CS561 : Performance Comparison between LSM-Trees and B+-Trees

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ABSTRACT

In this paper, we explore the the design space of key-value stores that utilize the Log-Structured merge-tree (LSM-Tree) structure. More specifically, we have implemented a base version of the LSM-Tree that have been explored in previous work in order to get a better understanding of the basic knowledge of it. We decided to compare between performance of our design to another data structure (B+-tree), to see which data structure performs better based on different workloads and operations.

1 INTRODUCTION

1.1 Motivation

Log-Structured merge-tree (LSM-trees) are one of the most commonly used data structures for persistent storage of key-value entries. LSM-tree based storages are in use in several modern key-value stores including RocksDB at Facebook, LevelDB and BigTable at Google, bLSM and cLSM at Yahoo!, Cassandra and HBase at Apache.

In addition to LSM Trees, B+ trees is another common data structure for key-value entries. A B+-tree is an index data structure that stores data pointers only in leaf nodes, and only pivot pivot pointers in the internal nodes. Additiaonlly, the leaf nodes are also linked to provide ordered access to the records,

1.2 Problem Statement

When choosing which data structure to use for indexing and searching, we typically would choose between these 2 data structures as they are widely known and have superior performance compared to the rest. However, this brings us to the next question, how do we pick between these two. In our paper, we will experiment on both data structures with various workloads and compare their performance in 4 operations: insert, delete, point scan, range scan. We believe our implementation of the LSM tree will be faster than that of B+ Trees.

2 BACKGROUND

In this section, we will be presenting the background of LSM-trees, by discussing the basic structure of LSM-trees used in today's storage systems.

2.1 Basic Structure

Today's LSM-Tree implementation applies updates out-of-place to reduce Random I/Os. All incoming writes are appended into a memory buffer. An insert or update operation simply adds a new entry, while a delete operation adds a graveyard pointer indicating the entry has been deleted.

A query over an LSM-Tree has to search multiple components to find the latest version of each key. A point look up query, which fetches the value of a specific key, simply search all components one by one, from newest to oldest, and stops immediately after the first match is found. A range scan can search all components at the same time, feeding the search results into a query.

As components or data blocks accumulate over time, the query performance of an LSM-Tree tends to degrade since more components must be examined. These components are merged to reduce the total number of components. There are two types of merge policies, leveling and tiering. Both policies organize components or data blocks, into logical levels (or tiers) and controlled by a size ratio of T. Each component is labeled with its key range.

In Leveling, each level only maintains one component, but the component at level L is T time larger than the component at level L-1. As a result, the component at level L will be merged multiple times with incoming components at level L-1 until it feels up, and it will then be merged into level L+1.

In Tiering merge policy maintains up to T components per level. When level L is full, its T components are merged together into a new component at level L+1. If level L is already the configured maximum level, then the resulting component remains at level L. Two components at level L-1 are merged together to form a new component/data block at level L.
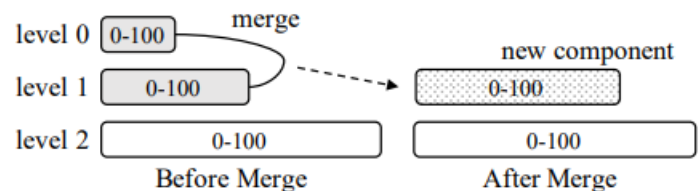
(a) Leveling Merge Policy: one component per level
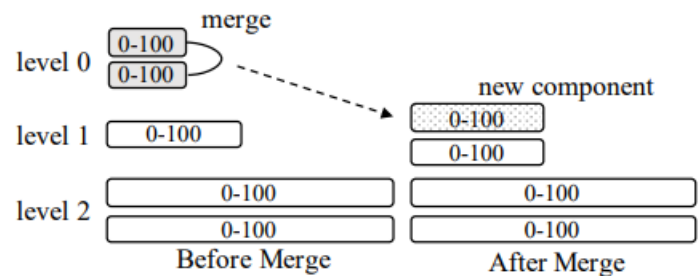
(b) Tiering Merge Policy: up to T components per level

3 ARCHITECTURE

In this section, we will analyze the main components of our LSM-Tree Architecture.

3.1 Bloom Filters

Bloom Filters are an essential component of the LSM-Tree. The concept of a bloom filter is suggested as the main mechanism to avoid double accesses. The main drawback is the possibility of giving a false positive result.

3.2 Fence Pointers

Fence Pointers are the limits of the virtual blocks of data. By implementing fence pointers, we are do not have to access every single data entry during scanning or point searching. By checking the min/max values in each fence pointer, this reduces the time it takes for searching as we ignore blocks of data that do not meet the requirements.

3.3 Testing

3.4 Benchmark Explanations

If you're doing some sort of quantitative analysis you may want your math to start being defined and analyzed here.
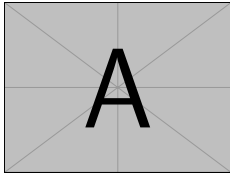
4 RESULTS

Graphs are basically a requirement here!

Figure 1: Example figure here

Table 1: An example table

	Col A	Col B
Row A	val 1	val a
Row B	val 2	val b
Row C	val 3	val c

You can also reference your old figures (Figure 1) and tables (Table 1)

5 CURRENT PROGRESS SO FAR

We have finished coding the basic features of the LSM-Tree: Fence Pointers, Leveling, Buffers, Bloom Filters and basic operations such as Insert. Our prototype works with a basic workload and is able to run smoothly.

6 FUTURE WORK TO BE DONE

We will finish up the remaining the operations: Delete, Range Scan and Point Scan.

We will start working on is testing the prototype with a bigger workload and various levels of unsorted-ness to measure the performance of our implementation.

We will use a provided implementation of a B+ tree, and run the same the tests that we have run on the LSM tree, to ensure fair testing between both data structures.

Setting up a Virtual Machine will be part of this process and we can run the experiments on it.

7 CONCLUSION

Final thoughts here.

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