I/O Determinism and Its Impact on Data Centers and Hyperscale Applications

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What is the requirement?

- Consistent latency
  - Eliminate the long tail
  - Prevent impact from background operations
    - Garbage Collection
    - Read Disturb – rewrite
  - Prevent impact from noisy neighbors

Alternate approaches

- Open Channel
- IO Determinism
- Other options

Open Channel Benefits

- Allows application to determine the applications best optimization of SSD
- Application is in control of when background operations are performed
- Application controls all neighbor activity

Open Channel Implications

- Application must be enhanced for EVERY SSD
  - Technology
    - NAND Flash
    - 3D NAND Flash
    - 3D XPoint
    - Other
  - Configuration
    - Number of independent regions
    - Constraints on background operation
    - Other
- Application must be aware of all neighbors
- Application must maintain a lookup table in addition to any FTL on the device
- Device may have to do some activities in spite of management by application management
  - Negates some of the application management
- Host processing used for something that device has processor power to accomplish
- Application must change from current implementation

Device considerations for Open Channel

- What requirements does a particular device have for re-writing data
  - Frequency
  - Read/Write impact
- What requirements for garbage collection
  - Block Size
  - Block configuration
- How are physical blocks accessed
  - What interaction between reads/writes are implied
    - Channel
    - Die
    - Other

IO Determinism Benefits

- Allows SSD vendors to add value due to knowledge of technology/configuration
  - As technology changes device vendors know the implications of those changes
  - Device vendors can tune performance as device characteristics change
  - Technology does not have to report unnecessary characteristics
- Uses compute power already present on device to manage device

IO Determinism Implications

- Device must communicate additional characteristics to the application
  - These are generic not technology/configuration specific
- Application must identify data associations to avoid performance implications of Reads vs Writes
- Application must be re-written to take advantage of the potential performance improvements

Device considerations for IO Determinism

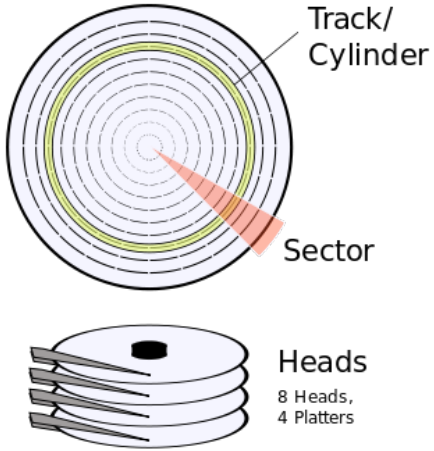
- What does the device communicate to the application
  - Generalized to be technology/configuration agnostic
- How do you report a generalized requirement by the application for specific class of latency
  - Per read/write?
- How do you communicate a device requirement to perform tasks that may impact latency
  - Interrupt
  - Polling
  - Time based

Alternative approaches

- Reduced latency technologies
  - Inherently without Tail Latency
  - With short enough latency that Tail Latency is within the requirements of the application
- “Tiny-Tail Flash: Near-Perfect Elimination of Garbage Collection Tail Latencies in NAND SSDs”
  - Shiqin Yan, et.al., University of Chicago, Fast17 proceedings

Historical perspective

- HDD industry started with physical addressing
  - Cylinder/Head/Sector
  - As media density grew, devices reported a logical geometry to increase addressability
  - Eventually abstracted to Logical Blocks
- Don’t repeat the mistakes of the past



Call to action

- NVMe technical committee is currently developing IO Determinism
  - Participate in defining how applications pick the right solution
- Allow devices to provide the latency that applications require
  - Do not re-write code for every change in SSD products

Thank You