Snapshots in a Flash with ioSnap

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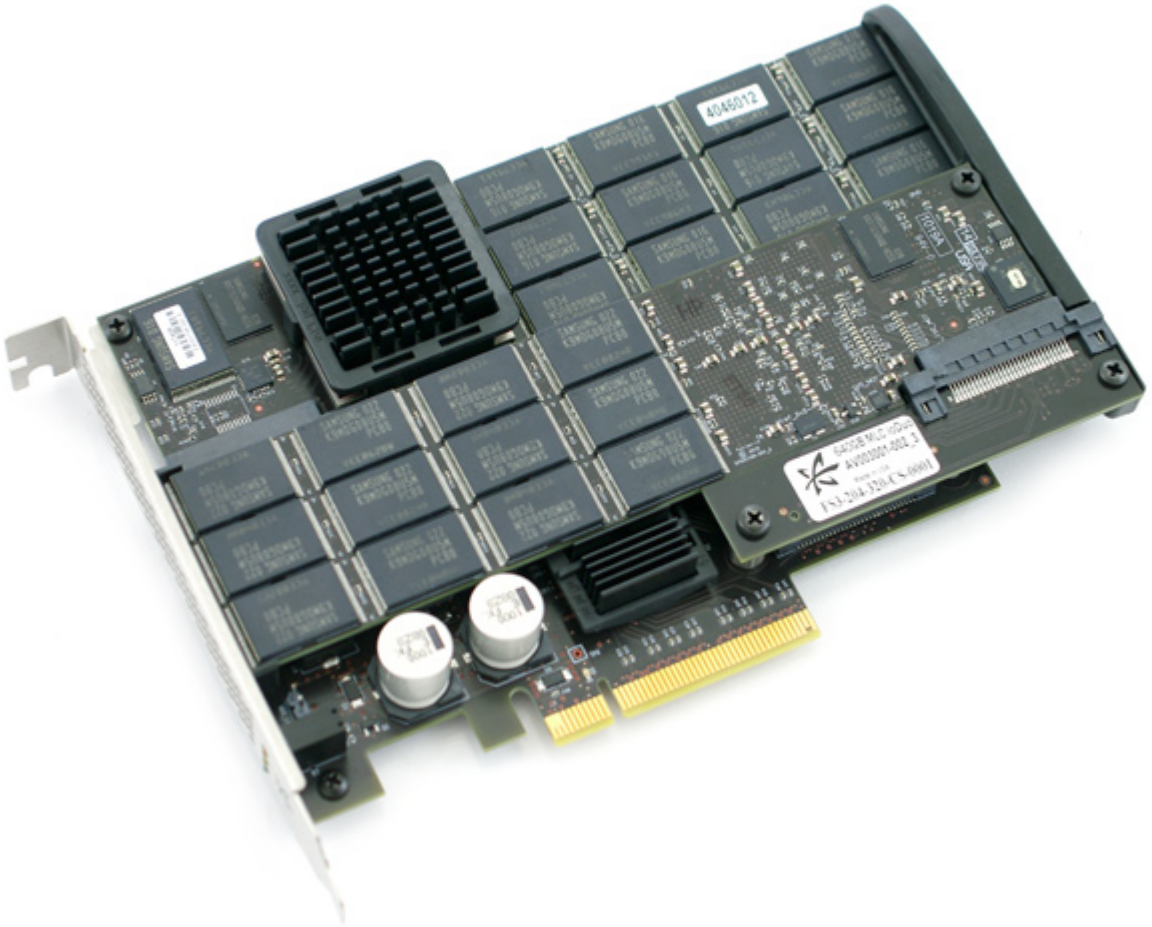
EuroSys '14 (Best Paper Award)

Fusion-io



http://www.storagereview.com/images/Fusion-io-ioDrive-Duo-640GB.jpg

Agenda

- Snapshots & flash drives
- Design
- Evaluation
- Conclusions

Snapshots

Snapshot: a read-only or read-write copy of the data set frozen at a point in time used e.g. for backups, replications, virtualization or audit trails.

Snapshot implementations

- Block layer (generic, easier to deploy)
- File System layer (metadata storage efficiency, consistency)

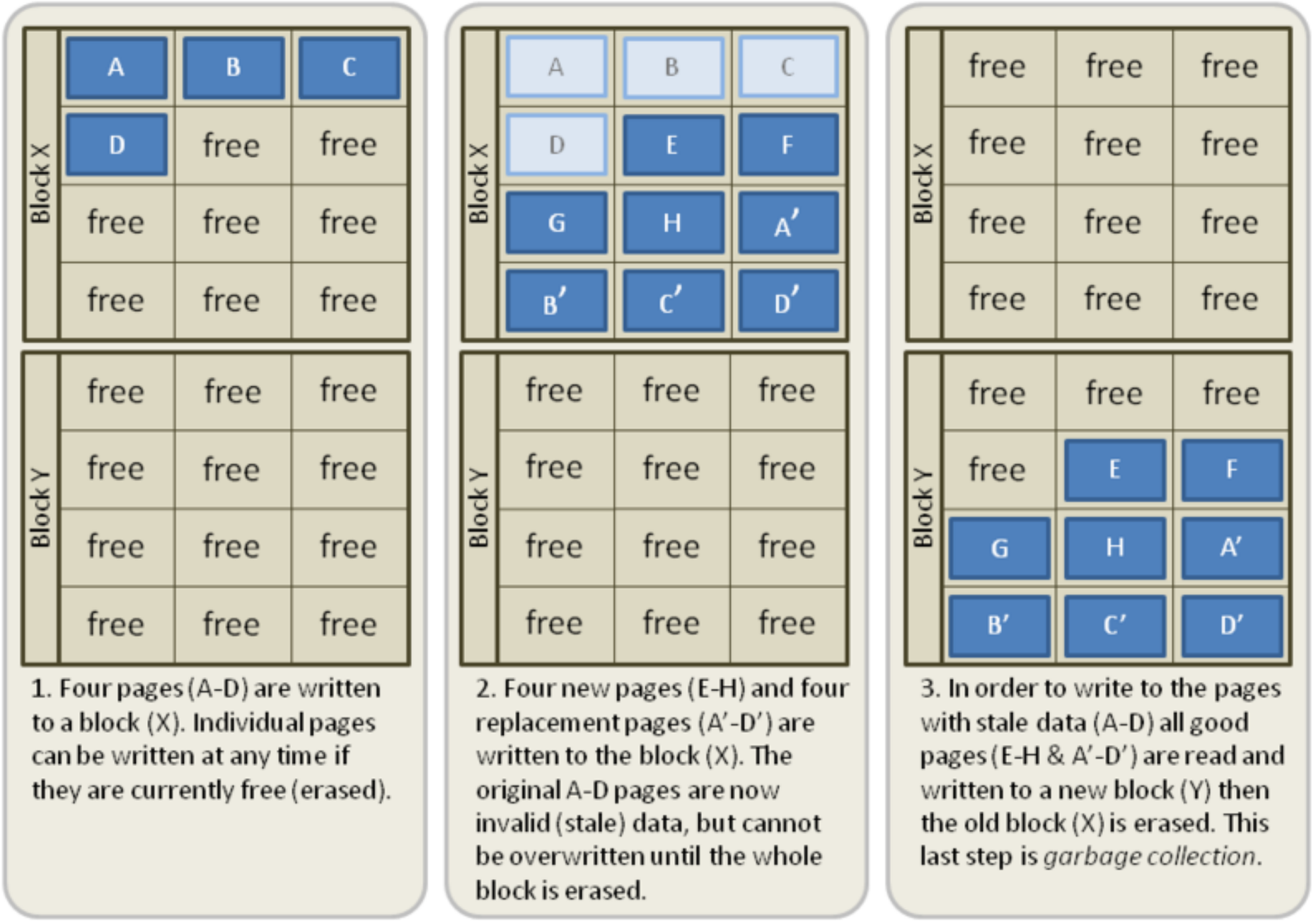
Snapshot implementations

- Copy-on-write (CoW) - when a write request is made, the data is copied into a new storage area, and then the original data is modified

- Redirect-on-write (RoW) - when a write request is made, it is redirected away from the original data into a new storage area

Flash memory based storages

- erasing blocks is required before write
- random access
- wear leveling
- write amplification



NAND flash memory writes data in 4 KiB pages and erases data in 256 KiB blocks

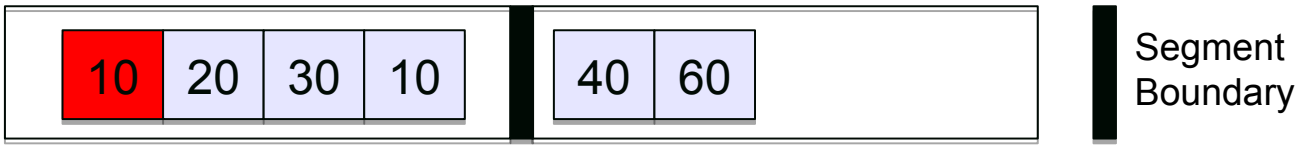
https://en.wikipedia.org/wiki/File:Garbage_Collection.png

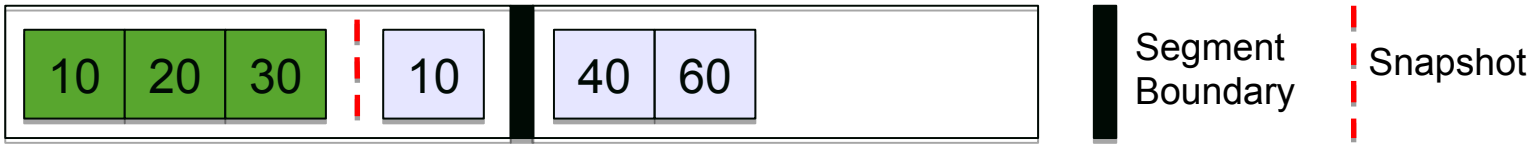
Design

Design goals

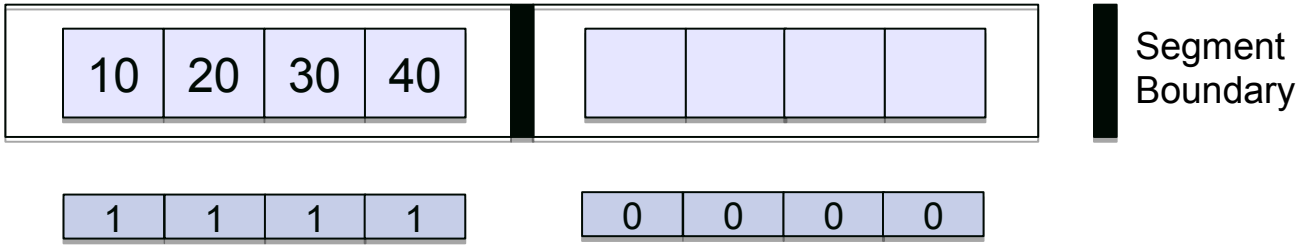
- Maintain primary device performance
- Predictable application performance
- Unlimited snapshots
- Minimal memory and storage consumption

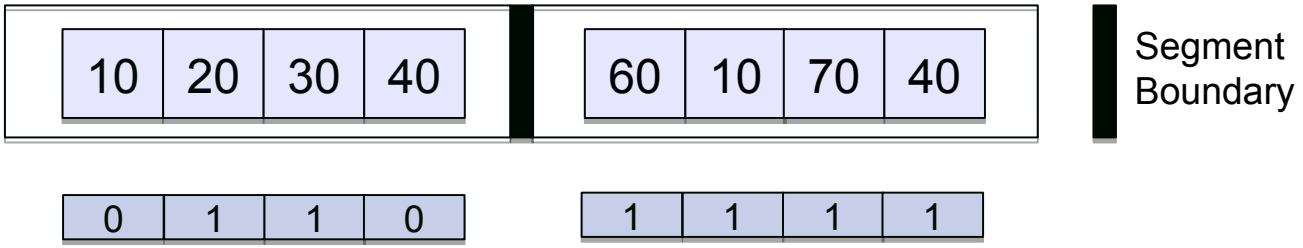
Snapshots on the log



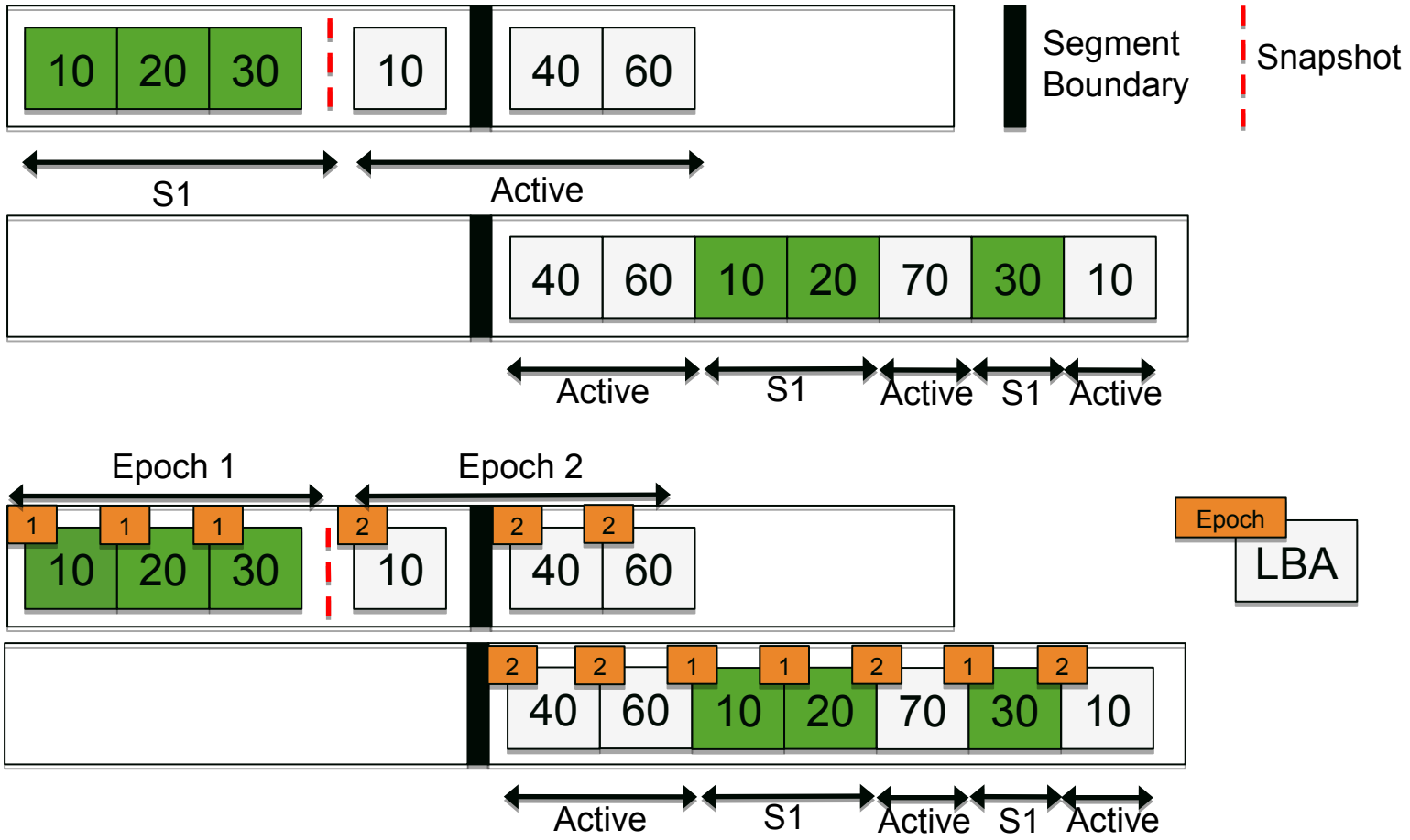


Validity Maps

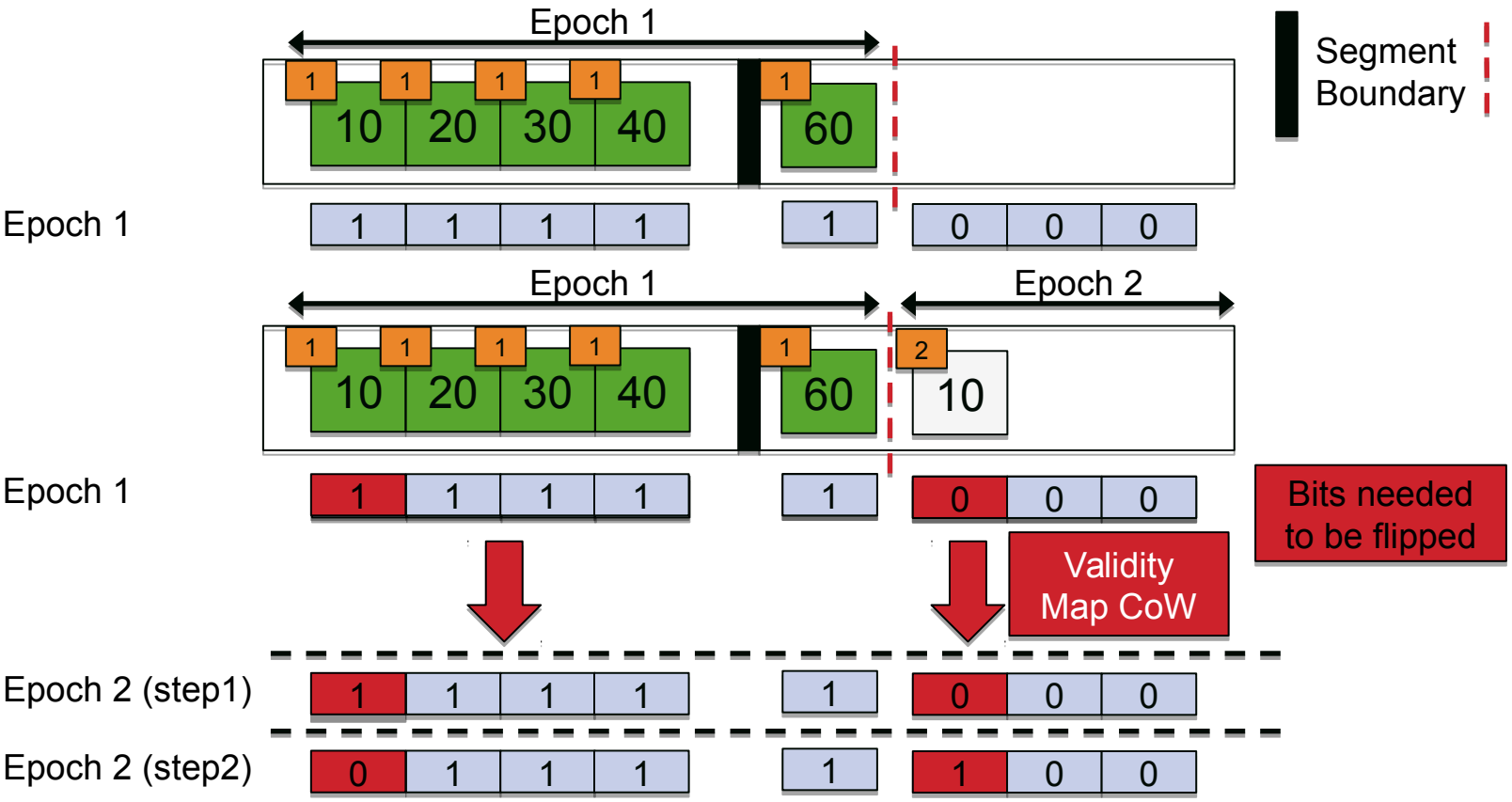




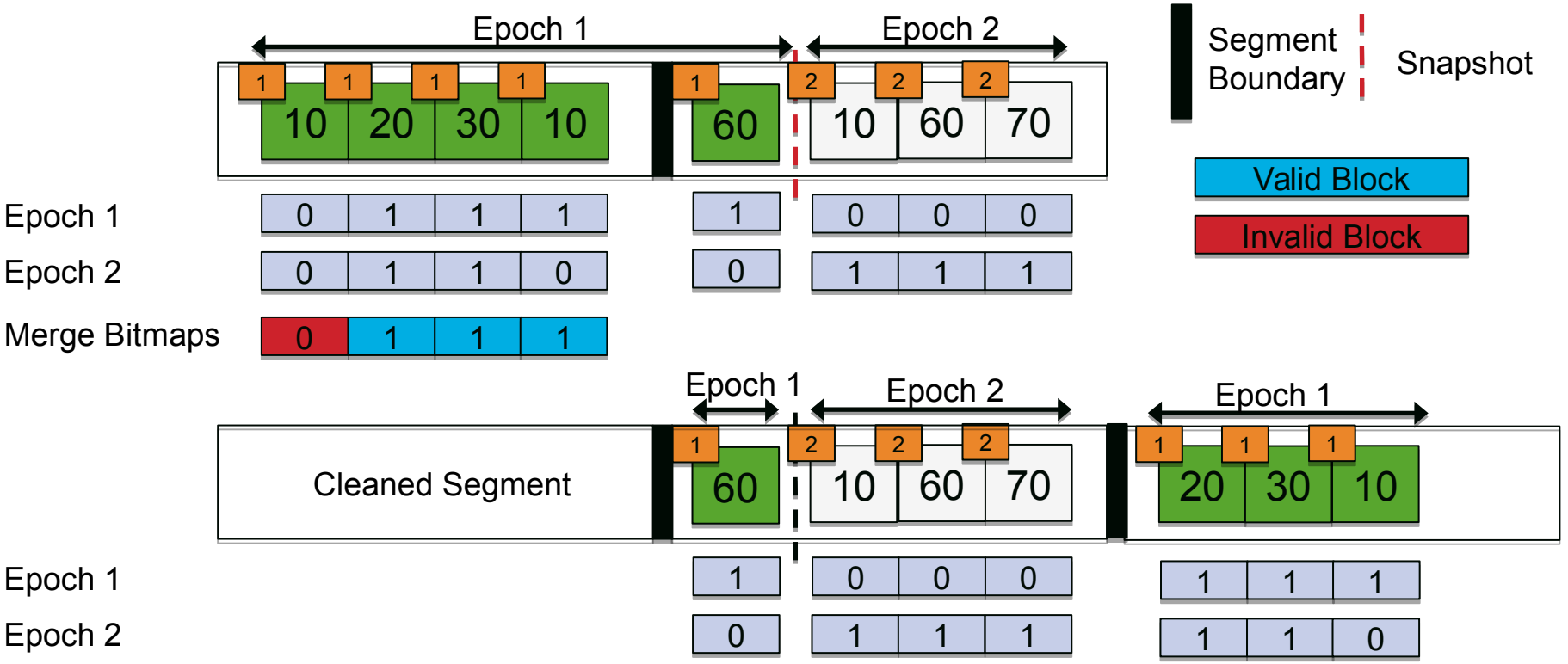
Epochs


10
20
30
10
40
60
Segment Boundary
Snapshot
S1
Active
40
60
10
20
70
30
10
Active
S1
Active
S1
Active
Epoch 1
Epoch 2
1
1
1
2
2
2
10
20
30
10
40
60
Epoch
LBA
2
2
1
1
2
1
2
40
60
10
20
70
30
10
Active
S1
Active
S1
Active

Epochs and validity maps



Snapshot-Aware Segment Cleaner

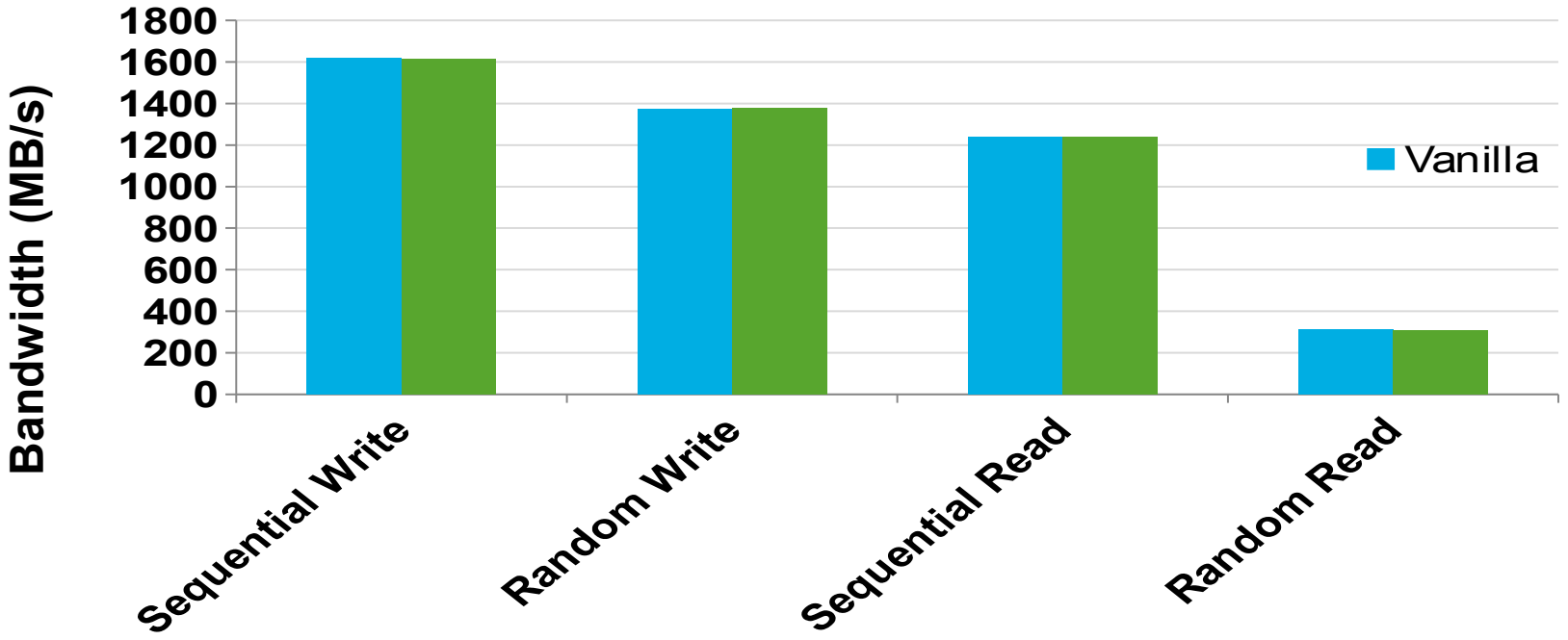


Snapshot activation

- Rare operation
- Can impact foreground user performance
- Produces a new writable device

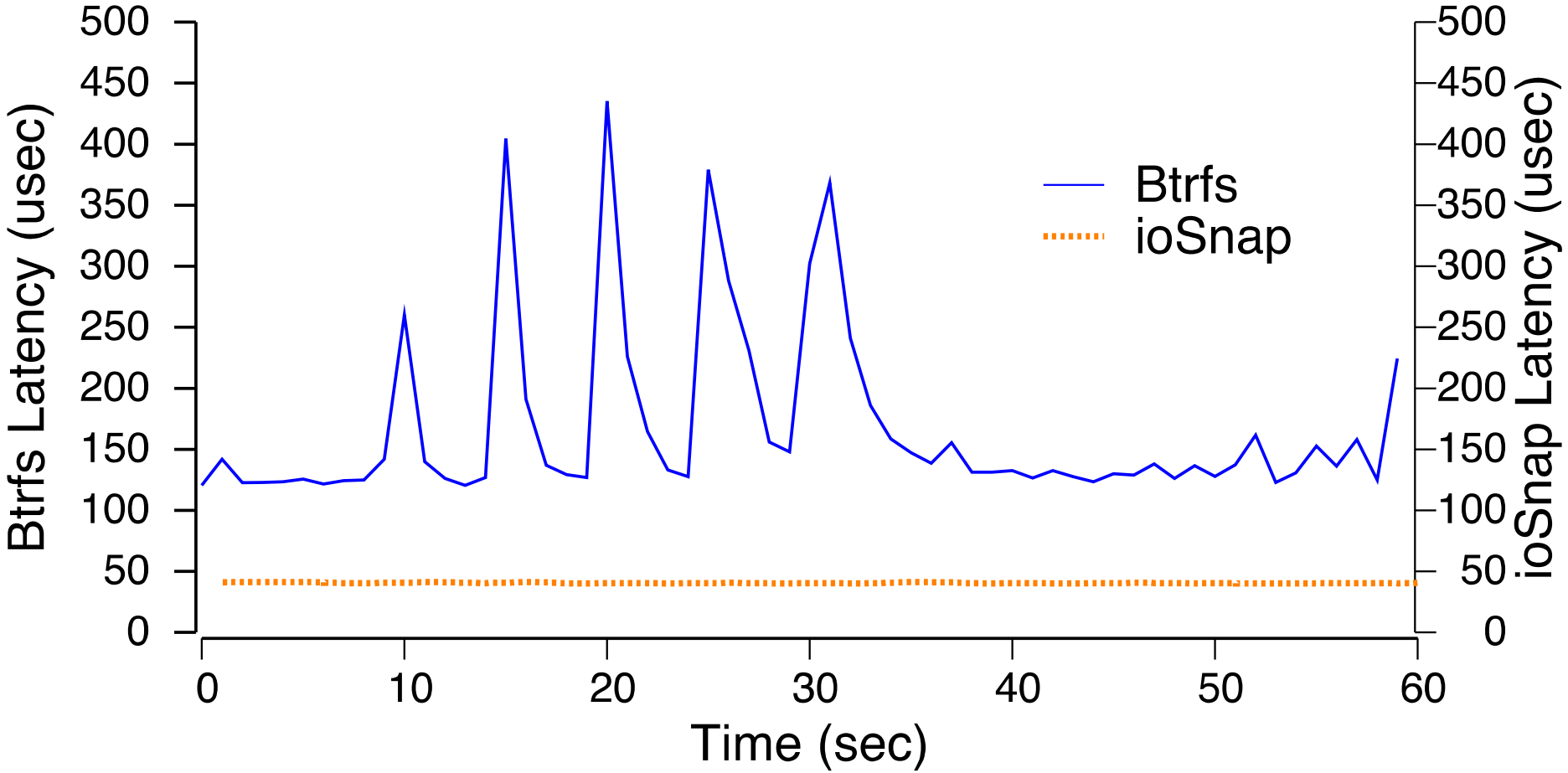
Validation

Regular operations

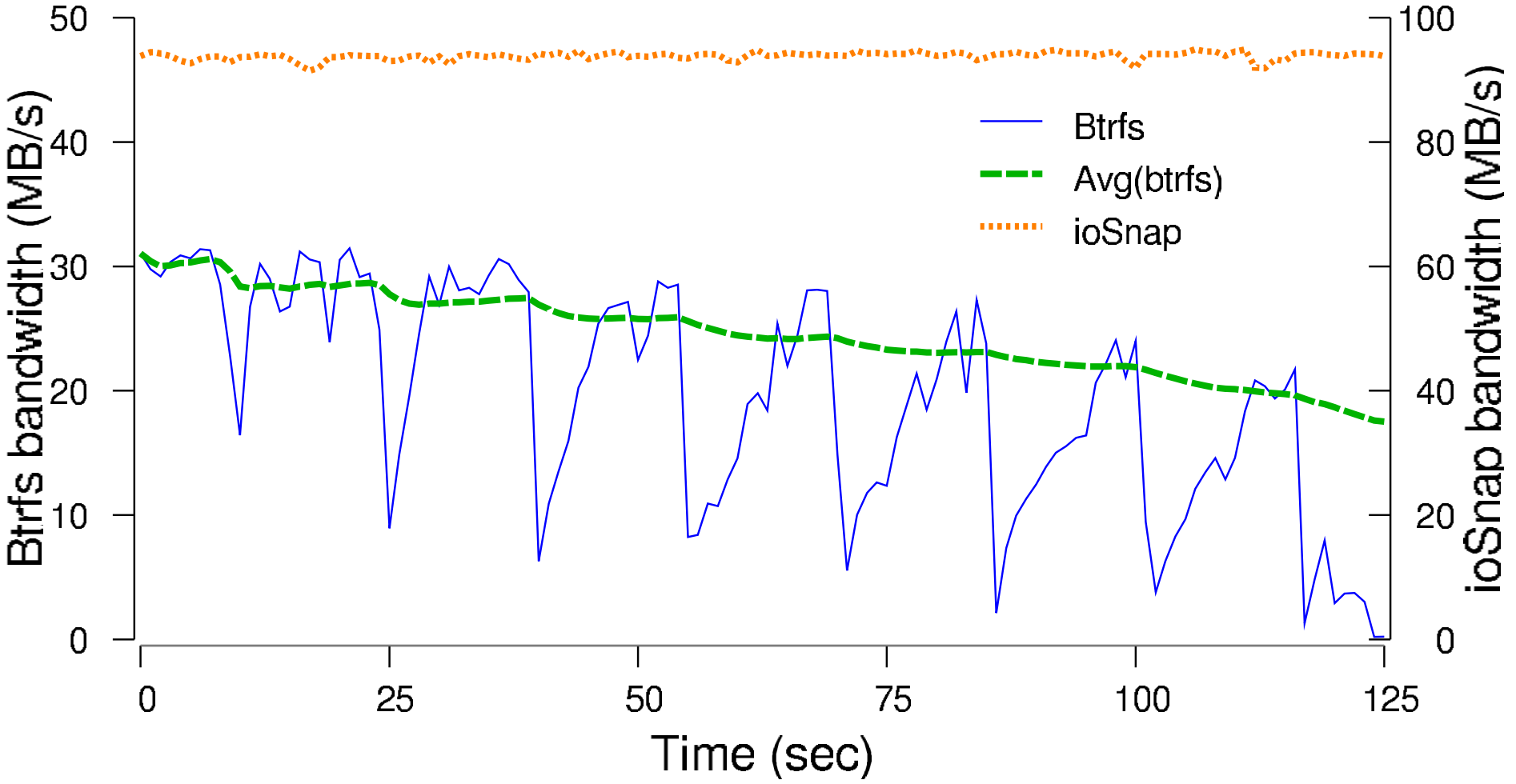


All experiments were performed on a quad core Intel i7 processor, with a 1.2 TB NAND Flash drive and 12 GB of RAM, running Linux 2.6.35 and an older generation of the VSL driver.

Impact of foreground writes upon snapshot creation



Impact of snapshots on sustained bandwidth



Conclusions

- Design choices are applicable to FTLs in general
- Despite RoW nature of FTL implementing snapshot is not trival
- During design performance trade-offs must be considered

Q&A