



Western Digital®

**Performance Benefits of
NVDIMMs in Enterprise Data
Storage Platforms**

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Agenda

- IntelliFlash Storage Arrays
- Write Cache
- I/O Flow Architecture
- NVDIMM Integration – IntelliFlash OS
- NVDIMM Optimal Usage Strategy
- IntelliFlash Write Cache
- Results



IntelliFlash Storage Arrays

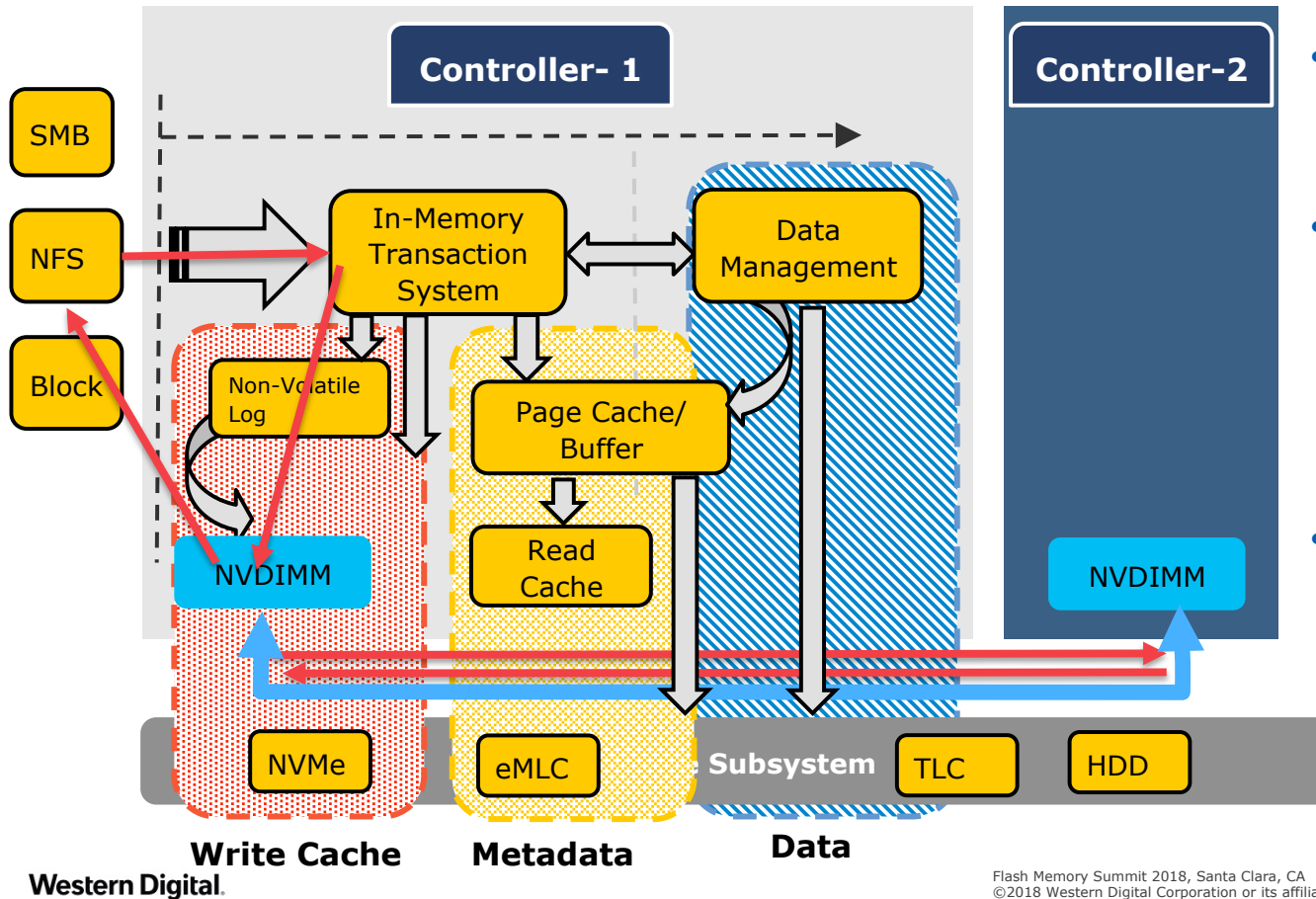
- High performance hybrid and all flash storage arrays
- Multi-protocol support including iSCSI, FC, NFS and SMB
- Highly Available Active/Active cluster
- Designed to leverage different grades of media
 - DRAM, NVDIMM, Flash, NVMe and HDD



Write Cache

- Separate logging for incoming writes
- Write is acknowledged after persisting to the write cache
- Data flush in sync cycles
 - Coalesced data is compressed, deduplicated and synced to drives
- High performance media
 - Latency is crucial for many applications like DBT and OLTP

I/O Flow Architecture



- Low-latency devices for Write Cache
- Availability via NTB mirror
 - Ctrl 1 → Ctrl 2
 - Ctrl 1 → Ctrl2
 - → [Ctrl 3 / ...]
- Data Management
 - Fingerprinting / dedupe
 - Compression
 - Coalescing

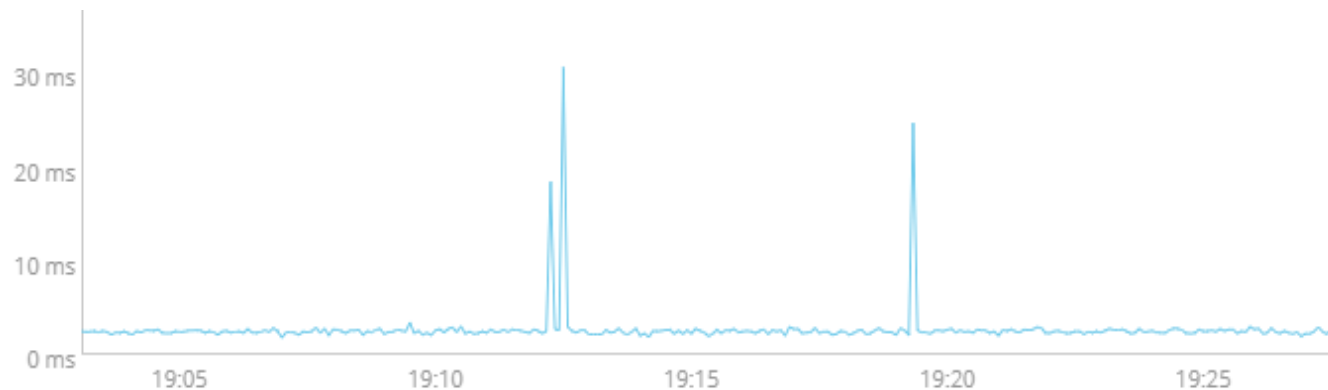
NVDIMM integration – IntelliFlash OS

- BIOS changes to detect and verify NVDIMM during boot
- Vendor specific driver integration
 - No standard three years ago
- Monitoring voltage, charge and temperature levels
- Block device interface for control path to fit into IntelliFlash device model
- Memory mapped I/O to local NVDIMM
- NTB based memory mapped I/O to remote (peer's) NVDIMM
- Write mirroring failure handling
 - Write succeeds locally but may fail to mirror because the remote node or the link is down
 - Write falls back to SSD in case of such failures

NVDIMM Optimal Usage Strategy

Effective utilization of limited size NVDIMM

- NVDIMM can quickly fill up when applications are generating burst writes
- Throttling the incoming writes can result in high latency variation





IntelliFlash Write Cache

- Intelligently use SSD log to supplement NVDIMM space shortage
 - Small logging latency is still better than throttling
- Use of SSD is proportional to the burst size
 - The SSD usage is spread over several sync cycles
- Reduce the sync cycle window and SSD logging to achieve fair distribution
 - For example, 90% to NVDIMM and 10% to SSD
 - Dynamically adjust the distribution based on burst size and sync time
- The latency is amortized over multiple sync cycles

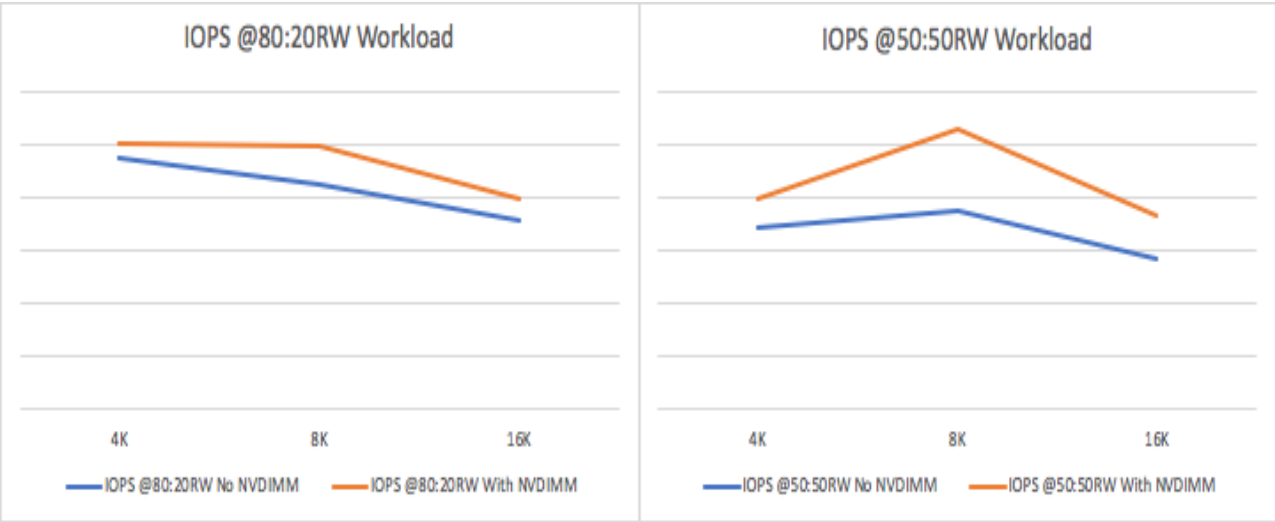
Results - Configuration

- IntelliFlash T4700 all flash array with 24x1TB capacity
- iSCSI protocol
- FIO benchmarking tool with 4 clients and 8 LUNs
- Each LUN is 100GB
- Test method - Fill the LUNs and 100% random read for 10 mins
- Actual test is done afterwards
- 80:20 RW – 80% random read, 20% random overwrite
- 50:50 RW – 50% random read, 50% random overwrite
- 4k, 8k and 16k block sizes

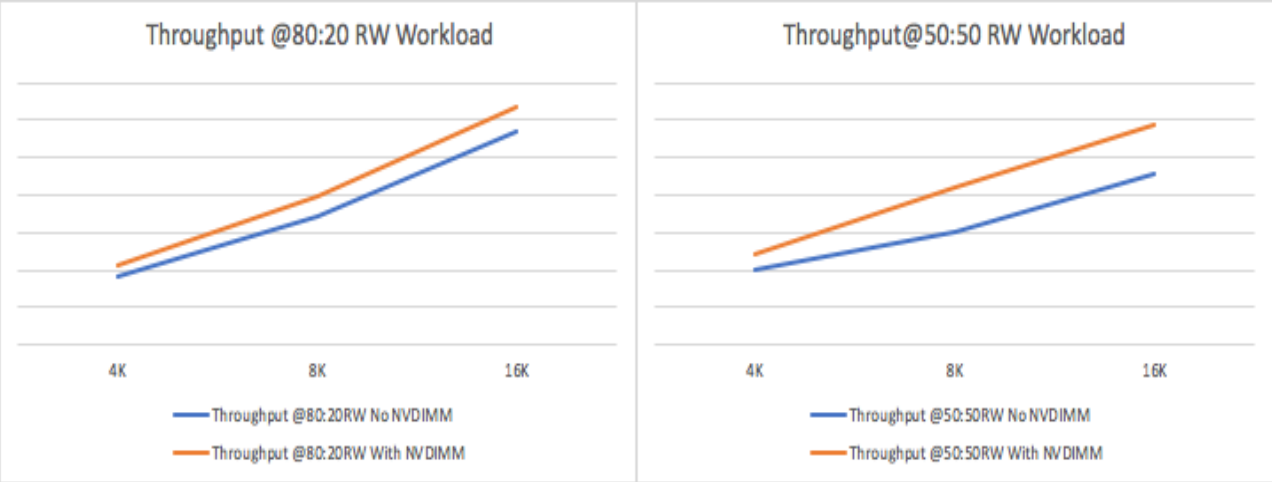
Latency comparison



IOPS comparison



Throughput comparison





Questions