Efficient Queries 101

Estimating Time Complexity of Your Query Plan

- The execution plan defines, among other things, what algorithm is used for each operation, which makes that every query execution time can be logically expressed as a function of the table size involved in the query plan, which is referred to as a complexity function.
- There are four main types of time complexity:
  - Constant.
  - Linear.
  - Logarithmic.
  - Quadratic.

O(1): Constant Time

- An algorithm is said to run in constant time if it requires the same amount of time regardless of the input size. When you're talking about a query, it will run in constant time if it requires the same amount of time irrespective of the table size.
- These type of queries are not really common, yet here's one such an example:

```
SELECT TOP 1 t.*
FROM t
```

- The time complexity is constant because you select one arbitrary row from the table. Therefore, the length of the time should be independent of the size of the table.

Linear Time: O(n)

- An algorithm is said to run in linear time if its time execution is directly proportional to the input size, i.e. time grows linearly as input size increases.
- For databases, this means that the time execution would be directly proportional to the table size: as the number of rows in the table grows, the time for the query grows.
- **Example:** a query with a WHERE clause on a un-indexed column:
    - A **full table scan** is needed.
    - This means that every row needs to be read to find the one with the right ID.
    - You don’t have a limit at all, so every row does need to be read, even if the first row matches the condition.

Linear Time: O(n) (cont.)

Consider also the following example of a query that would have a complexity of O(n) if there's no index on `i_id`:

```
SELECT i_id
FROM item;
```

- Other queries, such as count queries like `COUNT(*) FROM TABLE`; will have a time complexity of O(n), because a full table scan will be required unless the total row count is stored for the table.
- If that is the case, the complexity would be more like O(1).

Linear Time: JOIN

- A hash join has an expected complexity O(M + N). The classic hash join algorithm for an inner join of two tables first prepares a hash table of the smaller table. The hash table entries consist of the join attribute and its row. The hash table is accessed by applying a hash function to the join attribute. Once the hash table is built, the larger table is scanned and the relevant rows from the smaller table are found by looking in the hash table.

Linear Time: JOIN (cont.)

- Merge joins generally have a complexity of O(M+N) but it will heavily depend on the indexes on the join columns and, in cases where there is no index, on whether the rows are sorted according to the keys used in the join:
    - If both tables that are sorted according to the keys that are being used in the join, or if both tables have an index on the joined columns, then the complexity will be O(M + N).
    - If neither table has an index on the joined columns, a sort of both tables will need to happen first so that the complexity will look more like O(M log M + N log N).
    - For nested joins, the complexity is generally O(MN). This join is efficient when one or both of the tables are extremely small (for example, smaller than 10 records).

Logarithmic Time: O(log (n))

- An algorithm is said to run in logarithmic time if its time execution is proportional to the logarithm of the input size.
- For queries, this means that they will run if the execution time is proportional to the logarithm of the database size.
- **Example:** Suppose there is an index on `i_i`d. The following query has a complexity of O(log(n)):

```
SELECT i_stock
FROM item
WHERE i_id = N;
```

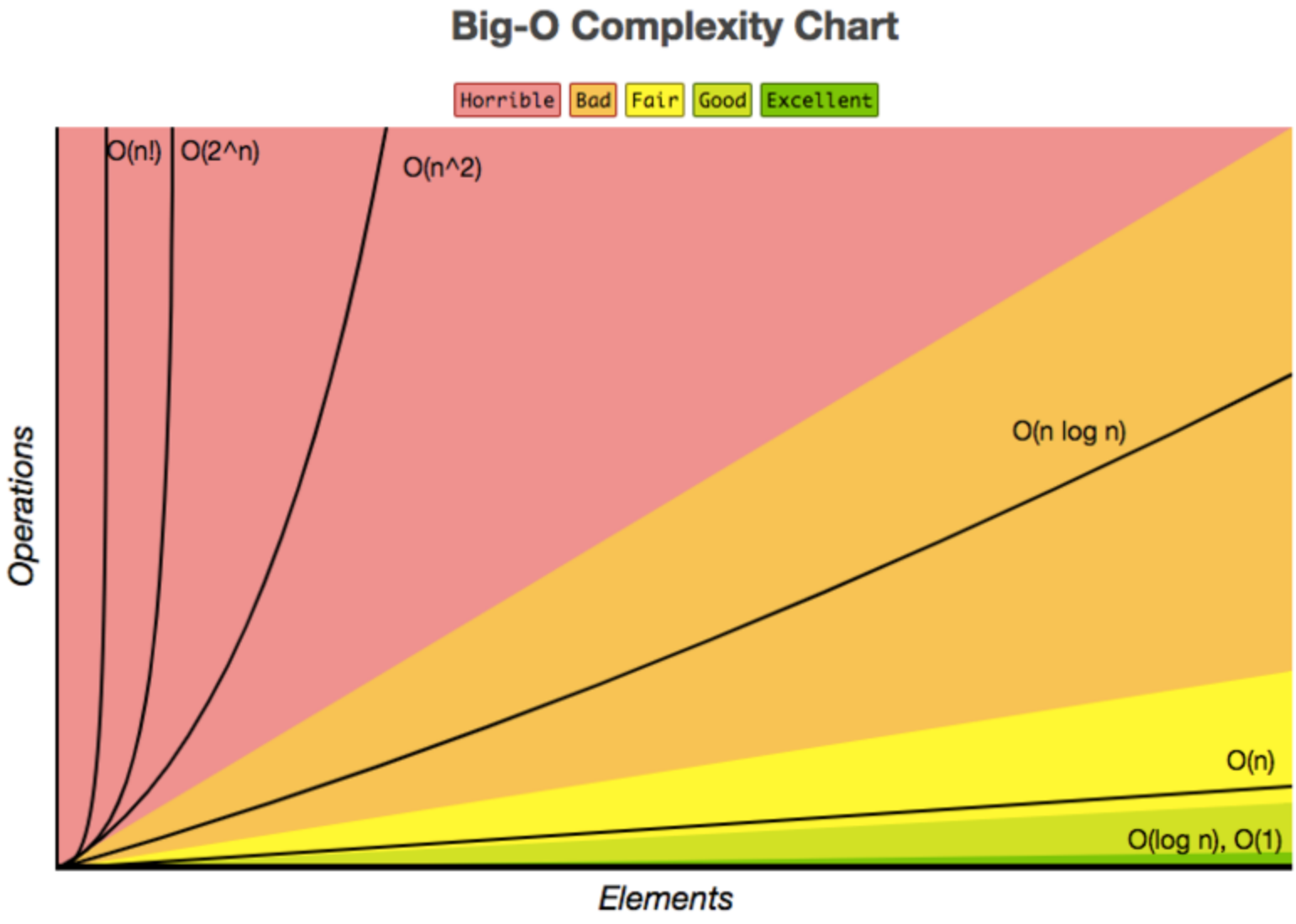
- Note that without the index, the time complexity would have been O(n).

Quadratic Time: O(n^2)

- An algorithm is said to run in quadratic time if its time execution is proportional to the square of the input size.
- Once again, for databases, this means that the execution time for a query is proportional to the square of the database size.
- **Example**:

```
SELECT *
FROM item, author
WHERE item.i_a_id=author.a_id
```

- This query has O(n^2) complexity as a worst-case scenario, depending on the index structure.



- First things to look after:
  - `JOIN ... ON` and index structure of the involved tables.
  - `WHERE` clauses.

General rules

- **Know your data:** Understand the relationships between tables, know your data, and *fetch only the required columns.*
- **`JOINs:`** Be reasonable with CROSS JOIN or LEFT joins. Bad joins with skew values result in high CPU and IO queries.
- **Data types:** Ensure appropriate data types for columns on the table(s). For example, don't define a `VARCHAR` data type for a `Salary` column.
- **Pre-aggregate data:** To avoid carrying a large number of rows, do aggregations and then join. Extra points if you do those in a volatile table.
- **Prioritize optimization:** A moderately slow query repeated often is a better candidate for tuning than a query running once a year that takes several hours.