Persistent Memory - Industry Standards
Persistent Memory - What’s in a name?

• Persistent Memory (PM) is:
  – Byte-addressable and accessed by memory semantics (Load/Store)
  – Fast (low-latency, much faster than block-accessed media)
  – Persistent (can be non-volatile and retain data for significant amount of time)

• Persistent Memory includes:
  – Persistent Memory devices: PM Media or PM Devices (aka Emerging Non-Volatile Memory)
  – Persistent Memory modules/cards: NVDIMM-N, NVDIMM-P, byte-addressable memory cards
  – Persistent Memory: used like storage in architecture of systems and software, can be main memory
Persistent Memory Standards

• Standards focus and industry enablement:

**PM SW and Programming:**
– SNIA NVM Programming (NVMP) TWG - NVM Programming Model
– pmem.io and PMDK for libraries and tools for implementing the NVM Programming Model

**PM HW:**
– JEDEC Hybrid DIMMs - Persistent Memory Module and HW Interface standards: NVDIMMs and standard non-volatile memory devices

**PM Fan-out interfaces / Fabric:**
– CCIX, CXL, OpenCAPI, Gen-Z, etc. - Low latency fabrics supporting PM directly in system or remote
– OFA - Remote Persistent Memory support API’s investigated leveraging SNIA’s NVMP model and developed use cases
Current JEDEC work on key PM Hardware

• JC42 Memory Devices Committee
  – Future Memory Task Group: lead discussions on emerging memory device standards
  – JC42.4 Non-volatile Memory: standardization for all NVM chips, including Flash and PM devices

• JC45 Memory Module Committee, JC45.6 Hybrid Modules Sub-Committee
  - Hybrid DIMM Task Group: lead discussions for Persistent Memory modules
    - Develop and standardize new NVDIMM types
    - Currently focused on NVDIMM-P standard
  - NVDIMM-N Task Group
    - Refine and maintain NVDIMM-N standards
    - Owns BAEBI and NVDIMM-N specifications
JEDEC Standards for Persistent Memory Modules: NVDIMMs

• JEDEC started persistent memory hardware standardization work in 2011, by starting the Hybrid DIMM Task Group

• First focus was NVDIMM, which was later renamed to the NVDIMM-N to allow for more NVDIMM types.

• NVDIMM’s are the main hardware devices used as Persistent Memory in the industry today.
JEDEC Industry Standard NVDIMMs

**NVDIMM-N** > 1st Persistent Memory with DRAM and Flash, providing capacity and performance of DRAM.

It doesn’t slow down the memory sub-system.

Standard NVDIMM-N’s are shipping today as first available Persistent Memory

**NVDIMM-P** > Persistent Memory Module standard interface with high capacity, typically leveraging Persistent Memory media (ReRAM, PRAM, MRAM, 3DXP, etc.).

NVDIMM interface and protocol standard enabling byte-addressable memory at low latency.

NVDIMM-P standard coming soon. JEDEC holding workshops for NVDIMM-P in Oct 2019
Coming (VERY) soon: NVDIMM-P standard

• The **NVDIMM-P** standard will enable many key features that greatly enhance its use as a **byte-addressable** persistent memory.

• The interface includes (simplify life for managing data in PM):
  – **Non-deterministic timings** to allow for runtime use of byte-addressable emerging NVM devices on very low latency interface
  – **Out-of-order operations** with read and write tracking enabled through ID numbers
  – **Persistent writes and Flush** commands that acknowledge when data is committed to NV media
Summary

• Many mature Persistent Memory standards exist and are being leveraged in industry for software, hardware and systems.

• Still not too late to influence the future of the industry by joining the fun in these standards organizations:

  ![JEDEC Logo](image1.png) ![SNIA Logo](image2.png) ![OpenFabrics Alliance Logo](image3.png)

• Visit JEDEC booth #803 and SNIA booth #820

• Come to the JEDEC workshops in Santa Clara, October 10, 2019 to get a deep dive on the upcoming NVDIMM-P standard: [www.jedec.com/nvdimm-p](http://www.jedec.com/nvdimm-p)
Thank you!