



The Future of Solid State Storage

Tom Coughlin

*Coughlin
Associates*

China Flash Forum: 5 November 2015

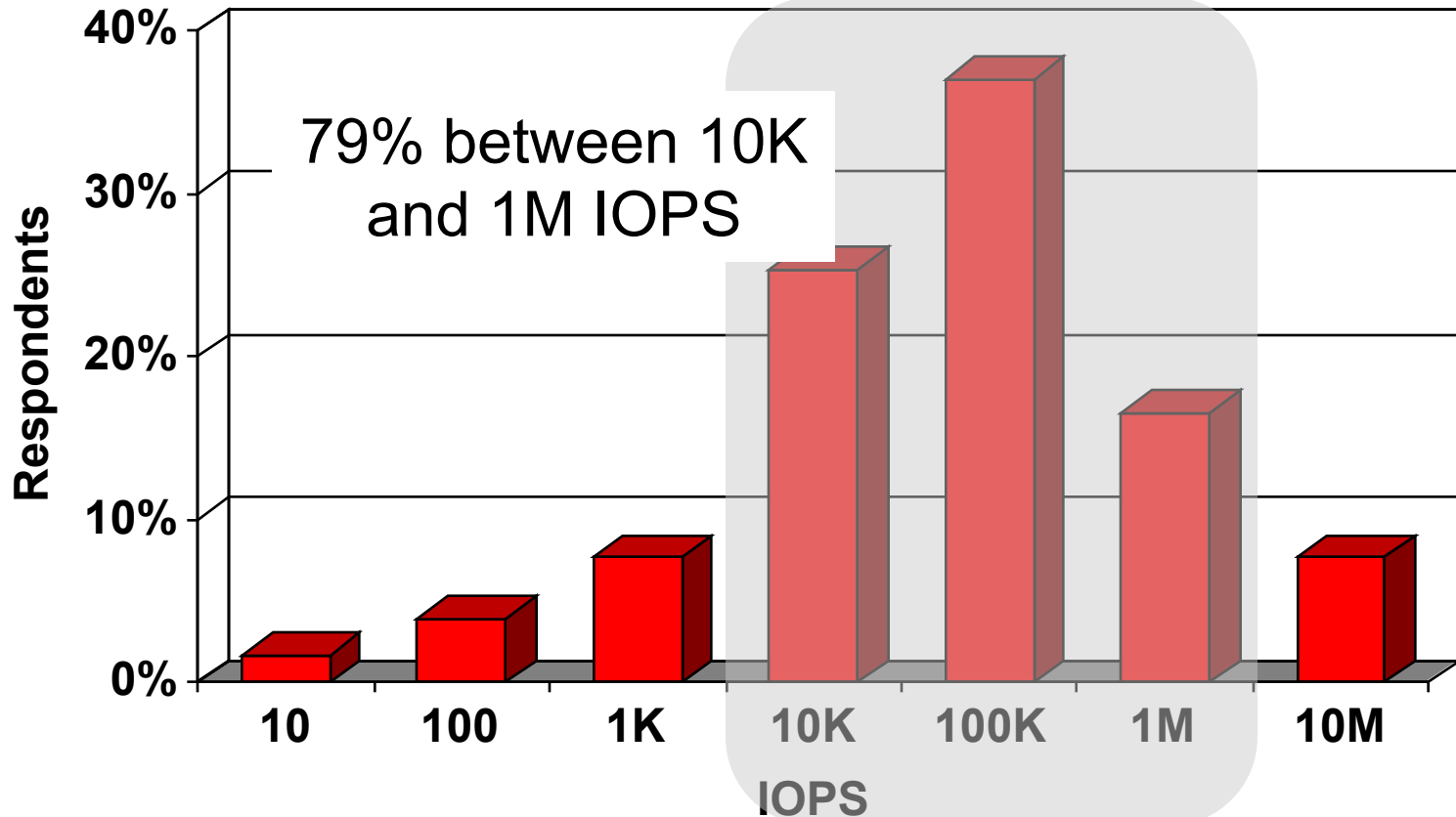
Outline

- The Shape of Things to Come
- Memory Developments at the 2015 FMS
- Intel/Micron's 3D XPoint Technology
- Storage System Evolution
- Conclusions



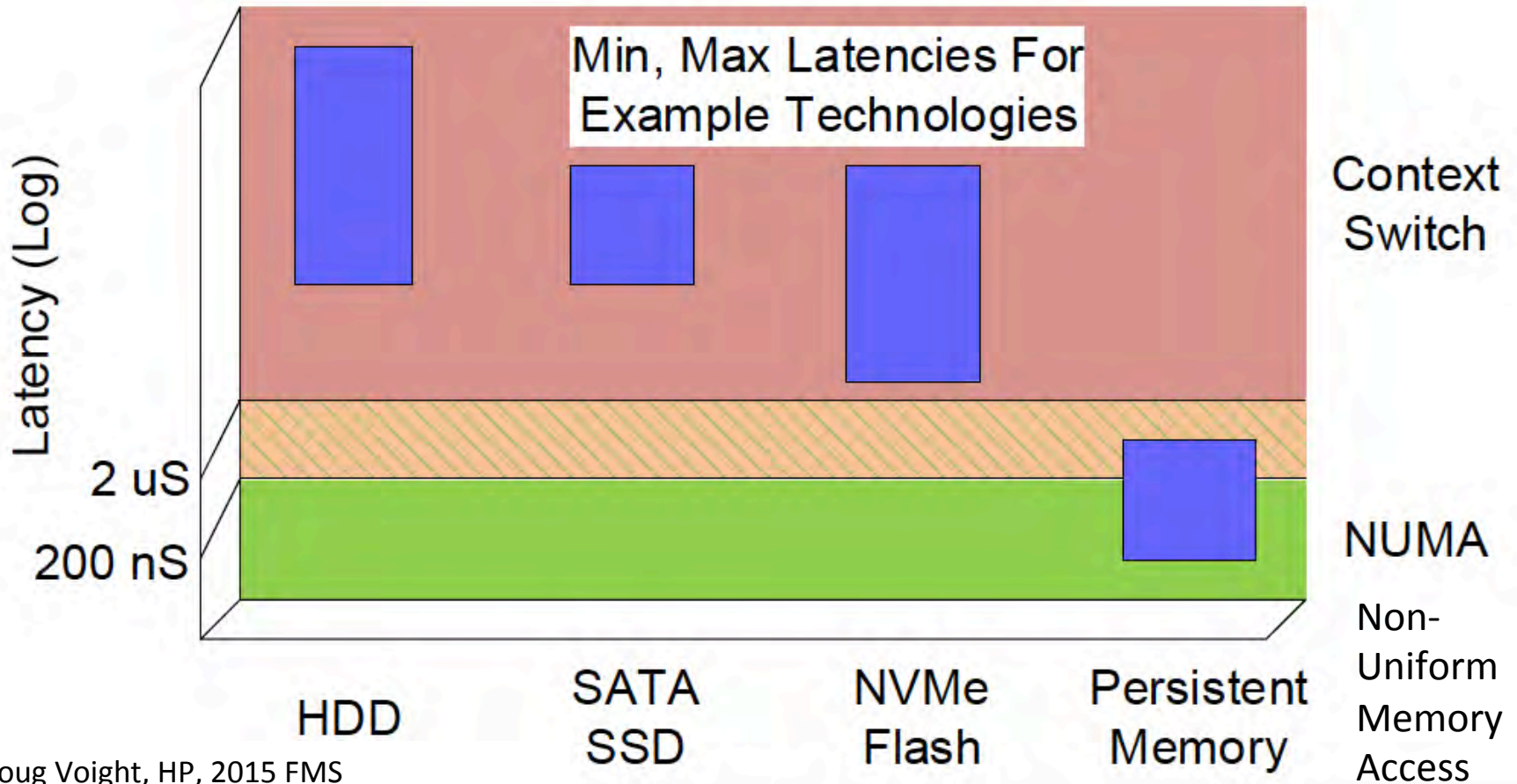
The Shape of Things to Come

IOPS Required



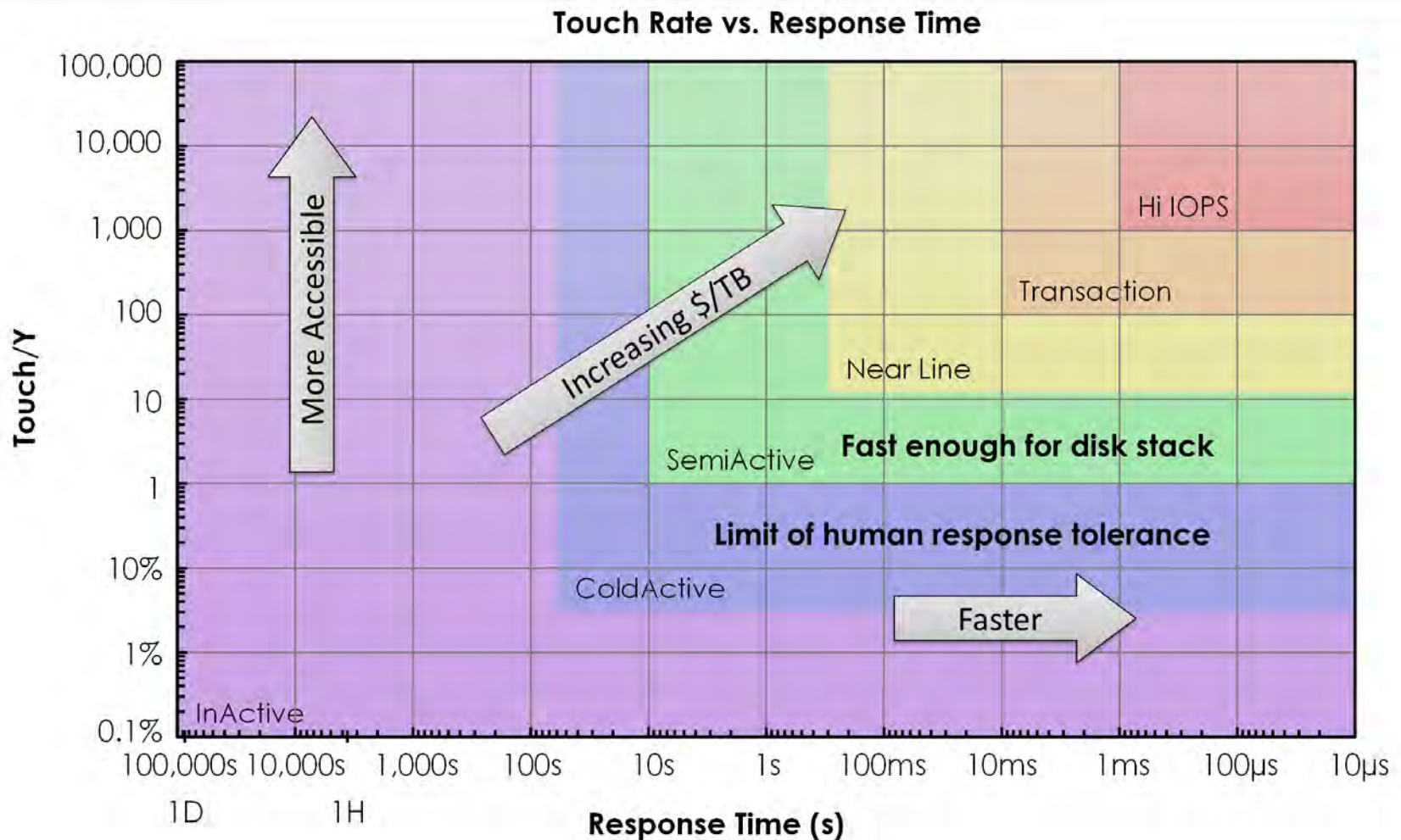
From the 2014 How Many IOPS Do You Really Need Report, Coughlin and Handy, <http://www.tomcoughlin.com/techpapers.htm>

Latencies Separate Computer Memory from Storage



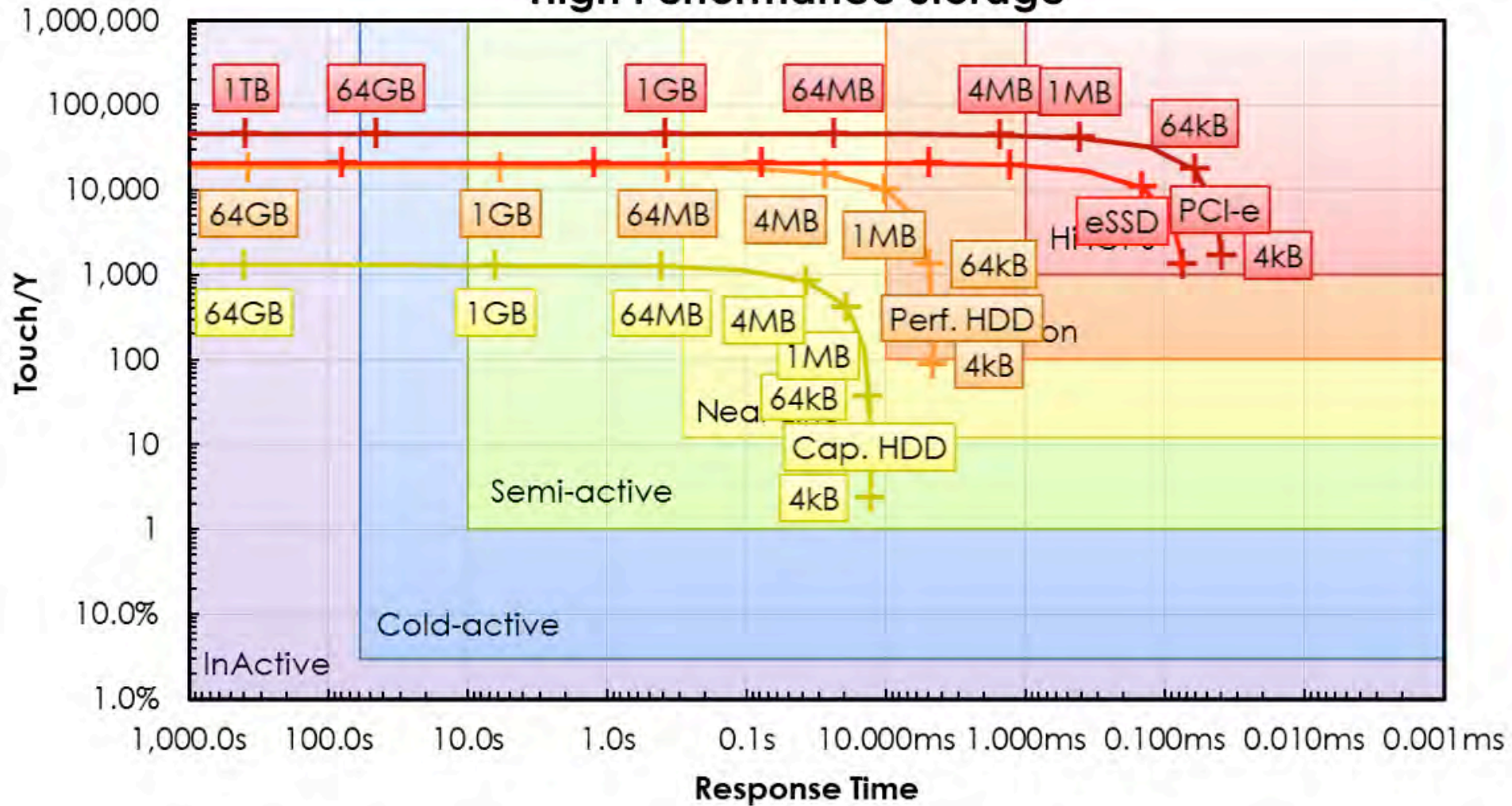
Doug Voight, HP, 2015 FMS

Touch rate versus response time indicating various types of uses



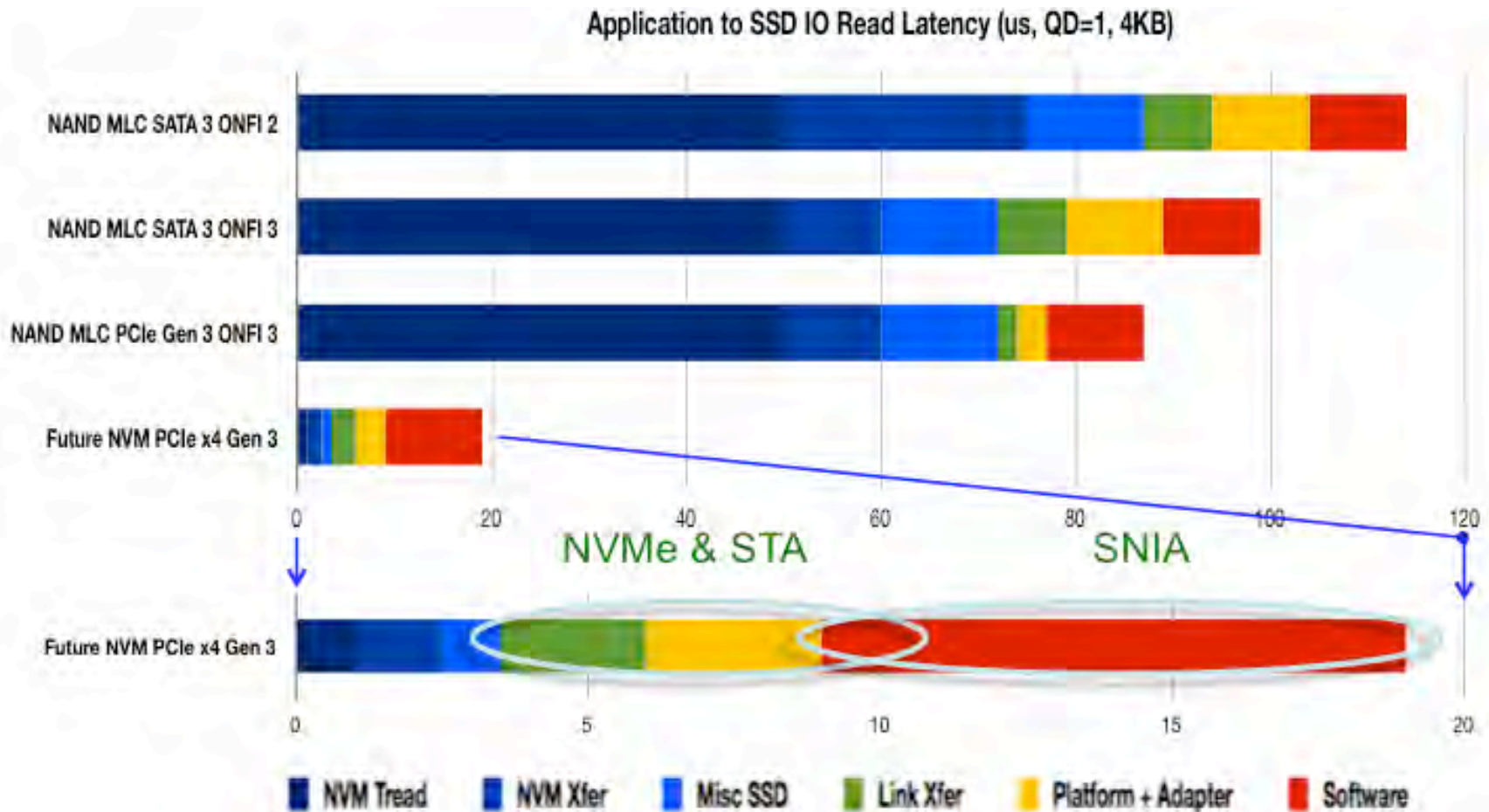
Ent. SSDs, perf. HDDs and capacity HDDs

High Performance Storage



Storage Latency Storage Latency with Current and Future NV Solid State NV Technologies

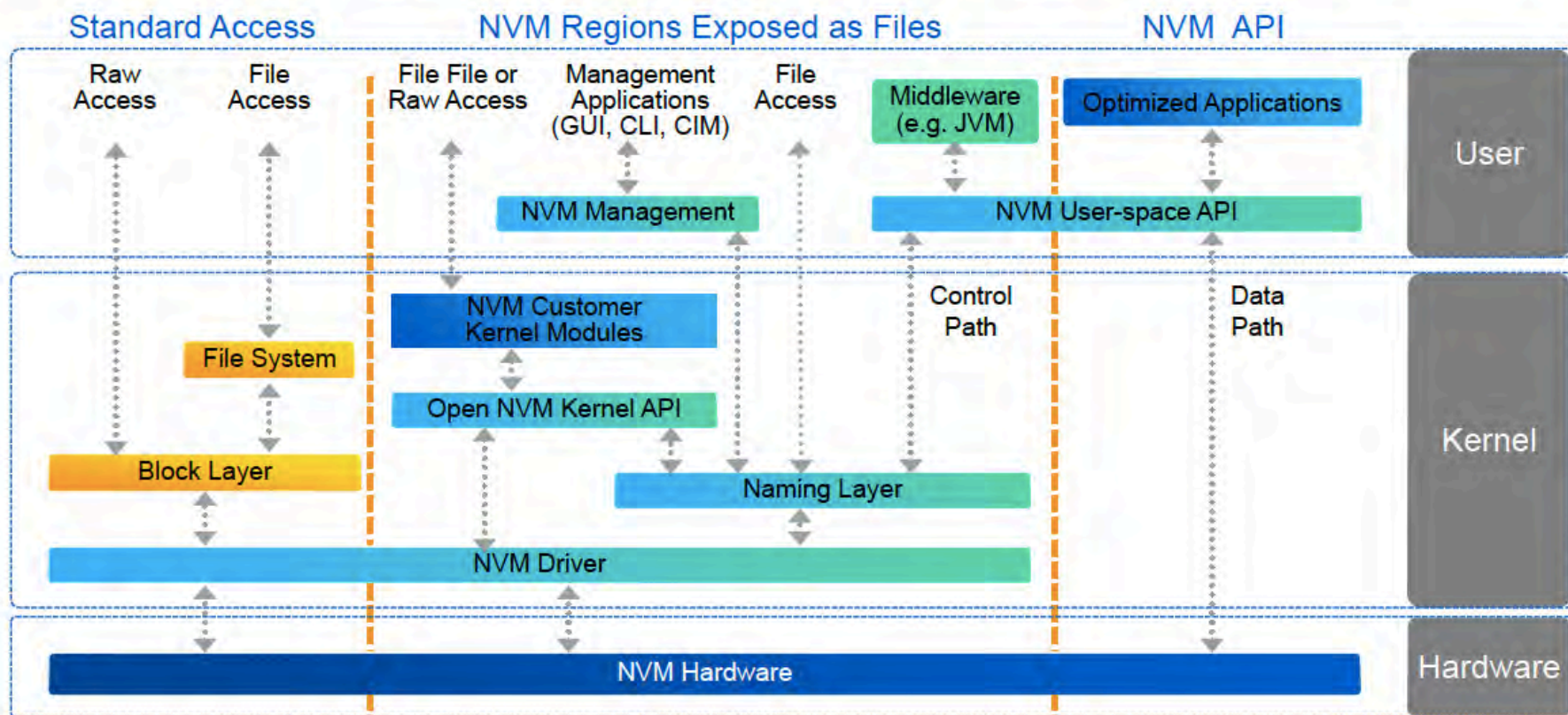
(from Doug Voight Talk at NVMP talk at SNIA Winter Symposium, 2014)



VM/Persistent Memory Programming Model

(NetApp Keynote, 2015 FMS)

NVM/Persistent Memory Programming Model – pmem.io

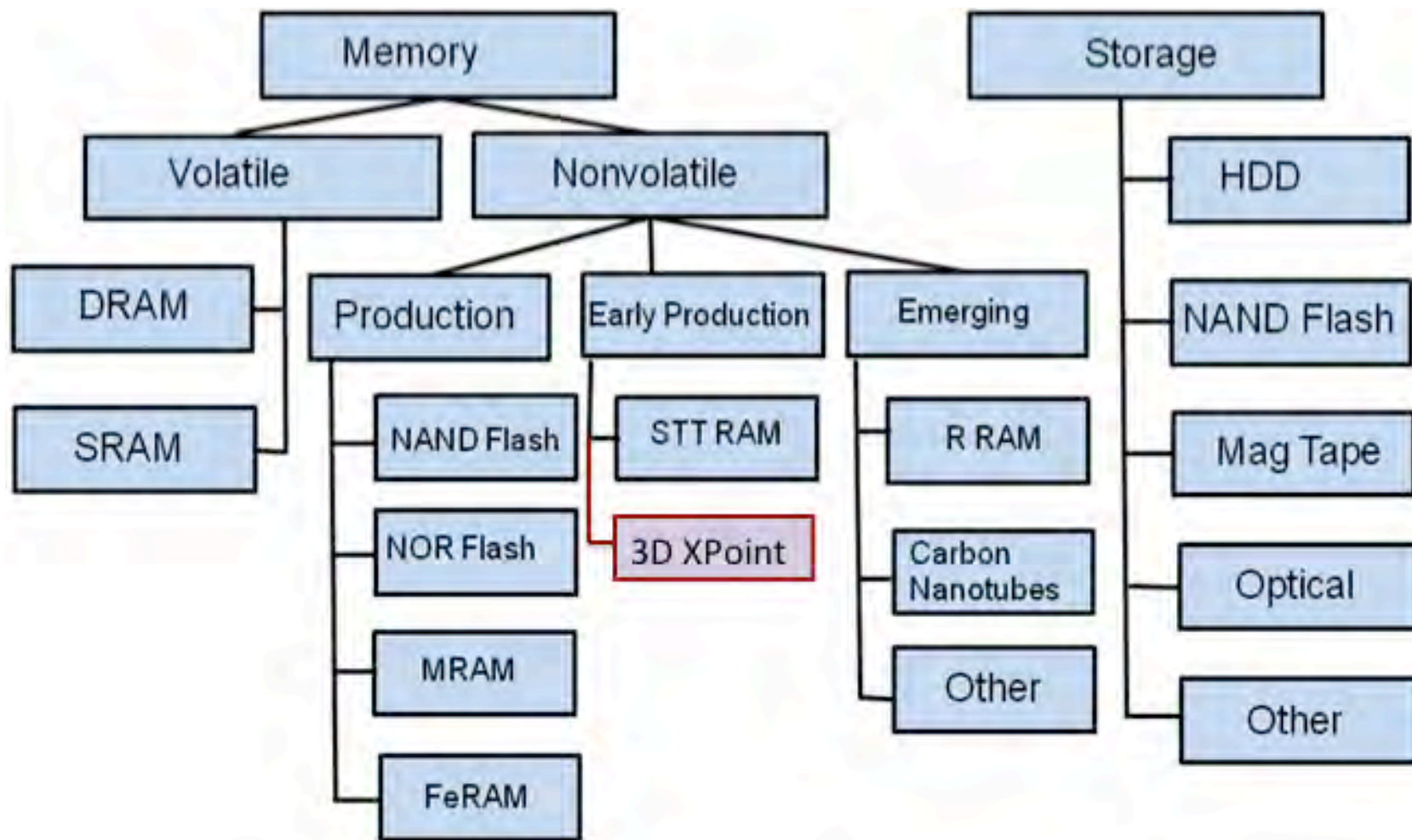




Memory Developments at the 2015 FMS

Memory and Storage Today

2015 Emerging NV Memory and Logic Technology and Manufacturing Report,
Coughlin Associates

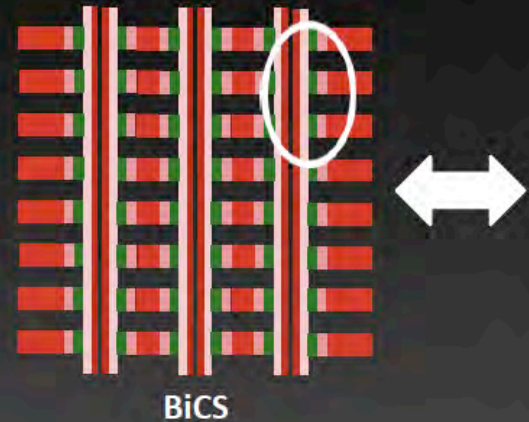
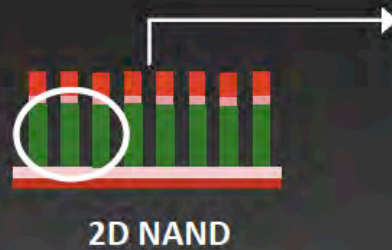
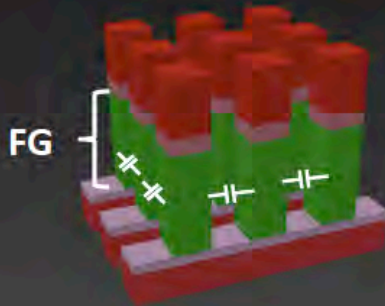
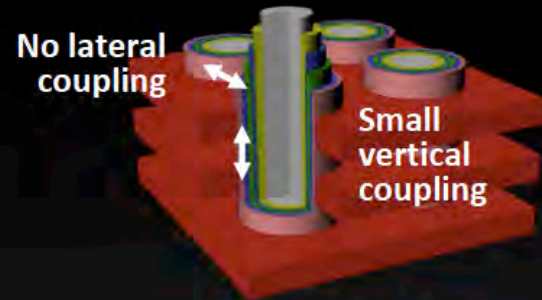


3D NAND

SanDisk Keynote, 2015 FMS 2015

3D NAND Flash: Tall is the New Small

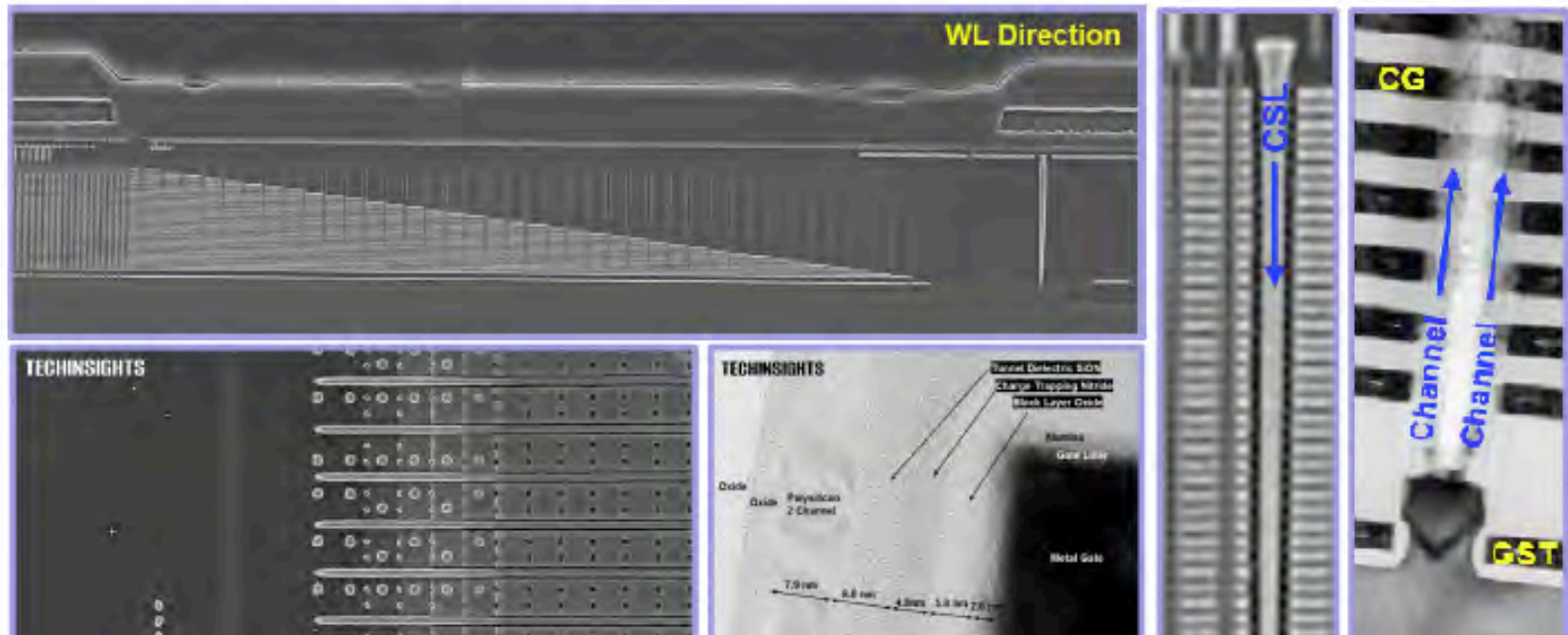
Proximity Effect (V)



3D Vertical NAND Future

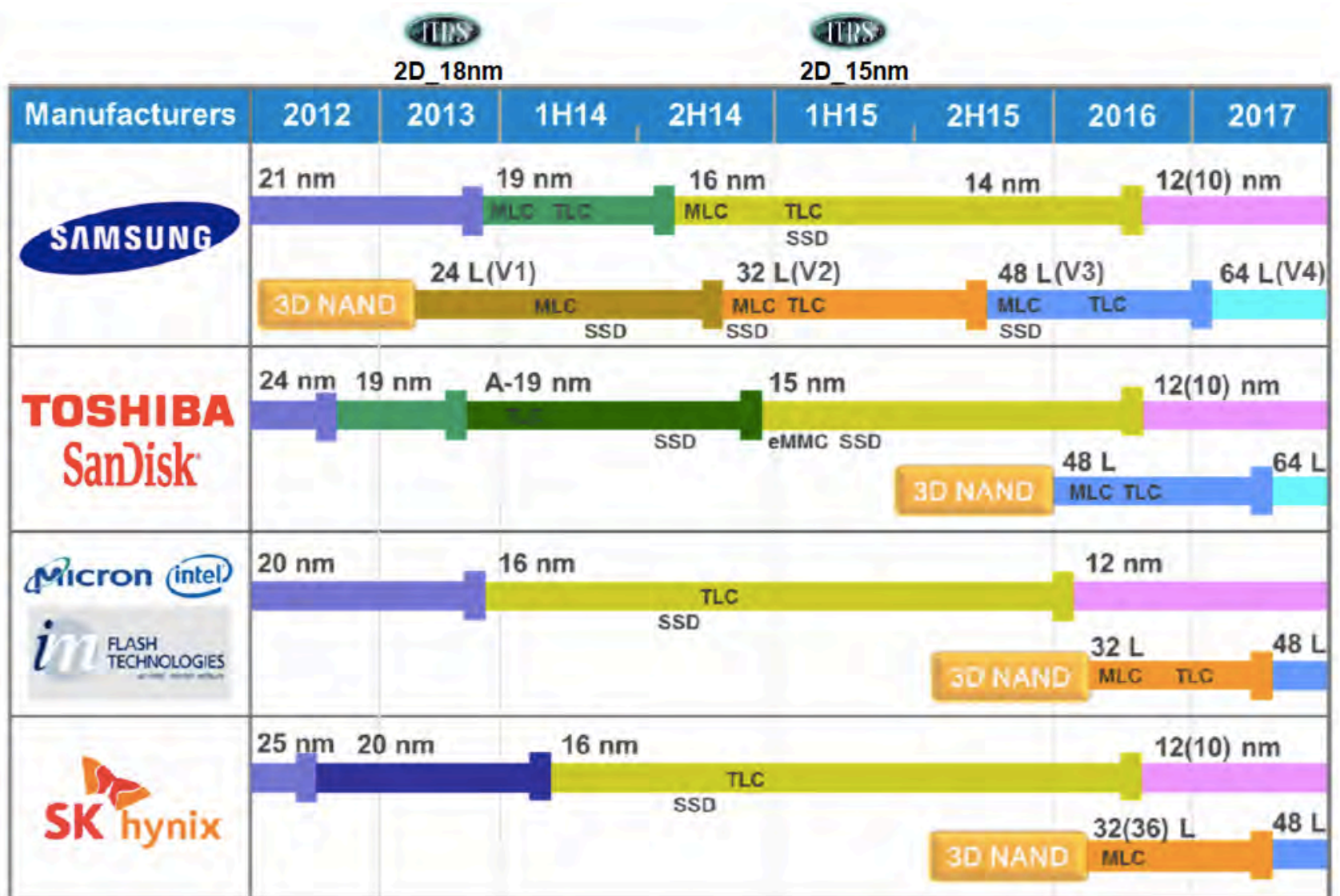
TECHINSIGHTS, 2015 FMS

- ✓ 48L, 64L, 96L and 128L with Higher Aspect Ratio Hole Process
- ✓ Cell WL Interconnection: # Masks, Layouts, Trimming, Uniformity
- ✓ Vertical Channel: Doping/Junction Engineering
- ✓ CTF/IPD Engineering



NAND Technology Roadmap

Tech Insights, 2015 FMS

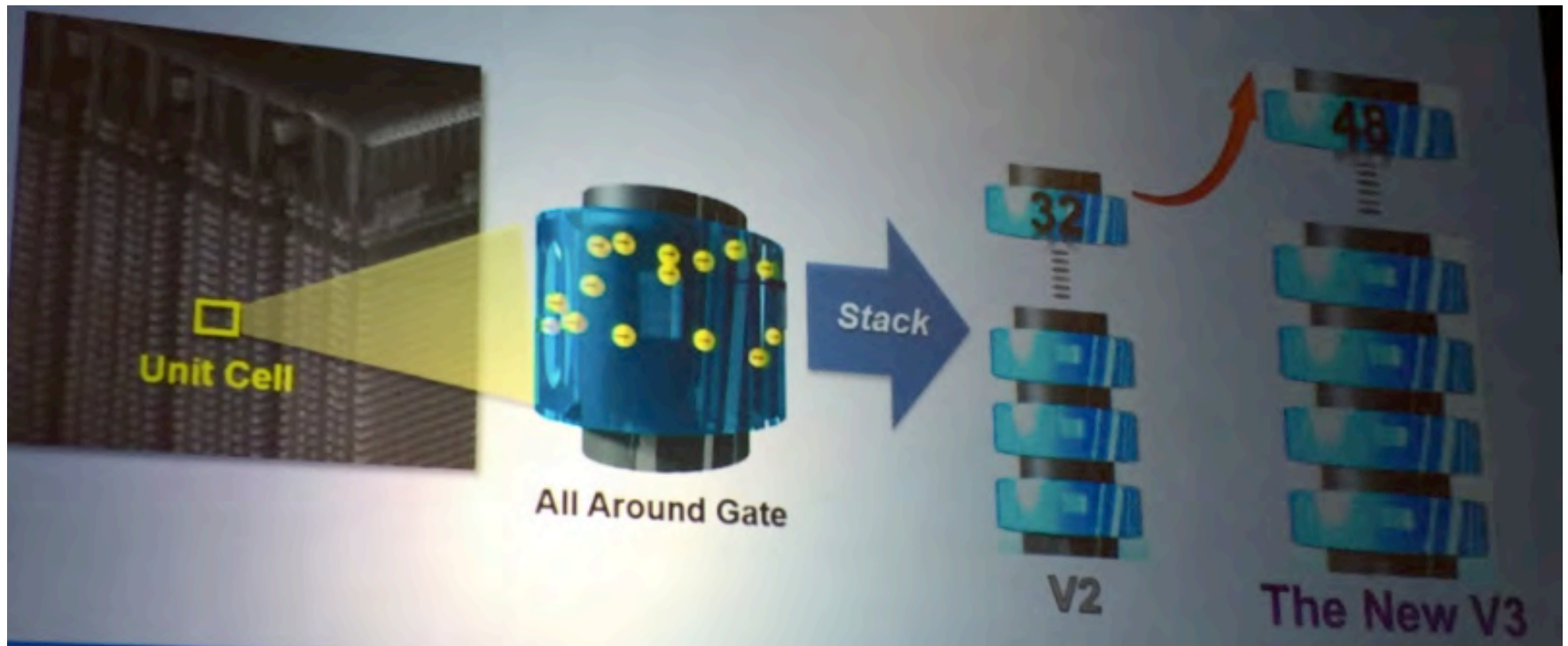


Samsung Announcements at the 2015 FMS

- 48 layer V3 V-NAND (256 Gb TLC chips)
- 1 M IOPS 6.4 TB NVMe SSD (PM1725)
- 15.36 TB SSD (PM1633a) with V3
- NVMe PM953 for datacenter scaleout
- 3-bit SAS SSD, PM1633
- Generation 2 of Storage Intelligence
- Reference SAS and NVMe storage systems

Samsung Increase V-NAND to 48 Layers

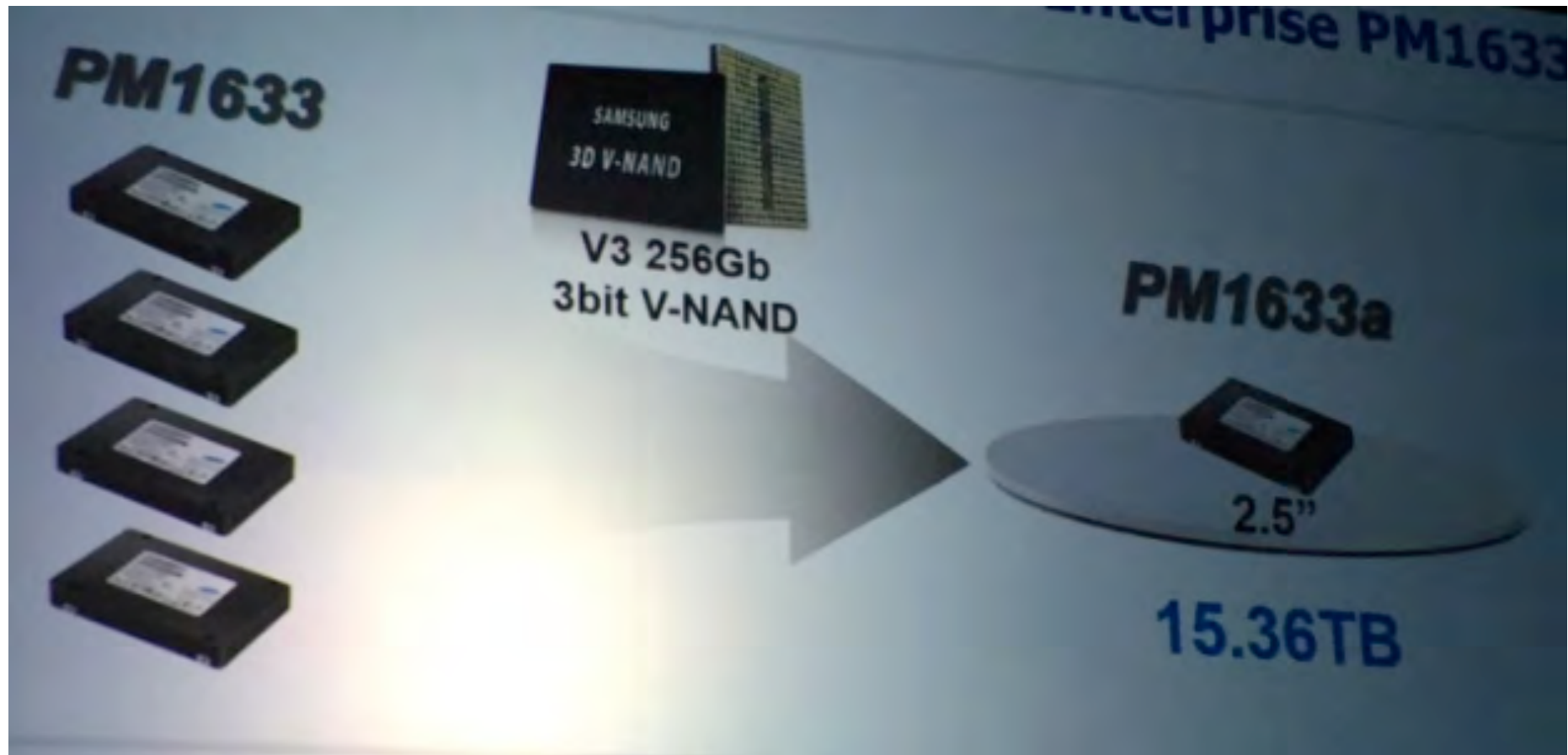
(Samsung Keynote, FMS 2015)



Samsung said they could go to over 100 layers and 1Tb chips with V-NAND. Performance doubled and power use halved with V3.

PM1633a, 15.36 TB SSD with V3

(Samsung Keynote, FMS 2015)



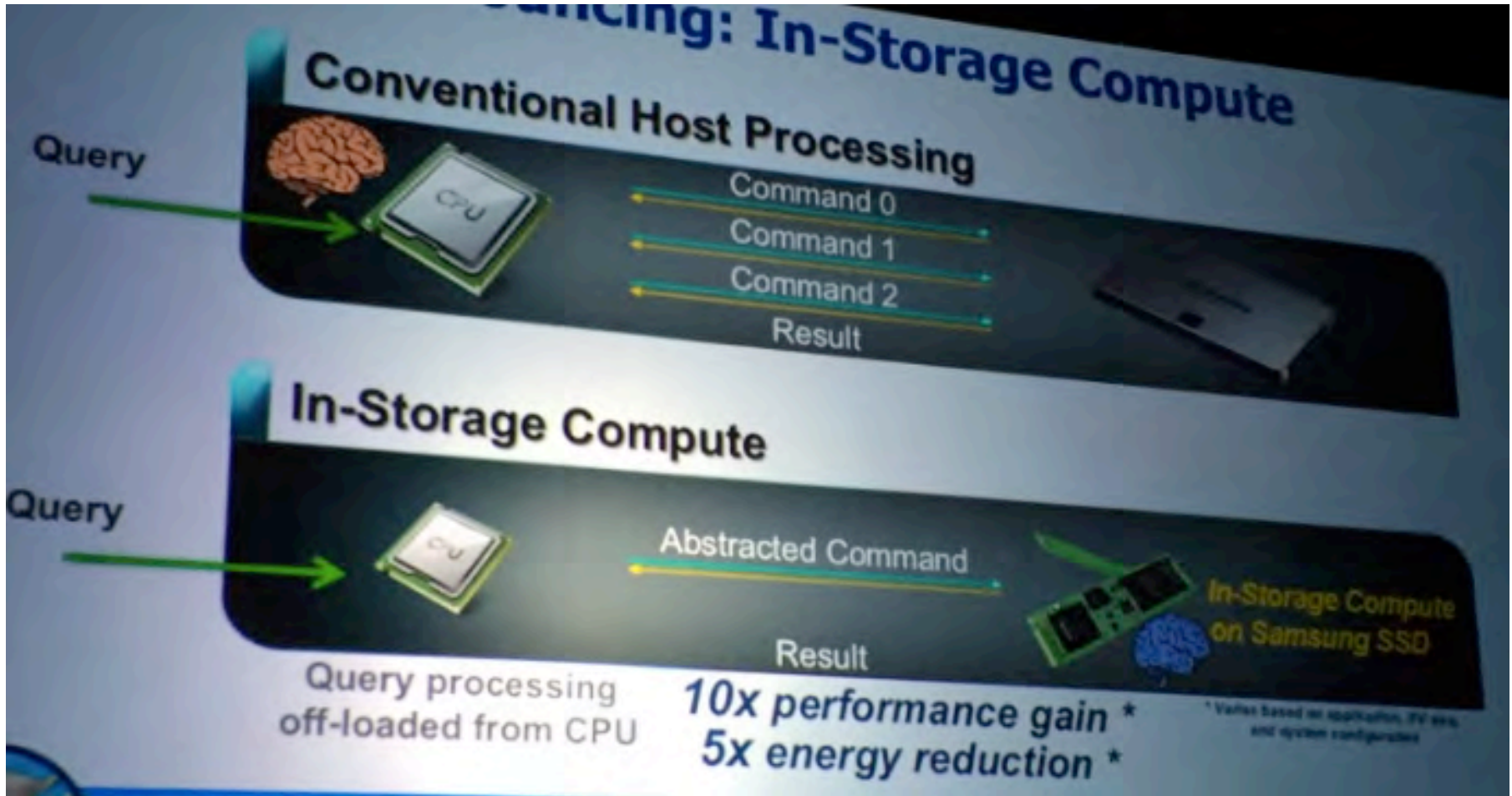
PM1725 1M IOPS NVMe SSD

(Samsung Keynote, FMS 2015)



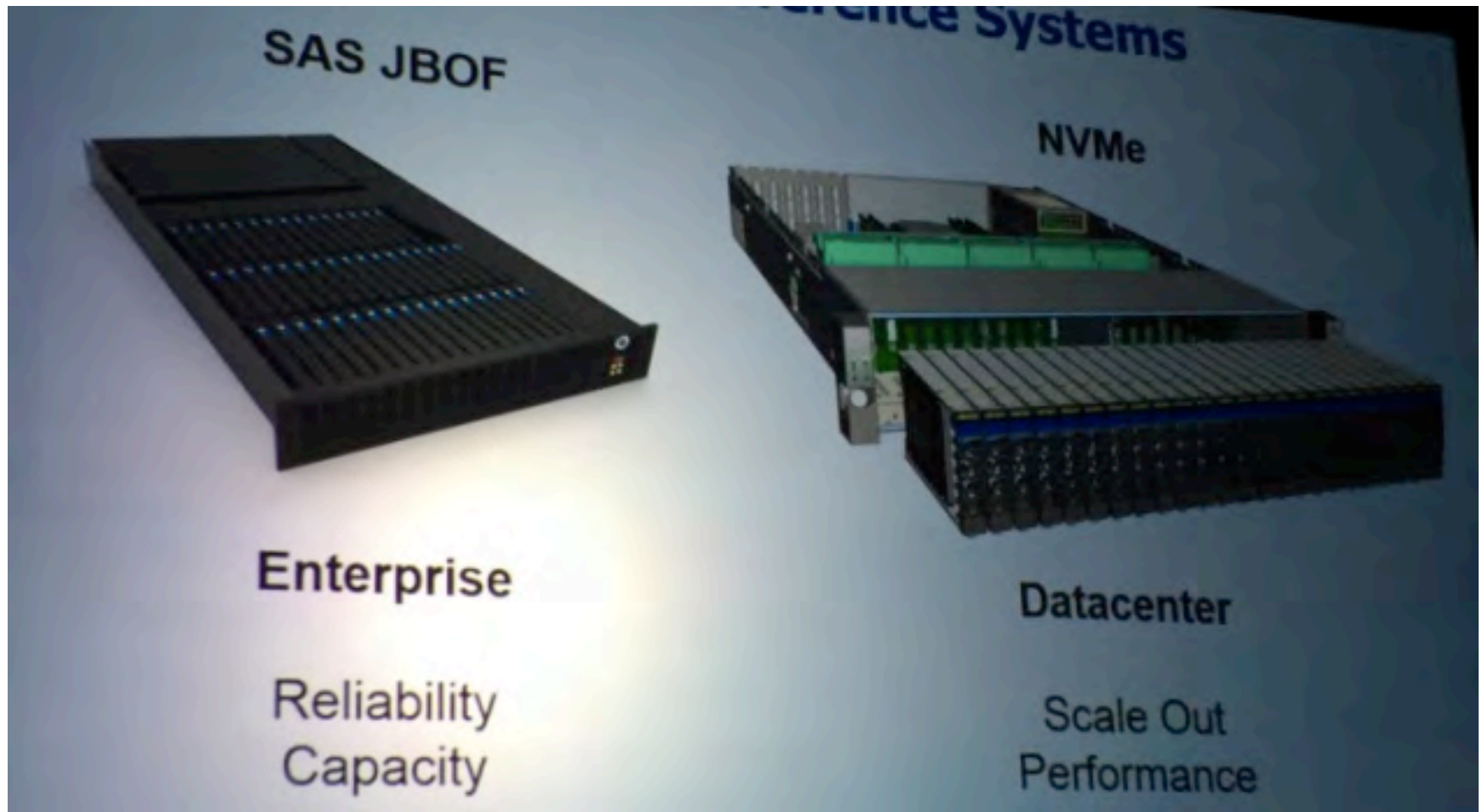
Storage Intelligence 2.0—In Storage Compute

(Samsung Keynote, FMS 2015)



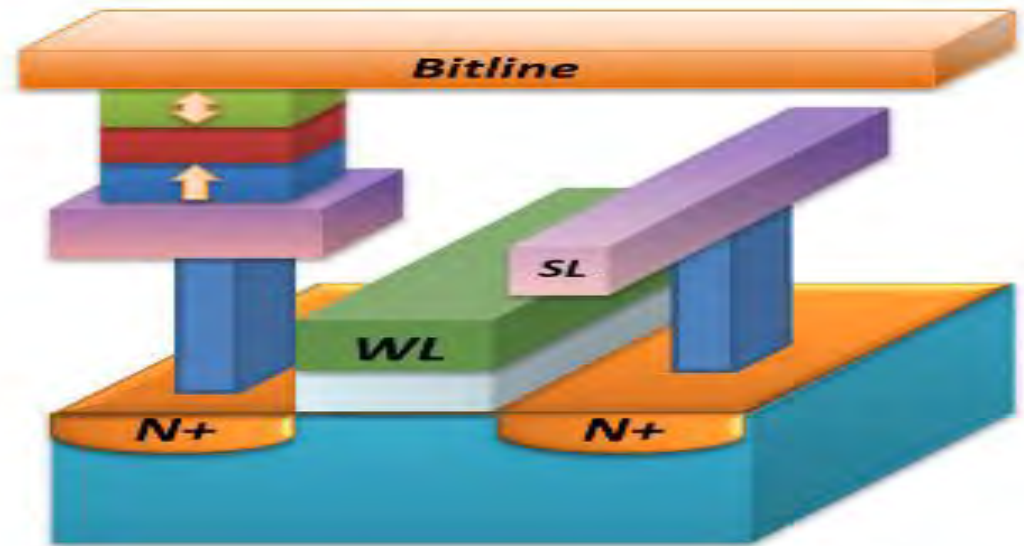
Samsung Storage Reference Systems

(Samsung Keynote, FMS 2015)



Emerging Memory Technology

- NVM will save power
- Persistent memory enables memory sharing (RDMA)
- Embedded NVM technology can lead to “logic-in-memory architecture”

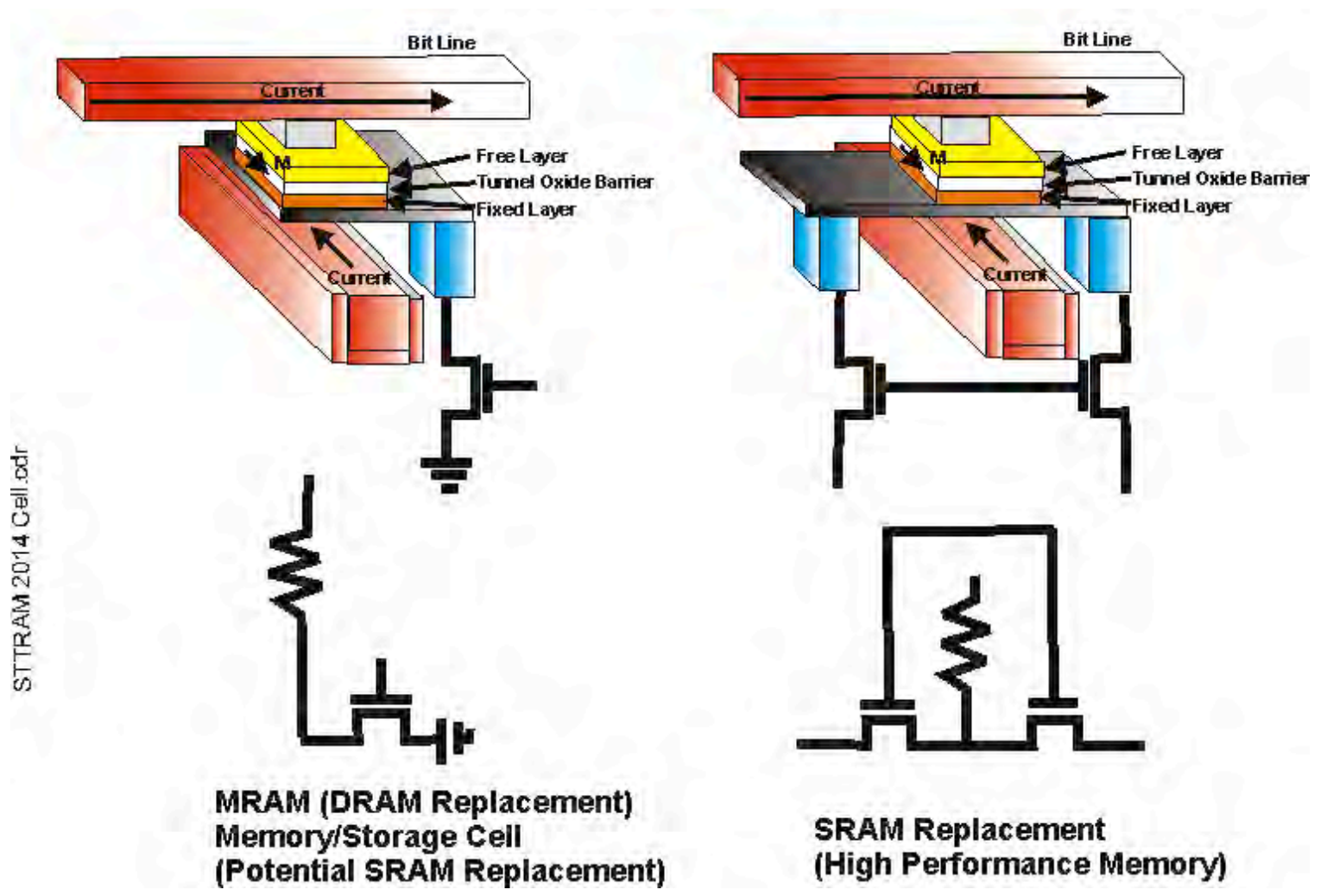


Emerging NVM market \$2.0 B to \$4.6 B by 2020

2015 Emerging NV Memory and Logic Technology and Manufacturing Report, Coughlin Associates

STT MRAM Replacing DRAM and SRAM

Over 50 M MRAM chips shipped by Everspin



STTRAM 2014 Cell.cdr

**MRAM (DRAM Replacement)
Memory/Storage Cell
(Potential SRAM Replacement)**

**SRAM Replacement
(High Performance Memory)**

MRAM is Proven and Shipping



300mm Wafer Production of Everspin MRAM Products
ST-MRAM process transfer successful
Initial 256Mb 40nm product is functional
Acceleration of pMTJ based products in 28nm and smaller
Versatile embedded memory with eMRAM



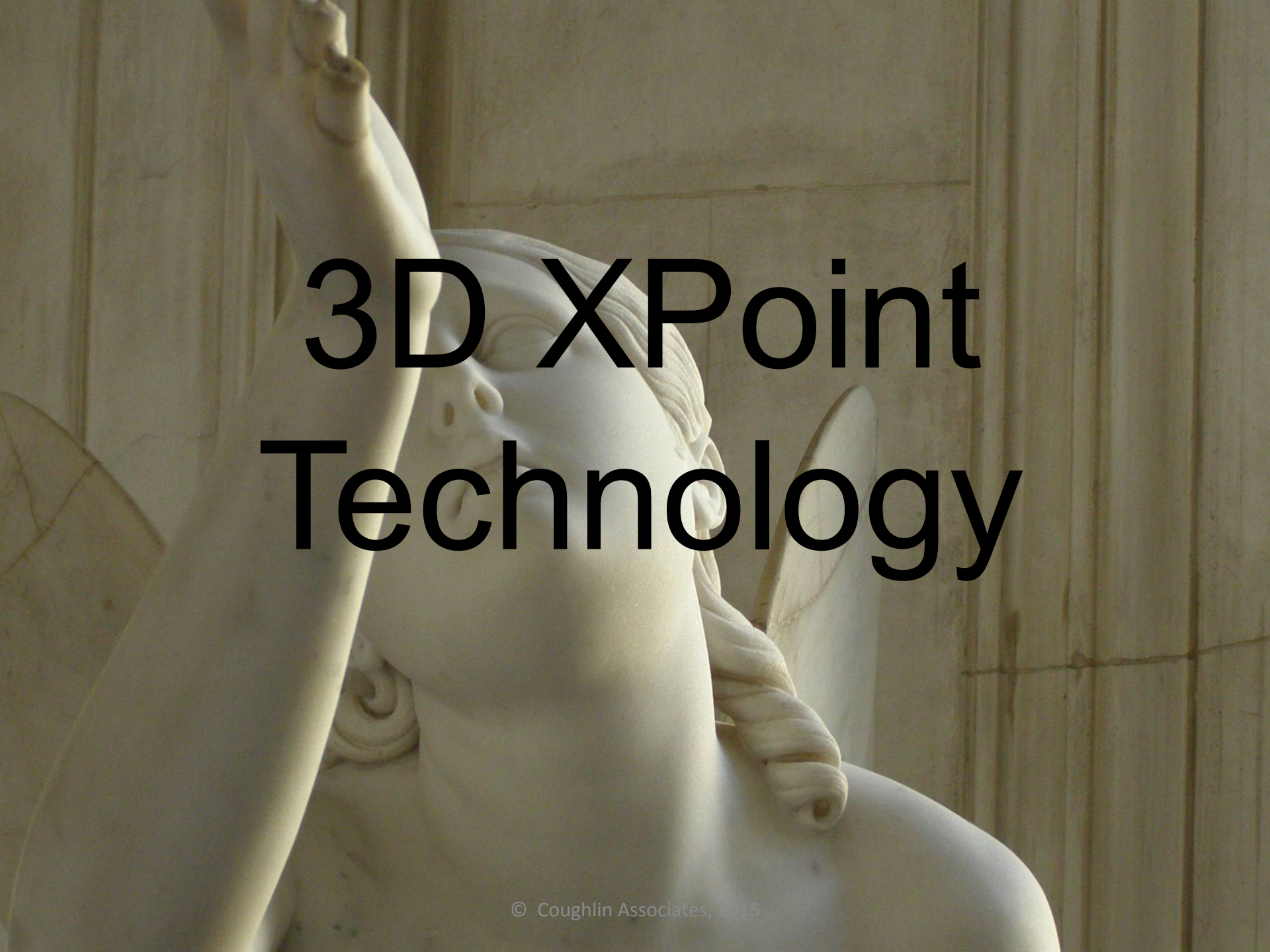
Strategic Investment



DDR3 and DDR4 controller optimization
NVMe and storage protocol optimization
Evaluation platforms and technology demos



Meeting the quality and supplier excellence needs of leading storage, industrial, and automotive customers



3D XPoint Technology

3D XPoint Memory

(Intel 3D XPoint Press Event, 2015)

WHAT IS 3D XPOINT™?

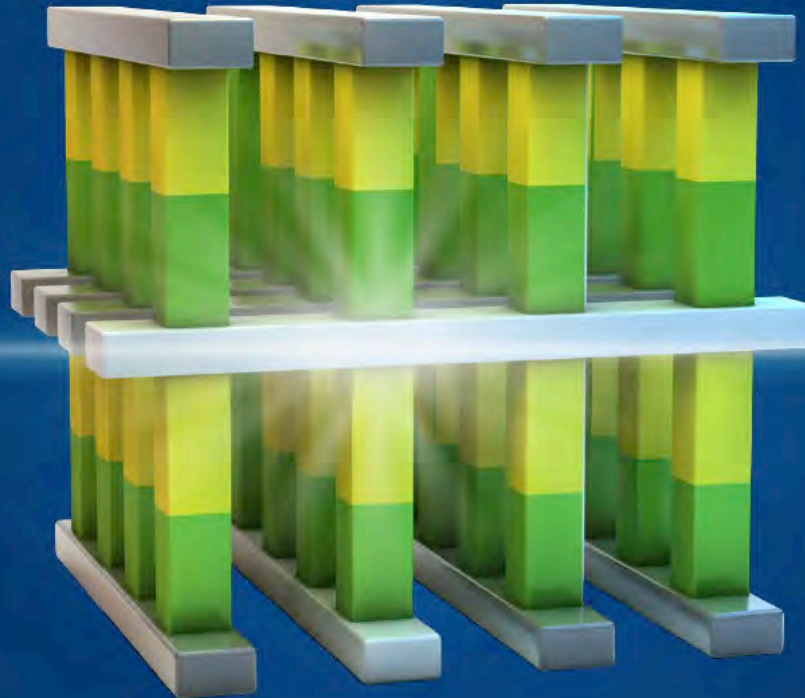
Crosspoint Structure

Selectors allow dense packing and individual access to bits



Scalable

Memory layers can be stacked in a 3D manner



Breakthrough Material Advances

Compatible switch and memory cell materials

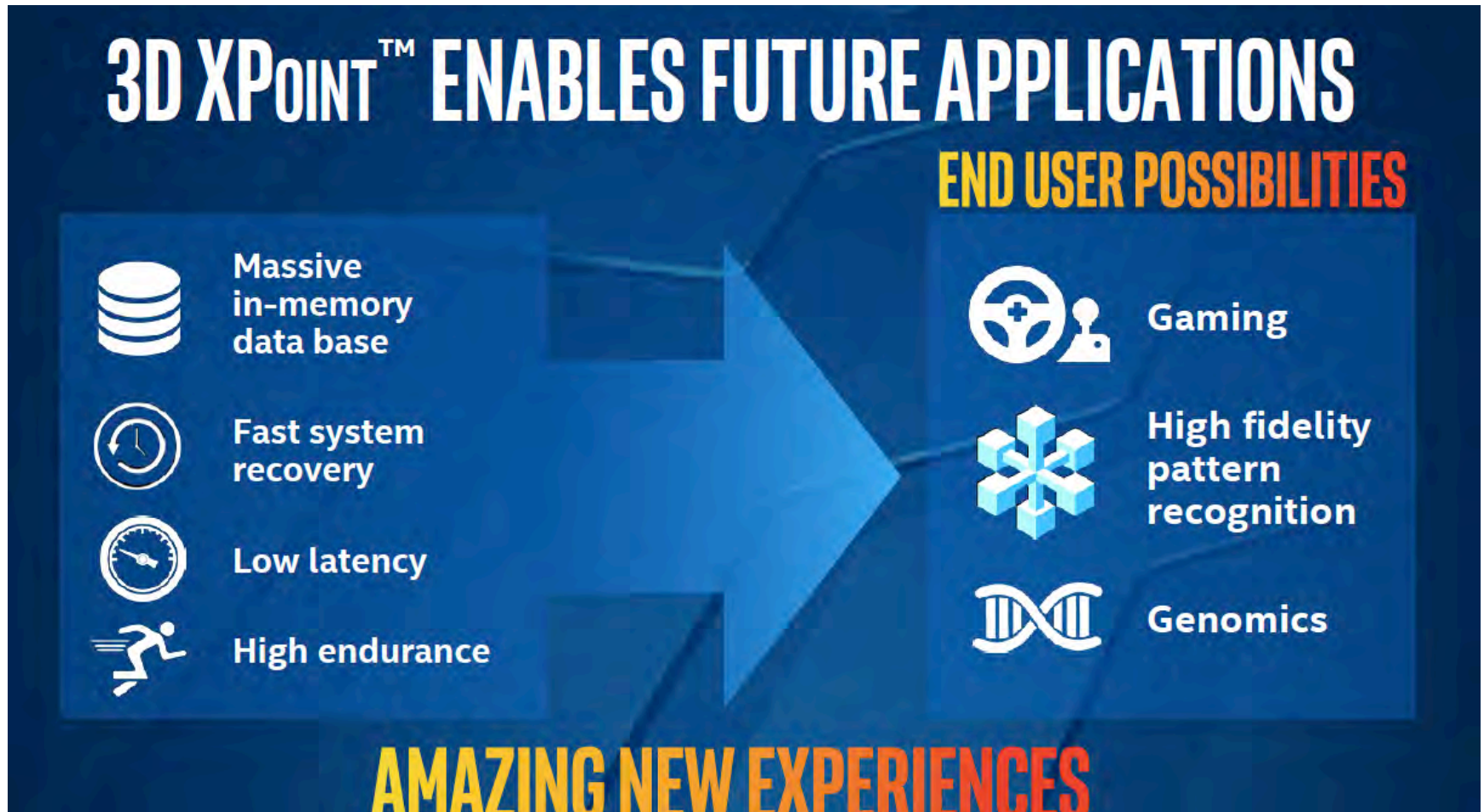


High Performance

Cell and array architecture that can switch states 1000x faster than NAND

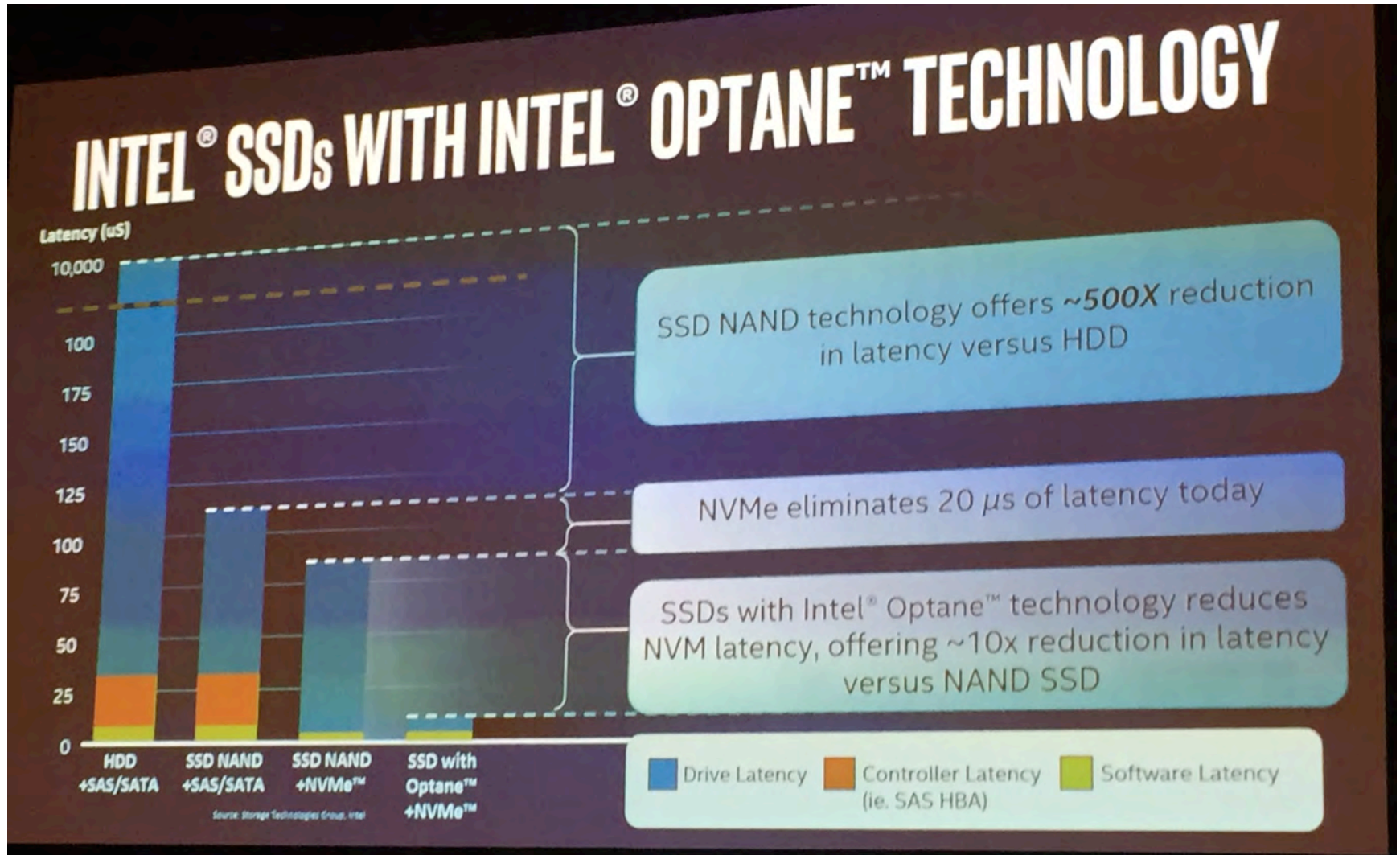
3D Xpoint Memory

(Intel Developers Forum, 2015)



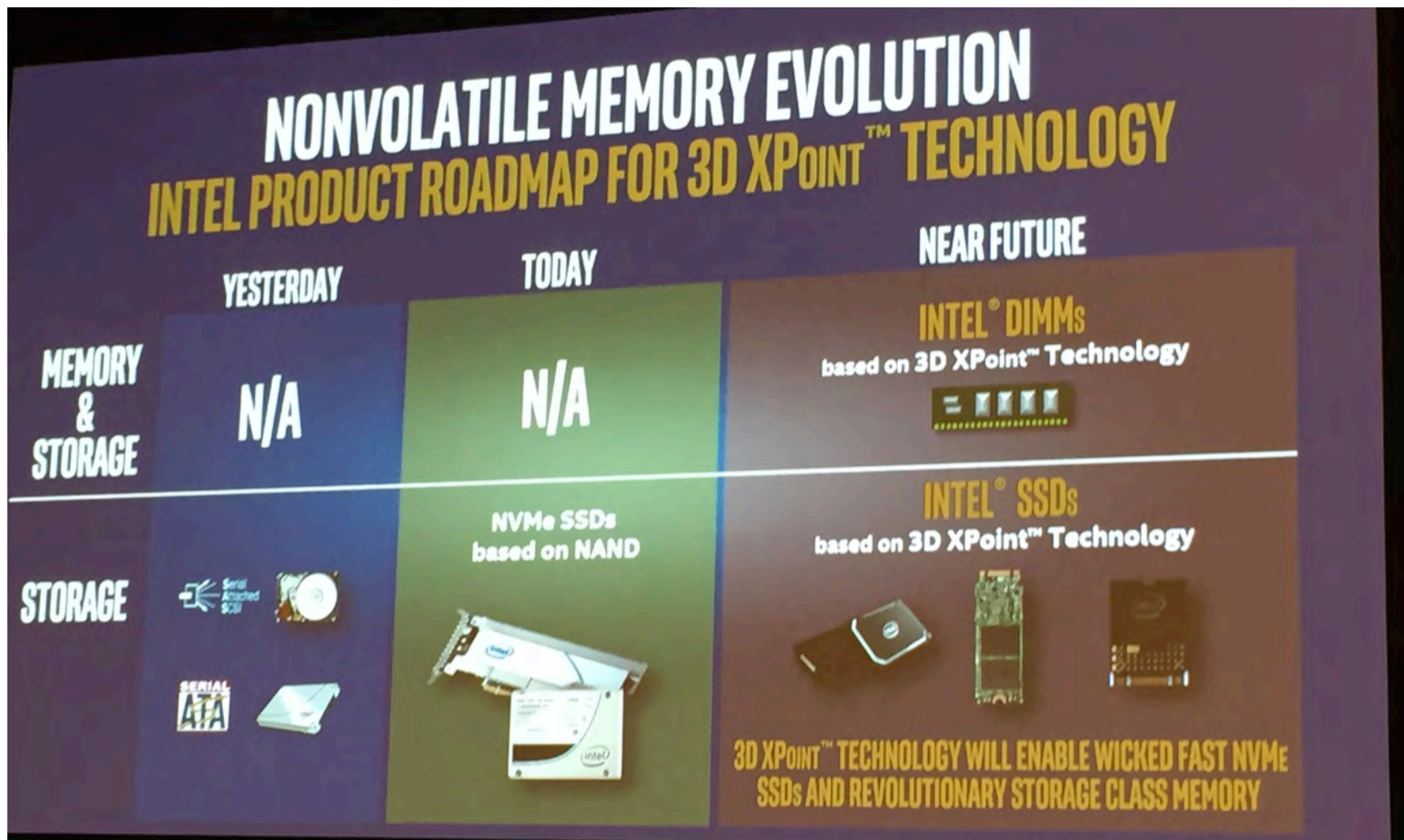
Intel's Optane

(Intel Developers Forum, 2015)



Future Products

(Intel Developers Forum, 2015)





Storage System Evolution

SanDisk Enterprise Products

SanDisk Keynote, 2015 FMS

Changing Shape of Flash Storage

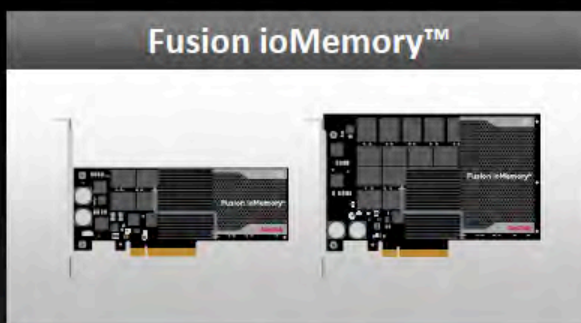
SSDs



- SATA
- SAS
- Reliability & Performance

Server & Storage Solution

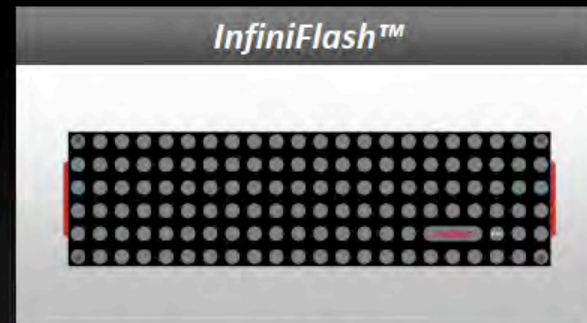
Fusion ioMemory™



- PCIe cards
- In-Server
- Highest App Performance
- High Capacity 6.4TB

**Highest Performance
Database & Log**

InfiniFlash™



- Block or File/Object
- 500TB
- Lowest \$/GB Storage

**Ultra-Dense Low
Cost Solution**

Growth of PCIe/NVMe SSD Storage

Forward Insights Projections from Jim Pappas Talk at the 2015 FMS



Market Overview

Massive data growth is driving SSDs into the data center with NVMe as the interface of choice



Data Center SSD Market
Will be approaching \$10B
in 2018, was \$4.6B in 2014



2018 DC Storage TAM
More than 40% of revenue
projected to be SSDs, the
rest on HDDs



NVMe by 2017
Half the data center SSD
market is NVMe by 2017

NVMe Over Fabrics

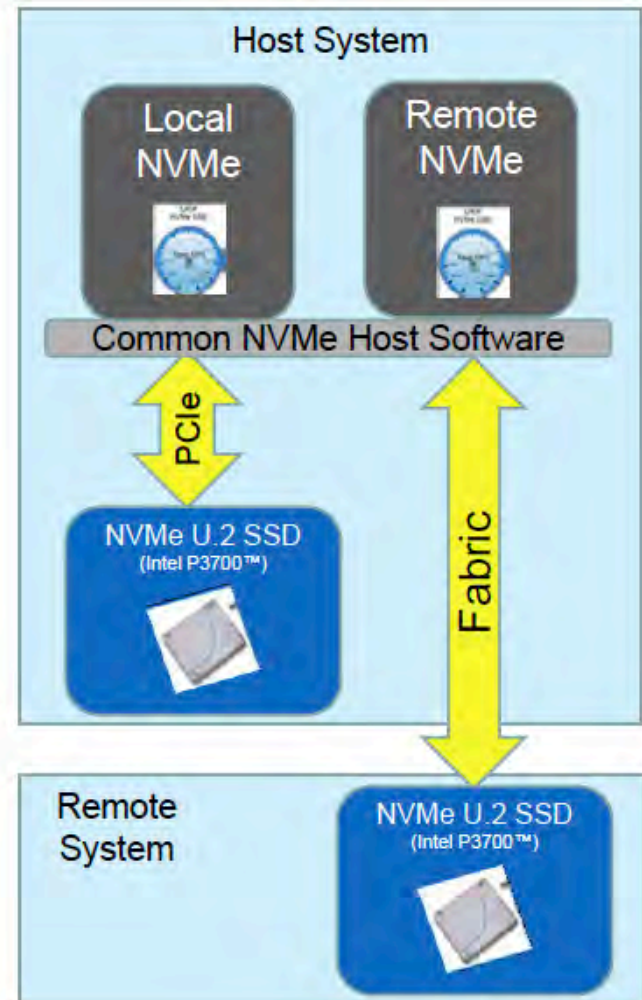
Jim Pappas, 2015 FMS

Goal: Establish viability of remote NVMe vs. local NVMe

- Within ~ 10 μ s latency
- Minimal IOPS decrease

Result:

- 8 μ s latency
- Zero IOPS decrease



All Flash Storage Systems

Oracle Keynote, 2015 FMS

FS: Advanced High Availability Scale-Out Architecture Grows with Your Business

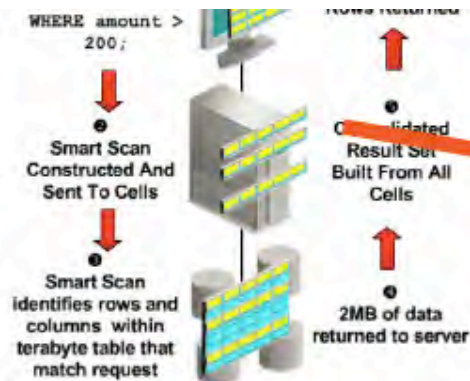
- Up to 16 HA Nodes
- Petabytes of Flash
- Up to 2M 50/50 R-W IOPS
- Up to 80 GB/sec Throughput
- Up to 6.6TB Cache, 128 Ports
- 512 Secure Storage Domains
- Full Suite of Data Services

ORACLE®



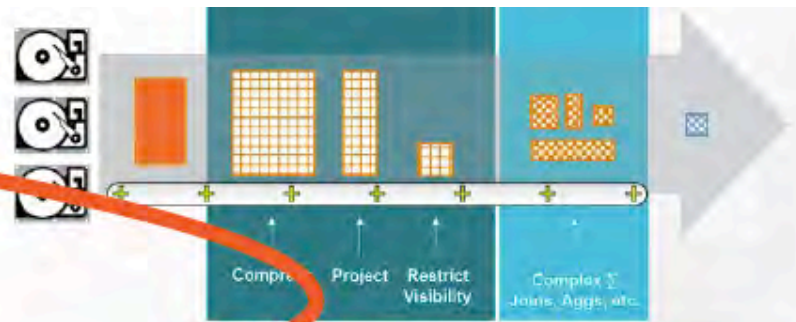
Near Data Processing Technologies

Yang Seok Ki, Samsung, 2015 FMS

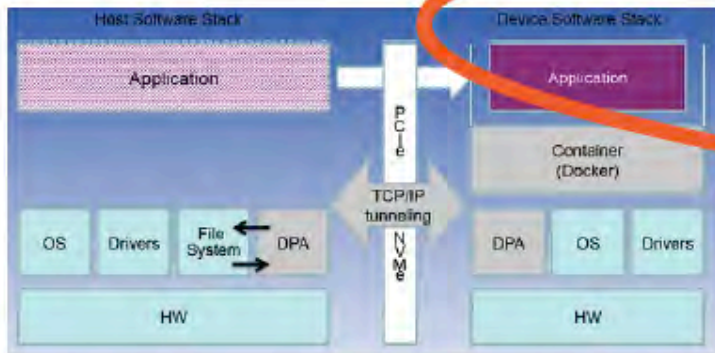


Exadata [Oracle]

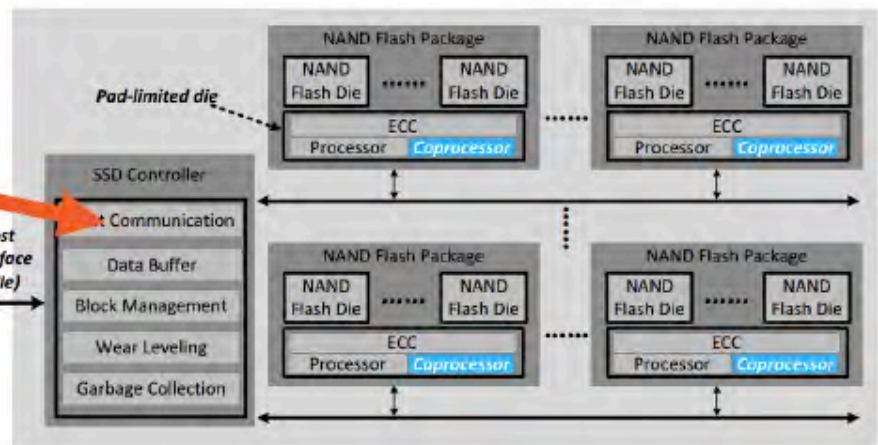
Closer to source



Netezza S-blade [IBM]



Intelligent SSD [NxGnData]



Conclusions

- Faster memory/storage is needed for modern applications
- Flash memory developing into 3D flash—many future generations
- The storage/memory landscape has more options than ever—e.g. STT MRAM and 3D XPoint
- Non-volatile memories will replace volatile memories
- NVM and processors want to come together

References

- 2014 How Many IOPS Do You Really Need Report, Coughlin and Handy, Coughlin Associates
- 2014 and 2015 Emerging NVM Report and Their Manufacture, Coughlin Associates
- 2015 Storage Visions Conference Presentations
- Touch Rate: A metric for analyzing storage system performance, Steven Heltzer and Tom Coughlin, 2015
- Information on all these documents are available at: <http://www.tomcoughlin.com/techpapers.htm>



Thanks