Exploiting Minipage-level Mapping to Solve the Size Discrepancy of I/O Requests and Flash Pages

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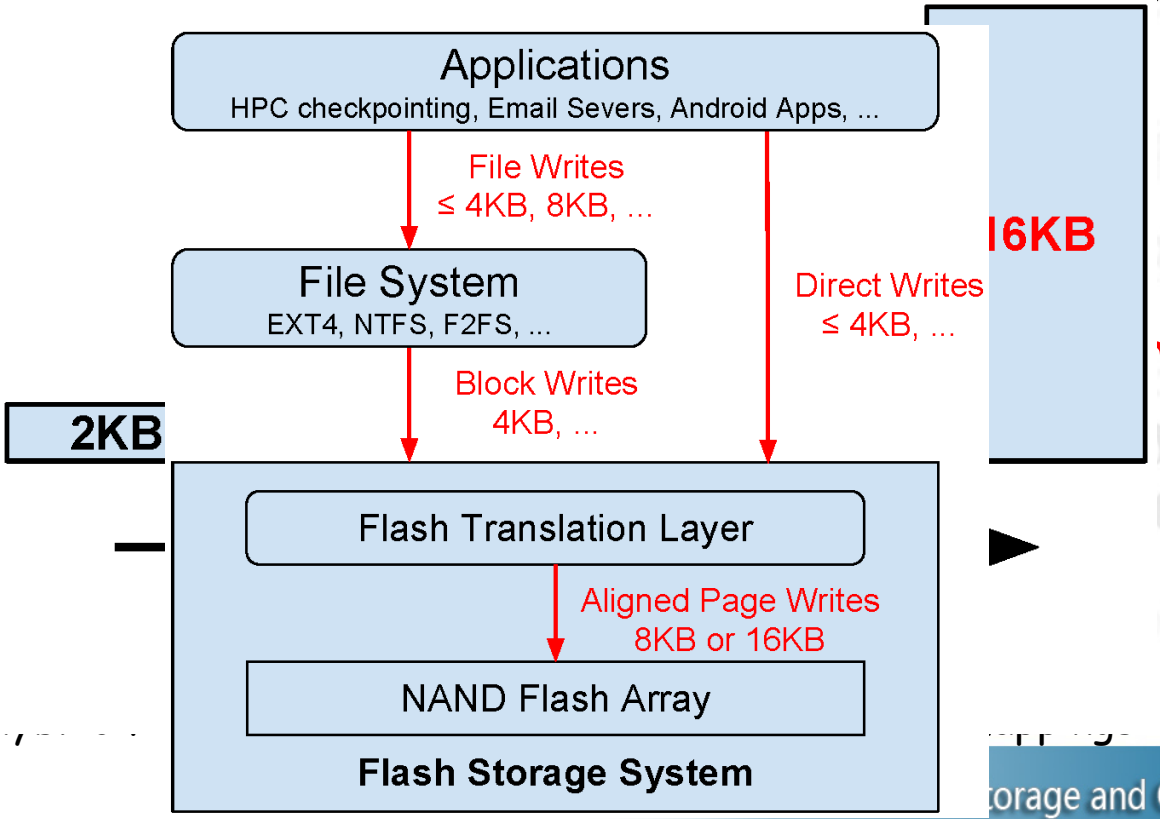
Outline

- Background and Problems
- Designs
- Experimental Results
- Conclusion

Size Discrepancy

- NAND flash page size is increasing to 16KB.
- I/O sizes do not grow accordingly in a wide range
  - **Sma**
- Size c … nd IO sizes:
  - **Whe**
    - P
    - B
    - H



Drawbacks of Traditional FTLs

- The page-level FTL performs better than the block-level FTL and hybrid FTL in handling writes.
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  - Unr
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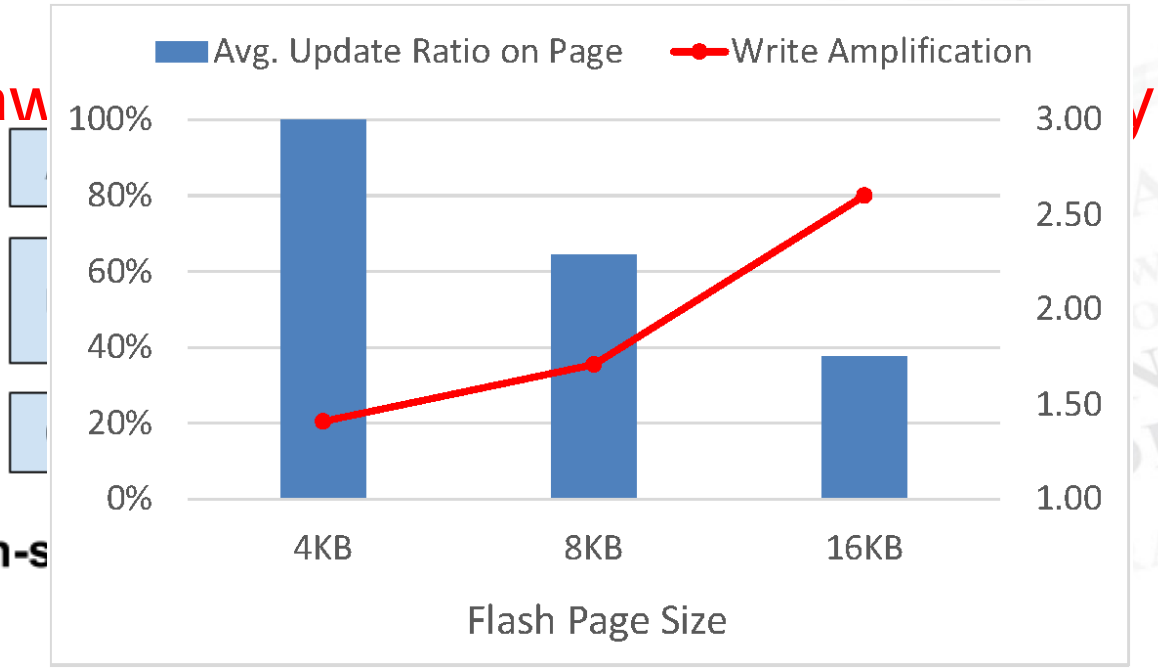

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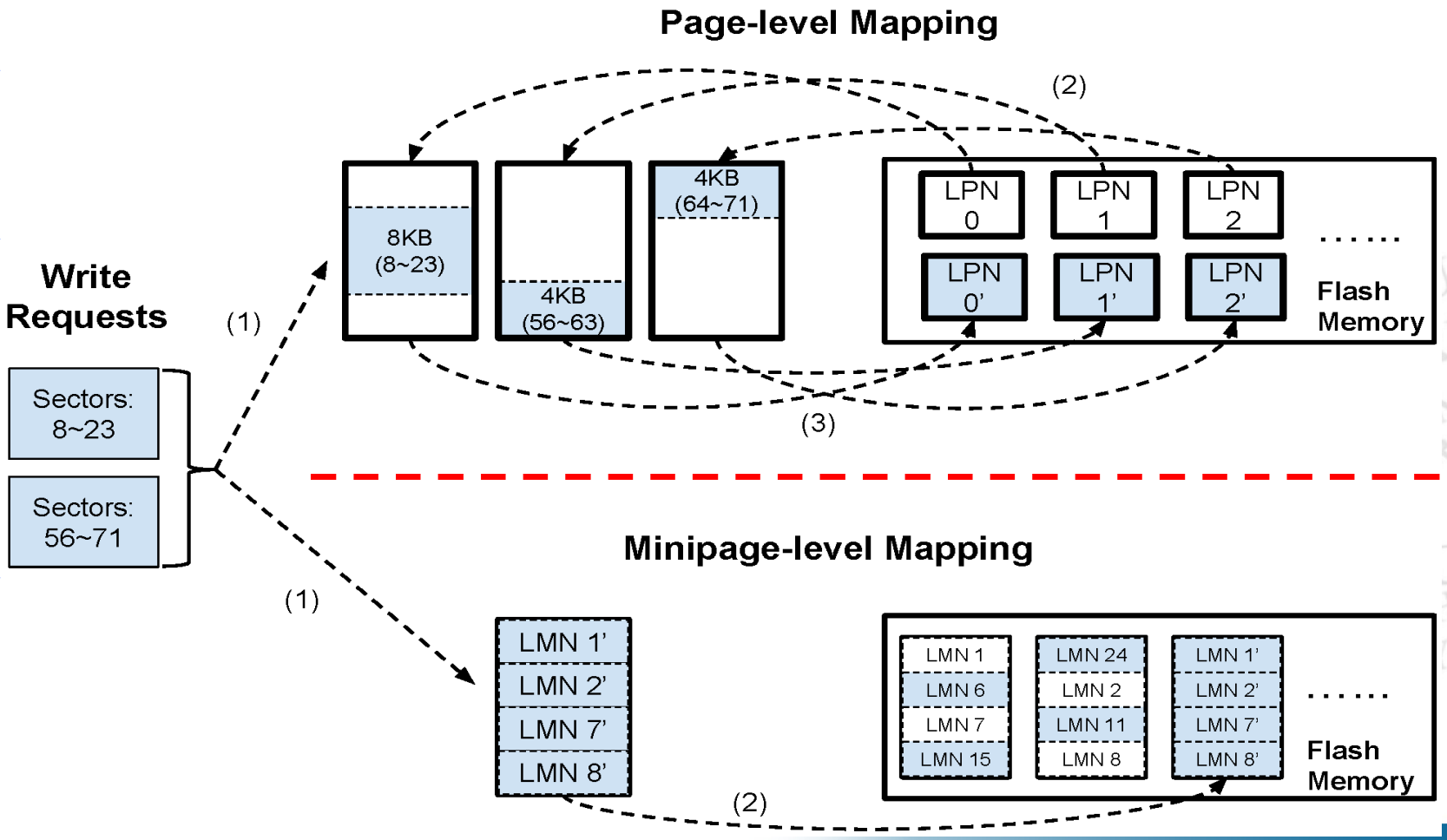
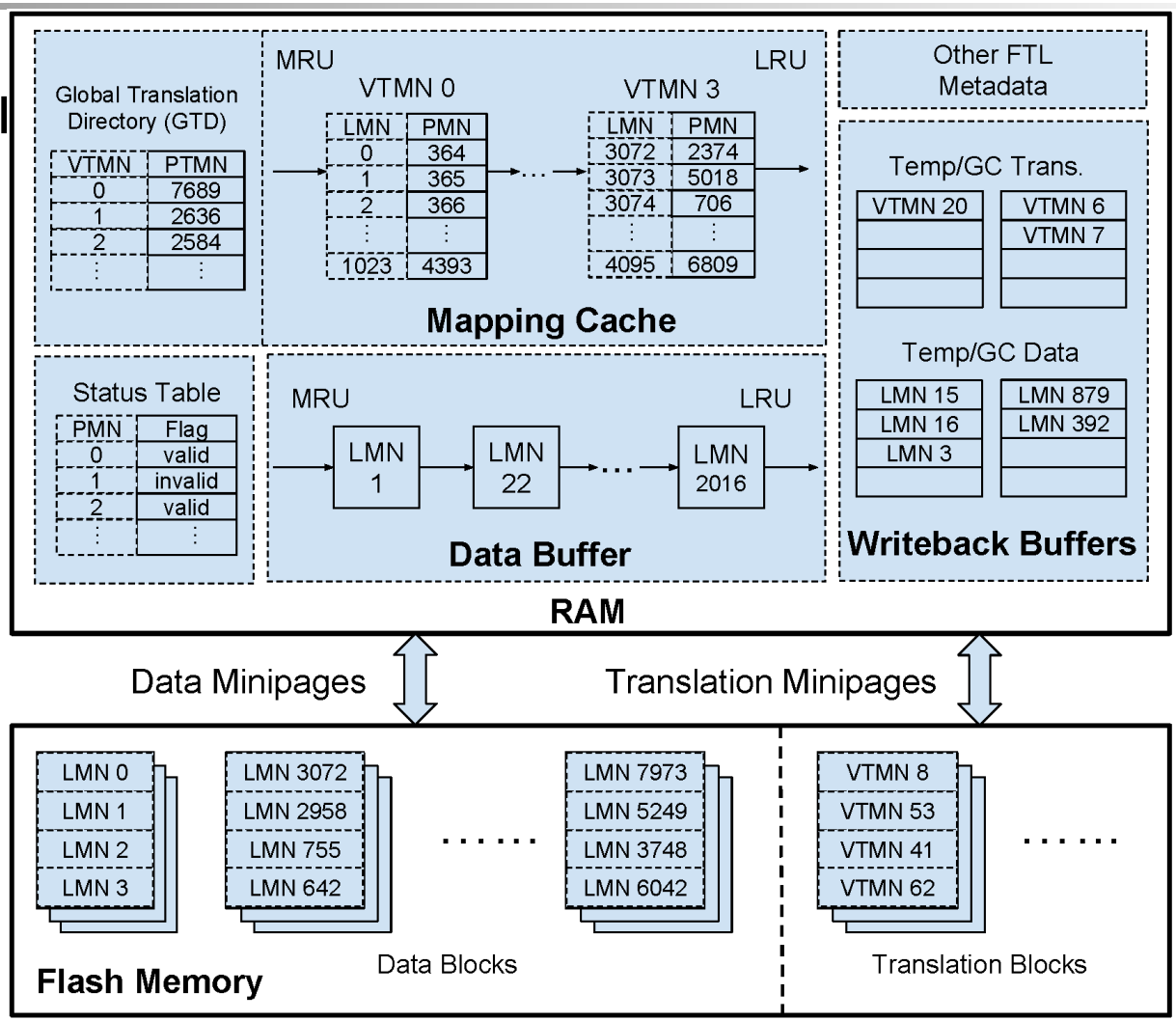
Minipage

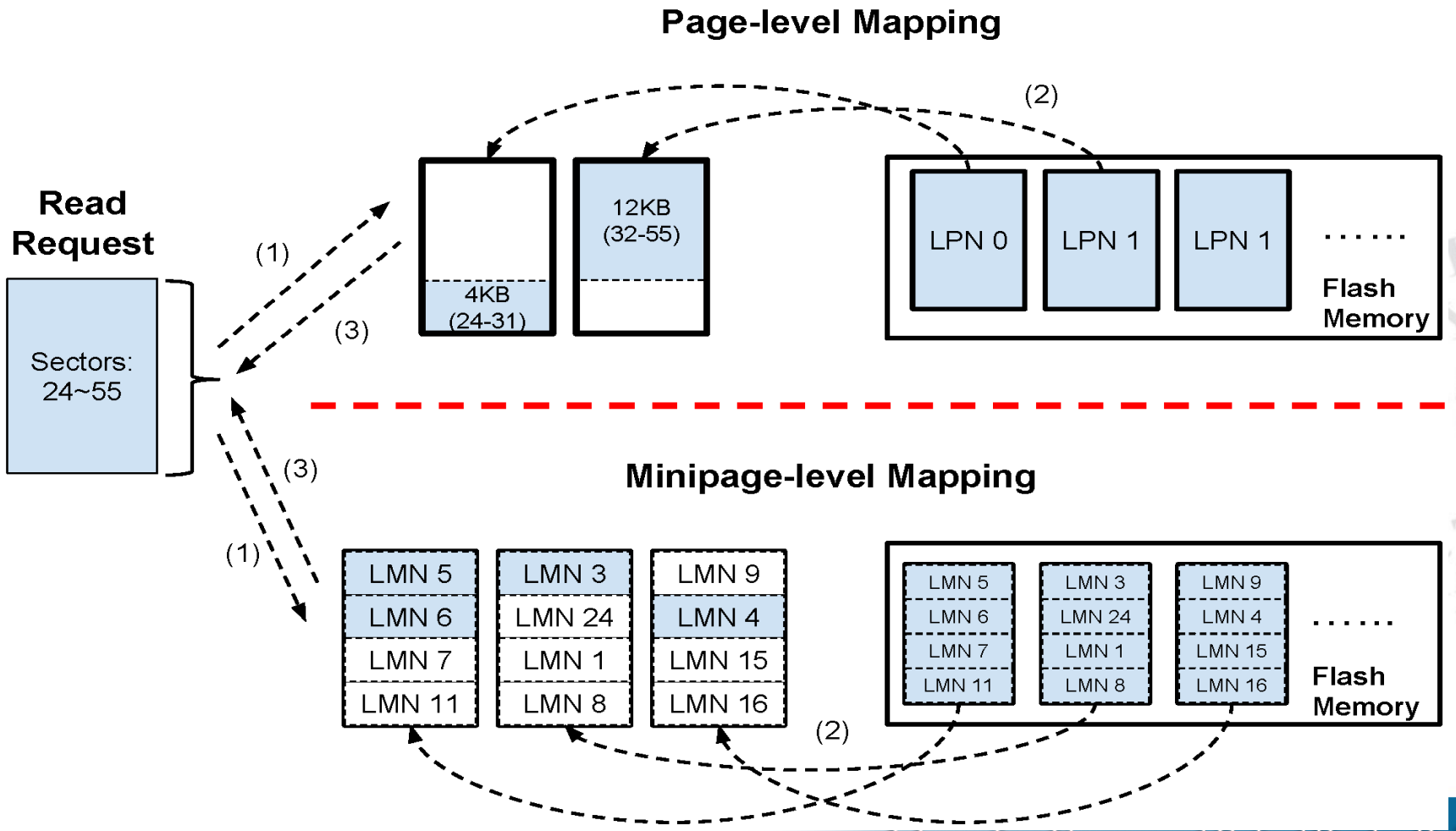

Page-level Mapping
(2)
8KB (8~23)
4KB (56~63)
4KB (64~71)
LPN 0
LPN 1
LPN 2
LPN 0'
LPN 1'
LPN 2'
Flash Memory
Write Requests
(1)
Sectors: 8~23
Sectors: 56~71
(3)
Minipage-level Mapping
(1)
LMN 1'
LMN 2'
LMN 7'
LMN 8'
LMN 1
LMN 6
LMN 7
LMN 15
LMN 24
LMN 2
LMN 11
LMN 8
LMN 1'
LMN 2'
LMN 7'
LMN 8'
Flash Memory
(2)

Minipage-FTL

- A del



Drawbacks of Minipage-FTL

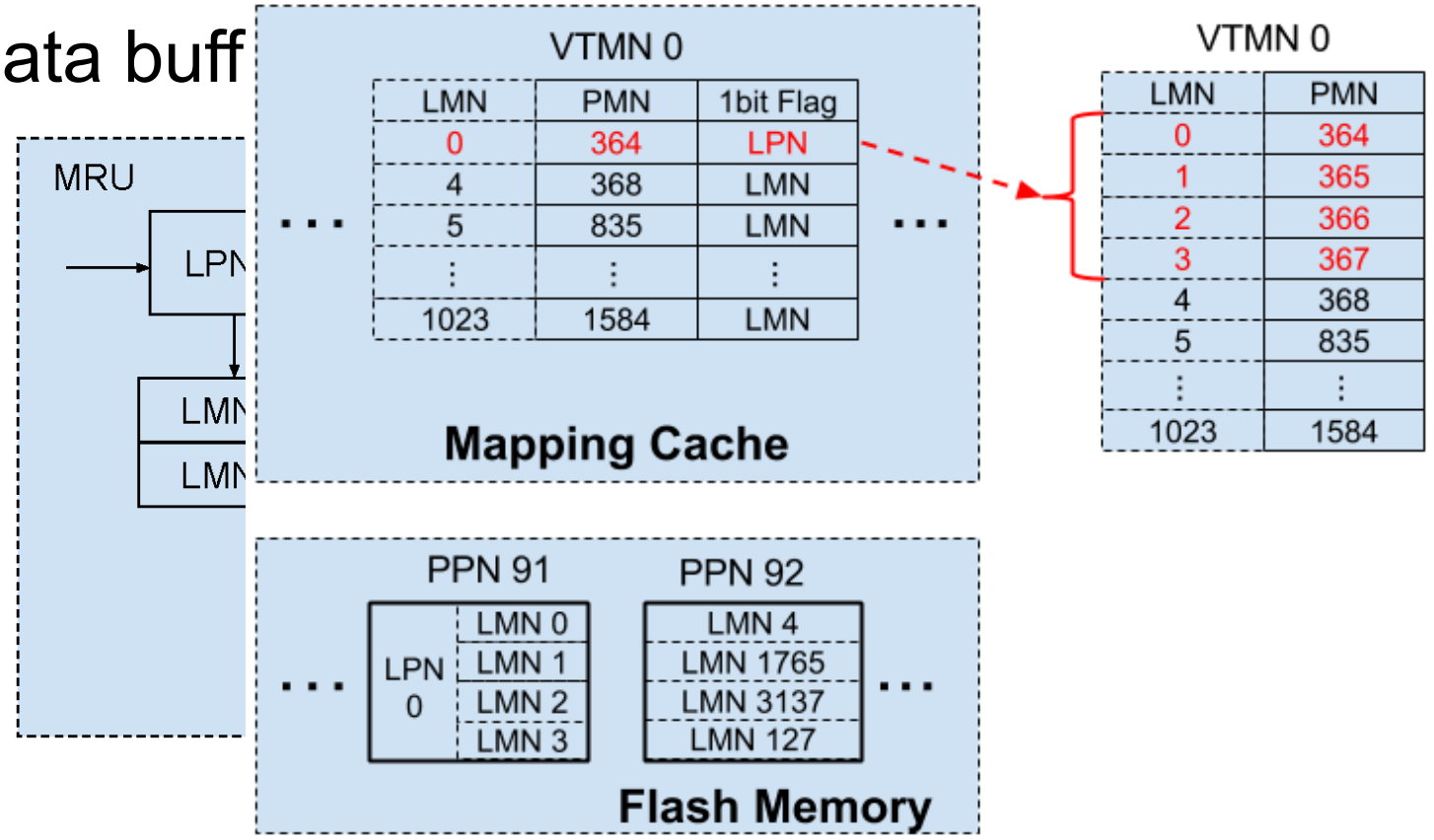


PM-FTL

- PM-FTL is workload-adaptive, taking both advantages of the page- and minipage-level mappings.
  - Randomly accessed data ➔ Minipage-mapped
  - Sequentially accessed data ➔ Page-mapped

PM-FTL

- Mapping cache management
- Data buff



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Simulation

- SSD simulator
  - Flashsim platform (Disksim + Flash module)
  - Page-FTL (baseline), Minipage-FTL, PM-FTL

- SSD configuration

Minipage Size	4KB
Page Size	8KB, 16KB
Block Size	128 pages per block
Page Read	50us
Page Write	900us
Block Erase	3.5ms
Over-provision	25%

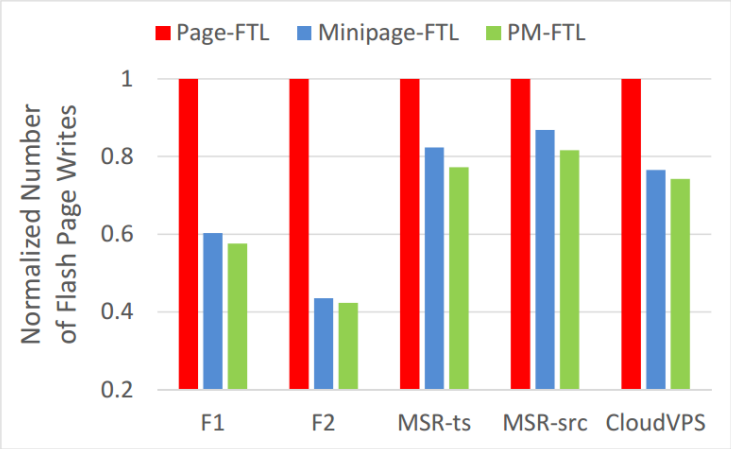
Workloads

- I/O characteristics of five typical workloads:

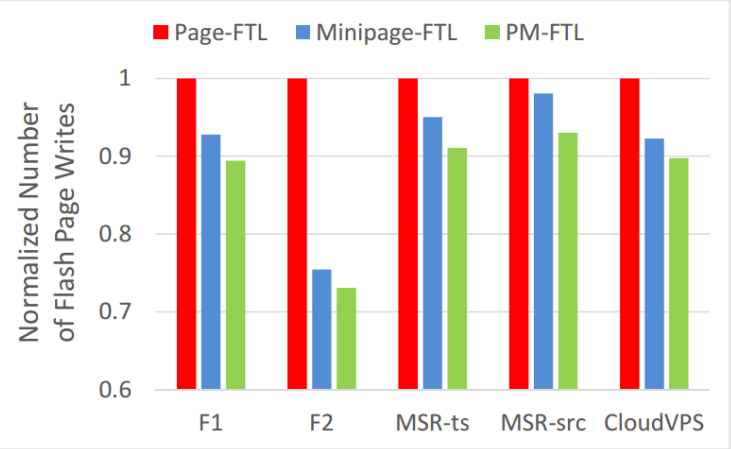
	Write Ratio	Average Request Size	# of Requests	Logical Space
F1	76.8%	6.87KB	5334944	512MB
F2	17.7%	5.88KB	3698863	512MB
MSR-ts	82.4%	9.36KB	1801486	16GB
MSR-src	88.7%	7.70KB	1557789	16GB
CloudVPS	51.0%	11.17KB	6451269	16GB

Write Efficiency

- Flash page writes and write amplification:



(a) 16KB flash pages.

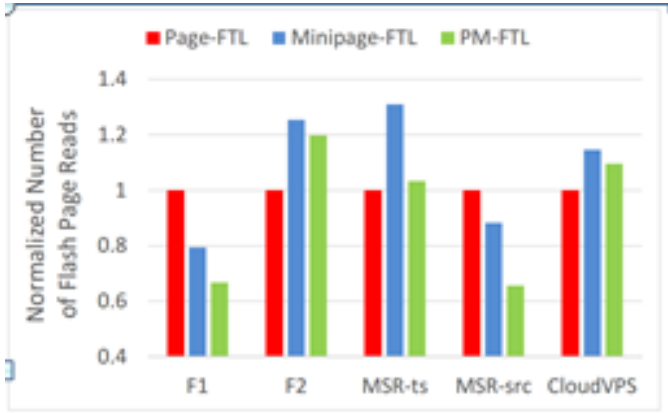


(b) 8KB flash pages.

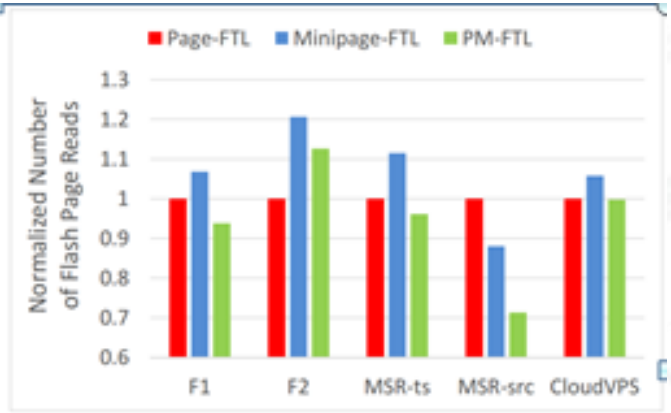
	16KB, avg	16KB, max	8KB, avg	8KB, max
PM-FTL	33.4%	57.7%	12.7%	26.9%
Minipage-FTL	30.1%	56.5%	9.3%	24.6%

Read Efficiency

- Flash page reads:



(c) 16KB flash pages.

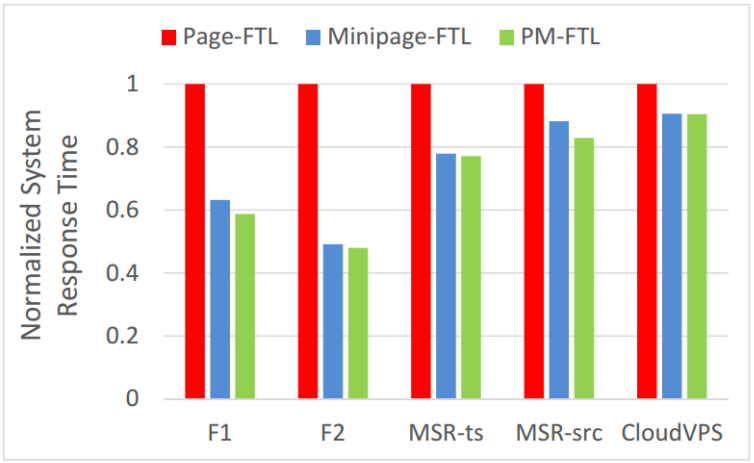


(d) 8KB flash pages.

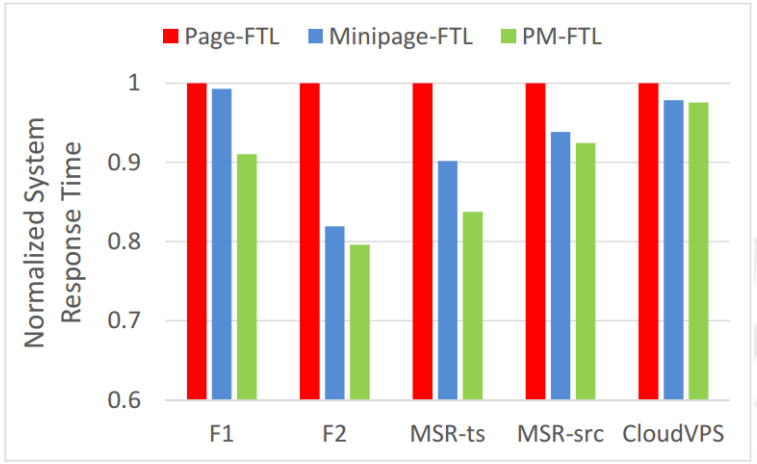
	16KB, avg	16KB, max	8KB, avg	8KB, max
Minipage-FTL	-7%	19.8%	-5.3%	12.6%
PM-FTL	7.7%	30.9%	6.5%	20.6%

Performance

- System response time:



(e) 16KB flash pages.



(f) 8KB flash pages.

	16KB, avg	16KB, max	8KB, avg	8KB, max
PM-FTL	28.6%	52%	11.1%	20.4%
Minipage-FTL	26.2%	50.1%	7.4%	18.1%

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Conclusion

- The I/O sizes do not grow in step with the increasing flash page size.
- Traditional FTLs are not favorable for large flash page sizes due to low write efficiency.
- The minipage-level mapping provides better flexibility and thus higher write efficiency than the page-level mapping.
- Minipage-FTL and PM-FTL significantly lower the write amplification and system response time of flash memory by up to 57.7% and 52%, respectively, for 16KB flash pages.