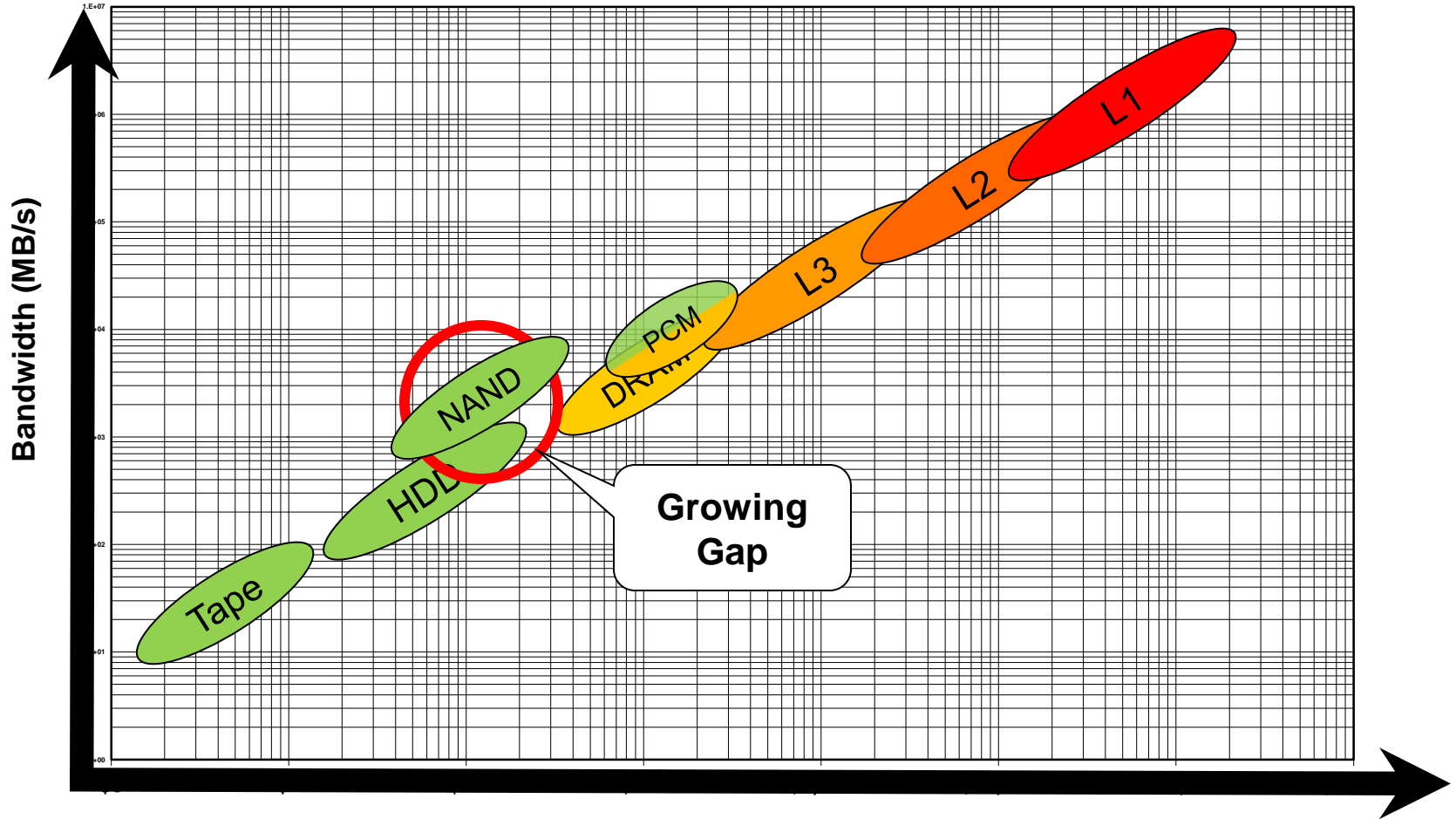# Flash Uses in High-Performance Platforms

Jim Cooke JCooke@Micron.com

Sr. Manager, Enterprise Storage Segment

Micron Technologies

The DRAM / HDD Speed Gap
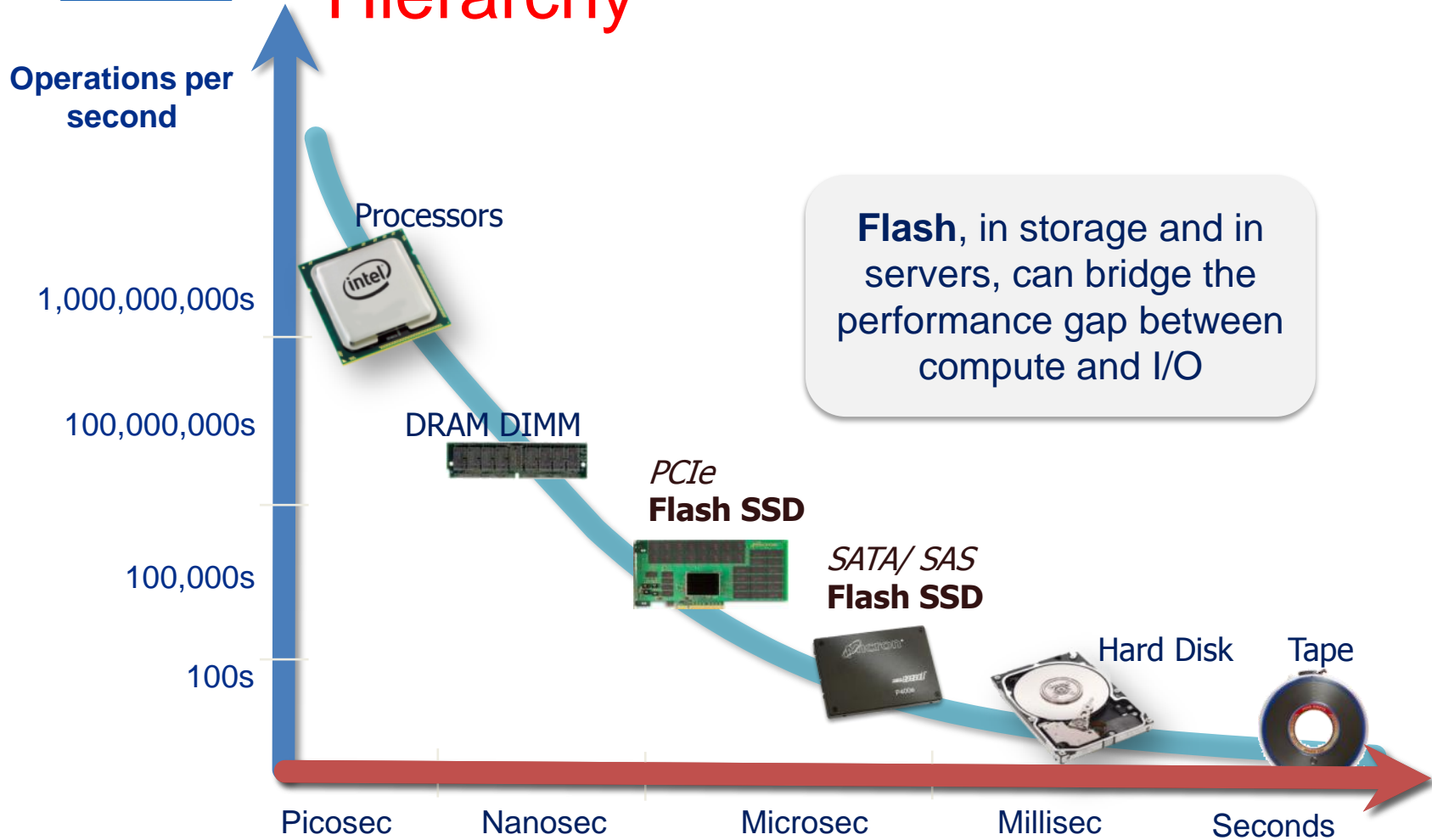

Source: Objective Analysis
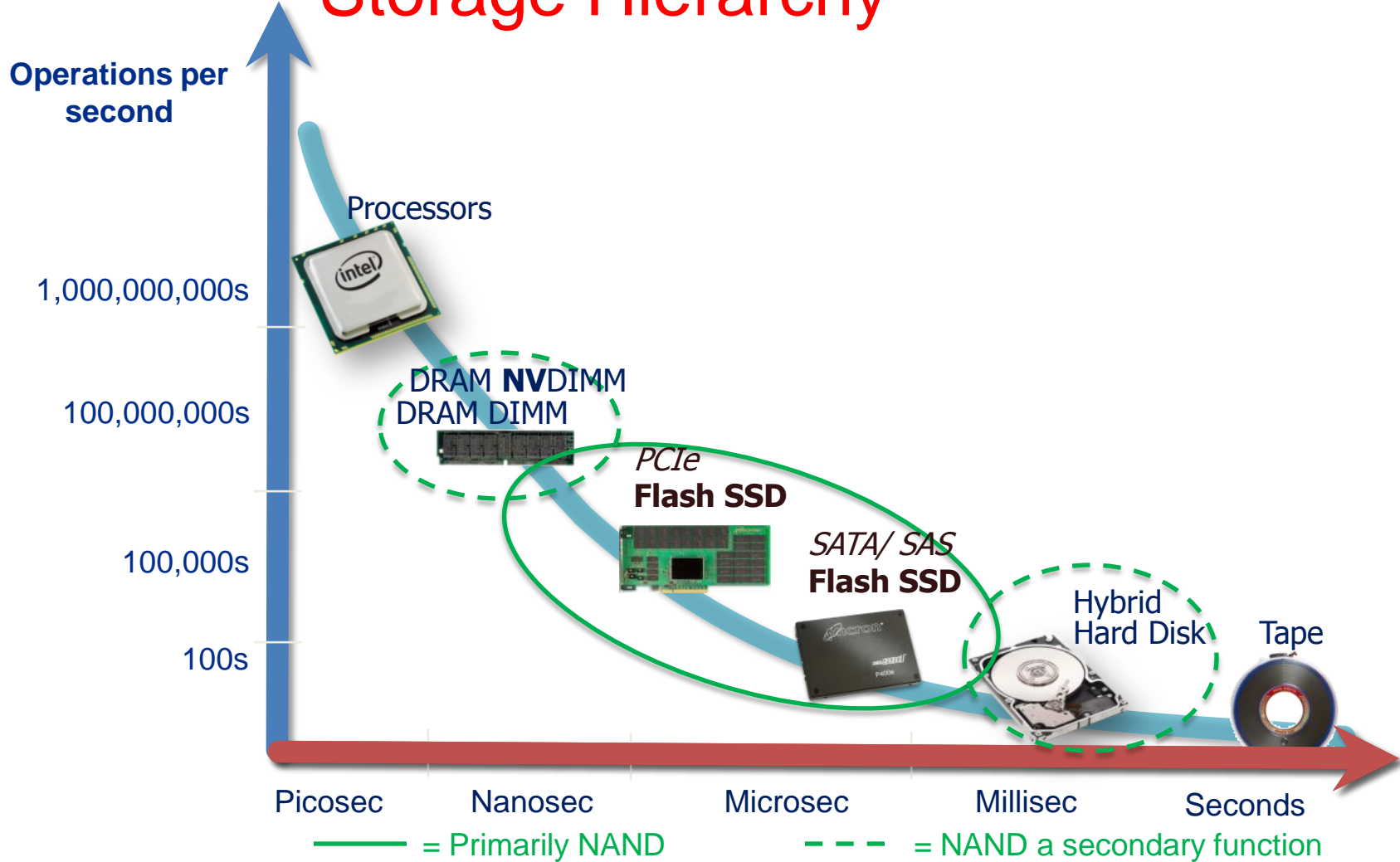
Evolving CPU / Memory / Storage Hierarchy

Operations per second

Processors

1,000,000,000s

100,000,000s

DRAM DIMM

PCIe
Flash SSD

100,000s

SATA/ SAS
Flash SSD

Hard Disk   Tape

100s

Picosec   Nanosec   Microsec   Millisec   Seconds

Flash, in storage and in servers, can bridge the performance gap between compute and I/O

NAND Uses in the Memory / Storage Hierarchy

Operations per second

Processors

1,000,000,000s

DRAM **NV**DIMM
DRAM DIMM

100,000,000s

PCIe
Flash SSD

SATA/ SAS
Flash SSD

100,000s

Hybrid Hard Disk

Tape

100s

Picosec   Nanosec   Microsec   Millisec   Seconds

—— = Primarily NAND   - - - = NAND a secondary function

Flash Memory Summit 2012
Santa Clara, CA

4

Some Examples

maxCache **adaptec**

Before: 6 x 300GB of 10k SAS HDDs

# Drives	Cost	IOPS	Power	IOPS/W	$/IOPS
6	$3,114	1,500	48W	31.25	$2.08

After: SSD Caching with 3 x 750GB SATA HDDs & 1 x 50GB SSD

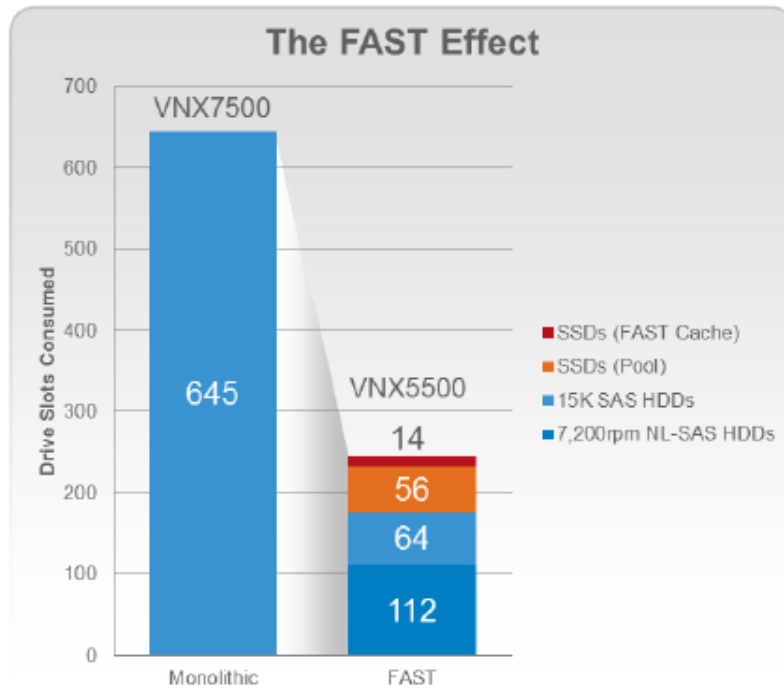| # Drives	Cost	IOPS	Power	IOPS/W	$/IOPS
4	$2,000	10,200	17.5W	583	$0.21
↓ 33%	↓ 29%	↑ 580%	↓ 64%	↑1,765%	↓ 90%

5.8x increase in IOPS & 17x IOPS per Watt
64% lower power & 33% less drives
30% lower hardware cost & 90% lower $/IOPS

Green IT & Data Center Efficiency to Drive Enterprise Flash Adoption

Source: PMC Sierra

The FAST Effect — Increased Storage Efficiency: 100 TB Usable Capacity Example

- 645 X 600GB 15K
- Replaced by 246 drives in a 6/10/84 blend:
  - 70 X 200GB SSDs
  - 64 X 600 GB 15K HDDs
  - 112 X 2TB NL-HDDs
- Smaller frame needed
  - 62% smaller footprint
  - 75% less power
  - 27% lower acquisition cost

Source: Denis Vilfort, EMC, FMS2011

What is most important to you?

	Hard Disk Drives (HDD)	Solid State Disks (SSD)
Density	✅	
Reliability		✅
Performance		✅
Lower Power		✅

SSDs far exceed HDDs in Reliability, Performance, and Power

New Value Metric – $$ per IOP

How much real performance do I get for my money?

HDD Enterprise	SSD Enterprise	HDD Client	SSD Client
~ $400	~ $500	~ $80	~ $400
~150 IOPs	~9,500 IOPs	~120 IOPs	~2600 IOPs
$2.66 / IOP	$0.05 / IOP	$.65 / IOP	$0.15 / IOP

53X

4X

~ = based on an average of several drives currently available

New Value Metric – IOPs per Watt

How much real performance do I get for electricity used?

HDD Enterprise
~ 150 IOPs
~ 16.5 Watts
9 IOPs / Watt

SSD Enterprise
~ 9500 IOPs
~ 7 Watts
1357 IOPs / Watt

150X

HDD Client
~ 120 IOPs
~ 9.3 Watts
13 IOPs / Watt

SSD Client
~ 2600 IOPs
~ 3 Watts
866 IOPs / Watt

66x

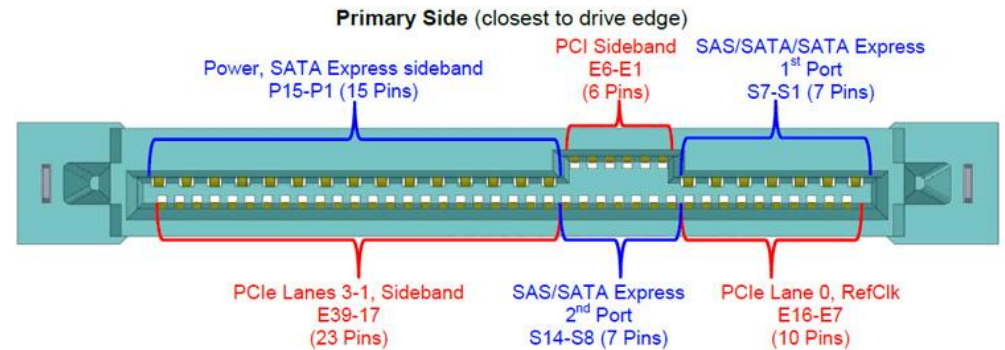~ = based on an average of several drives currently available

2.5" PCIe Form Factor

All the performance of PCIe with the serviceability standards of SATA/SAS

SSD Small Form Factor Working Group: 2.5" PCIe Focus

- Hot plug
- External access
- Combo connector
- PCIe performance
- Common SFF 15mm form factor
- Combo connector ([SFF-8639](#))

Primary Side (closest to drive edge)

Power, SATA Express sideband P15-P1 (15 Pins)
PCI Sideband E6-E1 (6 Pins)
SAS/SATA/SATA Express 1st Port S7-S1 (7 Pins)
PCIe Lanes 3-1, Sideband E39-17 (23 Pins)
SAS/SATA Express 2nd Port S14-S8 (7 Pins)
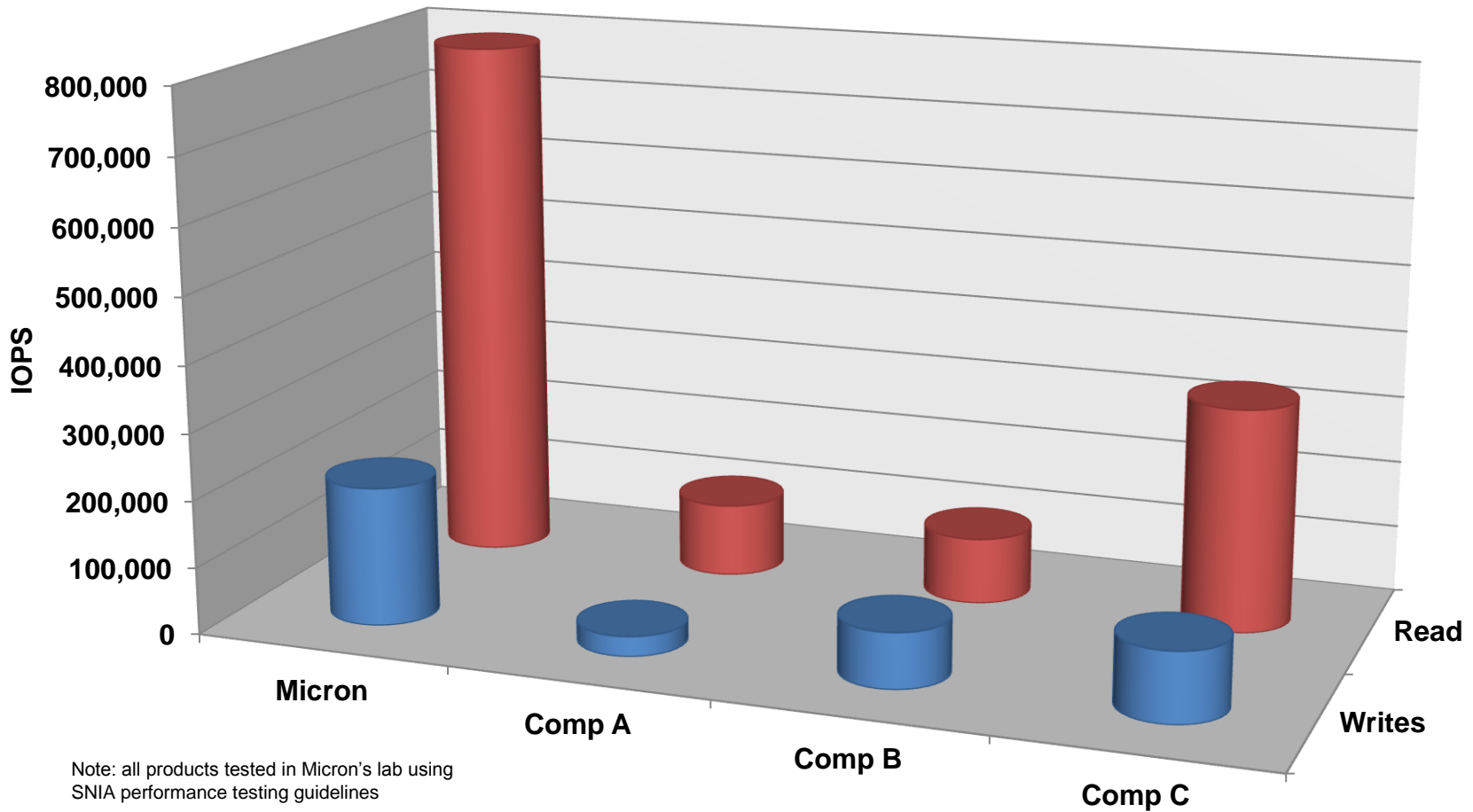PCIe Lane 0, RefClk E16-E7 (10 Pins)

ssdformfactor.org

2.5" PCIe Advantages

- PCIe performance

- Common Form Factor

- Compactness

- Serviceability

- Lower TCO
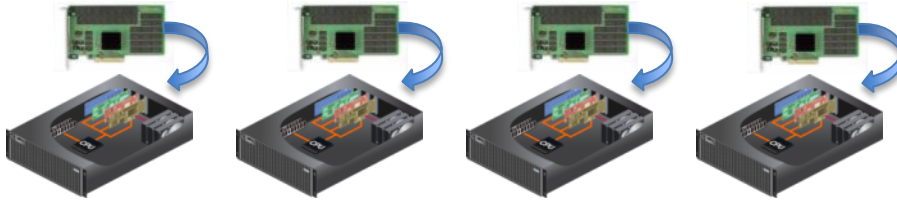
- Supports RAID

PCIe SSD:
4K Random R/W Performance

Note: all products tested in Micron's lab using SNIA performance testing guidelines

PCIe SSD: 128K Sequential R/W Performance

MB/S

Note: all products tested in Micron's lab using SNIA performance testing guidelines
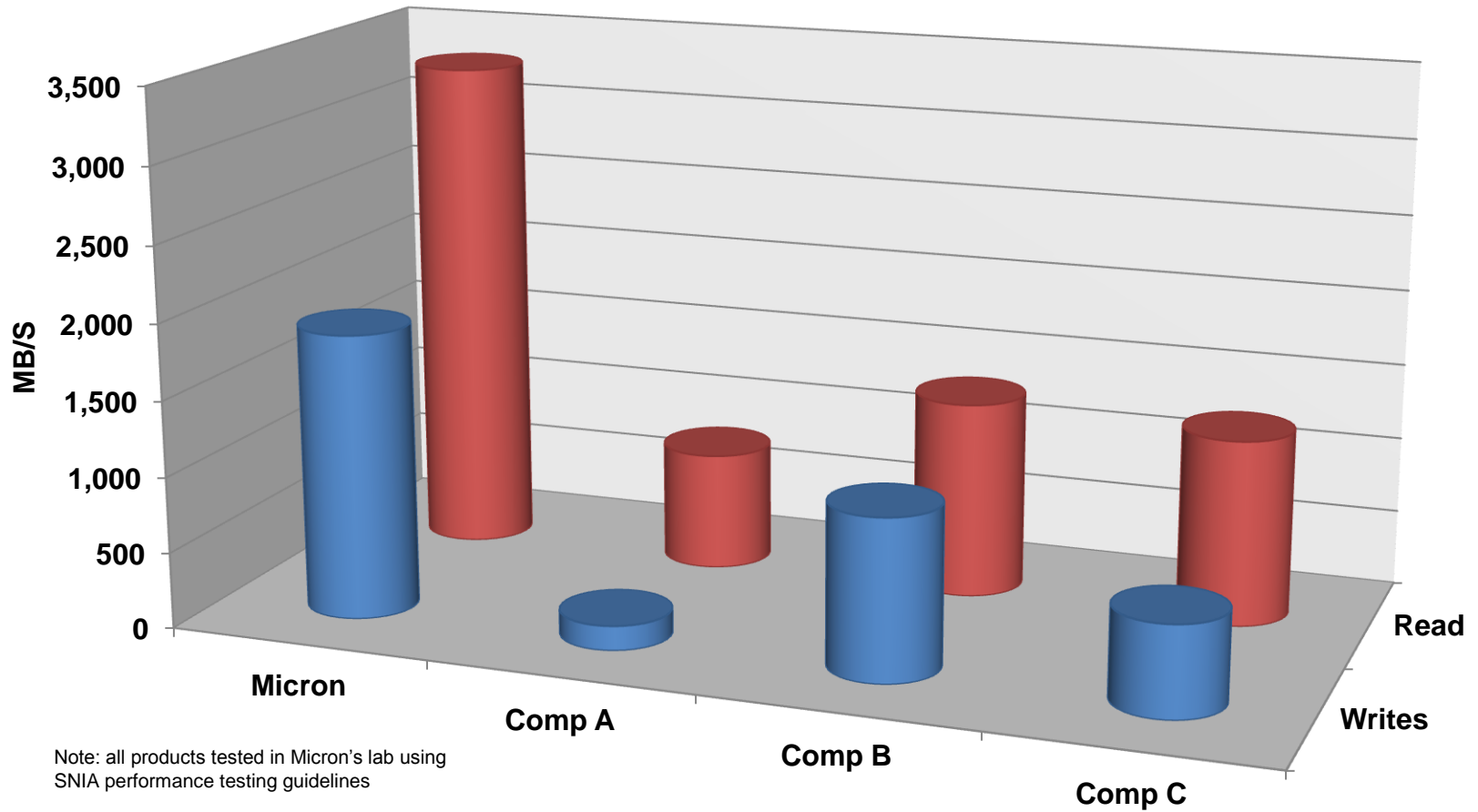
Is there a way to share High Performance SSD's?

What's Next To Share - PCIe SSD

Dedicated PCIe SSD Card
- Increased management
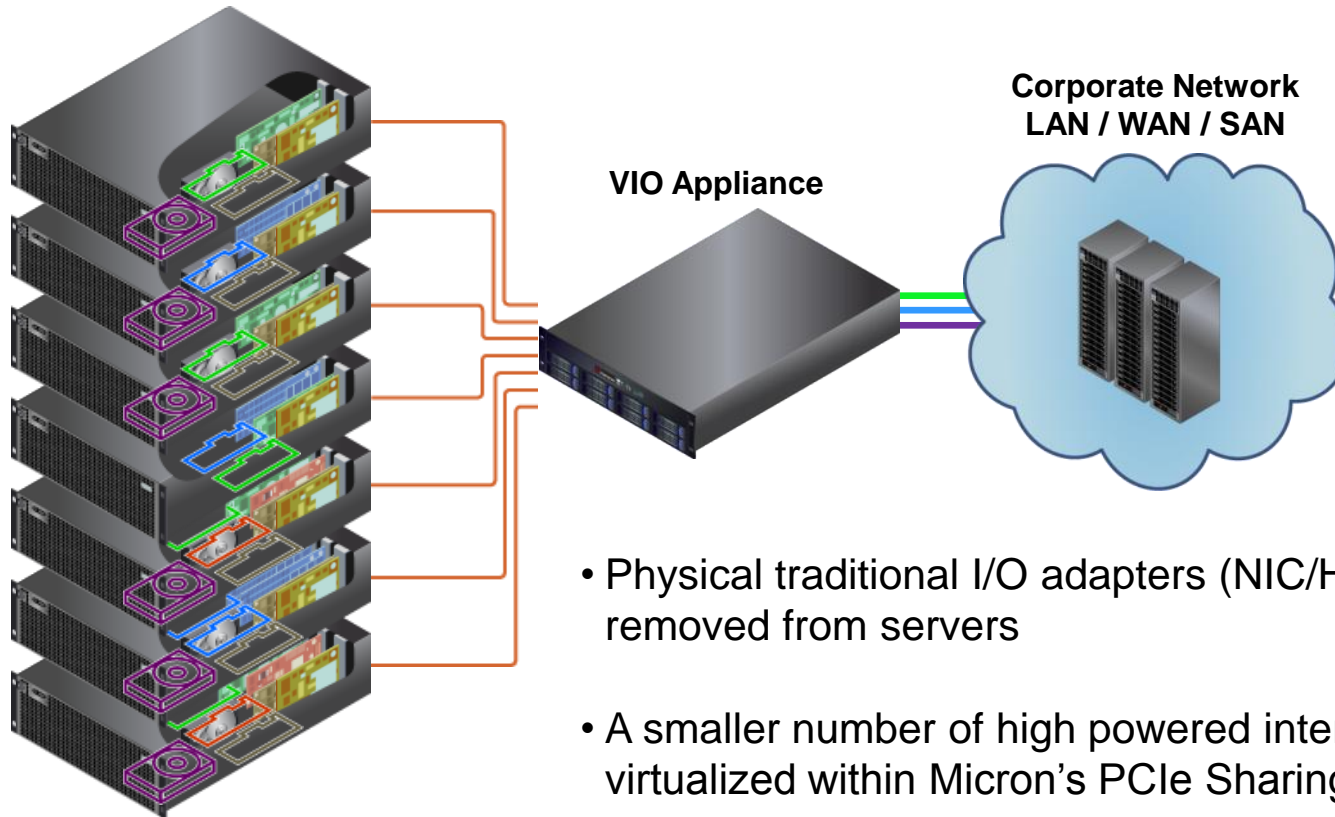- Poor resource utilization
- Expensive
- Fixed performance

Sharing provides precisely the _capacity_ and _performance_ a server/application needs _when_ it needs it
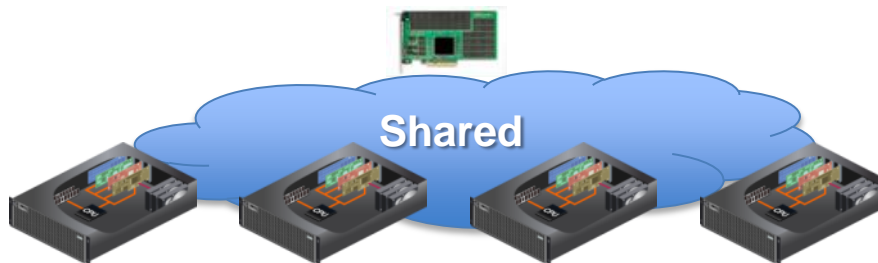
Shared

Shared PCIe SSD
- Centralized management, resource, data
- High resource utilization
- Cost effective
- Higher performance

Micron PCIe Sharing Technology

**Corporate Network
LAN / WAN / SAN**

VIO Appliance

- Physical traditional I/O adapters (NIC/HBA) are removed from servers

- A smaller number of high powered interfaces are virtualized within Micron's PCIe Sharing Appliance

- A simple, low power, low profile PCIe extender card is inserted into the servers connected to the VIO through a PCI extension cable

Sharing Benefits

- Dynamically provision bandwidth, capacity, and connectivity

- Move I/O resources from one machine to another without touching the systems

- Size resources based on average need, but get much higher peak performance for "bursty" application traffic

50%
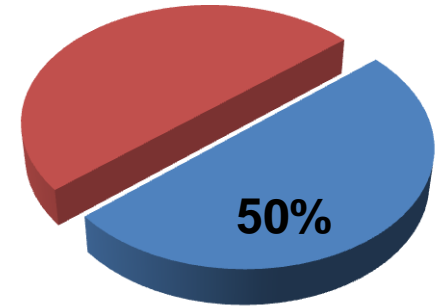
Equipment Cost Savings

80%
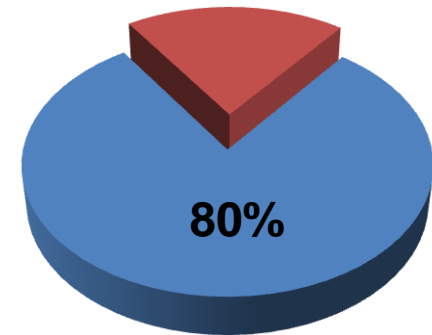
Power Cost Savings

Summary

- **SSDs are now a critical part of the storage hierarchy**
  - Bridge the performance gap between HDD and DRAM
  - Increase storage efficiency
- **SSD advantages change the way we measure value**
  - $ / IOP
  - IOPs / watt
- **High performance platforms adapting to take advantage of PCIe**
  - 2.5" PCIe form factor provides all the performance of PCIe with the ease of use of SATA/SAS
  - PCIe SSD sharing provides precise capacity and performance when you need it

Other Micron Presentations

- NAND uses in high performance platforms
  - Tutorial A-11 – Tuesday, August 21st @ 8:30 am

- NAND flash architecture and specification trends
  - Tutorial B-11 – Tuesday, August 21st @ 8:30 am

- MLC media discussion
  - Tutorial C-11 – Tuesday, August 21st @ 8:30 am

- Next-generation storage and the mobile computing ecosystem
  - Session 101-B – Tuesday, August 21st @ 8:30 am

- Why ECC-free NAND is the best solution for high-performance applications
  - Session 102-A – Tuesday, August 21st @ 10:10 am

- How ONFI standards are fueling high-performance SSDs
  - Session 102-C – Tuesday, August 21st @ 10:10 am

- The need for differentiated MLC solutions
  - Tutorial F-21 – Wednesday, August 22nd @ 8:30 am

- Virtualized SSD storage for enterprise systems
  - Tutorial H-22 – Wednesday, August 22nd @ 4:30 pm

- Performance trade-offs of flash-based client storage solutions
  - Tutorial A-31 – Thursday, August 23rd @ 8:30 am

- Phase Change Memory – Panel Discussion
  - Session 302-D – Thursday, August 23rd @ 9:50 am

- 2.5-inch PCIe interface for enterprise flash cache – Panel Discussion
  - Session 303-B – Thursday, August 23rd @ 3:10 pm