

8.2.1.17 GROUP BY Optimization

The most general way to satisfy a `GROUP BY` clause is to scan the whole table and create a new temporary table where all rows from each group are consecutive, and then use this temporary table to discover groups and apply aggregate functions (if any). In some cases, MySQL is able to do much better than that and avoid creation of temporary tables by using index access.

The most important preconditions for using indexes for `GROUP BY` are that all `GROUP BY` columns reference attributes from the same index, and that the index stores its keys in order (as is true, for example, for a `BTREE` index, but not for a `HASH` index). Whether use of temporary tables can be replaced by index access also depends on which parts of an index are used in a query, the conditions specified for these parts, and the selected aggregate functions.

There are two ways to execute a `GROUP BY` query through index access, as detailed in the following sections. The first method applies the grouping operation together with all range predicates (if any). The second method first performs a range scan, and then groups the resulting tuples.

- Loose Index Scan
- Tight Index Scan

Loose Index Scan can also be used in the absence of `GROUP BY` under some conditions. See Skip Scan Range Access Method.

Loose Index Scan

The most efficient way to process `GROUP BY` is when an index is used to directly retrieve the grouping columns. With this access method, MySQL uses the property of some index types that the keys are ordered (for example, `BTREE`). This property enables use of lookup groups in an index without having to consider all keys in the index that satisfy all `WHERE` conditions. This access method considers only a fraction of the keys in an index, so it is called a Loose Index Scan. When there is no `WHERE` clause, a Loose Index Scan reads as many keys as the number of groups, which may be a much smaller number than that of all keys. If the `WHERE` clause contains range predicates (see the discussion of the [range](#) join type in Section 8.8.1, “Optimizing Queries with EXPLAIN”), a Loose Index Scan looks up the first key of each group that satisfies the range conditions, and again reads the smallest possible number of keys. This is possible under the following conditions:

- The query is over a single table.
- The `GROUP BY` names only columns that form a leftmost prefix of the index and no other columns. (If, instead of `GROUP BY`, the query has a `DISTINCT` clause, all distinct attributes refer to columns that form a leftmost prefix of the index.) For example, if a table `t1` has an index on `(c1, c2, c3)`, Loose Index Scan is applicable if the query has `GROUP BY c1, c2`. It is not applicable if the query has `GROUP BY c2, c3` (the columns are not a leftmost prefix) or `GROUP BY c1, c2, c4` (`c4` is not in the index).
- The only aggregate functions used in the select list (if any) are [MIN\(\)](#) and [MAX\(\)](#), and all of them refer to the same column. The column must be in the index and must immediately follow the columns in the `GROUP BY`.
- Any other parts of the index than those from the `GROUP BY` referenced in the query must be constants (that is, they must be referenced in equalities with constants), except for the argument of [MIN\(\)](#) or [MAX\(\)](#) functions.
- For columns in the index, full column values must be indexed, not just a prefix. For example, with `c1 VARCHAR(20), INDEX (c1(10))`, the index uses only a prefix of `c1` values and cannot be used for Loose Index Scan.

If Loose Index Scan is applicable to a query, the [EXPLAIN](#) output shows `Using index for group-by` in the `Extra` column.

Assume that there is an index `idx(c1, c2, c3)` on table `t1(c1, c2, c3, c4)`. The Loose Index Scan access method can be used for the following queries:

```
SELECT c1, c2 FROM t1 GROUP BY c1, c2;
SELECT DISTINCT c1, c2 FROM t1;
SELECT c1, MIN(c2) FROM t1 GROUP BY c1;
SELECT c1, c2 FROM t1 WHERE c1 < const GROUP BY c1, c2;
SELECT MAX(c3), MIN(c3), c1, c2 FROM t1 WHERE c2 > const GROUP BY c1, c2;
SELECT c2 FROM t1 WHERE c1 < const GROUP BY c1, c2;
SELECT c1, c2 FROM t1 WHERE c3 = const GROUP BY c1, c2;
```

The following queries cannot be executed with this quick select method, for the reasons given:

- There are aggregate functions other than [MIN\(\)](#) or [MAX\(\)](#):

```
SELECT c1, SUM(c2) FROM t1 GROUP BY c1;
```

- The columns in the `GROUP BY` clause do not form a leftmost prefix of the index:

```
SELECT c1, c2 FROM t1 GROUP BY c2, c3;
```

- The query refers to a part of a key that comes after the `GROUP BY` part, and for which there is no equality with a constant:

```
SELECT c1, c3 FROM t1 GROUP BY c1, c2;
```

Were the query to include `WHERE c3 = const`, Loose Index Scan could be used.

The Loose Index Scan access method can be applied to other forms of aggregate function references in the select list, in addition to the `MIN()` and `MAX()` references already supported:

- `AVG(DISTINCT)`, `SUM(DISTINCT)`, and `COUNT(DISTINCT)` are supported. `AVG(DISTINCT)` and `SUM(DISTINCT)` take a single argument. `COUNT(DISTINCT)` can have more than one column argument.
- There must be no `GROUP BY` or `DISTINCT` clause in the query.
- The Loose Index Scan limitations described previously still apply.

Assume that there is an index `idx(c1,c2,c3)` on table `t1(c1,c2,c3,c4)`. The Loose Index Scan access method can be used for the following queries:

```
SELECT COUNT(DISTINCT c1), SUM(DISTINCT c1) FROM t1;

SELECT COUNT(DISTINCT c1, c2), COUNT(DISTINCT c2, c1) FROM t1;
```

Tight Index Scan

A Tight Index Scan may be either a full index scan or a range index scan, depending on the query conditions.

When the conditions for a Loose Index Scan are not met, it still may be possible to avoid creation of temporary tables for `GROUP BY` queries. If there are range conditions in the `WHERE` clause, this method reads only the keys that satisfy these conditions. Otherwise, it performs an index scan. Because this method reads all keys in each range defined by the `WHERE` clause, or scans the whole index if there are no range conditions, it is called a Tight Index Scan. With a Tight Index Scan, the grouping operation is performed only after all keys that satisfy the range conditions have been found.

For this method to work, it is sufficient that there be a constant equality condition for all columns in a query referring to parts of the key coming before or in between parts of the `GROUP BY` key. The constants from the equality conditions fill in any “gaps” in the search keys so that it is possible to form complete prefixes of the index. These index prefixes then can be used for index lookups. If the `GROUP BY` result requires sorting, and it is possible to form search keys that are prefixes of the index, MySQL also avoids extra sorting operations because searching with prefixes in an ordered index already retrieves all the keys in order.

Assume that there is an index `idx(c1,c2,c3)` on table `t1(c1,c2,c3,c4)`. The following queries do not work with the Loose Index Scan access method described previously, but still work with the Tight Index Scan access method.

- There is a gap in the `GROUP BY`, but it is covered by the condition `c2 = 'a'`:

```
SELECT c1, c2, c3 FROM t1 WHERE c2 = 'a' GROUP BY c1, c3;
```

- The `GROUP BY` does not begin with the first part of the key, but there is a condition that provides a constant for that part:

```
SELECT c1, c2, c3 FROM t1 WHERE c1 = 'a' GROUP BY c2, c3;
```