Accelerating PMEM access via SPDK acceleration framework

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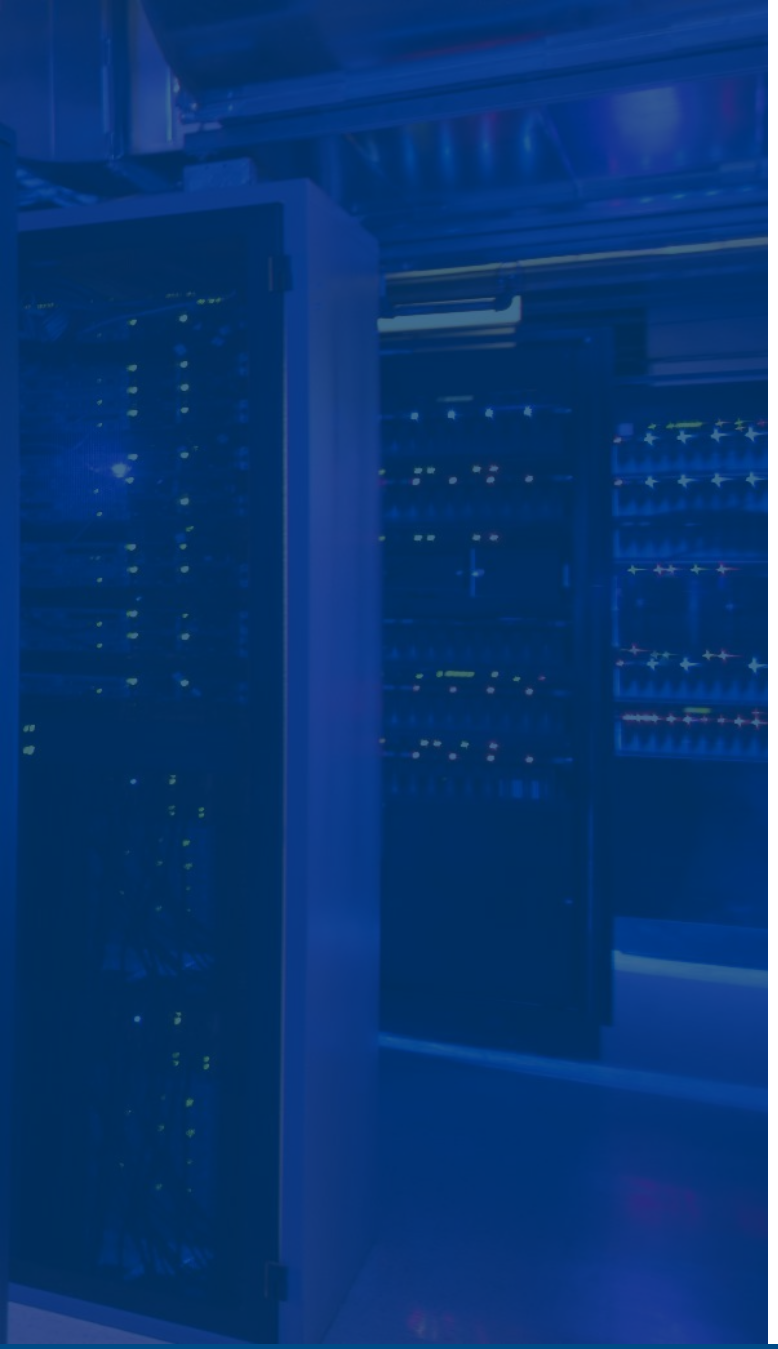
2021 Dec. 15th



Agenda

1. Background & Problem
2. SPDK acceleration framework introduction
3. New PMEM bdev (pmem_accel) development status
4. Conclusion

Background & Problem

Background & Problem

- With more and more deployment of fast NICs and storage devices in data center, there is more and more pressures on CPU, e.g., many users/customers find that CPU becomes ***a bottleneck*** to conduct operations between DRAM and PMEM (persistent memory, e.g., Intel® Optane™ Persistent Memory).
  - Data operations "between (persistent) Memory" is different from "data operations between Memory and device". ***For the latter case, there is (R)DMA capability on device, and CPU will not be very busy.***
- How to offload the work from CPU with some possible memory offloading engines (e.g., IOAT, DSA) is a real and valid requirement.
  - For example, cloud providers would like to utilize the important CPU resources in customer visible workloads (e.g., those host CPUs should be virtualized to launch more customers' Virtual Machines)

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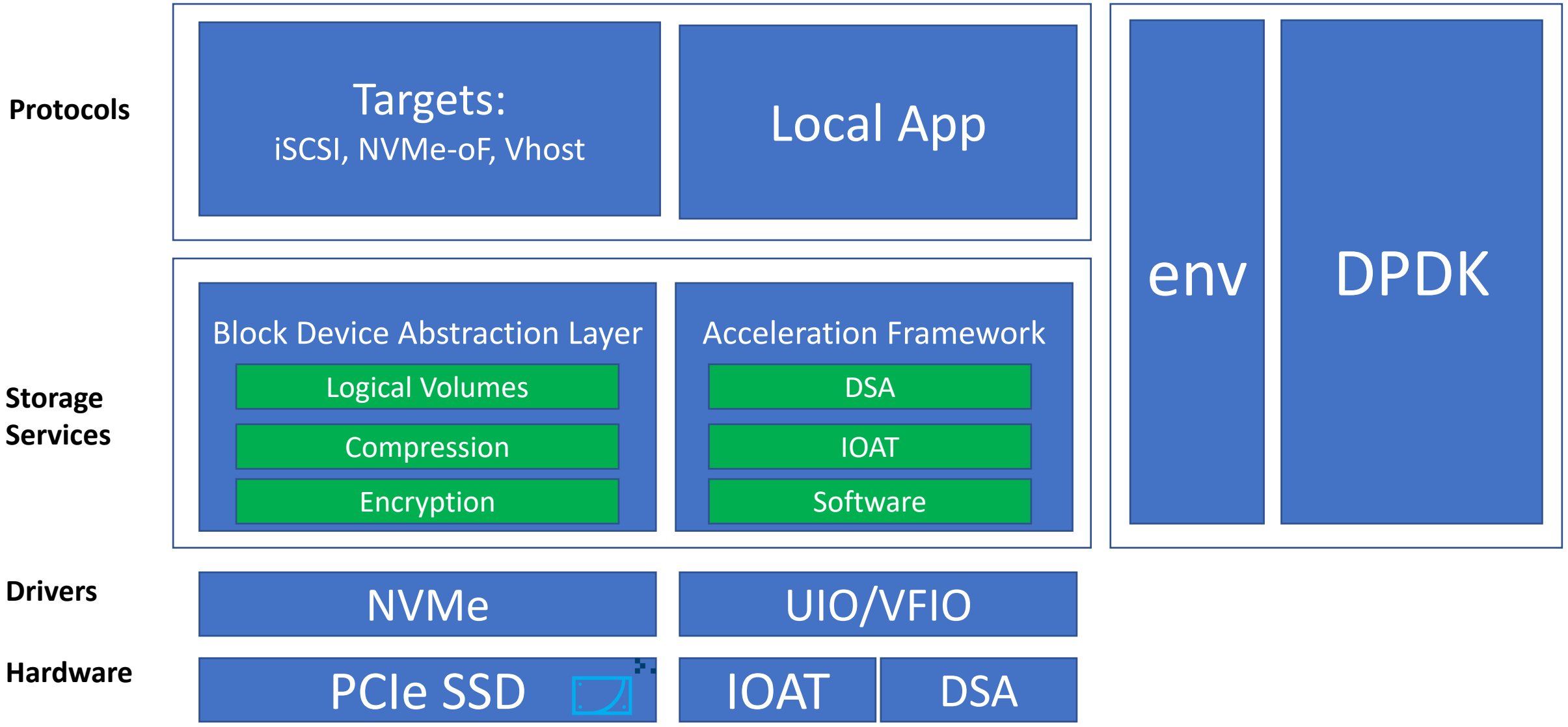
SPDK acceleration framework introduction

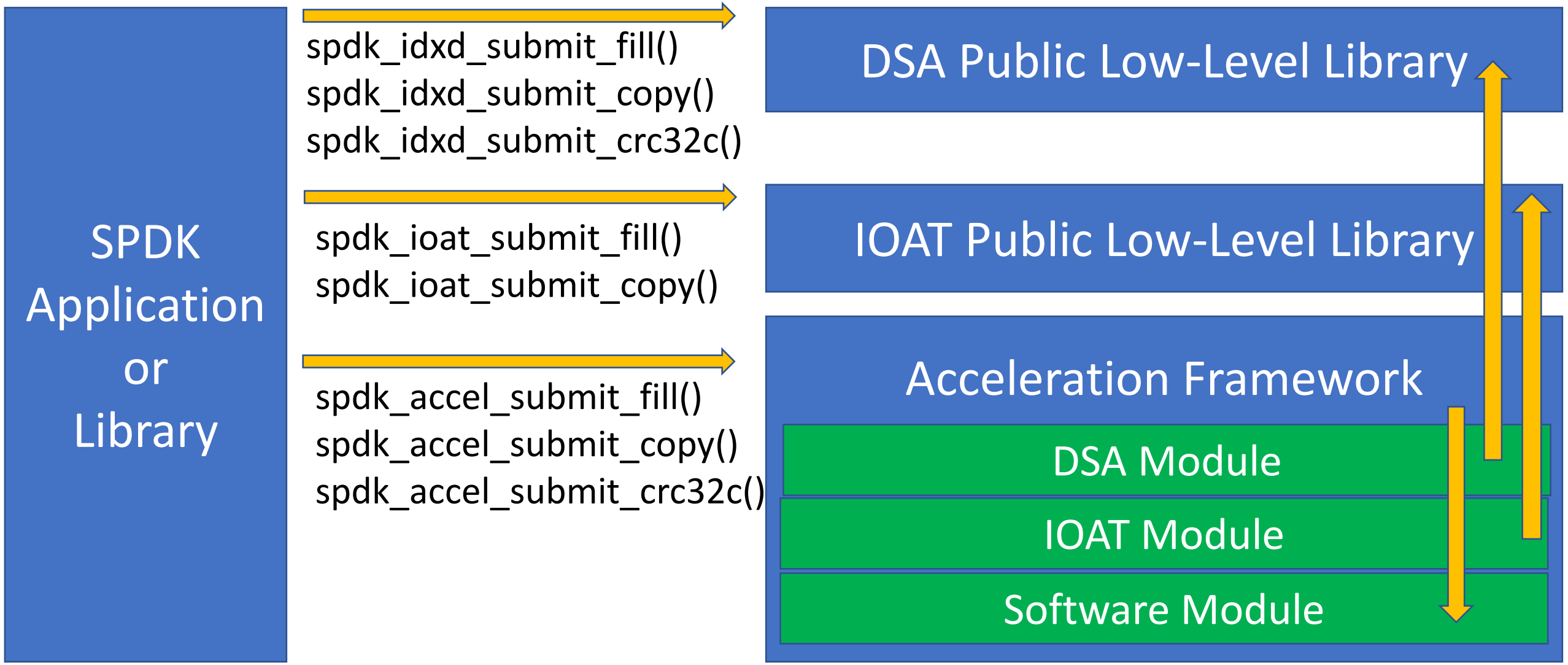
Some memory offloading devices

- Functionality: Support operations between (persistent) memory
- There are some memory offloading engines provided by Intel:
  - Intel IOAT: I/O Acceleration Technology
  - Intel DSA: Intel® Data Streaming Accelerator (Intel® DSA)
- Intel DSA is a high-performance data copy and transformation accelerator that will be integrated in future Intel® processors, targeted for optimizing streaming data movement and transformation operations common with applications for ***high-performance storage, networking, persistent memory***, and various data processing applications.
  - Supported operations: Mov (e.g., memory move, crc generation…), Fill, Compare, Flush
  - Available on Intel's Sapphire Rapids Platform.
- In SPDK: How to leverage those memory offloading devices?

SPDK high level architecture



SPDK acceleration framework



SDPK DSA Feature support (publicly available from 20.10)

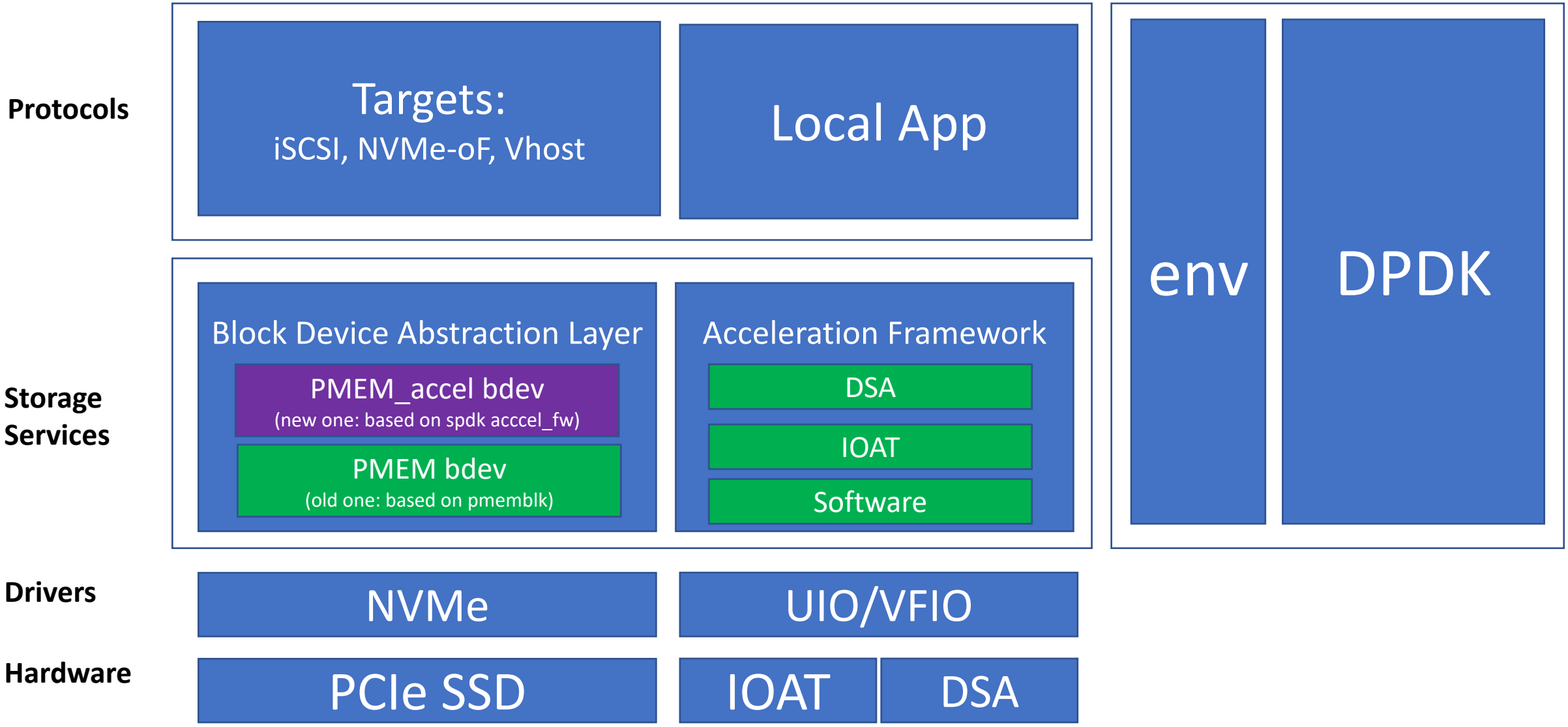
- Functionality: Support operations between (persistent) memory
  - ***Copy, Fill, CRC32C, Dual-cast, Compare***
- Optional batching support, application configurable batch sizes
- (May be deprecated in the future to make batch supporting inside the library)
- Dedicated work queues
- 2 pre-defined group/engine configurations selectable via API, easily changed in code as new/different configs are identified
- All DSA units are ganged together and collectively used, load balanced amongst SPDK threads
- Dynamic load balancing and flow control as threads come and go
- No interrupts or locking
- No dependency on other DSA software

New PMEM bdev (pmem_accel) development status

Purpose

- Design and implement a new bdev (named as pmem_accel) based on ***persistent memory*** and ***spdk accel_fw*** to demonstrate that hardware-based memory offloading engine (e.g., IOAT/DSA) can help improve the performance.
- For this new bdev, we will not consider some complicated I/O usage scenarios (e.g., I/O atomicity for large size, sequence order, which should be addressed and guaranteed by upper layer logic).
- Our purpose is to leverage IOAT/DSA in spdk accel_fw to reduce the CPU participation overhead.
- Ideally, such offloading should be provided by PMDK, but currently PMDK library has some limitations, i.e.,
  - ***It only provides the synchronized API interface.*** *(This will be an ongoing work inside PMDK)*
  - ***It does not have the ability to plugin memory offloading engines inside PMDK.***

PMEM_accel bdev
(based on PMEM device and spdk accel_fw)



Two possible PMEM integration in SPDK to implement pmem_accel bdev

- We use PMEM in ***App Direct*** (AD) mode for persistency purpose. And the PMEM usage in AD mode can be divided into
- Fsdax mode
  - Format the pmem device with “fsdax” choice. Users get block devices, e.g., /dev/pmem0, and users can create file system (especially kernel supported file system) upon that.
- Dax Mode
  - Format the pmem device with “dax” choice . Then we get char devices, e.g., /dev/dax0.0, then you directly operate on such device.

Supported combinations

- Using FSDAX mode,
  - For CPU execution, you can choose to use libpmemobj/libpmem or not use.
- Using DAX mode,
  - For CPU execution, you can use libpmem or not use.
  - Limitation of using libpmem, pmem_map_file API's limitation on the file size.
- Data persistency while using DSA/IOAT in spdk accel_fw
  - For using DSA, we need to enable the ***persistency support by revising SPDK's idxd and accel library*** since our purpose is not having data lost while there is sudden power lost)
  - *For using IOAT,* ***the write durability cannot be fully guaranteed while there is power lost****.*

Accessibility \PMEM mode	FSDAX (mount choice: -o DAX)	FSDAX	DAX
CPU	Y	Y	Y
IOAT	N	Y	Y
DSA	N	Y	Y

PMEM_accel bdev summary

- Current decision (According to analysis in previous pages):
  - We choose to use ***DAX mode*** directly. But we want to continue discussing with customers whether DAX mode can fully satisfy customers' requirements. And we provide the ongoing patch in public to notify our progress.
  - In this usage, file system can not be viewed directly on the char device. The pmem devices can be partitioned into different character devices. A SPDK process will directly use one or several /dev/dax* devices directly.
- Ideally, we think that "***PMEM + FSDAX + -O DAX***" should be the perfect solution.
  - But it requires the kernel support especially in file system in Linux kernel , and it may not be available for a long time.
  - We will not use PMEM + FSDAX, because it can not provide the data durability while using offloading devices because offloading devices operate on page caches .
    - **Data path: Cache + DRAM -> BLOCK device -> PMEM**

Conclusion

PMEM_accel bdev summary

- We realize the overhead/bottleneck of CPU to conduct data operations between (persistent) memory while performing storage workloads.
  - Data operations “between (persistent) Memory” is different from “data operations between Memory and device”. ***For the latter case, there is (R)DMA capability on device, and CPU is not very busy.***
  - So, additional memory operation offloading engines (e.g., IOAT/DSA) are needed to use in order to save CPU resources.
- We introduce SPDK acceleration framework (spdk **accel_fw**) to leverage different memory offloading engines to address such problems and give the usage on PMEM device.
- Next step: We will continue improving spdk **accel_fw** and leverage it to solve different problems in storage aspect.
- For performance report will be shown in spdk website in the future.

Q & A

Thanks!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