Improving the Performance of Parallelized Bitmap Index Compression Through Data Striping

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Introduction
As technology continues to be fundamental to our society, the abundance of data has increased exponentially. Because computer hard drives are slow, the more data is stored, the longer it takes to access useful information. For this reason, it is imperative to use efficient data structures to provide fast data access, such as bitmap indices.

What is a bitmap index?
A bitmap index is a way of representing large data sets by expanding its columns, or attributes, into “bins” and representing the values of each row, or tuple, by a 0 or 1 depending on whether it falls into each bin.

<table>
<thead>
<tr>
<th>Tuple</th>
<th>Name</th>
<th>Sex</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tom</td>
<td>M</td>
<td>20</td>
</tr>
<tr>
<td>2</td>
<td>Alex</td>
<td>M</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>Rick</td>
<td>M</td>
<td>12</td>
</tr>
</tbody>
</table>

To combat this problem, we split the index into N columns, and dispatch a thread to compress each column separately. Our research investigates the data-access bottlenecks and explores ways to reorganize our data set to increase performance. We hypothesize that the contention for shared last-level cache and disk I/O among the threads led to slowdowns in execution. To this end, we reformatted the bitmap files into striped files, that is, instead of storing one column per file, each striped file contains multiple columns interleaved, thereby decreasing the latency of accessing files from different regions of disk.

Speedup
Speedup achieved on bitmap_stack.txt compared to unstriped compression without parallelization

Scalability
Speedup achieved on bitmap_stack.txt compared to sequential method without parallelization

Results
While the striped method did result in a larger speedup some of the time, changing the format of the files for compression did not achieve a consistent or significant speedup up when compared to the unstripped, unparallelized results.

However, striping the files consistently resulted in a larger speedup relative to its own unparallelized version. This result shows promise for the method if optimized.

Future Work
Though the overall speedup gained from striping the files was not what we hypothesized, the algorithm shows a greater ability for scalability (relative speedup to its own unparallelized version). Because of this, we believe it is possible to optimize this method of compression to demonstrate a consistent benefit to striping bitmap indices before compression.

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