

G2M Research Multi-Vendor Webinar: Advanced NVMe[™] SSDs – Changing the Game

Tuesday September 24, 2019



Webinar Agenda

- **9:00-9:05** Ground Rules and Webinar Topic Introduction (G2M Research)
- **9:06-9:26** Sponsoring Vendor presentations on topic (7 minute each)
- **9:27-9:28** Audience Survey 1 (2 minutes)
- **9:29-9:39** Key Question 1 (2-minute question; 2 minutes response per vendor)
- **9:40-9:41** Audience Survey 2 (2 minutes)
- **9:42-9:52** Key Question 2 (2-minute question; 3 minutes response per vendor)
- **9:53-9:54** Audience Survey 3 (2 minutes)
- **9:55-10:05** Key Question 3 (2-minute question; 3 minutes response per vendor)
- **10:06-10:18** Audience Q&A (13 minutes)
- 10:19-10:20 Wrap-Up





G2M Research Introduction and Ground Rules

Mike Heumann Managing Partner, G2M Research







Dave Montgomery Director, Data Center Systems (<u>www.wdc.com</u>)





Scott Shadley VP of Marketing (<u>http://www.ngdsystems.com</u>)



TOSHIBA

Matt Hallberg Sr. Product Marketing Manager (<u>www.taec.toshiba.com</u>)



Jonmichael Hands Product Manager, SSDs (www.intel.com)

Host/Emcee:

Mike Heumann Managing Partner G2M Research www.g2minc.com







What is a Solid State Drive (SSD)?

- A simple view of SSDs is that they are a bunch of NAND chips on a board, mounted in a protective carrier
 - They can have more or less buffering RAM
 - Some "driver" or management capabilities can also be embedded in the controller
 - AND they have "standard" PC formats (2.5" drive or PCIe add-in card formats)





How Have SSDs Changed the Storage Landscape?

- SSDs ("Flash") have significantly reduced storage media latency vs HDDs
 - NVMe further accelerates this trend
 - SSDs have also made storage reliability more predictable
- SSD vendors are now adding new features and capabilities to NVMe SSDs
 Processing ("Computational Storage")
 - Interfaces beyond PCIe (Ethernet)
 - Accelerator functionality (FPGAs)
- How does the role of SSDs evolve/change in the near future?



VS







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Dave Montgomery Director, Data Center Systems <u>www.wdc.com</u>

Forward-Looking Statements

Safe Harbor | Disclaimers

This presentation contains certain forward-looking statements that involve risks and uncertainties, including, but not limited to, statements regarding solid-state storage technology, upcoming storage platforms, and product development efforts, business strategy, growth opportunities, market adoption, demand for digital storage and market trends. Forward-looking statements should not be read as a guarantee of future performance or results, and will not necessarily be accurate indications of the times at, or by, which such performance or results will be achieved, if at all. Forward-looking statements are subject to risks and uncertainties that could cause actual performance or results to differ materially from those expressed in or suggested by the forward-looking statements.

Key risks and uncertainties include volatility in global economic conditions, actions by competitors, business conditions, growth in our markets, product development, pricing trends and fluctuations in average selling prices, and other risks and uncertainties listed in our filings with the Securities and Exchange Commission (the "SEC") and available on the SEC's website at www.sec.gov, including our most recently filed periodic report, to which your attention is directed. We do not undertake any obligation to publicly update or revise any forward-looking statement, whether as a result of new information, future developments or otherwise, except as required by law.

What We'll Cover in Today's Webinar

- NVMe Expertise at Western Digital
- SSD portfolio
- NVMe portfolio- Platforms
- Additional Resources

We are Leading the NVMe (R)evolution

We design, tune and optimize across the entire NVMe Technology Stack







NVMe Components

NAND, 3D NAND, Controllers, Firmware/FTL

NVMe Flash Modules, SSD, and Adapters

NVMe Platforms

NVMe Servers, NVMe-oF JBOFs

Leading Cloud Vendors | Major Storage OEMs | Top PC Vendors

What We'll Cover in Today's Webinar

- NVMe Expertise at Western Digital
- SSD portfolio
- NVMe portfolio- Platforms
- NVMe portfolio- IntelliFlash System
- Additional Resources

Western Digital Data Center Storage Portfolio

A Trusted Partner Delivering Innovation Across All Technologies



NVMe SSD Segmentation

Ultrastar NMVe SSDs For Data Centers

0.3 or below DW/D	< 1 DW/D	1-3 DW/D	10+ DW/D
 VRI Storage Very Read-Intensive Workloads Content Delivery Networks Cloud Gaming Storage 	 Read-Intensive Workloads Scale-out Architectures Cloud SQL & Object Storage Hyperscale and Cloud Services 	 Caching & Compute Mixed Workloads SSD Caching Layer Hyper Converged & Database Compute-Intensive Workloads: AI/ML, Analytics, E-Commerce 	 Accelerator Write-Intensive Workloads In Memory Database Accelerator ERP, SaaS, Financial Memory Extension
Inc	creasing NVMe Performance	- & Endurance Requirements	
DC SN340 NVMe SSDs	DC SN640 NVMe SSDs	DC SN200 NVMe SSDs	DC ME200 Memory
 3.84TB & 7.68TB in 7mm 2.5" U.2 Focused on large block writes (32K/128K/) Delivers best IOPS/WATT and Optimized for Read QoS 	 800GB to 7.68TB in 2.5" U.2 4K/8K Writes support Read/Write QoS optimized Image: Constant of the second of the second	 Up to 7.68TB in Choice of HH-HL AIC or 2.5-inch SFF Optimized for 4K Random R/W Workloads -> up to 1.2M IOPS 	 Extension 1-4TB in Choice of HH-HL AIC or 2.5- inch SFF Combines Software + Hardware Solution for Transparent Memory Capacity

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What We'll Cover in Today's Webinar

- NVMe Expertise at Western Digital
- SSD portfolio
- NVMe portfolio- Platforms
- Additional Resources

Western Digital Platform Portfolio

Going "all in" on NVMe and NVMe-oF Storage



The "gold standard" for Software-Defined Storage

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What We'll Cover in Today's Webinar

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- SSD portfolio
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Additional Resources

Learn more about today's topic below:

- Western Digital Blogs
 - <u>2019 The Year of NVMe[™]</u>!
 - <u>The Next Generation Data Center: How the Data</u> <u>Center Will Evolve to Accommodate the</u> <u>Demands of Data</u>
 - <u>An Insider's View into the Future of Data</u> <u>Infrastructure</u>
- Related Webinar
 - <u>NVMe All-Flash Arrays: How to Make the Right</u> <u>Decision for your Enterprise Storage</u>

- Supporting Content
 - ESG Report: The Rise of NVMe
 - <u>eBook: NVMe Storage for Dummies</u>
 - Video: How NVMe Enables Data to Thrive

- Other Resources
- Western Digital Data Center Systems
- Western Digital Resources

https://www.westerndigital.com/products/storage-platforms

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NGD Systems

Scott Shadley
 Vice President of Marketing
 www.ngdsystems.com



Cool Vendor 2018







NGD Systems.

Advancing NVMe with Computational Storage

September 2019





NVMe is Simply Not Enough.

More Lanes, More Traffic

- Data lives among us in abundance
- IDC predicts we will churn out 175 zettabytes of data
- A number much like the US debt of <u>\$22 trillion</u>



NVMe Computational Products at a Glance.

- Large Breadth of HW solutions and Capacity Options
- Industry leading W/TB Energy Efficiency
- Industry's Only 16-Channel M.2
- Delivering the largest capacity U.2

Form Factor	Capacity	Power (W)
M.2 22110	2 to 8 TB	8
EDSFF 1U Short	4 to 16 TB	12
EDSFF 1U Long	4 to 32 TB	12
U.2 15mm	4 to 32 TB	12
AIC FHTQL	8 to 64 TB	15

M.2

U.2

EDSFF







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Amplifying TCO for Hadoop





 $\begin{array}{c} 38 \\ \hline 4 \text{-core host} \\ \hline 33 \\ 28 \\ 23 \\ 18 \\ 0 \\ 2 \\ 18 \end{array}$

Number of Computational Storage Devices



Datanode Config: Single E5-2620v4, 32GB DRAM, 12*8 TB SAS HDD **18U Total Density in 18U = 864TB**

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@ Scale Saves Power! Saves Space! Saves Time!



Datanode Config:

Single E5-2620v4, 32GB DRAM, 36*8TB NVMe

3U Total Density in 3U = 864TB

432 Additional Drive Cores

	Last Charles Color

Terasort energy consumption

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Cool Vendor 2018







How Can We Help?

info@ngdsystems.com

World Leader in NVMe Computational Storage





TOSHIBA

Toshiba

Matt Hallberg Sr. Product Marketing Manager <u>www.taec.toshiba.com</u>

Dual Port NVMe[™] Standard SSDs





Drive-level Security



Lower

Level of Data Security

Higher

RESEARCH

How secure does your data need to be?

SIE: Sanitize Instant Erase. SIE is compatible with the Sanitize device feature set. The Sanitize device feature set is the standard prescribed by T10 (SAS) and T13 (SATA) committees of American National Standards Association (ANSI), which makes it possible to invalidate the data recorded on the magnetic disks at a blink.

NVMe[™] Standard 1.3: Directives / Streams



NVMe[™] Standard 1.3 Telemetry

- Standardized method to pull telemetry logs
- Moves away from vendor-specific tools
- Gives customers the ability to pulls debug logs, etc. from the drive instead of having to send the drive to the supplier for further analysis
- Can view the logs after running workloads to help determine impact on SSD wear (WAF)



What NVMe[™] Standard SSDs does Toshiba Memory offer?

CM5 Series

- Consistent performance and reliability in demanding 24x7 environments
- ✓ Take advantage of the latest NVMe[™] 1.3 features
- Designed for high density storage deployments
- Supports single and dual-port operation

Key Features

E2E Data Correction	Yes
NVMe-MI – NVMe Basic Management CMDs	Yes
NVMe-MI – MCTP over SMBus	Yes
SRIS	Yes
Native Sector Size Support	512:0/8/16 4096: 0/8/64
Protection Information Support (PI)	Yes
Namespace - Number	16
Namespace - Management	Yes
Dual Port (2x2)	Yes
Multi-Stream	Yes
VMWare VSAN	Yes
Security	SIE, TCG- Opal, FIPS
¹ 4K aligned, sustained, entropy=100%	³ 128KB (QD=32

¹ 4K aligned, sustained, entropy=100% ² Read 128KB (QD=32)

⁴4KB (QD=32)

TOSHIBA Enterprise NVMe™ SSD Bics FLASH™

⁶ QD=1, aligned, random 4KB

User Capacity		800GB(3DWPD) to 15360GB (1DWPD)						
NAND		BiCS Gen. 3 eTLC						
Interface		PCle Gen 3.0 1x4 / NVMe 1.3c						
Form Factors		2.5" 15mm, AIC x4 HHHL						
	Sequential Read ² (MiB/s)	Up to 3100						
Performance ¹	Sequential Write ³ (MiB/s)	Up to 2900 (Capacity Dependent)						
renormance	Random Read ⁴ (KIOPS)	Up to 770K (Capacity Dependent)						
	Random Write ⁵ (KIOPS)	Up to 165K (Endurance Dependent)						
Latency								
Read/Write	μs (typ.) ⁶	110/30						
Endurance ⁸	DWPD	1/3						
Data Retention (@) EOL, power removed)	3 months @ 40 °C						
Security		Non-SED / SIE / TCG Opal / FIPS 140-2						
MTTF (MPOH)		2.5 (AFR 0.35%)						
Limited Warranty		5 yrs.						
Power Loss Protect	ction	Yes						
Power W/ (two)	Active	Configurable 9, 11, 14, 18W						
	Idle	6						
Temperature	Ор	0 to 70 Tc C°						
remperature	Non-op	-40 to 70 Ta C°						

Additional Details:

https://business.toshiba-memory.com/en-us/product/storageproducts/enterprise-ssd/cm5-r-1dwpd-series.html https://business.toshiba-memory.com/en-us/product/storageproducts/enterprise-ssd/cm5-v-3dwpd-series.html

⁷ QD=32, aligned, random 4KB
 ⁸ Per life w/ 4KB aligned random W



Additional Datacenter NVMe[™] Standard Offerings

Data Center U.2 NVMe[™] SSD Features

- Consistent performance and reliability in demanding 24x7 environments
- Superior QoS for greater service level agreement compliance
- Designed for high density server / hyperscale deployments

E2E Data Correction	Yes
NVMe-MI – NVMe Basic Management CMDs	Yes
NVMe-MI – MCTP over SMBus	Yes
NVMe-MI – MCTP over PCIe	No
SRIS	No
Native Sector Size Support	512, 4096
Protection Information Support (PI)	No
Namespace - Number (Per single port)	8
Namespace - Management	Yes
Controller Memory Buffer (CMB)	No
Dual Port (2x2)	No
SRIOV	No
Multi-Stream	No
Security	SIE, TCG- Opal, FIPS

Key Features



User Capacity		960GB	7680GB					
NAND		BiCS Gen. 3 eTLC						
Interface		PCIe Gen 3.0 1x4 / NVMe 1.3						
Form Factors			2.5″	15mm				
	Sequential Read ² (MiB/s)		Up to	0 3000				
Performance ¹	Sequential Write ³ (MiB/s)	840	840 750 1450					
renormance	Random Read ⁴ (KIOPS)	305	270	465	520			
	Random Write ⁵ (KIOPS)	20	20	40	50			
Latency								
Read/Write	µs (typ.) ⁶	130/30 135						
Endurance ⁸	DWPD	960/1920GB: 0.5 3840/7680GB: 0.64						
Data Retention (@	EOL, power removed)	3 months @ 40 °C						
Security		Non-SED / SIE / TCG Opal / FIPS						
MTTF (MPOH)		2.5 (AFR 0.35%)						
Limited Warranty		5 yrs.						
Power Loss Prote	ction	Yes						
Dowor M (two)	Active	Configurable 9, 11, 14W						
Power w (typ.)	Idle	6						
Temperature	Ор		0 to 7	O Tc C°				
remperature	Non-op		-40 to 7	70 Ta C°				

Additional Details:

https://business.toshiba-memory.com/en-us/product/storageproducts/data-center-ssd/cd5.html







Intel

Jonmichael Hands Product Manager, SSDs <u>www.intel.com</u>

Intel SSD DC P4510 Series Advanced Features



Features and Benefits



Cloud Inspired. Storage Optimized.

The DC P4510 meets the requirements of the modern data center. It significantly increases server agility and utilization, and accelerates applications across a wide range of workloads.



Do More Per Server

Intel's 64-layer, TLC, 3D NAND technology enables the DC P4510 to double the capacity available compared to its predecessor, the DC P4500. This increased density is key to supporting broader cloud workloads, allowing cloud service providers to increase users and improve data service levels.



Optimized QoS, Bandwidth, and Performance

With the increased density of Intel 64-layer 3D NAND and enhanced firmware features, the DC P4510 is built to handle read-intensive workloads and beyond. The DC P4510 creates greater Quality of Service, bandwidth, and performance to lead data centers through their evolving transformation.



Minimize Service Disruptions

Enhanced SMART monitoring of the drive health and status coupled with industry-leading end-to-end data path protection and power loss imminent (PLI) features ensures telemetry information without disrupting ongoing I/Os.



New Firmware Features for Intel SSD DC P4510/P4610/P4511

5th release of firmware supports the following new features

- Firmware activate without reset
- Multiple firmware slots (up to 4)
- Multiple Namespaces (up to 128)
- NVMe-MI 1.0 over SMBUS additional optional features
- OPAL 2.0 (Intel offers as separate product sku)



Firmware Update w/o Reset – Commit 03h



Example of firmware that is booted from SPI but stored in NAND for redundancy

- Commit action 03h functions similarly to standard 01h commit but does not require the reset.
- Internally the system will quiesce internal work and transition firmware without requiring a full internal warm reset action (to meet timing requirements).



Command line example on P4510 for Multiple Firmware Slot

Make sure the firmware on P4510 is MR5(VDV10152) or later version

[root@localhost ~]# nvme list grep nv	vme0							
/dev/nvme0n1	BTLJ7381008B2P0BGN	INTEL SSDPE2KX020T8	2.00	TB /	2.00	TB	512	B + 0 B	VDV10152

You can check available firmware in slots and active firmware slot. Below example shows there is only one firmware VDV10152 in FW slot 1 and the slot is also the active FW slot

[root(ğloc	alł	nost	t~]	# r	nvme	e ge	et - 1	Log	/de	ev/r	nvme	e0 -	·i 3	3 -1	. 64	ł
Device	<pre>Device:nvme0 log-id:3 namespace-id:0xfffffff</pre>																
	0	1	2	3	4	5	6	7	8	9	а	b	С	d	е	f	
0000:	01	00	00	00	00	00	00	00	56	44	56	31	30	31	35	32	"VDV10152"
0010:	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	""
0020:	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	""
0030:	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	""

Download another firmware (VDV10152 or later version), activate, and apply to firmware slot 2

<pre>[root@localhost ~]# nvme fw-download /dev/nvme0</pre>	-f VDV10153_VB1B015A_WFEM01K0_signed.bi
Firmware download success	
<pre>[root@localhost ~]# nvme fw-activate /dev/nvme0</pre>	-s 2 -a 3
Success activating firmware action:3 slot:2	
<pre>[root@localhost ~]# nvme get-log /dev/nvme0 -i 3</pre>	3 -1 64
<pre>Device:nvme0 log-id:3 namespace-id:0xfffffff</pre>	
0 1 2 3 4 5 6 7 8 9 a b c d	e f
0000: 12 00 00 00 00 00 00 00 56 44 56 31 30 31	35 32 "VDV10152"
0010: 56 44 56 31 30 31 35 33 00 00 00 00 00 00	00 00 "VDV10153"
0020: 00 00 00 00 00 00 00 00 00 00 00 00 0	00 00 ""
0030: 00 00 00 00 00 00 00 00 00 00 00 00 0	00 00 ""



- A namespace is a quantity of non-volatile memory that may be formatted into logical blocks. When formatted, a namespace of size n is a collection of logical blocks with logical block addresses from 0 to (n-1). Once it is created, it is seen as a physical device on OS level.
 - New firmware supports up to 128 namespaces
 - Create and Delete a namespace
 - Attach or Detach a namespace to/from a controller
 - Report of namespace & NVM pool status, including namespaces that exist, amount of unallocated space in NVM pool, etc.
 - Retrieve SMART, Get Features and NVM Format per Namespace supported (same host sector size across multiple NS, different sector sizes across NS not supported)





Methods of overprovisioning NVMe SSD

First format or sanitize SSD to TRIM all LBAs

- Create partition smaller than total user capacity of SSD
- Limit max LBA of drive through vendor specific tools
- Create a namespace smaller than total user capacity
- Limit application use to smaller LBA range





	Opal
	System Area (FW, TCG Tables, etc.)
	Shadow MBR (128 MB)
	DataStore (10 MB)
Iser Data Space, Iways encrypted	Global Range Access control to unlock assigned by Admin
	Range X [†] Access control to unlock assigned by Admin
	Range Y [†] Access control to unlock assigned by Admin
<u></u> а	Global Range, Continued Same access control settings as above range
	Opal 2.00 SSC:

- [†]Supports Global Range plus at least 8 configurable ranges
- -
- MBR Shadow feature Required 4 Admins and 8 Users (Minimum) -





Panel Discussion

What is are the greatest concerns your organization has for the adoption of flash storage, both in servers and in storage systems? (check all that apply):

 Cost (as measured in \$/TB): 	52%
 Cost/TB deflation: 	24%
 Capacity: 	17%
 Reliability: 	39%
 Impacts on Application Performance: 	22%
 Storage Management: 	26%
 Avoiding Vendor Lock-In: 	33%
 Difficulties Migrating from Hard Disk Drives: 	9%
Other:	7%





- With the "blast radius" of individual SSDs growing beyond the needs of a single server (in many cases), how important do you think "networked SSDs", SSD virtualization, and/or scale-out flash storage software will be to enabling further growth in the SSD market?
 - Western Digital
 - NGD Systems
 - Toshiba
 - Intel



Who will you primarily look to for guidance when considering adoption of a new flash form factor (choose one):

 Server Vendors: 	13%
 Storage Systems Vendors: 	30%
 My System Integrator (SI) or reseller: 	4%
 End-User Focused Analysts (Gartner, IDC, Forrester, etc.): 9% 	
 My peers in the industry: 	11%
 SSD Vendors: 	32%
Other:	2%





- "Intelligent" SSDs of a variety of formats and features have been appearing over the last few years. Is this a niche market, and how do you see it evolving over time?
 - NGD Systems
 - Toshiba
 - Intel
 - Western Digital



What would be your biggest concerns when considering SSDs with "extended capabilities" (choose all that apply):

 Development environment maturity: 	38%
 Lack of support from application vendors: 	25%
 Application porting/adapting: 	33%
 Vendor lock-in: 	50%
 Lack of interoperability across devices: 	48%
 Lack of a clear potential ROI: 	23%
Other:	40%





- Flash is essentially the de facto mainline storage medium today for nearly every type of computing, and NVMe is quickly becoming the primary datacenter interface standard for flash. Where does flash go from here?
 - Toshiba
 - -Intel
 - Western Digital
 - NGD Systems











Thank You For Attending

