G2M Research Multi-Vendor Webinar #3: NVMe All-Flash Array (AFA) Use Cases

October 9, 2018

Sponsored By:
<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
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</table>
| 9:00-9:05 | Ground Rules and Webinar Topic Introduction  
(G2M Research) |
| 9:06-9:20 | Sponsoring Vendor presentations on topic (5 minute each) |
| 9:21-9:34 | Key Question #1 (2-minute question; 4 minutes response per vendor) |
| 9:35-9:36 | Audience Survey #1 (2 minutes) |
| 9:37-9:38 | Audience Survey #2 (2 minutes) |
| 9:39-9:52 | Key Question #2 (2-minute question; 4 minutes response per vendor) |
| 9:53-9:54 | Audience Survey #3 (2 minutes) |
| 9:54-10:08 | Key Question #3 (2-minute question; 4 minutes response per vendor) |
| 10:09-10:10 | Audience Survey #4 (2 minutes) |
| 10:11-10:18 | Audience Q&A (8 minutes) |
| 10:19-10:20 | Wrap-Up |
Panelists

Julie Herd  
Director, Technical Marketing  
E8 Storage  
www.e8storage.com

Dan Liddle  
VP of Marketing  
Newisys  
www.newisys.com

Tom Spencer  
Sr. Director, Product Marketing  
Solarflare Communications  
www.solarflare.com

Host/Emcee:  
Mike Heumann  
Managing Partner  
G2M Research  
www.g2minc.com
The Evolution of Storage Arrays

- **Form Factors**
  - Historically storage arrays were multi-rack systems connected to director-class FC switches
  - Storage arrays today are disaggregated, networked systems that separate controllers and media enclosures

- **Data Management and Protection**
  - One of the most important historical capabilities of storage arrays was data protection
  - While data protection is still important, security, compliance and quality of service are just as important

- **Integration with the Cloud/Supporting the Cloud**
  - Many customers use both on-premises and cloud storage
  - Additionally, many storage systems are designed to support cloud-based business organizations
How Have Flash, NVMe, and 100Gb Ethernet Changed the Storage Landscape?

- Flash has significantly reduced the storage media latency
  - Reduced the need for huge RAM buffers, and eliminated the need to short-stroke hard disk drives
  - NVMe has further accelerated this trend
  - Does this reduce the importance of array controllers?

- Increases in Ethernet speed has impacted the advantages of Fibre Channel for SANs
  - 100GbE plus RoCE reduces latency and jitter

- Result: More storage array controllers are now based on X86 architectures, and less on ASICs, FPGAs, or other custom hardware
Storage Arrays: Important Questions for Users

- What is your use case for an AFA system (or for an NVMe-based AFA deployment)?

- As you migrate existing applications from HDD-based systems to flash, can you consolidate your storage systems?

- Is the ability to integrate cloud storage into your storage pool important, and how will you use the cloud storage?

- Are your ROI expectations realistic?
E8 Storage

Julie Herd
Director, Technical Marketing
E8 Storage Accelerates Data Hungry Applications

- Real-time image recognition and analysis
  - NVIDIA

- Massively accelerate genomic research
  - illumina®
  - BLAST

- AI / Machine Learning
- Genomic Sequencing
- Trading / FinTech

- Real-Time Analytics
  - Faster time to results at 70% better TCO
  - IBM Spectrum Scale
  - SAS

- Low latency for tick database analytics
  - kx
  - molbed
  - ORACLE

©2018 E8 Storage
The E8 Storage Difference

A new architecture built specifically for high performance NVMe

Unleash the parallelism of NVMe SSDs

Direct drive access for near line rate performance
• Separation of data and control paths; no controller bottleneck
• E8 Agent offloads up to 90% of data path operations

Simple, centralized management
• Intuitive management GUI for host / volume management
• E8 Agents auto-discover assigned LUNs

Scalable in multiple dimensions
• Up to 126 host agents per E8 Controller
• Up to 8 Controllers per host → 1PB in single management
SPEC SFS®2014_swbuild World Record*

• Record breaking response time!
  • 45% lower ORT for the same builds
  • 8x lower latency on average

• The power of Intel Optane
  • Ultra-low latency for data intensive apps

• More performance, less hardware

<table>
<thead>
<tr>
<th>E8 Storage</th>
<th>24 NVMe SSDs</th>
<th>2U</th>
</tr>
</thead>
<tbody>
<tr>
<td>NetApp FAS8200</td>
<td>144 HDDs, 8 NVMe SSDs</td>
<td>20U</td>
</tr>
<tr>
<td>WekaIO</td>
<td>64 NVMe SSDs</td>
<td>8U</td>
</tr>
<tr>
<td>Huawei 6800 F</td>
<td>60 SAS SSDs</td>
<td>14U</td>
</tr>
</tbody>
</table>

STAC®-M3™ Benchmark for High Speed Analytics

- **High performance with eXtremeDB®**
  - Real-time analytics for tick database
  - Designed for today’s financial systems
  - Accelerated with Intel Optane technology

- **Record breaking performance!**
  - Faster response times in 5 of 17 operations*
  - More consistent response times overall

- **Lowest overall execution time**
  - More than 2.5x faster than competition!

* Of the published, audited results on [https://stacresearch.com/](https://stacresearch.com/) as of May 2018. Graphs show the 2 closest competitors for overall results.

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Newisys is Wholly Owned by Sanmina Corporation
- Newisys has been designing high performance/high-density server and storage for 25+ years for OEMs and CSPs (Cloud Service Provider)

Award Winning Compute and Storage Platforms
- All-Flash & Hybrid Storage and Servers
- NVMe Flash-based Storage, Servers and NVMeoF Platforms
- Primary & Cold Storage Servers and Expansion Arrays

Key Market “Firsts”
- 4RU: x60, x84, x96 bay JBODs;
- 2RU: x60 bay storage server;
- NVMe PCIe JBOF; NVMe-over-Fabric storage

Focus on Product Innovation That Delivers
- Performance, capacity, cost leadership, power/cooling footprint
Application of NVMe Technology

Device Connectivity

Storage Networking

NVMe Hybrid & All-Flash Solutions

Newisys NVMe
Hyper-Converged Infrastructure

Newisys NVMe Storage

Newisys NVMe Servers
Use Cases for NVMe Adoption

➤ **Short-term Upgrades**
Complements IT infrastructure with NVMe storage and servers
• Offers initial NVMe storage and servers for testing, development, and proof-of-concepts
• Begin evaluations and proof-of-concepts now to boost existing DB and app performance
  • NVMe SSDs are available now
  • NVMe over Fabrics on Ethernet is available now from innovators and soon from incumbents
  • NVMe over Fabrics on Fibre Channel is expected to ramp in customer adoption in 2019

➤ **Medium/Long-term Migrations**
Replaces end-of-life SAS storage and servers with NVMe versions
• Migration is a standard approach for technology refresh and offers excellent outcomes
• Begin planning now and execute migrations as storage and servers approach end-of-service lives

➤ **Compelling Applications**
• Real-time ‘OLTP’ Applications
  • (e.g., eCommerce, commercial transactions, IoT transactions)
• Big Data & Analytic Decision Support Applications
  • (e.g., Artificial Intelligence, Machine Learning) tools such as Hadoop, Splunk
• Vertical Market Applications
  • (e.g., genome research, energy exploration)
• DevOps Applications
  • (e.g. Virtualization and Containerization) tools such as Docker, Kubernetes
This is an ongoing & evolving market so the roadmap matters
  • Rapidly changing as new applications are enabled by these tremendous latency, throughput, and overall performance advances
  • Still maturing and adding services and functionality
  • Prices coming down over time, further expanding uses, which would have previously been cost-prohibitive

Offering a broad-range of NVMe platforms really matters
  • Supports numerous third-party, purpose-built software applications
  • Allows alignment of the underlying hardware platform configurations with applications for the greatest TCO efficiency
  • Fewer NVMe vendors to manage

Multi-vendor interoperability is paramount (e.g., drives, cards, software, etc.)
  • Provides performance tailoring and fine-tuning based on desired characteristics
  • Avoids vendor lock-in, reduces system cost, and provides supply flexibility
Newisys NVMe Platforms Overview

NSS1160G-2N (1U8/16)  
NVMe Server

NDS-2244 (2U24)  
NVMe High-performance JBOF

NSS2247G-2N/4N (2U24)  
High-performance Quad Server

NSS22482F (2U24)  
NVMe over Fabrics JBOF

NXXXX  
U.2 NVMe SSD M.2 Carrier

NSS2560 (2U56)  
NVMe High-performance Dual Server

Achieving record breaking performance, new levels of density with a superior high availability design

Industry’s Broadest NVMe Product Portfolio
Solarflare

Tom Spencer
Sr. Director, Product Marketing
Solarflare Communications Solutions

We develop high performance network solutions based on our software, adapters cards and systems.

Deployed in enterprise, telco and cloud data centers.

For the world’s most demanding customers.
NVMe over Fabrics (NVMe-oF) Storage Networking for AFAs

• **Business Drivers for NVMe-oF**
  – Explosive growth of data center storage *(doubling every 18 months)*
    – Accelerate manipulation and consumption of actionable data
  – Infrastructure optimization
    – Scalability: Highly virtualized applications – increase in core/thread density
  – Efficient storage utilization
    – Pooled storage
  – Efficient centralized management Data Protection
    – Mitigate the "server stranded storage" problem (with DAS storage)

• **Technology Drivers**
  – Deliver NVMe performance & efficiency over a network fabric
  – Remove SCSI protocol translations latency/overhead
    – Legacy transports including iSCSI, Fibre Channel (FCP), FCoE

• **Fabric Options**
  – Ethernet TCP
  – Fibre Channel
  – Ethernet RDMA
  – Infiniband
### NVMe-oF Options – TCP is Lowest Cost; Ubiquitous; Scalable

<table>
<thead>
<tr>
<th>Fabric Type</th>
<th>Latency</th>
<th>Lossless</th>
<th>Deployability</th>
<th>Scalability</th>
<th>Deployment Footprint</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethernet (TCP)</td>
<td>Low</td>
<td>Yes</td>
<td>No Forklift (Extends current infrastructure)</td>
<td>High</td>
<td>Ubiquitous (98%)</td>
<td>Lowest</td>
</tr>
<tr>
<td>Fibre Channel</td>
<td>Low</td>
<td>Yes</td>
<td>No Forklift (Extends current infrastructure)</td>
<td>Medium</td>
<td>Specialized Storage (FORTUNE 500)</td>
<td>High</td>
</tr>
<tr>
<td>Ethernet (RoCE-RDMA)</td>
<td>Low</td>
<td>Yes</td>
<td>Forklift Upgrade (DCB/Converged Ethernet)</td>
<td>Medium</td>
<td>Negligible* (2%)</td>
<td>Medium</td>
</tr>
<tr>
<td>Infiniband</td>
<td>Very Low</td>
<td>Yes</td>
<td>Special Network</td>
<td>Limited</td>
<td>Limited (Scientific HPC)</td>
<td>High</td>
</tr>
</tbody>
</table>

Large & Fast Growing Market: NVMe-oF TCP offers the most attractive Solution

* - Microsoft Azure Cloud
### NVMe-oF TCP Standardization: Solarflare Engagement To-Date

<table>
<thead>
<tr>
<th>NVM Express</th>
<th>Linux Community</th>
<th>OEM</th>
<th>Solarflare Internal</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Org Membership • TCP working group</td>
<td>• Submitted NVMe-TCP plug-in RFC</td>
<td>• Demonstrated TCP as a viable transport with Tier-1 OEM#1</td>
<td>• PoC Code • Feature add • Debug • Port to RHEL 7.4</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Q1’17</th>
<th>Q2’17</th>
<th>Q3’17</th>
<th>Q4’17</th>
<th>Q1’18</th>
<th>Q2’18</th>
<th>Q3’18</th>
<th>Q4’18</th>
</tr>
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</table>

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Read Latency Measurement – Local Storage Equivalency

Sustained 4K Random Read - Kernel NVMe-oF TCP

Queue Depth

Latency (us)

Local
Remote TCP SF
Remote TCP MLNX
Remote RDMA
User Space Solutions Drive Performance & Scale
Intel Optane SSD and Solarflare NVMe-oF TCP

- Linux Kernel NVMe: Optane Latency ~10us
- SPDK: 54% Lower
- SPDK + Onload: Lower
- Linux Kernel: Lower
- SPDK: 28% Lower
- SPDK + Onload: 44% Lower

Block Size: 512, 4096
## Better Business Outcomes – AFAs + NVMe-oF TCP

<table>
<thead>
<tr>
<th>Workload</th>
<th>Industry</th>
<th>Workload Impact</th>
<th>Business Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Databases</strong></td>
<td>E-Commerce</td>
<td>• More transactions/sec</td>
<td>✓ Higher revenues</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Faster page view load</td>
<td>✓ Fewer “lost” customers</td>
</tr>
<tr>
<td></td>
<td>Healthcare</td>
<td>• Faster EHR processing</td>
<td>✓ Higher patient satisfaction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Efficient patient self scheduling</td>
<td>✓ Physician mobility &amp; efficiency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Enables BYOD VDI</td>
<td>✓ Efficient point-of-care data capture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Faster overnight reports</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Financial Services</td>
<td>• Efficient operation with anywhere, anytime, anyway</td>
<td>✓ Enables mobile banking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>customer access</td>
<td>✓ Customer retention</td>
</tr>
<tr>
<td></td>
<td>Retail</td>
<td>• Efficient operation with anywhere, anytime, anyway</td>
<td>✓ Efficient Omni-channel shopping</td>
</tr>
<tr>
<td></td>
<td></td>
<td>customer access</td>
<td>✓ Seamless experiences</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>✓ Higher revenues</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>✓ Consumer satisfaction</td>
</tr>
<tr>
<td></td>
<td>Mobile Telecom</td>
<td>• Real-time usage tracking</td>
<td>✓ Higher ARPU</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Content delivery</td>
<td>✓ Lower subscriber churn</td>
</tr>
<tr>
<td><strong>Mobility/VDI</strong></td>
<td>• Enterprise</td>
<td>• Fluid boot-storm, login experiences</td>
<td>✓ End user acceptance</td>
</tr>
<tr>
<td></td>
<td>• Education</td>
<td>• Optimized flash storage utilization</td>
<td>✓ Reduced IT TCO</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Data Protection</strong></td>
<td>Multiple</td>
<td>• Fast backup</td>
<td>✓ Narrow outage window</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Faster recovery</td>
<td>✓ Higher server utilization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Superior RTO/RPO SLA</td>
<td>✓ End user/LOB satisfaction</td>
</tr>
</tbody>
</table>
Panel Question #1

What do you see as the key use cases for NVMe/NVMe-oF all-flash arrays (AFAs)?

- E8 Storage
- Newisys
- Solarflare
Audience Survey Question #1

What use cases are the most compelling to you for NVMe/NVMe-oF based AFA? (check all that apply; 31 votes):

- Shared block storage: 71%
- Shared object storage: 13%
- Shared file storage: 23%
- Database clusters (including in-memory databases): 52%
- Big Data/analytics application clusters: 45%
- High Performance Computing (HPC) storage: 42%
- Hyper-Converged Infrastructure (HCI) storage: 29%
- Media/Imaging storage (including media workflows): 26%
- Other: 6%
- None: 3%
Audience Survey Question #2

Has your organization deployed or planning to deploy NVMe/NVMe-oF AFAs in the near future? (check one):

- We currently have NVMe/NVMe-oF AFAs deployed in our organization: 22%
- We are planning on deploying NVMe/NVMe-oF AFAs within the next 12 months: 22%
- We are planning on deploying NVMe/NVMe-oF AFAs between 12 months and 24 months from now: 4%
- We are currently evaluating NVMe/NVMe-oF AFAs, but we have not made a decision to deploy them yet: 6%
- We currently do not have a use case to deploy NVMe/NVMe-oF AFAs in our organization: 3%
- I am unsure of my organization’s plans to deploy NVMe/NVMe-oF AFAs: 6%
Even though all of the major storage companies now support NVMe in their AFAs, NVMe-oF is still in its infancy in AFAs. What do you think it will take for NVMe-oF to take off in AFAs?

– Solarflare
– E8 Storage
– Newisys
How important do you think that support for NVMe over Fabric (NVMe-oF) in all-flash arrays? (check one; 30 votes):

- Extremely important – NVMe-oF will become ubiquitous in enterprise AFAs: 52%
- Important – NVMe-oF AFAs will be the primary storage systems for high-performance workloads: 38%
- Not Important – Most storage users can’t take advantage of flash performance, let alone the performance of NVMe-oF: 10%
- Unsure – I don’t have the information to answer: 0%
- No Opinion: 3%
Panel Question #3

A lot of press in our industry has stated that NVMe flash media has allowed storage appliances to nearly “catch up” with all-flash arrays. What do you see as the greatest strengths of AFAs relative to storage appliances?

- Newisys
- Solarflare
- E8 Storage
What NVMe-oF fabric/transport options will your organization consider or require when you purchase NVMe-oF AFAs? (check all that apply; 20 votes):

- NVMe over InfiniBand (NVMe-oIB): 10%
- NVMe over Fibre Channel (NVMe-oFC): 50%
- NVMe over RoCE (NVMe-oRoCE): 40%
- NVMe over iWARP (NVMe-oiWARP): 5%
- NVMe over TCP (NVMe-oTCP): 60%
Thank You For Attending