ICE3028: Embedded Systems Design
- Project 2: Page Mapping FTL on NAND simulator

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Descriptions

• Develop a page mapping FTL simulator
  – Simulate the operations of page mapping FTL
    • Manage mapping with L2P table
  – Assumption
    • Uniform size of write request
    • Initial state of flash blocks: empty
  – Misc.
    • GC policy: greedy policy
    • GC triggering condition: when # of free blocks becomes one
    • Make Over-Provisioning (OP) ratio adjustable
  – Draw a graph on OP ratio vs. WAF
Data Structures

• L2P table
  – Index: logical page number (LPN)
  – Value: physical page number (PPN)
  – Updated on write and GC

• Store the LPN into the spare area of written page

• Per-block information
  – Which page is valid? (optional)
  – # of valid pages (optional)

• How to find the victim block for GC?
Configurations

• Flash memory
  – Total capacity: 4GB
  – Page size: 4KB
  – Pages per block: 128 (block size: 512KB)

• SSD
  – OP ratio: 7% (default), 10%, 13%, 16%, 19%, 22%, 25%, 28%

• Workload
  – Size of each write request: 4
  – Total number of write requests: x10 of the total SSD capacity visible to the user
Configurations (cont’d)

User-visible space
(N_USER_BLOCKS = 7656 blocks)

Over-provisioning space
(N_OP_BLOCKS = 536 blocks, 7%)

Total 4GB
(N_BLOCKS = 8192 blocks, 512KB/block)

PPN:
Block #  Page #
Code Analysis

```c
#define SSD_SHIFT 32
#define PAGE_SHIFT 12
#define PAGES_PER_BLOCK_SHIFT 7
#define OP_RATIO 7
#define N_RUNS 10

#define PPN_SHIFT (SSD_SHIFT - PAGE_SHIFT)
#define BLOCKS_SHIFT (PPN_SHIFT - PAGES_PER_BLOCK_SHIFT)
#define N_PAGE_SIZE (1 << PAGE_SHIFT)
#define N_PAGES_PER_BLOCK (1 << PAGES_PER_BLOCK_SHIFT)
#define N_PPNS (1 << PPN_SHIFT)
#define N_BLOCKS (1 << BLOCKS_SHIFT)
#define N_USER_BLOCKS (N_BLOCKS * 100 / (100 + OP_RATIO))
#define N_OP_BLOCKS (N_BLOCKS - N_USER_BLOCKS)
#define N_LPNS (N_USER_BLOCKS * N_PAGES_PER_BLOCK)
#define LPN_COUNTS (N_LPNS * N_RUNS)
```
Code Analysis (cont’d)

Execution result (Skeleton code)

- SSD capacity: 4GB
- Page size: 4KB
- Pages / Block: 128 pages
- Block size: 512KB
- OP ratio: 7%
- Physical Blocks: 8K (8192)
- User Blocks: 7656
- OP Blocks: 536
- PPNs: 1M (1048576)
- LPNs: 979968
- Total runs: x10
- Actual capacity: 4013948928 Bytes

```
show_info()

sim()

show_stat()
```

Results ------
- Host writes: 9799680
- GC writes: 0
- Number of GCs: 0
- Valid pages per GC: -nan pages
- WAF: 1.00
Code Analysis (cont’d)

Execution result, OP ratio=28% (Answer code)

NAND: 8192 blocks, 128 pages per block, 1048576 pages
SSD capacity: 4GB
Page size: 4KB
Pages / Block: 128 pages
Block size: 512KB
OP ratio: 28%
Physical Blocks: 8K (8192)
User Blocks: 6400
OP Blocks: 1792
PPNs: 1M (1048576)
LPNs: 819200
Total runs: x10
Actual capacity: 3355443200 Bytes

[Run 1] host 819200, valid page copy 0, GC# 0, WAF=1.00
[Run 2] host 1638400, valid page copy 284001, GC# 6828, WAF=1.17
[Run 3] host 2457600, valid page copy 1011555, GC# 18912, WAF=1.41
[Run 4] host 3276800, valid page copy 1994710, GC# 32993, WAF=1.61
[Run 5] host 4096000, valid page copy 3096437, GC# 48000, WAF=1.76
[Run 6] host 4915200, valid page copy 4247160, GC# 63390, WAF=1.86
[Run 7] host 5734400, valid page copy 5418483, GC# 78941, WAF=1.94
[Run 8] host 6553600, valid page copy 6596464, GC# 94544, WAF=2.01
[Run 9] host 7372800, valid page copy 7777775, GC# 110173, WAF=2.05
[Run 10] host 8192000, valid page copy 8958804, GC# 125800, WAF=2.09

Results ------
Host writes: 8192000
GC writes: 8958804
Number of GCs: 125800
Valid pages per GC: 71.21 pages
WAF: 2.09
pm.c

• ftl_read(long lpn, u32 *read_buffer)
• ftl_write(long lpn, u32 *write_buffer)
• garbage_collection()

• Write above APIs based on NAND simulator written at Project 1
Submission

• Compress your folder as YourStudentID-2.tar.gz
  – With codes and graph
  – Send email to minwoo.ahn@csl.skku.edu
  – Please send mail with uniformized title
    • [ICE3028]YourStudentID-2

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• Due date: 11/11(Sun.), 23:59:59 PM
  – -20% per day for delayed submission
Questions

• If you have questions, please email to TAs

• You can also visit Semiconductor Building #400509
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