Addressing Performance Challenges with Persistent Memory
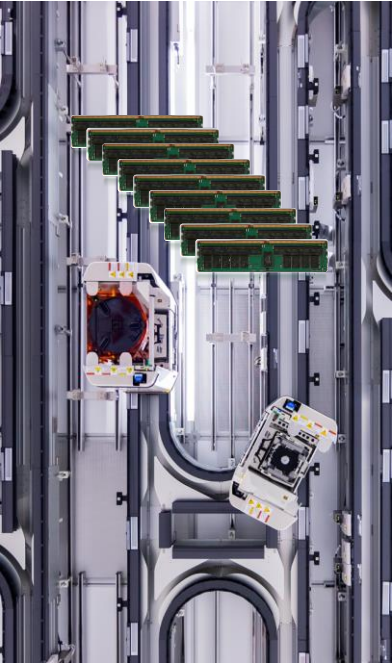
Frank Ross, Sr. System Architect
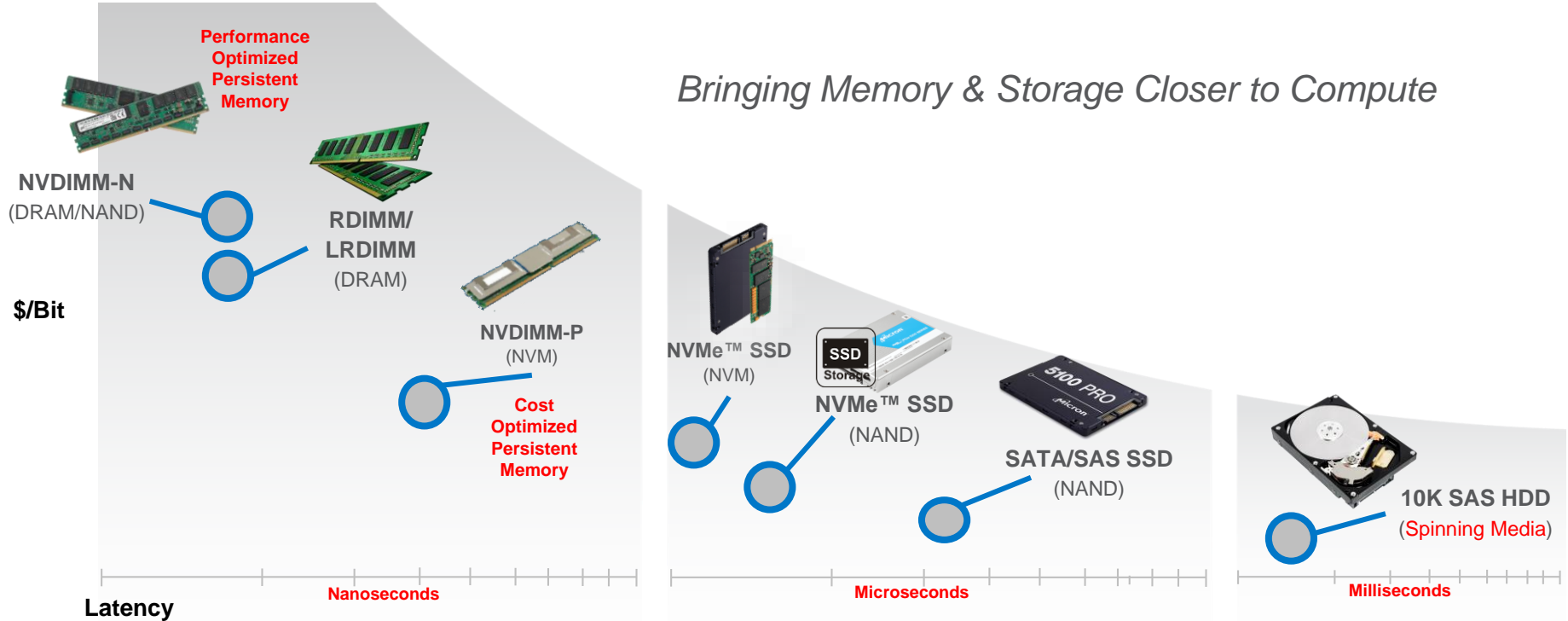
Micron Semiconductor Products, Inc.

Agenda

- Overview of Persistent Memory
- NVDIMM use cases
- NVDIMM performance
- Application Access Levels: Direct, OS, Virtualized
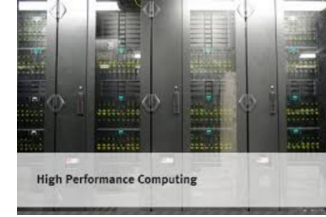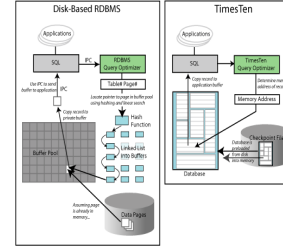- Summary

Convergence of Memory and Storage

Bringing Memory & Storage Closer to Compute

Performance Optimized Persistent Memory

NVDIMM-N
(DRAM/NAND)

RDIMM/ LRDIMM
(DRAM)

NVDIMM-P
(NVM)

Cost Optimized Persistent Memory

$/Bit

NVMe™ SSD
(NVM)

NVMe™ SSD
(NAND)

SATA/SAS SSD
(NAND)

10K SAS HDD
(Spinning Media)

Nanoseconds

Microseconds

Milliseconds

Latency

Persistent Memory Adds Value Across Diverse Applications

Relational Database	Scale-out Storage	Virtual Desktop Infrastructure	Big Data	In Memory Database	Middleware	HPC
MSFT SQL	VMware VSAN	VMware VDI	Mongo DB	SAP HANA	Java	HPC
MySQL	MSFT Azure	Citrix HDI	Cloudera	MSFT SQL Hekaton	.NET	
Maria DB	Store Virtual		HortonWorks	XAP Gigaspace		
Oracle			Hadoop			
			Cassandra			
			MSFT SQL Hadoop			
Log acceleration: write combining and caching	**Tiering, caching, write buffering, meta-data storage**	**Higher VM consolidation**	**Higher performance**	**Journaling, Transaction logs, Fast Restart**	**Optimized abstraction**	**Check point acceleration**

Direct Access to NVDIMM-N
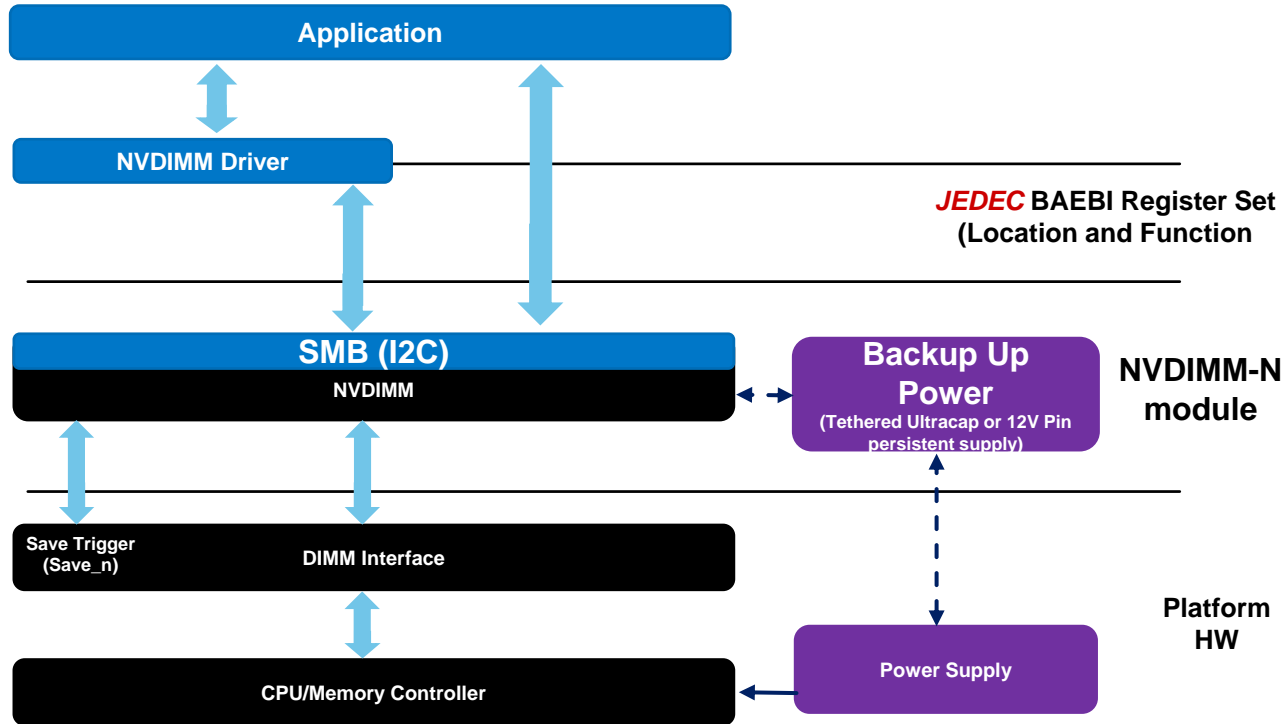
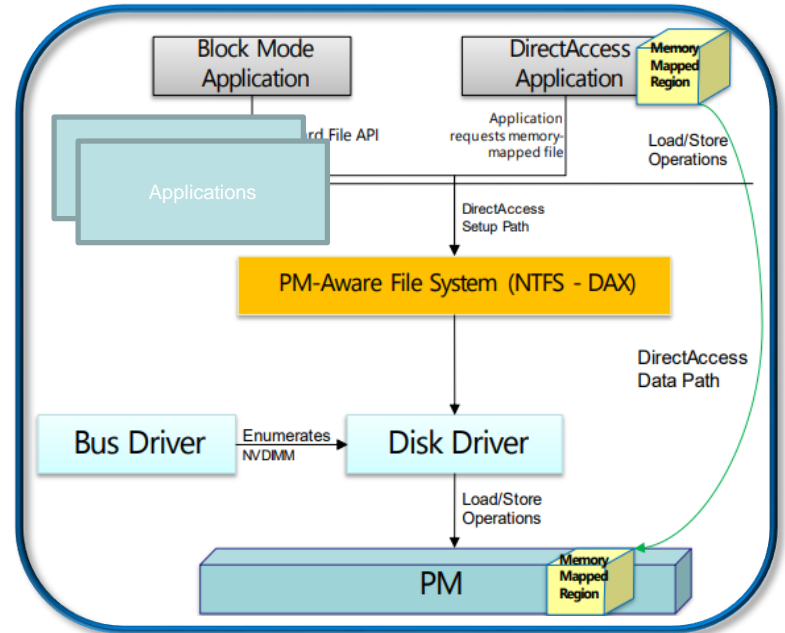# OS Level Access to Persistent Memory

SNIA NVM Programming Model

Linux
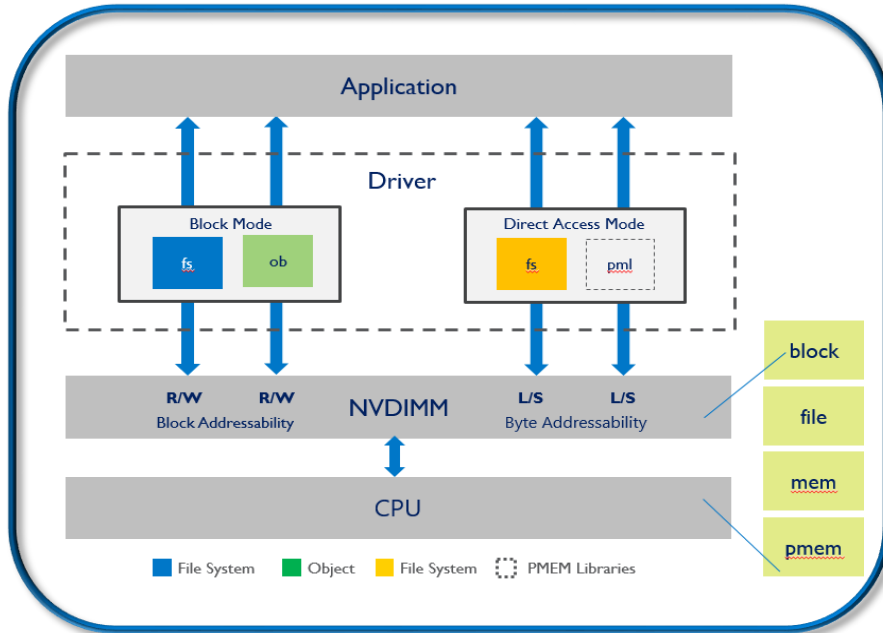
Source: SNIA

Windows 2016

Source: MSFT FMS - 2017

Windows Server 2016: Performance Improved by 10x to 75X

NVDIMM leveraged for Log Storage in SQL server DB Transactions
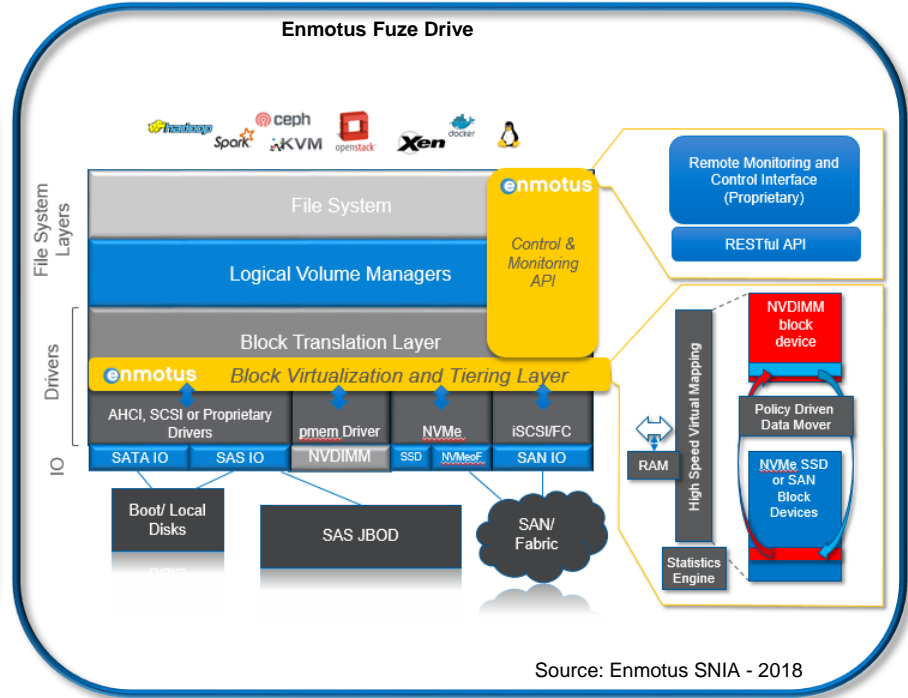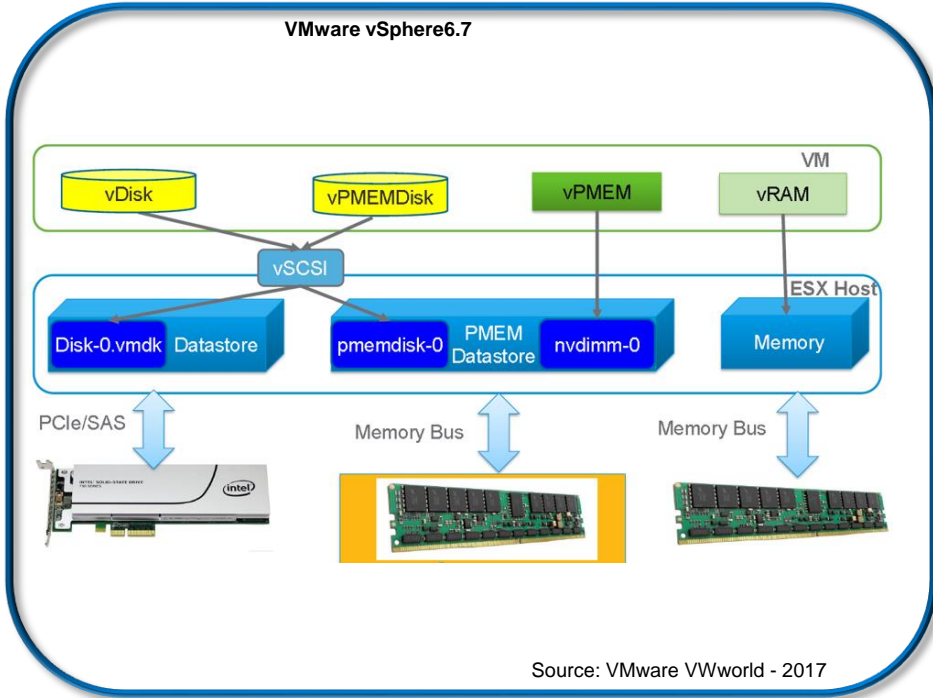
- **Block Mode Access - 10x**
  - Persistent ramdisk
  - Raw disc
  - Supported by SCM driver

- **Direct Access - 75X**
  - Memory-mapping semantics
  - DAX file system
  - No SW overhead
  - Byte Addressable
  - Filter drivers may require modification

4K Random write, QD=1	IOPS	Avg Latency (ns)	MB / Sec
NVMe SSD	14,553	66,632	56.85
Block Mode NVDIMM	148,567	6,418	580.34
DAX Mode NVDIMM	1,112,007	828	4,343.78

10X ! → 580.34

75X !! → 4,343.78

MSFT FMS - 2017

FMS Persistent Memory Track Presented by: SNIA JEDEC OPENFABRICS ALLIANCE

Virtualization Level Access to Persistent Memory

Source: VMware VWworld - 2017

Source: Enmotus SNIA - 2018

Virtualization Performance

Vmware vSphere (Block and Byte Mode)   Source: VMware VMWorld - 2017
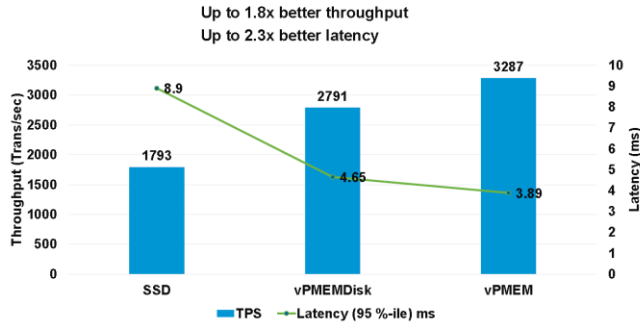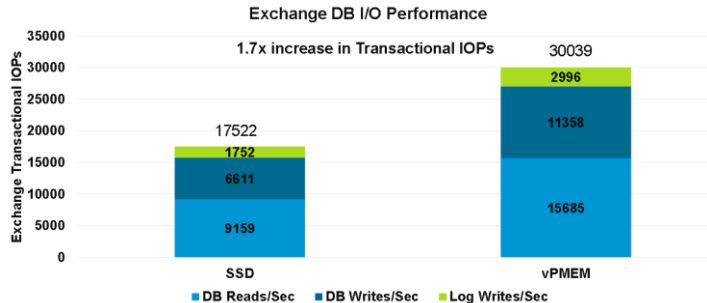
Enmotus Fuze Drive (Block Mode)   Source: Enmotus SNIA - 2018

NVDIMM Virtual Disk

Micron Booth – FMS 2018

- NVDIMM Virtualized
  - Significant Performance improvement using PM with SSD
    - Enmotus Virtualized Storage on Linux
    - 192GB Persistent Memory