



## CS561 Spring 2023 - Research Project

**Title:** Quantifying *Write Amplification in LSM-based Key-Value Stores on SSDs*

### Background:

Log-structured merge tree (*i.e.*, LSM-tree)-based key-value stores are very popular because of their good write and read performance. NAND Flash-based Solid-state disks (*i.e.*, SSDs) have become a popular storage device alternative to hard disk drives (*i.e.*, HDDs) because of their high performance and low power consumption. LSM-tree KV stores with SSDs are deployed in many large-scale storage systems, aiming to achieve high cloud performance. However, the 'log-on-log' problem [1] can cause severe write amplification (WA) both in LSM-trees and NAND SSDs. The former, which is attributed to compaction operations in LSM-tree-based KV stores, is a burden on I/O bandwidth between the host and the device. The latter, which results from out-place updates in NAND Flash memory, blocks user I/O requests between the host and NAND Flash memory, thereby degrading the SSD performance. In this project, we first attempt to quantify the cascaded WA of LSM-trees running on SSD. Through this analysis, we will then attempt to derive new data placement policies for modern open-channel SSDs [2] or ZNS SSDs [3, 4] so that we can reduce WA, consequently improving the overall performance of LSM trees on SSDs.

### Objective:

- (a) Study the basics of LSM tree and SSD characteristics.
- (b) Empirically quantify the write amplification of LSM-trees running on SSD. We can either develop a simulation framework or quantify it directly on RocksDB.
- (c) Go over the principles of ZNS SSD or Open-Channel SSD. Explore how these new devices can be exploited to minimize the WA of LSM on SSD.

**Responsible Mentor:** *Tarikul Islam Papon (papon@bu.edu)*

### References:

- [1] Yang, J., Plasson, N., Gillis, G., Talagala, N., & Sundararaman, S. (2014). Don't stack your log on my log. In *2nd Workshop on Interactions of NVM/Flash with Operating Systems and Workloads (INFLOW 14)*.
- [2] Wang, P., Sun, G., Jiang, S., Ouyang, J., Lin, S., Zhang, C., & Cong, J. (2014, April). An efficient design and implementation of LSM-tree based key-value store on open-channel SSD. In *Proceedings of the Ninth European Conference on Computer Systems* (pp. 1-14).
- [3] Purandare, D., Wilcox, P., Litz, H., & Finkelstein, S. (2022, January). Append is near: Log-based data management on zns ssds. In *12th Annual Conference on Innovative Data Systems Research (CIDR'22)*.
- [4] Lee, H. R., Lee, C. G., Lee, S., & Kim, Y. (2022, June). Compaction-aware zone allocation for LSM based key-value store on ZNS SSDs. In *Proceedings of the 14th ACM Workshop on Hot Topics in Storage and File Systems* (pp. 93-99).