Advanced Data Management Technologies

Unit 9 — SQL Query Specification and Processing

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Outline

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Query Specifications

- **Query specifiations** are the building block for most SQL statements.
- They determine much of the expressive power of SQL.

$$\left.\begin{array}{l}\texttt{<select clause>}\\ \left.\begin{array}{l}\texttt{<from clause>}\\ \texttt{<where clause>}\\ \texttt{<group-by clause>}\\ \texttt{<having clause>}\end{array}\right\}\text{table expression}\end{array}\right\}\text{query specification}$$

Table Expressions

- A **table expression** is defined as follows:

  ```
  from clause
  [where clause]
  [group-by clause]
  [having clause]
  ```

- The `FROM` clause is always required; the others are optional.
- The clauses are operators that take input and produce output.
- The output of each clause is a virtual table, i.e., a table that is not stored.

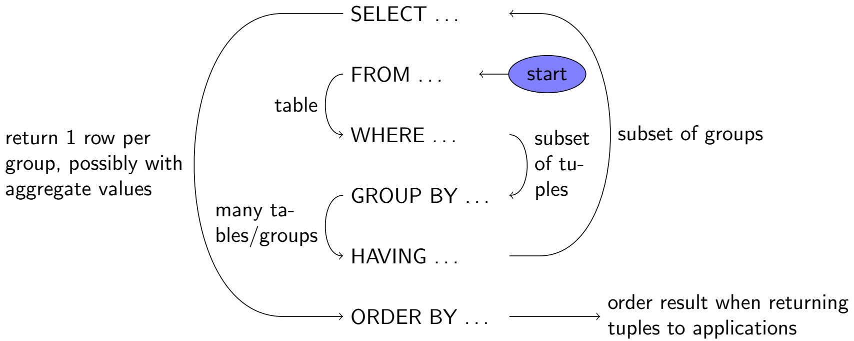
Query Expressions

- Query specifications can be combined with set operations to form **query expressions**.
- The set operations from the Relational Algebra (RA) are almost directly available in SQL
  - `UNION` ($\cup$)
  - `EXCEPT` ($\setminus$)
  - `INTERSECT` ($\cap$)

$$\left.\begin{array}{l}\left.\begin{array}{l}\texttt{SELECT X}\\\texttt{FROM r}\end{array}\right\}\text{query specification}\\\texttt{UNION}\\\left.\begin{array}{l}\texttt{SELECT Y}\\\texttt{FROM s}\end{array}\right\}\text{query specification}\end{array}\right\}\text{query expression}$$

Processing of SQL Statement

- Logical order of processing an SQL statement



The From Clause/1

-
  ```
  FROM <table reference_1>,
       ...,
       <table reference_n>
  ```
- Computes the Cartesian product of all input tables.
- A table reference is either a table name or a query expression that defines a derived table.

```
FROM   r                FROM   (
WHERE  ...                     SELECT ...
                               WHERE ...
                               FROM ...
                               WHERE ...
                               ) AS r
                        WHERE  ...
```

The From Clause/2

- SQL-92 supports many joins
  - `FROM t1 CROSS JOIN t2`
    - Cartesian product
  - `FROM t1 NATURAL JOIN t2`
    - Natural join (all identical columns)
  - `FROM t1 JOIN t2 ON <join condition>`
    - Theta join
  - `FROM t1 JOIN t2 USING (<columns>)`
    - Restricted natural join
  - `FROM t1 LEFT OUTER JOIN t2 ON <join cond>`
    - Left outer join (similar for `RIGHT` and `FULL` outer join)

The WHERE Clause

- `WHERE <condition>`
- The `WHERE` clause takes the virtual table produced by the `FROM` clause and filters out those rows that do not meet the condition.
- The `WHERE` clause is used to specify join and selection conditions.
- Before SQL allowed query expressions in the `FROM` clause, most of its expressive power came from subqueries in the `WHERE` clause.

The GROUP BY Clause

-
  ```
  GROUP BY <grouping_column_1>,
           ...
           <grouping_column_n>
  ```
- The result of the `GROUP BY` clause is a grouped table.
- Every row in a group has the same value for the grouping columns.
- Apart from grouping, input and output table are identical.

GROUP BY Example

movie_titles

Title	Type	Price
Lethal Weapon	Action	3
Unforgiven	Western	4
Once upon a time	Western	3
Star Wars	Fiction	3
Rocky	Action	2

$\downarrow$

```
FROM     movie_titles
GROUP BY Type
```

Title	Type	Price
Lethal Weapon	Action	3
Rocky	Action	2
Unforgiven	Western	4
Once upon a time	Western	3
Star Wars	Fiction	3

HAVING Clause

- `HAVING <condition>`
- The `HAVING` clause takes a grouped table as input and returns a grouped table.
- The condition is applied to each group.
  - Only groups that fulfill the condition are returned.
- The condition can either reference
  - grouping columns (because they are constant within agroup) or
  - aggregated columns (because an aggregate yields one value per group).

HAVING Clause Example/1

movie_titles

Title	Type	Price
Lethal Weapon	Action	3
Rocky	Action	2
Unforgiven	Western	4
Once upon a time	Western	3
Star Wars	Fiction	3

```
FROM     movie_titles
GROUP BY Type
HAVING   max(Price) <= 3
```

Title	Type	Price
Lethal Weapon	Action	3
Rocky	Action	2
Star Wars	Fiction	3

HAVING Clause Example/2

movie_titles

Title	Type	Price
Lethal Weapon	Action	3
Rocky	Action	2
Unforgiven	Western	4
Once upon a time	Western	3
Star Wars	Fiction	3

```
FROM     movie_titles
GROUP BY Type
HAVING   Price <= 3
```

↓

Illegal SQL

SELECT Clause/1

- `SELECT [<quantifier>] e_1, ..., e_n`
- The `SELECT` clause resembles a generalized projection.
- Each item in the `SELECT` clause is an expression.
- The `SELECT` clause can contain aggregates.
- If an item in a `SELECT` clause is an aggregate, then all items have to be aggregates, except the `GROUP BY` attributes.
- The quantifier enforces duplicate elimination (`DISTINCT`) or duplicate preservation (`ALL`).
  - The default is `ALL`.

SELECT Clause/2

- `SELECT *` expands to all columns of all tables in the from clause (i.e., no projection in RA).
- `r.*` expands to all columns of table `r`.
- `SELECT *` and `r.*` should be avoided because they cause a statement to change along with schema modifications.
- Columns can be (re)named in the `SELECT` clause.
  - `SELECT r.A B, r.B+r.C*2 X`
  - `SELECT r.A AS B, r.B+r.C*2 AS X`

Summary and Outlook

- The SQL fragment is fairly powerful.
- Over many years it developed into the "intergalactic data speak" [Stonebraker].
- At some point it was observed that SQL is not good for analytical queries:
  - too difficult to formulate;
  - too slow to execute.
- OLAP was born.
- A huge amount of activities during the last 1-2 decades.
- SQL provides several extensions for OLAP:
  - GROUP BY extension;
  - SQL for analysis and reporting.