Apacer

DataRAID™

White Paper

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1. Introduction

The manufacturing process of NAND Flash has tended towards larger density and smaller geometry in order to adapt to market trends. As flash technologies evolve, the amount of bits stored per cell has significantly increased. However, the trade-off has been a drop in reliability, because error rate increases as less cell space is available to contain electrons. Thus, mechanisms that provide protection for user data have become critical when choosing memory solutions.

3D NAND flash memory has been widely accepted due to its cost-performance ratio, better reliability, low power consumption and support for higher capacities, but there exists a downside that concerns Apacer most: data integrity. Data corruption often occurs through various scenarios, such as unexpected power loss, unstable power supply and flash wear-out. They can potentially occur at any point throughout the process when data travels from the host through the SSD controller to the NAND storage. Corruption like this is often undetected until the data is accessed again. Serious consequences such as data errors and system downtime may occur if the errors are not found and repaired in time. With smaller NAND flash geometry, flash memory storage manufacturers rely heavily on an ECC mechanism to reinforce data integrity. However, there is a limit to an ECC's ability to protect data, because it does not have the ability to determine the occurrence of errors throughout the process of data transmission.

As demand for data protection has increased, ensuring the integrity of data has become paramount. With only ECC technology implemented, the level of security is insufficient. This is when RAID (Redundant Array of Independent Disks) storage systems come in. Apacer has created DataRAID as an additional data safety feature to provide fault tolerance and improve data availability.

This white paper describes the general concept of DataRAID and explains how it is implemented in Apacer's SSD products.

2. DataRAID™

2.1 Concept

Although 3D NAND flash offers a cutting-edge way to store data, it is often criticized for its endurance and reliability due to its structure. In 3D NAND flash, depending on the number of layers a block contains, the quantity of contiguous pages connected by each layer via word lines (WL) varies. Therefore, a single error may cause collateral damage to nearby cells. When a failure occurs in a specific WL, all associated pages will be affected.

DataRAID is a firmware algorithm that ensures data integrity by creating parity to verify the completeness and correctness of the existing data in the flash memory, developed specifically for the 3D NAND structure, and based on the RAID structure which is already well established in the computing world. It is evenly distributed throughout the flash block for data recovery.

2.2 How It Works

In 3D NAND structure, flash densities are composed of multiple dies. Apacer's firmware algorithm connects those dies to form DataRAID (parity), and creates parity in each group during write operations (Figure 2-1).

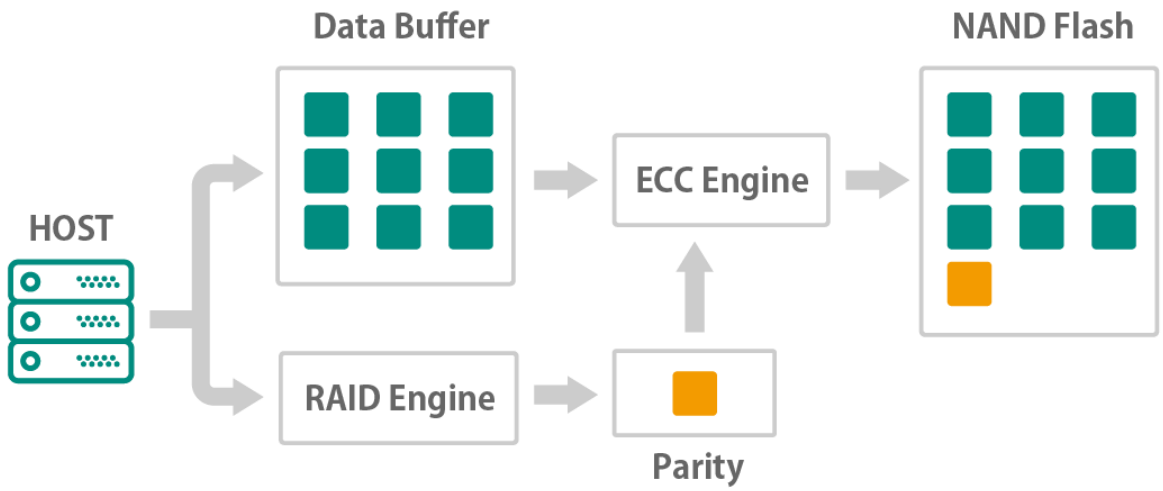

Figure 2-1 Write Operation - Creating Data-RAID with parity

Parity, stored to ensure data is properly protected, is created while data is transmitted through the data buffer, and then programmed to NAND flash for future error correction purposes.

Whenever data is being accessed, the controller will check the accuracy and consistency of the data using the ECC mechanism. If there is no error, the data will be transmitted to the host directly after the data integrity check.

When the host identifies errors while accessing data, the corrupted data will be recovered by the previously-generated parity (Figure 2-2). After recovery, data correctness will be checked once again. Once data completeness is verified, the data will be transmitted to the host.

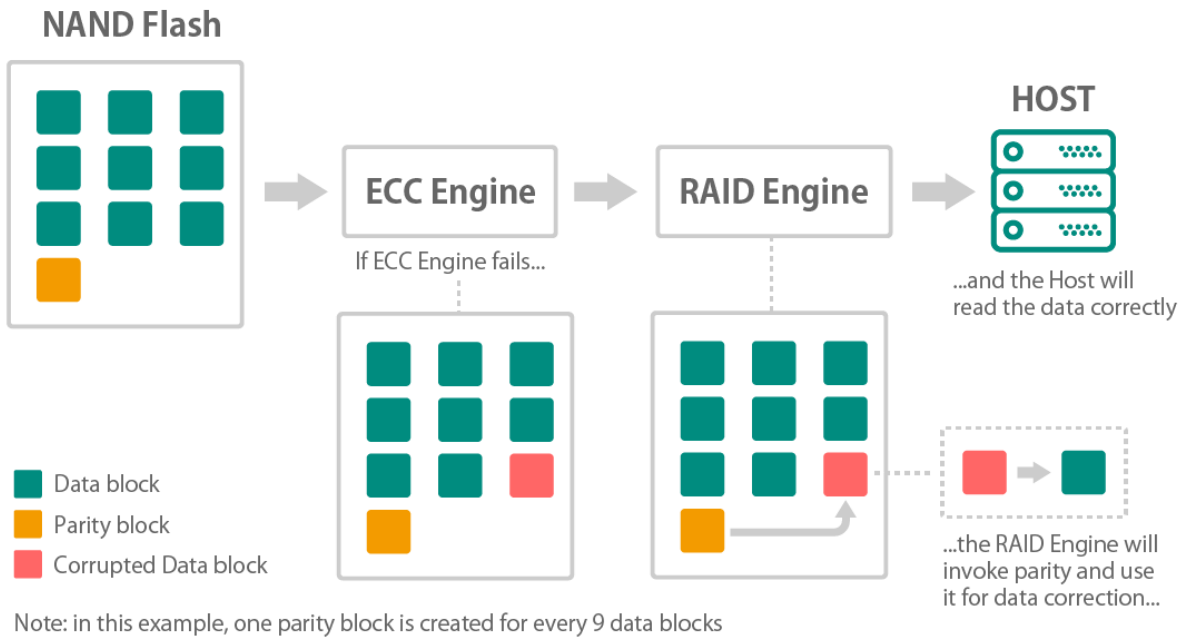

Figure 2-2 Read Operation: Data recovered from parity

3. Conclusion

As 3D NAND flash memory has been widely adopted for its high performance and high capacity, most world-leading NAND vendors are moving towards supplying 3D NAND. However, these SSDs have limitations, largely related to the inherent characteristics of storage media.

To reduce the risk of failure when an SSD reaches the end of its life cycle, most users have relied upon ECC in the past. But since this technology isn't foolproof, Apacer offers DataRAID, a second level of protection against data loss in the event of a drive failure. With parity used to check whether data has been successfully transmitted between a host and an SSD, DataRAID increases the chance that the corrupted data can be recovered by the parity to raise fault tolerance and data availability.

Revision History

Revision	Description	Date
1.0	Official release	9/11/2018
1.1	Grammatical revisions	11/22/2018
1.2	Textual and chart revisions	12/3/2018

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