Predicate Caching: Query-Driven Secondary Indexing for Cloud Data Warehouses

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13.06.2024

Motivation

Traditional indexes are not suited for the cloud:

- large data volumes
- high update costs
- slow lookup times

Cloud data warehouses rely on more lightweight caching techniques:

- result caching
- materialized views
- sorting

$\Rightarrow$ **Caches are query-driven and adapt to the workload.**

Workload Analysis

Query Repetitiveness

Caches require repetitive workloads to be effective.

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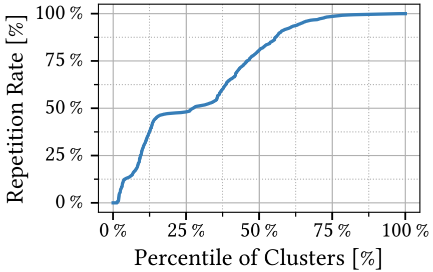


For more than half of the clusters, 75 % of the queries repeat.

Workload Analysis

Result Cache Hit Rate

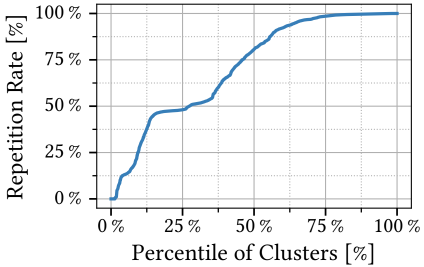


Figure: Query Repetitiveness

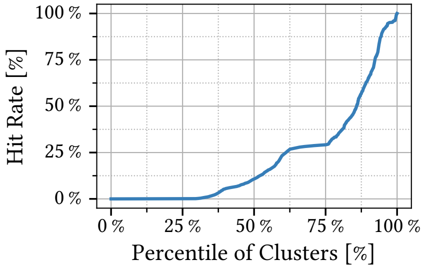


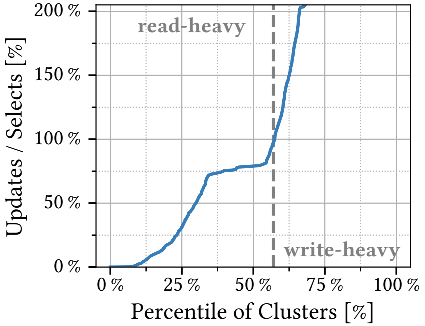
Figure: Result Cache Hit Rate

However, the result cache hit rate is relatively low.

Workload Analysis

Types of SQL Statements

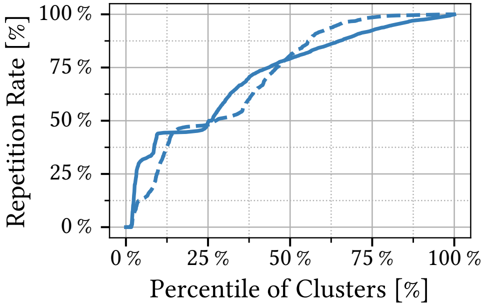
Type	Percentage
select	42.3 %
insert	17.8 %
copy	6.9 %
delete	6.3 %
update	3.6 %
other	23.3 %



60 % of the clusters execute more SELECT statements than updates.

Workload Analysis

Scan Repetitiveness



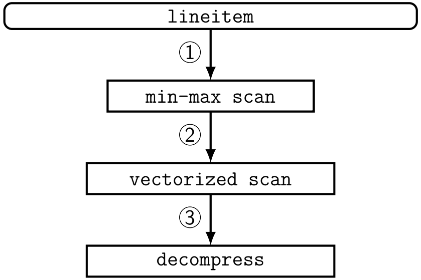
Scans and Queries are similarly repetitive.

Predicate Caching

High-Level Idea

Cache qualifying row ranges and inject them into subsequent scans.

```
select * from lineitem where l_discount = 0.1 and l_quantity >= 40
```



discount	quantity	
0.15	45	block 1
0.20	10	
0.10	30	
0.05	40	
0.10	40	block 2
0.05	20	
0.10	50	
0.15	40	
0.05	10	block 3
0.15	35	
0.00	20	
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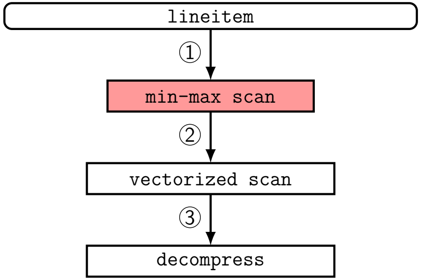

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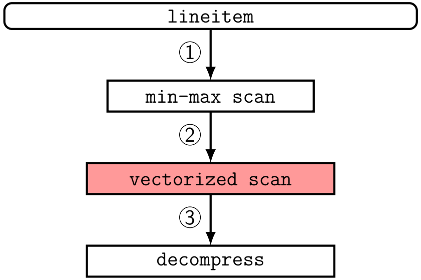

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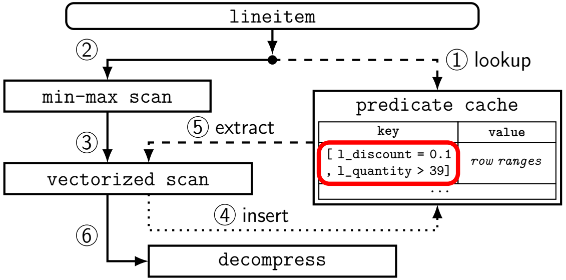

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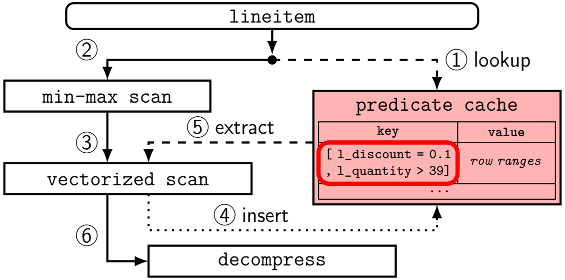

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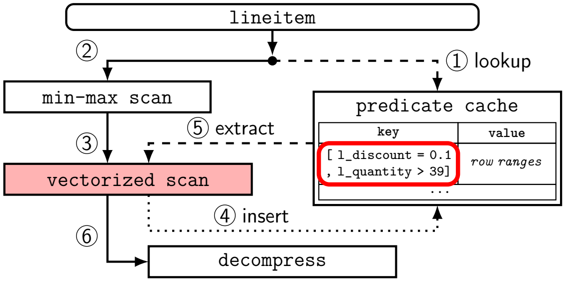

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Predicate Caching

Data Manipulation Operations

Inserts:	New tuples are appended to the end of the table; the new rows are scanned the next time.
Delete:	Rows are marked as deleted; the cached row ranges remain valid.
Update:	Combination of insert and delete.

Predicate Caching
Properties

On-the-Fly: The cache is populated as a by-product of query processing without additional build tasks.

Lightweight: Minimize resource usage, synchronization overhead, and impact on other operations

Online: Update, insert, or delete statements do not invalidate the caches' entries.

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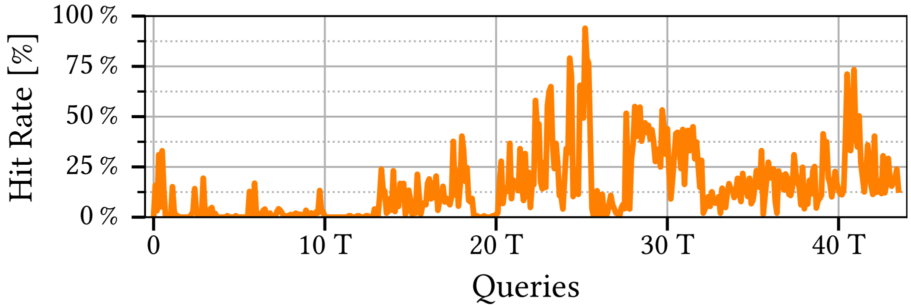
$\Rightarrow$ **Predicate Caching has almost no overhead and exploits repetitive queries in cloud data warehouses.**

Results

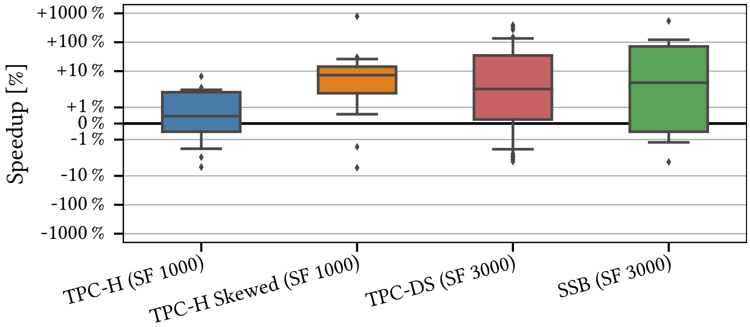
Hit Rate



⟹ **High hit rate on representative workloads.**

Results

Query Performance



Up to 10 % overall performance improvement and 10× speedup on selected queries.

Conclusion

Predicate Caching offers a lightweight, fast, and online query-driven index for Cloud Data Warehouses.

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Predicate Caching offers a lightweight, fast, and online query-driven index for Cloud Data Warehouses.

- no build overhead, and space efficient.
- online, does not affect inserts, deletes, and updates
- significant performance improvements, in particular, on skewed data or selective queries

Conclusion

Predicate Caching offers a lightweight, fast, and online query-driven index for Cloud Data Warehouses.

Check out the full paper for more details!

https://www.amazon.science/publications/predicate-caching-query-driven-secondary-indexing-for-cloud-data-warehouses