Wear Leveling

White Paper

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Version 1.2

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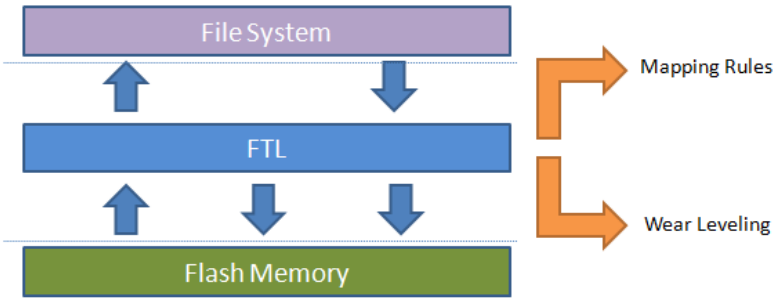
Wear Leveling

Overview

Solid State Drives (SSDs) differ from Hard Disk Drives (HDDs) in terms of how blocks are utilized. For HDDs, when a change is made to stored data, like erase or update, the controller mechanism on HDDs will perform overwrites on blocks. On the other hand, SSDs adopt flash as their primary media. Unlike HDDs, flash blocks cannot be overwritten and each P/E cycle wears down the lifespan of blocks gradually. Repeatedly program/erase cycles performed on the same memory cells will eventually cause some blocks to age faster than others. This would bring SSDs to their end of service term earlier. Wear leveling, embedded in Flash Translation Layer (FTL), is an important mechanism that level out the wearing of blocks so that the wearing-down of blocks can be almost evenly distributed. This will increase the lifespan of SSDs. Commonly wear leveling used two types are Dynamic and Global.

Wear Leveling and Flash Translation Layer (FTL)

Except mapping rules, Wear Leveling is implemented in the flash translation layer (FTL) between file system and NAND flash chips. The FTL provides mapping rules from logical to physical address. Wear Leveling helps to reduce the block wear out over the mapping rules.

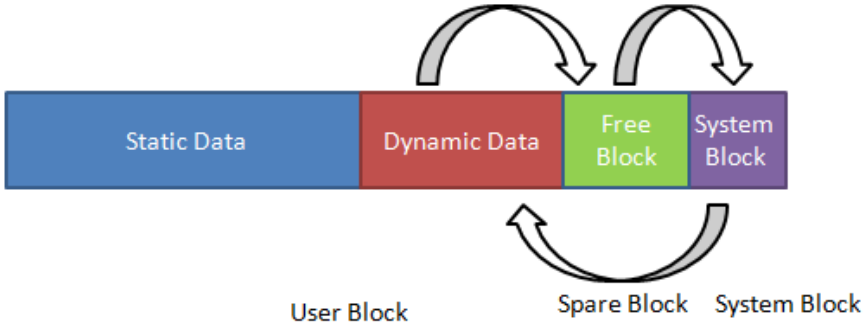


How Wear Leveling works

By default, wear leveling is disabled and it has a pre-defined wear leveling threshold to trigger the mechanism. Once the average erase count hits the pre-defined wear leveling threshold, the mechanism will be triggered and start block swapping. It checks whether the erase count of the block goes below the average erase count or not. If it is less than the average, it means the block is a less frequently used block and suitable for swapping with the block in free block. If the erase count of the checked block goes beyond the average, then it will check the next until another suitable one is found.

Dynamic Wear Leveling

Dynamic Wear Leveling uses a map to link logical block address from the operating system to the physical flash memory. It handles hot data which is frequently changing and constantly reprogrammed and rotates hot data to the free blocks that have had fewest program/erase cycle. However, flash memory blocks that never get replacement data would sustain no additional wear. It only recycles the data from the blocks which store hot data. Other blocks which store static data will be left unused and wasteful. Thus, this wear leveling technology does improve the life expectancy of blocks, but still far from being ideal.

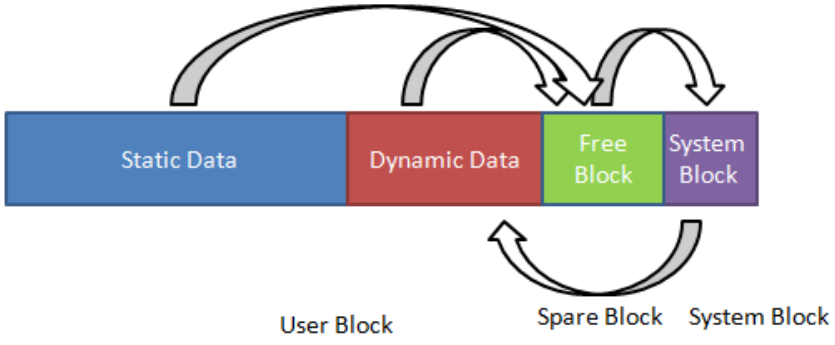


Flash Block Management:
User Block: user data
Spare Block: free block pool, bad block pool, etc.
System Block: firmware information

Dynamic Wear Leveling

Global Wear Leveling

Global Wear Leveling also uses a map to link logical block address from the operating system to the physical flash memory. It works the same as Dynamic Wear Leveling but also joins the static data into spare block, distributes the program/erase counts evenly on all blocks and prevents the shortcoming from Dynamic Wear Leveling.



Flash Block Management:
User Block: user data
Spare Block: free block pool, bad block pool, etc.
System Block: firmware information

Global Wear Leveling

Conclusion

Apacer Wear Leveling scheme is accomplished via Global Wear Leveling, which ensures the lifetime of the flash media can be increased, and the drive performance is optimized as well. This is a more ideal and suitable, especially for enterprise and industrial SSDs as it greatly prolongs the lifespan of the flash media.

Revision History

Revision	Date	Description	Remark
1.0	January 4, 2016	Official Release	
1.1	November 16, 2016	Modified overview, dynamic and static Wear Leveling	
1.2	December 2, 2016	Added how wear leveling work	

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