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Virtual BDEVs: The Secret to Customizing SPDK

Paul Luse, Intel Corporation
Fiona Trahe, Intel Corporation

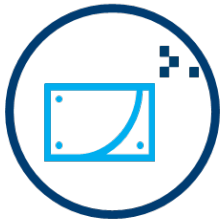
Agenda

- What Is SPDK?
- Block Device Layer
- Virtual Block Devices
- The PassThru Vbev Module
- The Crypo Vbdev Module via DPDK
- Future Work

What Is SPDK?

Storage Performance Development Kit

Available via spdk.io



Open Source Software

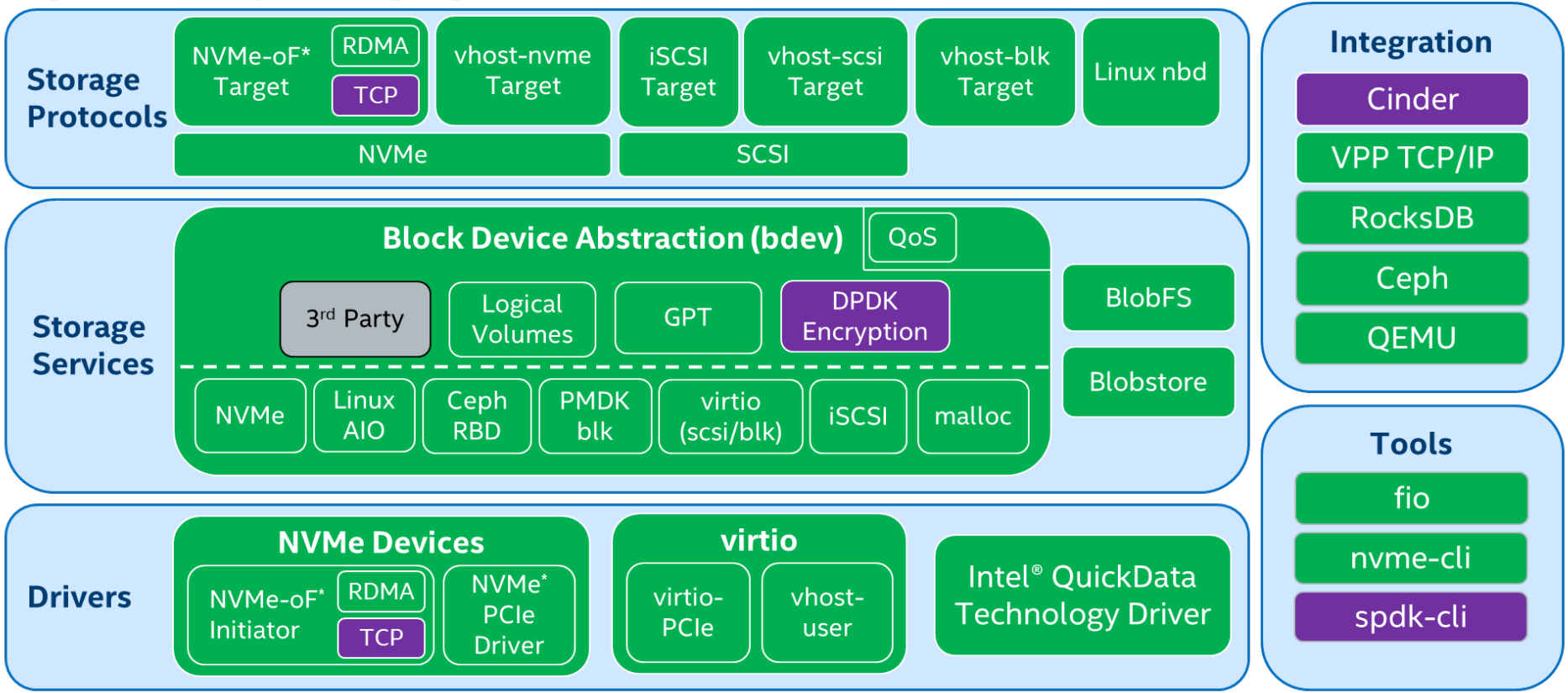
- Optimized for latest generation CPUs and SSDs
- Software building blocks (BSD licensed)
- Designed to extract maximum performance from non-volatile media

Scalable and Efficient Software Ingredients

- User space, lockless, polled-mode components
- Up to millions of IOPS per core
- Minimize average and tail latencies

SPDK ARCHITECTURE

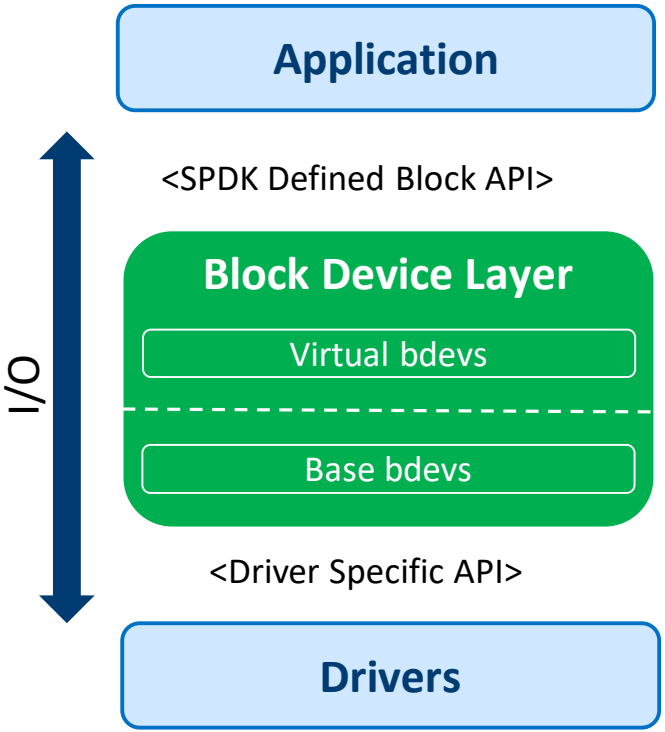
In Progress



Bdev Layer Terminology

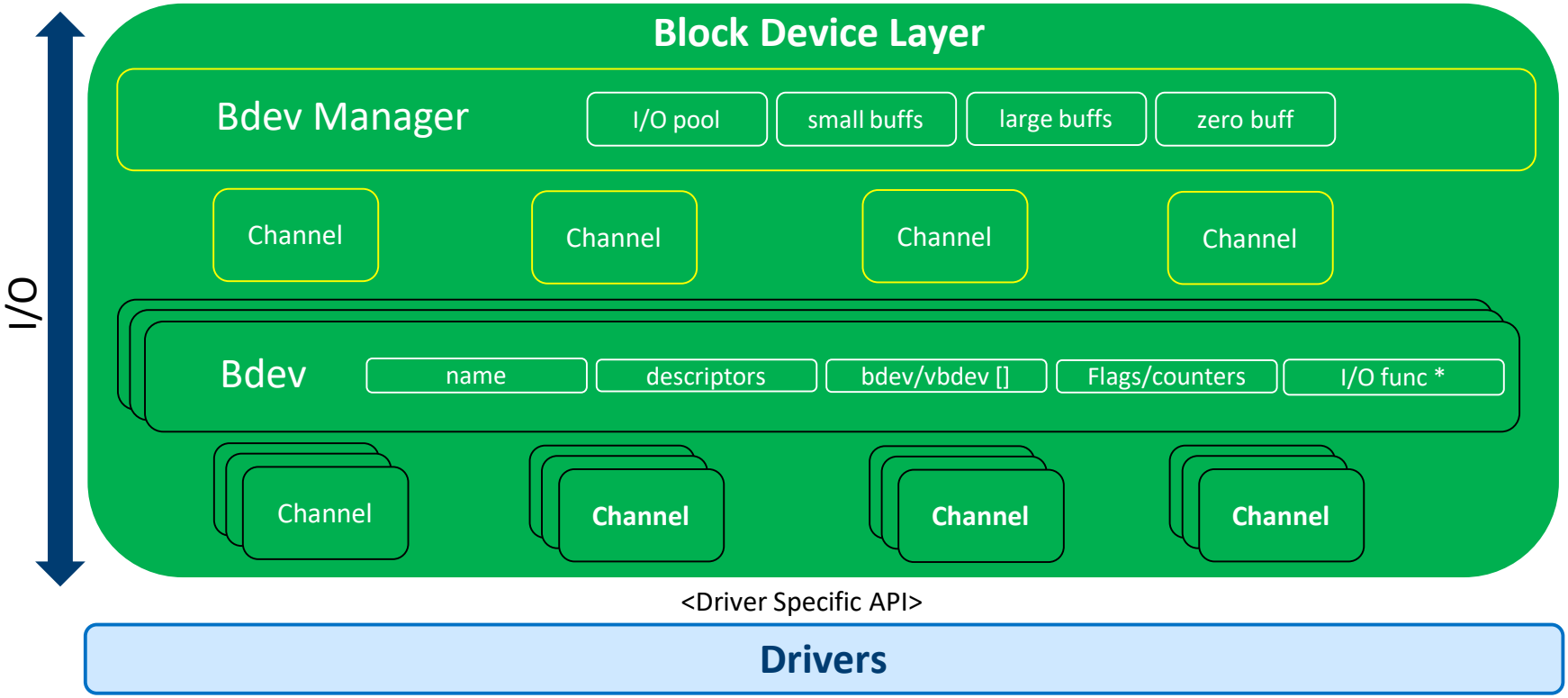
- **Bdev Layer**: The entire block device abstraction layer in the code. The public interface is in include/spdk/bdev.h and the implementation is in lib/bdev.
- **Bdev Module**: Block devices have types (NVMe, Malloc, AIO, etc.). The code to implement a specific type of block device is called a module.
- **Bdev**: An individual block device that may be sent I/O requests..
- **Base bdevs**: A bdev that handles I/O requests directly, as opposed to a virtual bdev..
- **Virtual bdevs (aka vbdevs)**: A bdev that handles I/O requests by routing them to other bdevs. *Note: This is only a distinction in terminology - all bdevs are represented in the code using the same structure and interface.*

Block device layer: 50K Foot View

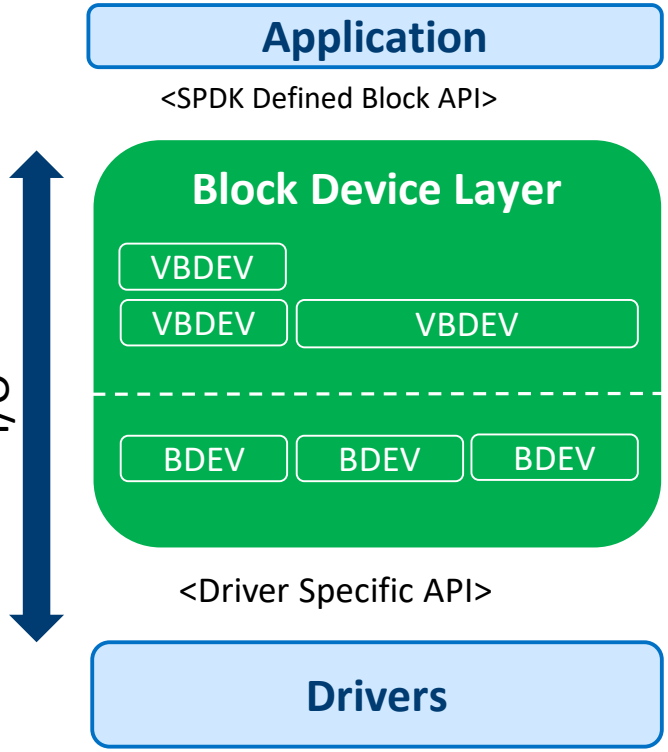


- Automatic queueing of I/O requests in response to queue full or out-of-memory conditions
- Hot remove support, even while I/O traffic is occurring.
- I/O statistics such as bandwidth and latency
- Device reset support and I/O timeout tracking
- Quality of Service Features

Block device layer: 1K Foot View

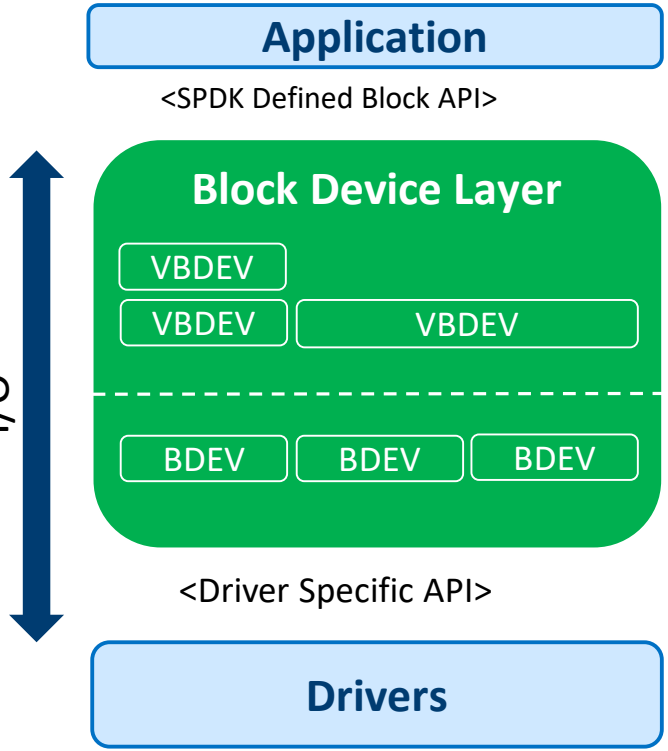


Virtual block devices: 50K Foot View



- Can represent multiple base bdevs and surface a single vbdev
- Can intercept I/O on the way down and the way back
- Same struct as Base bdevs, `struct spdk_bdev`
- Well defined API enables isolated IP for value added services

Virtual block devices: Examples



- Logical Volumes: Virtual bdevs carved out of non-contiguous regions on a larger backing bdev implemented using SPDK's Blobstore.
- Error: Enables the ability to inject errors at the block device layer API level.
- GPT: Surfaces GPT partitions as separate BDEVs.
- PassThru: An example/template for creating new VBDEV modules. Lots more on this in tomorrow's lab.
- Crypto: At rest data encryption via the DPDK Cryptodev Framework.

The passthru vbdev module - Initialization

```
static struct spdk_bdev_module passthru_if = {
        .name = "passthru",
        .module_init = vbdev_passthru_init,
        .config_text = vbdev_passthru_get_spdk_running_config,
        .get_ctx_size = vbdev_passthru_get_ctx_size,
        .examine = vbdev_passthru_examine,
        .module_fini = vbdev_passthru_finish
};
```

Bdev Module Function Table

Bdev Function Table

```
/* When we register our bdev this is how we specify our entry points. */
static const struct spdk_bdev_fn_table vbdev_passthru_fn_table = {
        .destruct               = vbdev_passthru_destruct,
        .submit_request         = vbdev_passthru_submit_request,
        .io_type_supported      = vbdev_passthru_io_type_supported,
        .get_io_channel         = vbdev_passthru_get_io_channel,
        .dump_info_json         = vbdev_passthru_info_config_json,
        .write_config_json      = vbdev_passthru_write_json_config,
};
```

The passthru vbdev module - initialization

```
/* On init, just parse config file and build
 *list of pt vbdevs and bdev name pairs.
 */
static int
vbdev_passthru_init(void)
```

The bdev layer calls this entry point where early setup stuff can be done, in the template the conf file is parsed.

Anytime a new bdev shows up, each vbdev module gets a chance to take action in its examine() callback.

```
/* Because we specified this function in our pt bdev function table when we
 * registered our pt bdev, we'll get this call anytime a new bdev shows up.
 * Here we need to decide if we care about it and if so what to do. We
 * parsed the config file at init so we check the new bdev against the list
 * we built up at that time and if the user configured us to attach to this
 * bdev, here's where we do it.
 */
static void
vbdev_passthru_examine(struct spdk_bdev *bdev)
```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The passthru vbdev module - examine

```
rc = spdk_bdev_module_claim_bdev(bdev, pt_node->base_desc, pt_node->pt_bdev.module);
if (rc) {
        SPDK_ERRLOG("could not claim bdev %s\n", spdk_bdev_get_name(bdev));
        spdk_bdev_close(pt_node->base_desc);
        TAILQ_REMOVE(&g_pt_nodes, pt_node, link);
        free(pt_node->pt_bdev.name);
        free(pt_node);
        break;
}
SPDK_NOTICELOG("bdev claimed\n");

rc = spdk_vbdev_register(&pt_node->pt_bdev, &bdev, 1);
if (rc) {
        SPDK_ERRLOG("could not register pt_bdev\n");
        spdk_bdev_close(pt_node->base_desc);
        TAILQ_REMOVE(&g_pt_nodes, pt_node, link);
        free(pt_node->pt_bdev.name);
        free(pt_node);
        break;
}
```

Too many steps to show all of them here, but as part of the examine() call, the vbdev module claims a base bdev and registers a virtual bdev..

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The passthru vbdev module - Submission

Submission Intercept

```
/* Called when someone above submits IO to this pt vbdev. We're simply passing it on here
 * via SPDK IO calls which in turn allocate another bdev IO and call our cpl callback provided
 * below along with the original bdiv_io so that we can complete it once this IO completes.
 */
static void
vbdev_passthru_submit_request(struct spdk_io_channel *ch, struct spdk_bdev_io *bdev_io)
{
        struct vbdev_passthru *pt_node = SPDK_CONTAINEROF(bdev_io->bdev, struct vbdev_passthru, pt_bdev);
        struct pt_io_channel *pt_ch = spdk_io_channel_get_ctx(ch);
        struct passthru_bdev_io *io_ctx = (struct passthru_bdev_io *)bdev_io->driver_ctx;
        int rc = 1;

        /* Setup a per IO context value; we don't do anything with it in the vbdev other
         * than confirm we get the same thing back in the completion callback just to
         * demonstrate.
         */
        io_ctx->test = 0x5a;

        switch (bdev_io->type) {
        case SPDK_BDEV_IO_TYPE_READ:
                rc = spdk_bdev_readv_blocks(pt_node->base_desc, pt_ch->base_ch, bdev_io->u.bdev.iovs,
                                            bdev_io->u.bdev.iovcnt, bdev_io->u.bdev.offset_blocks,
                                            bdev_io->u.bdev.num_blocks, _pt_complete_io,
                                            bdev_io);
```

The passthru vbdev module - completion

Completion Intercept

```
/* Completion callback for IO that were issued from this bdev. The original bdev_io
 * is passed in as an arg so we'll complete that one with the appropriate status
 * and then free the one that this module issued.
 */
static void
_pt_complete_io(struct spdk_bdev_io *bdev_io, bool success, void *cb_arg)
{
        struct spdk_bdev_io *orig_io = cb_arg;
        int status = success ? SPDK_BDEV_IO_STATUS_SUCCESS : SPDK_BDEV_IO_STATUS_FAILED;
        struct passthru_bdev_io *io_ctx = (struct passthru_bdev_io *)orig_io->driver_ctx;

        /* We setup this value in the submission routine, just showing here that it is
         * passed back to us.
         */
        if (io_ctx->test != 0x5a) {
                SPDK_ERRLOG("Error, original IO device_ctx is wrong! 0x%x\n",
                            io_ctx->test);
        }

        /* Complete the original IO and then free the one that we created here
         * as a result of issuing an IO via submit_reqeust.
         */
        spdk_bdev_io_complete(orig_io, status);
        spdk_bdev_free_io(bdev_io);
}
```


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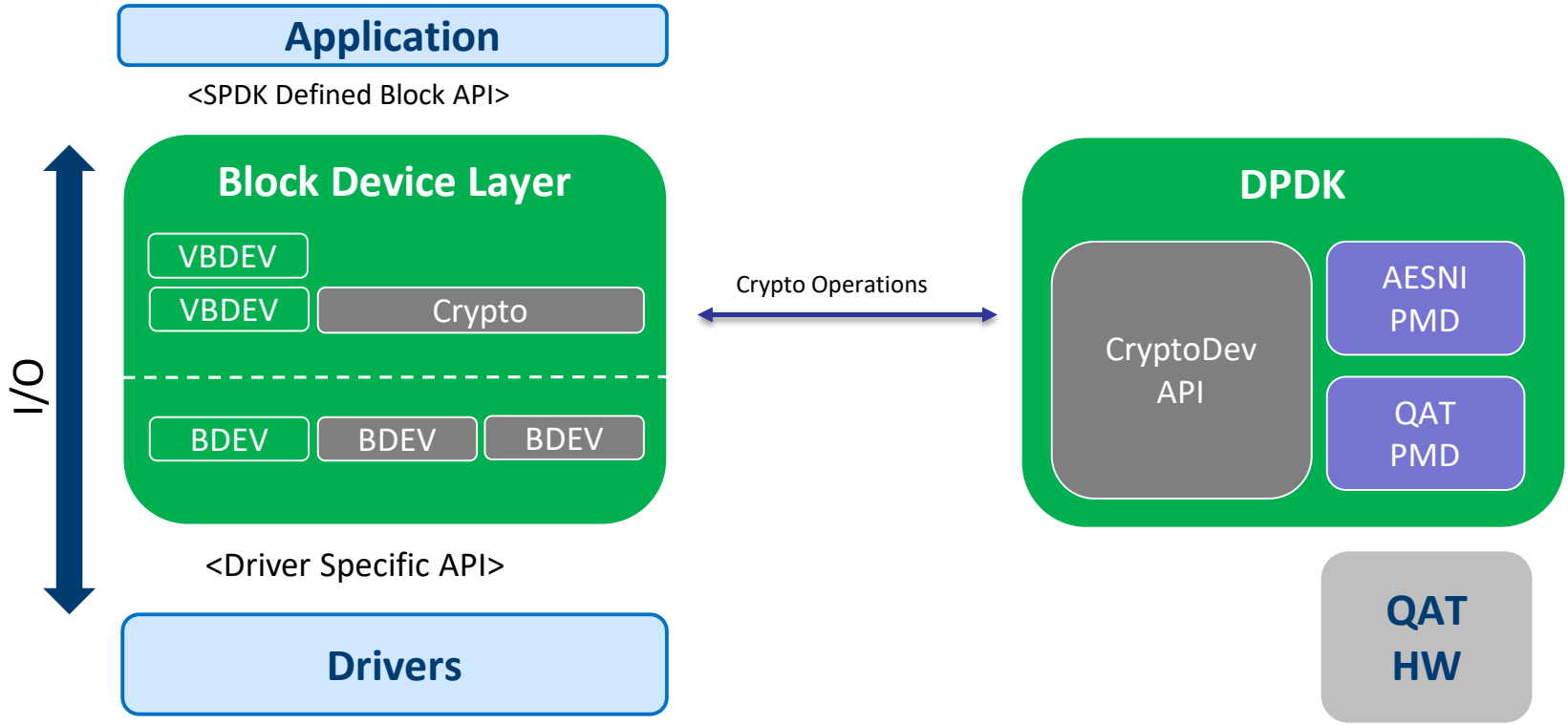
The Crypto Vbdev Module

- Relies on DPDK CryptoDev
- Initially supports software encryption AESNI multi-buffer CBC
- Also supports hardware offload with Intel® QuickAssist Technology (in validation still)
- Can be layred on any bdev or vbdev

The Crypto Vbdev Module

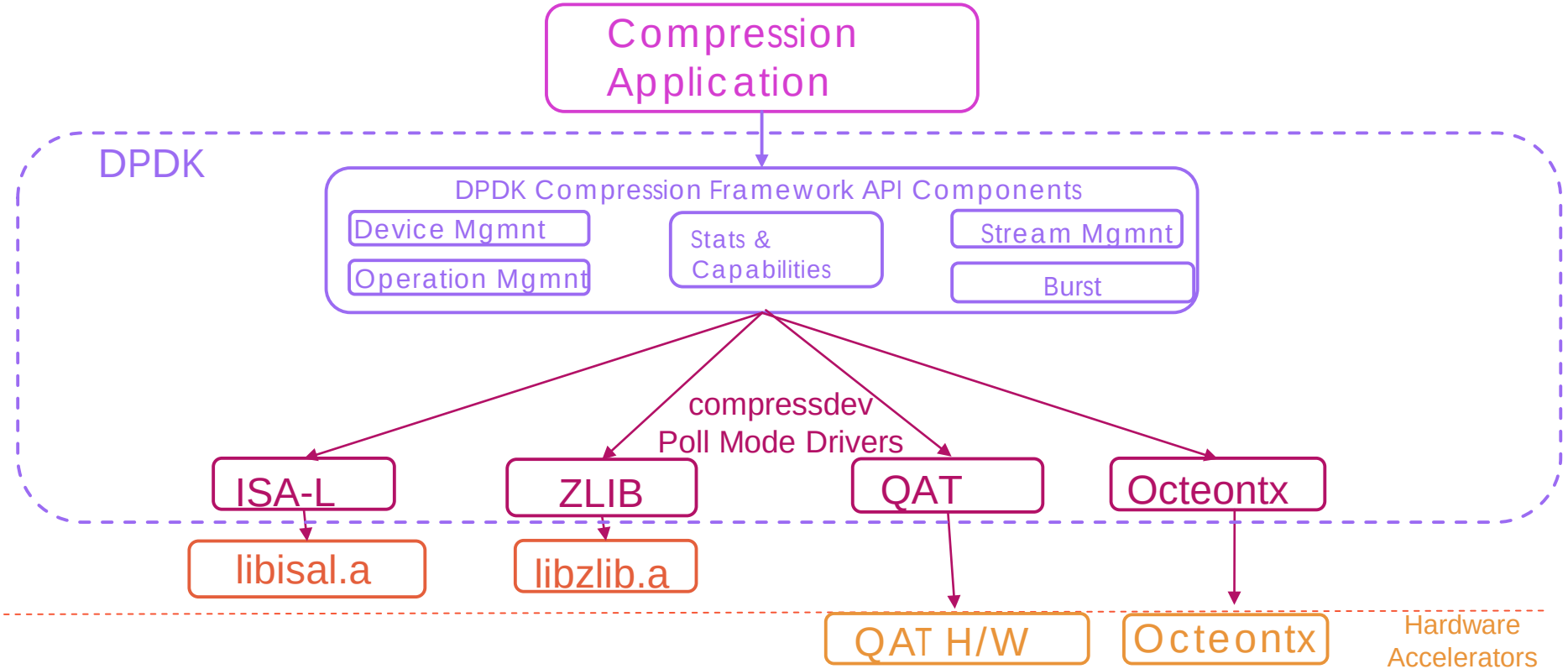


Future Work: Compression from DPDK

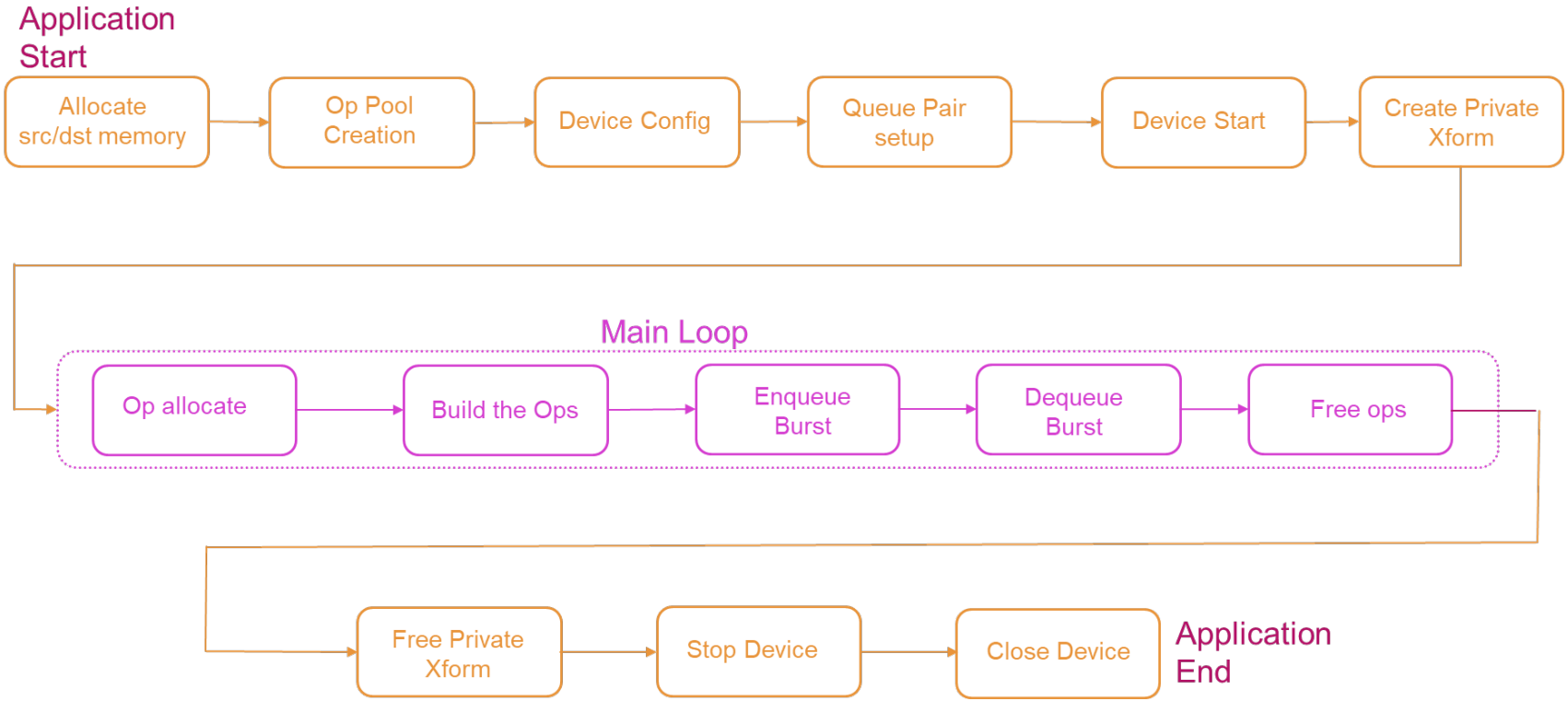
dpdk/compressdev key features

Asynchronous burst API	Chained Mbufs	Compression Algorithms	Compression Levels	Checksum	Hash Generation
To support HW & SW acceleration.	To allow compression for data greater than 64K.	Deflate LZS	-1: PMD Default 1: Fastest . . . 9: Best Ratio	#1 CRC32 #2 Adler32 #3 Combined - Adler32_CRC32	#1 SHA1 #2 SHA256

compressdev components



Typical compressdev API flow



Compression - stateless