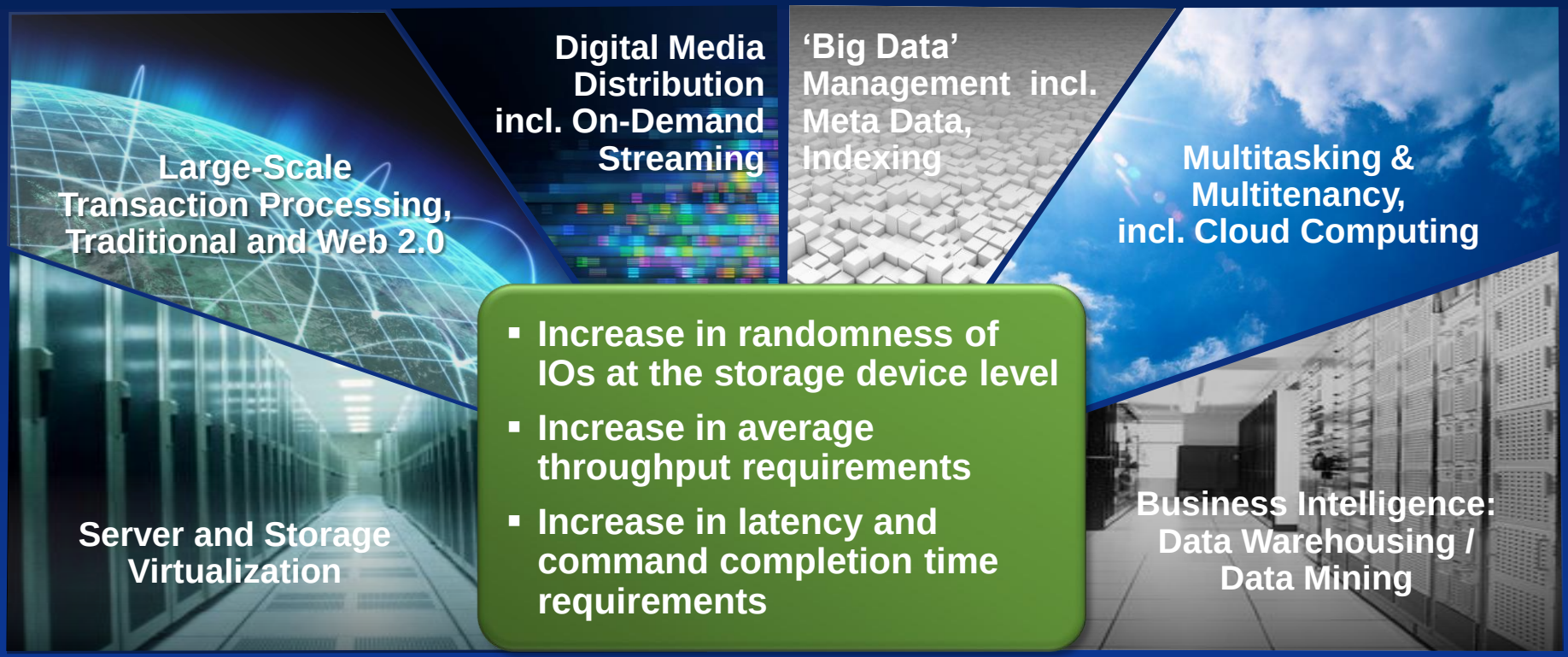
Drivers for High-Performance Storage

Several system and application drivers are increasing the demand for high-performance storage solutions going forward



- Increase in randomness of IOs at the storage device level
- Increase in average throughput requirements
- Increase in latency and command completion time requirements

Storage devices utilizing non-volatile memories are uniquely positioned to close the 'IO Gap' and deliver these high-performance storage solutions

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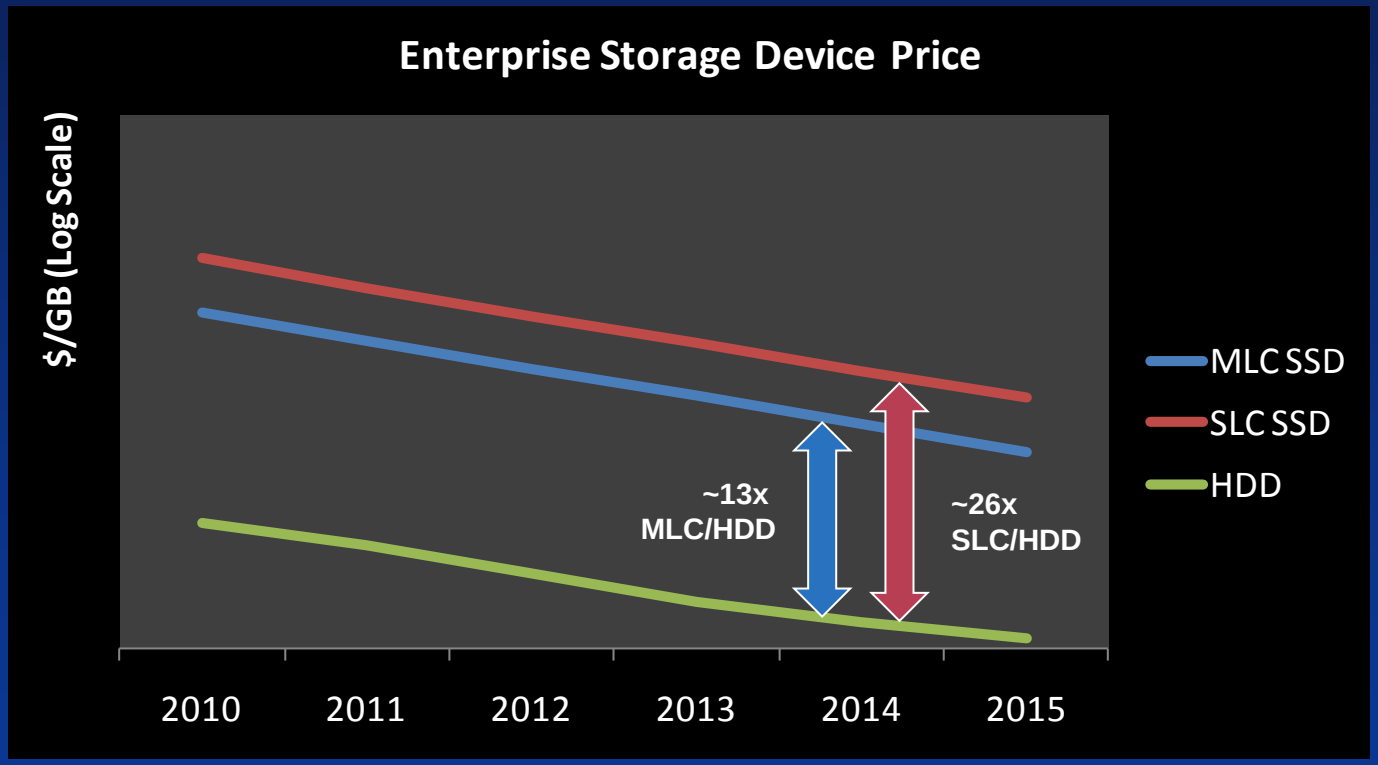
SSD & HDD – Complementary 'Building Blocks'

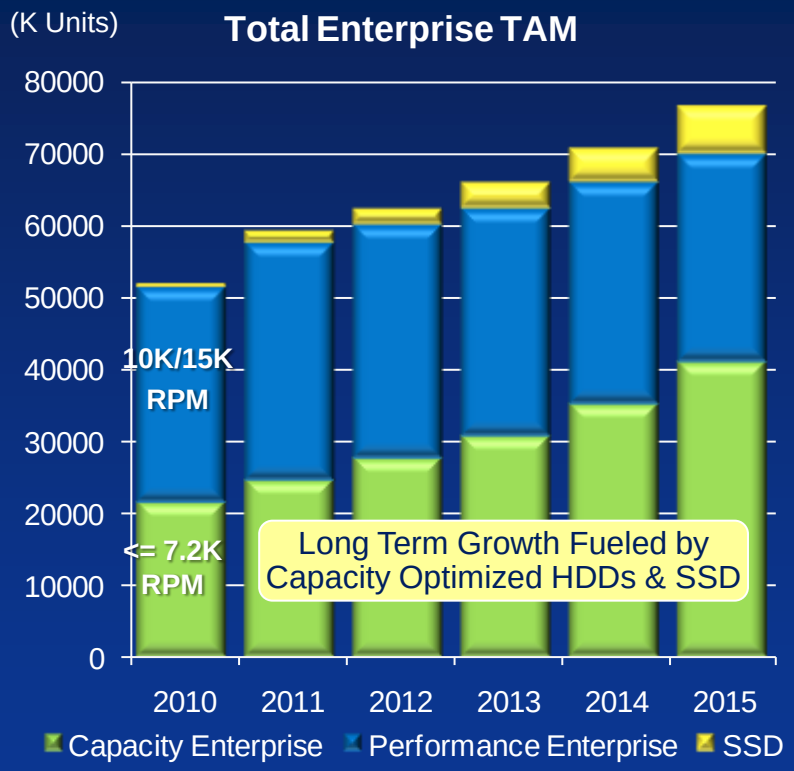
Enterprise SSDs will continue to carry a significant $/GB multiple over Enterprise HDDs – SSDs will be deployed where performance justified

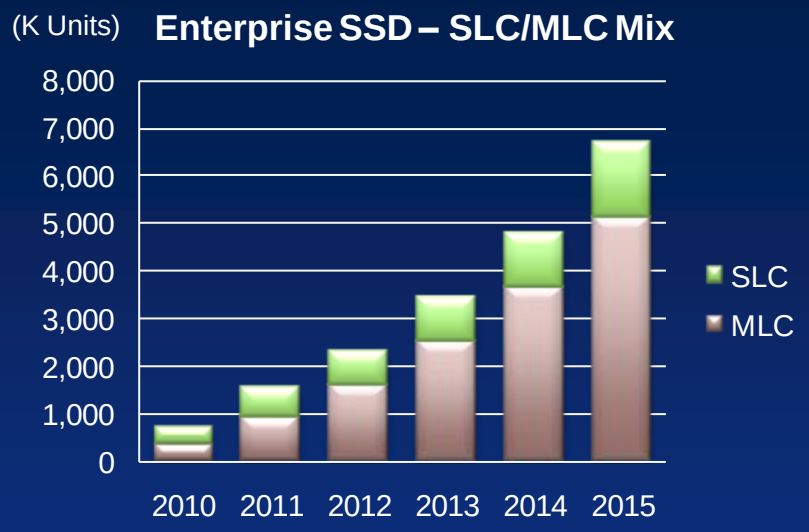


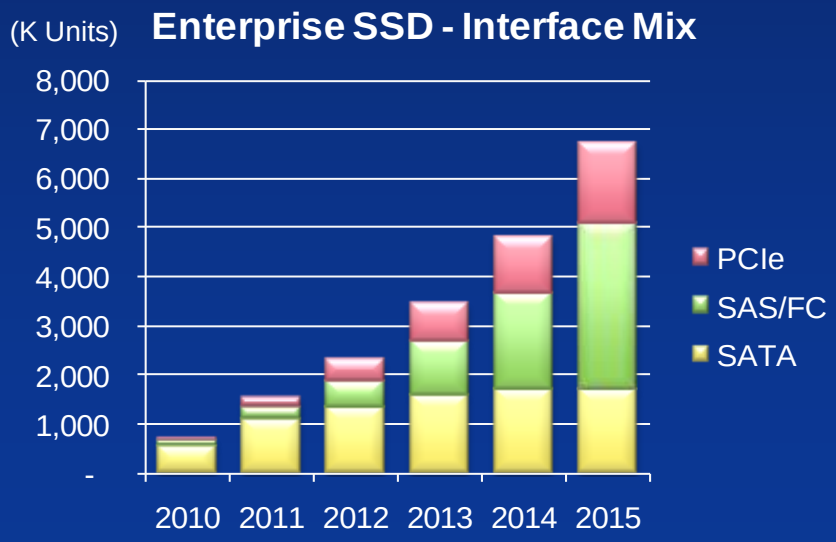
Note: HDD = 2.5" 10K RPM & 15K RPM HDD

Source: Hitachi GST Estimates

Enterprise Market Forecast







Source: Hitachi GST

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Storage Tiering & Caching

Storage solutions will deploy a combination of highly-optimized storage devices to strike the appropriate balance between performance and cost

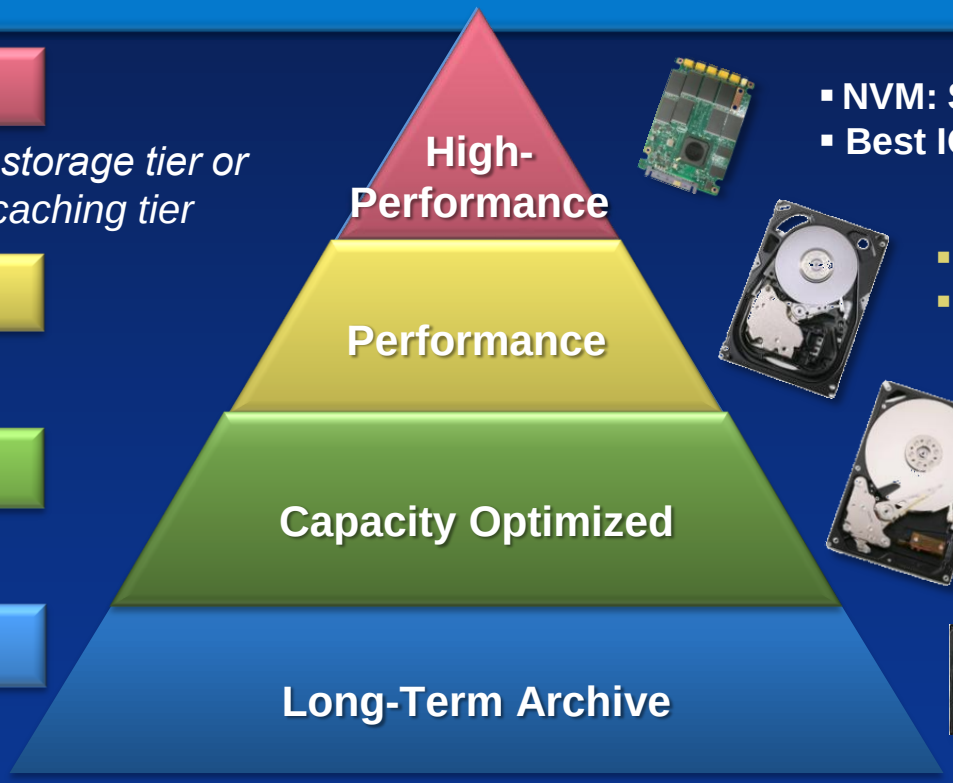
Tier 0

As 'permanent' storage tier or as transparent caching tier

Tier 1

Tier 2

Tier 3



- NVM: SLC & MLC NAND SSD
- Best IOPS/$, Best IOPS/Watt

- 10K / 15K RPM SAS HDD
- Best balance of Performance and Capacity

- 7200 RPM SAS & SATA HDD
- Best $/TB value

- Low-RPM HDD, Tape
- Best TB/Watt

A given storage solution may not implement all tiers and tiers may be split across systems or locations – e.g. a local Tier 0 Gateway combined with Tier 2 Cloud Storage

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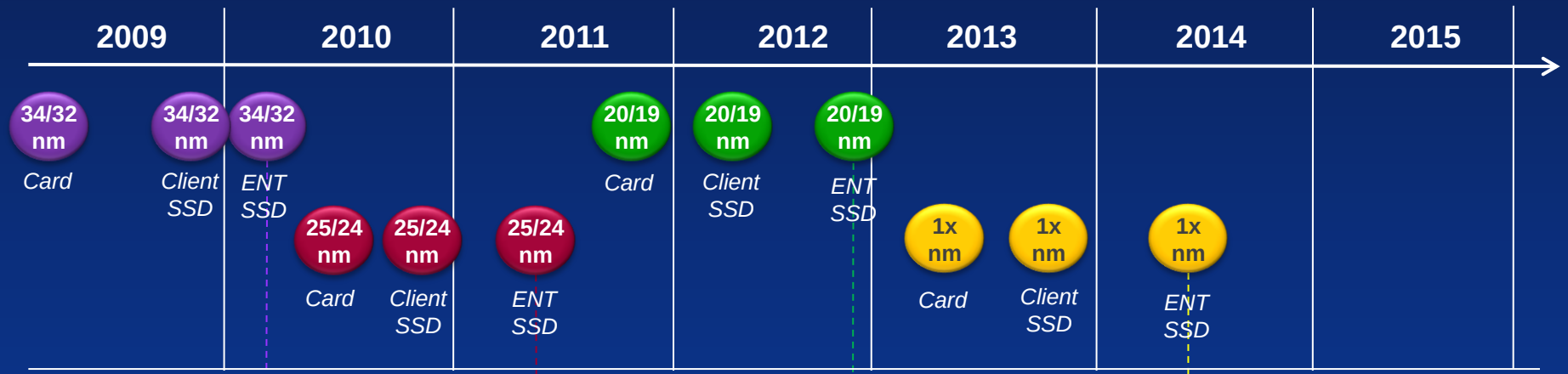
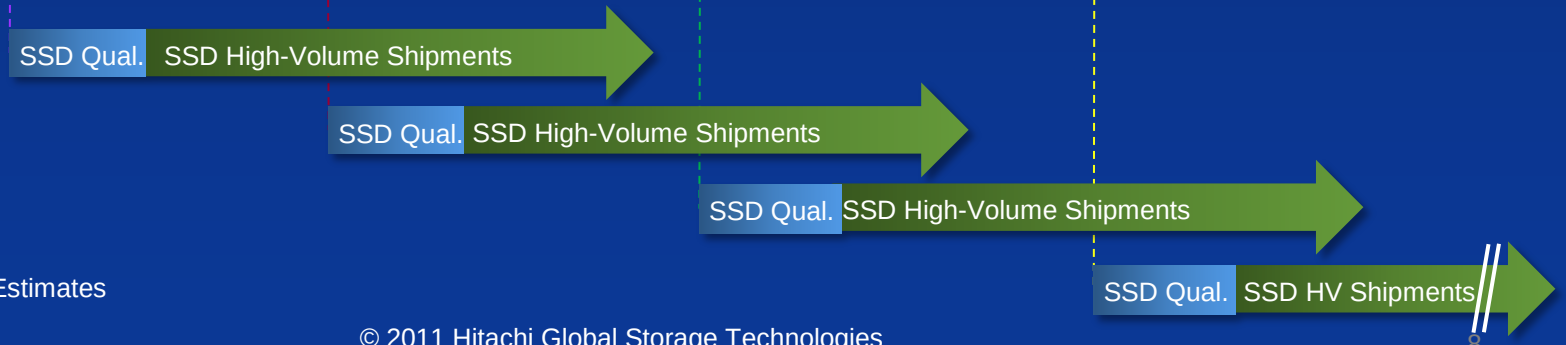
NAND Flash Component Outlook

Conventional NAND technology is expected to scale into 1xnm, providing a media roadmap for future Enterprise SSDs generations into 2015

NAND Flash Mass Production Dates



Enterprise SSD Product Generations



Source: Hitachi GST Estimates

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SLC & MLC For Enterprise Applications

MLC will emerge as a more cost-effective NAND media option for Enterprise applications this year

Key Take-Aways

- MLC will deliver performance close to SLC at significantly lower cost
- MLC write endurance is appropriate for a 3-5 year product life in the majority of Enterprise applications
- SLC is the more economic NAND choice for applications with very high write work-loads

* Note: Depending on workload IO size and queue depth
Source: Hitachi GST estimates

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Anatomy of an Enterprise SSD

When considering various SSD offerings, it is important to remember the fundamental ingredients of an SSD

Drive Interface
(SSD Controller)

SERIAL ATA

Serial Attached SCSI

PCI EXPRESS®

System integration, scaling and high-availability needs

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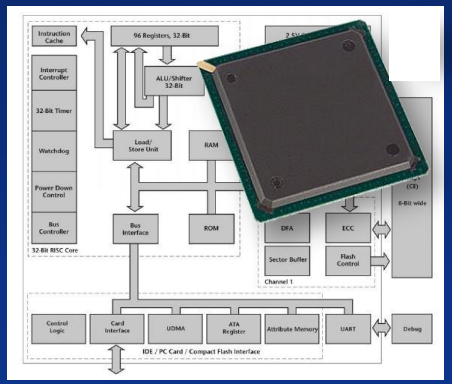
Enterprise Reliability
(SSD Controller)



Full set of Enterprise requirements, especially reliability and error recovery

+

NAND Array

NAND investment determined by amount of NAND and type of NAND

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Enterprise SSD – Interface Choices

For a given internal or external Enterprise storage system, numerous factors need to be considered to chose the most appropriate SSD interface

Interface	SATA	SAS	PCIe
Command Set	ATA	SCSI	Proprietary or NVM Express or SCIS-over-PCIe
Main Form Factor	2.5”	2.5”, Others?	2.5”, Cards
Mad Device Power	9W	9W Dual Port / 25W MultiLink SAS?	25W
Transport Bandwidth	6 Gb / Port	6Gb / Port -> 12Gb / Port	4Gb / Lane -> 8Gb / Lane
Interface Configurations	Single Port	Dual Port / MultiLink SAS Four Ports	Four / Eight Lanes
Standardization	INCITS / SATA-IO	INCITS / STA	Vendor Specific; NVM Express Group, INCITS / STA; PCI-SIG
Product Availability	Now	Two Port: Now MultiLink SAS: TBD	Proprietary: Now; NVM Express: TBD; SOP: TBD

SAS SSD – A Mature Building Block

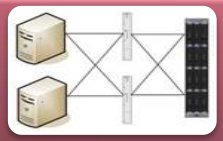
SAS SSDs enjoy the Enterprise maturity and support of the well-established SAS eco-system

Maturity & Interoperability

'Drop-In' support in all major Enterprise system environments

Scalability

Scales up to hundreds of drives with multi-port controllers & expanders



High-Availability

Dual-port drives, T10 DIF, hot-plug support, cost-effective redundancy options using RAID controllers

Technology Roadmap

12Gb SAS and Multi-Link SAS

Standardization & Industry Support

Track record of effective standardization in INCITS; broad set of industry offerings

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SSD – Enterprise System Fit

Application needs associated with certain Enterprise system segments typically lead to an SSD product preference

	Storage System SAN & NAS	Server App / DB	Blade Server	Web 2.0 Infrastructure
				
SATA	? No Port Redundancy, No T10 DIF	? Limited Interface Bandwidth at 6Gb, No T10 DIF	? Limited Interface Bandwidth at 6Gb	✓
SAS	✓ ✓ ✓	✓ ✓ ✓	✓ ✓	✓ ✓ ✓
PCIe	? No Good Scaling Option	✓ Limited RAID Options	✓ ✓	✓ ✓

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SAS SSD – Measuring Today's Solutions

The server test configuration consists of widely available, industry-standard components

Industry-Standard Server

SAS HBA or RAID Controller

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- 100/200/400GB SLC
- SAS 6Gb and FCAL 4Gb
- Leading Enterprise feature set and reliability

Hitachi Ultrastar™ SSD400S Solid State Drives

Other system configuration items: Windows Server 2008 R2, iometer 2007; 6Gb SAS, single port / SSD
SSD configuration: SSD completely full, access is full drive volume, all performance is sustained steady-state
Note: Trademarks are the property of their respective owners.

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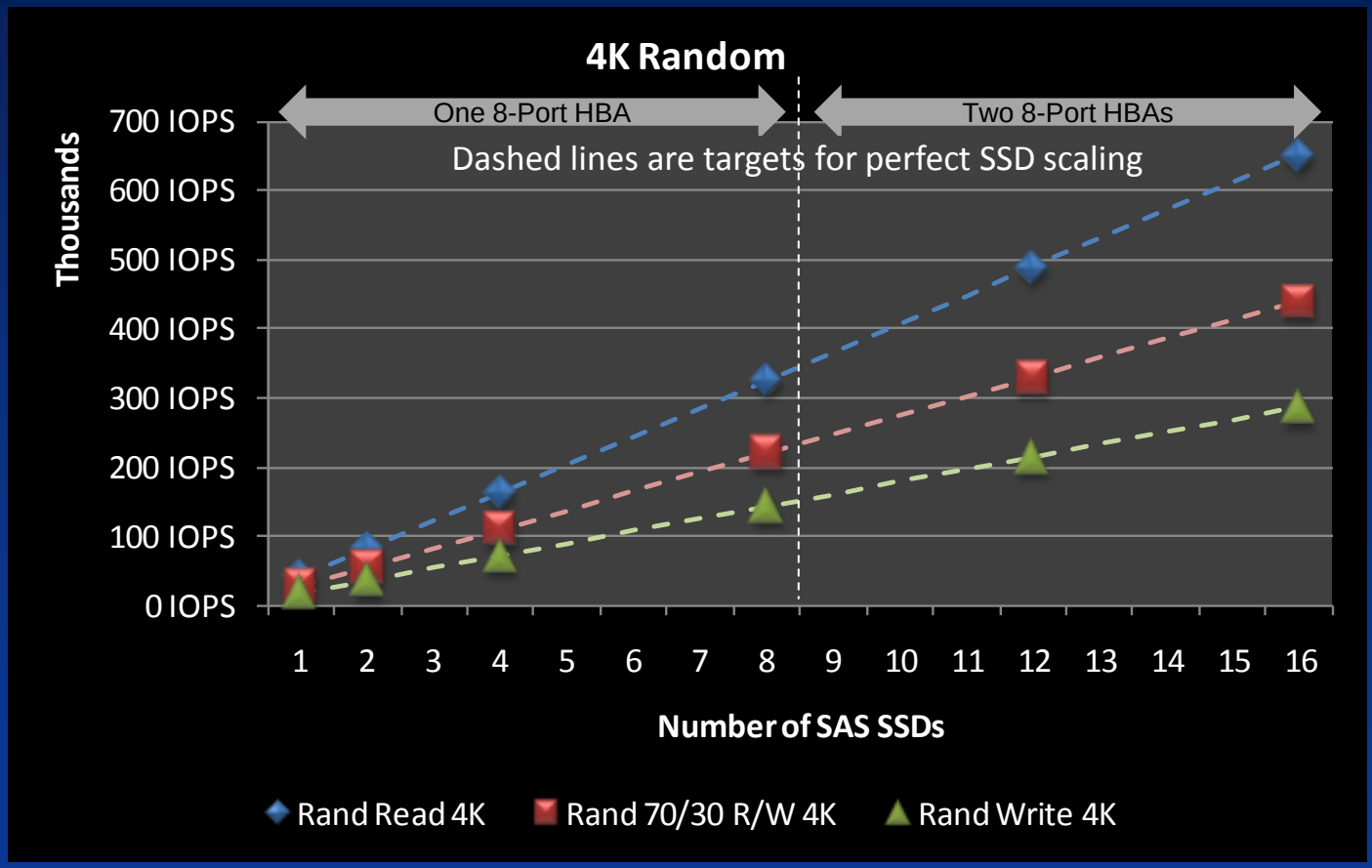
SAS SSD Scaling Example–Small Random IO

SAS SSDs connected to a multi-port SAS HBA show perfect performance scaling for small random IO



Note: Hitachi Ultrastar SSD400S SAS SSD, 200GB, QD=32 per drive; 4KB IO size, 4K-aligned

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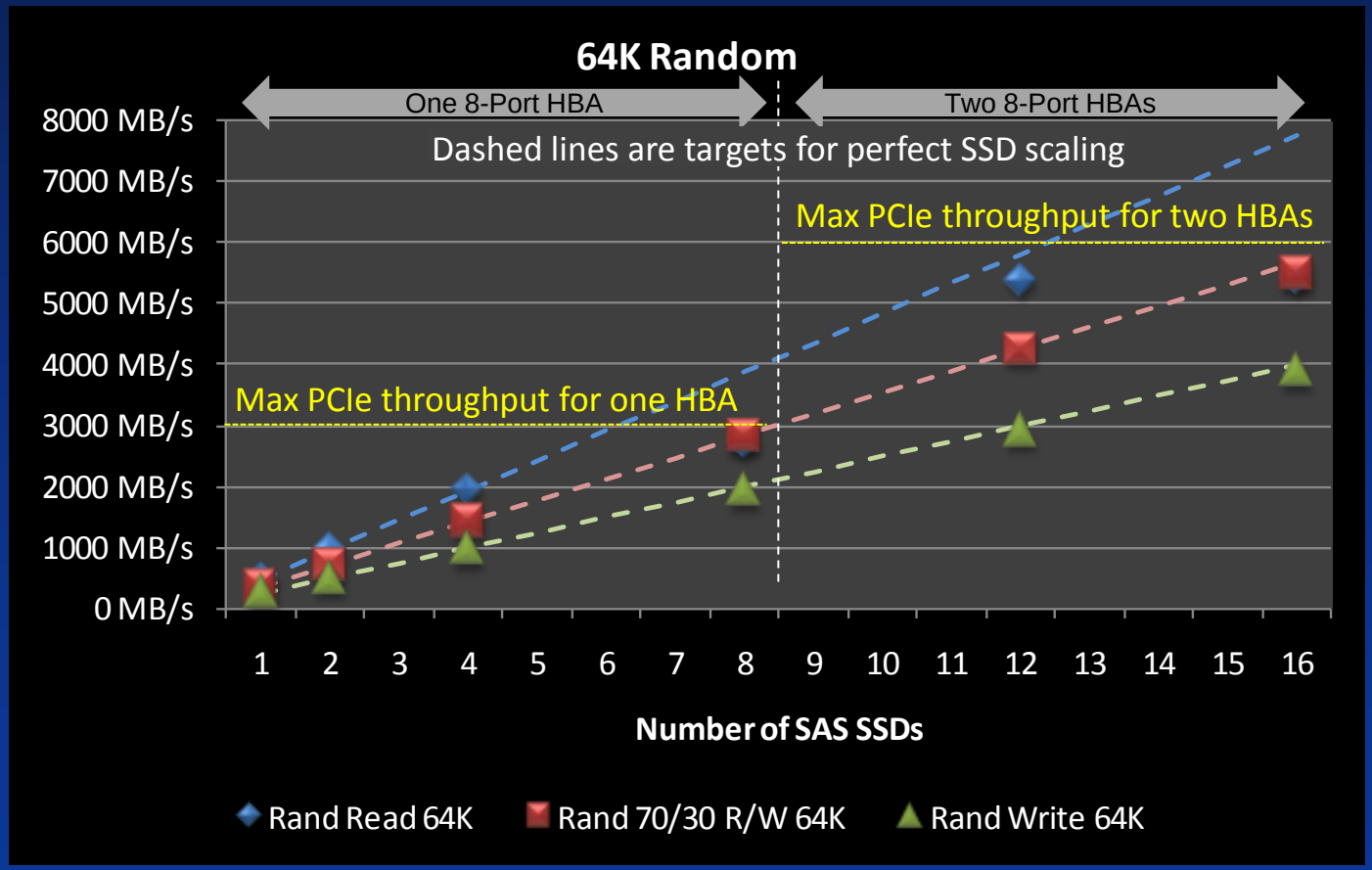
SAS SSD Scaling Example – Large Random IO

SAS SSDs connected to a multi-port SAS HBA show performance scaling for large random IO up to the max throughput limit of the HBA



Note: Hitachi Ultrastar SSD400S SAS SSD, 200GB, QD=32 per drive; 64KB IO size, 64K-aligned

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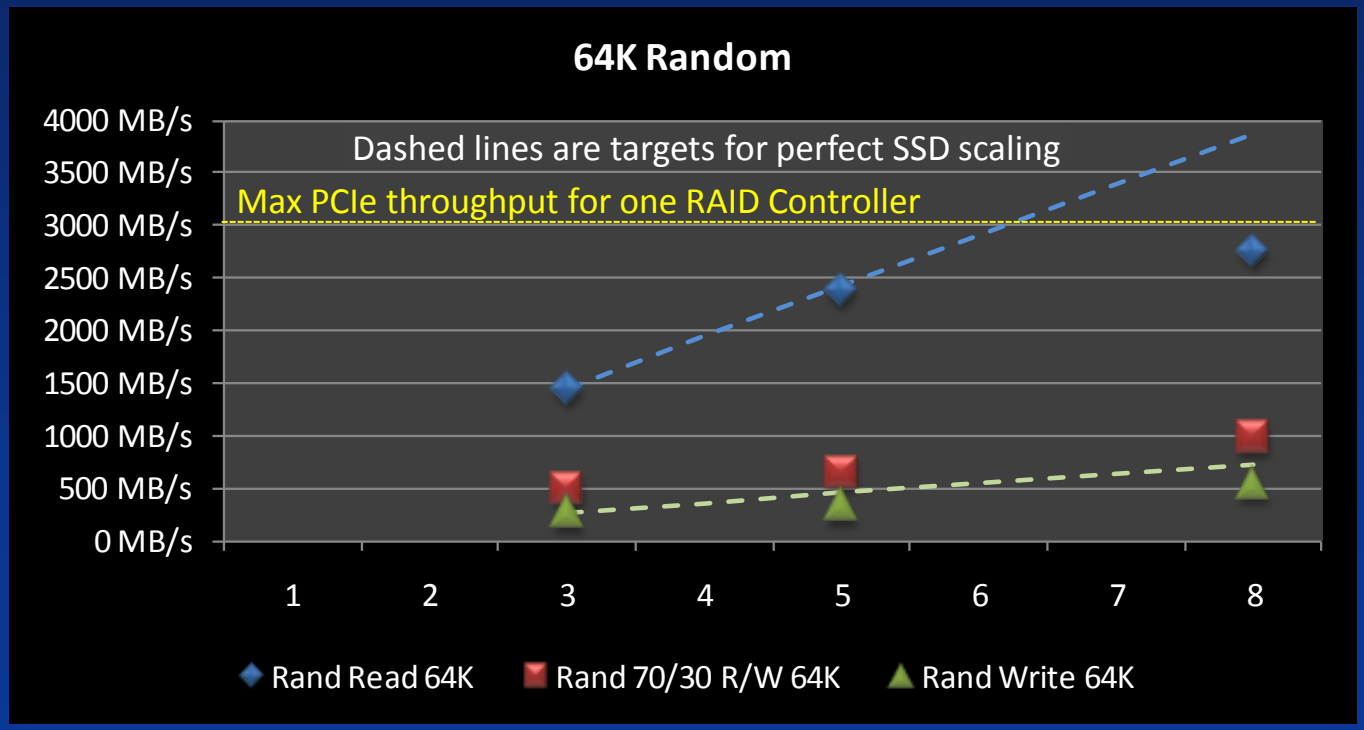
SAS SSD Redundancy Option – RAID 5

SAS SSDs in RAID 5 deliver cost-effective, high-performance solutions for applications with high read mix where redundancy is a requirement

RAID 5 targets for perfect SSD scaling:

- Read : (Number of SSDs) * Read Performance of a Single SSD
- Write : ~ (Number of SSDs) * 50/50 Read/Write Performance of a Single SSD / 4



Note: One 8-port RAID Controller, Hitachi Ultrastar SSD400S SAS SSD, 200GB, QD=32 per drive; 64KB IO size, 64K-aligned

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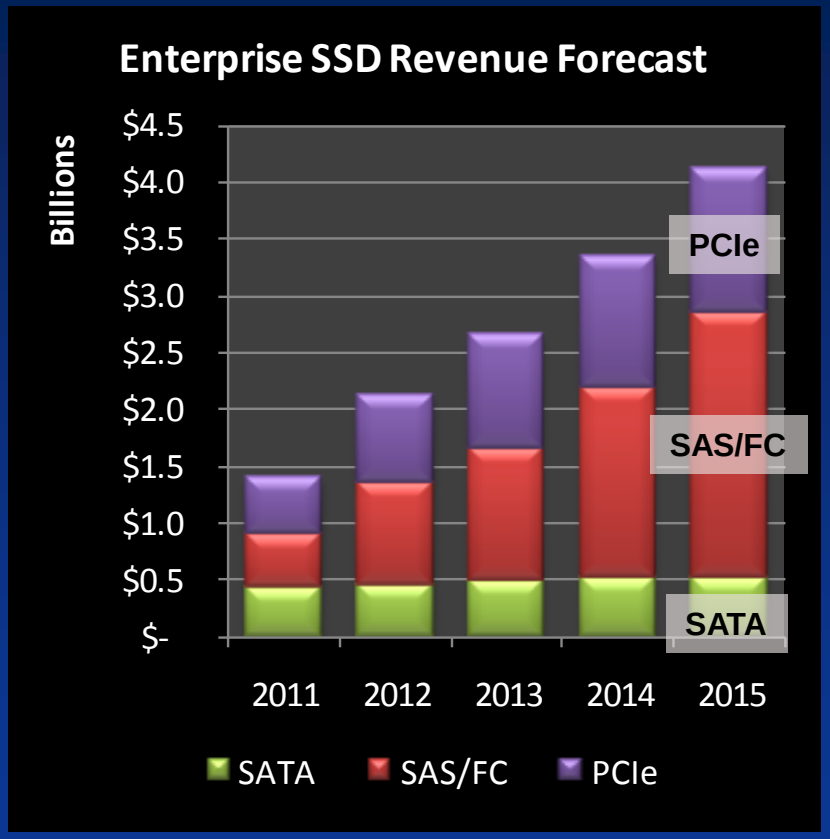
SAS SSD – The Preferred Enterprise SSD 'Building Block'

- New applications & virtualization increases the randomness of IOs, demanding high-performance storage
- "One Size Does Not Fit All": Storage solutions will be tiered to strike a balance between performance and cost
- When selecting an Enterprise SSD, the maturity and capabilities of the host interface and the SSD controller are as critical as the NAND memory
- SAS SSDs are expected to be the preferred, most broadly applicable 'building block' for high-performance Enterprise storage solutions going forward



Source: Hitachi GST Estimates

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Hitachi Global Storage Technologies