Two Techniques for Faster Transactional Atomicity on Flash and NVram

- SQLite/PPL [VLDB 15]
- CFS [USENIX ATC 15]

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SQLite Optimization with Phase Change Memory for Mobile Applications

VLDB 2015

Gihwan Oh, Sang-Won Lee,
Sangchul Kim, and Bongki Moon

Overview

- PCM: promise, reality, and opportunities
- SQLite
  - Standard data manager in mobile era
    - Android and iOS
- Characteristics of SQLite and mobile apps
  - Write amplification
  - Write locality
  - Small delta
- SQLite/PPL

PCM: Promise and Reality

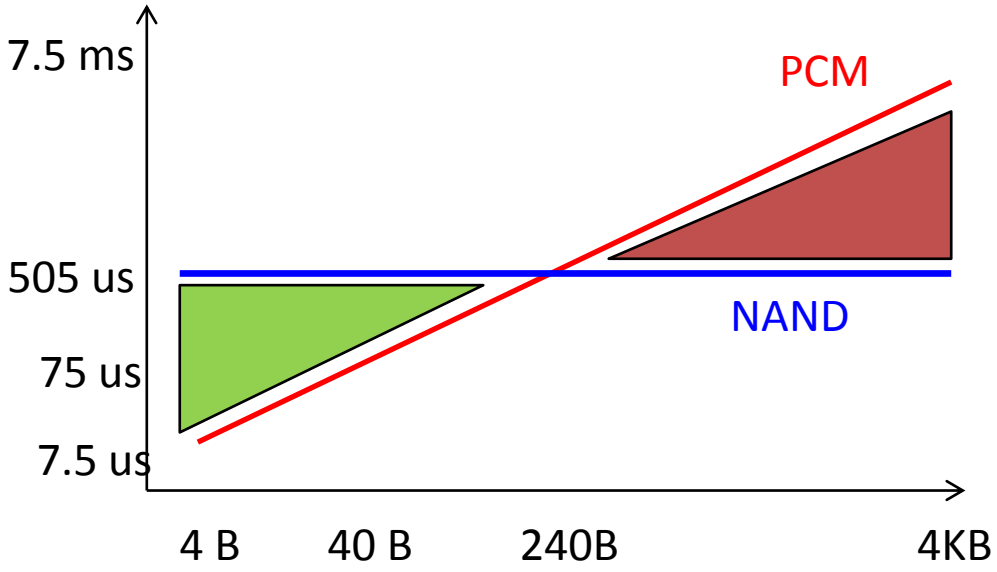
- Latency: DRAM vs. NAND vs. PCM

	DRAM	NAND Flash [29]	PCM (theoretical) [ISCA 09]	PCM (measured) [5,25]
Read	~ 30 ns (4B)	156 us (4KB)	48 ns (4B)	408 ns (4B)
Write	~ 30 ns (4B)	505 us (4KB)	150 ns (4B)	7.5 us (4B)

  - Similar observation [FAST '14]

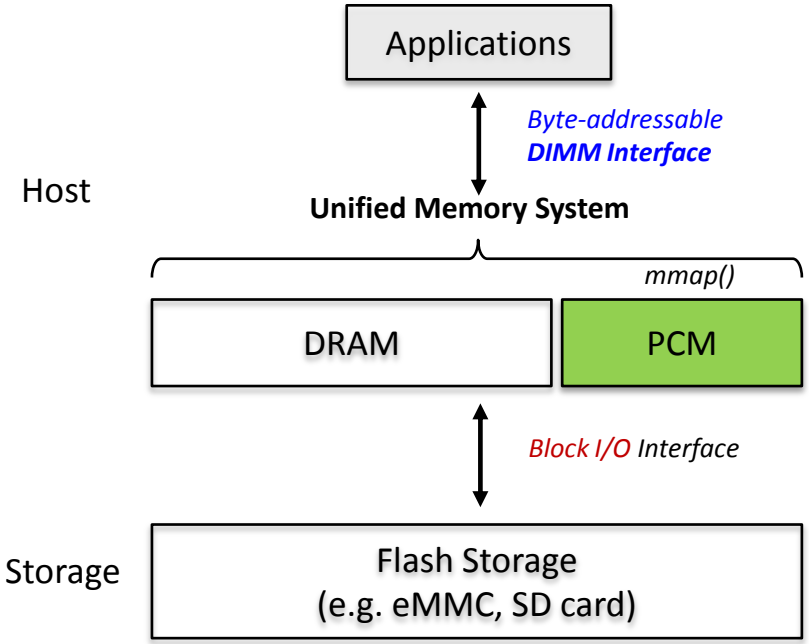
NAND vs. PCM

- Write Latency: PCM vs. NAND
  - 4B Write: 7.5us vs. 505us
  - 4KB Write: 7500us vs. 505us

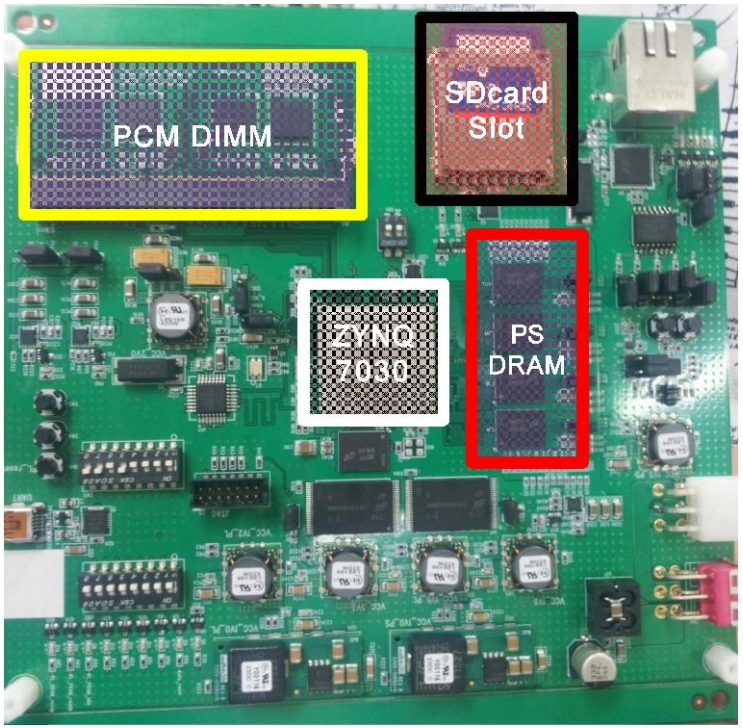


Unified Memory System

- UMS Architecture

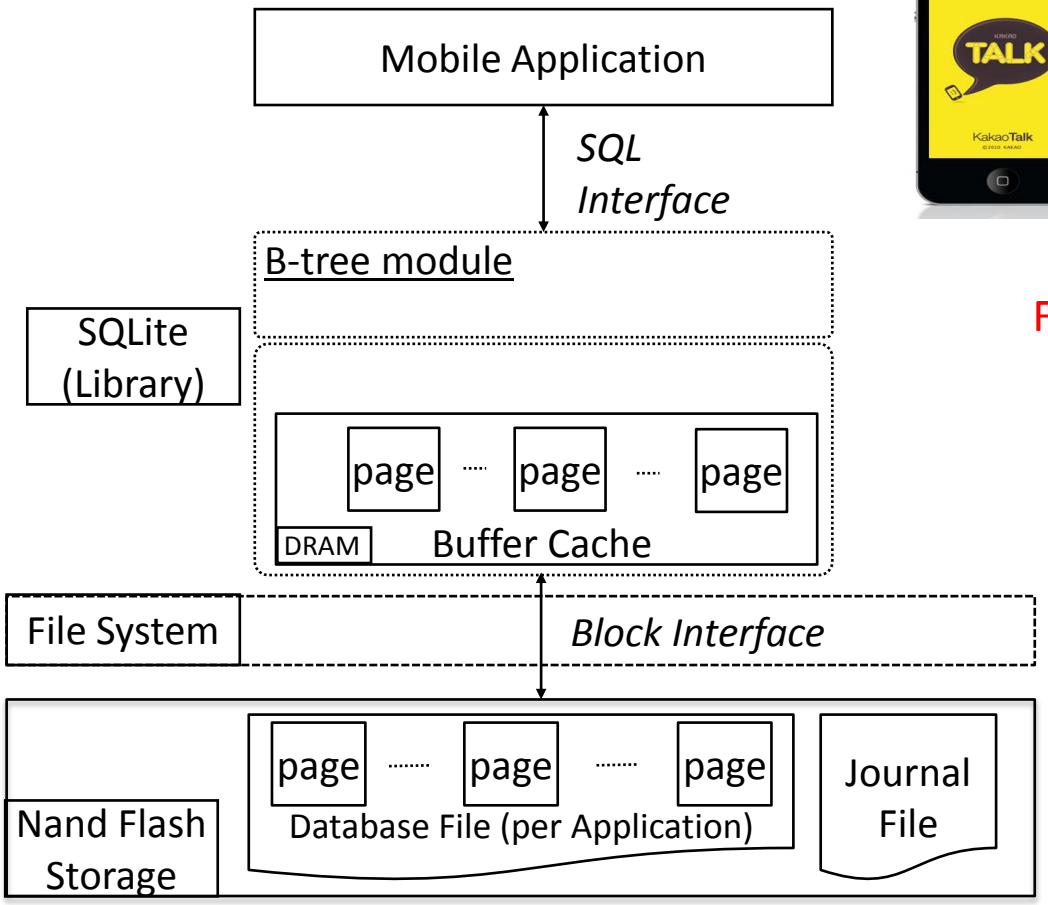


- UMS Board [RSP '14]



- 10,000$??

Write Amplification in Mobile Application



'Hi'

Auto-commit
Force-write
Block interface
Journaling
File system Metadata

Huge Write Amplification: 'Hi' → 11*4KB page writes [16,20]

Performance; Endurance

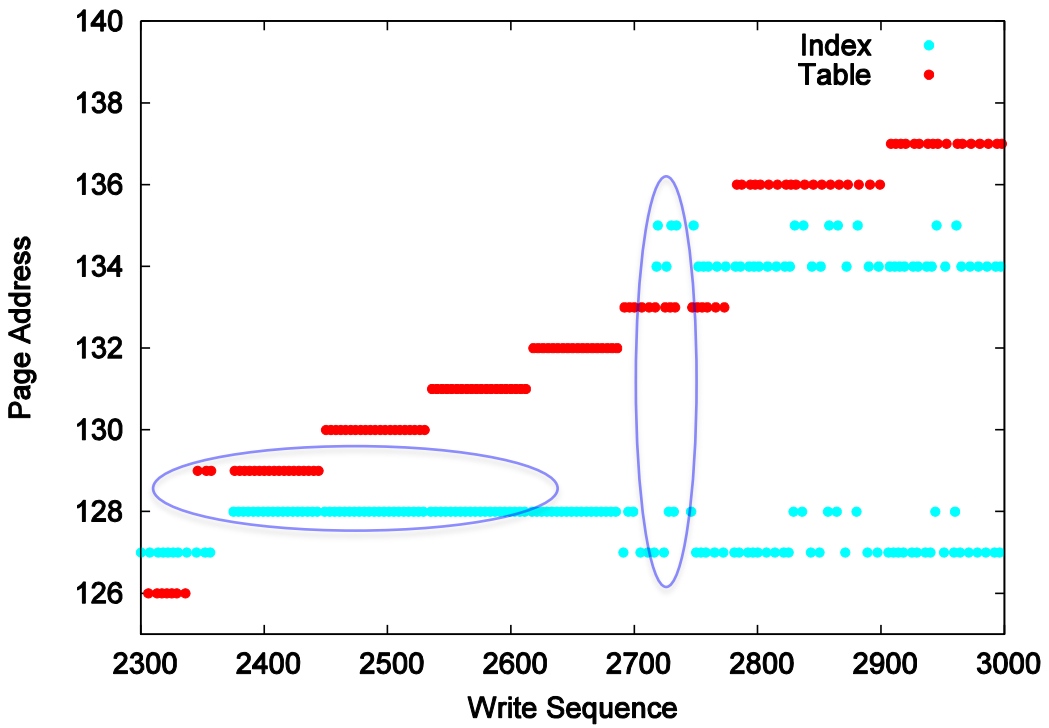
Write Locality in Mobile Apps

'Hi'

'What's up?'

Consecutive
Single Simple
Transactions
with Small Bytes

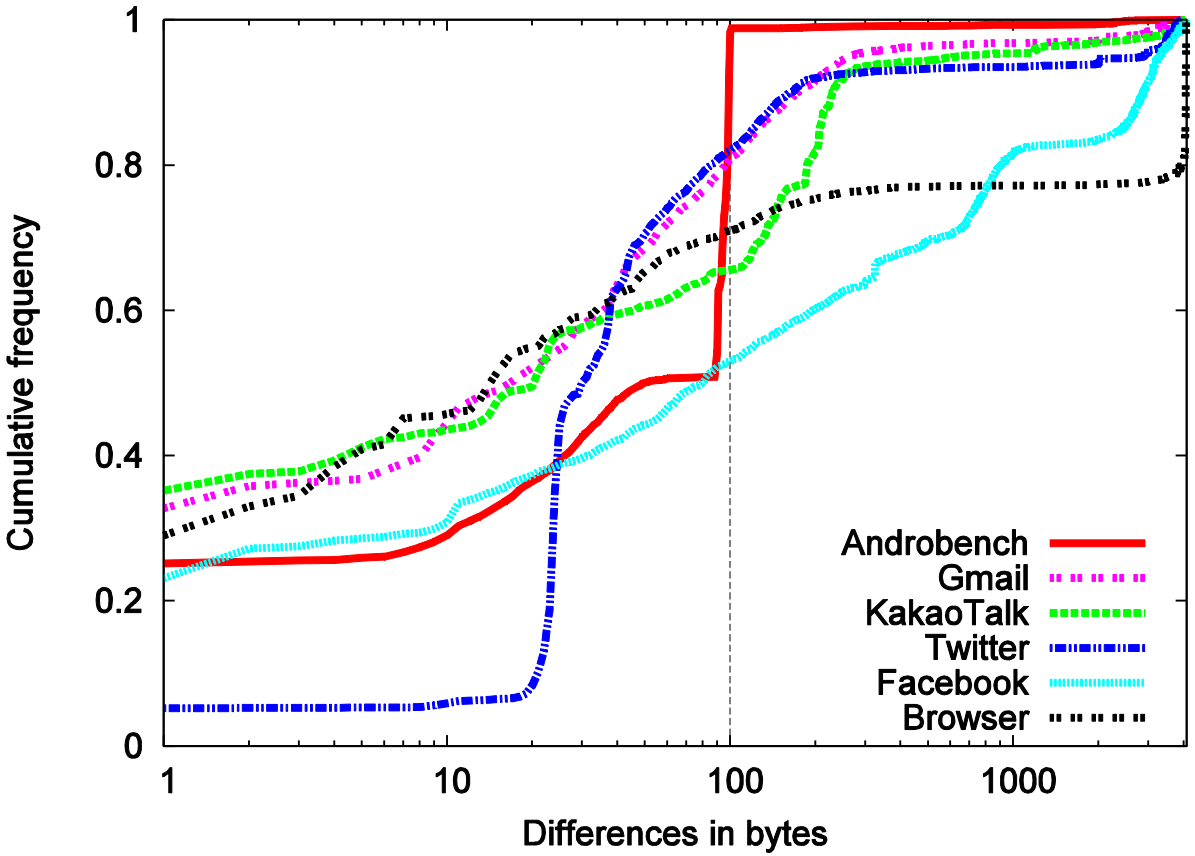
Same pages
are updated



Sequence of page-write request in SQLite

Small Delta Between Consecutive Writes

- Mostly less than several 100s bytes

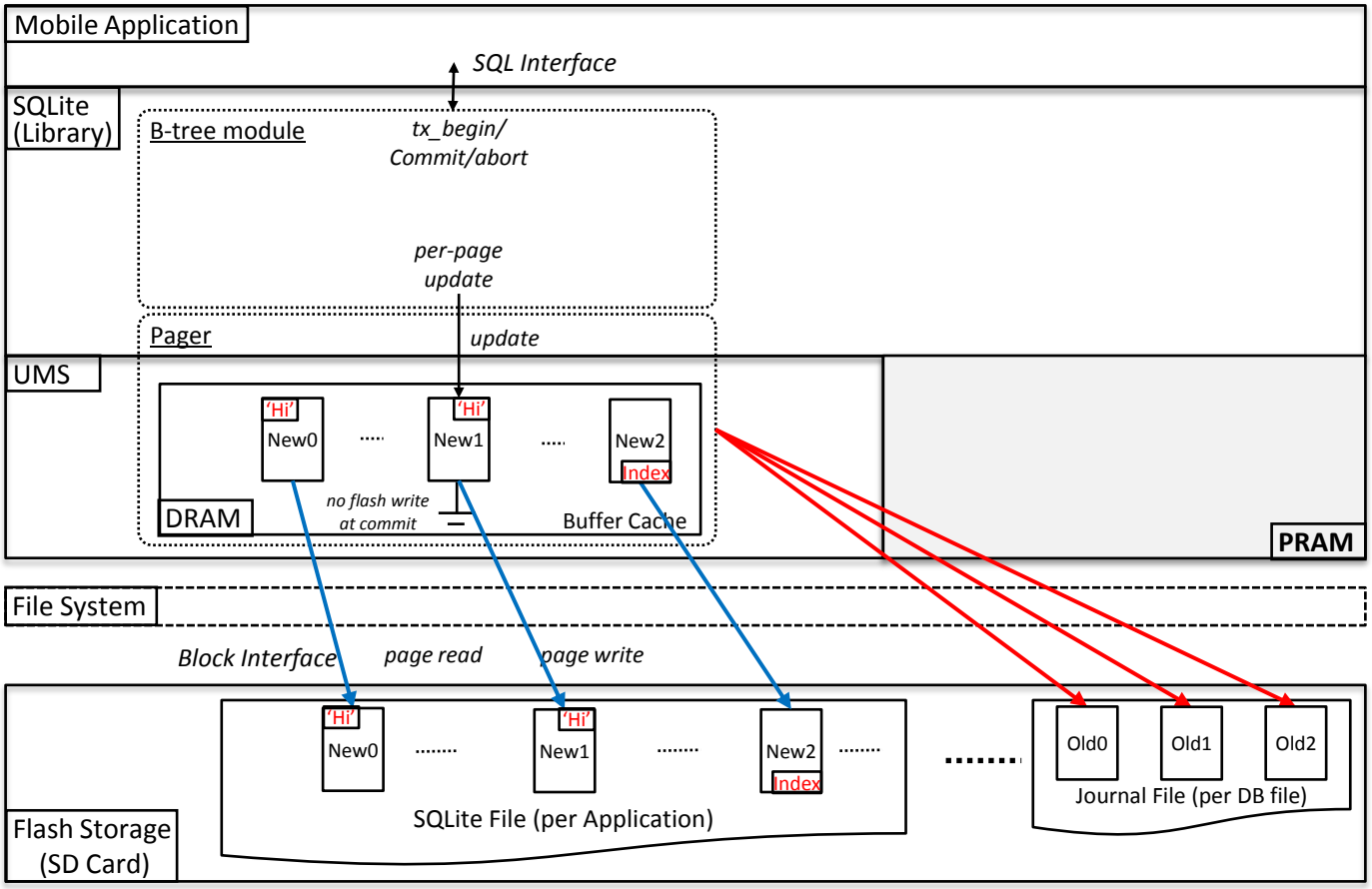


Implications

- The small deltas of SQLite pages
  - Capturing and storing the small deltas will avoid write amplification by SQLite
  - Avoiding write amplification will provide faster response time and longer lifespan of NAND flash
- Byte-addressable, Non-volatile PCM supporting short write latency of small data
  - PCM as a log area of small delta

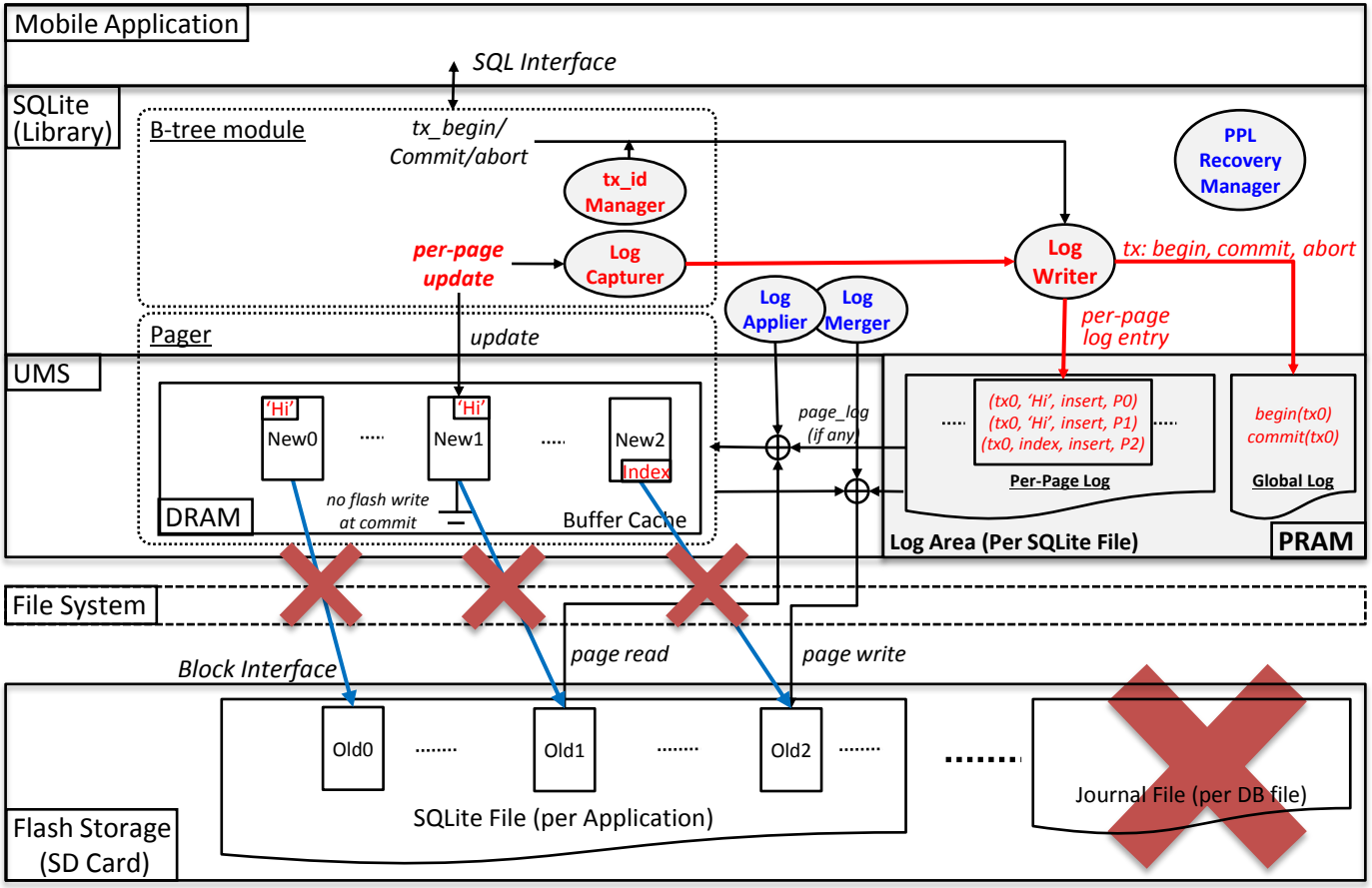
PPL Architecture

- PPL module is added



PPL Architecture

- PPL module is added

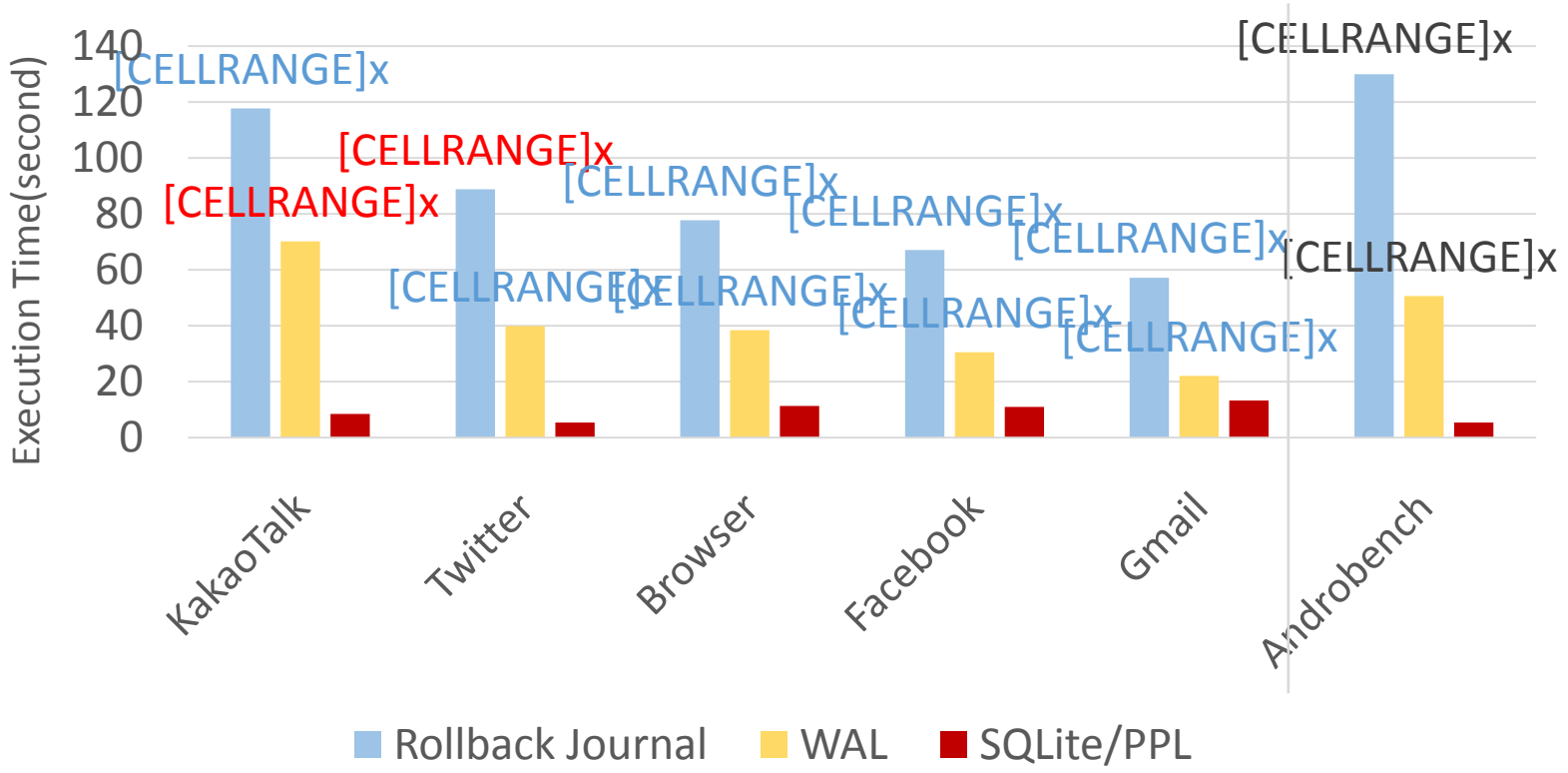


Evaluation Setup

- Compare SQLite/PPL with Rollback journal(RBJ) and WAL journal
- 6 mobile workloads
  - Real workloads: Kakaotalk, Twitter, Facebook, Gmail, Web Browser
  - Synthetic workload: AndroBench
- A Zync-7030 board equipped with the real PCM chip[RSP ‘14]

Baseline Performance Comparison

- Overall Execution Time: SQLite RBJ vs. WAL vs. PPL



- See paper for performance details of Latency, Effect of Log Sector Size/All in PCM, Read Performance

Conclusion

- Present the design and implementation of SQLite/PPL

- Future works
  - Apply PPL to enterprise DB: e.g. Postgres [CACM 91]
  - Xxxxxxx logging

Q & A

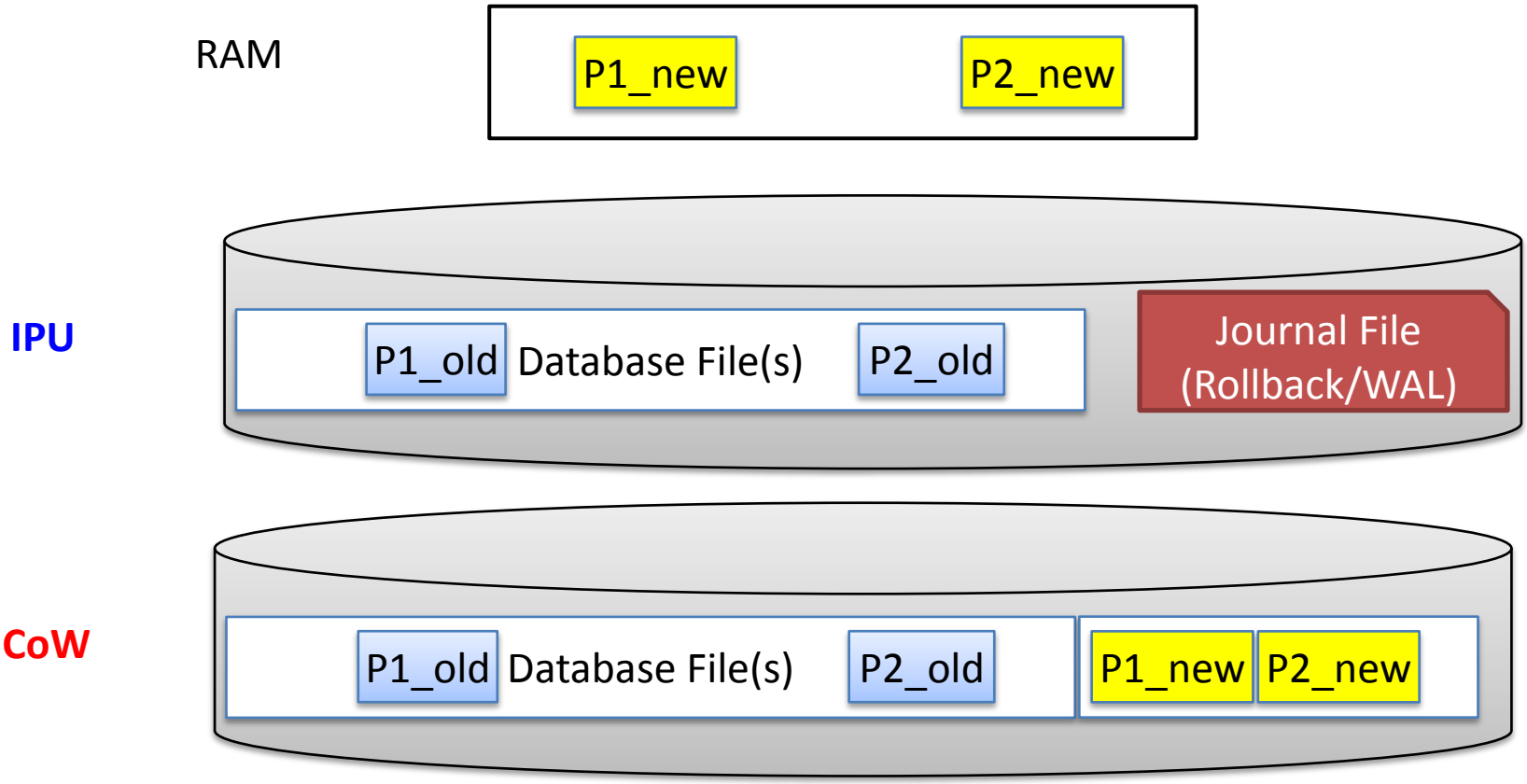
Lightweight Application-Level Crash Consistency on Transactional Flash Storage

Usenix ATC 2015

Changwoo Min, Woon-Hak Kang, Taesoo Kim,
Sang-Won Lee, Young Ik Eom

Two Update Approaches

- In-place update vs. copy-on-write
  - Durability and atomicity of tx app.



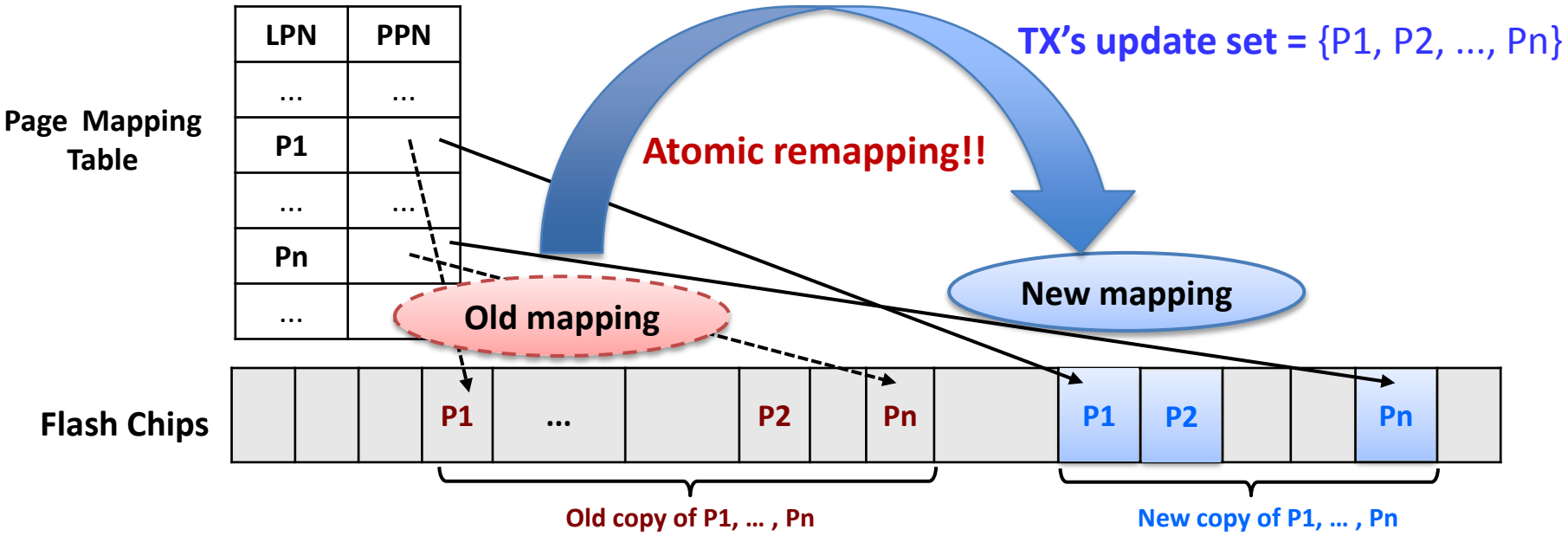
In-place Update vs. CoW

- Why IPU > CoW in computer science?
  - Storage cost
  - Clusteredness of pages in a file (for HDD?)

- But, historically, CoW > IPU! (Jim Gray)
  - Multi-version support
  - Clusteredness in flash is less important

X-FTL

- Flash-aware transactional atomicity for application taking IPU (e.g. SQLite)



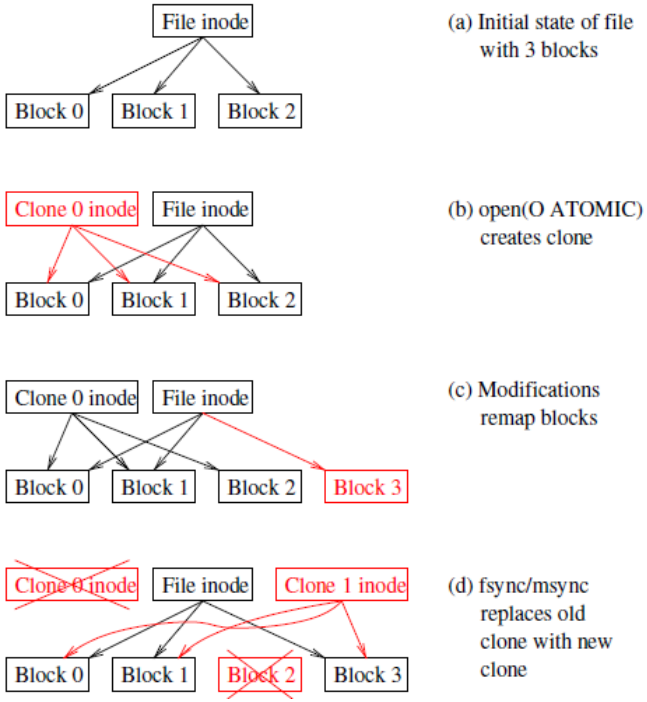
- Cf. FusionIO's atomic write (vs. 서울여대)

X-FTL and File Metadata

- X-FTL can support transactional atomicity of updated pages in user files.
- What about the shared metadata pages updated by concurrent transactional applications?
  - Feedback from Prof. Jin-Soo Kim
  - False sharing of metadata

More about CFS

- System-wise vs. transaction-wise consistency
  - Redo and undo logging for meta-data update
- cf. Application-level crash consistency @ Remzi group
  - Vijay@Wisconsin [OSDI12, SOSP13, FAST13, PhD thesis]
  - No multiple file support: cf. CFS
- cf. Failure-Atomic Update of Application Data (Usenix FAST 2015)

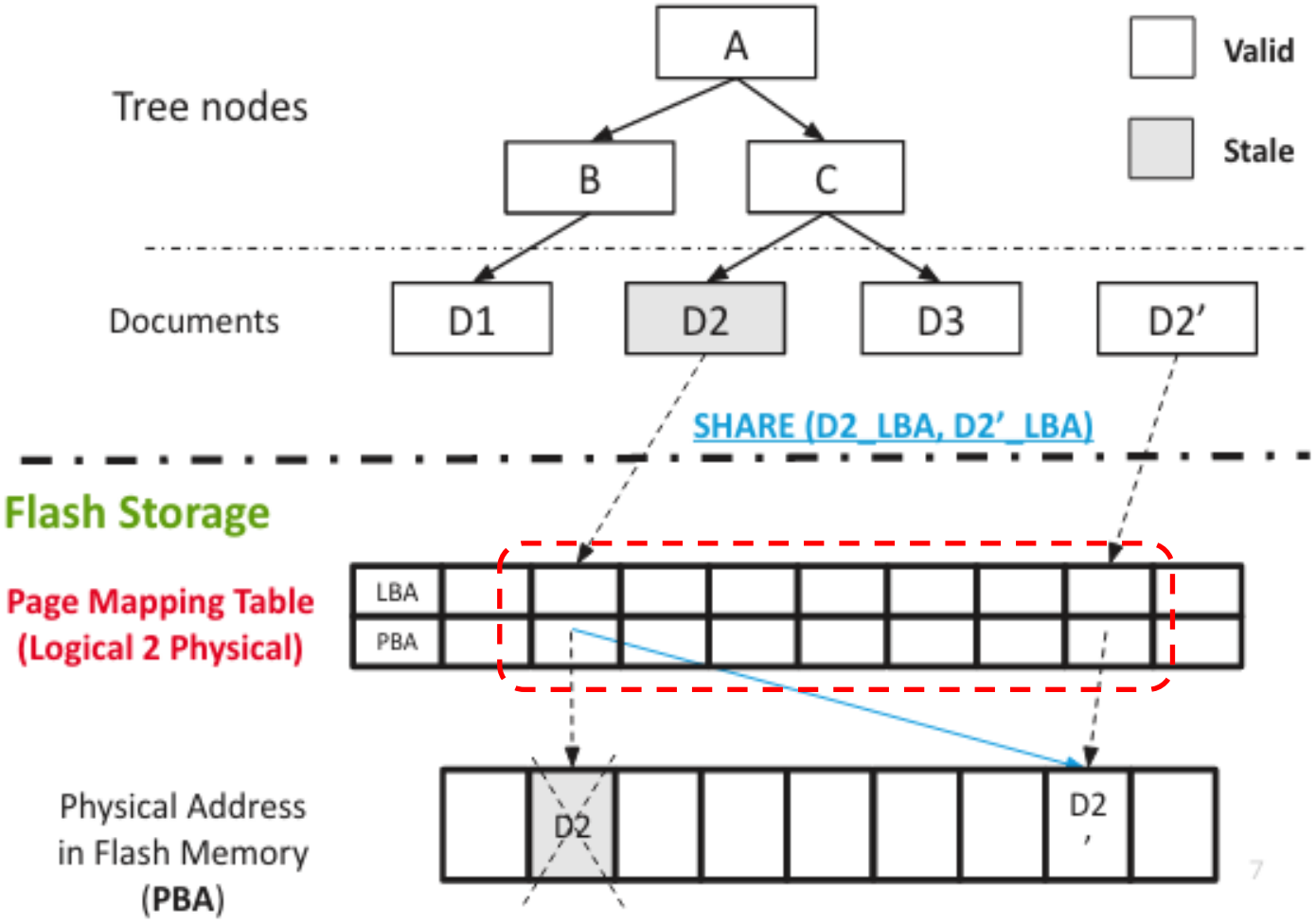


More about CFS (2)

- In flash era, “CFS + X-FTL” is an answer to
  - Application-level crash consistency
  - Journaling of journal

- More lightweight solution than ”CFS + X-FTL” ?
  - Problem in “CFS + X-FTL”: explicit tx concept (e.g. tid)
  - E.g. SHARE interface
  - SQLite journaling overhead: Xxxxxxx logging

What if address remapping feature is exposed to applications?



Q & A