Read Disturb Management Improvement in SSDs

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Outline

- Read Disturb in NAND Flash Array
- Read Disturb Management in SSDs
  - Read Disturb Impact Metrics
  - Read Disturb Management by Different Vendors/Products
- Improvement of Read Disturb Management
- Summary
Read Disturb in NAND Flash Array

- High $V_{\text{pass}}$ causes unwanted charge gain
- Happens to deselected WLs
- Electric-field driven, so mostly L0
- Worse with cycling
- More noticeable in TLC and QLC

Read Disturb must be dealt with to prevent data corruption
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Read Disturb Management

- **Objective:** refresh the data before read disturb causes ECC failures

- **Tasks:**
  - Track/Count the reads
  - Make room for data relocation
  - Copy data to a new location
  - Update LBA map and invalidate old data

All sorts of SSD internal activities run in parallel with host data requests ➔ Performance Impact
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Read Disturb Impact Metrics

- IOPs/IO Stability Drop
- Latency/QoS Increase
- IOPs Recovery Time
- Triggering Rate/Eviction Rate
- Write/Read Ratio in 100% read workloads

For all these metrics, smaller is better
Example (I)

- 30% IOPs Drop
- Takes more than half hour to recover
- Drop Occurs every 180 drv reads
- Average/Max latency increases more than 40%
Example (II)

- NAND Write/Host Read ratio:
  - $10^{-3}$ to $10^{-4}$.
  - Random read: triggering earlier and higher write/read ratio

- Power varies when data relocation takes place

Not all signatures manifest in all the products

Improvement ➔ Less visible in certain metrics
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  - Improvement of Read Disturb Management over Time
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Read Disturb Handling by Different Vendors (Client SSDs)

Some handles better than others
Read Disturb Management by Different Vendors (DC/Enterprise)

Two methods:
- Deal with it only when you have to
- Handle it regularly

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Read Disturb induced ECC Failures

• Delay/Inadequate management can lead to ECC failures

Not expected in today’s DC SSDs
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Improvement in Client SSDs

New SSD with same controller, different algorithm and much reduced IOPs drop
Improvement in DC SSDs

Contributing Factors:

- Better NAND (lower RBER and faster read/write)
- Richer features (erase/program/data transfer suspend)
- More powerful ASIC (processing power and ECC engine)
- Smarter read disturb policy
Summary

- Read disturb management is critical to a drive’s performance and reliability
- Industry has dramatically improved read disturb management over the years
- Thorough validation and assessment of read disturb policy are key to a robust SSD.
THANK YOU!