

# Persistent Memory - Industry Standards

Jonathan Hinkle  
Distinguished Researcher  
Lenovo Research  
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# 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

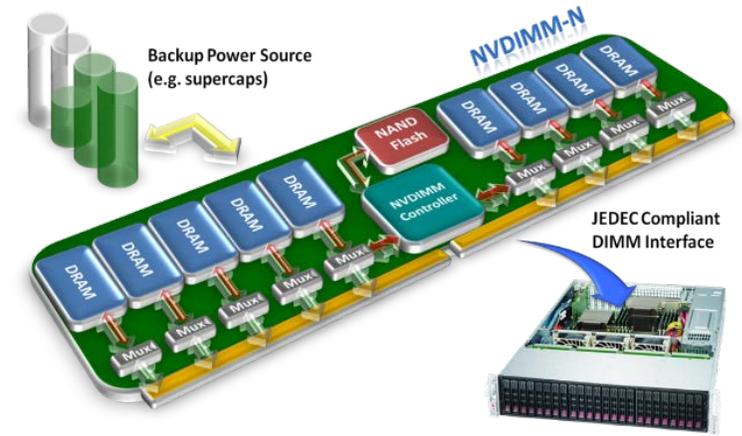
- JEDEC started persistent memory hardware standardization work in 2011, by starting the **Hybrid DIMM Task Group**
- First focus was **NVDIMM**, which was later renamed to the NVDIMM-N to allow for more NVDIMM types.
- NVDIMM's are the main hardware devices used as Persistent Memory in the industry today.

# JEDEC Industry Standard NVDIMMs

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

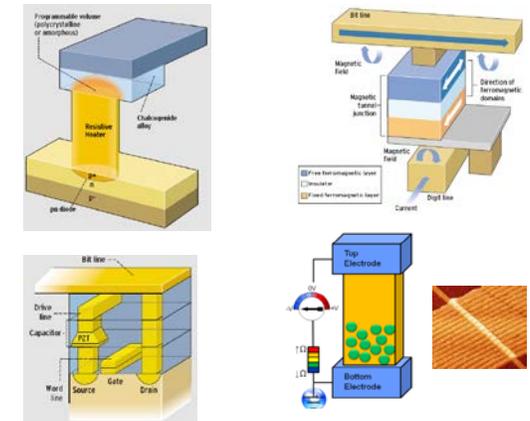
It doesn't slow down the memory sub-system.

**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:



- 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!