Disk Schedulers for Solid State Drives

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Outline

- Introduction
- Flash Translation Layer
- Linux Disk I/O Scheduler
- Logical Block
- Design of New Disk Schedulers
- Experimental Results
- Conclusions

Introduction

- The SSD (Solid State Drive) has been introduced and is gaining popularity in embedded systems and laptops
- Because of the differences in device characteristics, the current schedulers may not adequately schedule requests for SSDs

Flash Translation Layer (1/3)

- Solve the constraint that page overwrite is forbidden
- Maintain a pool of writable pages by pre-erasing the redundant blocks
- Approach
  - Page mapping
  - Block mapping

Flash Translation Layer (2/3)

- Page mapping
  - The map translates a sector number to a combination of page number and block number where the sector data exists
  - Be excellent random write performance
  - Increase garbage collection overhead after randomly write

Flash Translation Layer (3/3)

- Block mapping
  - The map translates a sector number to a combination of page number and block number where the sector data exists
  - To modify data, the block mapping FTL reserves some redundant blocks called **log blocks**

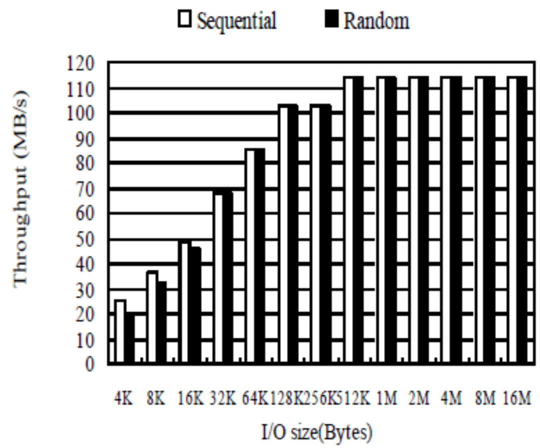
Linux Disk I/O Scheduler

- Noop
  - Merge adjacent requests to a larger one
- Deadline
  - If the waiting time of a request exceeds its deadline, the request is served immediately
- Anticipatory
  - Waits for new in-coming read requests for a predetermined period
- CFQ (Complete Fair Queuing)
  - Separate queue for each process and serves requests of queues in round-robin order

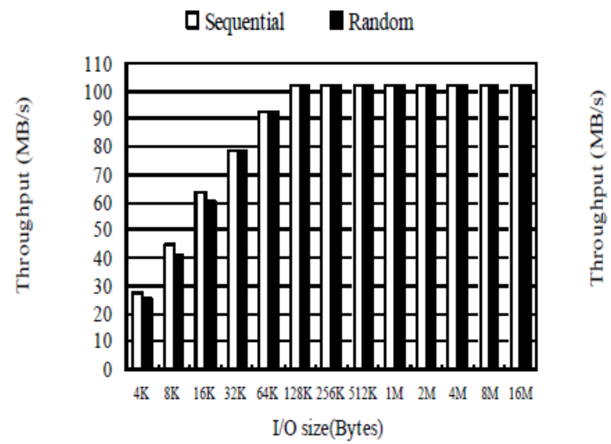
Logical Block (1/4)

- Read performance of an SSD is almost consistent and independent of the ordering and geometrical distance between read requests
- Sequential writes to a logical block is much more efficient than random writes going to various logical blocks

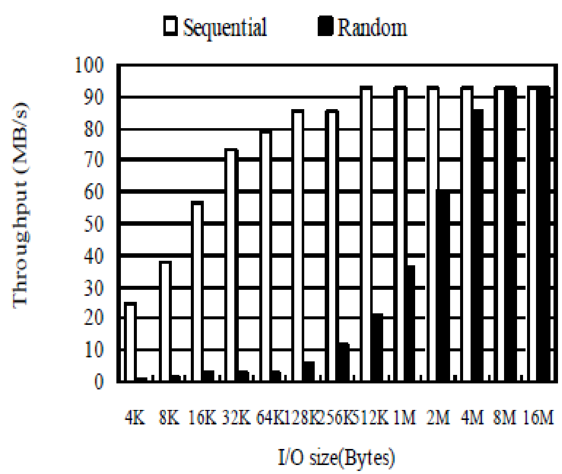
Logical Block (2/4)



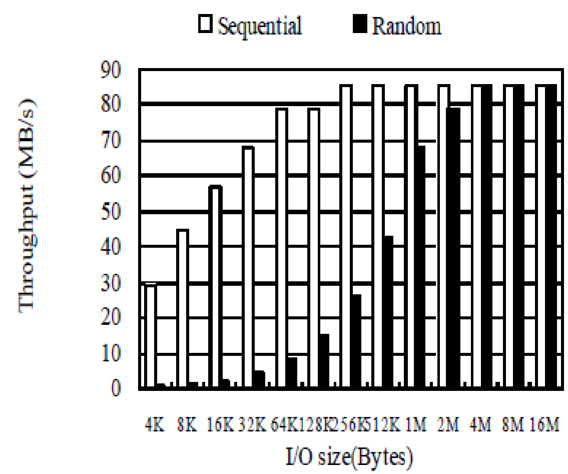
(a) Samsung SSD read



(b) Mtron SSD read



(c) Samsung SSD write

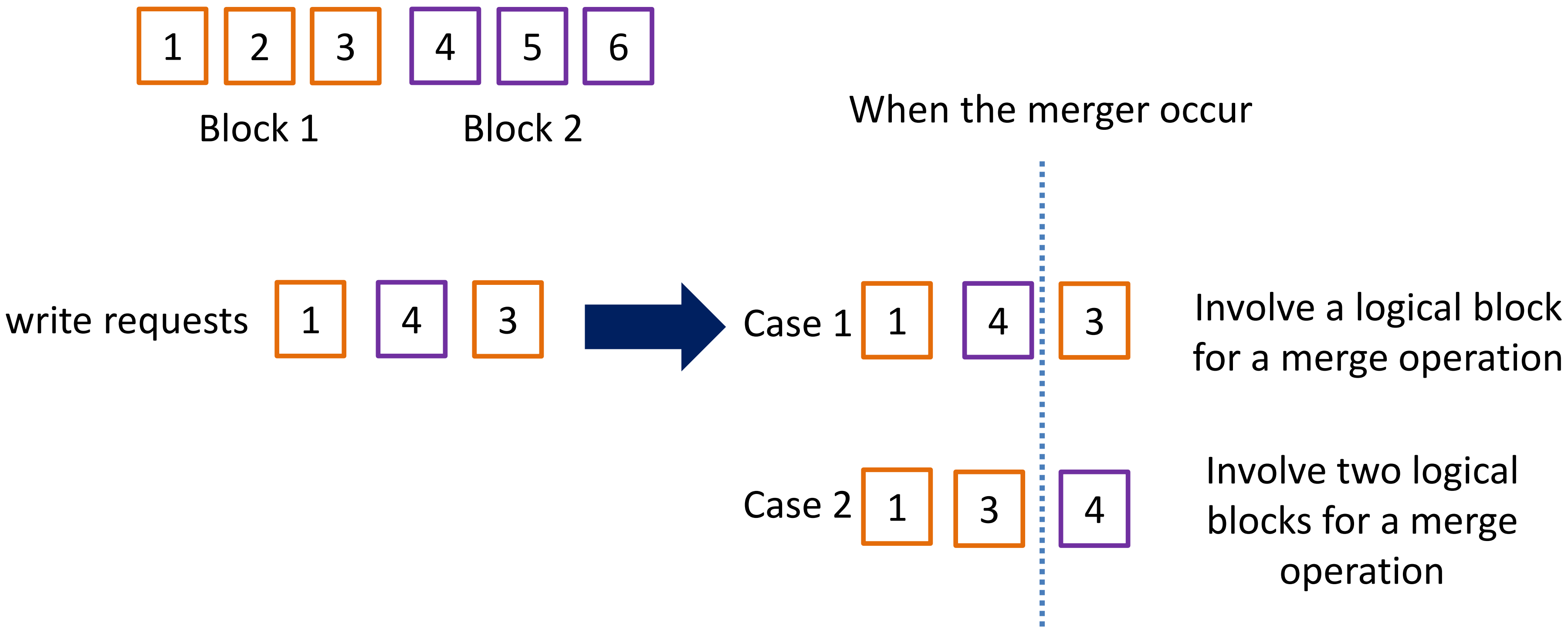


(d) Mtron SSD write

Logical Block (3/4)

- LBA-bundle (Logical Block Aligned-bundle)
  - A way to maximize write performance in an SSD
  - Arrange write requests into bundles the size of a logical block so that write requests falling in a logical block belong to the same bundle
- The writing order of the bundles themselves will not be important if all requests within the bundle are written sequentially at a time

Logical Block (4/4)



Design of New Disk Schedulers (1/2)

- The IRBW-FIFO (Individual Read Bundled Write FIFO) Scheduler
  - Apply FIFO ordering to the bundles of write requests and individual read requests.

Design of New Disk Schedulers (2/2)

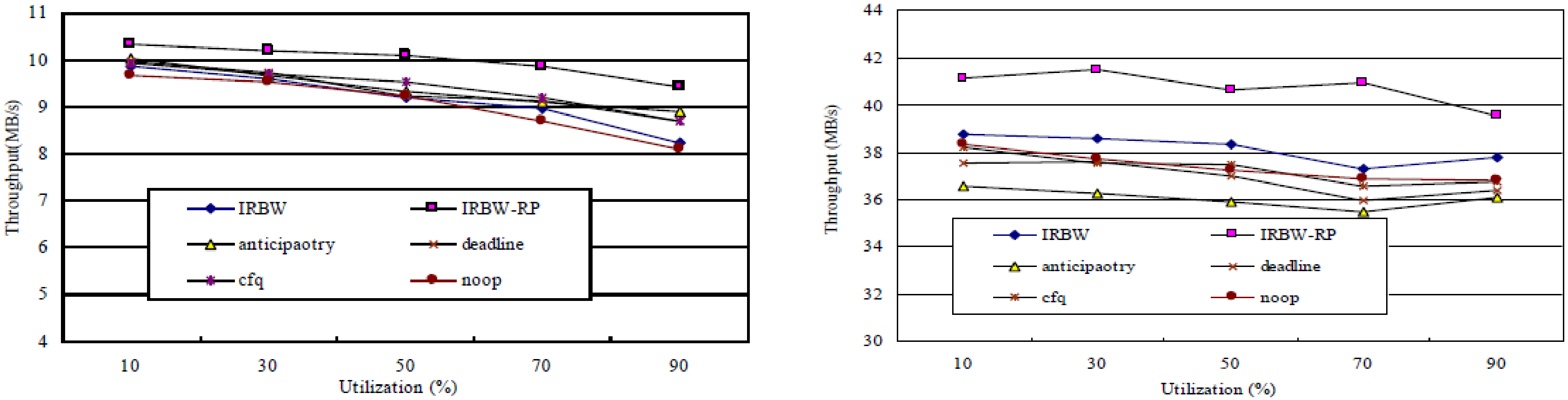
- The IRBW-FIFO-RP (Individual Read Bundled Write FIFO with Read Preference) Scheduler
  - Maintains separate FIFO ordering among read requests and among the bundles of write requests
  - Gives higher priority to read requests than to the bundles of write requests
  - To avoid write starvation, allow each LBA-bundle to yield to a read request only once

Experimental Results (1/3)

- Throughput results
- Response time results
- Experimental environment

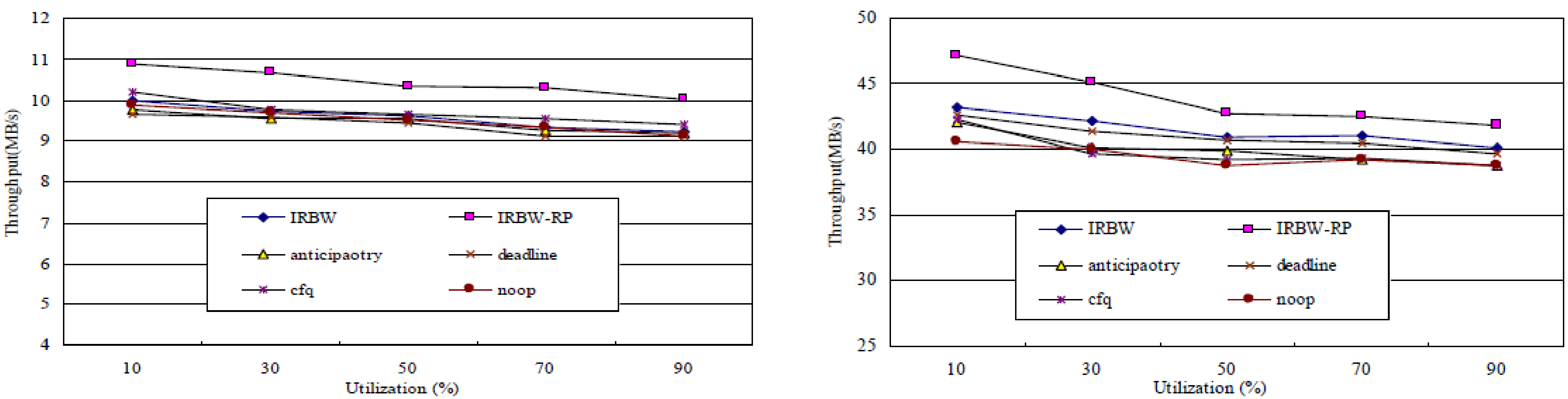
Type	Specifics	
CPU/RAM	Intel Core2 Duo E4500 2.2GHz / 2GB DRAM	
SSD	Samsung 64GB MCCOE64G5MPP SATA-2	
	Mtron 16GB MSD-SATA6025 SATA-1	
OS	Linux-kernel 2.6.23 / Ext3 File system	
Benchmark	Postmark	Type-A: 1KB~32KB file size
		Type-B: 1MB~16MB file size
	IOmeter	File server access pattern
Targets	IRBW-FIFO, IRBW-FIFO-RP, and existing Linux I/O schedulers	

Experimental Results (2/3) - Throughput Results



(a) Postmark Type-A (b) Postmark Type-B

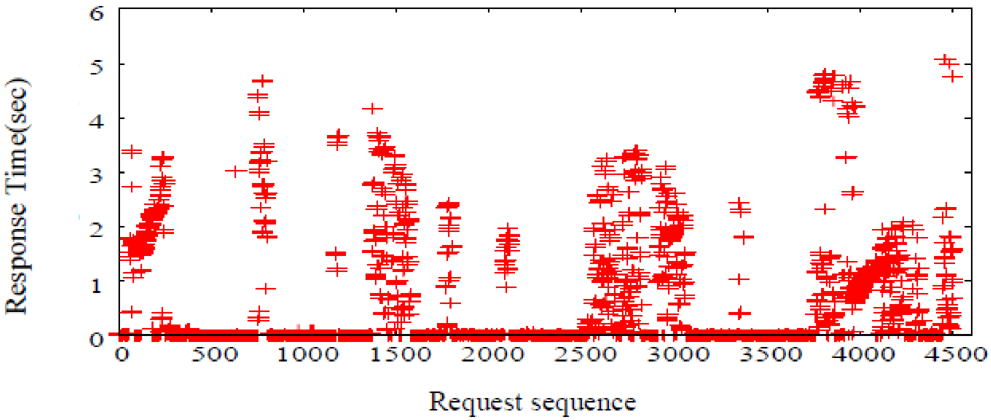
Figure 8. Throughput of Postmark benchmarks on Samsung SSD



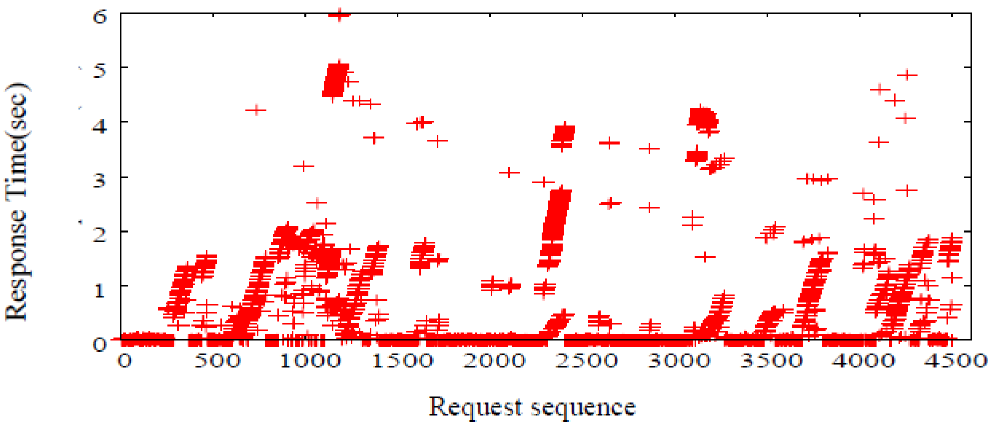
(a) Postmark Type-A (b) Postmark Type-B

Figure 9. Throughput of Postmark benchmarks on Mtron SSD

Experimental Results (3/3) - Response Time Results



(a) Deadline I/O scheduler



(b) IRBW-FIFO-RP I/O scheduler

Figure 11. Response time of Postmark benchmark on Samsung SSD

- Average response times of the two schedulers are 0.475 and 0.458

Conclusions

- SSDs have much faster read service times than the magnetic disks with the service times being almost constant, while write request service times are more complex
- IRBW-FIFO and IRBW-FIFO-RP arrange write requests into LBA-bundles while reads are independently scheduled