Roles for Persistent Memory in Computing Systems

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Overview

- Hardware Foundations
- General acceleration and specific targeted speedup of applications
- Further work to be done

Persistent Memory Applications

Hardware Foundations:

- Persistent Memory holds great new promise, but is often thought of as a universal, fast NV memory.. like a non-volatile DRAM.
- The next adopted persistent memory devices will have specific features that dictate best fitting applications.

Persistent Memory Applications: Foundational Hardware

- Usage Models for Persistent Memory depend on the principal hardware used.
- They take advantage of the key characteristics of underlying hardware.
- Very different benefits from various persistent memory options :

  DRAM/Flash Hybrid Memory, all NAND Flash modules, MRAM, PRAM, etc.

Persistent Memory Applications: Foundational Hardware

Very different characteristics depending on the persistent memory:

- Capacity per die (Mb, Gb, or Tb)
- Low cost per bit
- Performance
  - Bandwidth – 10MB/s or 1GB/s
  - Latency – 10ms, 10us, 10ns
- Endurance
- Reliability / Resilience / RAS

Persistent Memory Applications: Foundational Hardware

- Many different architectural approaches are being driven and promoted.

- Diversity of access options also exist including:
  - Byte addressable
  - Block device
  - How much NV capacity accessible by system

Persistent Memory Applications: Foundational Hardware

Top industry standards groups like JEDEC and SNIA are leading hardware NVDIMM definition work, NVM usage models, and NV software modeling work:

- JEDEC JC45.6 Hybrid Modules Committee
- JEDEC Hybrid DIMM Task Group (NVDIMM TG)
- SNIA SSI NVMP Technical Working Group
- SNIA NVDIMM SIG

Persistent Memory Applications: Foundational Hardware

- Currently working towards standardization for several different module architectures in **JEDEC**

- NVDIMM-N: DRAM memory module made persistent through the use of NAND Flash.

- NVDIMM-F: All-flash DIMM that's directly accessible by the memory controller.

Persistent Memory Applications: Foundational Hardware

Others coming?

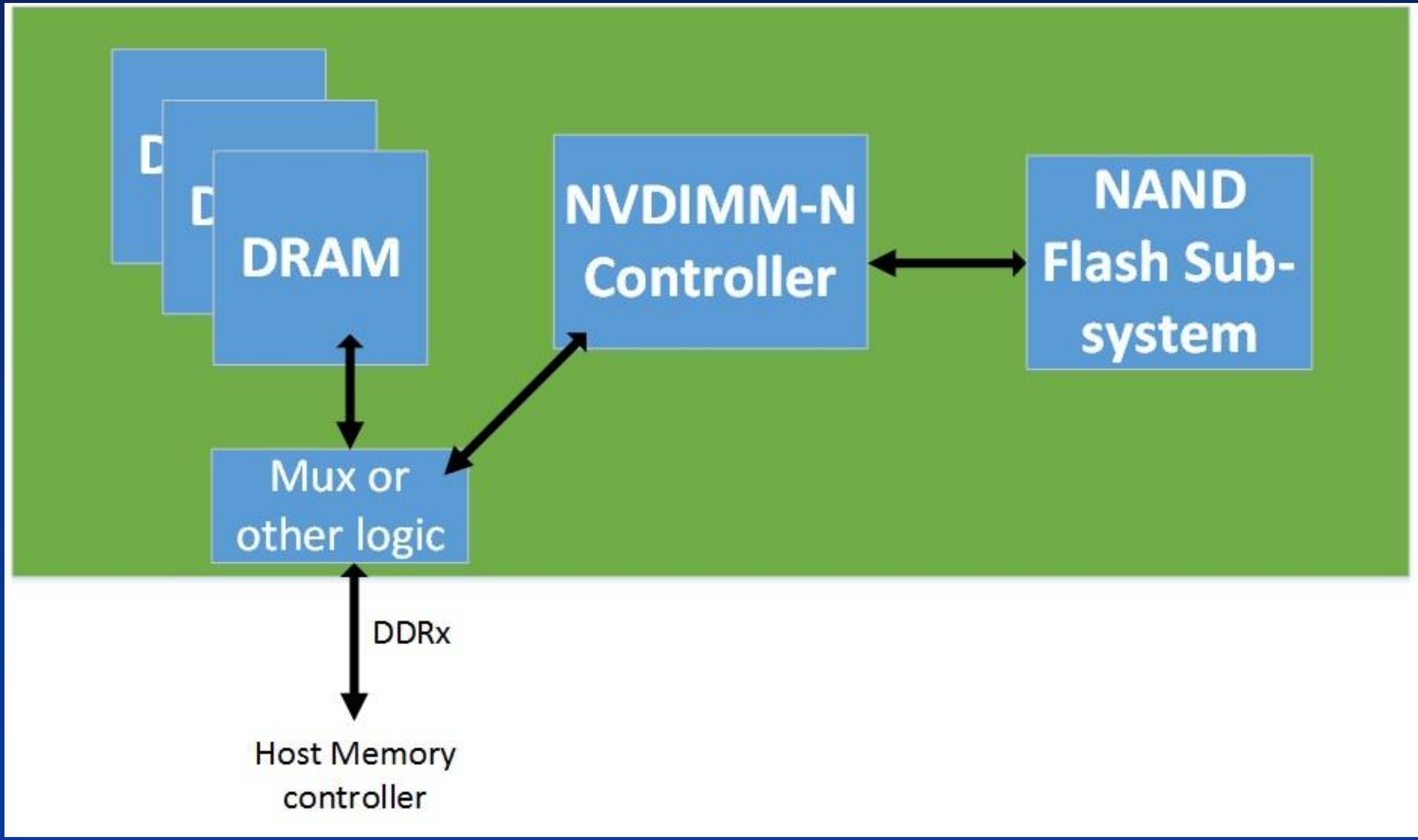
- NVDIMM-N2: Similar to NVDIMM-N, but with system-accessible Flash

- NVDIMM-M: STT MRAM based DIMM

- NVDIMM-x: PRAM, RRAM, NRAM?

Persistent Memory Applications: Foundational Hardware

NVDIMM-N general architecture



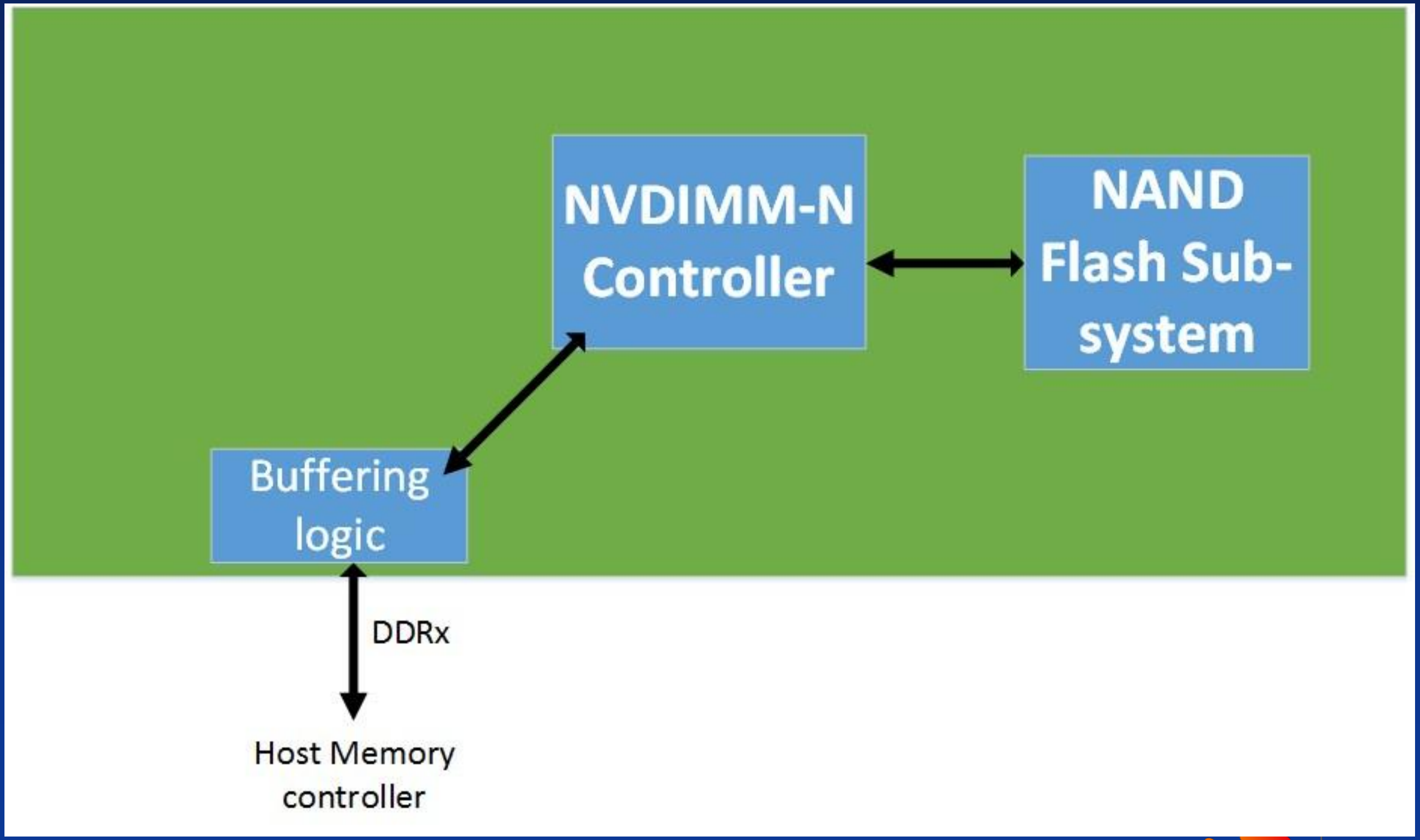
Persistent Memory Applications: Foundational Hardware

Example:

- NVDIMM-N: Frequently written dB log files may be mapped to a single module
  - Greatly enhanced speedup over flash/SSD
  - Unlimited write-endurance
  - 8GB capacity may be more than enough, but can scale to appropriate capacities

Persistent Memory Applications: Foundational Hardware

NVDIMM-F general architecture



Persistent Memory Applications: Foundational Hardware

Another Example:

- NVDIMM-F: Real-time analytics for financial data
  - Very low latency storage access - get analysis results from data while actionable
  - Helpful to scale to larger capacity along with performance
  - Well-suited for high throughput demands with flash on high bandwidth interface.

Persistent Memory Applications

- Persistent memory can be used for general acceleration or specific targeted speedup for an application

- Many different methods for gaining system speedup and this is still a rich area for research into new applications.

Persistent Memory Applications

- How does general acceleration work?
  - Paradigms can be similar to using SSD with HDD
  - Simple and take advantage of majority of performance benefits
  - Typically don't introduce disruptive new benefits, just faster operation

Persistent Memory Applications

One method:

- Access persistent memory as block device (if not already accessed through a driver, an optimized RAMDISK is often a solution)
- Utilize Caching or Tiering software to keep hot data in the fast (DDR-attached) persistent memory

Another method:

- Use all persistent memory in the system (like all SSD storage today)

Persistent Memory Applications

- What Applications can benefit directly?
  - Gain performance benefits through putting application-specific data in the persistent memory.
  - Re-write software to take advantage of the new benefits of persistent memory such as reduced or eliminated data movement for power fail recovery
  - Other benefits to take note – dB load time, versioning and compute progress protection

Persistent Memory Applications

- Further applications for persistent memory:

- OS-level integration of NV memory space allowing fast swap files and new virtual memory paradigms
- Instant-on computer systems with persistent state (like sleep/hibernate with no battery)
- Fully memory-mapped systems with no required internal storage IO protocols