Interface Trends for the Enterprise I/O Highway

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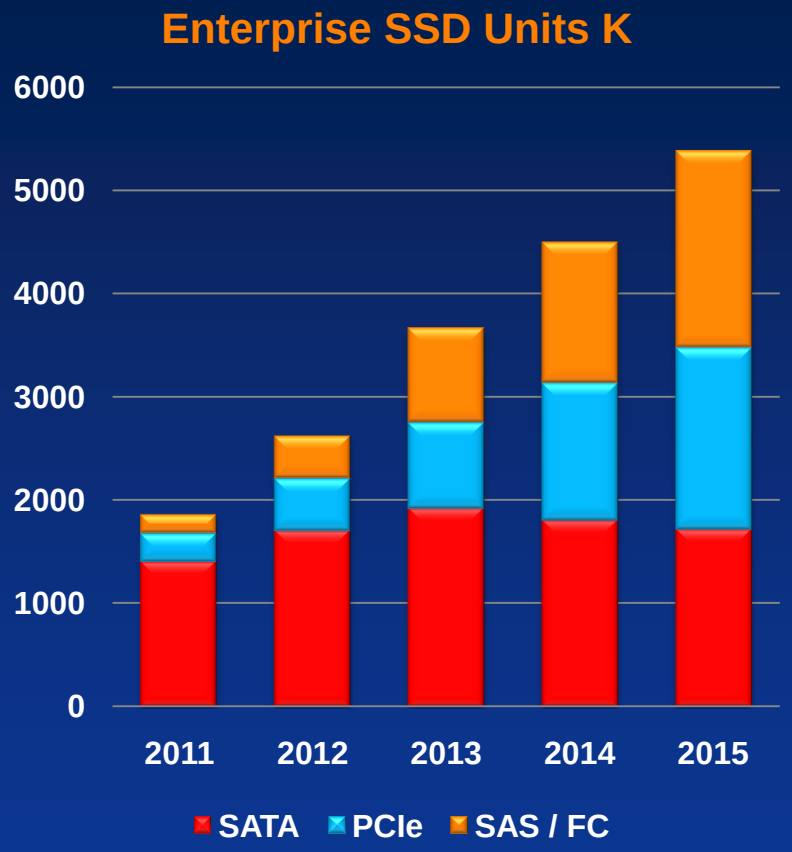
Enterprise SSD

Enterprise SSD Market Update

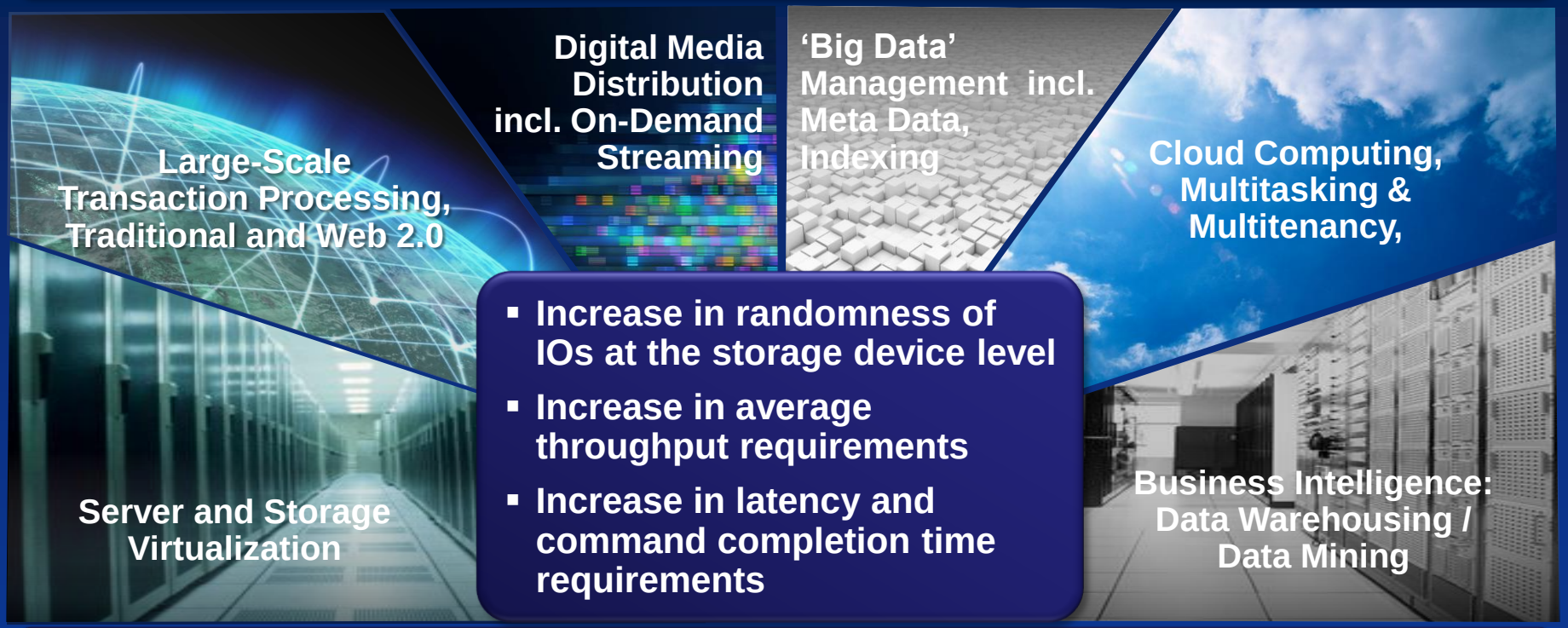
- "One Size Does Not Fit All": Storage solutions will be tiered to strike a balance between performance and cost
- When selecting an Enterprise SSD, the maturity and capabilities of the host interface and the SSD controller are as critical as the NAND memory
- The market outlook for Enterprise SSD remains strong; SAS and PCIe are expected to become the interfaces of choice going forward



Source: HGST

Drivers for High-Performance Storage

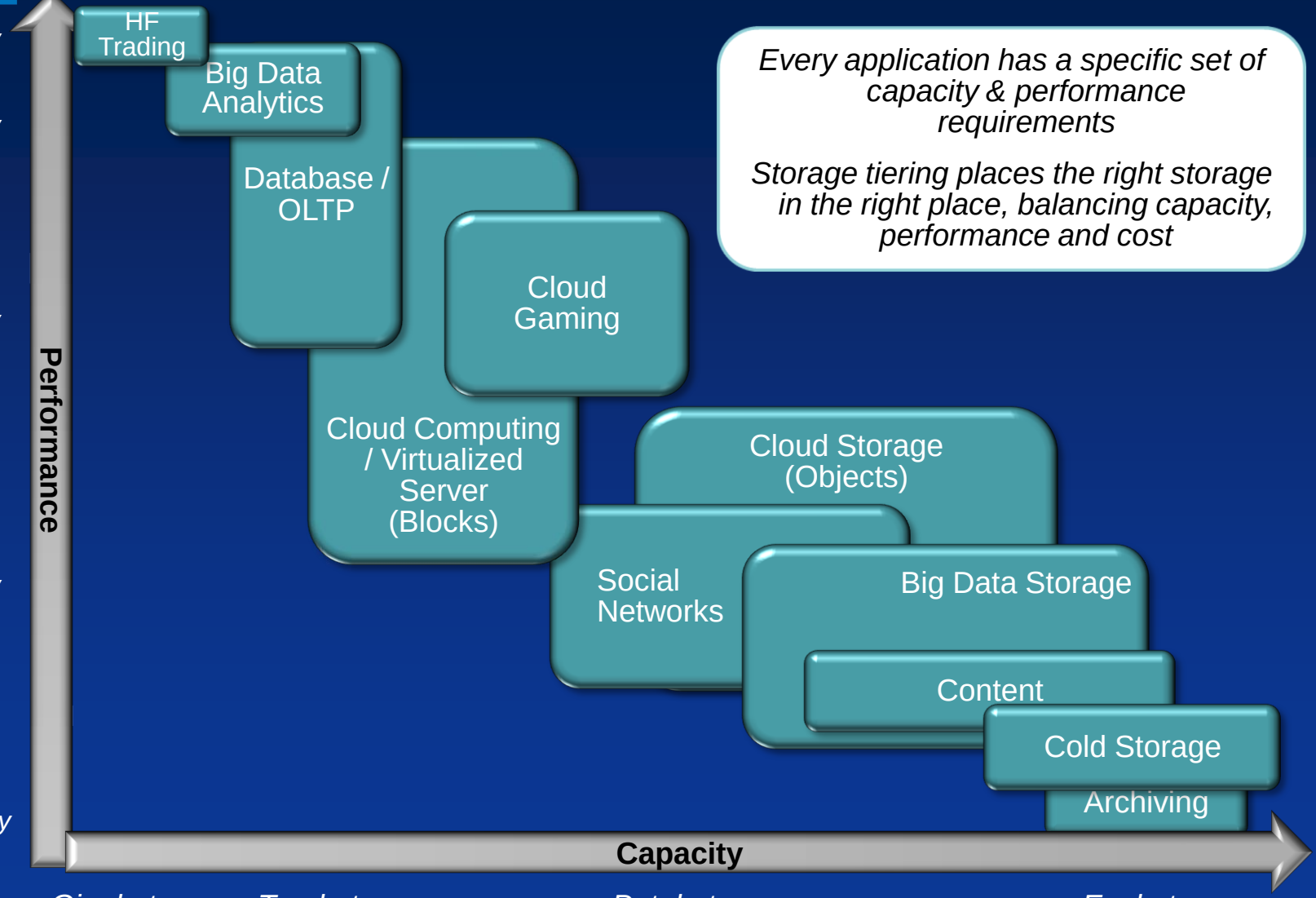
Several system and application drivers are increasing the demand for high-performance storage solutions going forward



- 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

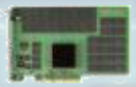
Storage Tiering: Optimizing for Applications



Every application has a specific set of capacity & performance requirements

Storage tiering places the right storage in the right place, balancing capacity, performance and cost

Storage Tiering: Choosing the Right Storage



PCI-e Solutions

- Highest performance

SLC & MLC NAND SSD

- Best IOPS/$, IOPS/Watt

10K & 15K SAS HDD

- Balances capacity & performance

7200 RPM SAS & SATA HDD

- Best $/TB value
- Highest capacities

Cold Storage Solutions

- *New storage class*
- *Very low $/TB, Low TCO*

"few" ms latency

~7ms latency

10-15ms latency

"10's" ms latency

sec-min latency

Performance

Capacity

Gigabytes *Terabytes* *Petabytes* *Exabytes*

SLC & MLC For Enterprise Applications

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

Market moving to MLC due to lower cost and lower workload requirements

2011-2012 Projections

MLC NAND Segmenting

- High Endurance
- Mainstream Endurance
- Read Intensive

Endurance, Performance, Price ($/GB)

- High Endurance (HE) 25DW/day
- Mainstream Endurance (ME) 10DW/day
- Read Intensive (RI) ~3DW/day

Key Take-Aways

- MLC will deliver performance close to SLC at significantly lower cost
- MLC write endurance shifting to support workload applications for a 3-5 year product life
- 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: HGST estimates

Anatomy of an Enterprise SSD

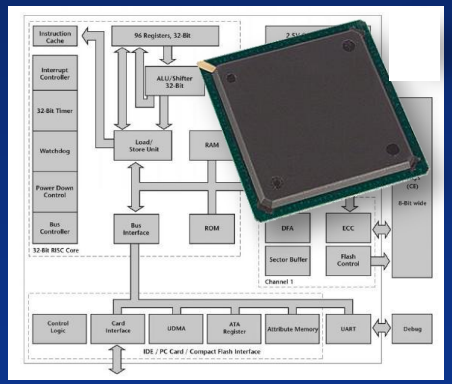
When considering various SSD offerings, it is important to remember the fundamental ingredients of an SSD

Drive Interface
(SSD Controller)

SERIAL ATA
Serial Attached SCSI
PCI EXPRESS®

+

Enterprise Reliability
(SSD Controller)



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NAND Array

System integration, scaling and high-availability needs

Full set of Enterprise requirements, especially reliability and error recovery

NAND investment determined by amount of NAND and type of NAND

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 SCSI-over-PCIe
Main Form Factor	2.5”	2.5”, Others?	2.5”, Cards
Max 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: 2012 SOP: late 2012/2013

PCIe as Drive Interface – Key Industry Initiatives

Two competing Enterprise initiatives have emerged in the attempt to align the industry around PCIe-based SSDs

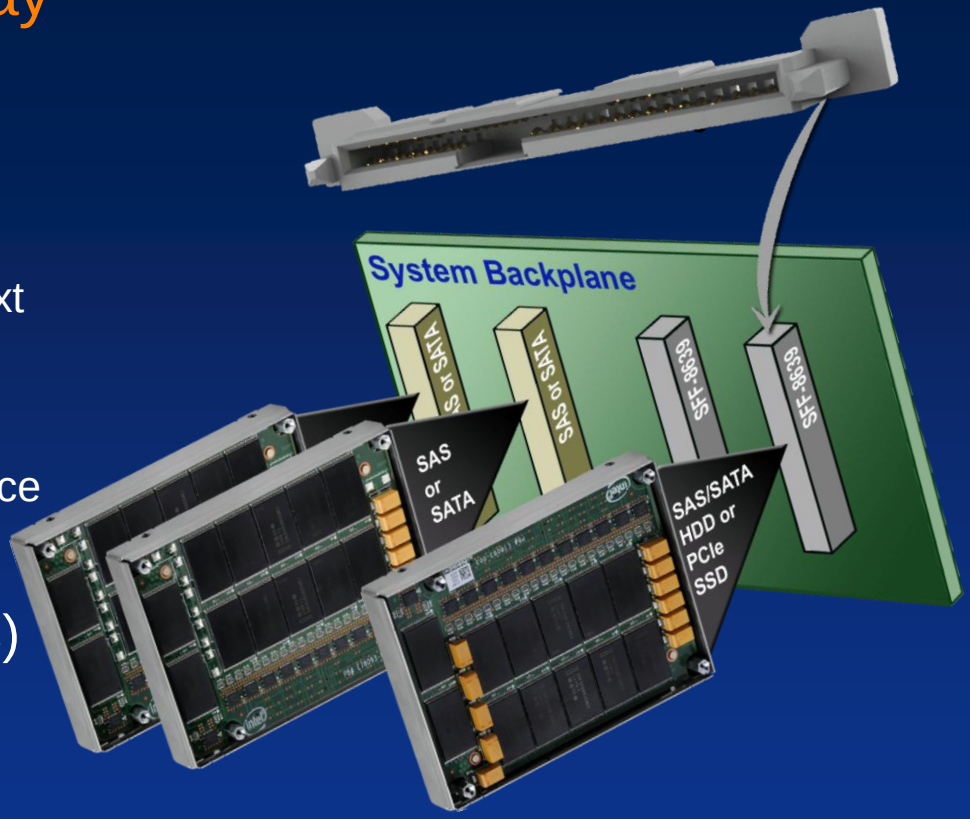
	SCSI Express	NVM Express	SATA Express
Primary Target	Enterprise SSD More Storage Based	Enterprise SSD More Sever Based	Client SSD & Hybrid
Host Command Interface	SCSI (w/ SOP & PQI)	NVMe (New)	ATA (via AHCI), followed by NVMe
Transport	PCIe x4	PCIe x4/x8	PCIe x2
Form Factor	2.5” Drive SFF Edge Card	2.5” Drive *, PCIe SIOM	2.5”, 1.8”, mSATA, etc.
Connectors	SFF 8639	SFF 8639, PCIe Edge Card	SATA-IO CabCon / SFF
Key Drivers	HP	Intel, Dell	Intel
Standardization	T10 & STA	NVMe Group	SATA-IO
OEM Endorsement	HP, IBM, most STA members?	Dell, EMC, NetApp, Oracle, Cisco	TBD
First SSD Products	2012? / 2013	2012	2012? / 2013

SAS – Looking to the Future

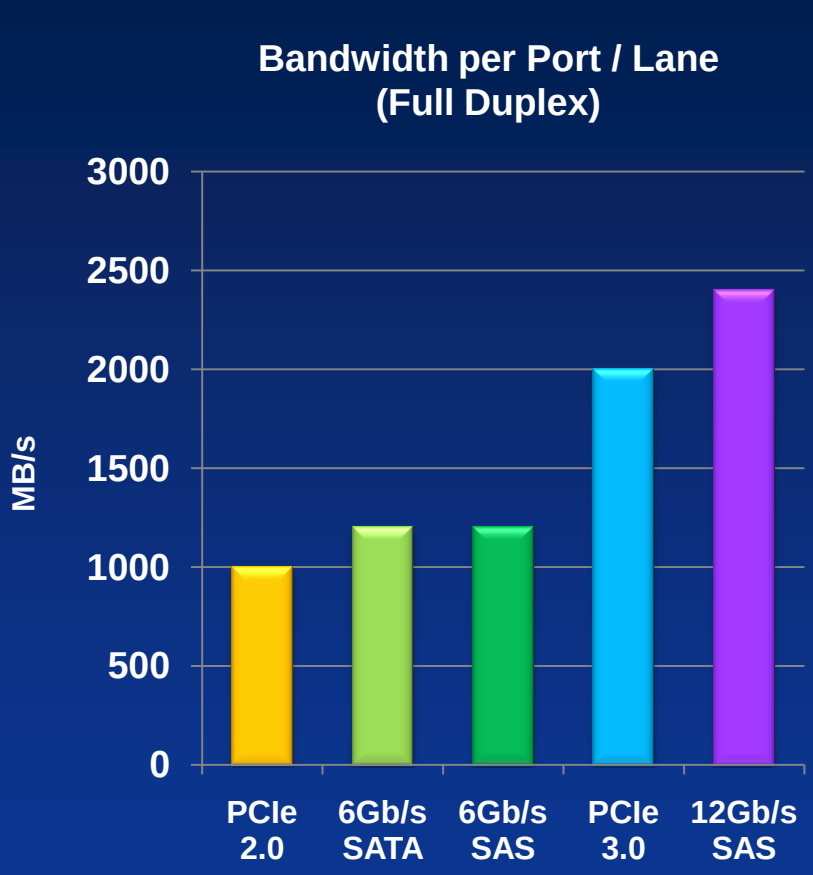
- 12Gb/s SAS standard in final stages of completion
  - Doubles the throughput while maintaining same distance use cases
    - Passive Copper (10M), Active Copper (10-25M), Optical (100M)
  - Power Control allows system to decide how much power a device consumes
    - Power = Performance (SCSI Express bay allowed to consume up to 25W)
  - Atomic Writes simplifies resilient system designs (Database, file system) improves performance in these applications
  - Pass “hints” makes operations more efficient and improves performance
  - Extended opens reduces latency in direct attached devices and can be implemented within existing standard
- 24Gb/s SAS connector proposal in the works
  - Show there is still extended life in SAS moving forward.

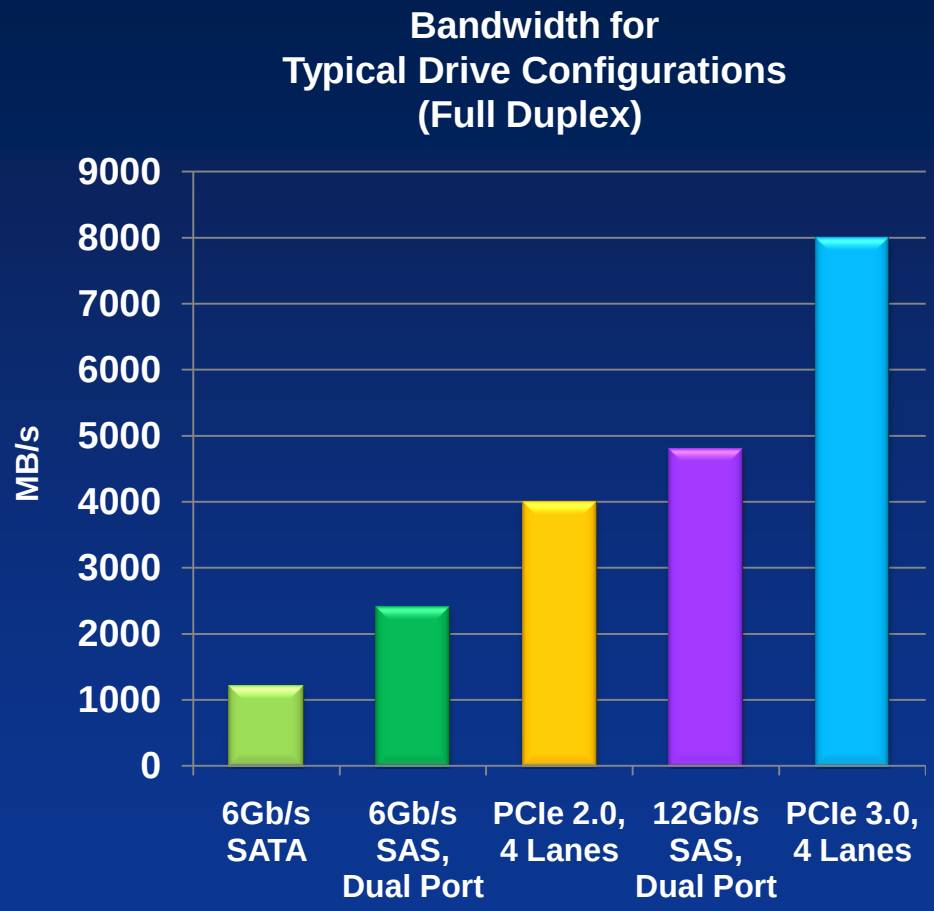
Multi-Function Bay

- Multi-Function SAS/PCIe bay
  - Uses SFF-8639 connector
    - Gives the flexibility needed in the next generation connector
  - High performance (up to 25W)
    - Ability to adjust power vs. performance
  - Hot swap, serviceability (SAS)
  - High availability (2 fault domains)
  - Supports a range of devices
    - 12Gb/s SAS,
    - Multilink SAS (4 SAS ports)
    - PCIe SSDs (NVMe, SOP-PQI, Proprietary)
    - SATA Express
    - 6Gb/s SATA



Removing Storage Bottlenecks





Not Shown: 4 port MultiLink SAS or 8 Lane PCIe

With Dual Port SAS and Multi-lane PCIe the bottleneck is not Storage I/O bandwidth

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	Cloud/ 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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  - **HGST Booth #809**
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  - **Industry-first breakthrough speed**

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