Open-Channel V LightNVM Brings SSDs to the Linux Kernel

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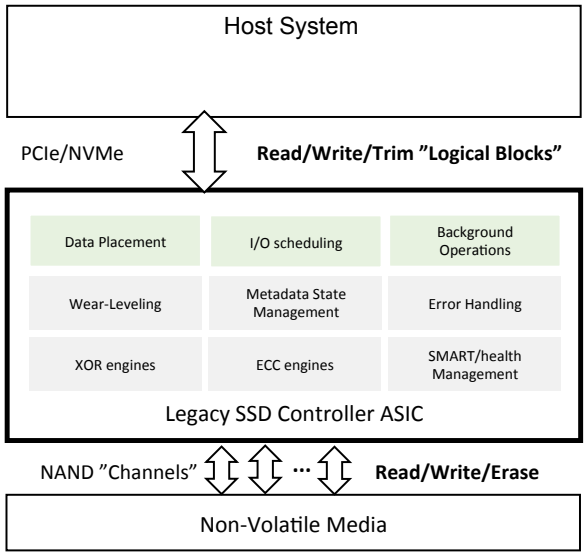
Introduction

- Matias Bjørling, LightNVM Principal Architect, CNEX Labs, Inc.

CNEXLABS

- CNEX is a privately held start-up company
- Founded in 2013 by semiconductor industry veterans in Silicon Valley
- Funded by VC and investments from Fortune 500 companies in storage and networking
- Chartered to deliver innovative system solutions in the form of semiconductors and software
- First product is a highly differentiated NVMe SSD controller ASIC
- Currently shipping SDK's; engaged with strategic customers and partners for mass production

SSD Controllers: Terminology and Core Functionality



All FTL Functionality Hardwired in <u>Device Firmware</u>

Flash Translation Layer (FTL) for a typical NVMe SSD device

Where does it shine?
When is this not-so-good?

Traditional SSD

- Logical Block Addressing (LBA) on Device
- FTL controlled by Device Firmware ("Black-Box")
- Fixed functionality & performance

Hint:
Jeffrey Dean, Luiz André Barroso, *"The Tale at Scale"*

Addressing Todays SSD Workloads

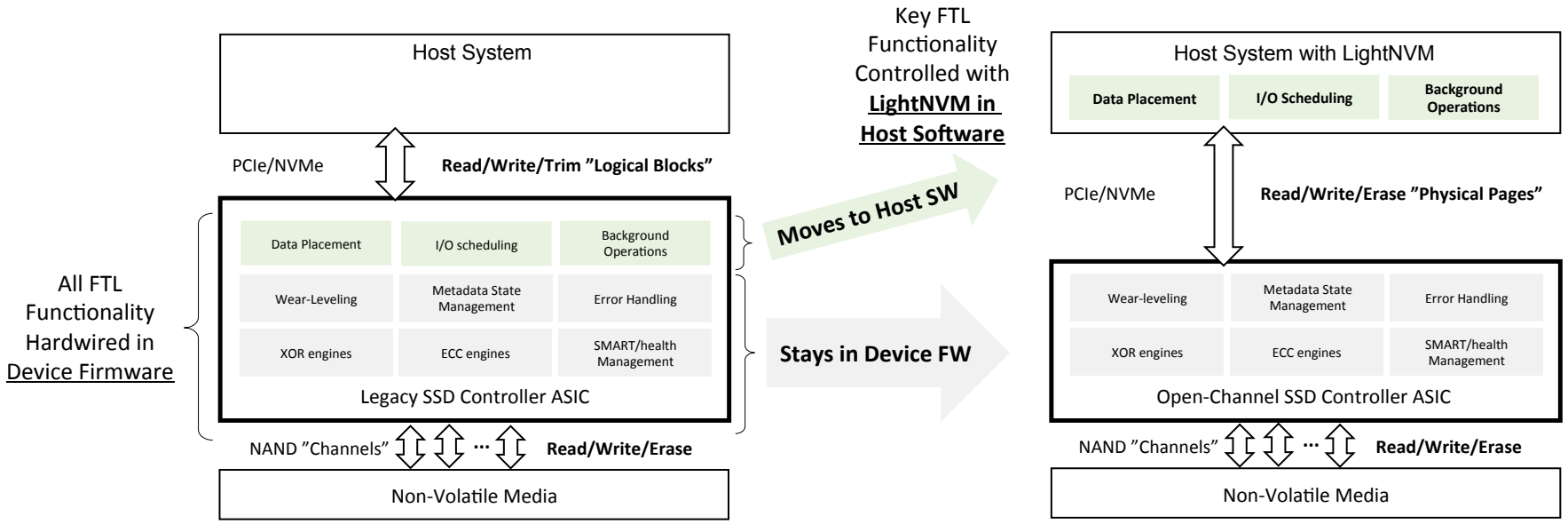
- Key Drivers:
  - Web-Scale Datacenters
  - Hyper-converged Infrastructure
  - Flash Array Products
  - High-Performance Computing

- Key Requirements
  - Latency
    - Low & Deterministic
    - Versus Endurance and Throughput
  - Power/Energy efficiency

LightNVM for Application-Defined-Storage

- Full host control of Physical data placement, I/O scheduling, and background operations
- FTL tailored for specific application types and workloads
- Low and predictable latency, DRAM-less controllers, and energy efficiency

LightNVM: Key Concepts



Traditional SSD

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Open-Channel SSD

- Physical Page Addressing (PPA) Command Set
- Key FTL functions exposed to LightNVM on Host
- Flexible for application-specific performance

LightNVM with Open-Channel SSD Hardware

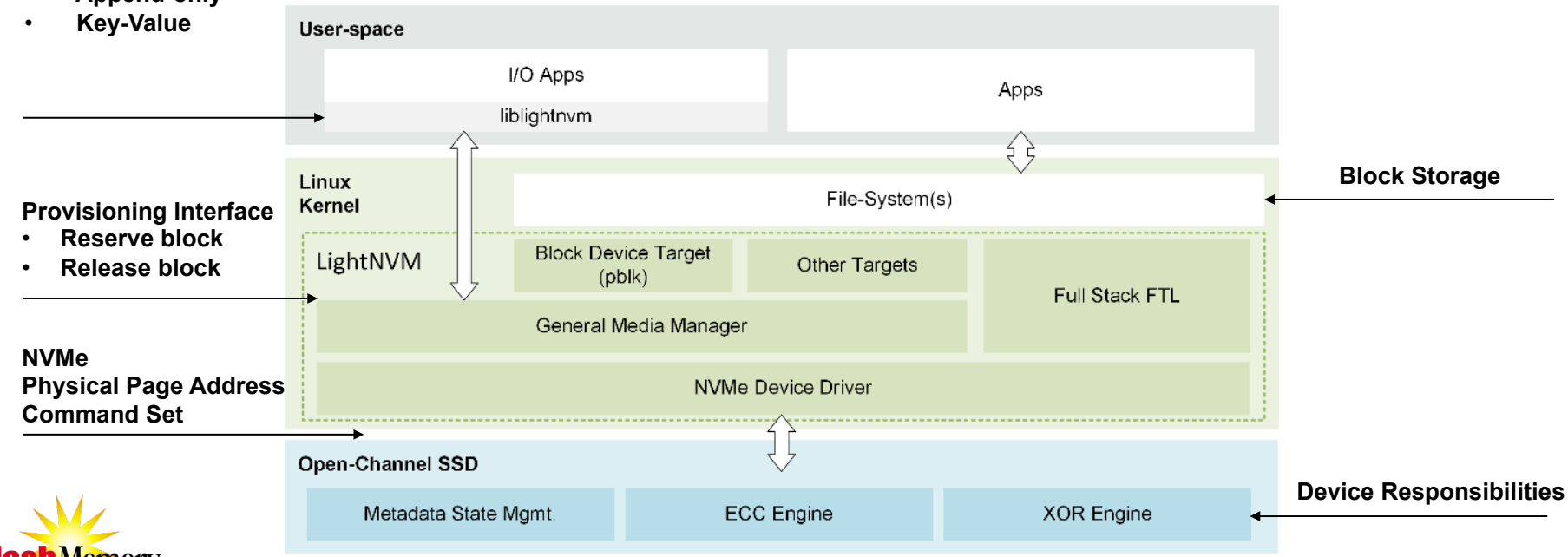
NVMe compatible:

- Physical Page Addressing (PPA) Command Set
- Linux kernel 4.4+
- Managed using standardlized nvme tools (nvme-cli)

Common Data Structures
- **Append-only**
- **Key-Value**

Provisioning Interface
- **Reserve block**
- **Release block**

NVMe Physical Page Address Command Set



Block Storage

Device Responsibilities

LightNVM Leverages NVMe for Minimal Disruption

- Use existing NVMe Admin and Queuing structure, and NVMe device driver
- Add I/O Commands for "Physical Page Addressing" (PPA)
  - Currently implemented as NVMe "vendor unique" commands;

Open-Channel PPA I/O Commands:

Read PPA: *"Read a PPA, in unit of a sector"*

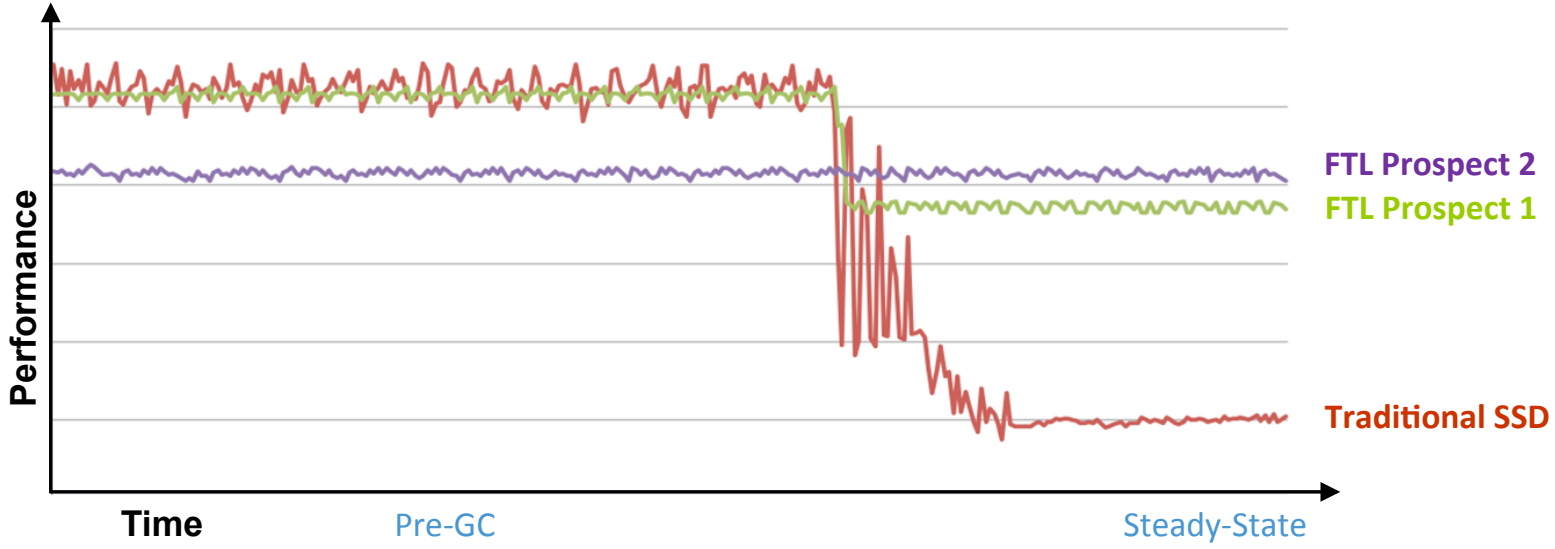
Write PPA: *"Write to a PPA, in unit of a sector"*

Erase PPA: *"Erase an NVM block"*

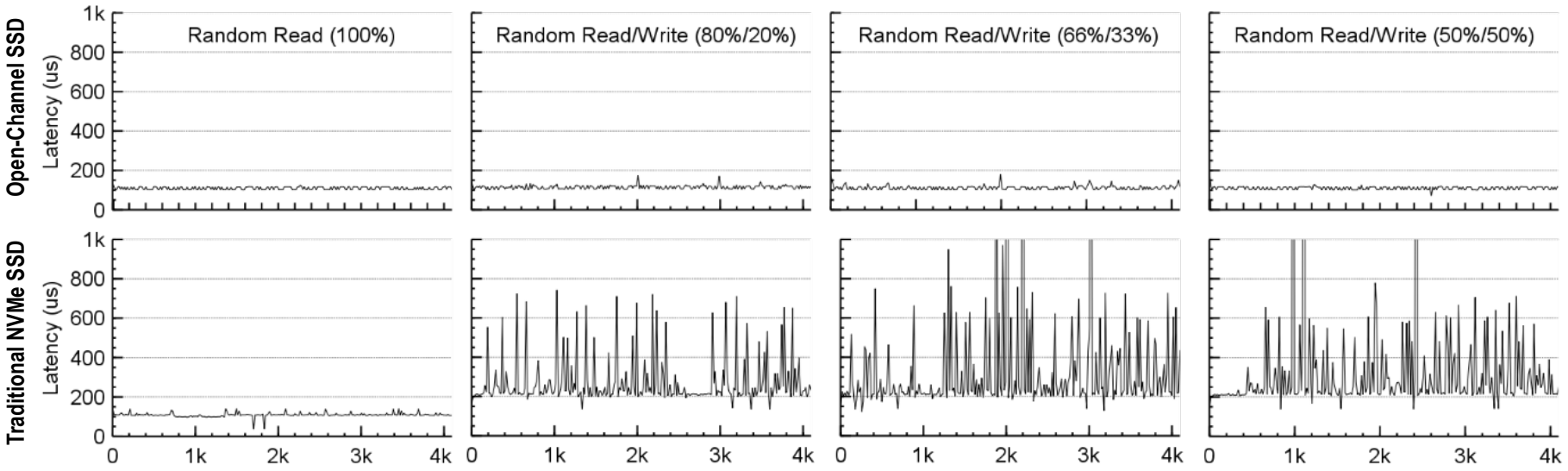
Identify Geometry: *"Get geometry of device & media"*

Predictable Performance, Latency

- With Open-Channel SSDs, host FTL software can be tuned for workloads and application types
- Enables data placement by data “type” or “class”, to avoid mixing data within NAND flash blocks
- Reduced overprovisioning, reduced write-amplification, intelligent garbage collection…
- A qualitative example:

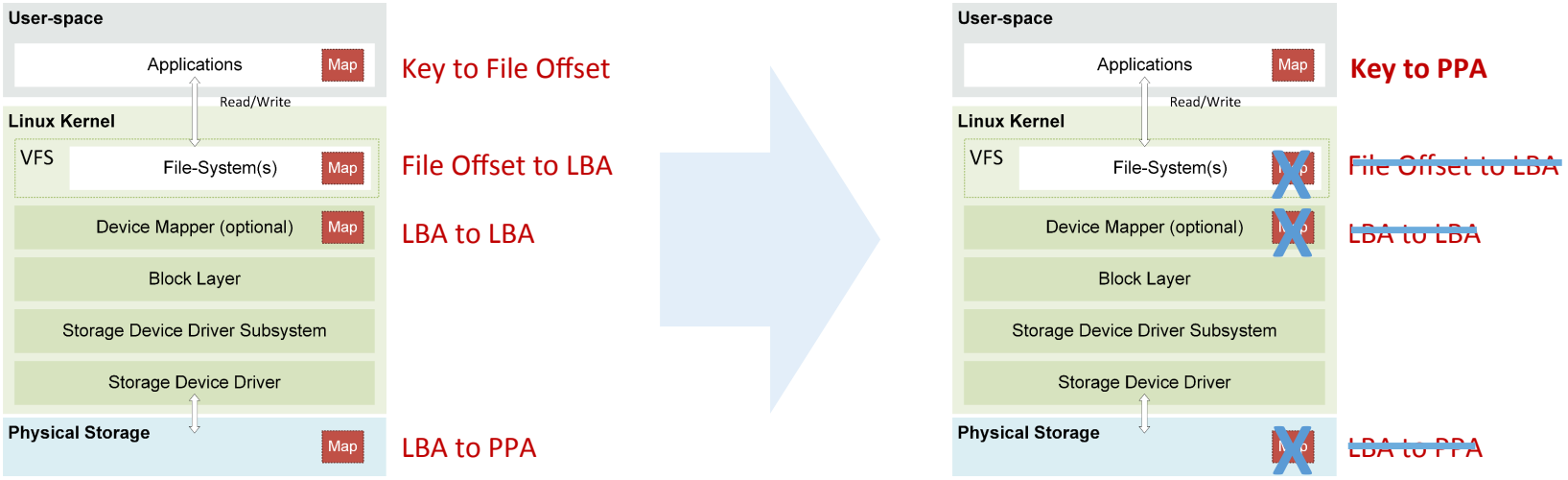


Read/Write Latency



User Space FTL with LightNVM, liblightnvm

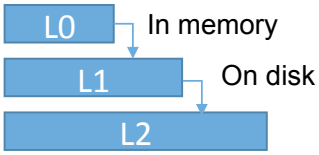
- Potential to collapse multiple layers of redundant mapping in application & filesystem
- Bypass Kernel processing, preserve low-latency characteristics of new/emerging NV Media types



Application Acceleration with LightNVM, liblightnvm

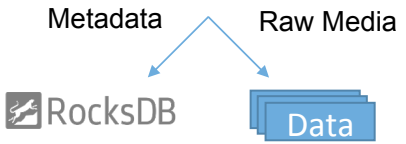
RocksDB

- Maps Flash blocks to RocksDB levels
  - Perfect Layout on SSD
  - No garbage collection
  - Reduced write amplification



ceph BLUESTORE

- Maps flash blocks to large data blocks
  - No garbage collection necessary
- Metadata in RocksDB
  - Fast updates



Predictable throughput and latency

Summary

- Significant advantages to OpenChannel SSD with Host FTL
  - Performance, Latency, Power, Endurance, Application Specific Performance, …
  - De-couples FTL SW from SSD Controller Hardware (Development Cycles) – Enables Rapid Innovation
- Minimal disruption
  - Utilize existing NVMe; add I/O commands for Physical Page Addressing
- OpenChannel SSD and LightNVM FTL is a Growing ecosystem!
  - Participate at: https://github.com/OpenChannelSSD

- **See OpenChannel/LightNVM SSD demos at FMS:**
  - **Liteon: Booth 621**
  - **Micron: Booth 134**
  - **Radian: Booth 615**

Thank-You!

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