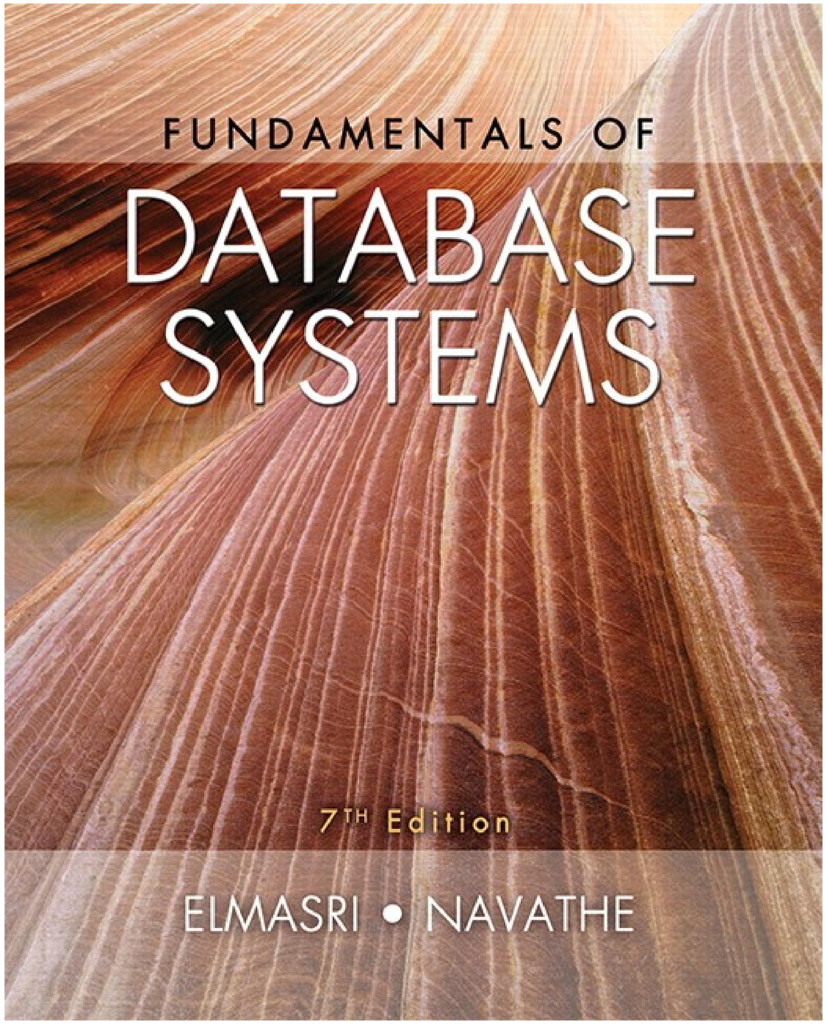
FUNDAMENTALS OF
DATABASE SYSTEMS
7TH Edition
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CHAPTER 7

More SQL: Complex Queries, Triggers, Views, and Schema Modification

More Complex SQL Retrieval Queries

- Additional features allow users to specify more complex retrievals from database:
  - Nested queries, joined tables, and outer joins (in the FROM clause), aggregate functions, and grouping

Comparisons Involving NULL and Three-Valued Logic

- Meanings of `NULL`
  - **Unknown value**
  - **Unavailable or withheld value**
  - **Not applicable attribute**
- Each individual `NULL` value considered to be different from every other `NULL` value
- SQL uses a three-valued logic:
  - `TRUE`, `FALSE`, and `UNKNOWN` (like Maybe)
- **NULL = NULL comparison is avoided**

Comparisons Involving NULL and Three-Valued Logic (cont'd.)

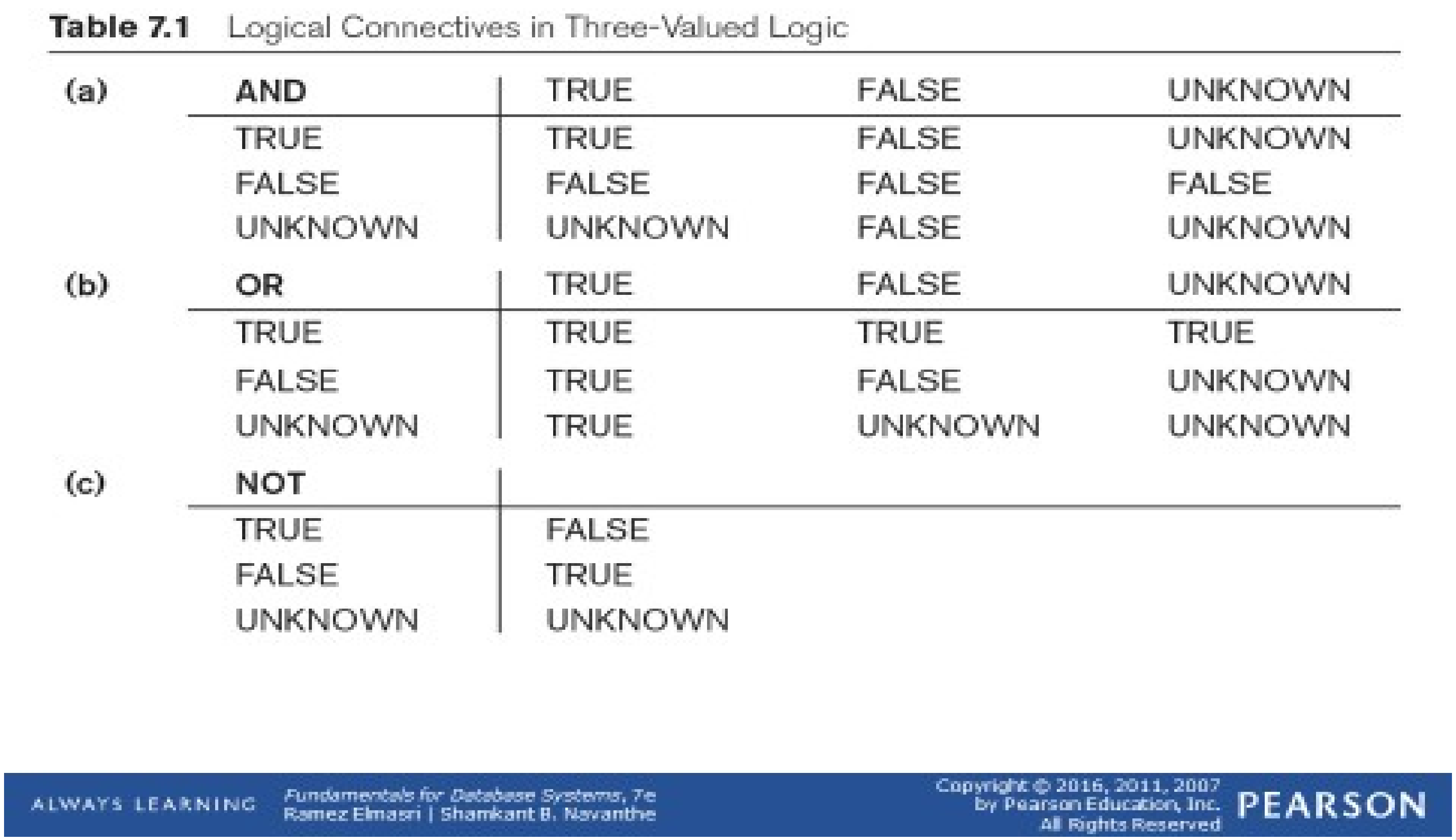


Table 7.1 Logical Connectives in Three-Valued Logic

(a)

AND	TRUE	FALSE	UNKNOWN
TRUE	TRUE	FALSE	UNKNOWN
FALSE	FALSE	FALSE	FALSE
UNKNOWN	UNKNOWN	FALSE	UNKNOWN

(b)

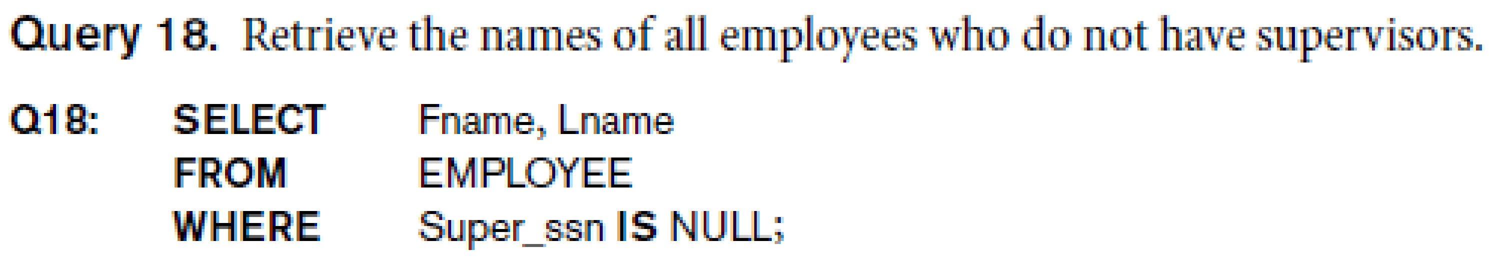
OR	TRUE	FALSE	UNKNOWN
TRUE	TRUE	TRUE	TRUE
FALSE	TRUE	FALSE	UNKNOWN
UNKNOWN	TRUE	UNKNOWN	UNKNOWN

(c)

NOT	
TRUE	FALSE
FALSE	TRUE
UNKNOWN	UNKNOWN

Comparisons Involving NULL and Three-Valued Logic (cont'd.)

- SQL allows queries that check whether an attribute value is `NULL`
  - `IS` or `IS NOT NULL`



Query 18. Retrieve the names of all employees who do not have supervisors.

```
Q18:    SELECT    Fname, Lname
        FROM      EMPLOYEE
        WHERE     Super_ssn IS NULL;
```

Nested Queries, Tuples, and Set/Multiset Comparisons

- **Nested queries**
  - Complete select-from-where blocks within WHERE clause of another query
  - **Outer query and nested subqueries**
- Comparison operator `IN`
  - Compares value *v* with a set (or multiset) of values *V*
  - Evaluates to `TRUE` if *v* is one of the elements in *V*

Nested Queries (cont’d.)

```
Q4A:    SELECT      DISTINCT Pnumber
        FROM        PROJECT
        WHERE       Pnumber IN
                    ( SELECT      Pnumber
                      FROM        PROJECT, DEPARTMENT, EMPLOYEE
                      WHERE       Dnum=Dnumber AND
                                  Mgr_ssn=Ssn AND Lname=‘Smith’ )
                    OR
                    Pnumber IN
                    ( SELECT      Pno
                      FROM        WORKS_ON, EMPLOYEE
                      WHERE       Essn=Ssn AND Lname=‘Smith’ );
```

Nested Queries (cont'd.)

- Use tuples of values in comparisons
  - Place them within parentheses

```
SELECT      DISTINCT Essn
FROM        WORKS_ON
WHERE       (Pno, Hours) IN ( SELECT      Pno, Hours
                              FROM        WORKS_ON
                              WHERE       Essn='123456789' );
```

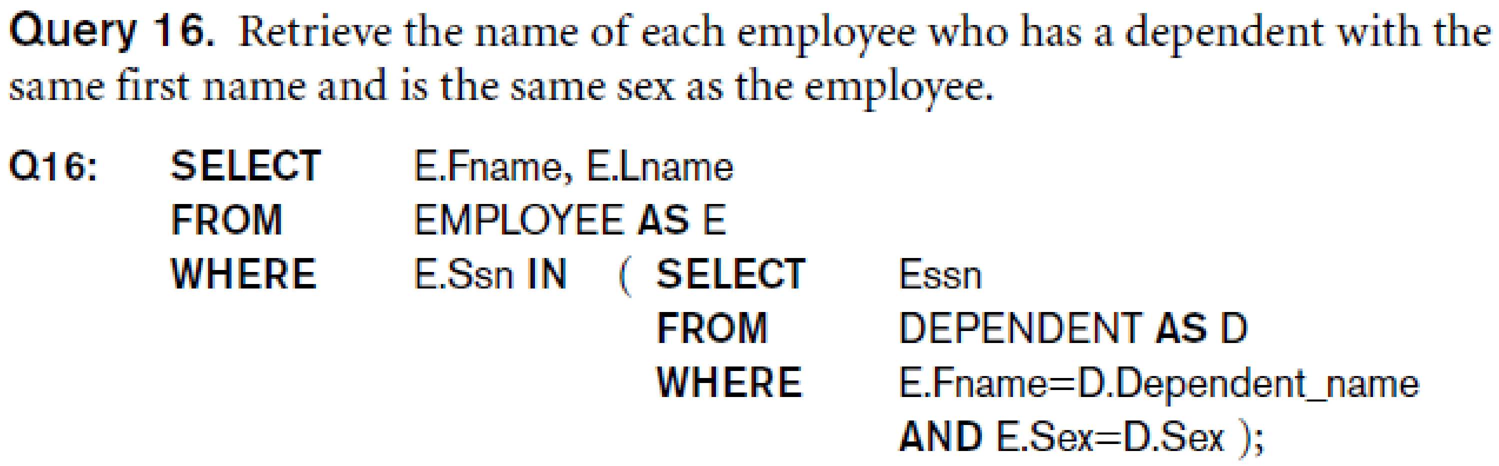
Nested Queries (cont'd.)

- Use other comparison operators to compare a single value *v*
  - `= ANY` (or `= SOME`) operator
    - Returns `TRUE` if the value *v* is equal to some value in the set *V* and is hence equivalent to `IN`
  - Other operators that can be combined with `ANY` (or `SOME`): `>`, `>=`, `<`, `<=`, and `<>`
  - `ALL:` value must exceed all values from nested query

```
SELECT    Lname, Fname
FROM      EMPLOYEE
WHERE     Salary > ALL    ( SELECT    Salary
                            FROM      EMPLOYEE
                            WHERE     Dno=5 );
```

Nested Queries (cont'd.)

- Avoid potential errors and ambiguities
  - Create tuple variables (aliases) for all tables referenced in SQL query



Query 16. Retrieve the name of each employee who has a dependent with the same first name and is the same sex as the employee.

```
Q16:   SELECT    E.Fname, E.Lname
       FROM      EMPLOYEE AS E
       WHERE     E.Ssn IN   ( SELECT    Essn
                              FROM      DEPENDENT AS D
                              WHERE     E.Fname=D.Dependent_name
                                        AND E.Sex=D.Sex );
```

Correlated Nested Queries

- **Queries that are nested using the = or IN comparison operator** can be collapsed into one single block: E.g., Q16 can be written as:

- **Q16A:** **SELECT** E.Fname, E.Lname
  FROM EMPLOYEE **AS** E, DEPENDENT **AS** D
  WHERE E.Ssn=D.Essn **AND** E.Sex=D.Sex **AND** E.Fname=D.Dependent_name;

- **Correlated** nested query
  - Evaluated once for each tuple in the outer query

The EXISTS and UNIQUE Functions in SQL for correlating queries

- `EXISTS` function
  - Check whether the result of a correlated nested query is empty or not. They are Boolean functions that return a TRUE or FALSE result.
- `EXISTS` and `NOT EXISTS`
  - Typically used in conjunction with a correlated nested query
- SQL function `UNIQUE(Q)`
  - Returns `TRUE` if there are no duplicate tuples in the result of query Q

USE of EXISTS

Q7:

```
SELECT Fname, Lname
FROM Employee
WHERE EXISTS (SELECT *
                    FROM DEPENDENT
                    WHERE Ssn= Essn)

           AND EXISTS (SELECT   *
                          FROM Department
                          WHERE Ssn= Mgr_Ssn)
```

USE OF NOT EXISTS

To achieve the “for all” (universal quantifier- see Ch.8) effect, we use double negation this way in SQL:

Query: List first and last name of employees who work on <u>ALL projects controlled by Dno=5.</u>

```
SELECT Fname, Lname
FROM Employee
WHERE NOT EXISTS ( (SELECT  Pnumber
                    FROM PROJECT
                   WHERE Dno=5)

            EXCEPT (SELECT   Pno
                    FROM WORKS_ON
                    WHERE Ssn= ESsn)
```

The above is equivalent to double negation: List names of those employees for whom there does NOT exist a project managed by department no. 5 that they do NOT work on.

Double Negation to accomplish "for all" in SQL

- **Q3B:**

```
SELECT  Lname, Fname
FROM            EMPLOYEE
WHERE           NOT EXISTS (       SELECT  *
FROM            WORKS_ON B
WHERE           ( B.Pno IN  (  SELECT Pnumber
       FROM PROJECT
       WHERE Dnum=5        AND
                                 NOT EXISTS (SELECT  *
      FROM  WORKS_ON C
      WHERE  C.Essn=Ssn
      AND             C.Pno=B.Pno )));
```

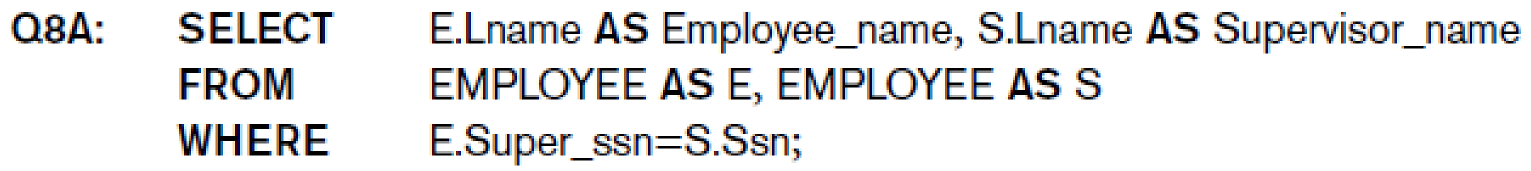
The above is a direct rendering of: List names of those employees for whom there does NOT exist a project managed by department no. 5 that they do NOT work on.

Explicit Sets and Renaming of Attributes in SQL

- Can use explicit set of values in WHERE clause

```
Q17:        SELECT      DISTINCT Essn
     FROM        WORKS_ON
     WHERE       Pno IN (1, 2, 3);
```

- Use qualifier AS followed by desired new name
  - Rename any attribute that appears in the result of a query



```
Q8A:   SELECT    E.Lname AS Employee_name, S.Lname AS Supervisor_name
       FROM      EMPLOYEE AS E, EMPLOYEE AS S
       WHERE     E.Super_ssn=S.Ssn;
```

Specifying Joined Tables in the FROM Clause of SQL

- **Joined table**
  - Permits users to specify a table resulting from a join operation in the FROM clause of a query
- The FROM clause in Q1A
  - Contains a single joined table. JOIN may also be called INNER JOIN

```
Q1A:    SELECT    Fname, Lname, Address
        FROM      (EMPLOYEE JOIN DEPARTMENT ON Dno=Dnumber)
        WHERE     Dname='Research';
```

Different Types of JOINed Tables in SQL

- Specify different types of join
  - NATURAL JOIN
  - Various types of OUTER JOIN (LEFT, RIGHT, FULL)
- NATURAL JOIN on two relations R and S
  - No join condition specified
  - Is equivalent to an implicit EQUIJOIN condition for each pair of attributes with same name from R and S

NATURAL JOIN

- Rename attributes of one relation so it can be joined with another using NATURAL JOIN:

```
Q1B:      SELECT      Fname, Lname, Address
     FROM      (EMPLOYEE NATURAL JOIN
               (DEPARTMENT AS DEPT (Dname, Dno, Mssn,
                          Msdate)))
     WHERE     Dname='Research';
```

The above works with EMPLOYEE.Dno = DEPT.Dno as an implicit join condition

INNER and OUTER Joins

- INNER JOIN **(versus** OUTER JOIN**)**
  - Default type of join in a joined table
  - Tuple is included in the result only if a matching tuple exists in the other relation
- LEFT OUTER JOIN
  - Every tuple in left table must appear in result
  - If no matching tuple
    - Padded with NULL values for attributes of right table
- RIGHT OUTER JOIN
  - Every tuple in right table must appear in result
  - If no matching tuple
    - Padded with NULL values for attributes of left table

Example: LEFT OUTER JOIN

```
SELECT E.Lname AS Employee_Name
              S.Lname AS Supervisor_Name

FROM Employee AS E LEFT OUTER JOIN EMPLOYEE AS S
                          ON E.Super_ssn = S.Ssn)
```

ALTERNATE SYNTAX:

```
SELECT E.Lname , S.Lname
FROM  EMPLOYEE E, EMPLOYEE S
WHERE E.Super_ssn + = S.Ssn
```

Multiway JOIN in the FROM clause

- FULL OUTER JOIN – combines result if LEFT and RIGHT OUTER JOIN
- Can nest JOIN specifications for a multiway join:

```
Q2A:        SELECT Pnumber, Dnum, Lname, Address, Bdate
     FROM   ((PROJECT JOIN DEPARTMENT ON
                  Dnum=Dnumber)  JOIN EMPLOYEE ON
                  Mgr_ssn=Ssn)
     WHERE  Plocation='Stafford';
```

Aggregate Functions in SQL

- Used to summarize information from multiple tuples into a single-tuple summary
- Built-in aggregate functions
  - **`COUNT`**, **`SUM`**, **`MAX`**, **`MIN`**, and **`AVG`**
- **Grouping**
  - Create subgroups of tuples before summarizing
- To select entire groups, `HAVING` clause is used
- Aggregate functions can be used in the `SELECT` clause or in a `HAVING` clause

Renaming Results of Aggregation

- Following query returns a single row of computed values from EMPLOYEE table:

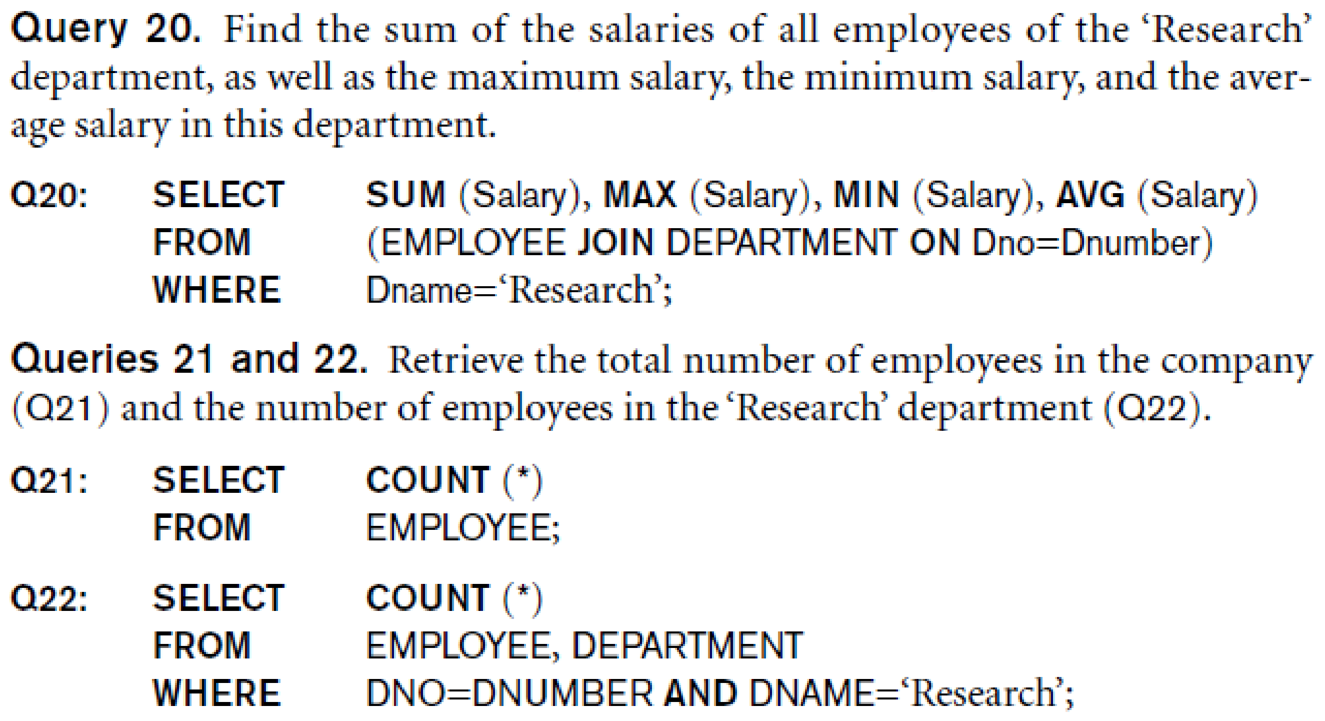
Q19: **SELECT** **SUM** (Salary), **MAX** (Salary), **MIN** (Salary), **AVG** (Salary)
FROM EMPLOYEE;

- The result can be presented with new names:

Q19A: **SELECT** **SUM** (Salary) **AS** Total_Sal, **MAX** (Salary) **AS** Highest_Sal, **MIN** (Salary) **AS** Lowest_Sal, **AVG** (Salary) **AS** Average_Sal
FROM EMPLOYEE;

Aggregate Functions in SQL (cont'd.)

- NULL values are discarded when aggregate functions are applied to a particular column



Query 20. Find the sum of the salaries of all employees of the 'Research' department, as well as the maximum salary, the minimum salary, and the average salary in this department.

```
Q20:    SELECT    SUM (Salary), MAX (Salary), MIN (Salary), AVG (Salary)
        FROM      (EMPLOYEE JOIN DEPARTMENT ON Dno=Dnumber)
        WHERE     Dname='Research';
```

Queries 21 and 22. Retrieve the total number of employees in the company (Q21) and the number of employees in the 'Research' department (Q22).

```
Q21:    SELECT    COUNT (*)
        FROM      EMPLOYEE;

Q22:    SELECT    COUNT (*)
        FROM      EMPLOYEE, DEPARTMENT
        WHERE     DNO=DNUMBER AND DNAME='Research';
```

Aggregate Functions on Booleans

- SOME and ALL may be applied as functions on Boolean Values.
- SOME returns true if at least one element in the collection is TRUE (similar to OR)
- ALL returns true if all of the elements in the collection are TRUE (similar to AND)

Grouping: The GROUP BY Clause

- **Partition** relation into subsets of tuples
  - Based on **grouping attribute(s)**
  - Apply function to each such group independently
- **`GROUP BY`** clause
  - Specifies grouping attributes
- COUNT (*) counts the number of rows in the group

Examples of GROUP BY

- The grouping attribute must appear in the SELECT clause:

```
Q24:        SELECT      Dno, COUNT (*), AVG (Salary)
FROM        EMPLOYEE
GROUP BY    Dno;
```

- If the grouping attribute has NULL as a possible value, then a separate group is created for the null value (e.g., null Dno in the above query)
- GROUP BY may be applied to the result of a JOIN:

```
Q25:        SELECT Pnumber, Pname, COUNT (*)
FROM        PROJECT, WORKS_ON
WHERE       Pnumber=Pno
GROUP BY    Pnumber, Pname;
```

Grouping: The GROUP BY and HAVING Clauses (cont'd.)

- `HAVING` clause
  - Provides a condition to select or reject an entire group:
- **Query 26.** For each project *on which more than two employees work*, retrieve the project number, the project name, and the number of employees who work on the project.

```
Q26:            SELECT      Pnumber, Pname, COUNT (*)
     FROM       PROJECT, WORKS_ON
     WHERE      Pnumber=Pno
     GROUP BY   Pnumber, Pname
     HAVING     COUNT (*) > 2;
```

Combining the WHERE and the HAVING Clause

- Consider the query: we want to count the *total* number of employees whose salaries exceed $40,000 in each department, but only for departments where more than five employees work.

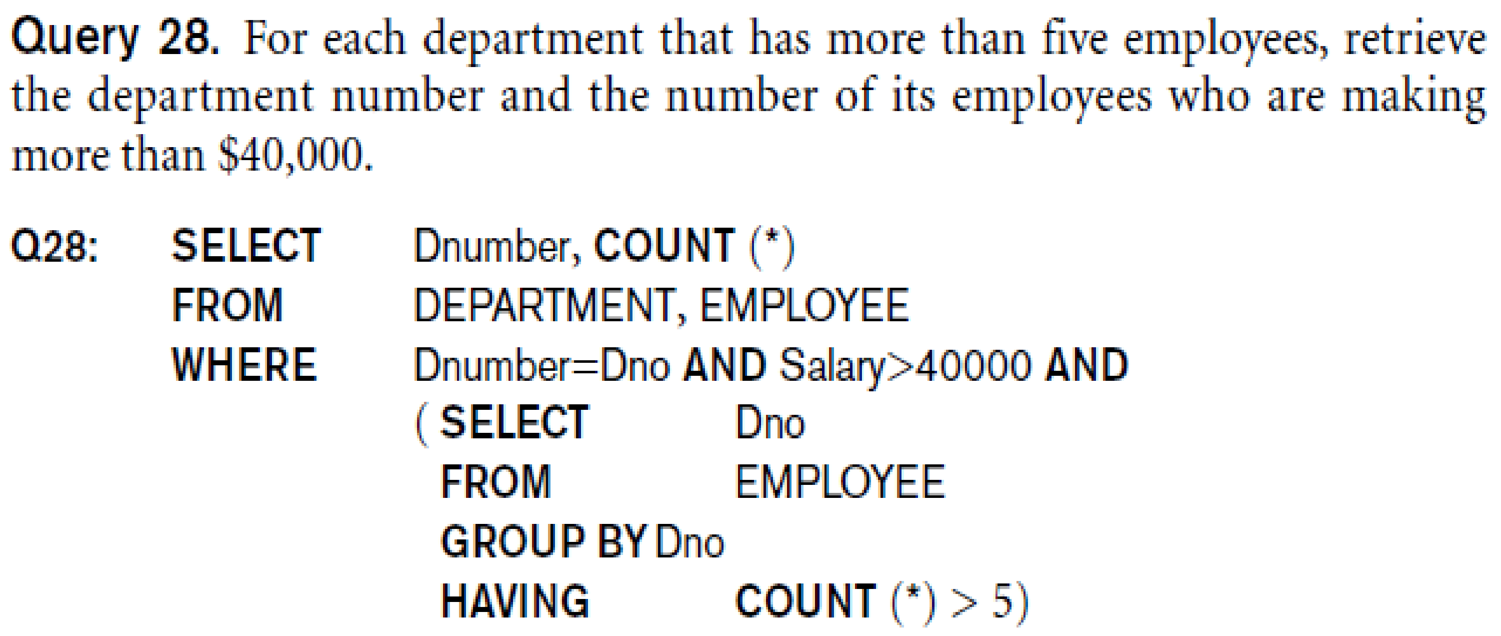
- INCORRECT QUERY:

```
SELECT      Dno, COUNT (*)
FROM        EMPLOYEE
WHERE       Salary>40000
GROUP BY    Dno
HAVING      COUNT (*) > 5;
```

Combining the WHERE and the HAVING Clause (continued)

Correct Specification of the Query:

- Note: the WHERE clause applies tuple by tuple whereas HAVING applies to entire group of tuples



Query 28. For each department that has more than five employees, retrieve the department number and the number of its employees who are making more than $40,000.

```
Q28:    SELECT      Dnumber, COUNT (*)
        FROM        DEPARTMENT, EMPLOYEE
        WHERE       Dnumber=Dno AND Salary>40000 AND
                    ( SELECT        Dno
                      FROM          EMPLOYEE
                      GROUP BY Dno
                      HAVING        COUNT (*) > 5)
```

Introduction to Triggers in SQL

- `CREATE TRIGGER` statement
  - Used to monitor the database
- Typical trigger has three components which make it a rule for an “active database “ (more on active databases in section 26.1) :
  - **Event(s)**
  - **Condition**
  - **Action**

USE OF TRIGGERS

- AN EXAMPLE with standard Syntax.(Note : other SQL implementations like PostgreSQL use a different syntax.)

```
R5:
CREATE TRIGGER SALARY_VIOLATION
BEFORE INSERT OR UPDATE OF Salary, Supervisor_ssn ON
EMPLOYEE

FOR EACH ROW
WHEN (NEW.SALARY > ( SELECT Salary FROM EMPLOYEE
                     WHERE Ssn = NEW. Supervisor_Ssn))
INFORM_SUPERVISOR (NEW.Supervisor.Ssn, New.Ssn)
```

Views (Virtual Tables) in SQL

- Concept of a view in SQL
  - Single table derived from other tables called the **defining tables**
  - Considered to be a virtual table that is not necessarily populated

Specification of Views in SQL

- **CREATE VIEW** command
  - Give table name, list of attribute names, and a query to specify the contents of the view
  - In V1, attributes retain the names from base tables. In V2, attributes are assigned names

```
V1:     CREATE VIEW    WORKS_ON1
        AS SELECT      Fname, Lname, Pname, Hours
             FROM      EMPLOYEE, PROJECT, WORKS_ON
             WHERE     Ssn=Essn AND Pno=Pnumber;

V2:     CREATE VIEW    DEPT_INFO(Dept_name, No_of_emps, Total_sal)
        AS SELECT      Dname, COUNT (*), SUM (Salary)
             FROM      DEPARTMENT, EMPLOYEE
             WHERE     Dnumber=Dno
             GROUP BY  Dname;
```

Specification of Views in SQL (cont'd.)

- Once a View is defined, SQL queries can use the View relation in the FROM clause
- View is always up-to-date
  - Responsibility of the DBMS and not the user
- `DROP VIEW` command
  - Dispose of a view

Table 7.2 Summary of SQL Syntax

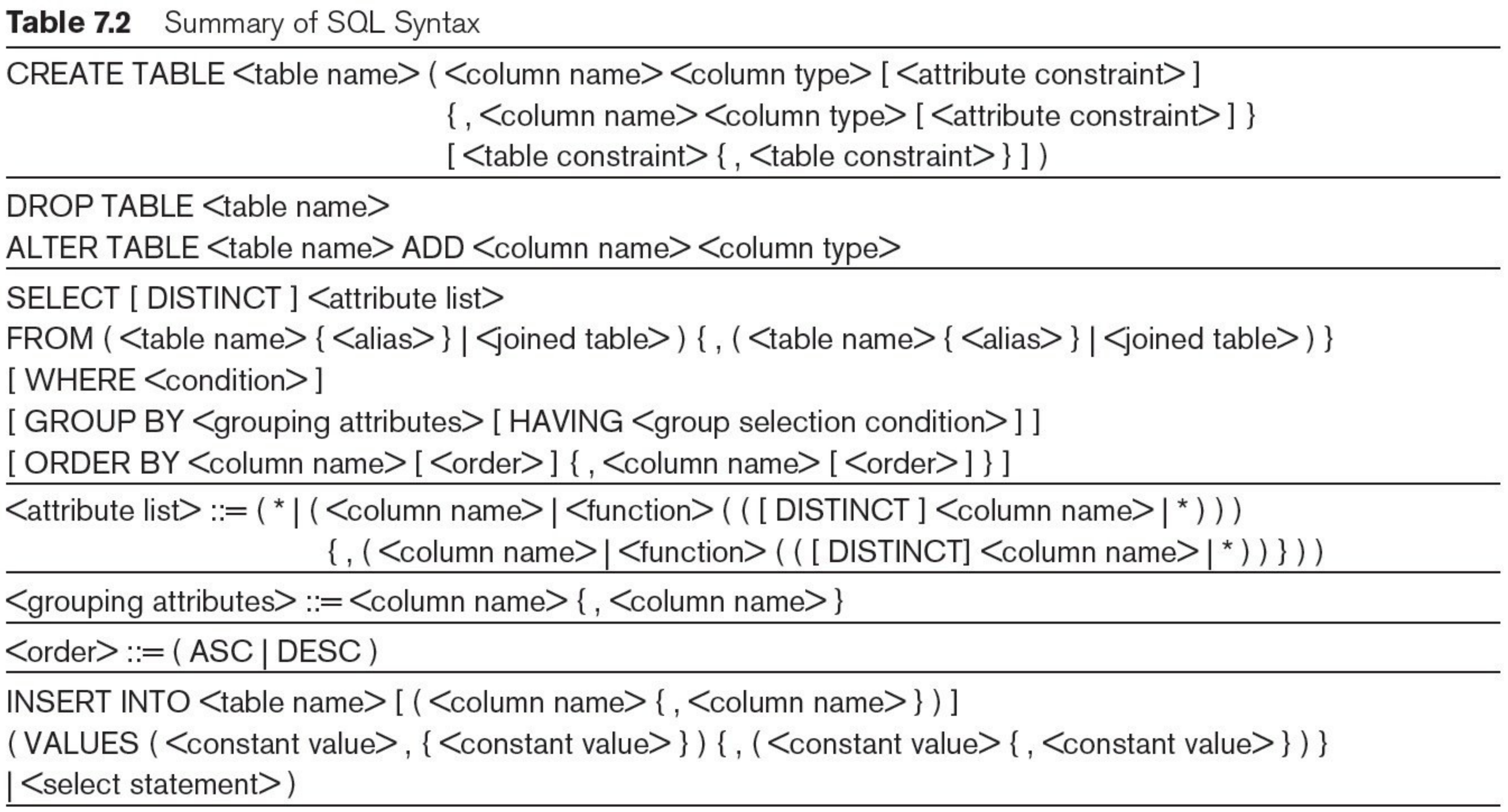


Table 7.2 Summary of SQL Syntax

```
CREATE TABLE <table name> ( <column name> <column type> [ <attribute constraint> ]
                            { , <column name> <column type> [ <attribute constraint> ] }
                            [ <table constraint> { , <table constraint> } ] )

DROP TABLE <table name>
ALTER TABLE <table name> ADD <column name> <column type>

SELECT [ DISTINCT ] <attribute list>
FROM ( <table name> { <alias> } | <joined table> ) { , ( <table name> { <alias> } | <joined table> ) }
[ WHERE <condition> ]
[ GROUP BY <grouping attributes> [ HAVING <group selection condition> ] ]
[ ORDER BY <column name> [ <order> ] { , <column name> [ <order> ] } ]

<attribute list> ::= ( * | ( <column name> | <function> ( ( [ DISTINCT ] <column name> | * ) ) )
                     { , ( <column name> | <function> ( ( [ DISTINCT] <column name> | * ) ) } ) )

<grouping attributes> ::= <column name> { , <column name> }

<order> ::= ( ASC | DESC )

INSERT INTO <table name> [ ( <column name> { , <column name> } ) ]
( VALUES ( <constant value> , { <constant value> } ) { , ( <constant value> { , <constant value> } ) }
| <select statement> )
```

continued on next slide

Table 7.2 (continued)
Summary of SQL Syntax

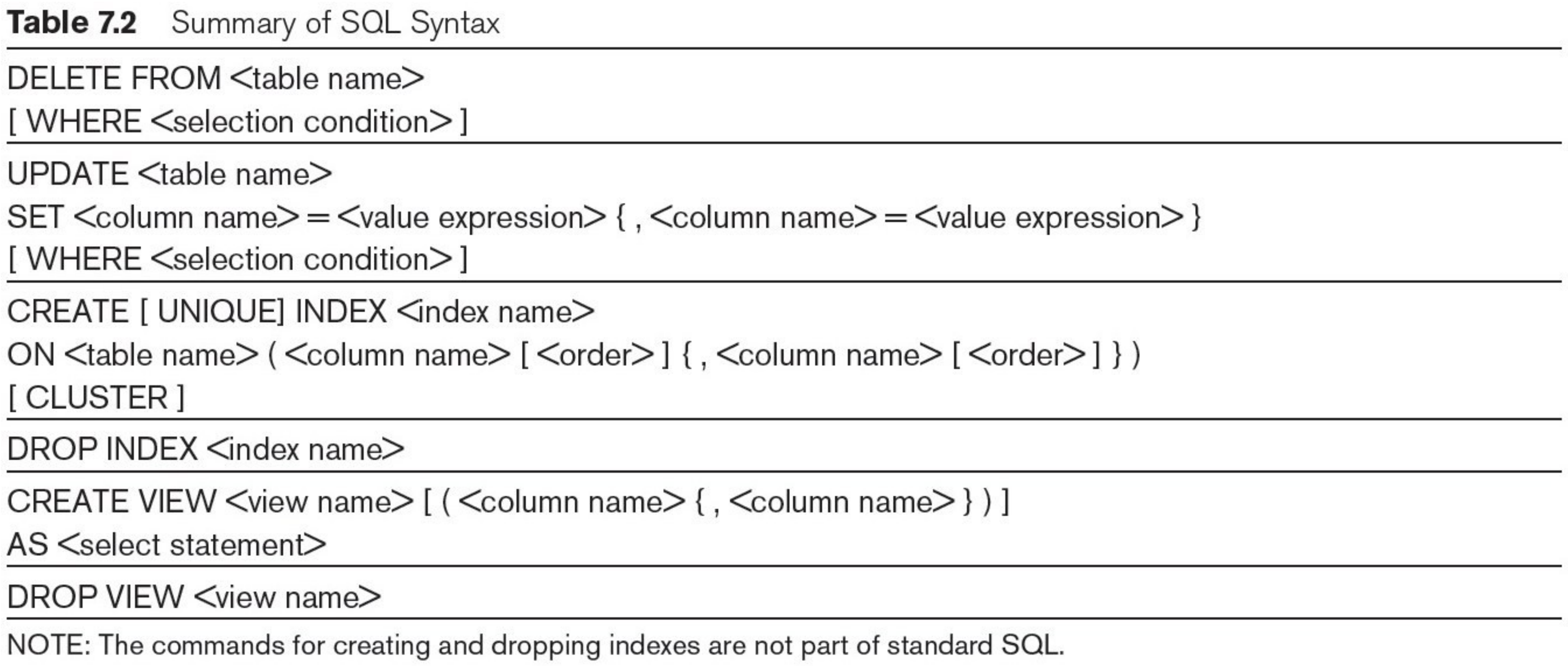


Table 7.2 Summary of SQL Syntax

DELETE FROM <table name>
[WHERE <selection condition>]

UPDATE <table name>
SET <column name> = <value expression> { , <column name> = <value expression> }
[WHERE <selection condition>]

CREATE [UNIQUE] INDEX <index name>
ON <table name> (<column name> [<order>] { , <column name> [<order>] })
[CLUSTER]

DROP INDEX <index name>

CREATE VIEW <view name> [(<column name> { , <column name> })]
AS <select statement>

DROP VIEW <view name>

NOTE: The commands for creating and dropping indexes are not part of standard SQL.

Summary

- Complex SQL:
  - Nested queries, joined tables (in the FROM clause), outer joins, aggregate functions, grouping
- Handling semantic constraints with `CREATE ASSERTION` and `CREATE TRIGGER`
- `CREATE VIEW` statement and materialization strategies
- Schema Modification for the DBAs using `ALTER TABLE , ADD and DROP COLUMN, ALTER CONSTRAINT` etc.