Logs on Logs on Logs No More

Append Atomic & Remap

Eric Mackay
Venkatesh Srinivas

Basics of Block Device Interfaces

- I/O is done in granularity of blocks
  - 512 bytes is pretty standard
  - Writing is slooooooow
- Data is addressable by block number

Basics of an FTL

- Interface has access to logical block address
- Flash Translation Layer maps the logical block address to a physical block on the device
- Wear-levelling extends lifetime of device by writing new data to a different physical block and mapping the LBA to that location

Write-Ahead Logging

- To make data updates durable and consistent:
  - First write update to log
  - When update in log is durable, then write update to actual data
- If we experience a failure, consistent state can be recovered from any intermediate state

Write-Ahead Logging on an FTL

- WAL performs 2 writes for every modification to data
- Wear-levelling not done across entire disk
  - Modifying same data repeatedly will wear out some regions faster

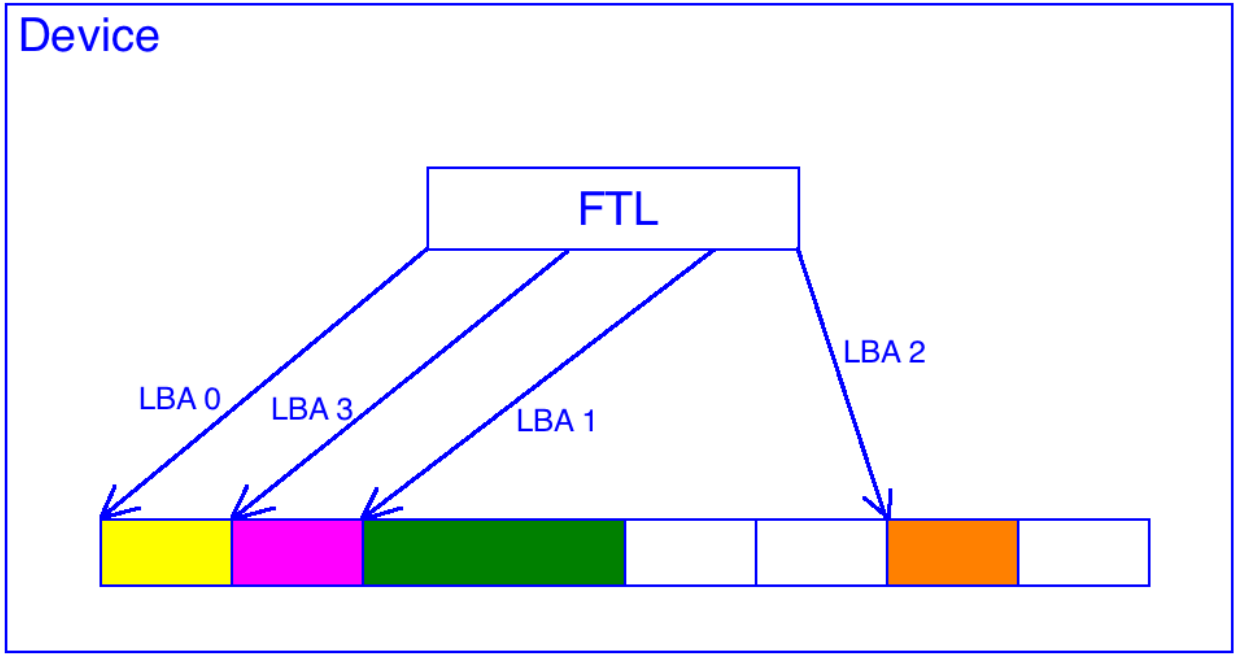
Write Atomic & Write Scattered, Atomic

- SCSI / T10 added Write Atomic command
  - Writes data as atomic operation
  - Can only be contiguous blocks
- Databases need a scattered Write Atomic
  - Ability to write non-contiguous blocks atomically
  - Proposed but not accepted
- Some vendor-specific solutions

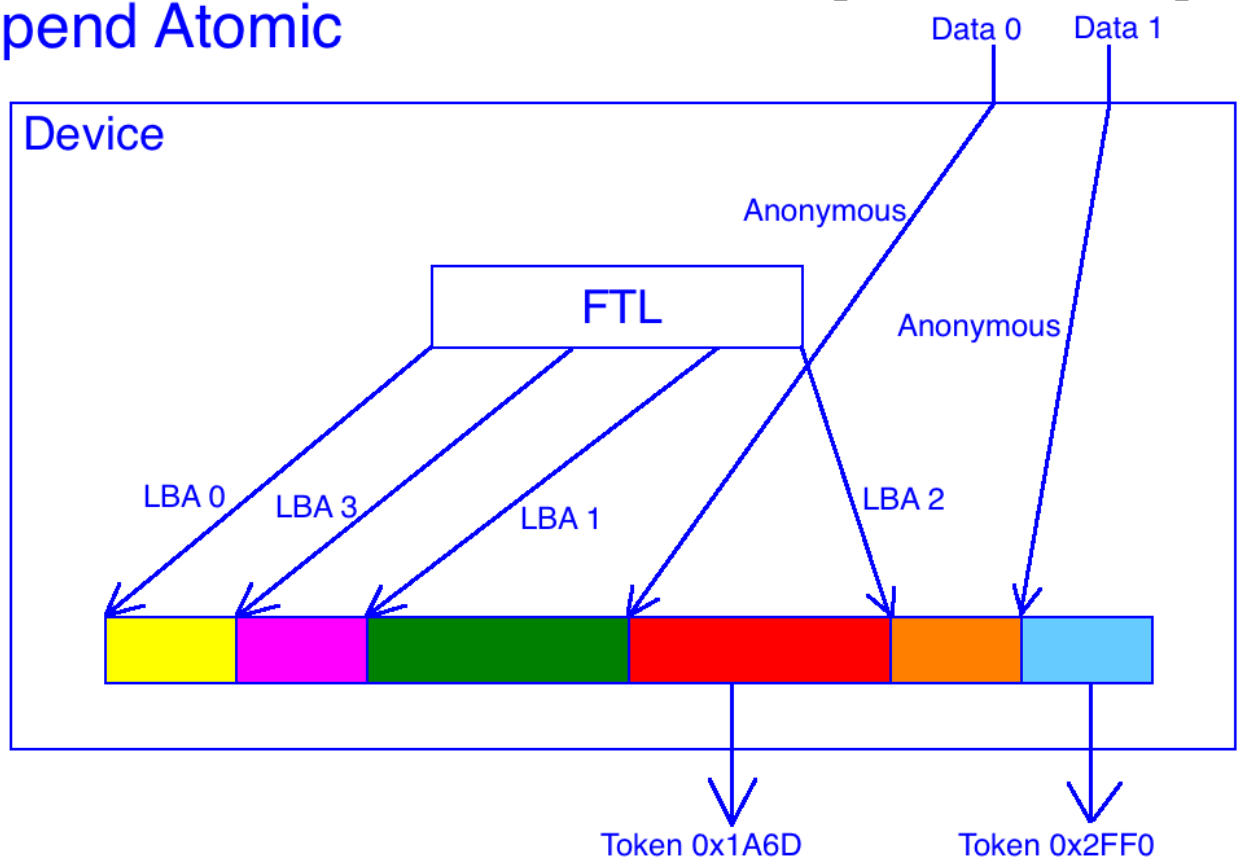
Append Atomic & Remap

- Write data to anonymous area of disk with Append Atomic
  - Return a token (ROD) identifying the data
  - Data not visible to anyone
- Remap the flash translation layer
  - Provide Logical Block Address and token
  - Associates LBA with the physical address corresponding to token
  - Free physical blocks that LBA used to point to
- Only intermediate state: data written but not remapped
  - Completely fine since it’s not addressable
- Also a good interface for SMR drives, not just SSDs

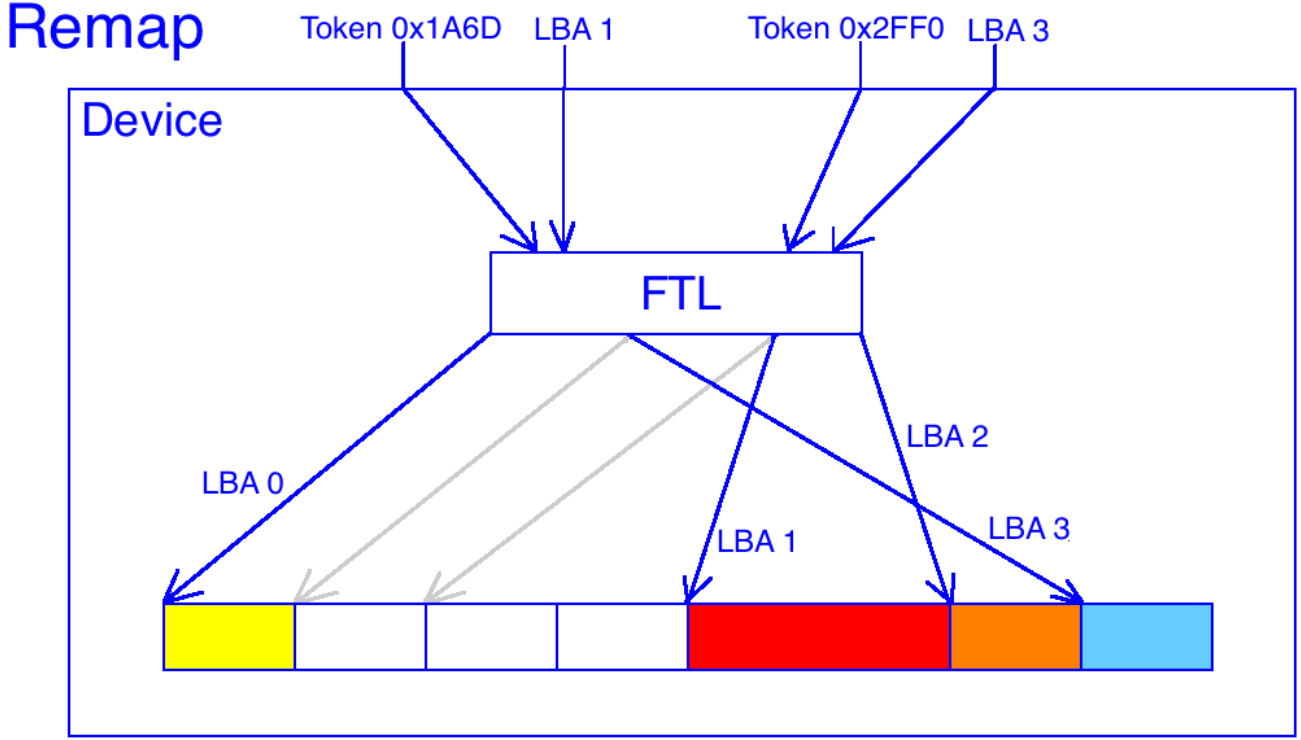
Append Atomic & Remap Example



Append Atomic & Remap Example



Append Atomic & Remap Example



Atomicity

Across a crash cycle, RODs not preserved

FTLs already support internal atomic update (for contiguous writes spanning channel / stripe boundaries)

If not, FTL could double-buffer map updates

Vs. Write Scattered

Pros :=

Deeper I/O concurrency -- overlap between flush groups is ok;

Does not require all data to be available at once

Vs. Write Scattered

Cons :=

Easy to fragment FTL tables with injudicious use of REMAP

Appended-but-not-remapped data is not visible; applications need to lock associated buffers until remap is done.

Implementation details

- Built a prototype using QEMU + iSCSI target
- Maintains in-core ‘divert’ table for non-linear regions of the disk
- Accessed via vendor-specific SCSI command
- Writes diverted blocks into a ‘divert’ file.

SQLite WAL vs. SQLite Append+Remap

Coming soon...