**FIOS: A Fair, Efficient Flash I/O Scheduler**

Stan Park  
Kai Shen  
University of Rochester

---

**Motivation**

- Disk-based schedulers + Flash-based storage = poor fairness and sub-par performance
- Recognize performance pitfalls due to Flash characteristics: I/O asymmetry, read-write interference
- Exploit Flash parallelism
- Proper I/O anticipation: Deceptive idleness can hurt fairness of Flash I/O

---

**Motivation: Read-Write Interference**

![Probability density](image1.jpg)

Fast read response is disrupted by interfering writes. Also note varying performance profiles across SSDs.

---

**Motivation: I/O Anticipation Support**

- Reduces potential seek cost for mechanical disks
- ...but largely negative performance effect on Flash
- Flash has no seek latency: no need for anticipation?
- No anticipation can result in unfairness: short service, I/O interference

---

**FIOS Design**

- Fair timeslice management: Basis of fairness
- Read-write interference management: Account for Flash I/O asymmetry and minimize harmful interference
- I/O parallelism: Recognize and exploit SSD internal parallelism while fairly accounting for I/O cost
- I/O anticipation for fairness: Still necessary on Flash; When and how long to anticipate?

---

**Experimental Setup**

- SSDs installed in workstation; CompactFlash in low-power node
- Random I/O microbenchmarks, SPECweb+TPC-C, FAWNDS
- Fairness measured by proportional slowdown: A task running concurrently with \( n \) tasks should experience a factor of \( n \) slowdown compared to running alone.

---

**Results: FAWNDS (CMU, SOSP’09) on CompactFlash**

**Results: SPECweb co-run TPC-C**

![Graph](image2.jpg)

FIOS exhibits the best fairness compared to the alternatives.

---

**Results: Fairness for Reads and Writes**

- FIOS provides fairness with good efficiency under differing I/O loads.

---

**Results: Fairness for Requests of Varying Cost**

- FIOS achieves fairness not only with read-write asymmetry but also requests of varying cost.

---

**Results: FAWNDS (CMU, SOSP’09) on CompactFlash**

![Graph](image3.jpg)

FIOS also applies to low-power Flash and provides efficient fairness.