Variable Sparing of Disk Drives Based on Failure Analysis

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Abstract

In enterprise storage, the achievement of disk drive failure tolerance and optimal disk utilization presents an immense challenge. Adding storage is a necessary step in ensuring the system is failure tolerant, but this also leads to an increase in overall costs due to redundant storage. Another difficulty arises from the inaccessibility of spare disks, resulting in underutilization of disk space until a system failure occurs. To address these challenges, we propose a novel drive sparing mechanism. The method maintains the optimal number of spare drives to provide failure tolerance while also addressing the issue of superfluous spare disks and reducing the total cost of ownership. The Venn-ABERS framework is utilized to identify the critical disks that are susceptible to failure within the RAID group, and a variable sparing mechanism is employed, wherein certain disks perform a dual purpose. We showcase our variable sparing approach using two scenarios, one in which a minimum spare pool is sufficient, and the other in which it is inadequate for failure tolerance. The proposed method enables efficient management of the RAID group by ensuring adequate redundancy for fault tolerance while minimizing the number of spare disks allocated, thereby reducing storage costs.

Keywords: failure tolerance, Venn-ABERS framework, dual-purpose disk

1. Problem Statement

To prevent the risk of losing data in a storage system, it is common to use a data protection scheme. However, the current schemes for data protection may not make the best use of the disks within the storage system, leading to inefficiencies. Currently, most of the storage vendors implement RAID Groups along with spare disks for a better read/write performance and fault tolerance. The roles of disks are strictly defined in the system, for example, *capacity* or *data disks* holds the user data and the *spare disks* remains unusable. The purpose of a spare drive is to be ready for replacement for the data disk in the event of its failure. Thus, they are not user addressable, and can't be used for writing data. Although its usage becomes critical in disk failure event; however, it still can not be used in the storage array.

2. Solution

The entirety of the proposed solution can be divided into two distinct sections. The first part detected the failing disks using Venn-ABERS method and the second part explains the proposed Variable Sparing Mechanism. The implementation of the Venn-ABERS framework in conjunction with a classification algorithm allows for the determination of the criticality of a failing disk based on the boundary values of its prediction (Singh et al., 2022). We used open source dataset (DrTycoon, 2023) collected from Seagate ST31000524NS enterprise-level HDDs, with a total of 12000 units and 13 SMART attributes features for experimental evaluation. We describe the two cases after the count of disks with failure probability is greater than the threshold.

Minimum Spare is sufficient: In this scenario, the AEL enables writing on disks based on load balancing, resulting in improved performance of the RAID Group due to the distribution of data nodes. Although the failure probability increases gradually, this process does not entail the additional overhead of frequently copying data across nodes.

Minimum Spare is NOT sufficient The second case arises when the RG has more disks expected to fail than the min spare. In this case, some DP disks need to be freed to be prepared for dealing with possible failure. For this, the data held by them should be copied to the other data disks. This phase called Copy Left Phase is instructed to the Load Balancer to carry out this operation by RAID Controller (after it gets the input from Analytics Engine). Once the data is copied, the AEL disables the user addressability of that DP disk and it becomes a spare disk. This phase is called Spare Augmentation.

3. Conclusion

We designed and evaluated a novel drive sparing mechanism that addresses the challenges faced by enterprise storage in achieving disk drive failure tolerance and optimal disk utilization. The study's main contributions are the introduction of the novel approach utilizing the Venn-ABERS framework, the dual-role of disks, and the implementation of the Variable Sparing Mechanism. The results demonstrate the effectiveness of the proposed mechanism, improving disk utilization efficiency and reducing the total cost of ownership. Future work includes the validation of the mechanism in different storage environments, analysis of its impact on system performance, integration with other data protection mechanisms, study of its scalability, and evaluation of its security implications.

References

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