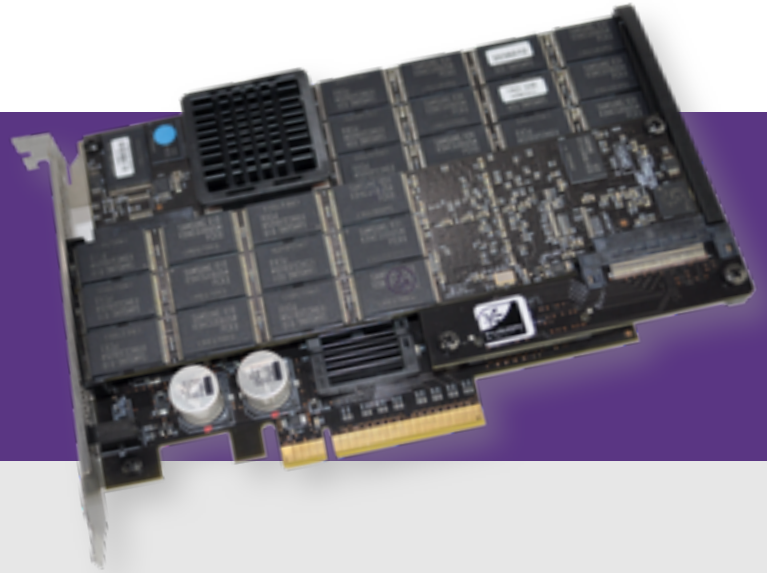
Session 303-B
SNIA SSSI PCIe SSD Round Table

Thursday, August 23, 2012
3:10 pm- 4:25 pm

Eden Kim, Chair

Solid State Storage PCIe . . .

a Round Table



What are issues facing Adoption of PCIe Solid State Storage devices?

- Standards for PCIe Attached Storage
- Technology & Architectural Issues
- Mass Storage Ecosystem Adoption & Optimization
- Market & Product Positioning
- Deployment Strategies

Flash Memory SUMMIT

Panelists - Session 303-B

Moderator: Eden Kim, Calypso Systems, Inc.

3:10 – 3:15: Eden Kim, Calypso - Introduction

Speakers

3:15 – 3:20: Easen Ho, Calypso – PCIe Performance Testing

3:20 – 3:25: Gary Orenstein, Fusion-io – Lessons from the Front Lines & A Look to the Future

3:25 – 3:30: Paul Wassenberg, Marvel – SATA Express

3:30 – 3:35: Mark Myers, Intel – SFF Working Group – PCIe 2.5" Form Factor

3:35 – 3:40: Marty Czekalski, Seagate – SCSI Express: Extending the SCSI Platform

3:45 – 3:50: Don Jeanette, Toshiba – PCIe Love & Stuff that needs to Happen

3:50 – 3:55: Tony Rogue, Virident – PCIe & Storage Class Memory

Question & Answer Session – 3:55 – 4:10

Audience Questions **Please fill out Questionnaire Cards**

SNIA SSSI PCIe SSD Task Force

Paul Mitchell

Santa Clara, CA August 2012

Open Forum April – July 2012

62 Companies
130 Individuals

- SSD OEMs ODMs
- Controller Companies
- Semiconductor Fabs
- VARs, SAN, NAS
- Analysts, Blogs
- Industry Associations
- Standards Groups
- End Users

SNIA SSSI PCIe SSD Task Force

8 MEETINGS 24 PRESENTATIONS

PRESENTING COMPANIES

HP - Marvell - Micron – Toshiba - Seagate

STEC - Fusion-io - Virident - Intel

NVMe - SATA-IO – STA - PCI SIG

Calypso – Agilent – HyperIO - LeCroy – eASIC

Coughlin Associates - Objective Analysis

SNIA IOTTA – NVMP – SSS - Security TWGs

TOPICS

- Standards
- Testing & Instrumentation
- PCIe Performance
- System Integration
- Form Factors
- System Architectures
- PCIe Driver Topics
- Analysts View
- Market Development
- Deployment Strategies

Presentations can be downloaded in mtg minutes at *www.snia.org/forums/sssi/pcie*

PCIe SSD Standards

ITEM	GROUP → STANDARD	CLIENT PCIe SSD	ENTERPRISE PCIe SSD
PHYSICAL INTERFACE	PCI-SIG → *PCI Express* SATA-IO → *SATA Express* SCSI Trade Assn → *SCSI Express*	up to 2 LANES Drive up to 4 LANES Card	Up to 4 LANES
REGISTER INTERFACE & COMMAND SET	Intel → *AHCI* NVM Express Group → *NVMe* T10 → *SOP/PQI w/support for NVMe*	AHCI or NVMe	SOP / PQI Or SOP / NVMe Or NVMe
HOST CONNECTOR	SATA-IO → *SATA Express* SSD FF WG → *multifunction connector* Small FF Committee → *SFF-8639*	SATA Express Host Connector Or SFF-8639	SFF-8639
DEVICE CONNECTOR	SATA-IO → *SATA Express* SSD FF WG → *multifunction connector* Small FF Committee → *SFF-8639*	SATA Express Drive & Card Connectors	SFF-8639

Advancing Solid State Storage

Panelist Easen Ho, Calypso

Speaker Name	Company Title	Introductory Bio
Easen Ho	**Calypso** **CTO** eho@calypsotesters.com	Dr. Ho is the CTO of Calypso Systems, Inc. and has been a principal architect of the recently released SNIA Solid State Storage Performance Test Specification. Dr. Ho has been intimately involved in the development of performance benchmarking for NAND Flash based solid state storage devices. Dr. Ho received his doctorate in laser physics from MIT and his BSEE from the Tokyo Institute of Technology. Dr. Ho previously was founder, CEO and CTO of digital papyrus,

PCIe SSD Roundtable

Testing of PCIe SSDs

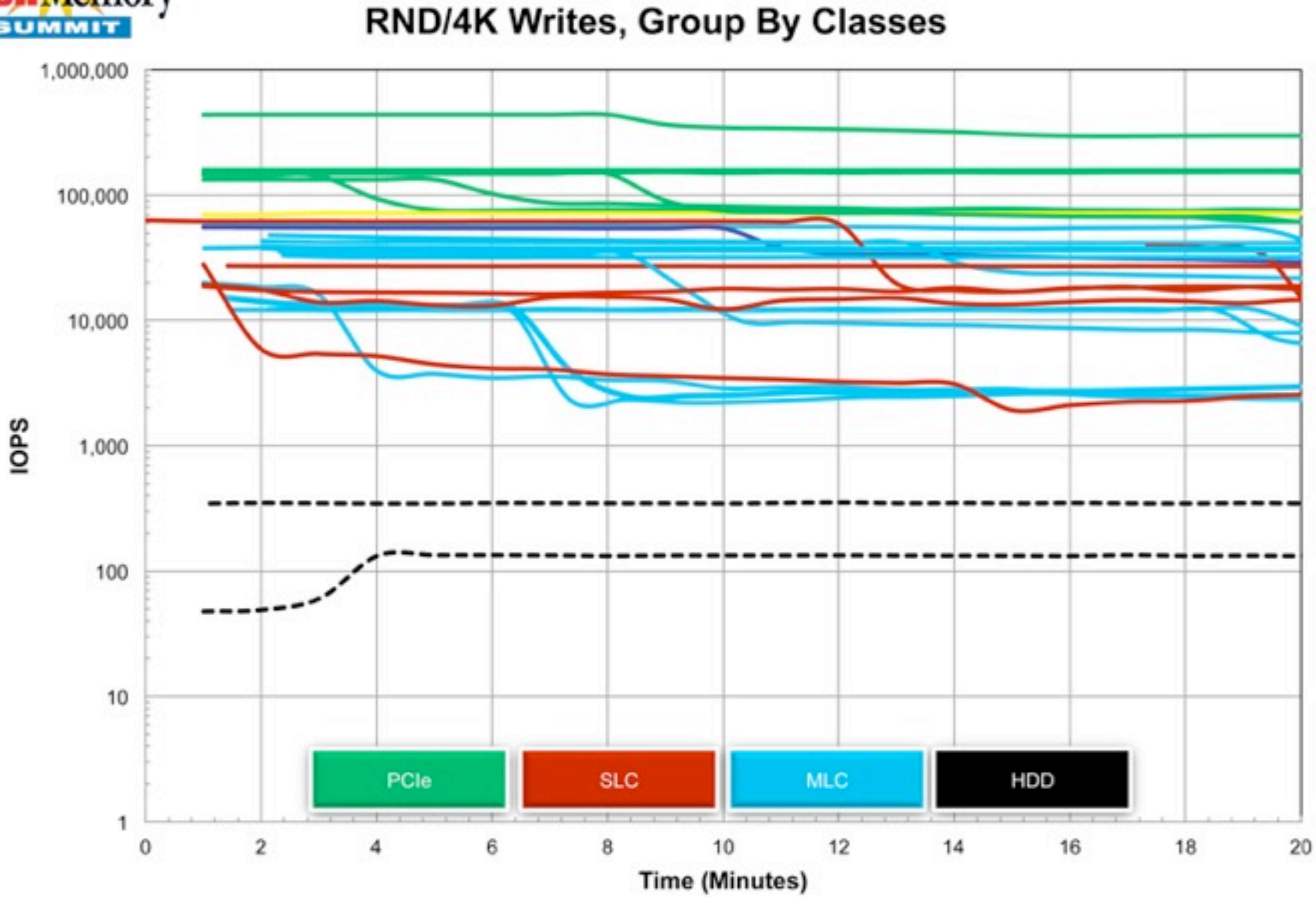
Easen Ho
CTO, Calypso Systems, Inc.

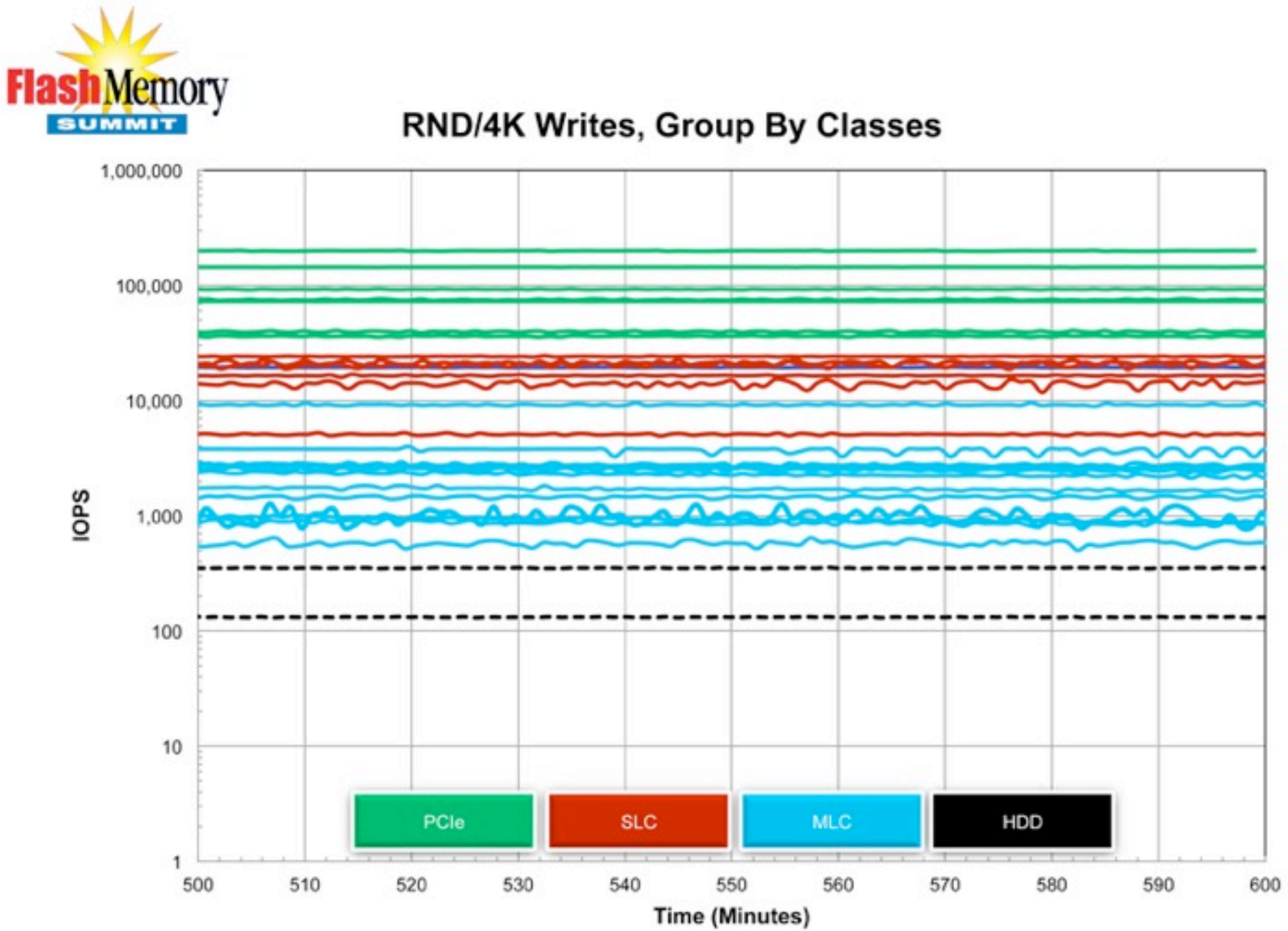
PCIe SSD Testing Issues

- From a testing perspective, PCIe SSDs looks just like another drive to the application, however…

  - Generally targeted at high end → faster TP, IOPS, and latencies
  - Wider variety of architectures possible:
    - no longer gated by a specific protocols such as SATA/SAS → possible to reduced IO latencies
    - host system can become part of the drive by design in some architectures → additional testing metrics needed; standardization becomes important
  - Variety of form factors → heat dissipation; power measurement issues
  - Variety of protocol standards → how do they affect performance?

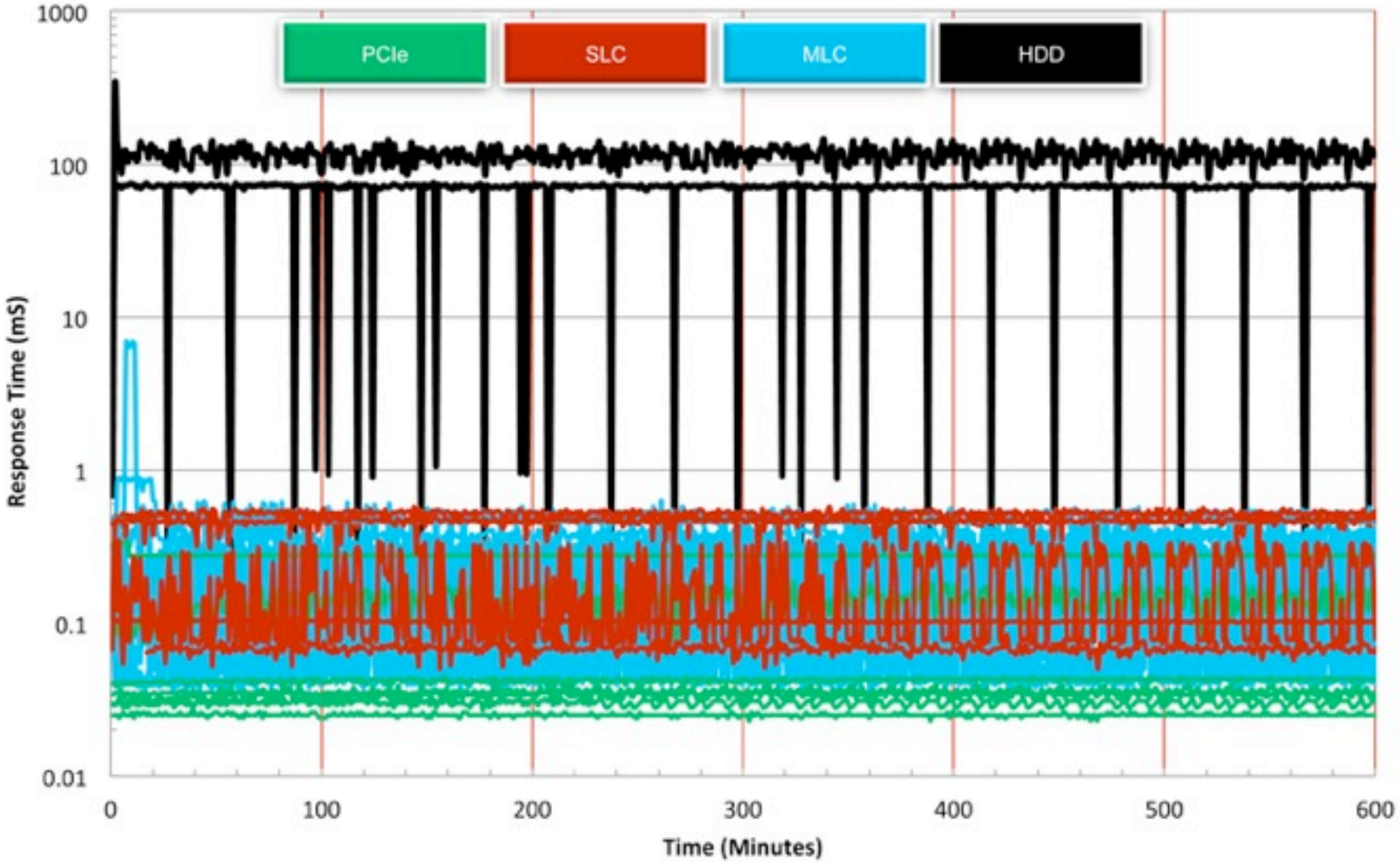
Flash Memory SUMMIT



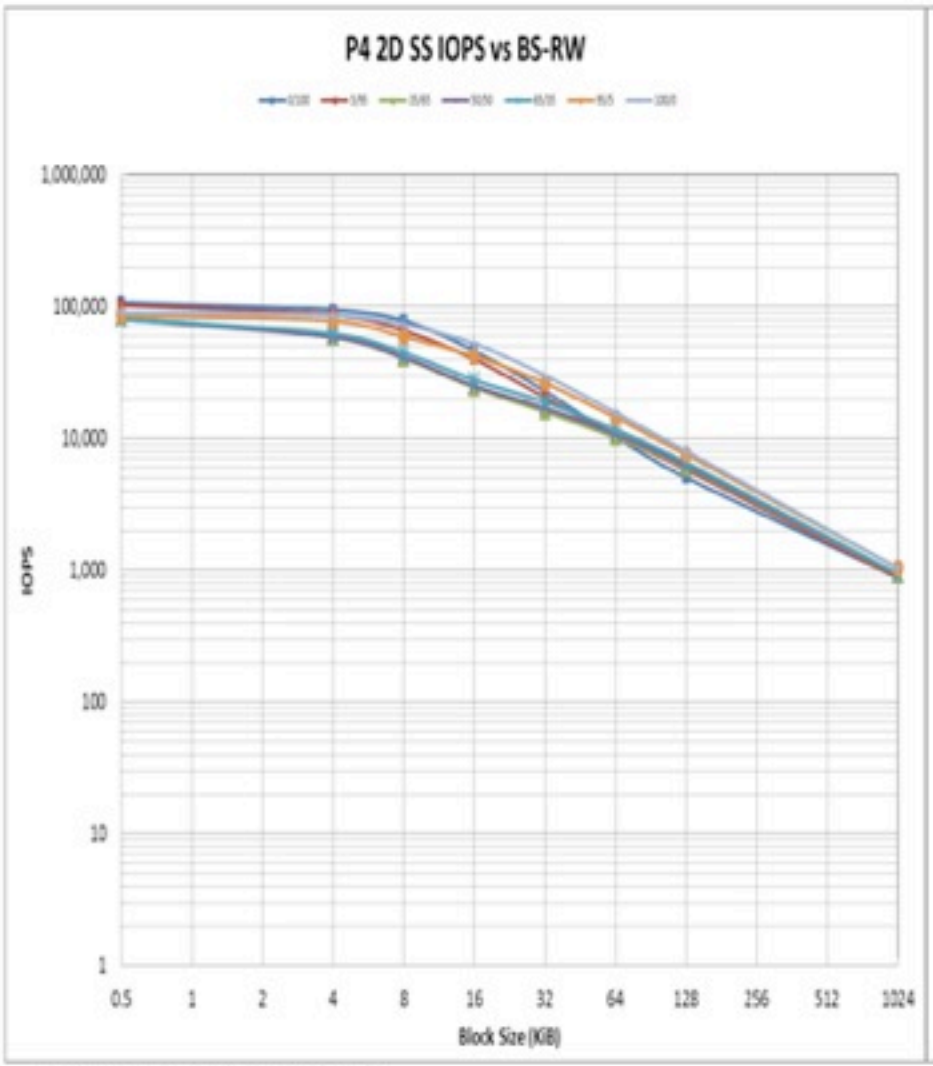

Flash Memory SUMMIT
RND/4K Writes, Group By Classes
1,000,000
100,000
10,000
1,000
100
10
1
IOPS
500
510
520
530
540
550
560
570
580
590
600
Time (Minutes)
PCIe
SLC
MLC
HDD

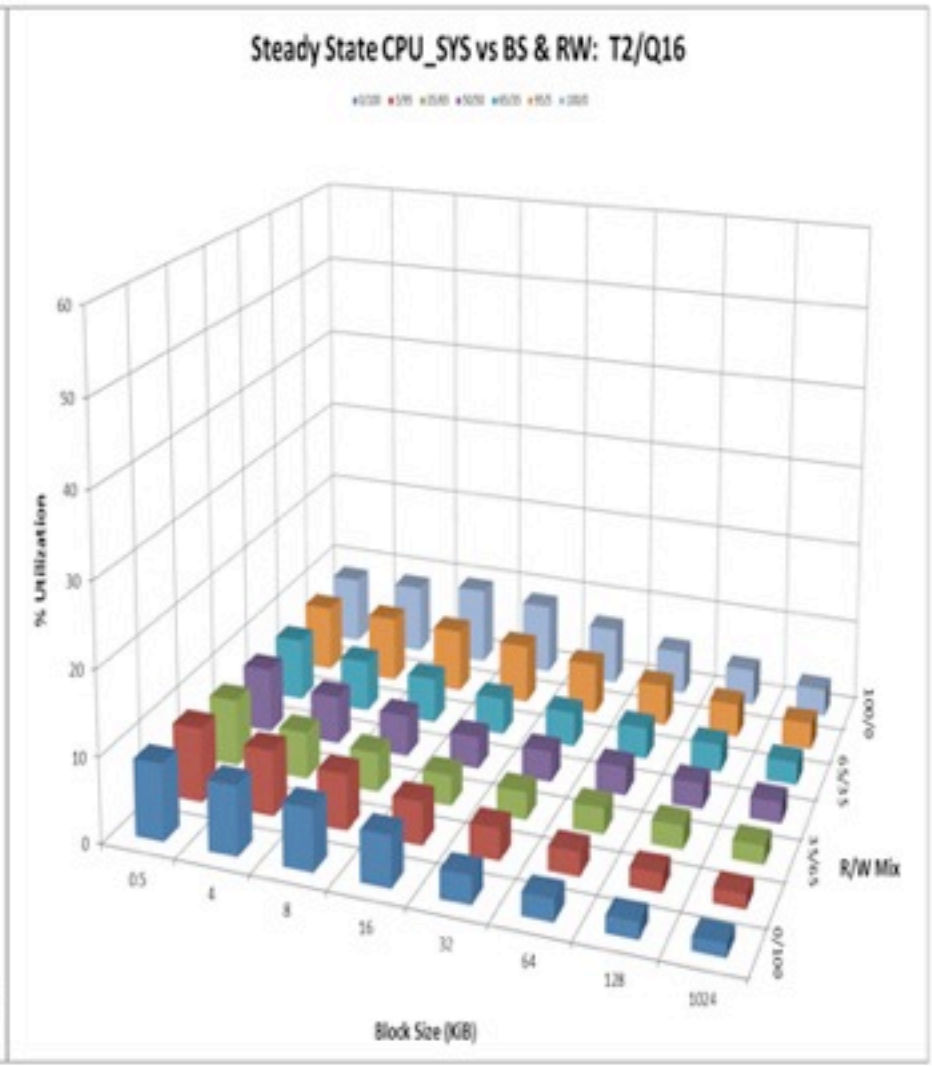
Flash Memory SUMMIT

RND/4K Writes: Minimum Response Time – Group By Classes

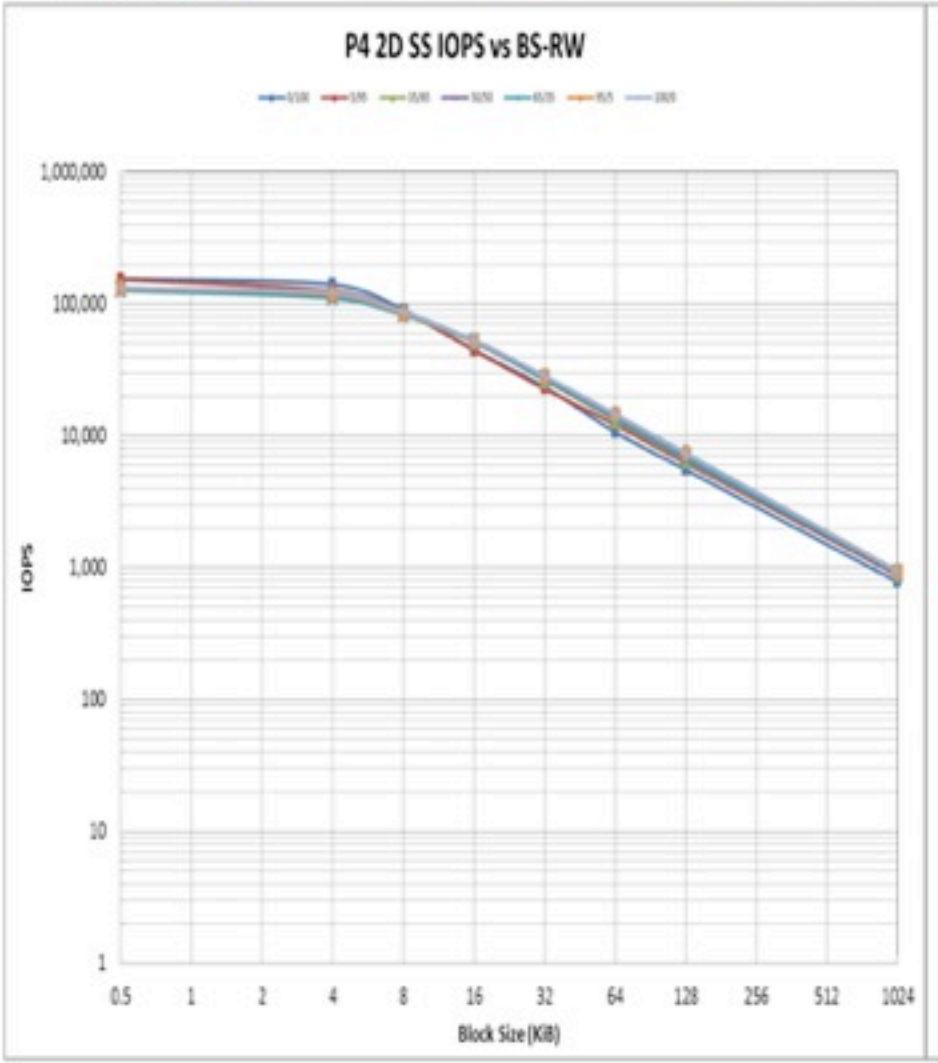


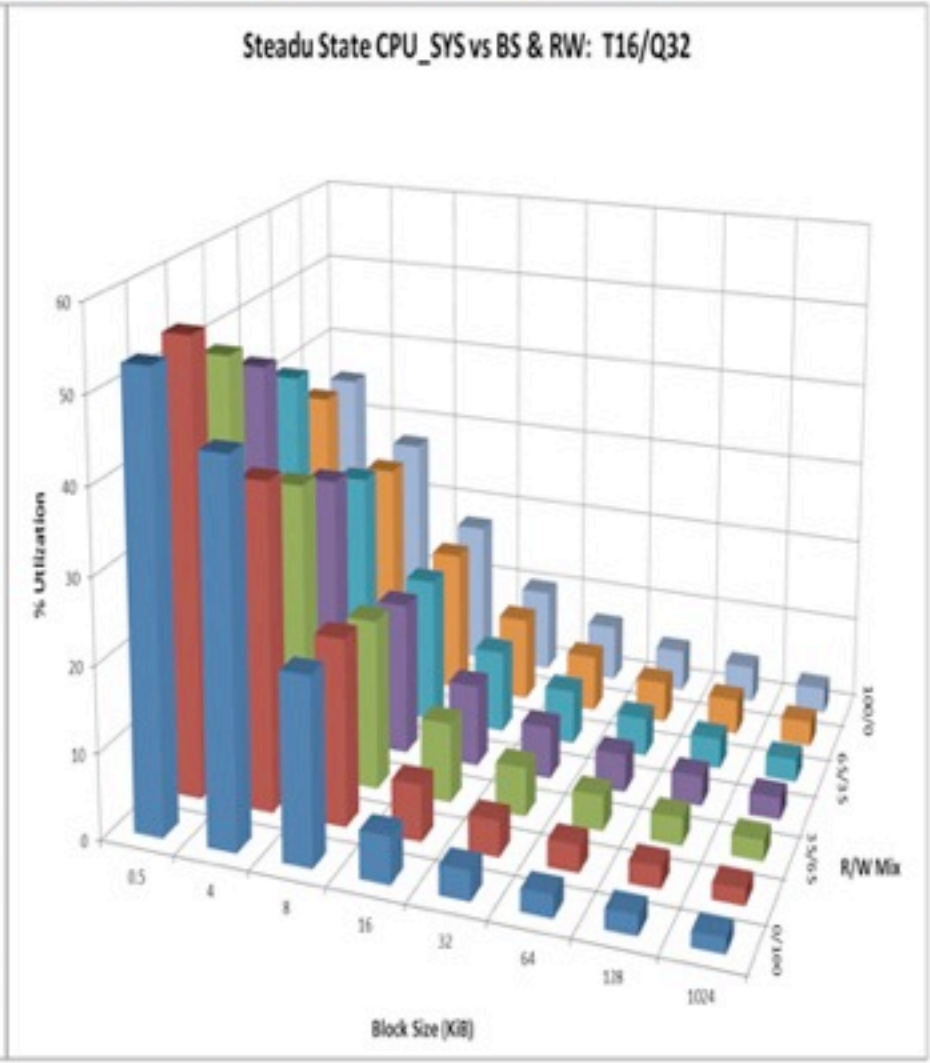
SNIA PTS-E 1.0 IOPS: T2/Q16





SNIA PTS-E 1.0 IOPS: T16/Q32





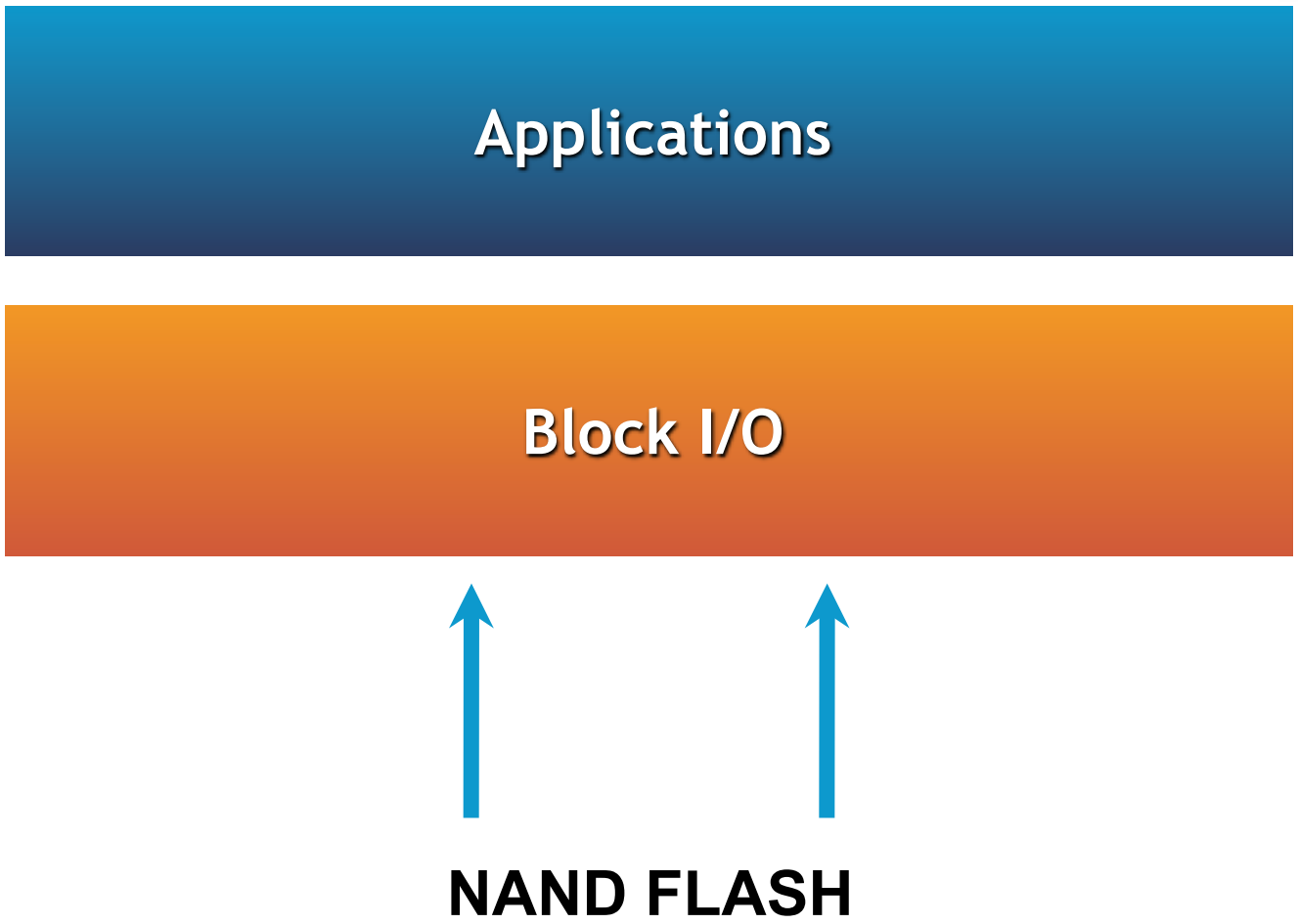
Panelist Gary Orenstein, Fusion-io

Speaker Name	Company Title	Introductory Bio
Gary Orenstein	**VP Products**	Gary has served in leadership roles at numerous data center infrastructure companies. Prior to Fusion-io he was the vice president of marketing at MaxiScale, focused on web scale file systems and acquired by Overland Storage. Prior to MaxiScale, he was the vice president of marketing and business development at Gear6, focusing on storage and web caching. He also served as vice president of marketing at Compellent which went public and 2007, and was a co-founder at Nishan Systems, acquired by McDATA/


FUSION-iO
Flash Memory
SUMMIT
August 23, 2012
Lessons from the Front Lines and
a Look to the Future
Gary Orenstein, SVP of Products, Fusion-io, @garyorenstein

Initial Stage of NAND Flash deployment

FUSION-IO



Architectural Differences

FUSION-IO

Applications

Block I/O

Architected like a disk

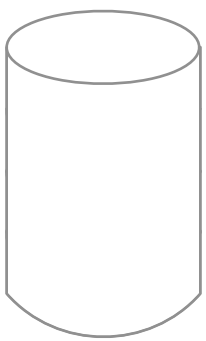
Architected like memory

Memory-like Architecture

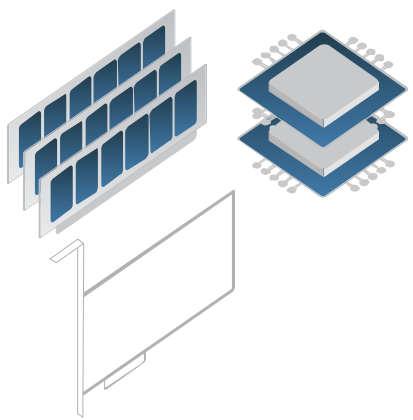
FUSION-IO

Applications

Block I/O

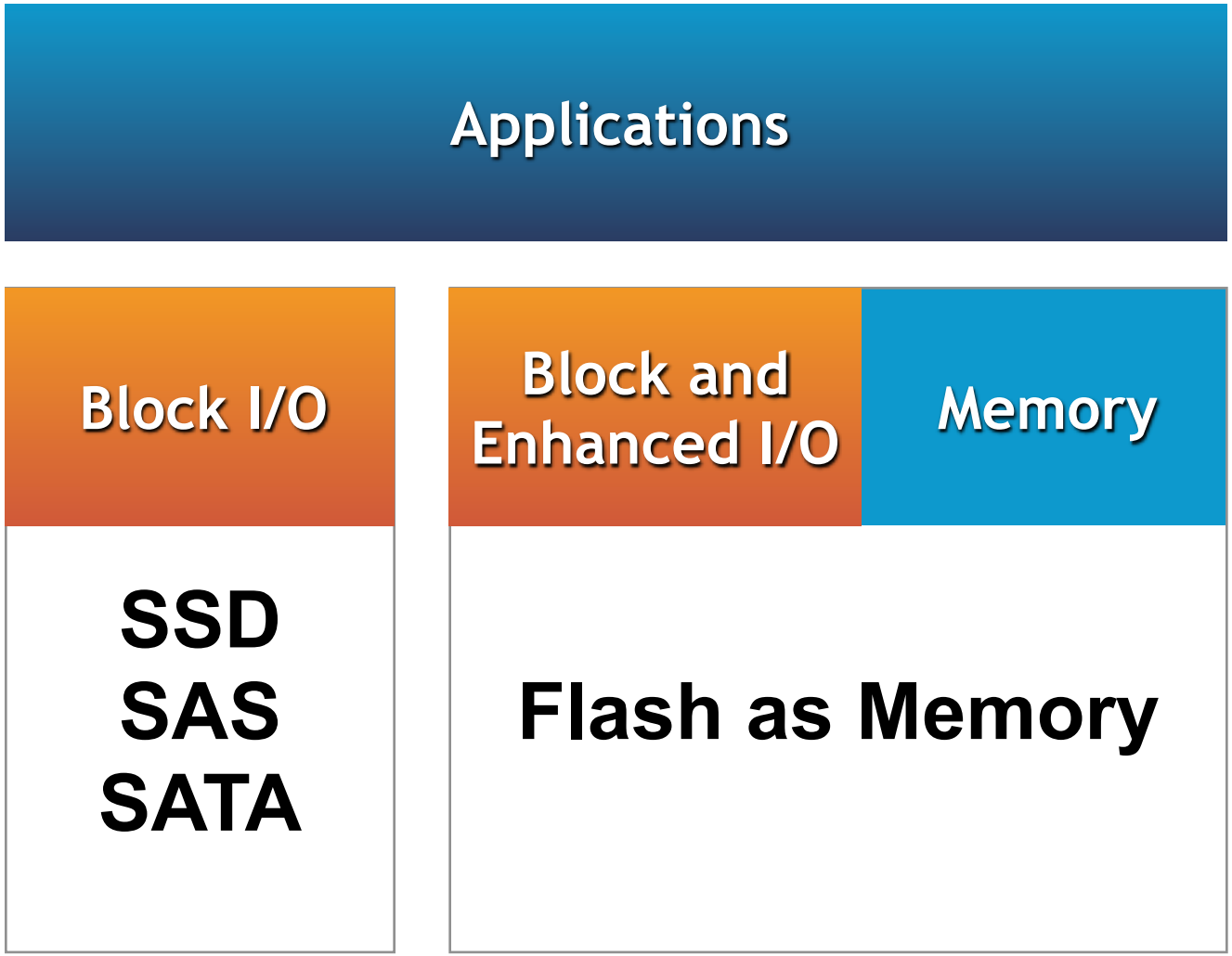


SSD approach



Flash as Memory approach

Beyond Block I/O Access



Storage


amazon
web services™

S3 API – Bucket and Object operations

FUSION-IO

DELETE Bucket

DELETE Bucket lifecycle
DELETE Bucket policy
DELETE Bucket website

GET Bucket (List Objects)

GET Bucket acl
GET Bucket lifecycle
GET Bucket policy
GET Bucket location
GET Bucket logging
GET Bucket notification
GET Bucket Object versions
GET Bucket requestPayment
GET Bucket versioning
GET Bucket website
HEAD Bucket
List Multipart Uploads

PUT Bucket

PUT Bucket acl; PUT Bucket lifecycle
PUT Bucket policy; PUT Bucket logging
PUT Bucket notification; PUT Bucket requestPayment
PUT Bucket versioning; PUT Bucket website

DELETE Object

Delete Multiple Objects

GET Object

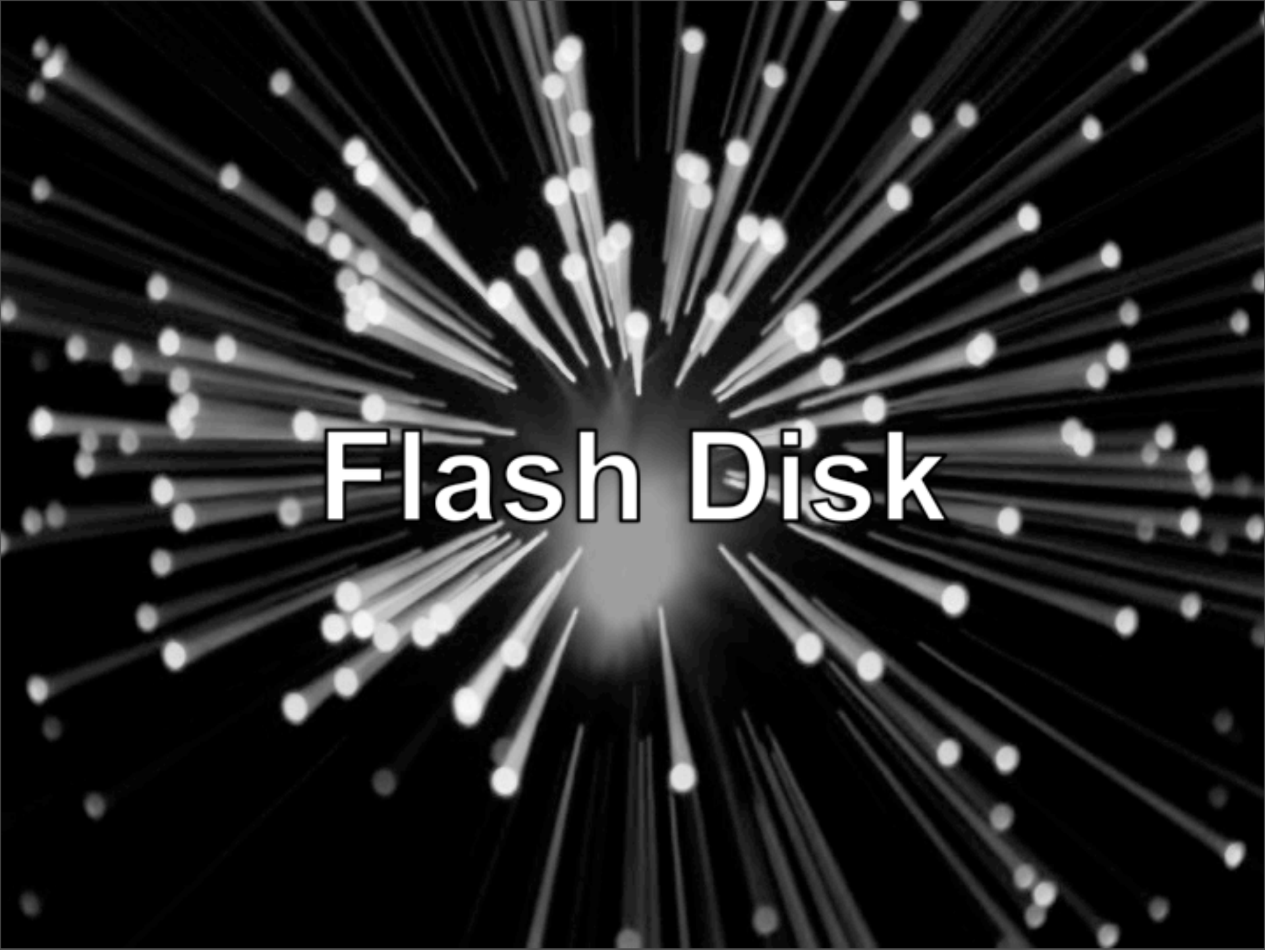
GET Object ACL
GET Object torrent
HEAD Object
POST Object

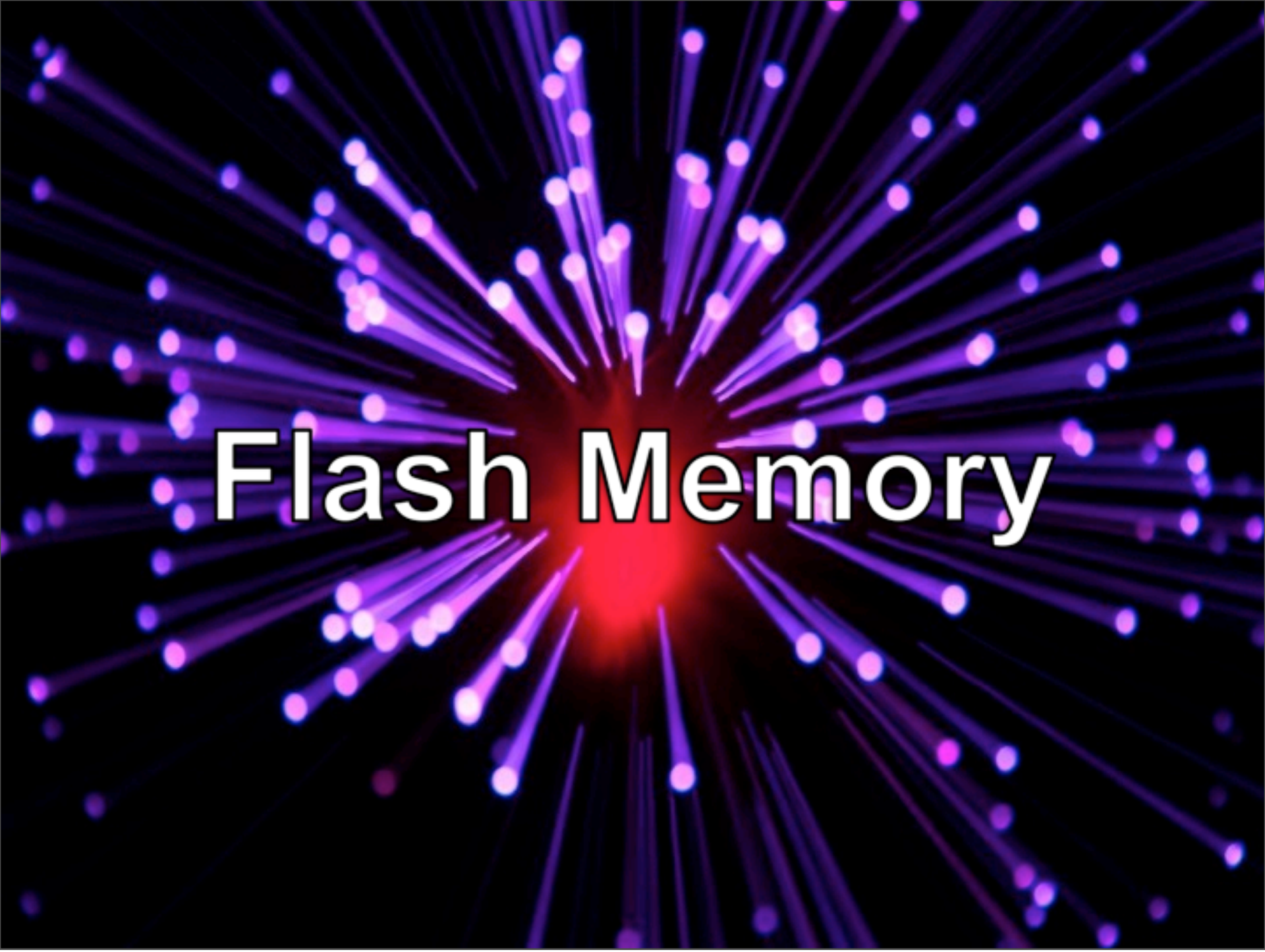
PUT Object

PUT Object acl
PUT Object – Copy
Initiate Multipart Upload

Upload Part

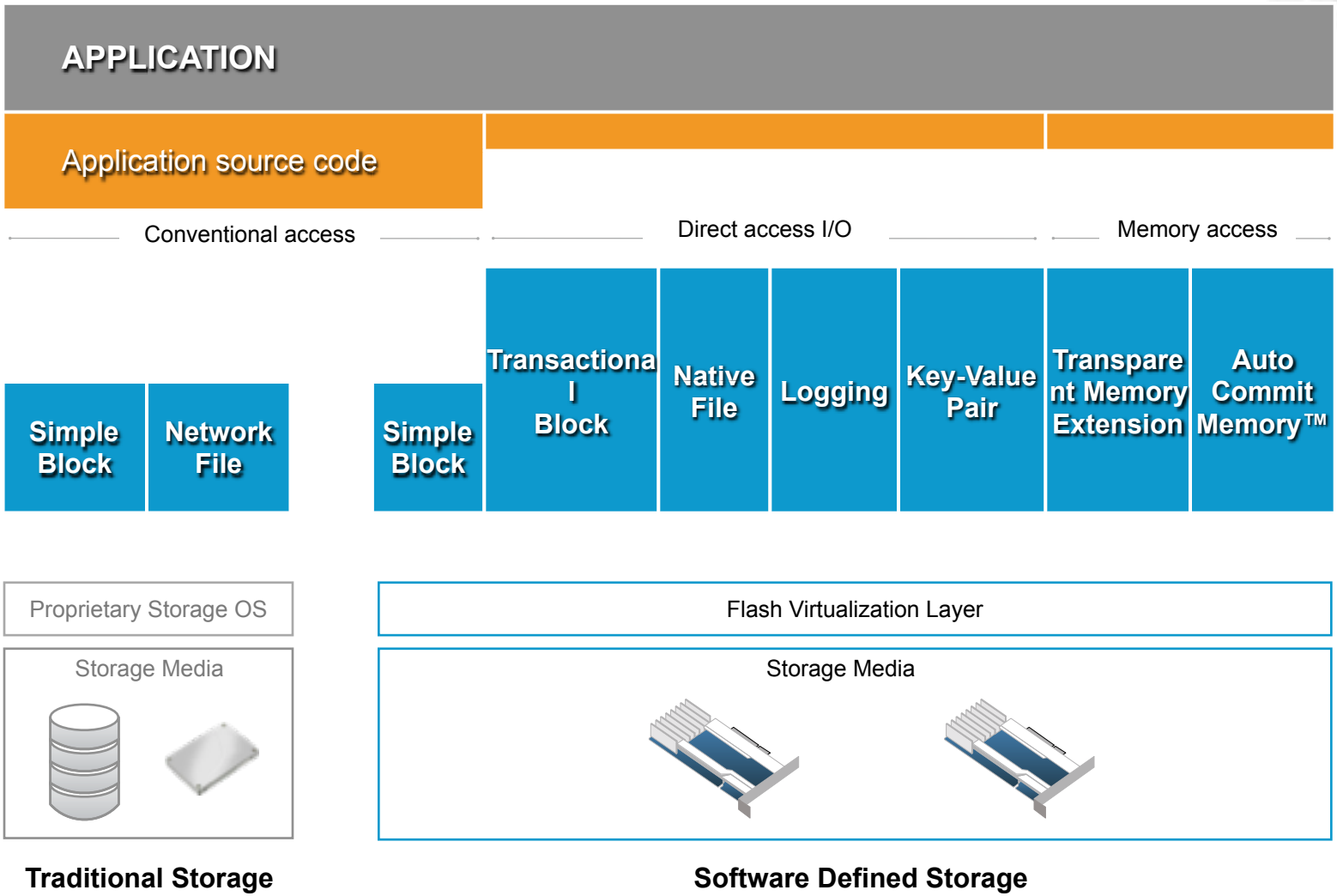
Upload Part – Copy
Complete Multipart Upload
Abort Multipart Upload
List Parts


Flash Disk


Flash Memory

Software Development Kit ADVANTAGES

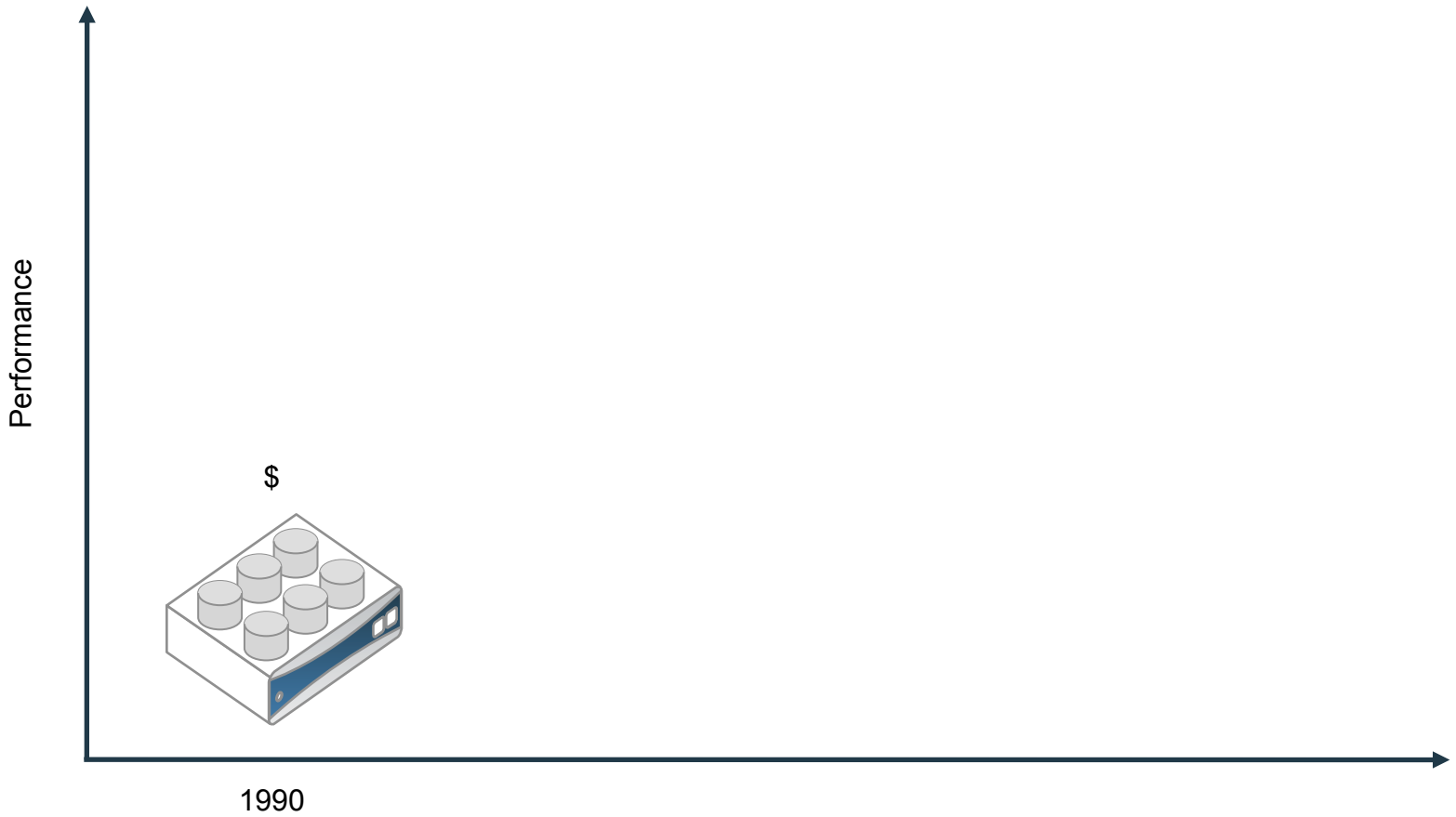
FUSION-IO



Flash Deployment Architectures

A NEW APPROACH IS NEEDED

FUSION-IO



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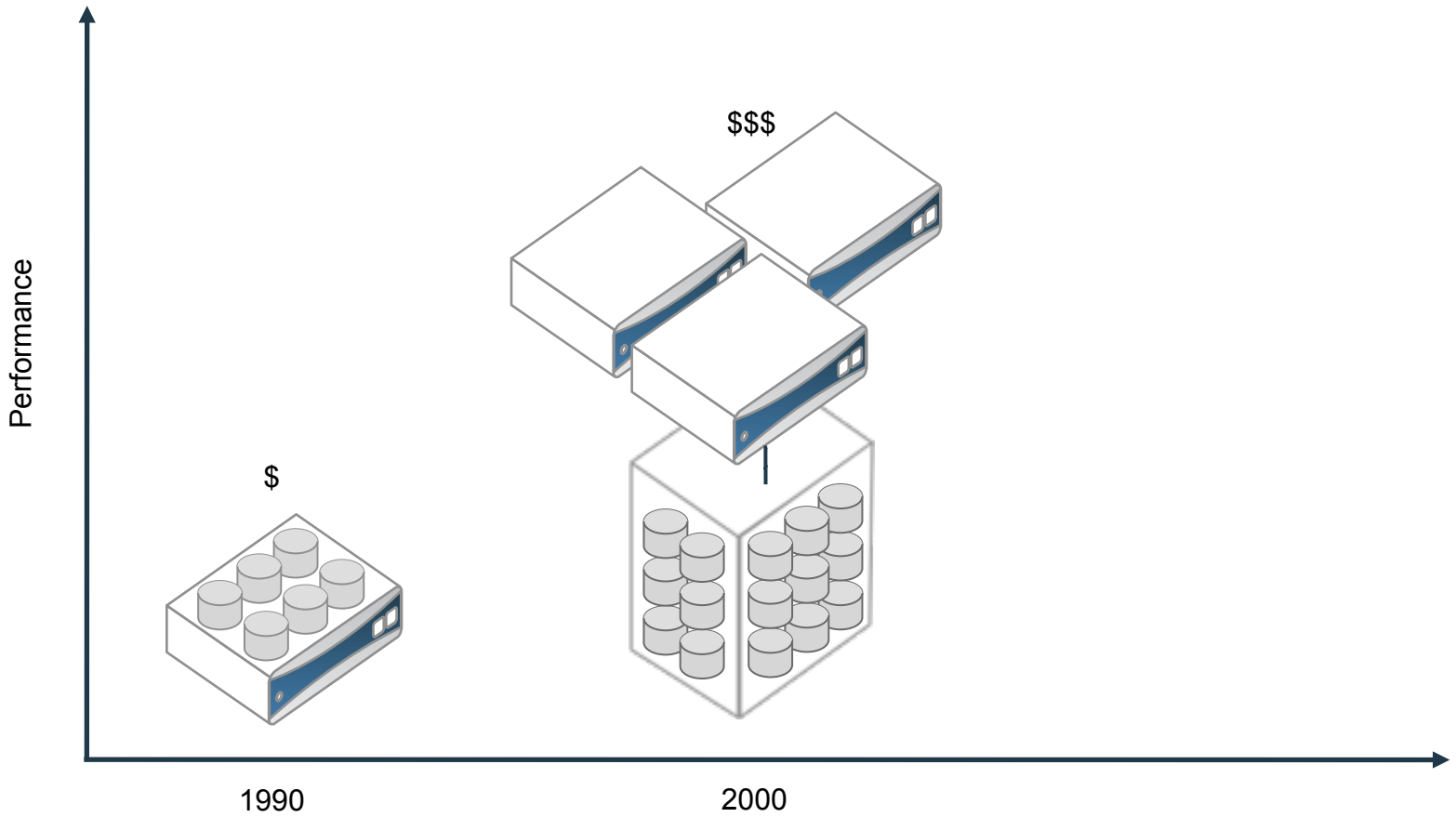
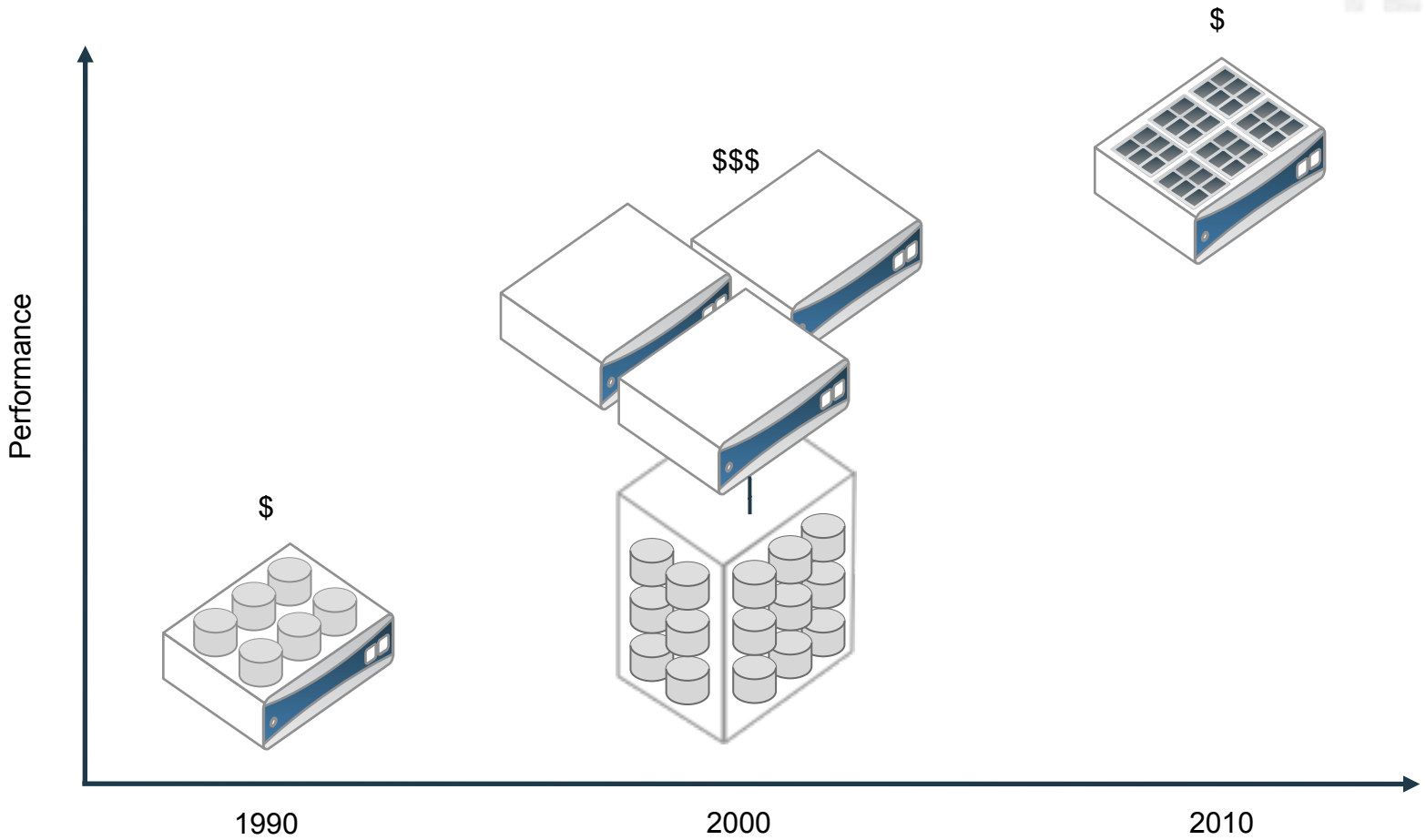
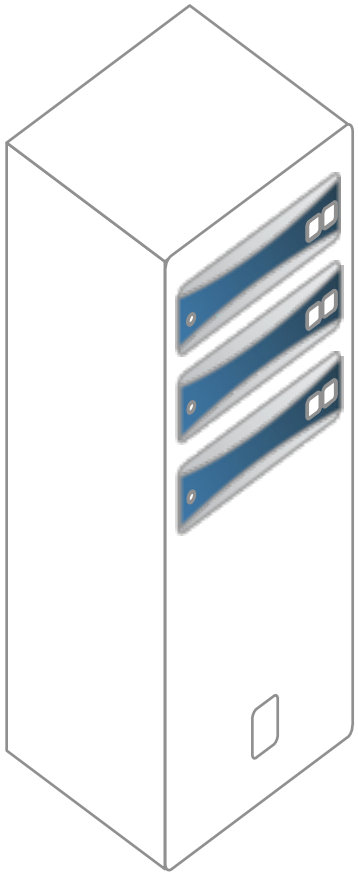


A NEW APPROACH IS NEEDED

FUSION-IO



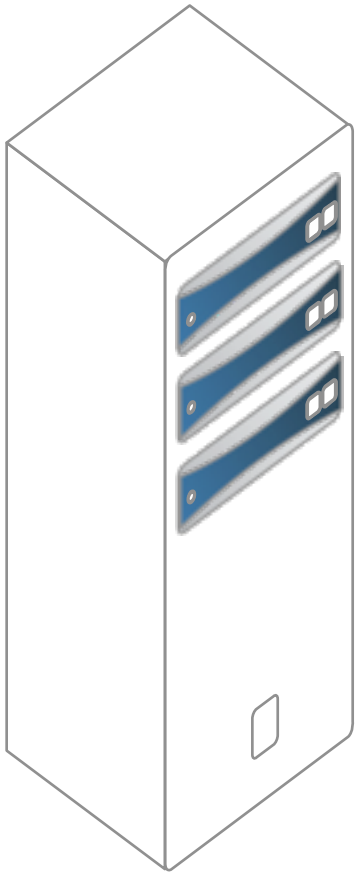
The Power of A SAN

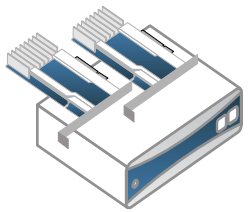


The Power of A SAN

FUSION-IO

IN A 1 U SERVER





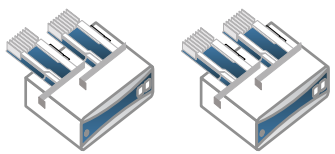
acceleration solutions

FUSION-IO

Direct

Max Acceleration

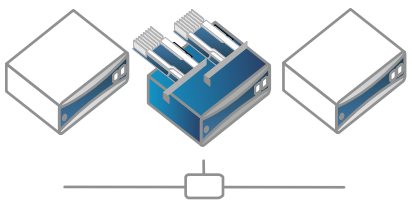
- Lowest latency
- Smallest footprint
- For I/O intensive applications



Shared

Max Scalability

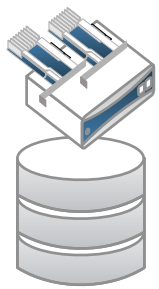
- Multi-protocol
- Platform Independent
- For clustered architectures



Caching

Max Interoperability

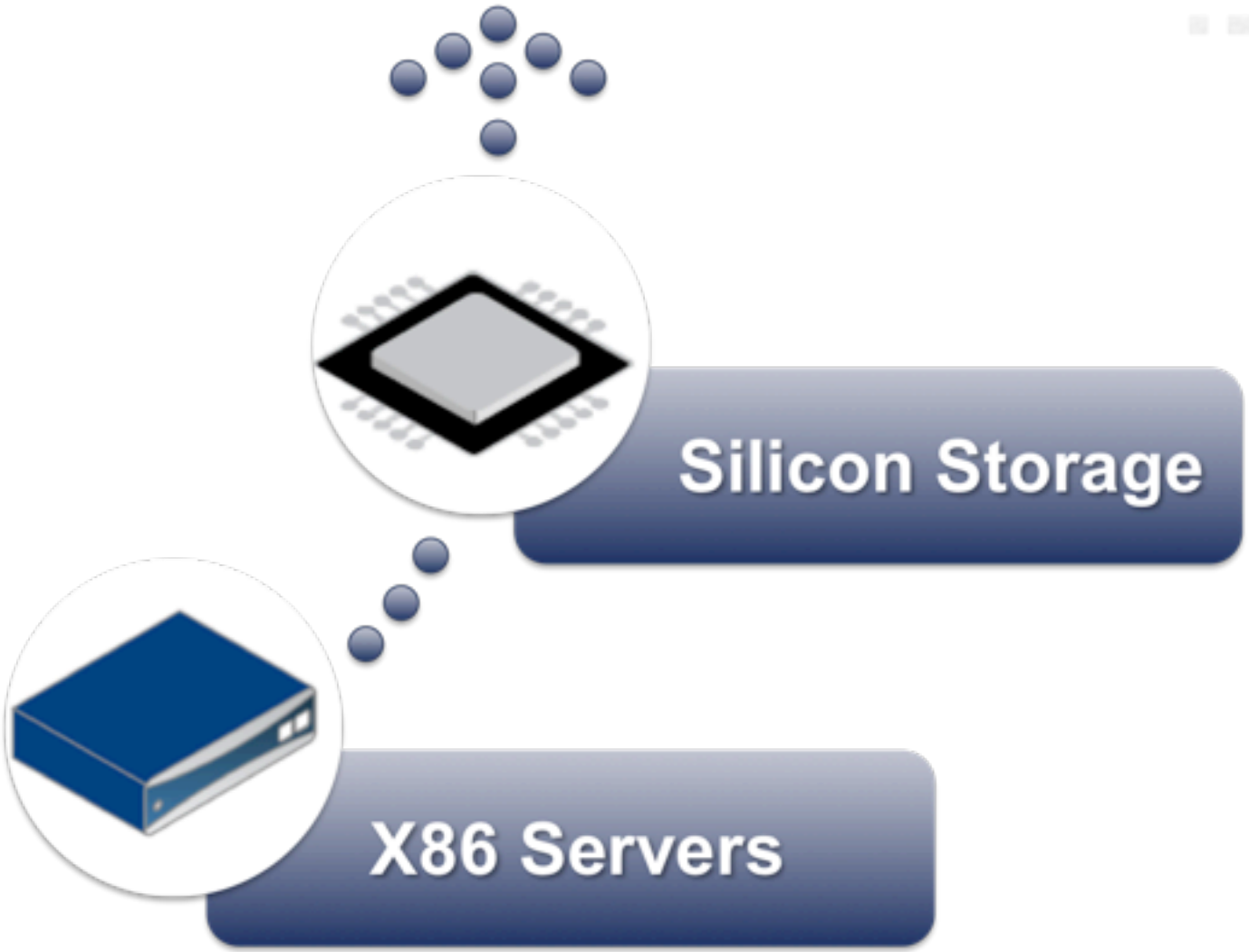
- Drop-in SAN/NAS acceleration
- Storage workload reduction
- Greater VM density



Performance — **Native Flash Memory** — **Interoperability**

Market Growth Accelerators

FUSION-IO




Thank You
@garyorenstein

Panelist Paul Wassenberg, Marvell

Speaker Name	Company Title	Introductory Bio
Paul Wassenberg	**Marvell**	Paul Wassenberg has over 20 years of experience in data storage and has been deeply involved with storage interface technology, including SATA since its inception. Early in his career, he was a storage controller designer, before moving into Marketing in the HDD industry, and eventually into storage semiconductors. Paul currently holds the position of Director, Product Marketing with Marvell Semiconductor. In that role, he has responsibility for transceiver technology and HDD/SSD storage standards. He is on the SATA-IO board of directors and chairs the SNIA Solid State Storage Initiative. Paul holds

SATA Express

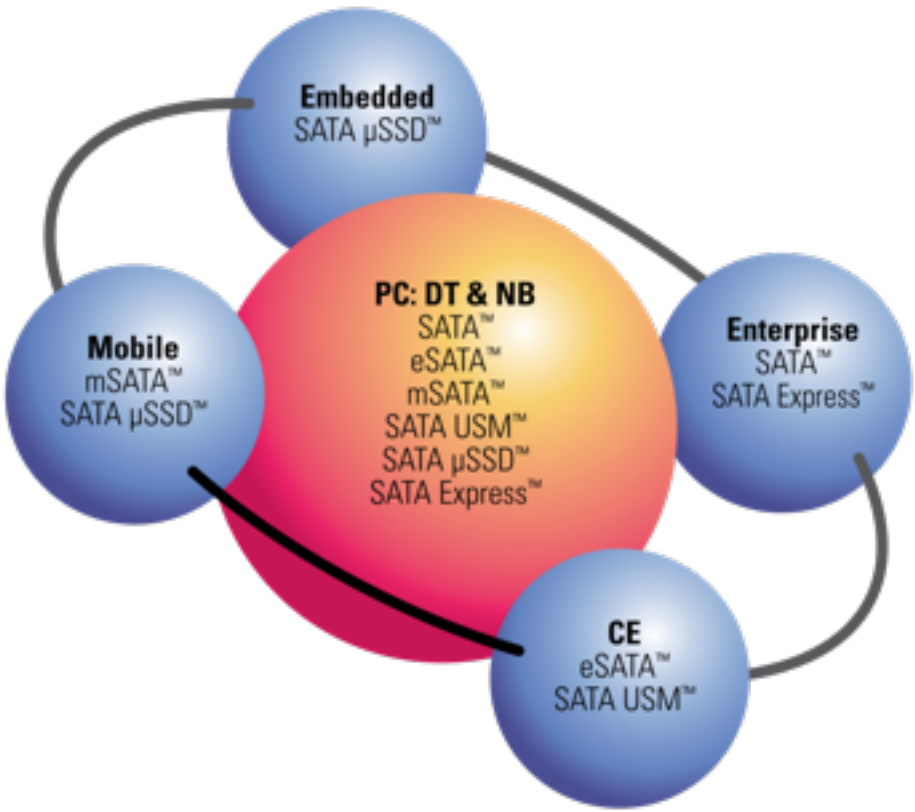
Evolving SATA for High-Speed Storage

Paul Wassenberg
SATA-IO Marketing Chair

SATA is Everywhere

SATA is the de facto standard for PC storage

Since its introduction, SATA has evolved into new application spaces and now provides storage interface solutions for HDDs, ODDs, SSDs, and Hybrid HDDs in client, mobile, enterprise, CE, and embedded storage markets



A Need for Speed

Today, most applications are well-served by SATA 6Gb/s and will be for the foreseeable future

However, some client SSDs and Hybrid HDDs (HHDD) will soon require greater speeds than those enabled by the current generation of SATA

SATA-IO is developing SATA Express which utilizes PCI Express® (PCIe®) as the physical interface

Why SATA Express?

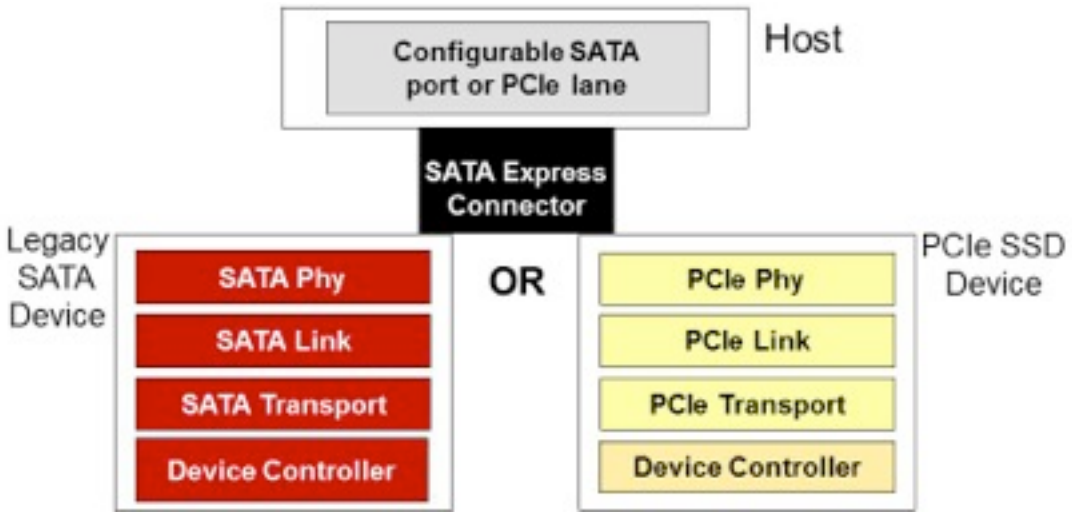
- Some client SSDs & HHDDs will soon require more than 6Gb/s
  - 12Gb/s SATA would take too long; PCIe is here now
- With the next speed increase, the client storage infrastructure has to change in any case
  - Whether 12Gb/s or PCIe
- SATA Express must be low cost
  - 6Gb/s SATA will be more than adequate for HDDs for the foreseeable future
  - Portion of client SSDs that will require greater than 6Gb/s is fairly small
  - Difficult for 12Gb/s to achieve low cost within a reasonable timeframe – PCIe is already widely used

What is SATA Express?

- Client storage with a PCIe interface, utilizing SATA Express connectors
- Provides up to 8Gb/s and 16Gb/s
  - One lane or two lanes of PCIe Gen 3, 2 or 1
- Defines new device and host connectors to support both new SATA Express and current SATA devices

SATA Express Connectivity

- The SATA Express host connector can mate with a SATA Express device or a SATA device
  - A signal driven by the device tells the host whether it is connected to a SATA Express or a SATA device



- A SATA Express device can also mate with the SFF-8639 connector for enterprise applications

SATA Express Software Architecture

- Although not defined by the specification, there are two choices for register interface / command set:

1. AHCI, which is used for SATA, would enable a SATA Express device to be compatible with SATA software environments
   - AHCI is supported in most major O/Ses
   - But AHCI is not optimized for SSD performance
2. NVM Express is architected for high performance SSDs
   - But NVMe does not provide SATA software compatibility
   - Drivers for Windows, Linux, and VMWare are available at

Next Steps and Timeline

- SATA Express is currently under development within SATA-IO
- Completed specification expected by late 2012

- In the meantime, SATA-IO will continue to optimize the existing SATA infrastructure for a wide variety of applications
- SATA will continue to be the mainstream storage interface for the foreseeable future

For More Information…

- Go to the SATA Express page on the SATA-IO site www.sata-io.org/technology/sataexpress.asp
- Check out the NVM Express site at www.nvmexpress.org
- Download the SFF-8639 connector specification at ftp://ftp.seagate.com/sff/SFF-8639.PDF

Panelist Mark Meyers, Intel

Speaker Name	Company Title	Introductory Bio
Andrew Ku	**Intel**	Mark is a Server Platform Architect working in Intel's Datacenter and Connected System group. Mark is technical chair of the Enterprise SSD Form Factor WG which includes definition of proposed SFF-8639 connector. Mark has been at Intel for 12 years in various server and IO architecture projects.

PCIe SSD 2.5” Form Factor

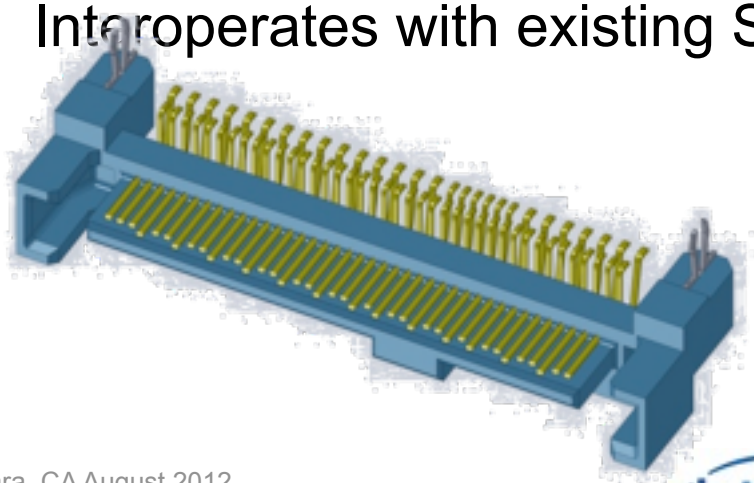
Mark Myers
Datacenter Platform Architect
Intel

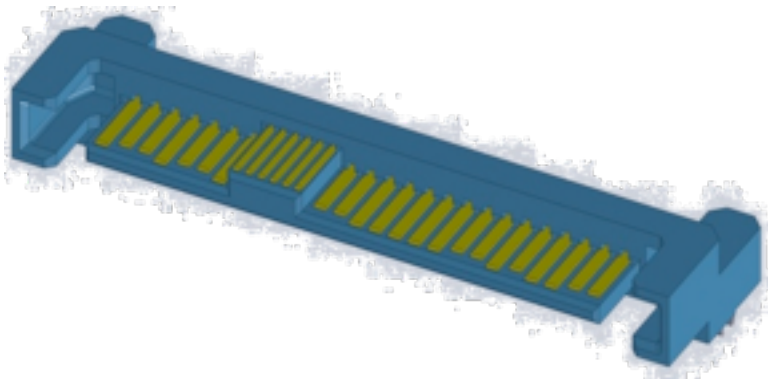
Some Notes about this template

- **PCIe value**
  - Industry standard, high BW, multilane, low latency
  - Flexible attach models, discoverable, and supports many form factors
    → Our work adds a classic 2.5” disk form factor
- **PCIe for high performance; Coexisting with many other**
  - Hard Disks stay on SATA/SAS for long time
  - High performance SSD will 1st to move to PCIe
    - higher BW & low latency
  - PCIe supports multiple device types:
    - NVM-Express, SOP, proprietary, expect interface models to evolve as devices improve
    - Many form factors: Client’s NGFF, 2.5” drives, PCIe Cards

Enterprise SSD Form Factor WG Status

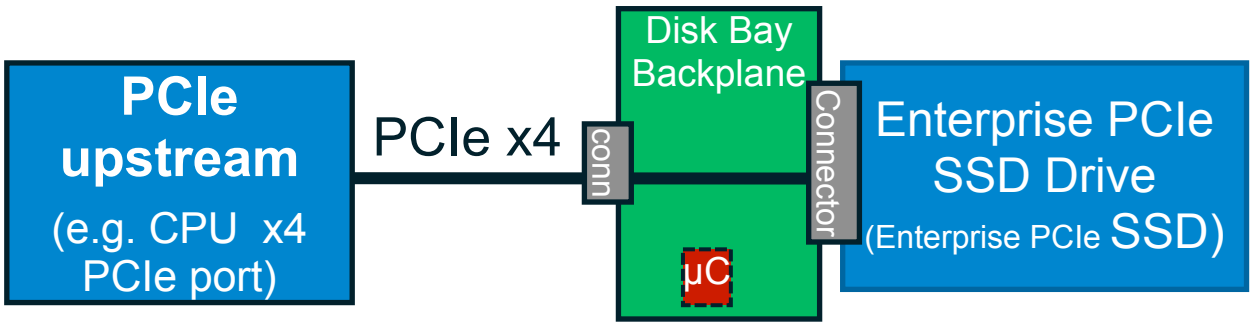
- Defined usages and requirement and connector
  - 5 promoters; >50 contributor companies
- Rev 1.0 Specification Approved http://www.ssdformfactor.org/
  - Mechanical piece is SFF-8639 ftp://ftp.seagate.com/sff/SFF-8639.PDF
- Extends SAS connector with pins all across both sides
  - Interoperates with existing SATA/SAS connector



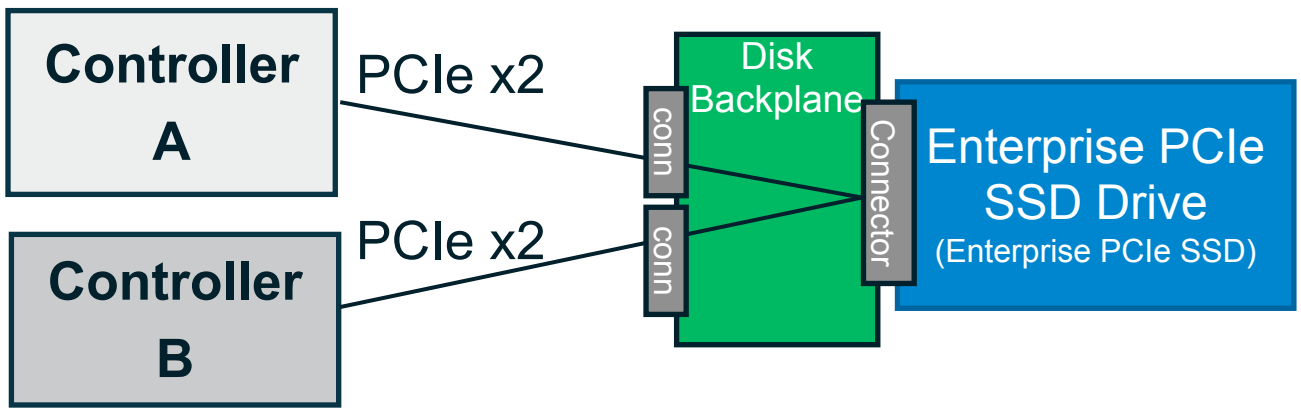


Common Usages: Server x4, Dual Port for Storage

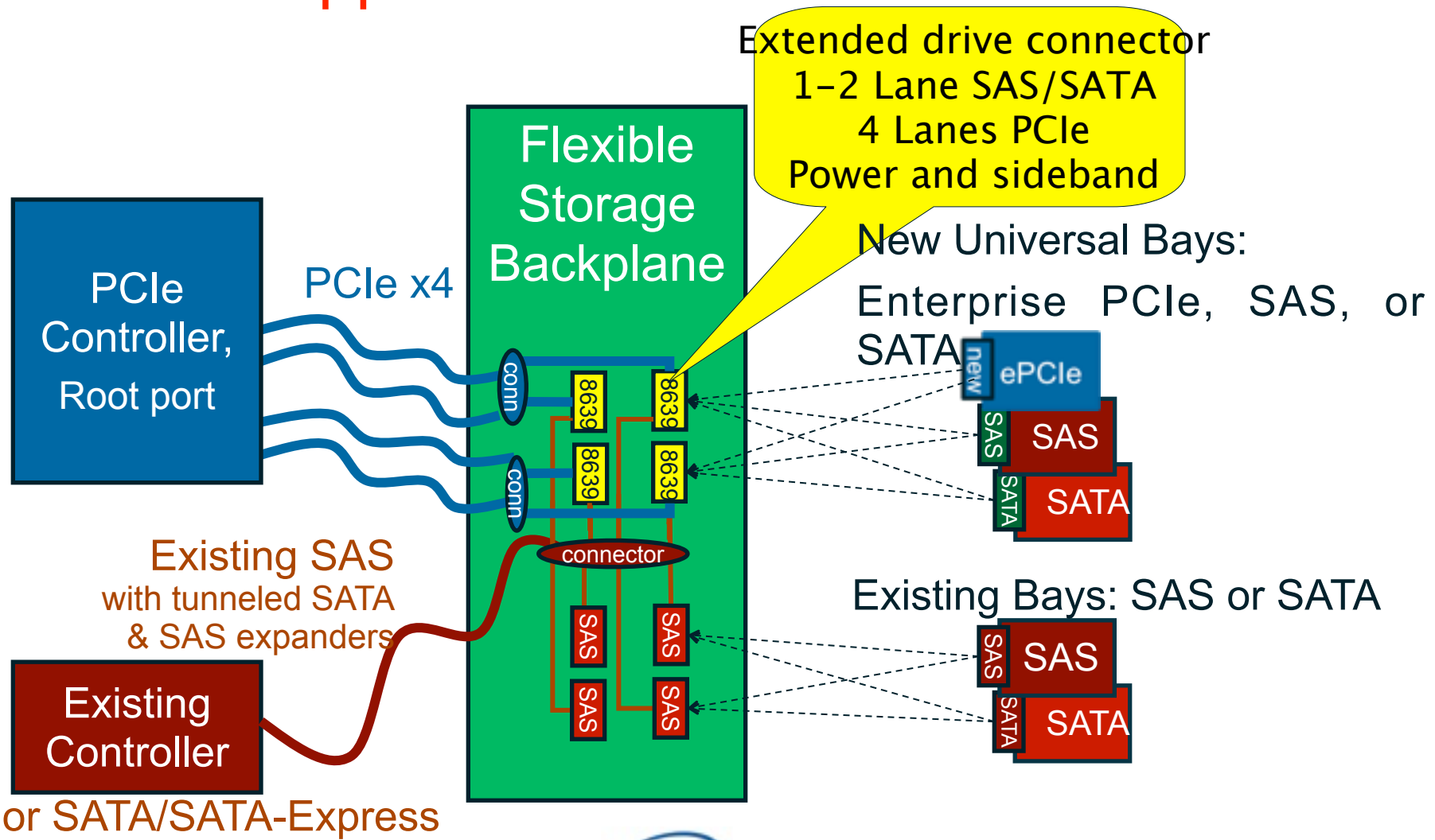
Typical Server configuration



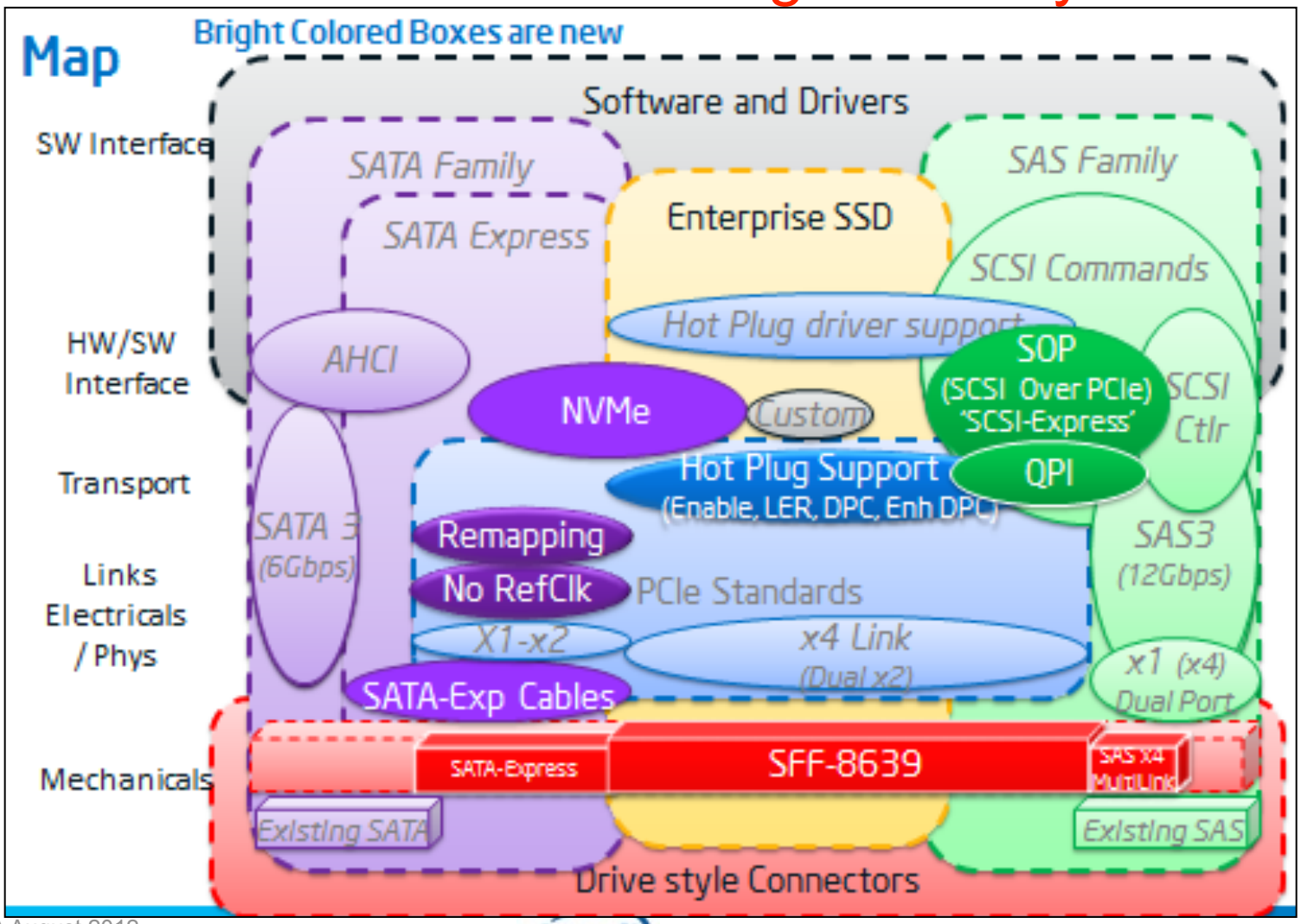
Typical High Availability Storage configuration



Flexible Backplane Supports PCIe and SAS/SATA



Layered and Completing Standards
- Common in the Storage industry



Conclusion

- Enterprise PCIe SSD Form Factor Specification
  - PCIe 2.5” drives are in the market
- 2.5” supports Flexible Storage Backplanes
  - High Performance Enterprise x4 PCIe SSDs
  - Existing SAS/SATA drives
  - Emerging SATA-Express and x4 SAS
- Many Standards, provide choices and innovation opportunities

Panelist Marty Czekalski, Seagate

Speaker Name	Company Title	Introductory Bio
Marty Czekalski	**Seagate**	Marty Czekalski brings over thirty years of senior engineering management experience in advanced architecture development for Storage and IO subsystem design, ASIC, and Solid State Storage Systems. He is currently Sr. Staff Program Manager within Seagate's Strategic

SCSI Trade Association

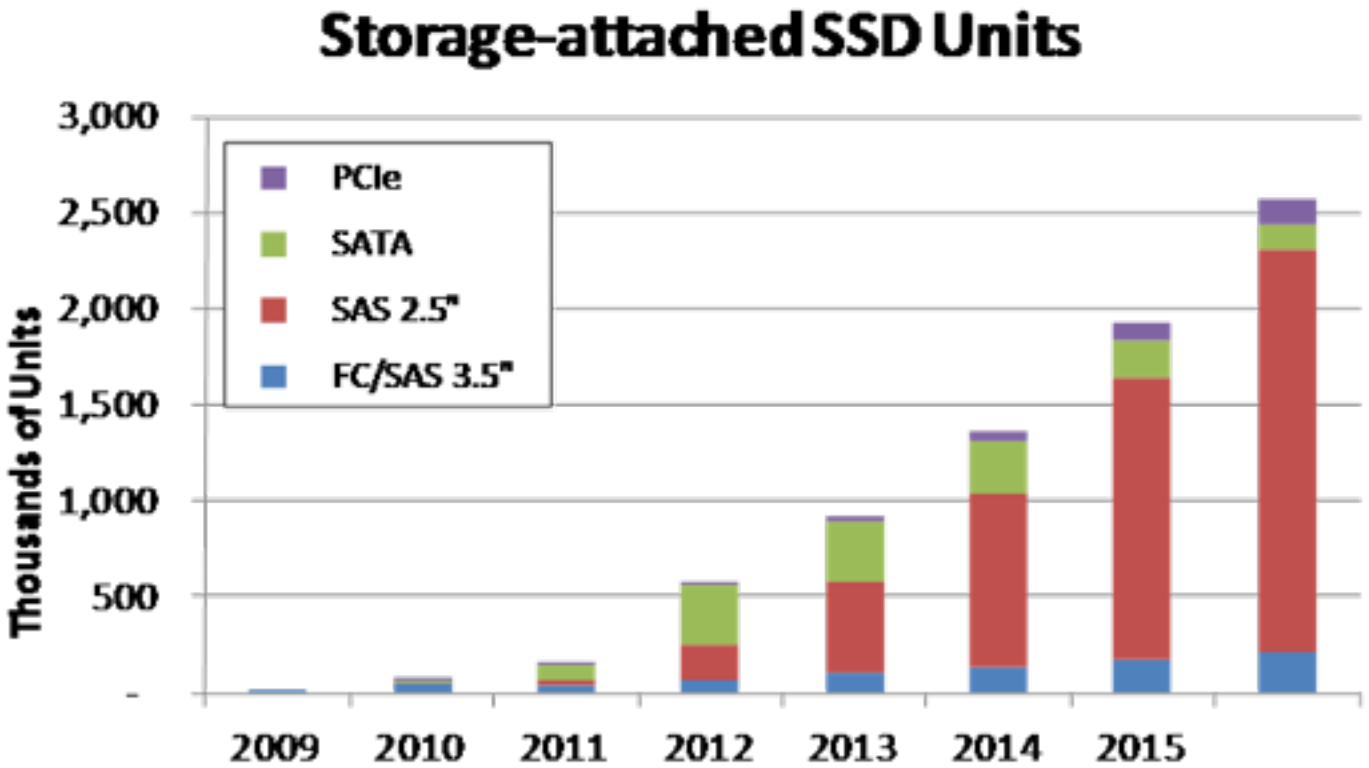
Extending the SCSI Platform of Innovation

SCSI EXPRESS

Santa Clara, CA August 2012

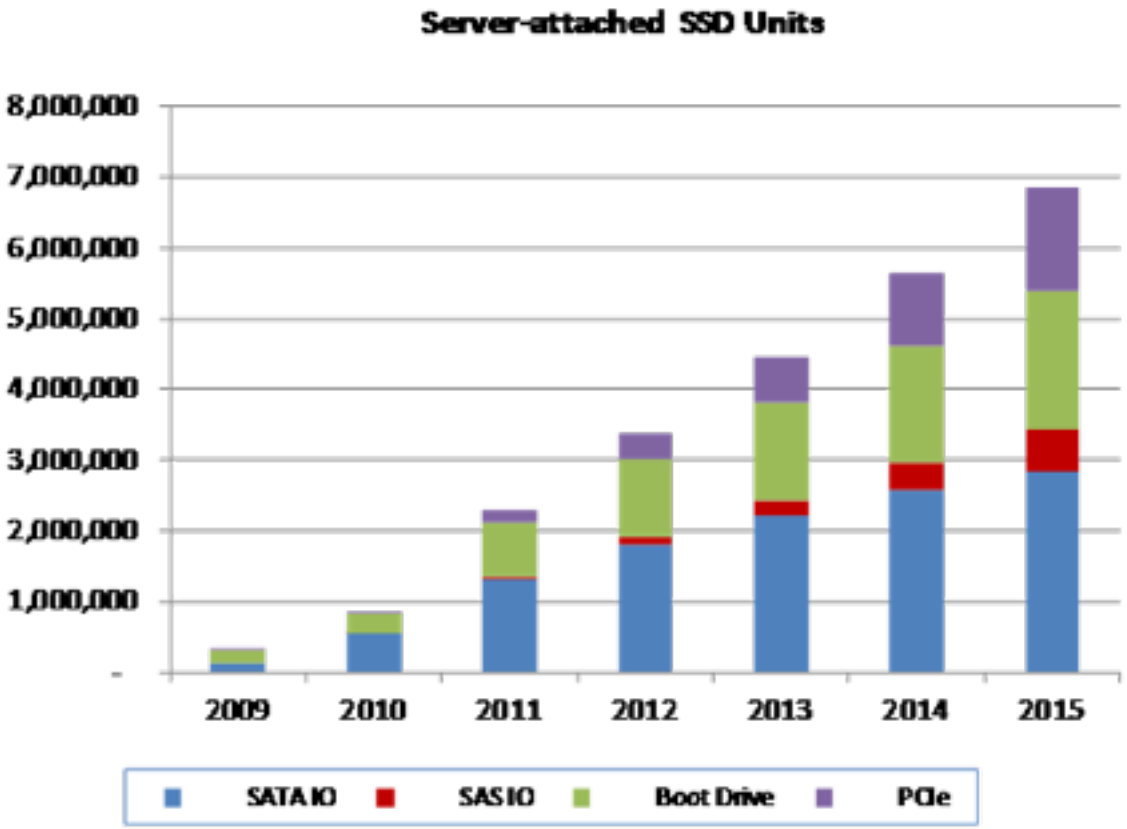
SAS is the preferred SSD Interface for Storage Systems

SCSI Trade Association



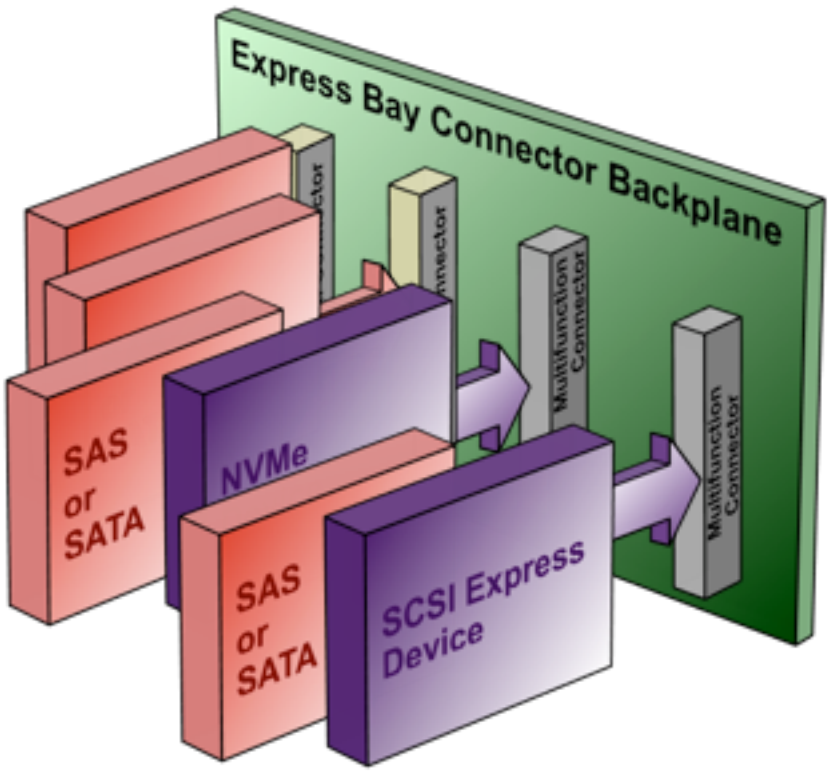
Forward-Insights 11-2011

Server Attached SSDs



Forward-Insights 11-2011

Express Bay



Express Bay

- Up to 25 Watts
- SFF-8639 connector
- PCI-SIG electrical specification

Objectives

- Preserve the enterprise storage experience for PCI Express storage
- Meet SSD performance demands
- Serviceable, hot-pluggable Express Bay opens up new possibilities…

SCSI Express Overview

SCSI Trade Association

Proven SCSI protocol combined with PCIe creating an industry standard path to PCIe-based storage

- Enterprise storage for PCIe based storage devices
- Increased performance through lower latency
- Coexistence with SAS via Express Bay and common command set
- Unified management and programming interface

STA Member Companies

ACARD Amphenol ATTO BizLink DELL FCI FOXCONN Fujikura FUSION-IO HGST hp intel JDSU LeCroy LSI MARVELL MAXIM molex NetApp PMC SanDisk Seagate SerialTek TE connectivity TOSHIBA Volex WD Western Digital xyratex

SCSI Express Components

SCSI Trade Association

Existing industry initiatives delivering enterprise storage using PCI Express

Technology	Description
SCSI	The storage command set
SCSI Over PCIe (SOP)	Packages SCSI for a PQI queuing layer
PCIe Queuing Interface (PQI)	Flexible, high-performance queuing layer
Express Bay connector (SFF 8639)	Accommodates PCIe, SAS, and SATA drives
PCI Express	Leading server I/O interconnect

SCSI/SAS – Looking to the Future

SCSI Trade Association

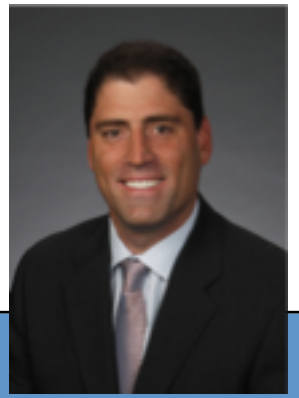
- 12Gb/s, 24Gb/s SAS
- Extended Copy Feature
- Power Limit Control - up to 25W SAS devices
- Atomic Writes
- Hinting & other NVM features
- SCSI Express (SOP/PQI spec out for letter ballot)

So where do we go from here?

SCSI Trade Association

- SAS controllers > 1 Million IOPS and increased power for SAS drives diminish PCIe SSD differentiation
  - Standardized SAS solutions exist today and will continue to be deployed
  - Increased power in Express Bays allow SAS devices to achieve similar performance levels to PCIe devices
- PCIe SSD Storage Call to Action
  - Once the PCIe capable bays are available, any PCIe device can be packaged in a 2.5” FF and used, in as long as a driver exists.
    - SCSI Express, NVMe, proprietary, non-storage devices, etc.
  - Interoperability – Electrical spec for SFF-8639 (Express Bay) started
    - Compliance tests
  - Hot plug – work underway (DPC and enhanced DPC)
- New form factors will emerge
  - How will they effect the market?

Panelist Don Jeanette, Toshiba



Speaker Name	Company Title	Introductory Bio
Don Jeanette	**Director, Product Marketing Toshiba America Electroni**	Don Jeanette is Toshiba's Director of Product Marketing. He is responsible for Storage Products Marketing and New Business Development for Toshiba's Hard Disk Drives and Solid State Drives. He brings to the

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ELECTRONIC COMPONENTS

Flash Memory Summit

Toshiba America Electronic Components, Inc.
Storage Products Business Unit

August 2012

Toshiba Storage – 44 Years Of Innovation

1967 Start

1980

1990

1992

1994

1996

1998

2000

2002

2004

2006

2008

2010

2011

2012

No.1 Glass Substrate Media

No.1 GMR Head Technology

No.1 0.85 type HDD

No.1 2.5” Automotive HDDs

No.1 Perpendicular Recording

No.1 1.8” HDDs Ignited the digital music revolution

No.1 Wipe Technology

No.1 19nm NAND-based SSD

- Innovation partner with customers.
  - Automotive HDDs enable enriched GPS and entertainment systems
  - 1.8” HDDs inspired customers to enable the digital music revolution
- Leading Storage Innovation
  - Pioneered advancing areal density through the first commercialized PMR technology
  - Pioneering Wipe technology to improve security
  - Celebrating the 25th birthday of our invention NAND flash

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PCIe Love and Stuff That Has To Happen

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Image Source: http://www.ibm.com/developerworks/rational/library/4620.html

PCIe Love and Stuff That Has To Happen

- Hottest issues in SSD

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Image Source: http://www.ibm.com/developerworks/rational/library/4620.html

PCIe Love and Stuff That Has To Happen

- Hottest issues in SSD
  - Performance

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PCIe Love and Stuff That Has To Happen

- Hottest issues in SSD
  - Performance
  - Cost

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Image Source: http://www.ibm.com/developerworks/rational/library/4620.html

PCIe Love and Stuff That Has To Happen

- Hottest issues in SSD
  - Performance
  - Cost
  - Reliability

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PCIe Love and Stuff That Has To Happen

- Hottest issues in SSD
  - Performance
  - Cost
  - Reliability
  - NAND management

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Image Source: http://www.ibm.com/developerworks/rational/library/4620.html

PCIe Love and Stuff That Has To Happen

- Hottest issues in SSD
  - Performance
  - Cost
  - Reliability
  - NAND management
  - Retention

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Image Source: http://www.ibm.com/developerworks/rational/library/4620.html

PCIe Love and Stuff That Has To Happen

- Hottest issues in SSD
  - Performance
  - Cost
  - Reliability
  - NAND management
  - Retention
- PCIe - Why we love it
  - Least amount of latency!
  - High bandwidth!
  - Maximum performance between the host and the SSD!

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PCIe Love and Stuff That Has To Happen

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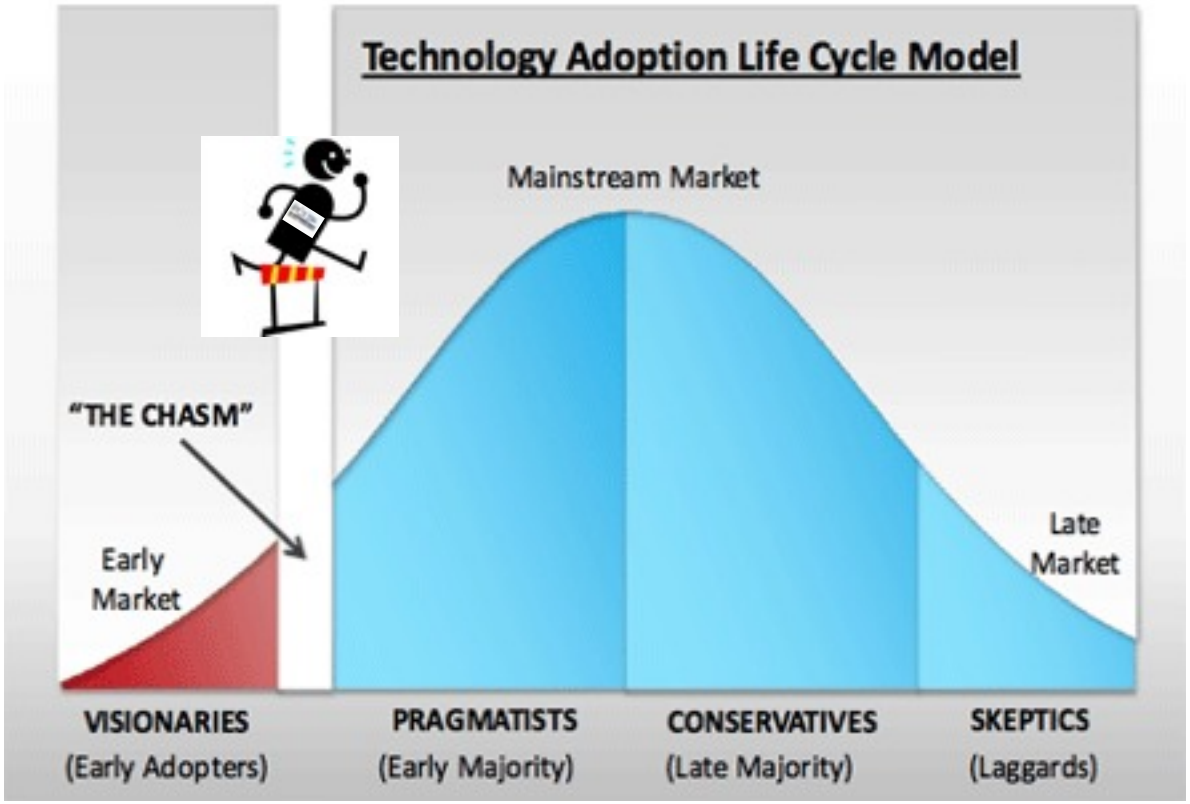
- PCIe - Why we love it
  - Least amount of latency!
  - High bandwidth!
  - Maximum performance between the host and the SSD!
- Today… internet data centers… tomorrow the World!
  - But hold on… not so fast…..

Image Source: http://www.ibm.com/developerworks/rational/library/4620.html

Crossing the Chasm – What Will It Take?



Geoffrey Moore

- What will it take?
  - Unified standards
  - Driver, OS and software development
  - Hot pluggability
  - Physical access to PCIe SSD
  - Familiarity with technology
  - Acceptance of technology
  - Continuity of supply
- And Remember….
  - Other offerings may be 'good enough'

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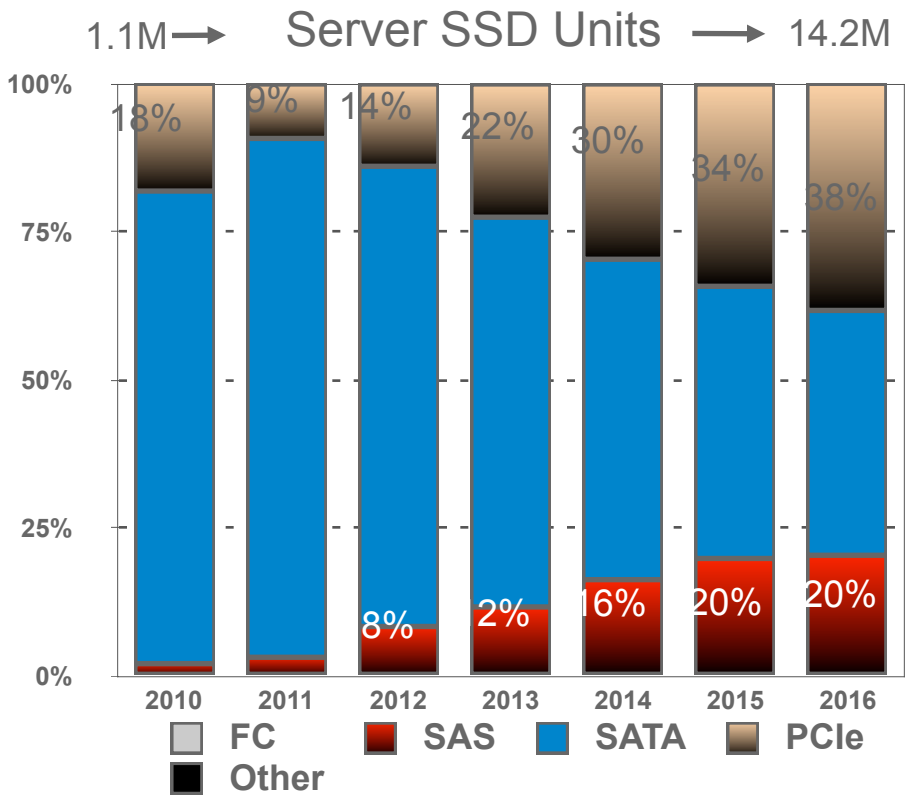
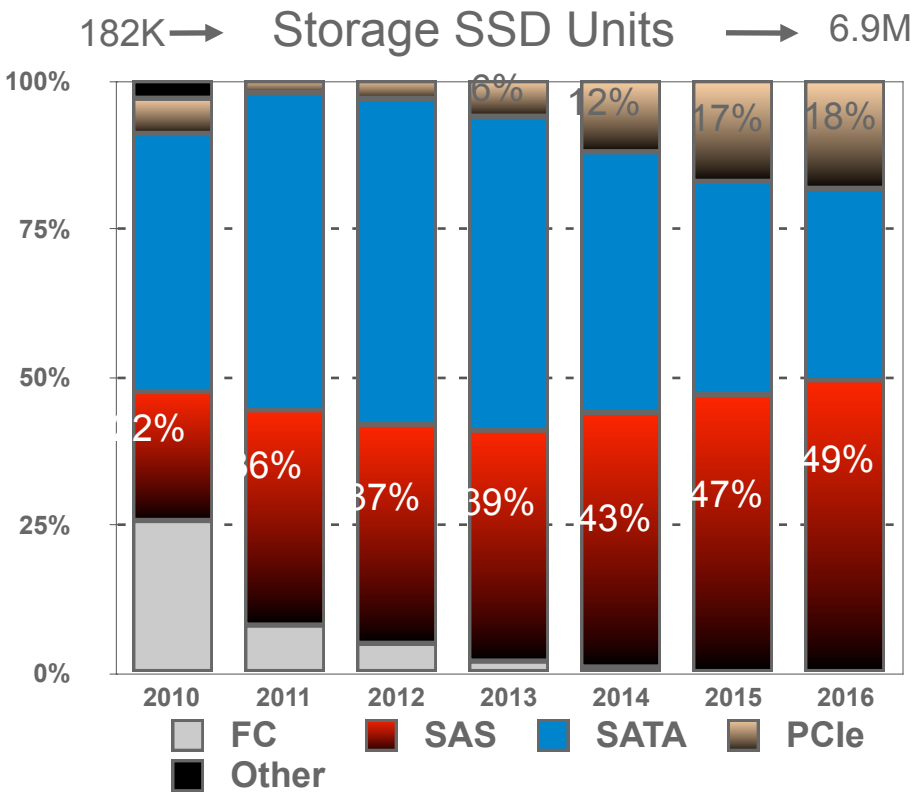
Image source: http://www.dshen.com/blogs/business/archives/when_an_investment_thesis_moves_beyond_you.shtmlI

Evolution of Enterprise Grade SSD Units by Interface





- PCIe steady adoption reaches >1M units in 2013; 31% of Total Enterprise Shipments in 2016
- SATA dominates Total Enterprise shipments with 7.7M units in 2015 with SAS at 6.0M units

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Source: Gartner June 2012 "Q2 '12 NAND: Sinking Before Upwelling

TOSHIBA


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Panelist Tony Rogue, Toshiba

Speaker Name	Company Title	Introductory Bio
Tony Rogue	**Virident**	Tony Rogue

VIRIDENT

SNIA PCIe Roundtable
Flash Memory Summit 2012

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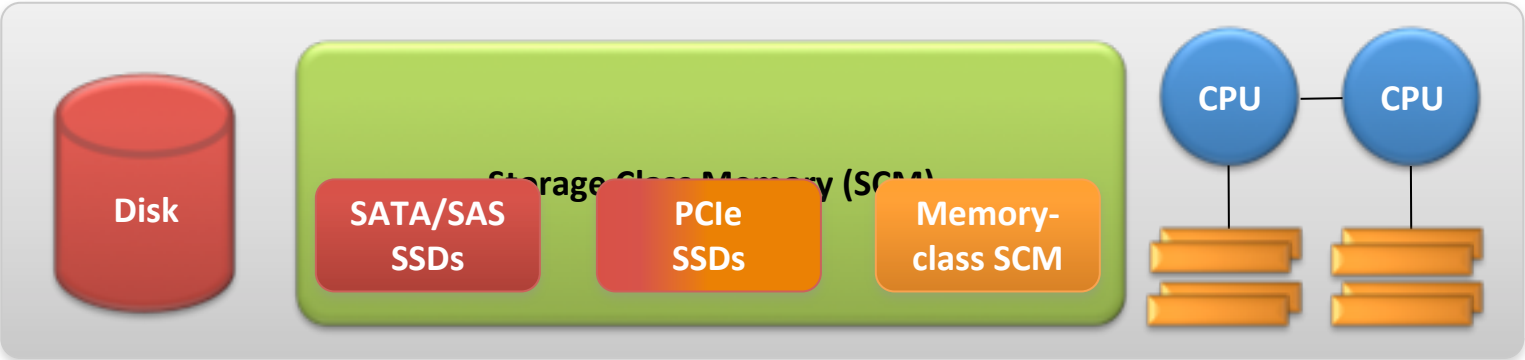
Storage Class Memory (SCM) in Datacenter
New Layer In Storage Hierarchy



PCIe SSDs established, Memory-class emerging

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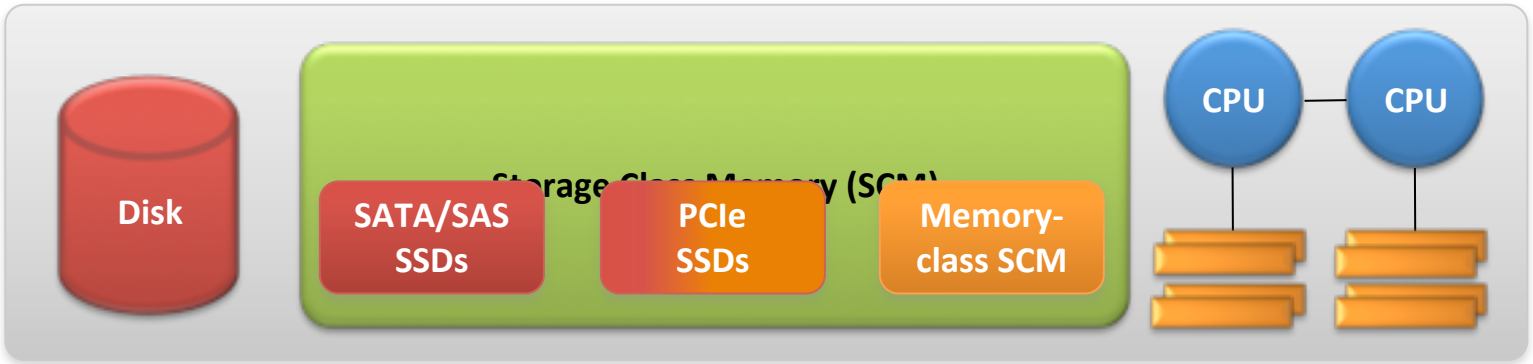
Storage Class Memory (SCM) in Datacenter
New Layer In Storage Hierarchy



Attribute	Disk	SATA/SAS SSDs	PCIe SSD	*Memory-class* SCM	DRAM
Capacity (GB)	100's - 1000's	100's	100's – 1000's	100's-1000's	10's-100's
Read performance	10's ms, ~100 MB/s	100's us, ~100's MB/s	10's us, 1's GB/s	100's ns, 1's GB/s	~100 ns, 10's GB/s
Write performance	10's ms ~100 MB/s	100's us ~100 MB/s	~10's us, ~1's GB/s	1's us, 1's GB/s	

PCIe SSDs established, Memory-class emerging

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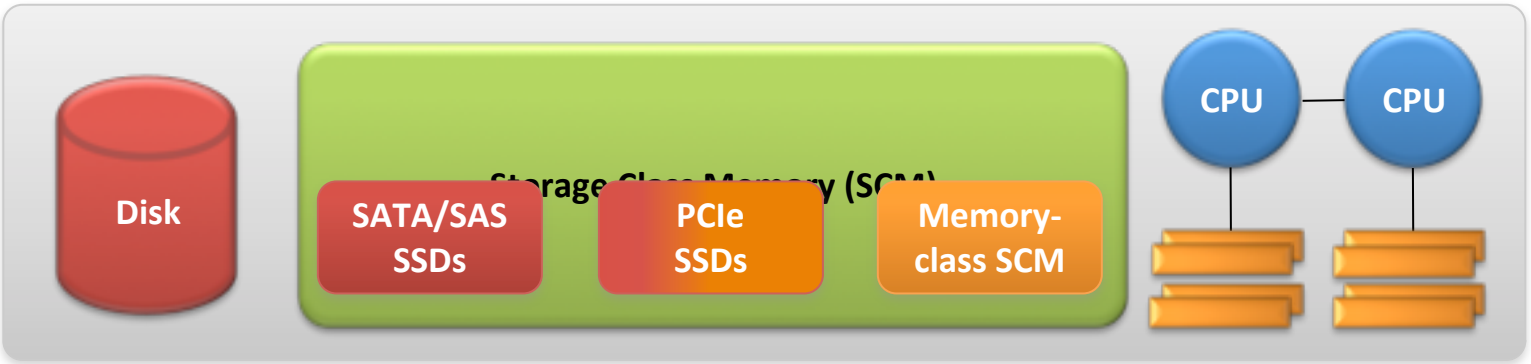

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Write performance	10's ms ~100 MB/s	100's us ~100 MB/s	~10's us, ~1's GB/s	1's us, 1's GB/s	

PCIe SSDs established, Memory-class emerging

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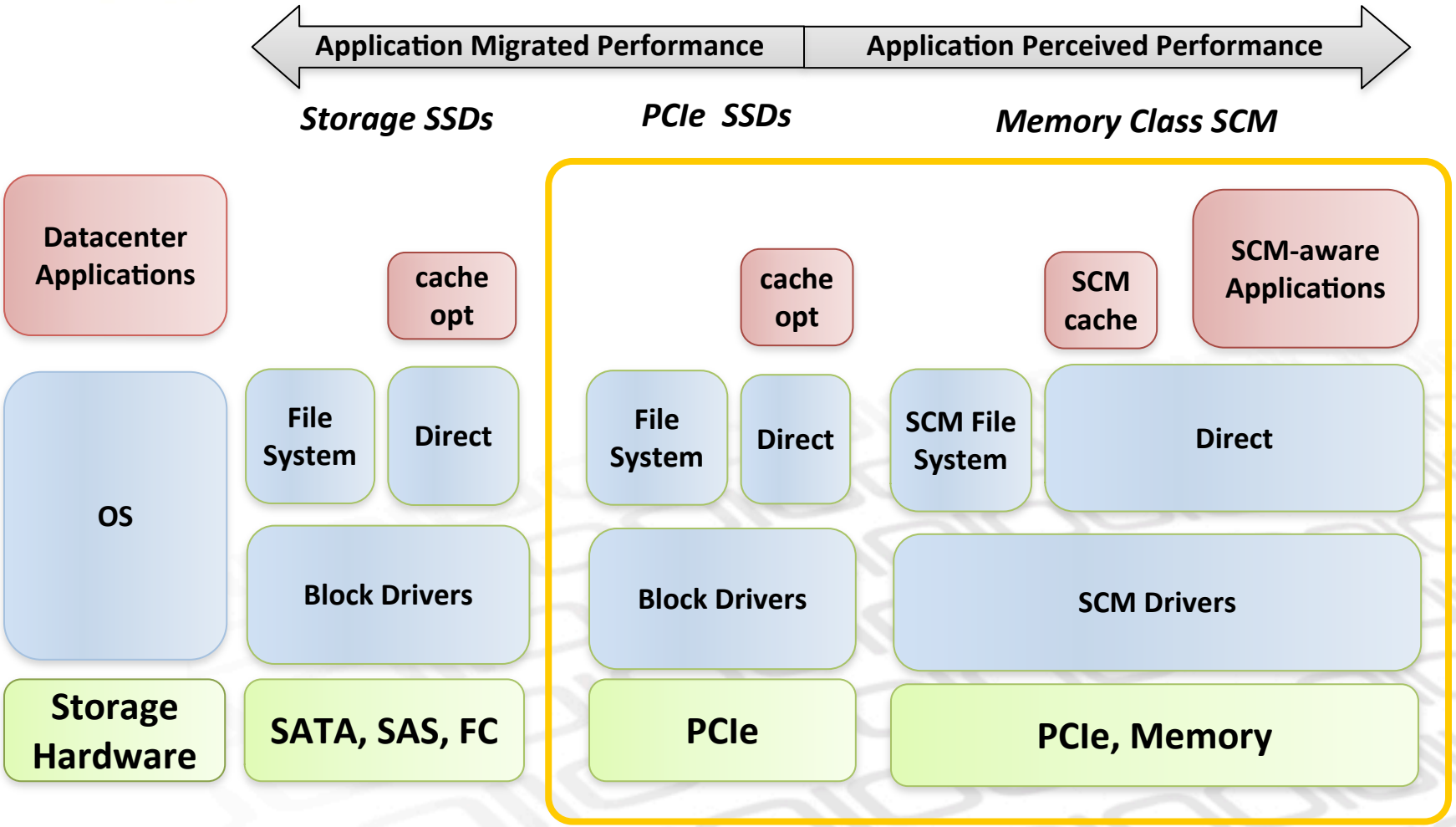
Storage Class Memory (SCM) in Datacenter:
From Block Applications to SCM Applications



Optimization required for applications to realize memory class benefit

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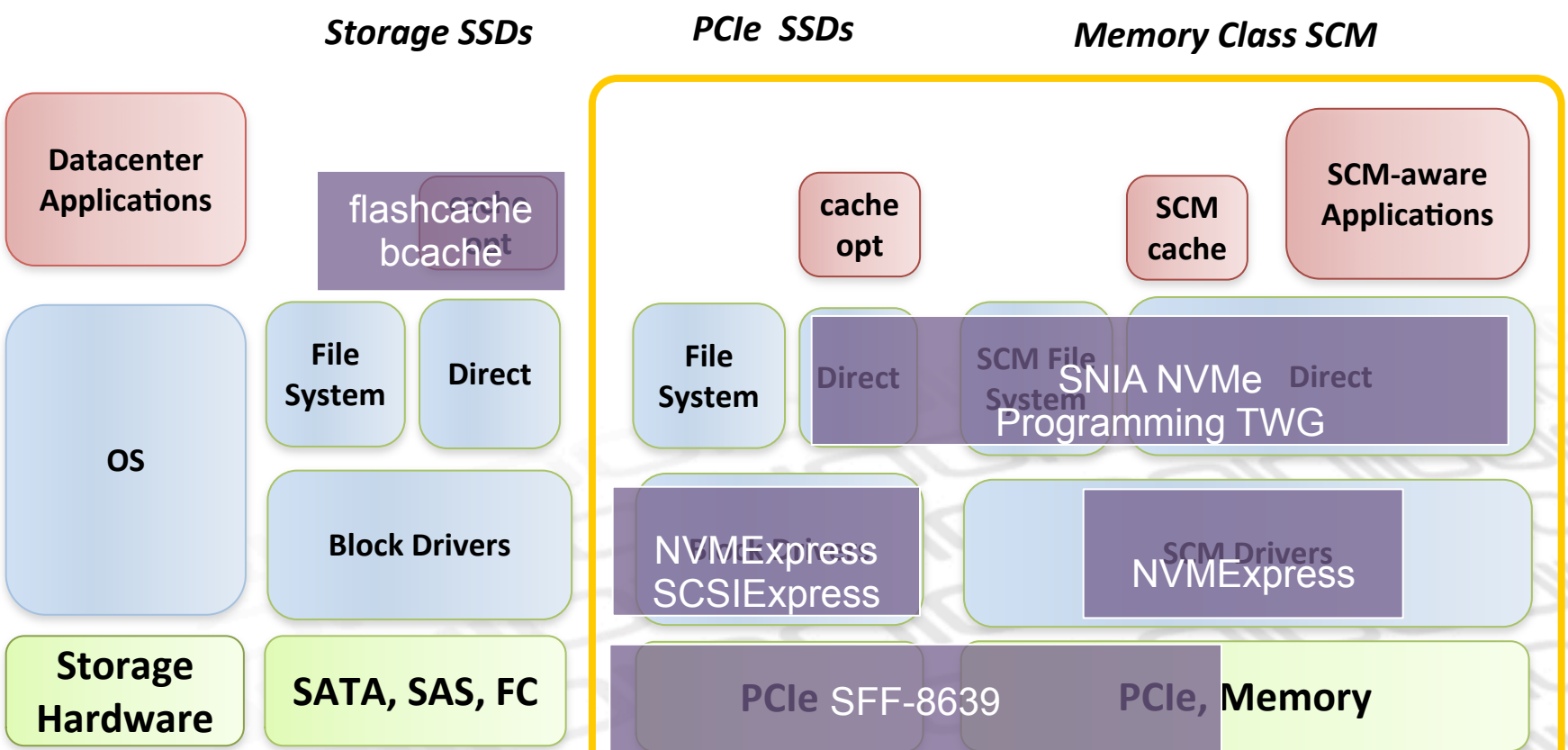
Storage Class Memory (SCM) in Datacenter:
An industry activity mapping…



Industry agreement for optimized architecture in place

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Thank you!

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Questions for Q & A

Questions:

1. **Please explain the roles of NVM and SOP/PQI – will SOP/PQI play on NVM? What is the future of the inter relationships of these, and other, specs?**
2. **What issues do you see needing to be solved before PCIe becomes a standard mass storage bus? Please comment on hot plugging, scatter gather, heat and performance and other issues.**
3. **What are some of the key issues facing test & qualification of PCIe Storage?**
4. **Please comment on the pros/cons of adding a Flash Translation Layer and its future impact to current system design architecture and performance.**
5. **PCIe SSDs already produce prodigious throughput which is usually measured in GB/s, and IOPs on the order of hundreds of thousands. With the advent of PCIe Gen3, that may double. How does one get all that performance to move outside of the system that houses the SSD and into the system requesting the data?**

Thank You Very Much!