Why Persistent Memory Matters

*How did we get here, and what lies ahead?*

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How did this PM Effort Start?

- MRAM
- Memristor
- PCM
- Spin Torque
- FeRAM
- Carbon Nanotube
- ReRAM
Storage vs. Memory

Typical NUMA range: 0 - 200 nS
Typical context switch range: above 2-3 uS
Relative media speeds

- **Memory** (10’s ns)
- **SSD** (10’s us)
- **HDD** (10’s ms)

![Diagram showing relative speeds of memory, SSD, and HDD](image-url)
Convergence of Storage & Memory

Latency Budgets

Typical NUMA range: 0 - 200 nS
Typical context switch range: above 2-3 uS

Latency (nS)

HDD  SATA SSD  NVMe Flash  Persistent Memory

Context Switch

Load/Store
PM Changes the Application View of Computer Architecture.

Block Diagram of Von Neumann Architecture
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Block Diagram of Von Neumann Architecture
SNIA NVM Programming TWG
Formed 06-11-2012

- Dell
- EMC
- Fujitsu
- HP
- Intel
- Netapp
- Oracle
- QLogic

PM Aware Apps → File APIs → Ld/St

PM Aware File Systems
PM VOLUME Mode
PM capable Driver
PM Device

NVM.PM.FILE Mode
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PM capable Driver
PM Device
Operating System Support
“The obvious next focus”

- Both Linux and Microsoft joined the SNIA effort to help steer the direction of PM.
  - Applications have direct Load/Store access to PM
  - End result: Both OS’s are structured almost identically (ex: DAX)
- VMWare has also offered support for PM

Persistent Memory support in OS’s ahead of volume adoption
PM Usage Launch on NVDIMMs!
NVDIMMs

• NVDIMMs become the first HW available to run PM Applications.
  • Success stories emerge highlighting the application benefits of PM.
  • Example: “Tail of Log” for SQL Server
• Alliance formed between JEDEC and SNIA to effectively drive adoption of the technology

NVDIMMs Prove the Benefits of PM
Big and Affordable Memory

High Performance Storage

Direct Load/Store Access

Native Persistence

128, 256, 512GB

DDR4 Pin Compatible

Hardware Encryption

High Reliability

Now shipping for revenue to select customers
Persistent Memory
What’s Next?
Remote Persistent Memory

- Remote Persistent Memory (RPM) allows the programming model to extend beyond a single node, to datacenter (or beyond) scalability.
  - RPM is the basis for a relationship between Open Fabrics Alliance (OFA) and SNIA.
  - The first use case (High Availability) defined and spec in progress
  - New usage models are in the queue... example, pooled PM and memory-centric architectures.
Persistent Memory Applications
Application Horizons

Traditional Storage

1. Application
2. File System
3. Disk Driver
4. HDD or SSD

Horizon 1: PM Middleware

1. Application
2. File System
3. PM

Horizon 2: PM Libraries

1. Application
2. PM Library
3. File System
4. PM

Horizon 3: Languages

1. Compiler
2. Application
3. File System
4. PM
Application Horizons - Today

Traditional Storage

- Application
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Horizon 1: PM Middleware

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- File System
- PM

Horizon 2: PM Libraries

- Application
- PM Library
- File System
- PM

Horizon 3: Languages

- Compiler
- Application
- File System
- PM
Application Horizons – Ultimate Goal

- **Traditional Storage**
  - Application
  - File System
  - Disk Driver
  - HDD or SSD

- **Horizon 1: PM Middleware**
  - Application
  - File System
  - PM

- **Horizon 2: PM Libraries**
  - Application
  - PM Library
  - File System
  - PM

- **Horizon 3: Languages**
  - Compiler
    - Application
    - File System
    - PM
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Early PM System Support & Applications

A sample of companies publically showing PM support
SNIA PM Application Enabling

- A program is needed to enable the application development community to build native PM applications
- Early planning stages... expected program in ’19
- PMDK continues to be a key enabler for new applications

Goal: Accelerate Development of PM Applications
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Application

File System

Disk Driver

HDD or SSD

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PM Application

Compiler

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File System

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File System

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Summary

Why Persistent Memory Matters
Learn More

• SNIA PM Summit
  • January 24, 2019 (Santa Clara Hyatt)

• OFA Annual Workshop
  • March 19-21 2019 (Austin Tx)
Get Involved

• SNIA (www.snia.org)
• JEDEC (www.jedec.org)
• OFA (www.openfabrics.org)
Thank You!

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