An Exploratory Study on Data Layout Configurable Shingled Recoding Hard Disk Drives

Ning Zheng*, Minjie Lv†, and Tong Zhang*
*ECSE department, Rensselaer Polytechnic Institute, USA
†Institute of artificial intelligence and robotics, Xi'an Jiaotong University, China

***Abstract*—This paper presents a design strategy that makes one shingled magnetic recording (SMR) hard disk drive behave as a dynamic configurable data storage system consisting of low write throughput, high read throughput zones and high write throughput, low read throughput zones. The key is to leverage the multi-sensor read head and 2D read channel signal processing of SMR drives to config a zone either as read-favored or as write-favored during the runtime. Disksim simulations show that the proposed design strategy is promising for disk drives used in appropriate environments.**

***Index Terms*—2D signal processing, data layout, dynamic configurable, shingled magnetic recording.**

I. Introduction

SMR has emerged as the most promising near-term option to continue the scaling of magnetic recording areal density. Although SMR reduces the track pitch by well-controlled track overlap, it results in significant inter-track interference (ITI) that may severely degrade signal-to-noise ratio and hence data storage reliability. To address this challenge, we must deploy multi-sensor read head and 2D read channel signal processing [1], [2], which can capture read-back signals across adjacent tracks and explicitly cancel ITI. This in turn brings a unique read and write throughput trade-off. To favor write, physical block addresses (PBAs) should be continuous along track, and only data detected in the main track is used to serve IO requests; to favor read, data detected in all tracks serves IO requests, while PBAs are dispersed among these tracks.

II. Background

In SMR, tracks are partially overlapped with each other for improving the storage areal density. To effectively cancel the severe ITI, the industry is now actively investigating the fabrication of multi-sensor read head and design of 2D read channel signal processing. With multiple sensors integrated in one head, we have multiple read-back signal sequences at the same time and can also detect multiple tracks simultaneously with 2D signal processing. Comparatively, we have only one read-back sequence and one detected track in traditional drives with single-sensor read head. Therefore, besides improving the data detection reliability, multi-sensor read head brings hard drives potential higher-than-normal read throughput as well.

III. Proposed Design Strategy

Consider a read head integrating m sensors. Given m read-back sequences from m adjacent tracks, 2D read channel can jointly detect the data on all m tracks. To maximize the read performance, we should use all the read-back data to serve read requests. This *data-all-serve* mode, however, requires that PBAs are first continuous in cross-track direction and then grow in along-track direction. Moreover, it degrades the write throughput due to the new data layout. To maintain the write performance, we should only use read-back data in the main track to serve requests. This *data-partial-serve* mode holds the current write mechanism, but wastes the potential read capability of multi-sensor read head. We propose to use *zone* as the data layout configuration unit because zone is a natural partition unit in disk drives and also has fine-grained flexibility.

IV. Preliminary Evaluation Results

Disksim [3] simulations are carried out to evaluate the read response time reduction and write response time degradation when using data-all-serve mode, as shown in Fig. 1. It clearly shows the trade-off between read and write performance.

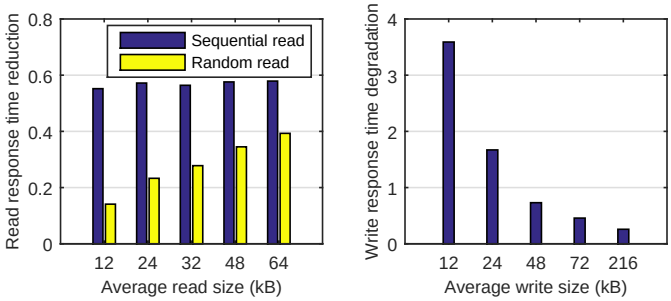

Fig. 1. Read response time reduction and write response time degradation under different average request sizes in data-all-serve mode.

V. Conclusion

The proposed data layout configurable design strategy provides a trade-off between read and write throughput. It has a promising potential to improve performance of disk drives used in certain environments.

References

[1] N. Zheng, K. S. Venkataraman, A. Kavcic, and T. Zhang, "A study on multi-track joint 2D signal detection performance and implementaion cost for shingled magnetic recording," *IEEE Transactions on Magnetics*, vol. 50, no. 6, Jun. 2014.

[2] Y. Wang, B. Yuan, and K. K. Parhi, "Improved BER performance with rotated head array and 2-D detector in two-dimensional magnetic recording," *IEEE Transactions on Magnetics*, vol. 52, no. 7, Jul. 2016.

[3] J. S. Bucy, J. Schindler, S. W. Schlosser, and G. R. Gauger, *The Disksim Simulation Environment Version 4.0 Reference Manual*, Parallel Data Laboratory, Carnegie Mellon University, Pittsburgh, PA, USA, tech. rep. cmu-pdl-08-101 edition, May 2008.