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Testing Controller Memory Buffer Performance In An NVM Express SSD

Ramyakanth Edupuganti, Senior Product Research Engineer,
Dr. Stephen Bates, Senior Technical Director,
Microsemi Corporation

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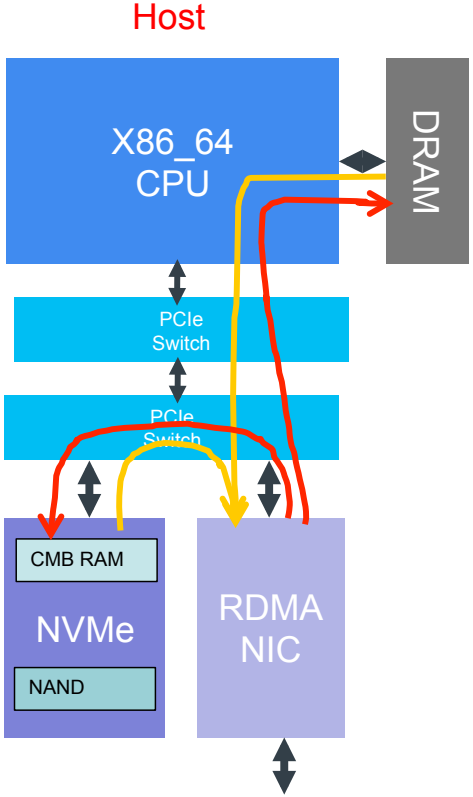
Overview

- Background
- Controller Memory Buffers
- High-Speed SSDs
- Enabling Linux Support
- Performance Results
- Conclusions

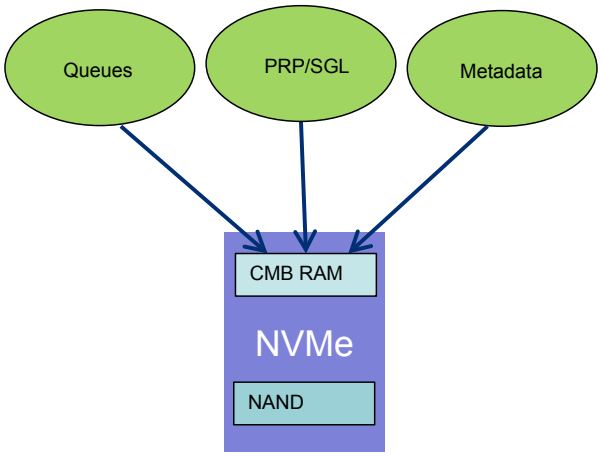
Background

- PCIe network and storage devices can generate and consume several GB/s.
- Devices have either a high performance DMA engine, a number of exposed PCIe BARs or both.
- Until the Controller Memory Buffer, any high-performance transfer of information between two PCIe devices has required the use of a staging buffer in system memory.
- The bandwidth to system memory is not compromised when high-throughput transfers occurs between PCIe devices.



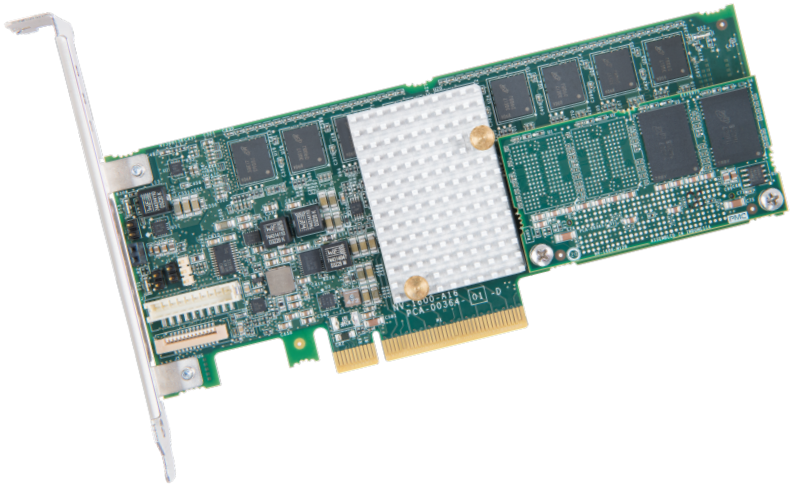
Controller Memory Buffers

- Controller Memory Buffers (CMBs) were added to the NVM Express standard in revision 1.2
- CMBs are PCIe BARs (or regions within a BAR) that can be used to store either generic data or data associated with an NVMe block command
- With appropriate implementation, CMBs can be made persistent across power cycles (MRAM, poly-caps, 3DX-point, etc.,)



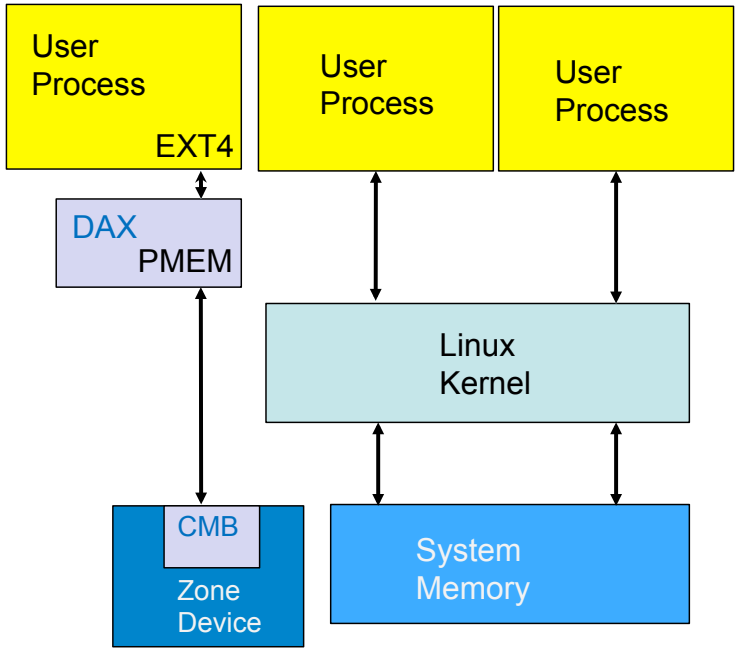
High-Speed Solutions

- In Direct Memory Interface (DMI) mode, Microsemi Flashtec NVRAM cards achieve:
- Sub-microsecond latency for small access sizes
- 10 million IOPs for small access sizes



Enabling Linux Support Features

- Linux support has been enabled by several recent additions to the kernel, including:
- ZONE_DEVICE-the ability to associate a range of memory addresses (PFNs)
- PMEM-a ZONE_DEVICE device driver that exposes memory region to the rest of the OS
- DAX-a framework that allows a memory-addressable block device to bypass the page cache
- STRUCT PAGE SUPPORT-PMEM devices can optionally include struct page backing for DMA

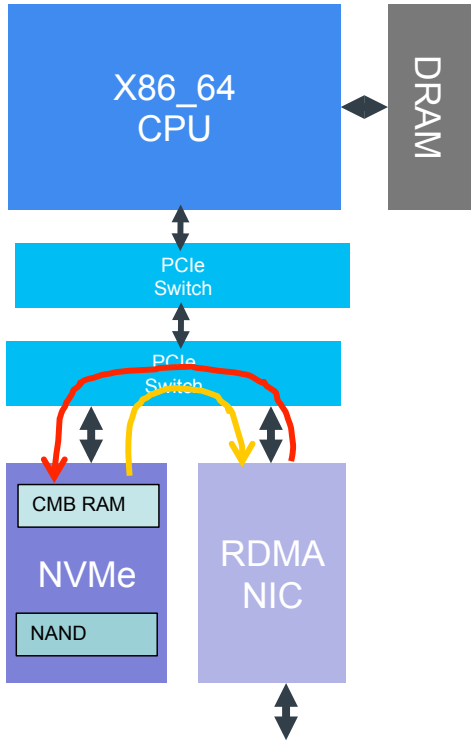


Performance Results

- The DMA engines in the RDMA device can target the BAR on the IOPMEM device and can either use the mmap() on the IOPMEM direct or mmap() files on a DAX-mounted filesystem as the RDMA memory regions.

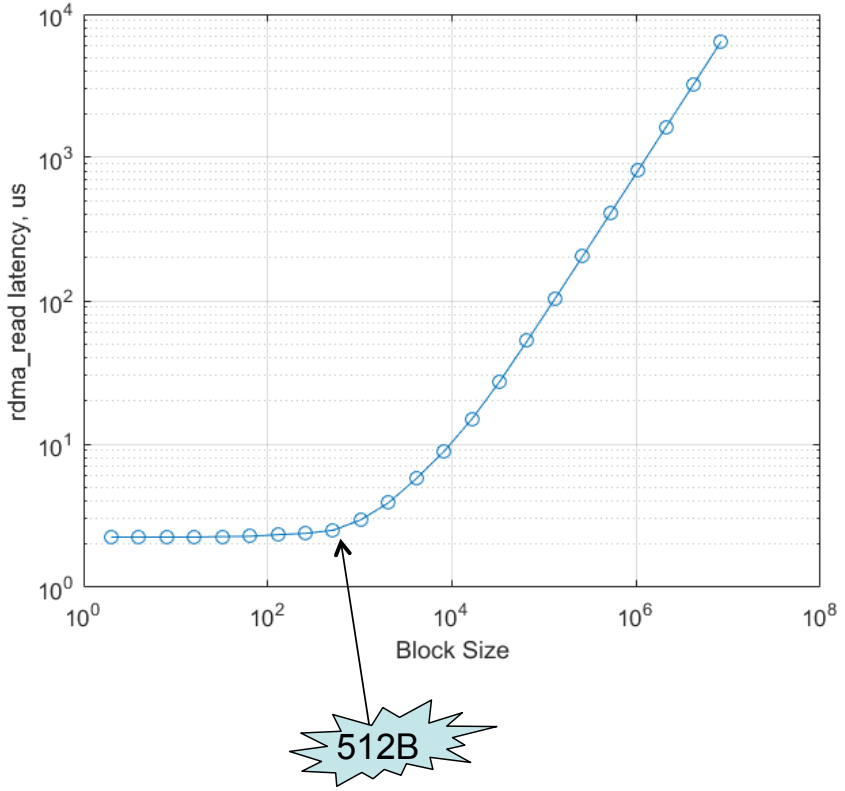
- Performance:

Write BW	Read BW
4 GB/s	1.2 GB/s



Performance Results (continued)

- Sub 3 µs read times for small access sizes
- CX4, RoCE, and no RDMA switch
- Latency rises for larger accesses (these are unaligned and byte addressable)
- Results for 4 KB are around 6 µs. This is 6 µs total, not incremental!



Conclusions

- The Linux kernel has been adapted in preparation for new NVMs and memory-attached NVM.
- We are building upon prior advancements in PCIE IO memory subsystem technology by adding new performance-enhancing features, and have enabled IO memory as a DMA target.
- Our example driver exposes IOMEM as both a DAX-enabled block device and an mmap()'-able region.
- We show good performance between PCIe devices (the datapath avoids CPU when a PCIe switch is used).

THANKS!!

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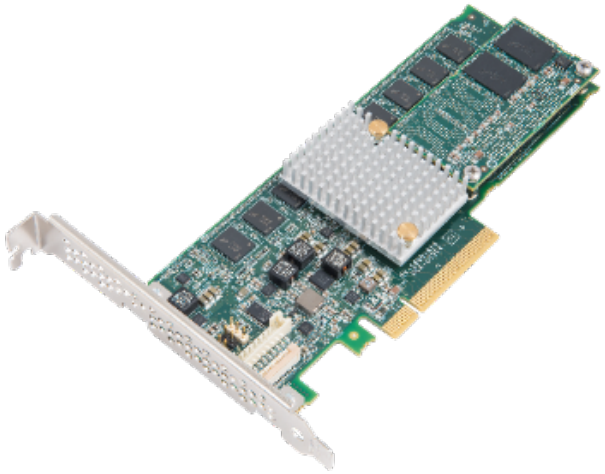

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