FLIN: Enabling Fairness and Enhancing Performance in Modern NVMe Solid State Drives

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SSDs are widely used as a storage medium.

SSDs initially adopted conventional host interface protocols (e.g., SATA)

- Designed for magnetic hard disk drives: only thousands of IOPS per device.
Modern SSDs use **high-performance** host interface protocols (e.g., NVMe)
- Takes advantage of SSD throughput: enables **millions of IOPS** per device
- Bypasses OS intervention: **SSD must perform scheduling, ensure fairness**

Fairness should be provided by the SSD itself. Do modern SSDs provide fairness?
Motivation

- We study fairness control in real state-of-the-art SSDs
  - An example of two datacenter workloads running concurrently

Modern NVMe SSDs focus on providing high performance at the expense of large amounts of unfairness
Our First Contribution

- We perform a comprehensive analysis of inter-application interference in state-of-the-art SSDs
  1. The intensity of requests sent by each application
  2. Differences in request access patterns
  3. The ratio of reads to writes
  4. Garbage collection
Our Second Contribution

- We propose the Flash-Level INterference-aware scheduler (FLIN)

- FLIN is a lightweight device-level I/O request scheduling mechanism that provides fairness among requests from different applications

- FLIN carefully reorders transactions within the SSD controller to balance the slowdowns incurred by concurrent applications
Our Third Contribution

- We comprehensively evaluate FLIN using a wide variety of enterprise and datacenter storage workloads

- On average, 70% fairness and 47% performance improvement over a state-of-the-art device-level I/O request scheduler

- FLIN is implemented fully within the SSD firmware with a very modest DRAM overhead (< 0.06%)