How Facebook and Microsoft Leverage NVMe™ Cloud Storage

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SNIA-At-A-Glance

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NVMe™ In The Real World
Facebook’s mission is to give people the power to build community and bring the world closer together.
Facebook @ Scale

1 Billion

1.3 Billion

2.7 Billion
Why NVMe? - Exploding Storage Growth
Hyperscale Requires IOPS to Scale with Capacity

Graph showing the relationship between system flash capacity and IOPS per TB for NVMe SSDs and SATA SSDs.
• Issues at Scale
  – Deallocate
  – Remote debugging
  – Security
  – “Rot in Place”
  – Form factors
• What’s New?
NVMe De-Allocate: Challenges and Improvements

- **NVMe De-allocate**
  - Goal: It’s a hint from the system to the SSD that the system is no longer tracking certain LBAs
  - Good
    - Reduces Write Amplification
    - Improves performance/endurance
  - Bad
    - Latency spikes due to De-allocate blocking Read/Write

- **Old Solution**
  - Tune De-Allocate size on a system
  - Problem: The optimized de-allocate size varies based on supplier. Thus which supplier should I optimize for?

- **Improved solution**
  - NVMe 1.4 allows the SSD to advertise it’s preferred De-allocation size
    - If NSFEAT bit 4 = 0x1 then Namespace Preferred Deallocate Granulatirity (NPDG) is valid
  - This allows systems to be optimized standard mechanisms.
Managing at Scale

- **Challenge:** Hyperscale Requires Debug with no physical access to the SSD.
- **Challenge#1:** Restricted access for vendor unique tools
- **Solution:**
  - NVMeTM CLI – Open source with active industry contribution and updates
    - [https://github.com/linux-nvme/nvme-cli](https://github.com/linux-nvme/nvme-cli)
  - Vendor-unique CLI plugin that pulls and reports the logs in a common format
- **Challenge#2:** How do I get the debug information needed to resolve the issue
- **Solution:** Telemetry
  - This allows SSD providers to get remote debug information to resolve issues
  - Different data areas allows for different levels of debugging

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Issues at Scale – Need for Remote Debugging

- **Timestamp**
  - Drive events correlated to system (BIOS and OS) events

- **Telemetry**
  - Host initiated - IO failures
  - Drive Initiated - Firmware panic?

- **SMART**
  - Both standard and vendor unique collected once an hour
    - Hey SSD IHVs. How many terabytes would you like to see?

- **Caveat:** Any data that leaves the datacenter must be in human readable form!
Managing at Scale

- **Background:** The amount of data written to a SSD may exceed the endurance of the SSD given the expected lifetime of the SSD. Given a fixed amount of write bandwidth a low the capacity SSD will wear out faster than a higher capacity SSD. Examples of applications where this can occur are logging and caching.

- **Challenge/Real World Example:**
  - Application only needs 256 GB but will use all the SSD capacity
  - Application write rate is high enough that it will wear out the 256 GB SSD
  - Application write rate scales per TB: Thus increasing capacity will not keep the SSD from wearing out

- **Solution: Namespace Management**
  - Allows a 512 GB SSD to be configured as a 256GB SSD with double the endurance of a 256 GB SSD
  - Thus the application view is a 256GB with double the endurance
Managing at Scale

Challenge: How many blocks in my SSD have data and how many do not? If I de-allocate some blocks how many blocks really contain data? What is the effective over provisioning from a performance perspective?

Solution:

- Namespace Utilization (NUSE)
- Allows user to determine the number of LBAs that actually contain data.
Challenge

.Security challenges are growing

- NVM Express supports SECURITY_SEND/RECEIVE will allows for security protocols to be tunneled into NVM Express
- There is even an open source tool for NVMeTM Opal security:
  - [https://github.com/Drive-Trust-Alliance/sedutil](https://github.com/Drive-Trust-Alliance/sedutil)
- Secure Boot is also a common security requirement. This is a process that ensures the firmware running on the device is from the manufacture and not some other source.

Problem/Industry call to action:

- There is no standard way to know if secure boot failed
- If firmware on a device is compromised, how is this identified vs any other type of failure?
Issues at Scale – Need for Security

eDrive on Windows
- Opal v2 plus IEEE 1667 secure silo

Hardware Root of Trust
- Secure boot
- Signed firmware
- Cerberus

Device Hardening
- Pen and Fuzz testing
- Locking of debug ports and vendor unique commands

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Issues at Scale – Need to allow for “Rot in Place”

Use the Endurance and Performance metrics for auto tiering

- Allows for fitting the workload to the device
- Allows for the ability to adjust the temperature of the data over time
- Allow for 5 to 7-year device service life

Zoned Name Spaces for QLC

- Reduce WAF due to large sequential writes
- Reduce DRAM due to large indirection unit
- Reduce overprovisioning due to minimal garbage collection
Issues at Scale – Form Factors

- m.2 has run its course
  - Power and thermal constraints
  - Fragile PCB and connector
  - Not hot-swappable

- E1.L and E1.S are here to replace it
  - Built from the ground up for datacenter use cases

- Good news is that they support NVMe too!
What’s new in storage with Microsoft & Facebook?
Microsoft/Facebook are merging their SSD drive requirements into a single document
What is the Problem?

- Hyperscale providers have features that are needed to manage SSDs at scale but are not sharing these features with the rest of the industry.
- Many features are common across providers. Each implemented slightly differently.
- Cloud SSD consumers have confidential SSD specifications which doesn’t encourage industry collaboration and discussion.
- There is no public document on what a Cloud SSD should be.
- SSD industry fragmentation due to lots of different skews that are “similar” but different.
- 3rd Party compliance suites don’t know what features cloud providers care about since they do not know what features Cloud consumers use.
Solution

- Microsoft/Facebook have merged their SSD drive requirements into a single document
  - *Microsoft/Facebook would like to contribute this document to OCP*
- Benefits:
  - Allows the market to understand what features Microsoft/Facebook need to manage a SSD at scale
  - Allows the market to understand and use the SSD’s Microsoft/Facebook are using
  - Reduces SSD market fragmentation
  - Enables open source tools like NVMe CLI to manage the SSD
  - Allows 3rd parties to focus their test/validation efforts
- Summary
  - Benefits both system makers and SSD providers

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