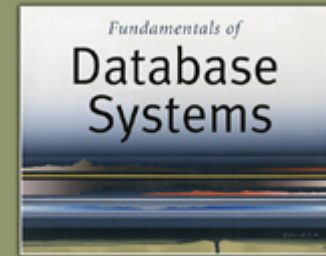


5th Edition

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Chapter 8

SQL-99: SchemaDefinition, Constraints, and Queries and Views



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Data Definition, Constraints, and Schema Changes

- *Used to CREATE, DROP, and ALTER the descriptions of the tables (relations) of 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  );
```

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 DEPENDENT;

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.

Features Added in SQL2 and SQL-99

- *Create schema*
- *Referential integrity options*

CREATE SCHEMA

- *Specifies a new database schema by giving it a name*

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  
    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 ,  
    SUPERSSN       CHAR(9) ,  
    PRIMARY KEY   (ESSN) ,  
    FOREIGN KEY   (DNO) REFERENCES DEPT  
        ON DELETE SET DEFAULT ON UPDATE  
        CASCADE ,  
    FOREIGN KEY   (SUPERSSN) REFERENCES EMP  
        ON DELETE SET NULL ON UPDATE CASCADE) ;
```

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

Additional Data Types in SQL2 and SQL-99 (contd.)

- ***TIMESTAMP:***

- Has both DATE and TIME components

- ***INTERVAL:***

- Specifies a relative value rather than an absolute value
 - Can be DAY/TIME intervals or YEAR/MONTH intervals
 - Can be positive or negative when added to or subtracted from an absolute value, the result is an absolute value

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--Figure 5.5

EMPLOYEE

FNAME	MINIT	LNAME	<u>SSN</u>	BDATE	ADDRESS	SEX	SALARY	SUPERSSN	DNO
-------	-------	-------	------------	-------	---------	-----	--------	----------	-----

DEPARTMENT

DNAME	<u>DNUMBER</u>	MGRSSN	MGRSTARTDATE
-------	----------------	--------	--------------

DEPT_LOCATIONS

<u>DNUMBER</u>	<u>DLOCATION</u>
----------------	------------------

PROJECT

PNAME	<u>PNUMBER</u>	PLOCATION	DNUM
-------	----------------	-----------	------

WORKS_ON

<u>ESSN</u>	<u>PNO</u>	HOURS
-------------	------------	-------

DEPENDENT

<u>ESSN</u>	<u>DEPENDENT_NAME</u>	SEX	BDATE	RELATIONSHIP
-------------	-----------------------	-----	-------	--------------

Populated Database--Fig.5.6

EMPLOYEE	FNAME	MINIT	LNAME	<u>SSN</u>	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
DEPARTMENT					DNUMBER	DLOCATION
DNAME	DNUMBER	MGRSSN	MGRSTARTDATE			
Research	5	333445555	1988-05-22		1	Houston
Administration	4	987654321	1995-01-01		4	Stafford
Headquarters	1	888665555	1981-06-19		5	Bellaire
					5	Sugarland
					5	Houston

WORKS_ON	<u>ESSN</u>	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	<u>PNUMBER</u>	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	<u>ESSN</u>	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: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: 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 numbers 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
          WHERE       DNUM=DNUMBER AND
                   MGRSSN=SSN AND LNAME='Smith')

          UNION

          (SELECT      PNAME
          FROM        PROJECT, WORKS_ON, EMPLOYEE
          WHERE       PNUMBER=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
	EMPLOYEES 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	<i><attribute list></i>
FROM	<i><table list></i>
[WHERE	<i><condition>]</i>
[GROUP BY	<i><grouping attribute(s)>]</i>
[HAVING	<i><group condition>]</i>
[ORDER BY	<i><attribute list>]</i>

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
           FROM      DEPARTMENT, EMPLOYEE
           WHERE     DNUMBER=DNO
           GROUP BY  DNAME ;
```

INSERT (contd.)

- *Note: The DEPTS_INFO table may not be up-to-date if we change the tuples in either the DEPARTMENT or the EMPLOYEE relations after issuing U3B. We have to create a view (see later) to keep such a table up to date.*

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
 WHERE

EMPLOYEE
LNAME='Brown'

U4B: DELETE FROM
 WHERE

EMPLOYEE
SSN='123456789'

U4C: DELETE FROM
 WHERE

EMPLOYEE
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***