Unit 3(SQL- Schema Definition, Constraints, and Queries and Views)

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Overview of SQL

- Structured Query Language (SQL)
  - DDL + DML
  - A standard for relational databases
    - Easily migrate database applications between different relational DBMS
    - Easily access data stored in different rational DBMS
  - Evolution
    - SQL-86 or SQL1
    - SQL-92 or SQL2
    - SQL-99

Overview of SQL

- SQL language may be considered one of the major reasons for the commercial success of relational databases.
- it became a standard for relational databases
- This is because even if the users became dissatisfied with the particular relational DBMS product they were using,
- converting to another relational DBMS product was not expected to be too expensive and time-consuming because both systems followed the same language standards

Overview of SQL

- Another advantage of having such a standard is that users may write statements in a database application program
- that can access data stored in two or more relational DBMSs without having to change the database sublanguage (SQL), as long as both/all of the relational DBMSs support standard SQL.

Overview of SQL

- This chapter presents the *practical relational model, which is based on the SQL* standard for *commercial relational DBMSs*
- Previous chapter presented the most important concepts underlying the *formal relational data model.*
- *Also discussed* the *relational algebra operations, which are* very important for understanding the types of requests that may be specified on a relational database.
- However, the relational algebra operations are too low-level for most commercial DBMS users because a query in relational algebra is written as a sequence of operations that, when executed, produces the required result.

Overview of SQL

- Hence, the user must specify how—that is, *in what order—to execute the query operations.*
- *On the other hand, the SQL language* provides a higher-level *declarative language interface, so the user only specifies what the result is to be, leaving the actual optimization and decisions on how to* execute the query to the DBMS.

Overview of SQL

- The name **SQL is presently expanded as Structured Query Language. Originally,** SQL was called SEQUEL (Structured English QUEry Language) and was designed and implemented at IBM Research as the interface for an experimental relational database system called SYSTEM R.
- The standardization of SQL is a joint effort by the American National Standards Institute (ANSI) and the International Standards organization (ISO), and the first SQL standard is called SQL-86 or SQL1.

Overview of SQL

- A revised and much expanded standard called SQL-92 (also referred to as SQL2) was subsequently developed. The next standard that is well-recognized is
- SQL:1999, which started out as SQL3.
- Additional updates to the standard are SQL:2003 and SQL:2006, which added XML features
- Among other updates to the language. Another update in 2008 incorporated more object database features into SQL and a further update is SQL:2011.

Overview of SQL

- SQL is a comprehensive database language: It has statements for data definitions, queries, and updates.
- Hence, it is both a DDL *and a DML. In addition, it has facilities* for defining views on the database, for specifying security and authorization, for defining integrity constraints, and for specifying transaction controls

SQL Data Definition Statements

- Used to CREATE, DROP, and ALTER the descriptions of the tables (relations) of a database

Structure of a Database

- A database *system* may contain many **databases**.
- Each database is composed of **schema** and **tables**.

```
sql> SHOW databases;
+--------------+
| Database     |
+--------------+
| mysql        |
| test         |
| bank         |
| world        |
+--------------+
```

```
sql> USE bank;
sql> SHOW tables;
+---------------+
| Tables_in_bank |
+---------------+
| accounts      |
| clients       |
+---------------+
```

MySQL only shows databases that a user has permission to access.

Structure of a Table

Every field has:

- a name
- a data type and length

To view the structure of a table use:

```
DESCRIBE tablename;
```

```
sql> DESCRIBE City;
+-------------+-----------+-----+-----+---------+----------------+
| Field       | Type      | Null| Key | Default | Extra          |
+-------------+-----------+-----+-----+---------+----------------+
| ID          | int(11)   | NO  | PRI |         | auto_increment |
| Name        | char(35)  | NO  |     |         |                |
| CountryCode | char(3)   | NO  |     |         |                |
| District    | char(20)  | NO  |     |         |                |
| Population  | int(11)   | NO  |     | 0       |                |
+-------------+-----------+-----+-----+---------+----------------+
```

SQL Data Definition

- The main SQL command for data definition is the CREATE statement, which can be used to
  - create schemas,
  - tables (relations),
  - types, and
  - domains,
  - as well as other constructs such as views, assertions, and triggers.

CREATE SCHEMA

- Specifies a new database schema by giving it a name
    - CREATE SCHEMA COMPANY AUTHORIZATION Jsmith;

- In general, not all users are authorized to create schemas and schema elements. The privilege to create schemas, tables, and other constructs must be explicitly granted to the relevant user accounts by the system administrator or DBA.
- The concept of an SQL schema was incorporated starting with SQL2 in order to group together tables and other constructs that belong to the same database application (**in some systems, a *schema is called a database***).

CREATE TABLE

- Specifies a new base relation by giving it a name, and specifying each of its attributes and their data types (INTEGER, FLOAT, DECIMAL(i,j), CHAR(n), VARCHAR(n))

- A constraint NOT NULL may be specified on an attribute

```
CREATE TABLE DEPARTMENT (
        DNAME               VARCHAR(10)  NOT NULL,
        DNUMBER             INTEGER      NOT NULL,
        MGRSSN          CHAR(9),
        MGRSTARTDATE    CHAR(9)  );
```

CREATE TABLE

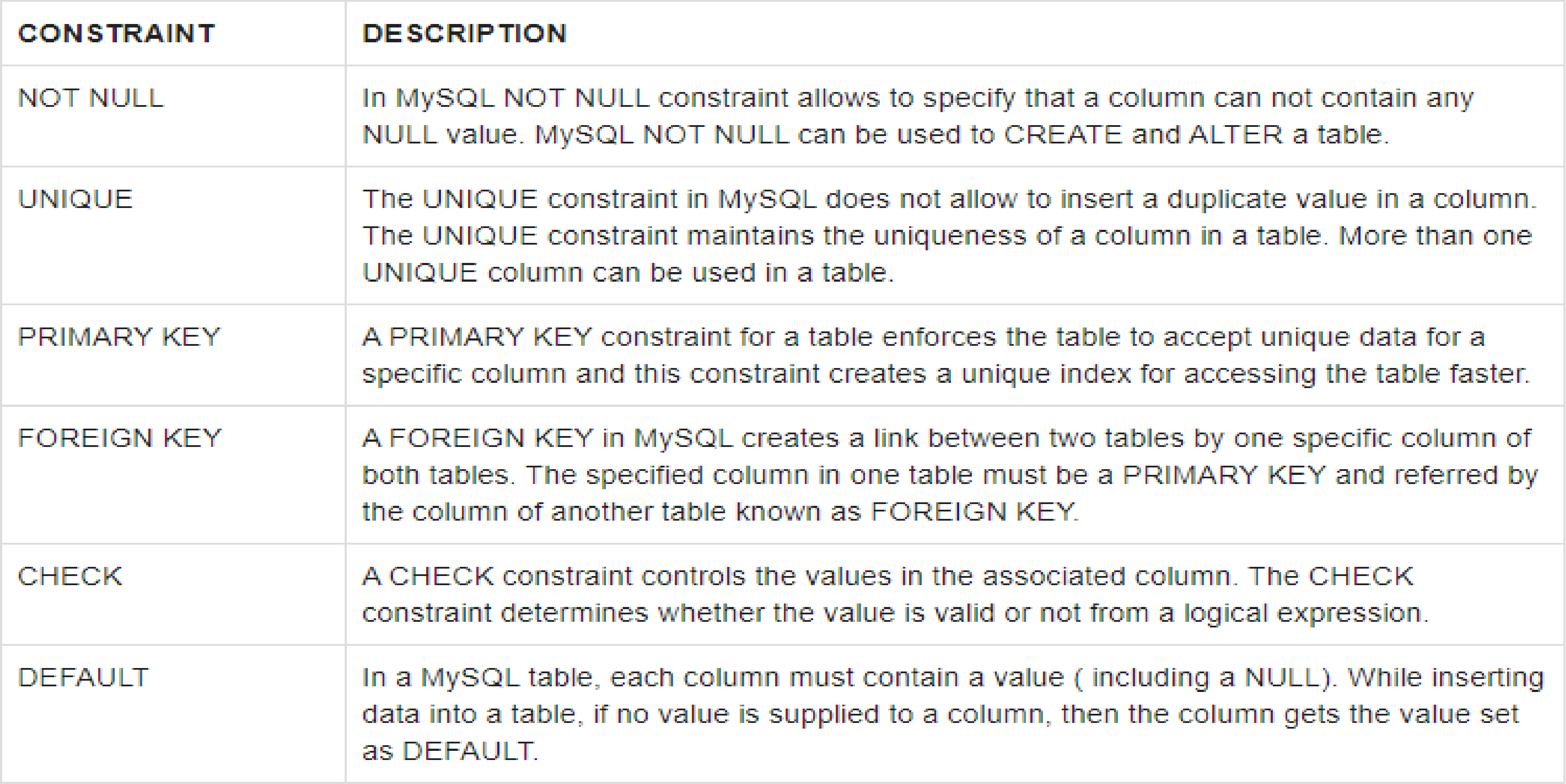
- In SQL2, can use the CREATE TABLE command for specifying the primary key attributes, secondary keys, and referential integrity constraints (foreign keys).

- Key attributes can be specified via the PRIMARY KEY and UNIQUE phrases
  - CREATE TABLE DEPT (
  - DNAME VARCHAR(10) NOT NULL,
  - DNUMBER INTEGER NOT NULL,
  - MGRSSN CHAR(9),
  - MGRSTARTDATE CHAR(9),
  - PRIMARY KEY (DNUMBER),
  - UNIQUE (DNAME),
  - FOREIGN KEY (MGRSSN) REFERENCES EMP);

- Link to specify different constraints with CREATE TABLE

https://www.w3resource.com/mysql/creating-table-advance/constraint.php#cons14

CREATE TABLE



CONSTRAINT	DESCRIPTION
NOT NULL	In MySQL NOT NULL constraint allows to specify that a column can not contain any NULL value. MySQL NOT NULL can be used to CREATE and ALTER a table.
UNIQUE	The UNIQUE constraint in MySQL does not allow to insert a duplicate value in a column. The UNIQUE constraint maintains the uniqueness of a column in a table. More than one UNIQUE column can be used in a table.
PRIMARY KEY	A PRIMARY KEY constraint for a table enforces the table to accept unique data for a specific column and this constraint creates a unique index for accessing the table faster.
FOREIGN KEY	A FOREIGN KEY in MySQL creates a link between two tables by one specific column of both tables. The specified column in one table must be a PRIMARY KEY and referred by the column of another table known as FOREIGN KEY.
CHECK	A CHECK constraint controls the values in the associated column. The CHECK constraint determines whether the value is valid or not from a logical expression.
DEFAULT	In a MySQL table, each column must contain a value (including a NULL). While inserting data into a table, if no value is supplied to a column, then the column gets the value set as DEFAULT.

REFERENTIAL INTEGRITY OPTIONS

- We can specify RESTRICT, CASCADE, SET NULL or SET DEFAULT on referential integrity constraints (foreign keys)

```
CREATE TABLE DEPT (
    DNAME           VARCHAR(10)     NOT NULL,
    DNUMBER         INTEGER         NOT NULL,
    MGRSSN          CHAR(9),
    MGRSTARTDATE    CHAR(9),
    PRIMARY KEY (DNUMBER),
    UNIQUE (DNAME),
    FOREIGN KEY (MGRSSN) REFERENCES EMP(ESSN)
  ON DELETE SET DEFAULT ON UPDATE CASCADE);
```

REFERENTIAL INTEGRITY OPTIONS (continued)

```
 CREATE TABLE EMP(

 ENAME        VARCHAR(30)  NOT NULL,
ESSN          CHAR(9),
BDATE         DATE,
DNO           INTEGER            DEFAULT  1,
GENDER        VARCHAR (9),
SUPERSSN      CHAR(9),
 AGE                INT                       NOT NULL,

PRIMARY KEY (ESSN),

FOREIGN KEY (DNO) REFERENCES DEPT(DNUMBER)
         ON DELETE SET DEFAULT ON UPDATE CASCADE,


 FOREIGN KEY (SUPERSSN) REFERENCES EMP(ESSN)
ON DELETE SET NULL ON UPDATE CASCADE,

 check (GENDER in ('Male', 'Female', 'Unknown')),
check (AGE >= 17));
```

DROP TABLE

- Used to remove a relation (base table) and its definition
- The relation can no longer be used in queries, updates, or any other commands since its description no longer exists
- Example:

  DROP TABLE *table_name*;

  DROP DATABASE database_name;

  DROP TABLE DEPENDENT;
- A DROP statement in SQL removes a component from a relational database management system (RDBMS).

ALTER TABLE

- Used to add an attribute to one of the base relations
- The new attribute will have NULLs in all the tuples of the relation right after the command is executed; hence, the NOT NULL constraint is not allowed for such an attribute
  - Example:
    ALTER TABLE EMPLOYEE ADD JOB VARCHAR(12);
- The database users must still enter a value for the new attribute JOB for each EMPLOYEE tuple.
- This can be done using the UPDATE command.
- Link for Alter Table Commands:

  https://www.tutorialspoint.com/sql/sql-alter-command.htm

ALTER TABLE

- The basic syntax of an ALTER TABLE command to add a **New Column** in an existing table is as follows.
    - ALTER TABLE table_name ADD column_name datatype;

- The basic syntax of an ALTER TABLE command to **DROP COLUMN** in an existing table is as follows.
    - ALTER TABLE table_name DROP COLUMN column_name;

ALTER TABLE

- The basic syntax of an ALTER TABLE command to add a **NOT NULL** constraint to a column in a table is as follows.
  - ALTER TABLE table_name MODIFY column_name datatype NOT NULL;
  - ALTER TABLE table_name MODIFY column_name datatype NULL;

- The basic syntax of ALTER TABLE to **ADD UNIQUE CONSTRAINT** to a table is as follows.
  - ALTER TABLE table_name ADD CONSTRAINT MyUniqueConstraint UNIQUE(column1, column2...);

  - ALTER TABLE Persons
    DROP INDEX UC_Person;

ALTER TABLE

- The basic syntax of an ALTER TABLE command to DROP CONSTRAINT from a table is as follows.
  - ALTER TABLE table_name DROP CONSTRAINT MyUniqueConstraint;

- The basic syntax of an ALTER TABLE command to ADD FOREIGN KEY constraint CONSTRAINT from a table is as follows.

```
ALTER TABLE Orders
ADD CONSTRAINT FK_PersonOrder
FOREIGN KEY (PersonID) REFERENCES Persons(PersonID);
```

```
ALTER TABLE Orders
DROP FOREIGN KEY FK_PersonOrder;
```

ALTER TABLE

- The basic syntax of an ALTER TABLE command to **ADD CHECK CONSTRAINT** to a table is as follows.
  - ALTER TABLE table_name ADD CONSTRAINT MyUniqueConstraint CHECK (CONDITION);
  - ALTER TABLE Persons DROP CHECK CHK_PersonAge;
- The basic syntax of an ALTER TABLE command to ADD PRIMARY KEY constraint to a table is as follows.
  - ALTER TABLE table_name ADD CONSTRAINT MyPrimaryKey PRIMARY KEY (column1, column2...);
  - ALTER TABLE Persons
    DROP PRIMARY KEY;

ALTER TABLE

- The basic syntax of an ALTER TABLE command to **ADD and DROP DEFAULT CONSTRAINT** to a table is as follows.
  - ALTER TABLE Persons
    ALTER City SET DEFAULT 'Sandnes';
  - ALTER TABLE Persons ALTER City DROP DEFAULT;

- The basic syntax of an ALTER TABLE command to change the **DATA TYPE** of a column in a table is as follows.
  - ALTER TABLE table_name MODIFY COLUMN column_name datatype;

INSERT statement

- The INSERT statement allows you to insert one or more rows into a table. The following illustrates the syntax of the INSERT statement

```
INSERT INTO tablename (c1,c2,...)
VALUES (v1,v2,...);
```

```
INSERT INTO tablename
VALUES (v1,v2,...);
```

INSERT statement

- To insert multiple rows into a table using a single INSERT statement, you use the following syntax:

INSERT INTO tablename (c1,c2,...)

VALUES

(v11,v12,...),

(v21,v22,...),

... (vnn,vn2,...);

Additional Data Types in SQL2 and SQL-99

Has DATE, TIME, and TIMESTAMP data types

- **DATE:**
  - Made up of year-month-day in the format yyyy-mm-dd
- **TIME:**
  - Made up of hour:minute:second in the format hh:mm:ss
- **TIME(i):**
  - Made up of hour:minute:second plus i additional digits specifying fractions of a second
  - format is hh:mm:ss:ii...i

Retrieval Queries in SQL

- SQL has one basic statement for retrieving information from a database; the SELECT statement
  - This is not the same as the SELECT operation of the relational algebra
- Important distinction between SQL and the formal relational model:
  - SQL allows a table (relation) to have two or more tuples that are identical in all their attribute values
  - Hence, an SQL relation (table) is a multi-set (sometimes called a bag) of tuples; it is not a set of tuples
- SQL relations can be constrained to be sets by specifying PRIMARY KEY or UNIQUE attributes, or by using the DISTINCT option in a query

Retrieval Queries in SQL (contd.)

- A bag or multi-set is like a set, but an element may appear more than once.
    - Example: {A, B, C, A} is a bag. {A, B, C} is also a bag that also is a set.
    - Bags also resemble lists, but the order is irrelevant in a bag.
- Example:
    - {A, B, A} = {B, A, A} as bags
    - However, [A, B, A] is not equal to [B, A, A] as lists

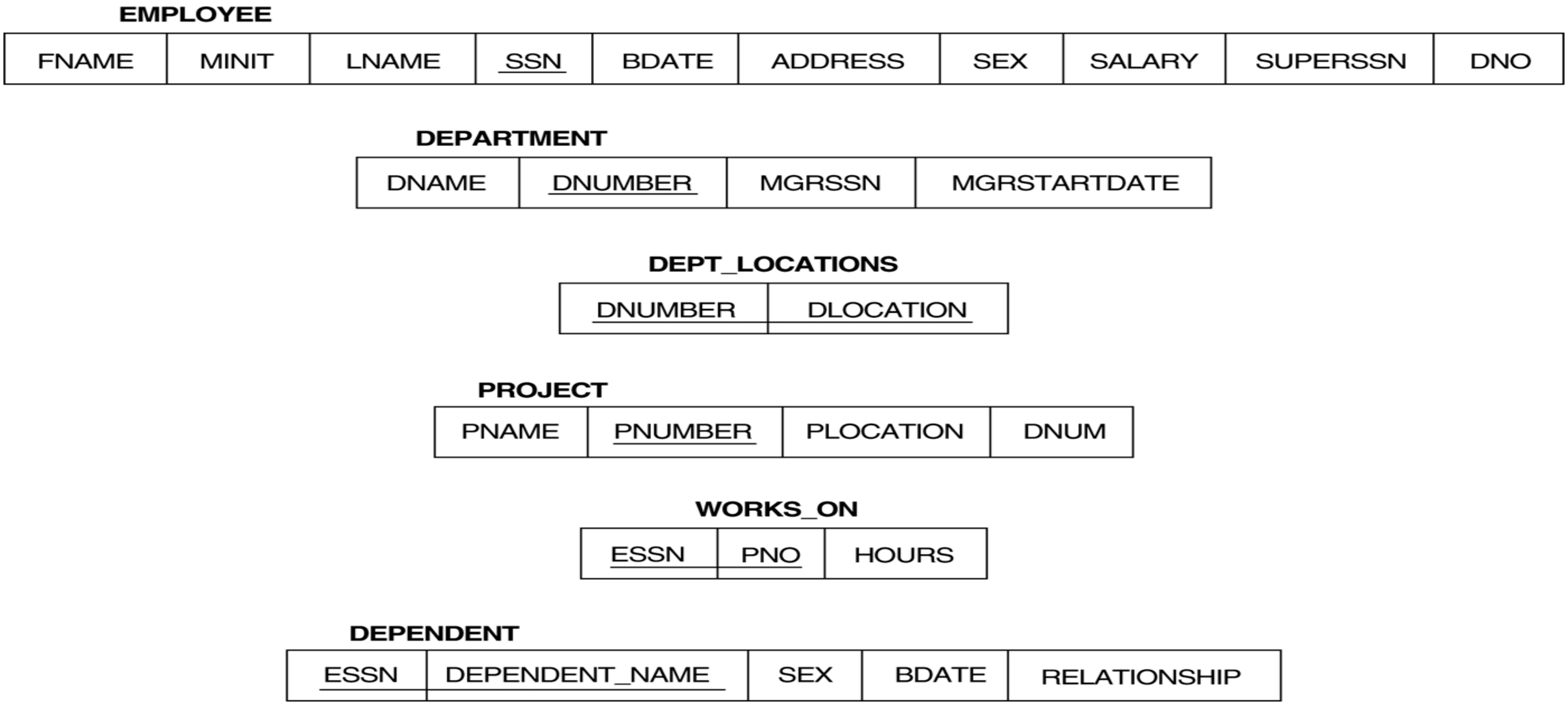
Retrieval Queries in SQL (contd.)

- Basic form of the SQL SELECT statement is called a mapping or a SELECT-FROM-WHERE block

- SELECT <attribute list>
- FROM <table list>
- WHERE <condition>

  - <attribute list> is a list of attribute names whose values are to be retrieved by the query
  - <table list> is a list of the relation names required to process the query
  - <condition> is a conditional (Boolean) expression that identifies the tuples to be retrieved by the query

Relational Database Schema



EMPLOYEE

FNAME	MINIT	LNAME	SSN	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	DNO

DEPARTMENT

DNAME	DNUMBER	MGRSSN	MGRSTARTDATE

DEPT_LOCATIONS

DNUMBER	DLOCATION

PROJECT

PNAME	PNUMBER	PLOCATION	DNUM

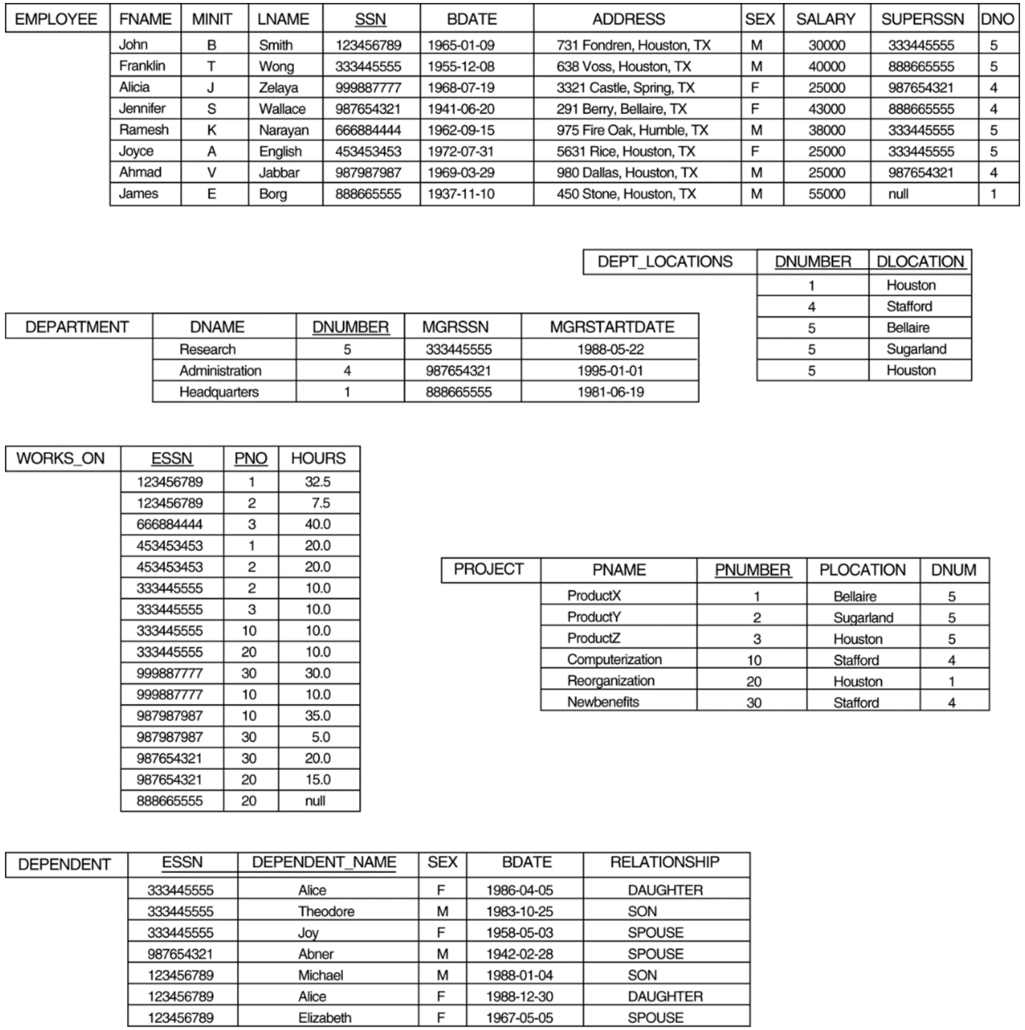
WORKS_ON

ESSN	PNO	HOURS

DEPENDENT

ESSN	DEPENDENT_NAME	SEX	BDATE	RELATIONSHIP

Populated Database



EMPLOYEE	FNAME	MINIT	LNAME	SSN	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	DNO
	John	B	Smith	123456789	1965-01-09	731 Fondren, Houston, TX	M	30000	333445555	5
	Franklin	T	Wong	333445555	1955-12-08	638 Voss, Houston, TX	M	40000	888665555	5
	Alicia	J	Zelaya	999887777	1968-07-19	3321 Castle, Spring, TX	F	25000	987654321	4
	Jennifer	S	Wallace	987654321	1941-06-20	291 Berry, Bellaire, TX	F	43000	888665555	4
	Ramesh	K	Narayan	666884444	1962-09-15	975 Fire Oak, Humble, TX	M	38000	333445555	5
	Joyce	A	English	453453453	1972-07-31	5631 Rice, Houston, TX	F	25000	333445555	5
	Ahmad	V	Jabbar	987987987	1969-03-29	980 Dallas, Houston, TX	M	25000	987654321	4
	James	E	Borg	888665555	1937-11-10	450 Stone, Houston, TX	M	55000	null	1

DEPT_LOCATIONS	DNUMBER	DLOCATION
	1	Houston
	4	Stafford
	5	Bellaire
	5	Sugarland
	5	Houston

DEPARTMENT	DNAME	DNUMBER	MGRSSN	MGRSTARTDATE
	Research	5	333445555	1988-05-22
	Administration	4	987654321	1995-01-01
	Headquarters	1	888665555	1981-06-19

WORKS_ON	ESSN	PNO	HOURS
	123456789	1	32.5
	123456789	2	7.5
	666884444	3	40.0
	453453453	1	20.0
	453453453	2	20.0
	333445555	2	10.0
	333445555	3	10.0
	333445555	10	10.0
	333445555	20	10.0
	999887777	30	30.0
	999887777	10	10.0
	987987987	10	35.0
	987987987	30	5.0
	987654321	30	20.0
	987654321	20	15.0
	888665555	20	null

PROJECT	PNAME	PNUMBER	PLOCATION	DNUM
	ProductX	1	Bellaire	5
	ProductY	2	Sugarland	5
	ProductZ	3	Houston	5
	Computerization	10	Stafford	4
	Reorganization	20	Houston	1
	Newbenefits	30	Stafford	4

DEPENDENT	ESSN	DEPENDENT_NAME	SEX	BDATE	RELATIONSHIP
	333445555	Alice	F	1986-04-05	DAUGHTER
	333445555	Theodore	M	1983-10-25	SON
	333445555	Joy	F	1958-05-03	SPOUSE
	987654321	Abner	M	1942-02-28	SPOUSE
	123456789	Michael	M	1988-01-04	SON
	123456789	Alice	F	1988-12-30	DAUGHTER
	123456789	Elizabeth	F	1967-05-05	SPOUSE

Simple SQL Queries

- Basic SQL queries correspond to using the following operations of the relational algebra:
  - SELECT
  - PROJECT
  - JOIN
- All subsequent examples use the COMPANY database

Simple SQL Queries (contd.)

- Example of a simple query on one relation
- Query 0: Retrieve the birthdate and address of the employee whose name is 'John B. Smith'.
  - Q0:
    ```
    SELECT      BDATE, ADDRESS
    FROM        EMPLOYEE
    WHERE       FNAME='John' AND MINIT='B’
    AND         LNAME='Smith’
    ```
  - Similar to a SELECT-PROJECT pair of relational algebra operations:
    - The SELECT-clause specifies the projection attributes and the WHERE-clause specifies the selection condition
  - However, the result of the query may contain duplicate tuples

Simple SQL Queries (contd.)

- Query 1: Retrieve the name and address of all employees who work for the 'Research' department.

  - Q1:

    ```
    Q1:     SELECT      FNAME, LNAME, ADDRESS
            FROM        EMPLOYEE, DEPARTMENT
            WHERE       DNAME='Research' AND DNUMBER=DNO
    ```

  - Similar to a SELECT-PROJECT-JOIN sequence of relational algebra operations
  - (DNAME='Research') is a selection condition (corresponds to a SELECT operation in relational algebra)
  - (DNUMBER=DNO) is a join condition (corresponds to a JOIN operation in relational algebra)

Simple SQL Queries (contd.)

- Query 2: For every project located in 'Stafford', list the project number, the controlling department number, and the department manager's last name, address, and birthdate.

- Q2:
```
Q2: SELECT        PNUMBER, DNUM, LNAME, BDATE, ADDRESS
      FROM        PROJECT, DEPARTMENT, EMPLOYEE
      WHERE       DNUM=DNUMBER AND MGRSSN=SSN
                          AND PLOCATION='Stafford'
```

  - In Q2, there are two join conditions
  - The join condition DNUM=DNUMBER relates a project to its controlling department
  - The join condition MGRSSN=SSN relates the controlling department to the employee who manages that department

Aliases, * and DISTINCT, Empty WHERE-clause

- In SQL, we can use the same name for two (or more) attributes as long as the attributes are in different relations
- A query that refers to two or more attributes with the same name must qualify the attribute name with the relation name by prefixing the relation name to the attribute name
- Example:

- EMPLOYEE.LNAME, DEPARTMENT.DNAME

ALIASES

- Some queries need to refer to the same relation twice
- In this case, aliases are given to the relation name
- Query 8: For each employee, retrieve the employee's name, and the name of his or her immediate supervisor.

```
Q8:   SELECT        E.FNAME, E.LNAME, S.FNAME, S.LNAME
      FROM                    EMPLOYEE E S
      WHERE         E.SUPERSSN=S.SSN
```

- In Q8, the alternate relation names E and S are called aliases or tuple variables for the EMPLOYEE relation
- We can think of E and S as two different copies of EMPLOYEE; E represents employees in role of supervisees and S represents employees in role of supervisors

ALIASES (contd.)

- Aliasing can also be used in any SQL query for convenience
- Can also use the AS keyword to specify aliases

```
Q8:     SELECT     E.FNAME, E.LNAME,
                   S.FNAME, S.LNAME
        FROM       EMPLOYEE AS E,
                   EMPLOYEE AS S
        WHERE      E.SUPERSSN=S.SSN
```

UNSPECIFIED WHERE-clause

- A *missing WHERE-clause* indicates no condition; hence, all tuples of the relations in the FROM-clause are selected
  - This is equivalent to the condition WHERE TRUE
- Query 9: Retrieve the SSN values for all employees.
  - Q9:

```
SELECT    SSN
FROM      EMPLOYEE
```

- If more than one relation is specified in the FROM-clause *and* there is no join condition, then the *CARTESIAN PRODUCT* of tuples is selected

UNSPECIFIED WHERE-clause (contd.)

- Example:

```
Q10:        SELECT        SSN, DNAME
            FROM  EMPLOYEE, DEPARTMENT
```

  - It is extremely important not to overlook specifying any selection and join conditions in the WHERE-clause; otherwise, incorrect and very large relations may result

USE OF *

- To retrieve all the attribute values of the selected tuples, a * is used, which stands for *all the attributes* Examples:

```
Q1C:        SELECT *
            FROM          EMPLOYEE
            WHERE  DNO=5

Q1D:        SELECT *
            FROM          EMPLOYEE, DEPARTMENT
            WHERE  DNAME='Research' AND DNO=DNUMBER
```

USE OF DISTINCT

- SQL does not treat a relation as a set; duplicate tuples can appear
- To eliminate duplicate tuples in a query result, the keyword **DISTINCT** is used
- For example, the result of Q11 may have duplicate SALARY values whereas Q11A does not have any duplicate values

```
Q11:    SELECT      SALARY
        FROM EMPLOYEE


Q11A:   SELECT      DISTINCT SALARY
        FROM EMPLOYEE
```

SET OPERATIONS

- SQL has directly incorporated some set operations
- There is a union operation (UNION), and in *some versions* of SQL there are set difference (MINUS) and intersection (INTERSECT) operations
- The resulting relations of these set operations are sets of tuples; *duplicate tuples are eliminated from the result*
- The set operations apply only to *union compatible relations*; the two relations must have the same attributes and the attributes must appear in the same order

SET OPERATIONS (contd.)

- Query 4: Make a list of all project names for projects that involve an employee whose last name is 'Smith' as a worker or as a manager of the department that controls the project.

```
Q4:             (SELECT          PNAME
                FROM   PROJECT, DEPARTMENT, EMPLOYEE
                WHEREDNUM=DNUMBER AND MGRSSN=SSN AND LNAME='Smith')
                UNION
                (SELECT          PNAME
                FROM   PROJECT, WORKS_ON, EMPLOYEE
                WHEREPNUMBER=PNO AND ESSN=SSN AND NAME='Smith')
```

NESTING OF QUERIES

- A complete SELECT query, called a *nested query*, can be specified within the WHERE-clause of another query, called the *outer query*
  - Many of the previous queries can be specified in an alternative form using nesting
- Query 1: Retrieve the name and address of all employees who work for the 'Research' department.

```
Q1:     SELECT     FNAME, LNAME, ADDRESS
        FROM                  EMPLOYEE
        WHERE      DNO IN  (SELECT  DNUMBER
        FROM       DEPARTMENT
        WHERE      DNAME='Research' )
```

NESTING OF QUERIES (contd.)

- The nested query selects the number of the 'Research' department
- The outer query select an EMPLOYEE tuple if its DNO value is in the result of either nested query
- The comparison operator IN compares a value v with a set (or multi-set) of values V, and evaluates to TRUE if v is one of the elements in V
- In general, we can have several levels of nested queries
- A reference to an unqualified attribute refers to the relation declared in the innermost nested query
- In this example, the nested query is not correlated with the outer query

CORRELATED NESTED QUERIES

- If a condition in the WHERE-clause of a *nested query* references an attribute of a relation declared in the *outer query*, the two queries are said to be *correlated*
  - The result of a correlated nested query is different for each tuple (or combination of tuples) of the relation(s) the outer query
- Query 12: Retrieve the name of each employee who has a dependent with the same first name as the employee.

```
Q12: SELECT     E.FNAME, E.LNAME
     FROM       EMPLOYEE AS E
     WHERE      E.SSN IN
                    (SELECT    ESSN
                    FROM DEPENDENT
                    WHERE      ESSN=E.SSN AND
                    E.FNAME=DEPENDENT_NAME)
```

CORRELATED NESTED QUERIES (contd.)

- In Q12, the nested query has a different result in the outer query
- A query written with nested SELECT... FROM... WHERE... blocks and using the = or IN comparison operators can ***always*** be expressed as a single block query. For example, Q12 may be written as in Q12A

```
Q12A:   SELECT       E.FNAME, E.LNAME
        FROM  EMPLOYEE E, DEPENDENT D
        WHERE        E.SSN=D.ESSN AND
              E.FNAME=D.DEPENDENT_NAME
```

CORRELATED NESTED QUERIES (contd.)

- The original SQL as specified for SYSTEM R also had a **CONTAINS** comparison operator, which is used in conjunction with nested correlated queries
    - This operator was *dropped from the language*, possibly because of the difficulty in implementing it efficiently
    - Most implementations of SQL do not have this operator
    - The CONTAINS operator compares *two sets of values*, and returns TRUE if one set contains all values in the other set
        - Reminiscent of the division operation of algebra

CORRELATED NESTED QUERIES (contd.)

- Query 3: Retrieve the name of each employee who works on all the projects controlled by department number 5.

```
Q3:     SELECT      FNAME, LNAME
        FROM        EMPLOYEE
        WHERE  (    (SELECT       PNO
                    FROM   WORKS_ON
                    WHERE         SSN=ESSN)
                           CONTAINS
                    (SELECT       PNUMBER
                    FROM   PROJECT
                    WHERE         DNUM=5) )
```

CORRELATED NESTED QUERIES (contd.)

- In Q3, the second nested query, which is *not correlated* with the outer query, retrieves the project numbers of all projects controlled by department 5
- The first nested query, which is correlated, retrieves the project numbers on which the employee works, which is *different for each employee tuple* because of the correlation

THE EXISTS FUNCTION

- EXISTS is used to check whether the result of a correlated nested query is empty (contains no tuples) or not
  - We can formulate Query 12 in an alternative form that uses EXISTS as Q12B

THE EXISTS FUNCTION (contd.)

- Query 12: Retrieve the name of each employee who has a dependent with the same first name as the employee.

```
Q12B:     SELECT      FNAME, LNAME
          FROM        EMPLOYEE
          WHERE       EXISTS  (SELECT      *
                               FROM  DEPENDENT
                               WHERE SSN=ESSN
                               AND
                               FNAME=DEPENDENT_NAME)
```

THE EXISTS FUNCTION (contd.)

- Query 6: Retrieve the names of employees who have no dependents.

```
Q6:     SELECT      FNAME, LNAME
        FROM        EMPLOYEE
        WHERE       NOT EXISTS  (SELECT     *
                           FROM        DEPENDENT
                           WHERE       SSN=ESSN)
```

- In Q6, the correlated nested query retrieves all DEPENDENT tuples related to an EMPLOYEE tuple. If *none exist*, the EMPLOYEE tuple is selected
  - EXISTS is necessary for the expressive power of SQL

EXPLICIT SETS

- It is also possible to use an **explicit (enumerated) set of values** in the WHERE-clause rather than a nested query
- Query 13: Retrieve the social security numbers of all employees who work on project number 1, 2, or 3.

```
Q13:     SELECT     DISTINCT ESSN
         FROM       WORKS_ON
         WHERE      PNO IN  (1, 2, 3)
```

NULLS IN SQL QUERIES

- SQL allows queries that check if a value is **NULL** (missing or undefined or not applicable)
- SQL uses **IS** or **IS NOT** to compare NULLs because it considers each NULL value distinct from other NULL values, so *equality comparison is not appropriate*.
- Query 14: Retrieve the names of all employees who do not have supervisors.

```
Q14:    SELECT   FNAME, LNAME
        FROM     EMPLOYEE
        WHERE    SUPERSSN  IS  NULL
```

  - Note: If a join condition is specified, tuples with NULL values for the join attributes are not included in the result

Joined Relations Feature in SQL2

- Can specify a "joined relation" in the FROM-clause
  - Looks like any other relation but is the result of a join
  - Allows the user to specify different types of joins (regular "theta" JOIN, NATURAL JOIN, LEFT OUTER JOIN, RIGHT OUTER JOIN, CROSS JOIN, etc)

Joined Relations Feature in SQL2 (contd.)

- Examples:

```
Q8:SELECT       E.FNAME, E.LNAME, S.FNAME, S.LNAME
   FROM         EMPLOYEE E S
   WHERE        E.SUPERSSN=S.SSN
```

- can be written as:

```
Q8:SELECT       E.FNAME, E.LNAME, S.FNAME, S.LNAME
   FROM         (EMPLOYEE E LEFT OUTER JOIN        EMPLOYEE S
   ON  E.SUPERSSN=S.SSN)
```

Joined Relations Feature in SQL2 (contd.)

- Examples:

```
Q1:        SELECT      FNAME, LNAME, ADDRESS
           FROM        EMPLOYEE, DEPARTMENT
           WHERE       DNAME='Research' AND DNUMBER=DNO
```

- could be written as:

```
Q1:        SELECT      FNAME, LNAME, ADDRESS
           FROM        (EMPLOYEE JOIN DEPARTMENT
                       ON DNUMBER=DNO)
           WHERE       DNAME='Research’
```

- or as:

```
Q1:        SELECT      FNAME, LNAME, ADDRESS
           FROM        (EMPLOYEE NATURAL JOIN DEPARTMENT
           AS DEPT(DNAME, DNO, MSSN, MSDATE)
           WHERE       DNAME='Research’
```

Joined Relations Feature in SQL2 (contd.)

- Another Example: Q2 could be written as follows; this illustrates multiple joins in the joined tables

```
Q2:          SELECT       PNUMBER, DNUM, LNAME,
                                   BDATE, ADDRESS
                          FROM  (PROJECT JOIN
                    DEPARTMENT ON DNUM=DNUMBER) JOIN
                                         EMPLOYEE ON MGRSSN=SSN) )
                    WHERE        PLOCATION='Stafford’
```

AGGREGATE FUNCTIONS

- Include **COUNT, SUM, MAX, MIN, and AVG**
- Query 15: Find the maximum salary, the minimum salary, and the average salary among all employees.

```
Q15:     SELECT     MAX(SALARY),
                    MIN(SALARY), AVG(SALARY)
         FROM       EMPLOYEE
```

- Some SQL implementations *may not allow more than one function* in the SELECT-clause

AGGREGATE FUNCTIONS (contd.)

- Query 16: Find the maximum salary, the minimum salary, and the average salary among employees who work for the 'Research' department.

```
Q16:    SELECT    MAX(SALARY),
        MIN(SALARY), AVG(SALARY)
        FROM      EMPLOYEE, DEPARTMENT
        WHERE     DNO=DNUMBER AND
                  DNAME='Research'
```

AGGREGATE FUNCTIONS (contd.)

- Queries 17 and 18: Retrieve the total number of employees in the company (Q17), and the number of employees in the 'Research' department (Q18).

```
Q17:      SELECT     COUNT (*)
          FROM       EMPLOYEE


Q18:      SELECT     COUNT (*)
          FROM       EMPLOYEE, DEPARTMENT
          WHERE      DNO=DNUMBER AND
                     DNAME='Research’
```

GROUPING

- In many cases, we want to apply the aggregate functions to *subgroups of tuples* in a relation
- Each subgroup of tuples consists of the set of tuples that have the *same value* for the *grouping attribute(s)*
- The function is applied to each subgroup independently
- SQL has a **GROUP BY**-clause for specifying the grouping attributes, which *must also appear in the SELECT-clause*

GROUPING (contd.)

- Query 20: For each department, retrieve the department number, the number of employees in the department, and their average salary.

```
Q20:        SELECT      DNO, COUNT (*), AVG (SALARY)
            FROM        EMPLOYEE
            GROUP BY    DNO
```

  - In Q20, the EMPLOYEE tuples are divided into groups-
    - Each group having the same value for the grouping attribute DNO
  - The COUNT and AVG functions are applied to each such group of tuples separately
  - The SELECT-clause includes only the grouping attribute and the functions to be applied on each group of tuples
  - A join condition can be used in conjunction with grouping

GROUPING (contd.)

- Query 21: For each project, retrieve the project number, project name, and the number of employees who work on that project.

```
Q21:        SELECT      PNUMBER, PNAME, COUNT (*)
            FROM        PROJECT, WORKS_ON
            WHERE       PNUMBER=PNO
            GROUP BY    PNUMBER, PNAME
```

- In this case, the grouping and functions are applied after the joining of the two relations

THE HAVING-CLAUSE

- Sometimes we want to retrieve the values of these functions for only those *groups that satisfy certain conditions*
- The **HAVING-**clause is used for specifying a selection condition on groups (rather than on individual tuples)

THE HAVING-CLAUSE (contd.)

- Query 22: For each project *on which more than two employees work*, retrieve the project number, project name, and the number of employees who work on that project.

```
Q22:        SELECT      PNUMBER, PNAME,
                                  COUNT(*)
            FROM        PROJECT, WORKS_ON
            WHERE       PNUMBER=PNO
            GROUP BY    PNUMBER, PNAME
            HAVING      COUNT (*) > 2
```

SUBSTRING COMPARISON

- The **LIKE** comparison operator is used to compare partial strings
- Two reserved characters are used: '**%**' (or '*****' in some implementations) replaces an arbitrary number of characters, and '**_**' replaces a single arbitrary character

SUBSTRING COMPARISON (contd.)

- Query 25: Retrieve all employees whose address is in Houston, Texas. Here, the value of the ADDRESS attribute must contain the substring 'Houston,TX‘ in it.

```
Q25:     SELECT    FNAME, LNAME
         FROM      EMPLOYEE
         WHERE     ADDRESS LIKE
                        '%Houston,TX%'
```

SUBSTRING COMPARISON (contd.)

- Query 26: Retrieve all employees who were born during the 1950s.
  - Here, '5' must be the 8th character of the string (according to our format for date), so the BDATE value is '_______5_', with each underscore as a place holder for a single arbitrary character.

```
Q26:      SELECT     FNAME, LNAME
          FROM EMPLOYEE
          WHERE      BDATE LIKE '_______5_’
```

- The LIKE operator allows us to get around the fact that each value is considered atomic and indivisible
  - Hence, in SQL, character string attribute values are not atomic

ARITHMETIC OPERATIONS

The standard arithmetic operators '+', '-'. '*', and '/' (for addition, subtraction, multiplication, and division, respectively) can be applied to numeric values in an SQL query result

- Query 27: Show the effect of giving all employees who work on the 'ProductX' project a 10% raise.

```
Q27:     SELECT     FNAME, LNAME, 1.1*SALARY
         FROM       EMPLOYEE, WORKS_ON, PROJECT
         WHERE      SSN=ESSN AND PNO=PNUMBER
                    AND PNAME='ProductX’
```

ORDER BY

- The **ORDER BY** clause is used to sort the tuples in a query result based on the values of some attribute(s)
- Query 28: Retrieve a list of employees and the projects each works in, ordered by the employee's department, and within each department ordered alphabetically by employee last name.

```
Q28:    SELECT      DNAME, LNAME, FNAME, PNAME
        FROM        DEPARTMENT, EMPLOYEE,
                    WORKS_ON, PROJECT
        WHERE       DNUMBER=DNO AND SSN=ESSN
                    AND PNO=PNUMBER
        ORDER BY    DNAME, LNAME
```

ORDER BY (contd.)

- The default order is in ascending order of values
- We can specify the keyword **DESC** if we want a descending order; the keyword **ASC** can be used to explicitly specify ascending order, even though it is the default

Summary of SQL Queries

A query in SQL can consist of up to six clauses, but only the first two, SELECT and FROM, are mandatory. The clauses are specified in the following order:

SELECT	<attribute list>
FROM	<table list>
[**WHERE**	<condition>]
[**GROUP BY**	<grouping attribute(s)>]
[**HAVING**	<group condition>]
[**ORDER BY**	<attribute list>]

Summary of SQL Queries (contd.)

- The SELECT-clause lists the attributes or functions to be retrieved
- The FROM-clause specifies all relations (or aliases) needed in the query but not those needed in nested queries
- The WHERE-clause specifies the conditions for selection and join of tuples from the relations specified in the FROM-clause
- GROUP BY specifies grouping attributes
- HAVING specifies a condition for selection of groups
- ORDER BY specifies an order for displaying the result of a query
  - A query is evaluated by first applying the WHERE-clause, then GROUP BY and HAVING, and finally the SELECT-clause

Specifying Updates in SQL

- There are three SQL commands to modify the database: **INSERT**, **DELETE**, and **UPDATE**

INSERT

- In its simplest form, it is used to add one or more tuples to a relation
- Attribute values should be listed in the same order as the attributes were specified in the **CREATE TABLE** command

INSERT (contd.)

- Example:

```
U1:     INSERT INTO     EMPLOYEE
        VALUES ('Richard','K','Marini', '653298653', '30-DEC-52',
        '98 Oak Forest,Katy,TX', 'M', 37000,'987654321', 4 )
```

- An alternate form of INSERT specifies explicitly the attribute names that correspond to the values in the new tuple
  - Attributes with NULL values can be left out
- Example: Insert a tuple for a new EMPLOYEE for whom we only know the FNAME, LNAME, and SSN attributes.

```
U1A:   INSERT INTO     EMPLOYEE (FNAME, LNAME,
                       SSN)
       VALUES ('Richard', 'Marini', '653298653')
```

INSERT (contd.)

- Important Note: Only the constraints specified in the DDL commands are automatically enforced by the DBMS when updates are applied to the database
  - Another variation of INSERT allows insertion of *multiple tuples* resulting from a query into a relation

INSERT (contd.)

- Example: Suppose we want to create a temporary table that has the name, number of employees, and total salaries for each department.
  - A table DEPTS_INFO is created by U3A, and is loaded with the summary information retrieved from the database by the query in U3B.

```
U3A:    CREATE TABLE  DEPTS_INFO
                  (DEPT_NAME                  VARCHAR(10),
                   NO_OF_EMPS                 INTEGER,
                   TOTAL_SAL          INTEGER);


U3B:    INSERT INTO           DEPTS_INFO (DEPT_NAME,
                                      NO_OF_EMPS, TOTAL_SAL)
        SELECT        DNAME, COUNT (*), SUM (SALARY)
        FROM          DEPARTMENT, EMPLOYEE
        WHERE         DNUMBER=DNO
        GROUP BY      DNAME ;
```

DELETE

- Removes tuples from a relation
  - Includes a WHERE-clause to select the tuples to be deleted
  - Referential integrity should be enforced
  - Tuples are deleted from only *one table* at a time (unless CASCADE is specified on a referential integrity constraint)
  - A missing WHERE-clause specifies that *all tuples* in the relation are to be deleted; the table then becomes an empty table
  - The number of tuples deleted depends on the number of tuples in the relation that satisfy the WHERE-clause

DELETE (contd.)

- Examples:

```
U4A:      DELETE FROM     EMPLOYEE
          WHERE           LNAME='Brown’

U4B:      DELETE FROM     EMPLOYEE
          WHERE           SSN='123456789’

U4C:      DELETE FROM     EMPLOYEE
          WHERE           DNO  IN
                                 (SELECT     DNUMBER
                          FROM DEPARTMENT
                          WHERE
                               DNAME='Research')

U4D:      DELETE FROM     EMPLOYEE
```

UPDATE

- Used to modify attribute values of one or more selected tuples
- A WHERE-clause selects the tuples to be modified
- An additional SET-clause specifies the attributes to be modified and their new values
- Each command modifies tuples *in the same relation*
- Referential integrity should be enforced

UPDATE (contd.)

- Example: Change the location and controlling department number of project number 10 to 'Bellaire' and 5, respectively.

```
U5:     UPDATE   PROJECT
        SET      PLOCATION = 'Bellaire',
                 DNUM = 5
        WHERE    PNUMBER=10
```

UPDATE (contd.)

- Example: Give all employees in the 'Research' department a 10% raise in salary.

```
U6:        UPDATE      EMPLOYEE
           SET         SALARY = SALARY *1.1
           WHERE       DNO  IN (SELECT    DNUMBER
                       FROM          DEPARTMENT
                       WHERE         DNAME='Research')
```

- In this request, the modified SALARY value depends on the original SALARY value in each tuple
  - The reference to the SALARY attribute on the right of = refers to the old SALARY value before modification
  - The reference to the SALARY attribute on the left of = refers to the new SALARY value after modification

Recap of SQL Queries

- A query in SQL can consist of up to six clauses, but only the first two, SELECT and FROM, are mandatory. The clauses are specified in the following order:

```
SELECT          <attribute list>
FROM            <table list>
[WHERE          <condition>]
[GROUP BY       <grouping attribute(s)>]
[HAVING         <group condition>]
[ORDER BY       <attribute list>]
```

- There are three SQL commands to modify the database: **INSERT**, **DELETE**, and **UPDATE**

Thank YOU