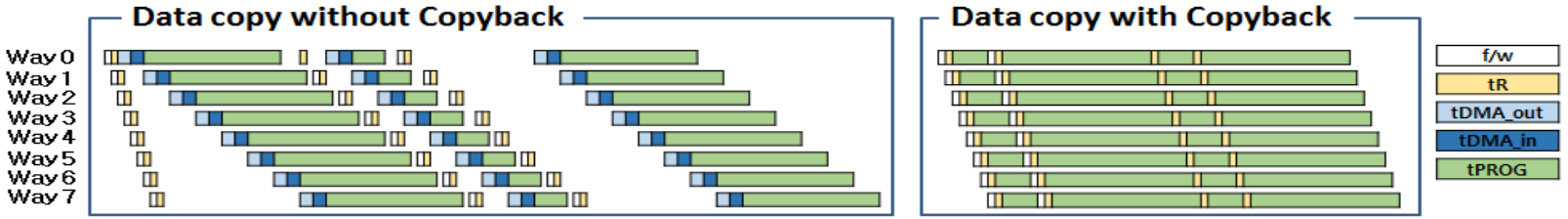
Improving SSD Performance Using Restricted Copyback Operations

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Copyback Operation in SSD

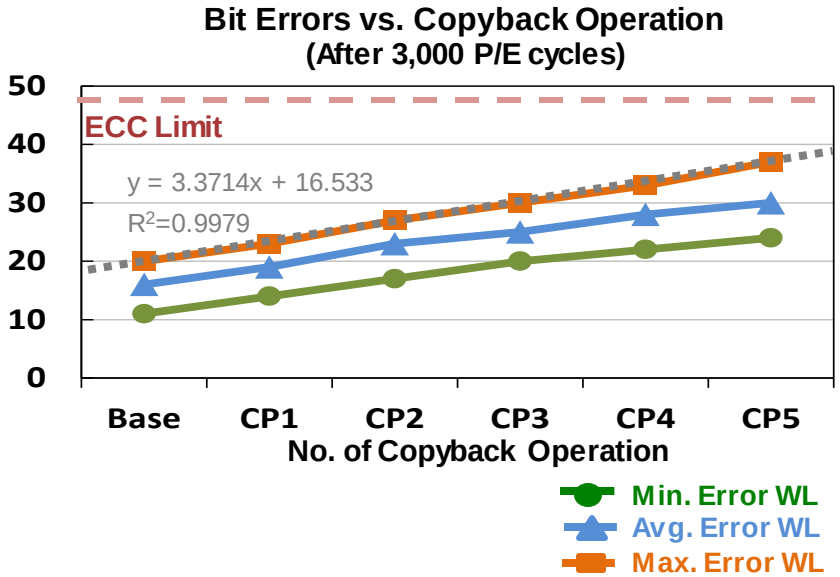
- **Advantage of Copyback**
  - DMA time during data copy can be hidden
    - *tDMAout* and *tDMAin* are not needed
  - More effective when the number of channel/way are bigger



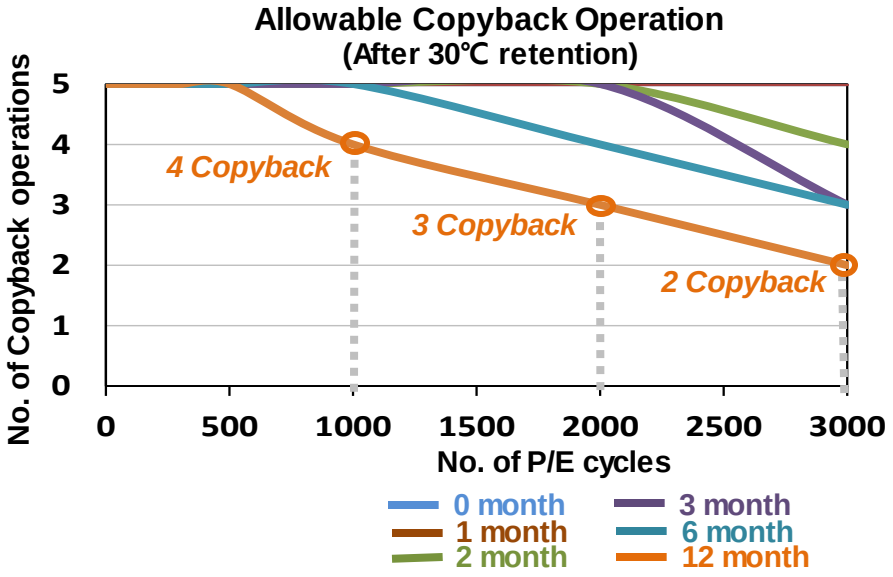
- **Difficulty of applying Copyback in SSD**
  - Error Propagation Issue
    - Consecutive Copyback can cause ***Uncorrectable Error***
  - Same Plane Constraint
    - Source/destination pages should be located in ***Same Plane***
  - Partial Invalid Page Management

Characterization of Copyback Error Propagation

- **Bit Errors are increased by the number of Copyback**
  - **3~4 bits** per each Copyback on **1x MLC NAND**

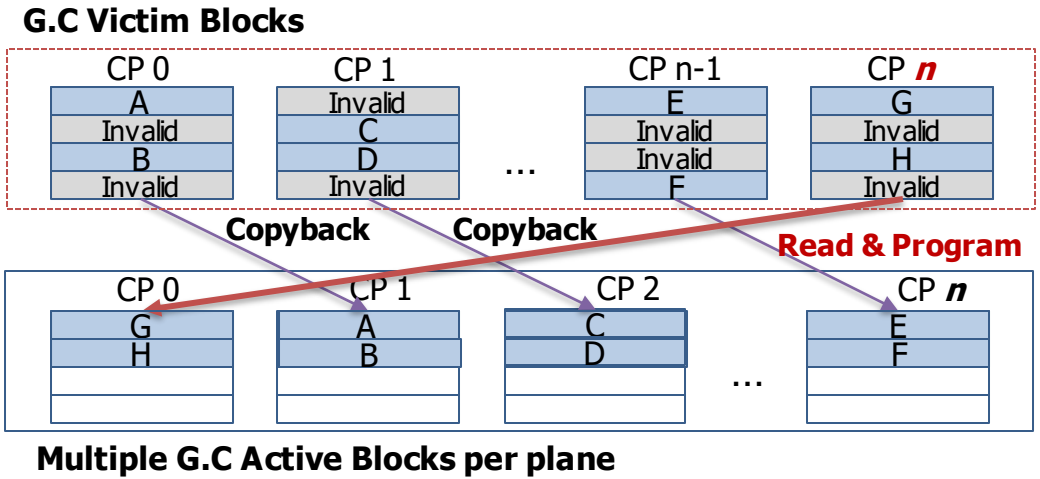


- **Minimum two Copybacks are allowed at Max P/E cycle**
  - Without sacrificing retention (12 months)



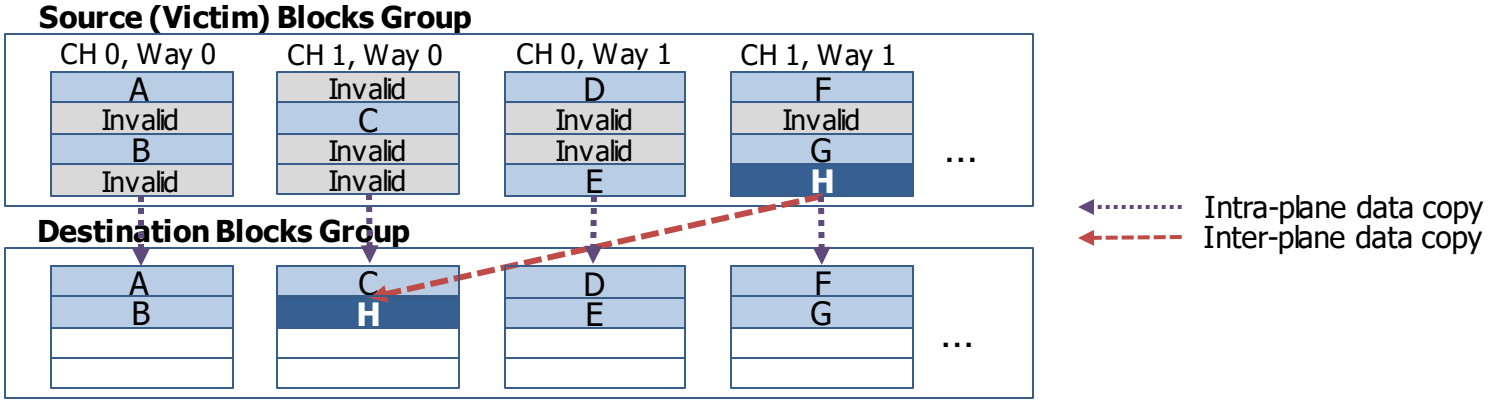
Error Propagation Management

- **Restricted Version of Copyback**
  - ***R_Copyback*** : executing error correction using off-chip ECC after ***n*** consecutive Copybacks
- **Copyback Count Management**
  - Per page management overhead is high
  - **Block based count management** (**Multiple G.C Active Blocks**)



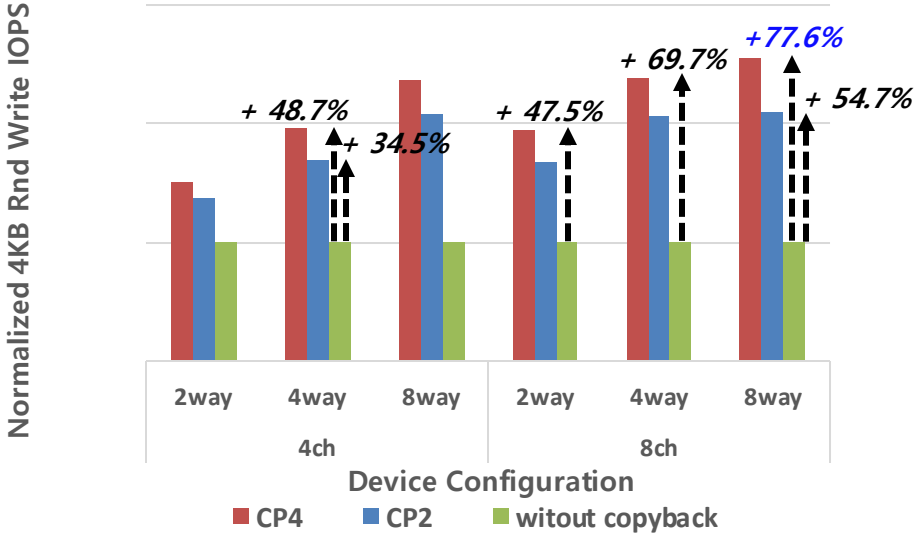
Same Plane Constraint

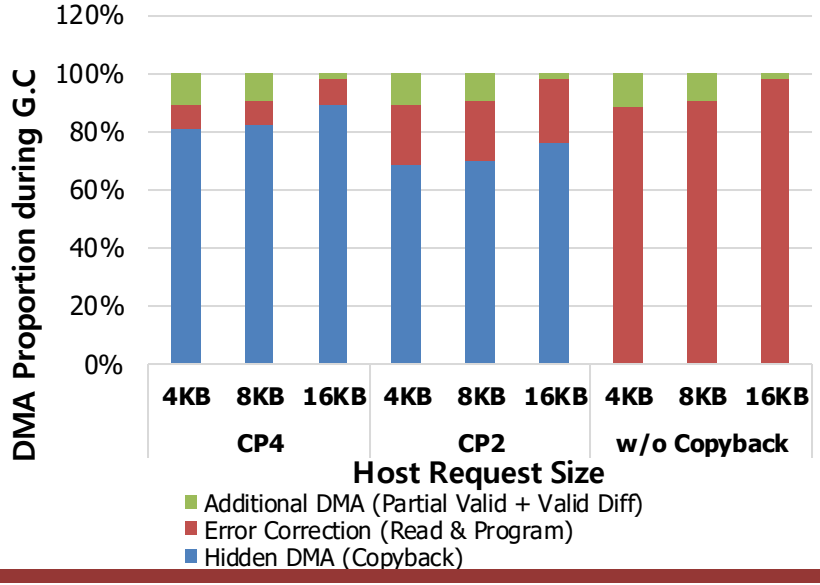
- **Existing Approach**
  - Plane Based Static Mapping → Host workload dependency
- **Our Approach**
  - Global Mapping Scheme
    - Host workload independency, but GC efficiency difference per plane
  - GC Efficiency Balancing
    - Doesn't allocate new victim block for specific plane until all blocks of victim group are invalidated



Evaluation Results

- **Performance improvement: up to 77.6%**
  - 8ch x 8way with Copyback up to 4 times (77.6%), 2 times (54.7%)
  - Improvement of 8ch is higher than 4ch
  - Improvement of 8way is higher than 2/4 way





Q & A

