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

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1970–E. F. Codd develops relational database concept

1974-1979–System R with Sequel (later SQL) created at IBM Research Lab

1979–Oracle markets first relational DB with SQL

1981 – SQL/DS (Data System) first available RDBMS system on DOS/VSE, Others followed: INGRES (1981), IDM (Intelligent Database machine)(1982), DG/SQL (1984), Sybase (1986)

1986–ANSI SQL standard released

1989, 1992, 1999, 2003, 2006, 2008–Major ANSI standard updates

Current–SQL is supported by most major database vendors

Purpose of SQL Standard

Specify syntax/semantics for data definition and manipulation

Define data structures and basic operations

Enable portability of database definition and application modules

Allow for later growth/enhancement to standard (referential integrity, transaction management, user-defined functions, extended join operations, national character sets)

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 relational DBMS
  - Evolution
    - SQL-86 or SQL1
    - SQL-92 or SQL2
    - SQL-99

Features Added in SQL2 and SQL-99

- Create schema
- Referential integrity options

CREATE SCHEMA

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

- Authorization identifier – user or account who owns the schema and the descriptors for each element (tables, constraints, domains and other constraints) in the schema

Data Definition, Constraints, and Schema Change

- 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;

Four choices for maintaining referential integrity

- **CASCADE**: make same update to child as made to parent
- **SET NULL**: set the child value to NULL when the parent is updated
- **SET DEFAULT**: set the child value to its DEFAULT when the parent is updated
- **Restrict (NO ACTION)**: prevent parent from being updated if children are affected

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);
```

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 (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(DNUMBER) ON DELETE SET DEFAULT ON UPDATE CASCADE,

FOREIGN KEY (SUPERSSN) REFERENCES EMP(ESSN) ON DELETE SET NULL 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));
```

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.

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.

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

- 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 MyUniqueConstraint;

ALTER TABLE

- to DROP CONSTRAINT from a table is as follows.
  - ALTER TABLE table_name DROP CONSTRAINT MyUniqueConstraint;

- 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,...);

- UPDATE *table_name*
  SET *column1 = value1, column2 = value2, ...*
  WHERE *condition*;

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

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:  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 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
        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

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) )
```

- 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
  - 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

SUBQUERIES AND COMPARISON OPERATORS

- The general form of the WHERE clause with a comparison operator is similar to that used thus far in the text.
- Note that the subquery is again enclosed by parentheses.

WHERE <expression> <comparison_operator> (subquery)

SUBQUERIES AND COMPARISON OPERATORS

- examine a subquery that will not execute because it violates the "single value" rule.
- The query shown below returns multiple values for the *emp_salary* column.

```
SELECT emp_salary
FROM employee
   WHERE emp_salary > 40000;
EMP_SALARY
------------------
         55000
43000
43000
```

SUBQUERIES AND COMPARISON OPERATORS

- If we substitute this query as a subquery in another SELECT statement, then that SELECT statement will fail.
- This is demonstrated in the next SELECT statement. Here the SQL code will fail because the subquery uses the greater than (>) comparison operator and the subquery returns multiple values.

```
SELECT emp_ssn
FROM employee
   WHERE emp_salary >
  (SELECT emp_salary
   FROM employee
      WHERE emp_salary > 40000);
```

ERROR at line 4:

ORA-01427: single-row subquery returns more than one row

Comparison Operators Modified with the ALL or ANY Keywords

- The ALL and ANY keywords can modify a comparison operator to allow an outer query to accept multiple values from a subquery.
- The general form of the WHERE clause for this type of query is shown here.

```
WHERE <expression> <comparison_operator> [ALL |       ANY] (subquery)
```

- Subqueries that use these keywords may also include GROUP BY and HAVING clauses.

The ALL Keyword

- The ALL keyword modifies the greater than comparison operator to mean greater than all values.

```
SELECT emp_last_name "Last Name",
   emp_first_name "First Name",
   emp_salary "Salary"
FROM employee
WHERE emp_salary > ALL
   (SELECT emp_salary
      FROM employee
      WHERE emp_dpt_number = 7);
```

Last Name	First Name	Salary
Bordoloi	Bijoy	$55,000

The ANY Keyword

- The ANY keyword is not as restrictive as the ALL keyword.
- When used with the greater than comparison operator, "> ANY" means greater than some value.

Example

```
SELECT emp_last_name "Last Name",
   emp_first_name "First Name",
   emp_salary "Salary"
FROM employee
WHERE emp_salary > ANY
   (SELECT emp_salary
      FROM employee
      WHERE emp_salary > 30000);
```

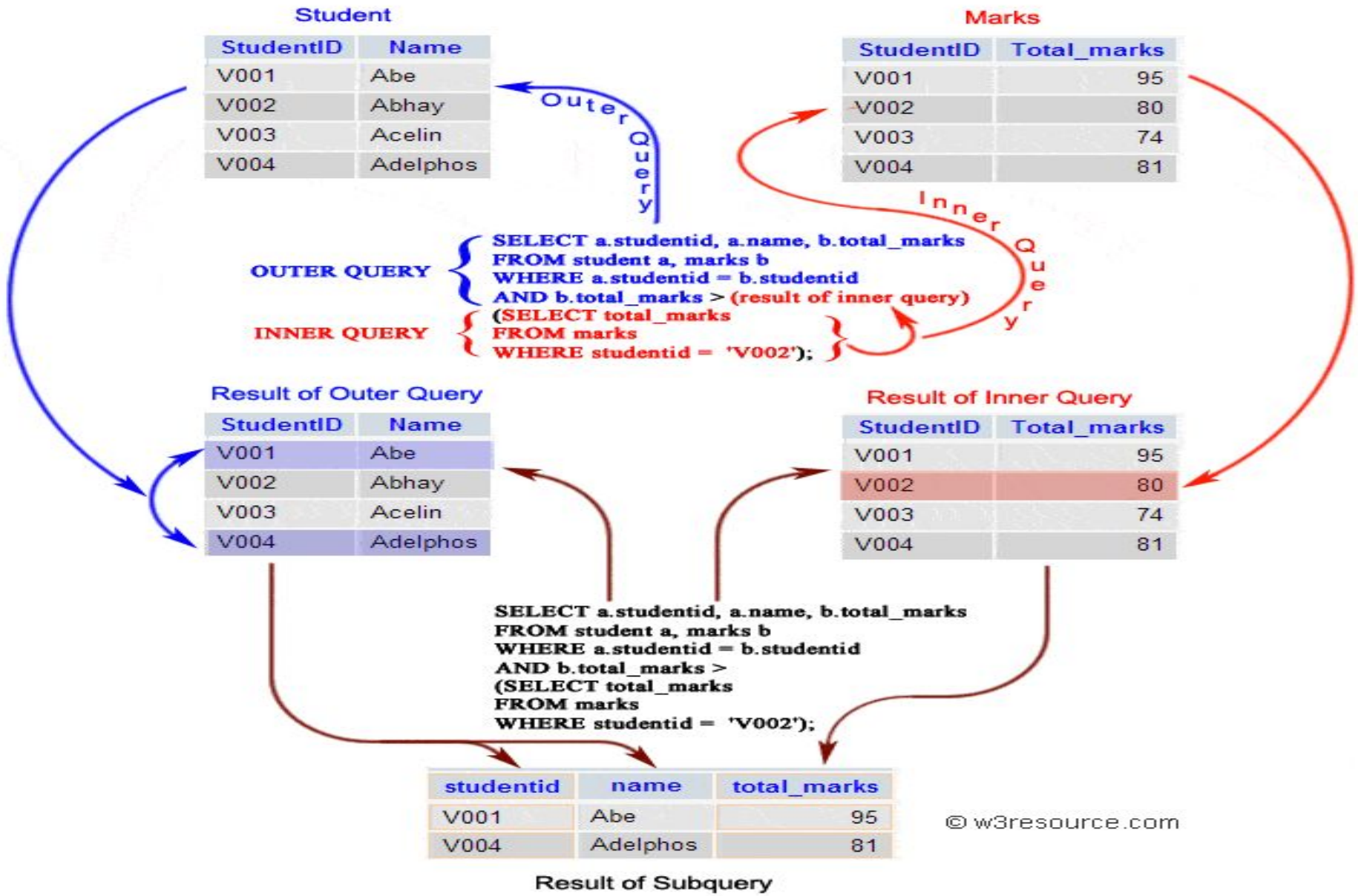
Last Name	First Name	Salary
Bordoloi	Bijoy	$55,000
Joyner	Suzanne	$43,000
Zhu	Waiman	$43,000

An "= ANY" (Equal Any) Example

- The "= ANY" operator is exactly equivalent to the IN operator.
- For example, to find the names of employees that have male dependents, you can use either IN or "= ANY" – both of the queries shown below will produce an identical result table.

```
SELECT emp_last_name "Last Name", emp_first_name "First Name"
FROM employee
WHERE emp_ssn IN
   (SELECT dep_emp_ssn
    FROM dependent
    WHERE dep_gender = 'M');

SELECT emp_last_name "Last Name", emp_first_name "First Name"
FROM employee
WHERE emp_ssn = ANY
   (SELECT dep_emp_ssn
    FROM dependent
    WHERE dep_gender = 'M');
```


Student
StudentID Name
V001 Abe
V002 Abhay
V003 Acelin
V004 Adelphos
Outer Query
Marks
StudentID Total_marks
V001 95
V002 80
V003 74
V004 81
Inner Query
OUTER QUERY
SELECT a.studentid, a.name, b.total_marks
FROM student a, marks b
WHERE a.studentid = b.studentid
AND b.total_marks > (result of inner query)
INNER QUERY
(SELECT total_marks
FROM marks
WHERE studentid = 'V002');
Result of Outer Query
StudentID Name
V001 Abe
V002 Abhay
V003 Acelin
V004 Adelphos
Result of Inner Query
StudentID Total_marks
V001 95
V002 80
V003 74
V004 81
SELECT a.studentid, a.name, b.total_marks
FROM student a, marks b
WHERE a.studentid = b.studentid
AND b.total_marks >
(SELECT total_marks
FROM marks
WHERE studentid = 'V002');
studentid name total_marks
V001 Abe 95
V004 Adelphos 81
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Result of Subquery

>ANY means greater than at least one value,
that is, greater than the minimum.

WHERE 70 > ANY (20, 5, 69, 56, 15, 10);

So >ANY (20,56,5,15,69,10) means greater than 5.

So 70 >5 is true, and data returns.

< ANY means less than at least one value,
that is, less than the maximum.

WHERE 70 < ANY (20, 5, 69, 56, 15, 10);

So <ANY (20,56,5,15,69,10) means less than 69.

So 70 < 69 is false, and no data returns.

>ANY means greater than at least one value,
that is, greater than the minimum.

WHERE 4 > ANY (20, 5, 69, 56, 15, 10);

So >ANY (20,56,5,15,69,10) means greater than 5.

So 4 >5 is false, and no data returns.

< ANY means less than at least one value,
that is, less than the maximum.

WHERE 4 < ANY (20, 5, 69, 56, 15, 10);

So <ANY (20,56,5,15,69,10) means less than 69.

So 4 < 69 is true, and data returns.

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
```

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