The Future of Memory and Storage

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Tom Coughlin, President, Coughlin Associates is a widely respected digital storage analyst as well as business and technology consultant. He has over 37 years in the data storage industry with multiple engineering and management positions at high profile companies.

Dr. Coughlin has many publications and six patents to his credit. Tom publishes the *Digital Storage Technology Newsletter, the Media and Entertainment Storage Report*, the *Emerging Non-Volatile Memory Report* and other industry reports. Tom is also a regular contributor on digital storage for Forbes.com and other blogs.

Tom is the founder and organizer of the Annual Storage Visions Conference (www.storagevisions.com), a partner to the International Consumer Electronics Show, as well as the Creative Storage Conference (www.creativestorage.org). He has been the general chairman of the annual Flash Memory Summit, the world's largest independent storage event. He is a Senior member of the IEEE and a member of the Consultants Network of Silicon Valley (CNSV). For more information on Tom Coughlin and his publications go to www.tomcoughlin.com.

Outline

- A Hierarchy of Storage and Memory
- Non-Volatile Memory Trends
- NVMe-Fabrics and Memory Centric Computing

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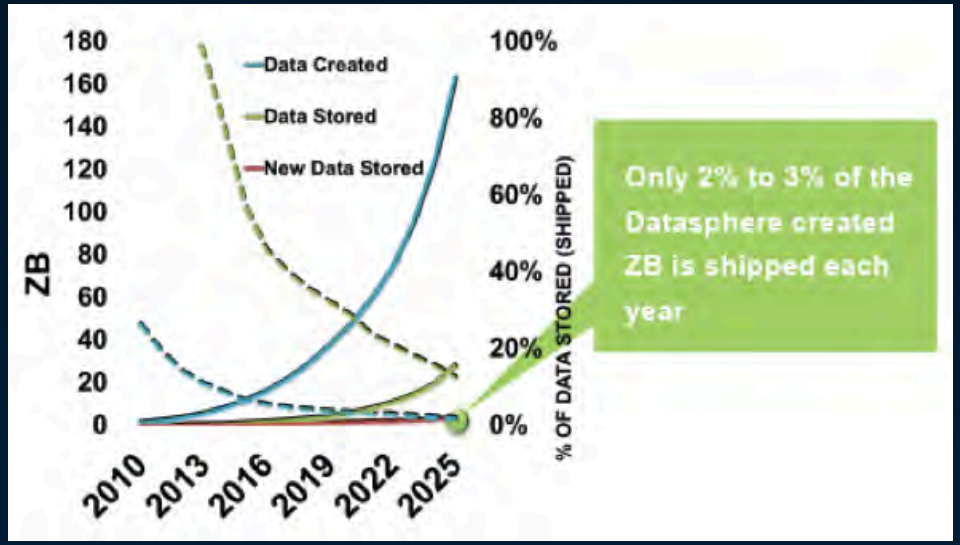
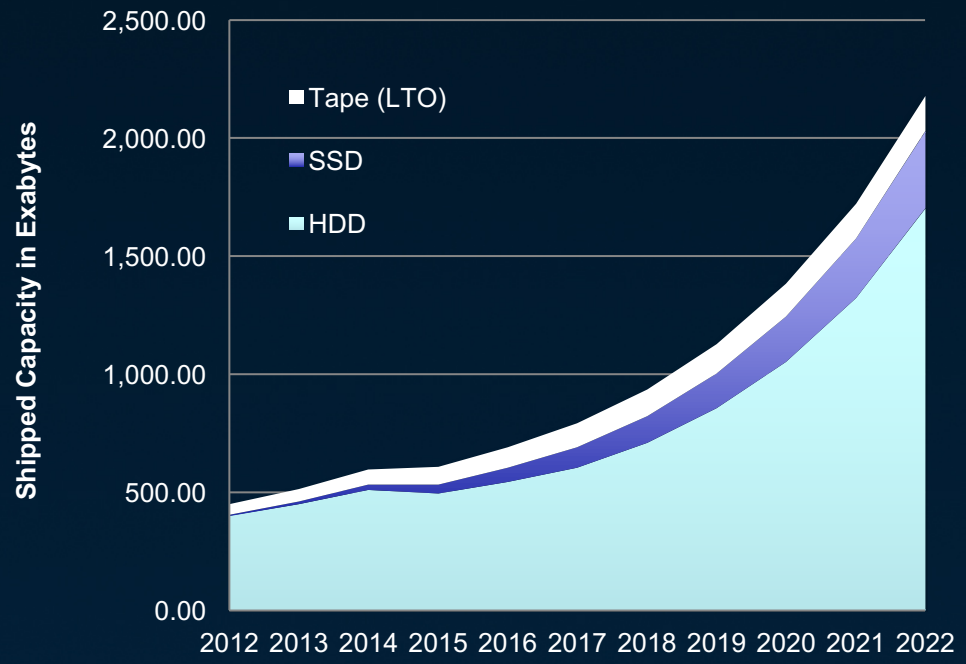
A Hierarchy of Storage and Memory

Drivers for Storage and Memory

- Increasing storage demands—IDC 163 Zetabytes of data created by 2025 (16 ZB in 2016)
- New sources for unstructured data from media and entertainment, IoT, medicine, geo-science and big data
- Growth in local storage, storage at the edge (or the fog) and storage in large data centers (the cloud)
- There is a need for fast memory and storage to support processing and accessing this data and cheap storage to keep it for the long term

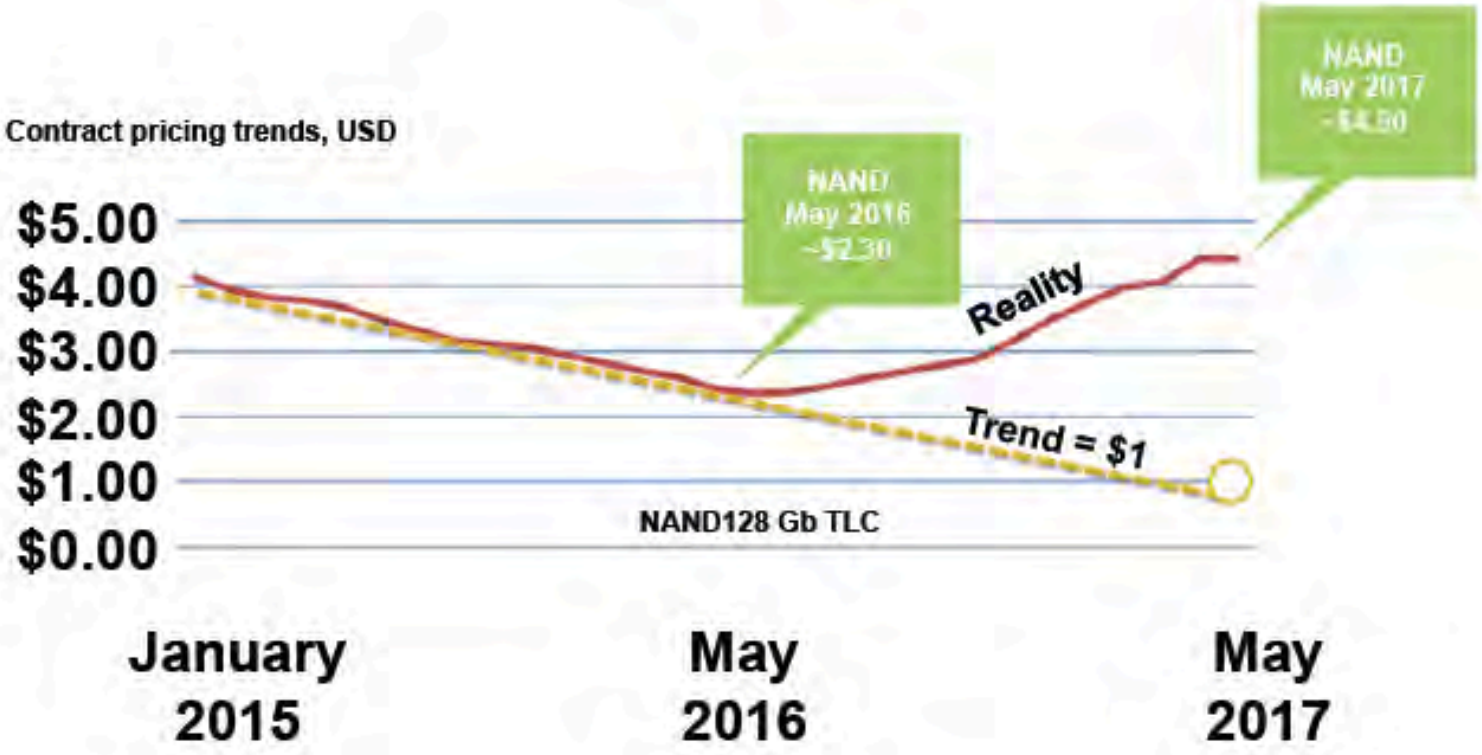


Digital Storage Capacity Projections



- The growth and processing of data will lead to the use of many types of digital storage
- SSDs will dominate for high performance storage
- HDDs will be high capacity and used for colder storage
- Magnetic tape will be used by some organizations for the lowest cost (currently <1 cent/GB)

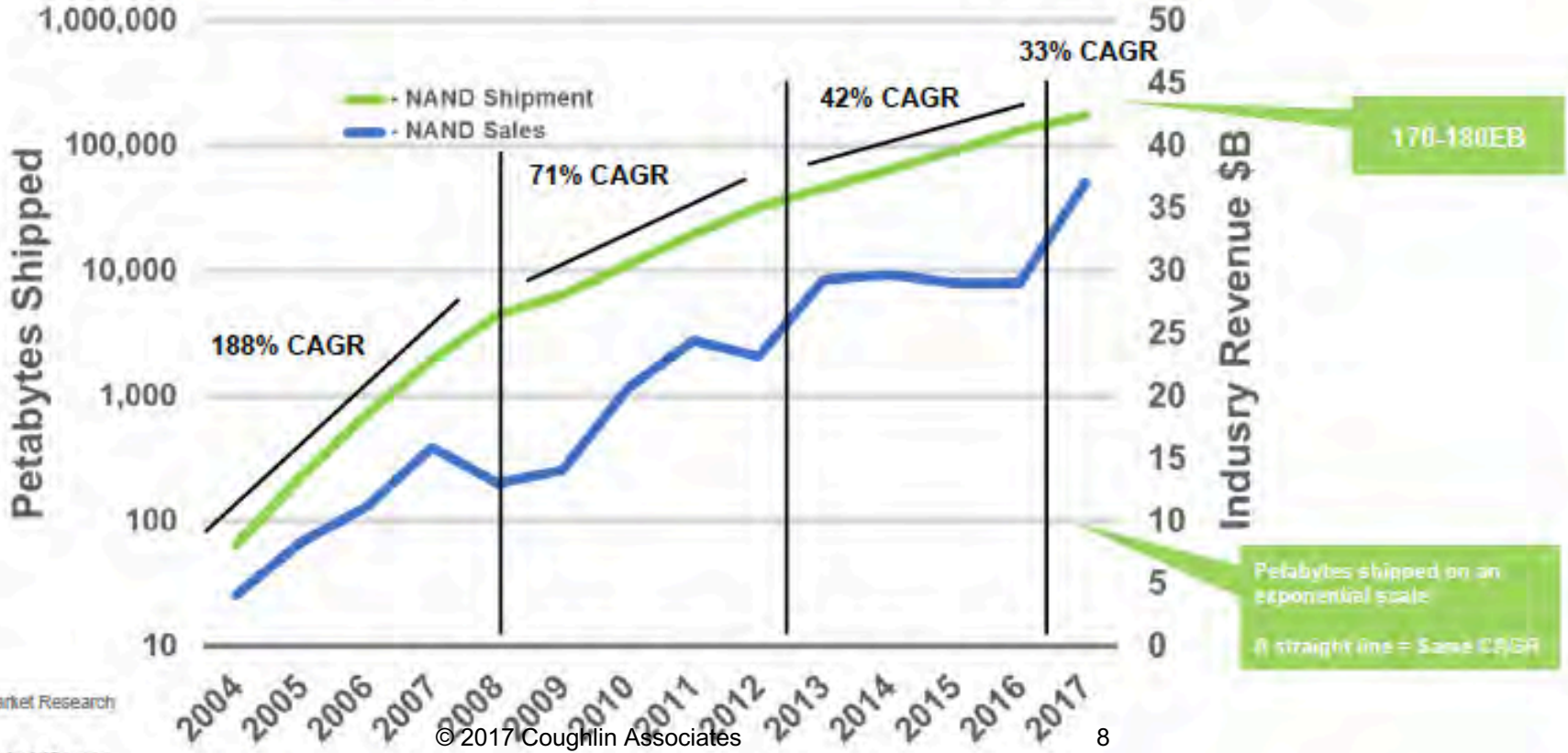
Our storage pie just got upset



Seagate Market Research

Looking at NAND from the long run

THE EB SHIPPED CAGR IS SLOWING, BUT STEADY GROWTH[1]



Seagate Market Research

1 Over the last 13 years

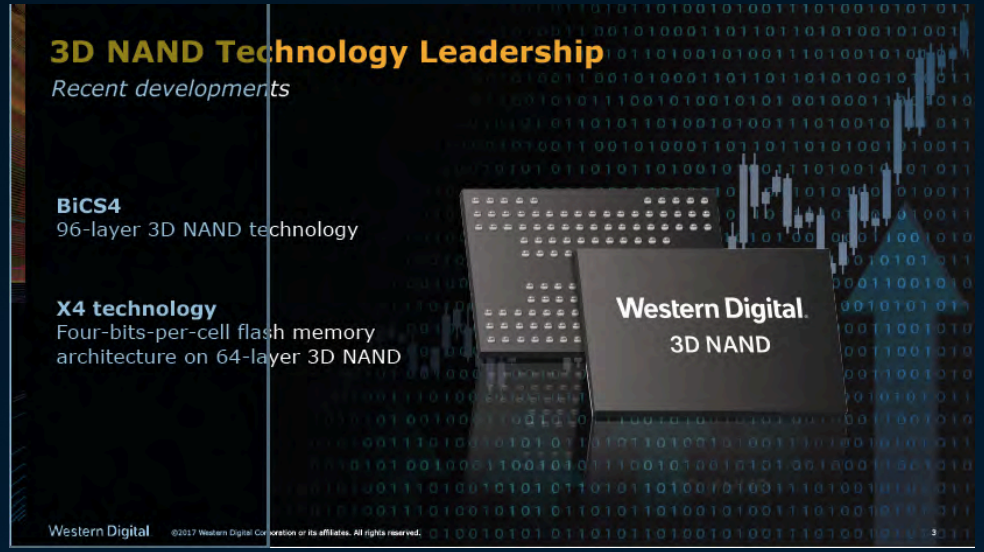
Non-Volatile Memory Trends

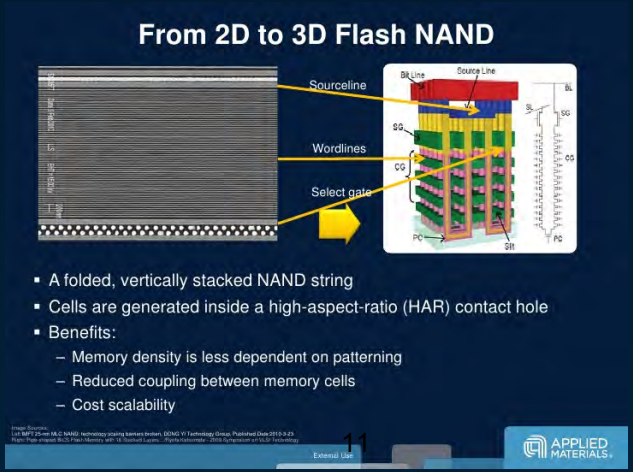
The move to Non-Volatile Storage

- NVMe PCIe-based storage interfaces avoid much of the overhead of hard disk drives—designed for fast solid state storage
- 2D to 3D manufacturing transition is underway with 3D yields improving and achieving cost parity with 2D by 2018
- 3D flash fab investments are over $10 B US per plant-many being build—now at 96 layers
- Shortage of flash memory throughout 2017 and into 2018 is due to yield issues with the 3D flash transition

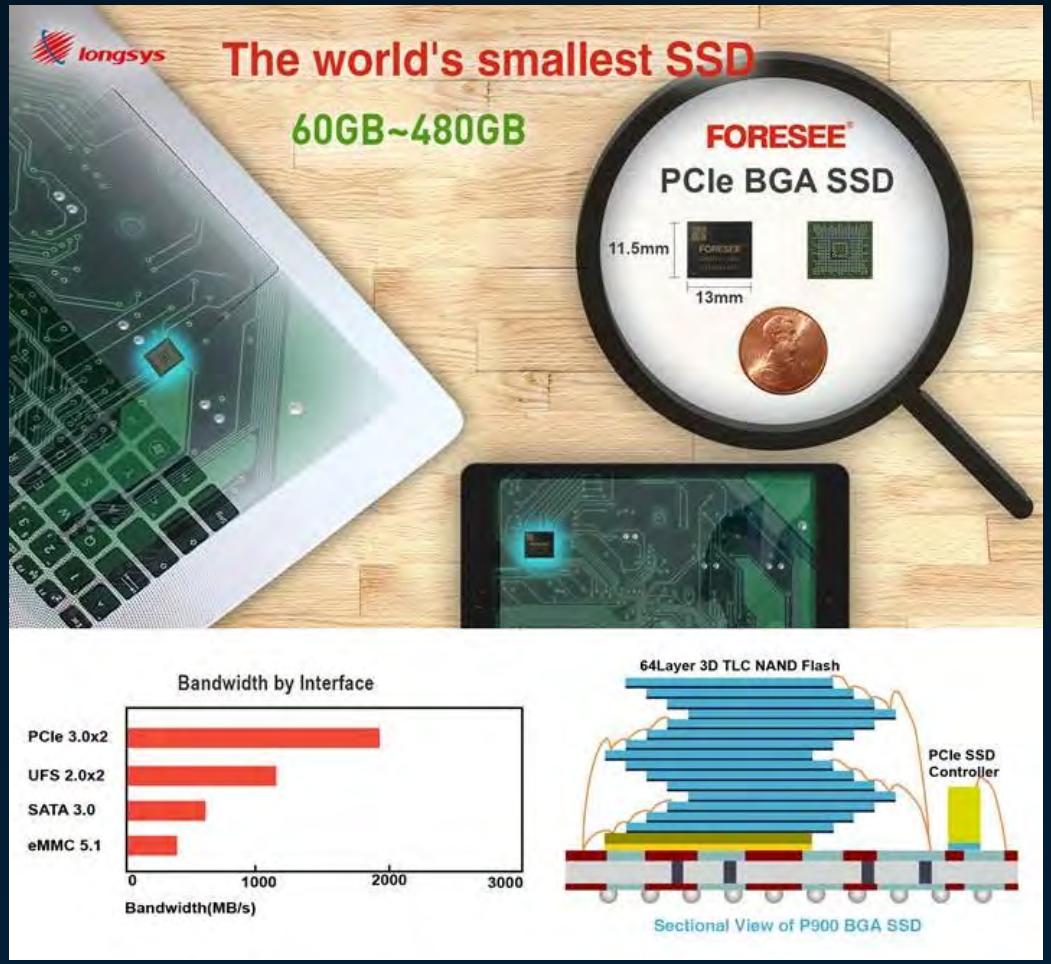
3D Flash

- Shipments up to 64 layer—common by end of year
- Announcements up to 96 layers—1 Tb per die
- Technology projections of hundreds of layers
- Announced quad-level cells for higher density

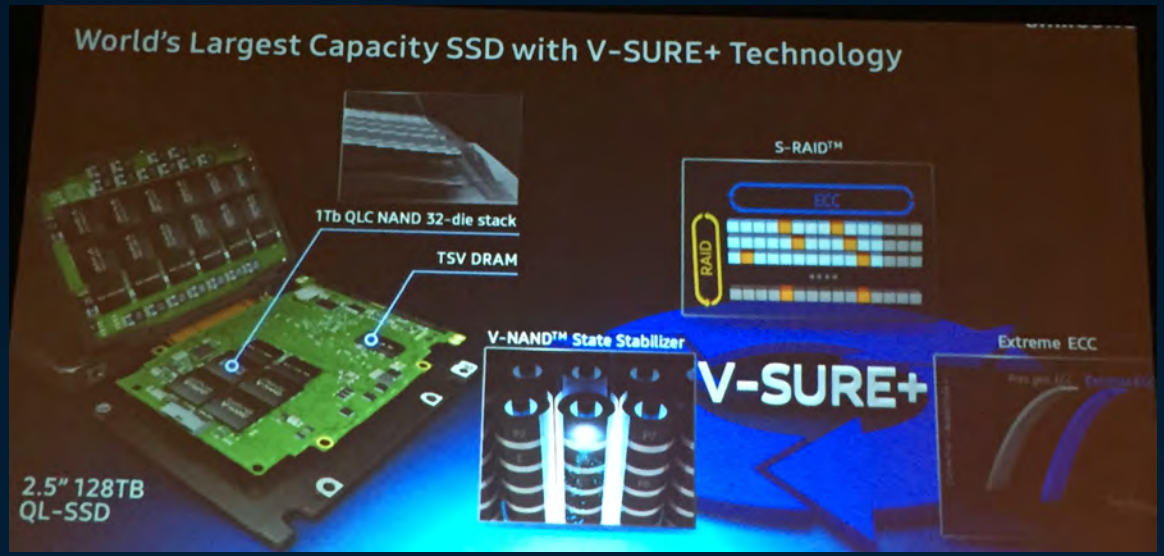




1U Form Factor NVMe SSDs


longsys
The world's smallest SSD
60GB~480GB
FORESEE
PCIe BGA SSD
11.5mm
13mm
Bandwidth by Interface
PCIe 3.0x2
UFS 2.0x2
SATA 3.0
eMMC 5.1
0
1000
2000
3000
Bandwidth(MB/s)
64Layer 3D TLC NAND Flash
PCIe SSD Controller
Sectional View of P900 BGA SSD

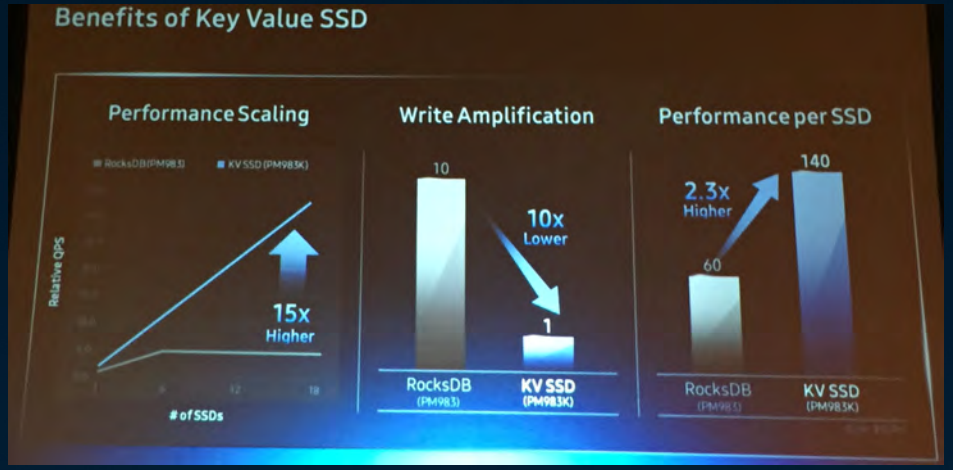
Samsung's 128 TB SSD



- Samsung's latest V-NAND chip is a a 1Tb V-NAND chip, available next year.
- This will enable 2TB of memory in a single V-NAND package by stacking 16 1Tb dies
- Using 32-die stack of 1 Tb QLC NAND the company was showing a 2.5" form factor 128 TB SSD.

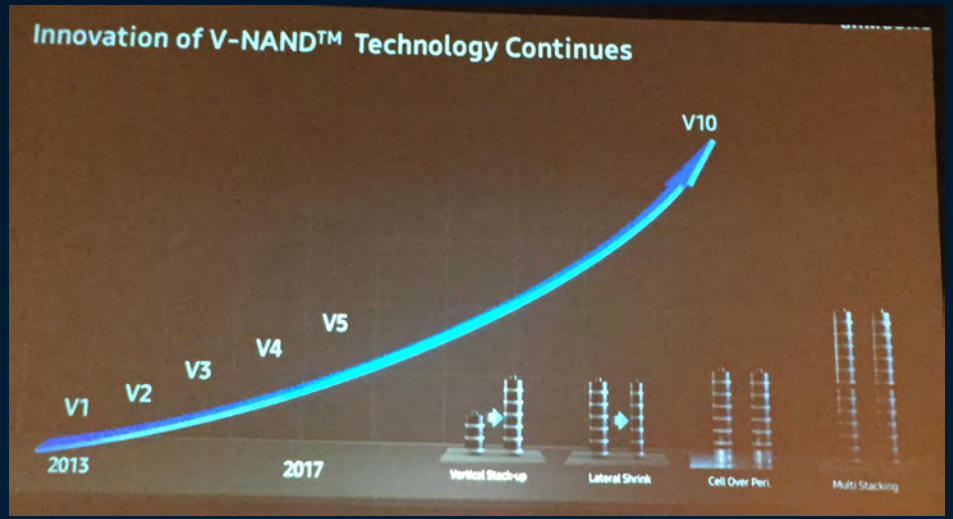
Key Value SSD

- Samsung introduced a Key Value SSD. KVS is a way to organize data in storage for more rapid access that is commonly used in object storage systems.
- Samsung's Key Value assigns a 'key' or specific location to each "value," or piece of object data – regardless of its size, enabling direct addressing of a data location
- Samsung's Key Value technology enables SSDs to scale-up (vertically) and scale-out (horizontally) in performance and capacity.



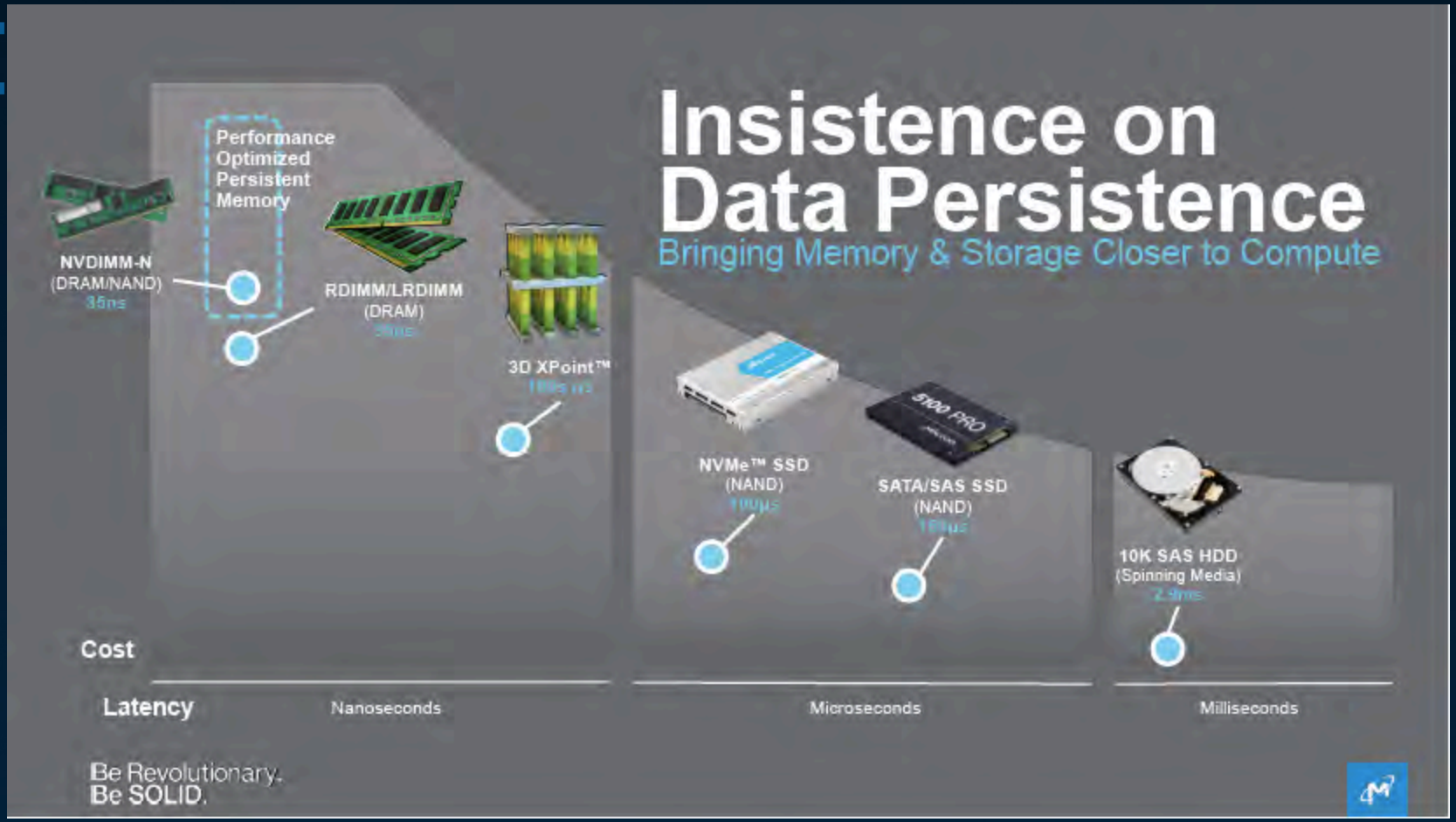
When data is read or written, a Key Value SSD can reduce redundant steps, which leads to faster data inputs and outputs, as well as increasing TCO and significantly extending the life of an SSD

More Generations of V-NAND



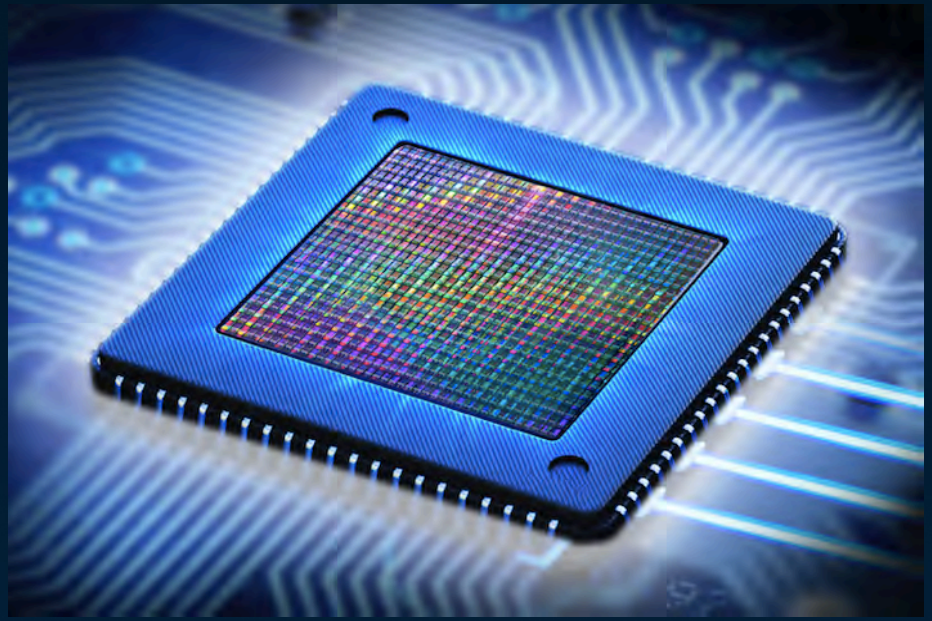
- Samsung was presented their V-NAND roadmap showing--at least 5 more generations of V-NAND beyond their announced 5th generation.
- These higher capacity products will leverage three technological developments.
- These include continued vertical stacks (more 3D layers), lateral shrink (smaller features) and cell over peripheral (building the cell layers over the supporting CMOS logic.

Storage Fabrics and Memory Centric Computing


Insistence on Data Persistence
Bringing Memory & Storage Closer to Compute
Performance Optimized Persistent Memory
NVDIMM-N (DRAM/NAND)
35ns
RDIMM/LRDIMM (DRAM)
3D XPoint™
NVMe™ SSD (NAND)
SATA/SAS SSD (NAND)
10K SAS HDD (Spinning Media)
Cost
Latency
Nanoseconds
Microseconds
Milliseconds
Be Revolutionary.
Be SOLID.

NVMe over Fabric

- Mellanox announced their BlueField SoC for accelerating NVMe over Fabrics (200 Gb/s of throughput and more than 10 million IOPS in a single SoC device)
- A French company, Kalray said that it has released a high-performance NVMe-oF target controller for enabling NVMe-based (JBOF) array boxes.



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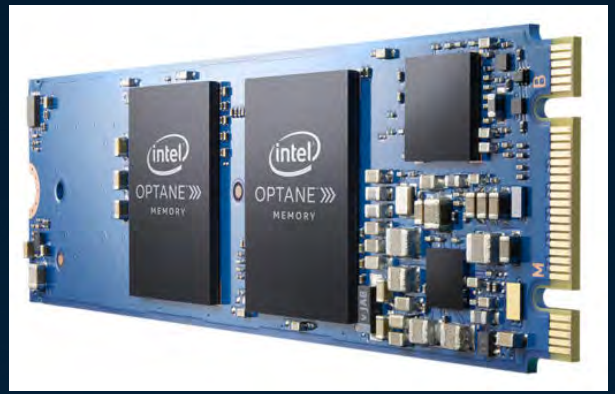
MRAM and PRAM

- MRAM
  - Everspin shipped over 70 M MRAM Chips. Company has partnership with Global Foundries, who is building 300 mm wafers and targeting embedded memory applications
  - Samsung--plans to ship STT MRAM product samples by 2018.
  - Seagate was showing an Everspin MRAM boot SSD at the 2017 FMS
- PRAM
  - Intel says their Optane NVMe products will ship this year.
  - Micron planning to introduce DIMM-based 3D XPoint product

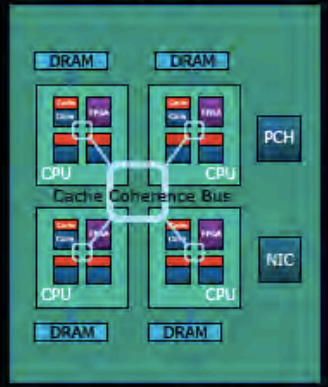


Memory-centric Computing

For many emerging challenges, memory capacity, memory access latency and memory bandwidth are more constrained than compute resources

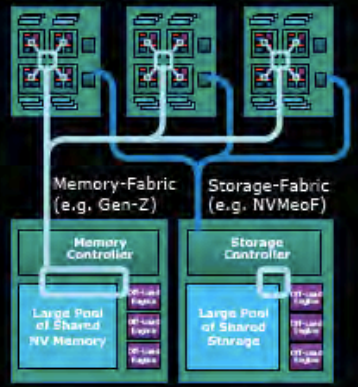
- **Memory Disaggregation**
  Remove memory from behind the processor
- **Memory Pooling & Sharing**
  Enable efficient use of memory. Address new class of problems with large memory footprint
- **Heterogeneous Compute**
  Enable multi-vendor heterogeneous compute (e.g. ML accelerators)

2018



CPU-centric architecture

2020



Data-centric architecture

Western Digital 19

Conclusions

- More data means faster data processing and greater demand for fast memory
- There will be many types of storage technology used for several more years
- NVMe and NVMe-oF allow building storage devices and network storage without restrictions from HDD interfaces
- 2017 FMS brought many interesting products to market
- The groundwork is being laid for memory centric computing

References

- 2017 FMS Keynote Presentations by Intel, Micron, Samsung, Seagate, Western Digital
- Steve Hetzler and Tom Coughlin, Touch Rate: A metric for analyzing storage system performance, www.tomcoughlin.com/Techpapers


Thanks