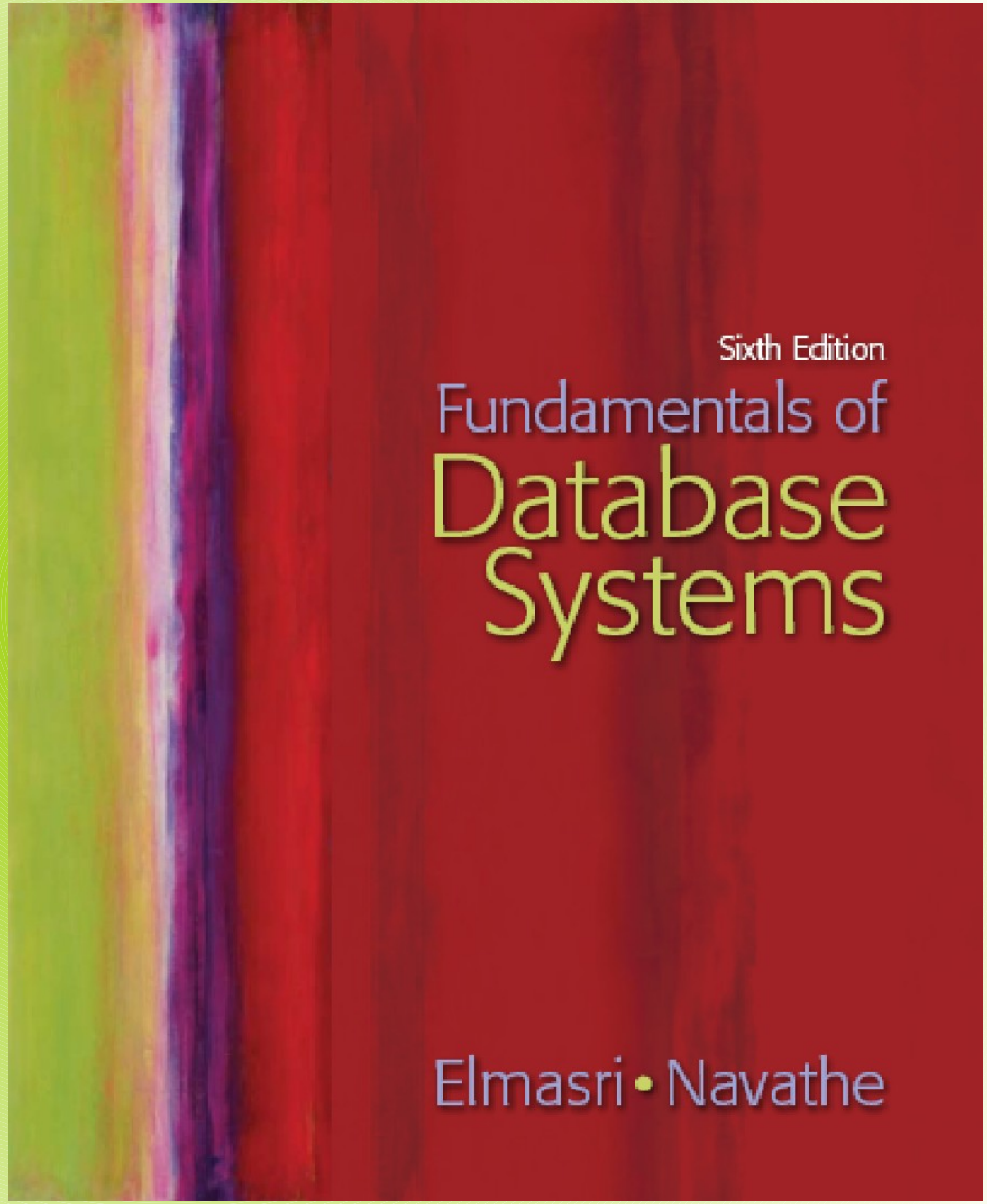
Chapter 4

Basic SQL



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Chapter 4 Outline

SQL Data Definition and Data Types

Specifying Constraints in SQL

Basic Retrieval Queries in SQL

`INSERT`, `DELETE`, and `UPDATE` Statements in SQL

Additional Features of SQL

Basic SQL

SQL language

Considered one of the major reasons for the commercial success of relational databases

SQL

Structured Query Language

Statements for data definitions, queries, and updates (both DDL and DML)

Core specification

Plus specialized **extensions**

SQL Data Definition and Data Types

Terminology:

Table, **row**, and **column** used for relational model terms relation, tuple, and attribute

`CREATE` statement

Main SQL command for data definition

Schema and Catalog Concepts in SQL

SQL schema

- Identified by a **schema name**
- Includes an **authorization identifier** and **descriptors** for each element

Schema **elements** include

- Tables, constraints, views, domains, and other constructs

Each statement in SQL ends with a semicolon

Schema and Catalog Concepts in SQL (cont'd.)

`CREATE SCHEMA` statement

```
CREATE SCHEMA COMPANY
AUTHORIZATION 'Jsmith';
```

Catalog

Named collection of schemas in an SQL environment

SQL **environment**

Installation of an SQL-compliant RDBMS on a computer system

The CREATE TABLE Command in SQL

Specify a new relation

- Provide name
- Specify attributes and initial constraints

Can optionally specify schema:

```
CREATE TABLE COMPANY.EMPLOYEE ...
```

or

```
CREATE TABLE EMPLOYEE ...
```

The CREATE TABLE Command in SQL (cont'd.)

Base tables (**base relations**)

Relation and its tuples are actually created and stored as a file by the DBMS

Virtual relations

Created through the `CREATE VIEW` statement

```
CREATE TABLE EMPLOYEE
        ( Fname          VARCHAR(15)        NOT NULL,
          Minit          CHAR,
          Lname          VARCHAR(15)        NOT NULL,
          Ssn            CHAR(9)            NOT NULL,
          Bdate          DATE,
          Address        VARCHAR(30),
          Sex            CHAR,
          Salary         DECIMAL(10,2),
          Super_ssn      CHAR(9),
          Dno            INT                NOT NULL,
        PRIMARY KEY (Ssn),
        FOREIGN KEY (Super_ssn) REFERENCES EMPLOYEE(Ssn),
        FOREIGN KEY (Dno) REFERENCES DEPARTMENT(Dnumber) );
CREATE TABLE DEPARTMENT
        ( Dname          VARCHAR(15)        NOT NULL,
          Dnumber        INT                NOT NULL,
          Mgr_ssn        CHAR(9)            NOT NULL,
          Mgr_start_date DATE,
        PRIMARY KEY (Dnumber),
        UNIQUE (Dname),
        FOREIGN KEY (Mgr_ssn) REFERENCES EMPLOYEE(Ssn) );
```

Figure 4.1
SQL CREATE TABLE data definition statements for defining the COMPANY schema from Figure 3.7.

```
CREATE TABLE DEPT_LOCATIONS
        ( Dnumber           INT             NOT NULL,
          Dlocation         VARCHAR(15)     NOT NULL,
        PRIMARY KEY (Dnumber, Dlocation),
        FOREIGN KEY (Dnumber) REFERENCES DEPARTMENT(Dnumber) );
CREATE TABLE PROJECT
        ( Pname             VARCHAR(15)     NOT NULL,
          Pnumber           INT             NOT NULL,
          Plocation         VARCHAR(15),
          Dnum              INT             NOT NULL,
        PRIMARY KEY (Pnumber),
        UNIQUE (Pname),
        FOREIGN KEY (Dnum) REFERENCES DEPARTMENT(Dnumber) );
CREATE TABLE WORKS_ON
        ( Essn              CHAR(9)         NOT NULL,
          Pno               INT             NOT NULL,
          Hours             DECIMAL(3,1)    NOT NULL,
        PRIMARY KEY (Essn, Pno),
        FOREIGN KEY (Essn) REFERENCES EMPLOYEE(Ssn),
        FOREIGN KEY (Pno) REFERENCES PROJECT(Pnumber) );
CREATE TABLE DEPENDENT
        ( Essn              CHAR(9)         NOT NULL,
          Dependent_name    VARCHAR(15)     NOT NULL,
          Sex               CHAR,
          Bdate             DATE,
          Relationship      VARCHAR(8),
        PRIMARY KEY (Essn, Dependent_name),
        FOREIGN KEY (Essn) REFERENCES EMPLOYEE(Ssn) );
```

Figure 4.1
SQL CREATE TABLE data definition statements for defining the COMPANY schema from Figure 3.7.

The CREATE TABLE Command in SQL (cont'd.)

Some foreign keys may cause errors

Specified either via:

- Circular references
- Or because they refer to a table that has not yet been created

Attribute Data Types and Domains in SQL

Basic **data types**

Numeric data types

- Integer numbers: `INTEGER`, `INT`, and `SMALLINT`
- Floating-point (real) numbers: `FLOAT` or `REAL`, and `DOUBLE PRECISION`

Character-string data types

- Fixed length: `CHAR(`*n*`)`, `CHARACTER(`*n*`)`
- Varying length: `VARCHAR(`*n*`)`, `CHAR VARYING(`*n*`)`, `CHARACTER VARYING(`*n*`)`

Attribute Data Types and Domains in SQL (cont'd.)

Bit-string data types

- Fixed length: `BIT(`*n*`)`
- Varying length: `BIT VARYING(`*n*`)`

Boolean data type

- Values of `TRUE` or `FALSE` or `NULL`

DATE data type

- Ten positions
- Components are `YEAR`, `MONTH`, and `DAY` in the form YYYY-MM-DD

Attribute Data Types and Domains in SQL (cont'd.)

Additional data types

Timestamp data type (`TIMESTAMP`)

- Includes the `DATE` and `TIME` fields
- Plus a minimum of six positions for decimal fractions of seconds
- Optional `WITH TIME ZONE` qualifier

`INTERVAL` data type

- Specifies a relative value that can be used to increment or decrement an absolute value of a date, time, or timestamp

Attribute Data Types and Domains in SQL (cont'd.)

Domain

- Name used with the attribute specification
- Makes it easier to change the data type for a domain that is used by numerous attributes
- Improves schema readability
- Example:
  - `CREATE DOMAIN SSN_TYPE AS CHAR(9);`

Specifying Constraints in SQL

Basic constraints:

- Key and referential integrity constraints
- Restrictions on attribute domains and NULLs
- Constraints on individual tuples within a relation

Specifying Attribute Constraints and Attribute Defaults

`NOT NULL`

`NULL` is not permitted for a particular attribute

Default value

`DEFAULT` `<value>`

`CHECK` clause

```
Dnumber INT NOT NULL CHECK
(Dnumber > 0 AND Dnumber < 21);
```

```
CREATE TABLE EMPLOYEE
    (  . . . ,
       Dno        INT            NOT NULL        DEFAULT 1,
    CONSTRAINT EMPPK
       PRIMARY KEY (Ssn),
    CONSTRAINT EMPSUPERFK
       FOREIGN KEY (Super_ssn) REFERENCES EMPLOYEE(Ssn)
                    ON DELETE SET NULL          ON UPDATE CASCADE,
    CONSTRAINT EMPDEPTFK
       FOREIGN KEY(Dno) REFERENCES DEPARTMENT(Dnumber)
                    ON DELETE SET DEFAULT       ON UPDATE CASCADE);
CREATE TABLE DEPARTMENT
    (  . . . ,
       Mgr_ssn    CHAR(9)        NOT NULL        DEFAULT '888665555',
       . . . ,
    CONSTRAINT DEPTPK
       PRIMARY KEY(Dnumber),
    CONSTRAINT DEPTSK
       UNIQUE (Dname),
    CONSTRAINT DEPTMGRFK
       FOREIGN KEY (Mgr_ssn) REFERENCES EMPLOYEE(Ssn)
                    ON DELETE SET DEFAULT   ON UPDATE CASCADE);
CREATE TABLE DEPT_LOCATIONS
    (  . . . ,
    PRIMARY KEY (Dnumber, Dlocation),
    FOREIGN KEY (Dnumber) REFERENCES DEPARTMENT(Dnumber)
                    ON DELETE CASCADE           ON UPDATE CASCADE);
```

Figure 4.2
Example illustrating how default attribute values and referential integrity triggered actions are specified in SQL.

Specifying Key and Referential Integrity Constraints

PRIMARY KEY clause

Specifies one or more attributes that make up the primary key of a relation

```
Dnumber INT PRIMARY KEY;
```

UNIQUE clause

Specifies alternate (secondary) keys

```
Dname VARCHAR(15) UNIQUE;
```

Specifying Key and Referential Integrity Constraints (cont'd.)

`FOREIGN KEY` clause

Default operation: reject update on violation

Attach **referential triggered action** clause

- Options include `SET NULL`, `CASCADE`, and `SET DEFAULT`
- Action taken by the DBMS for `SET NULL` or `SET DEFAULT` is the same for both `ON DELETE` and `ON UPDATE`
- `CASCADE` option suitable for "relationship" relations

Giving Names to Constraints

Keyword **`CONSTRAINT`**

- Name a constraint
- Useful for later altering

Specifying Constraints on Tuples Using CHECK

- `CHECK` clauses at the end of a `CREATE TABLE` statement
  - Apply to each tuple individually

```
CHECK (Dept_create_date <=
Mgr_start_date);
```

Basic Retrieval Queries in SQL

- `SELECT` statement
  - One basic statement for retrieving information from a database
- SQL allows a table to have two or more tuples that are identical in all their attribute values
  - Unlike relational model
  - Multiset or bag behavior

The SELECT-FROM-WHERE Structure of Basic SQL Queries

Basic form of the SELECT statement:

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

where

- <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.

The SELECT-FROM-WHERE Structure of Basic SQL Queries (cont'd.)

Logical comparison operators

=, <, <=, >, >=, and <>

Projection attributes

Attributes whose values are to be retrieved

Selection condition

Boolean condition that must be true for any retrieved tuple

Figure 4.3
Results of SQL queries when applied to the COMPANY database state shown in Figure 3.6. (a) Q0. (b) Q1. (c) Q2. (d) Q8. (e) Q9. (f) Q10. (g) Q1C.

(a)

Bdate	Address
1965-01-09	731Fondren, Houston, TX

(b)

Fname	Lname	Address
John	Smith	731 Fondren, Houston, TX
Franklin	Wong	638 Voss, Houston, TX
Ramesh	Narayan	975 Fire Oak, Humble, TX
Joyce	English	5631 Rice, Houston, TX

Query 0. Retrieve the birth date and address of the employee(s) whose name is 'John B. Smith'.

```
Q0:   SELECT   Bdate, Address
      FROM     EMPLOYEE
      WHERE    Fname='John' AND Minit='B' AND Lname='Smith';
```

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;
```

Figure 4.3
Results of SQL queries when applied to the COMPANY database state shown in Figure 3.6. (a) Q0. (b) Q1. (c) Q2. (d) Q8. (e) Q9. (f) Q10. (g) Q1C.

(c)

Pnumber	Dnum	Lname	Address	Bdate
10	4	Wallace	291Berry, Bellaire, TX	1941-06-20
30	4	Wallace	291Berry, Bellaire, TX	1941-06-20

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 birth date.

```
Q2:   SELECT   Pnumber, Dnum, Lname, Address, Bdate
      FROM     PROJECT, DEPARTMENT, EMPLOYEE
      WHERE    Dnum=Dnumber AND Mgr_ssn=Ssn AND
               Plocation='Stafford';
```

Ambiguous Attribute Names[28]

Same name can be used for two (or more) attributes

As long as the attributes are in different relations

Must **qualify** the attribute name with the relation name to prevent ambiguity

```
Q1A:  SELECT  Fname, EMPLOYEE.Name, Address
      FROM    EMPLOYEE, DEPARTMENT
      WHERE   DEPARTMENT.Name='Research' AND
              DEPARTMENT.Dnumber=EMPLOYEE.Dnumber;
```

Aliasing, Renaming, and Tuple Variables

Aliases or **tuple variables**

Declare alternative relation names E and S

```
EMPLOYEE AS E(Fn, Mi, Ln, Ssn, Bd,
Addr, Sex, Sal, Sssn, Dno)
```

Query 8. For each employee, retrieve the employee's first and last name and the first and last name of his or her immediate supervisor.

```
Q8:   SELECT   E.Fname, E.Lname, S.Fname, S.Lname
      FROM     EMPLOYEE AS E, EMPLOYEE AS S
      WHERE    E.Super_ssn=S.Ssn;
```

Aliasing, Renaming, and Tuple Variables

Query 8. For each employee, retrieve the employee's first and last name and the first and last name of his or her immediate supervisor.

```
Q8:   SELECT   E.Fname, E.Lname, S.Fname, S.Lname
      FROM     EMPLOYEE AS E, EMPLOYEE AS S
      WHERE    E.Super_ssn=S.Ssn;
```

E.Fname	E.Lname	S.Fname	S.Lname
John	Smith	Franklin	Wong
Franklin	Wong	James	Borg
Alicia	Zelaya	Jennifer	Wallace
Jennifer	Wallace	James	Borg
Ramesh	Narayan	Franklin	Wong
Joyce	English	Franklin	Wong
Ahmad	Jabbar	Jennifer	Wallace

Unspecified WHERE Clause and Use of the Asterisk

Missing `WHERE` clause

Indicates no condition on tuple selection

`CROSS PRODUCT`

All possible tuple combinations

Queries 9 and 10. Select all EMPLOYEE Ssns (Q9) and all combinations of EMPLOYEE Ssn and DEPARTMENT Dname (Q10) in the database.

```
Q9:     SELECT    Ssn
        FROM      EMPLOYEE;

Q10:    SELECT    Ssn, Dname
        FROM      EMPLOYEE, DEPARTMENT;
```

Unspecified WHERE Clause and Use of the Asterisk

Q9

E.Fname
123456789
333445555
999887777
987654321
666884444
453453453
987987987
888665555

Q10

Ssn	Dname
123456789	Research
333445555	Research
999887777	Research
987654321	Research
666884444	Research
453453453	Research
987987987	Research
888665555	Research
123456789	Administration
333445555	Administration
999887777	Administration
987654321	Administration
666884444	Administration
453453453	Administration
987987987	Administration
888665555	Administration
123456789	Headquarters
333445555	Headquarters
999887777	Headquarters
987654321	Headquarters
666884444	Headquarters
453453453	Headquarters
987987987	Headquarters
888665555	Headquarters

Unspecified WHERE Clause and Use of the Asterisk (cont'd.)

- Specify an asterisk (*)
  - Retrieve all the attribute values of the selected tuples

```
Q1C:    SELECT    *
        FROM      EMPLOYEE
        WHERE     Dno=5;

Q1D:    SELECT    *
        FROM      EMPLOYEE, DEPARTMENT
        WHERE     Dname='Research' AND Dno=Dnumber;

Q10A:   SELECT    *
        FROM      EMPLOYEE, DEPARTMENT;
```

Tables as Sets in SQL

- SQL does not automatically eliminate duplicate tuples in query results
- Use the keyword **`DISTINCT`** in the `SELECT` clause
  - Only distinct tuples should remain in the result

Query 11. Retrieve the salary of every employee (Q11) and all distinct salary values (Q11A).

```
Q11:    SELECT    ALL Salary
        FROM      EMPLOYEE;

Q11A:   SELECT    DISTINCT Salary
        FROM      EMPLOYEE;
```

Tables as Sets in SQL

Figure 4.4
Results of additional SQL queries when applied to the COMPANY database state shown in Figure 3.6. (a) Q11. (b) Q11A.

(a)

Salary
30000
40000
25000
43000
38000
25000
25000
55000

(b)

Salary
30000
40000
25000
43000
38000
55000

Tables as Sets in SQL (cont'd.)

Set operations

UNION, **EXCEPT** (difference), **INTERSECT**

Corresponding multiset operations: UNION ALL, EXCEPT ALL, INTERSECT ALL)

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

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

Substring Pattern Matching and Arithmetic Operators

- **`LIKE`** comparison operator
  - Used for string **pattern matching**
  - % replaces an arbitrary number of zero or more characters
  - underscore (_) replaces a single character
- Standard arithmetic operators:
  - Addition (+), subtraction (–), multiplication (*), and division (/)
- **`BETWEEN`** comparison operator

Substring Pattern Matching and Arithmetic Operators

Query 12. Retrieve all employees whose address is in Houston, Texas.

```
Q12:    SELECT    Fname, Lname
        FROM      EMPLOYEE
        WHERE     Address LIKE '%Houston,TX%';
```

Query 12A. Find all employees who were born during the 1950s.

```
Q12:    SELECT    Fname, Lname
        FROM      EMPLOYEE
        WHERE     Bdate LIKE '_ _ 5 _ _ _ _ _ _ _';
```

Query 13. Show the resulting salaries if every employee working on the 'ProductX' project is given a 10 percent raise.

```
Q13:    SELECT    E.Fname, E.Lname, 1.1 * E.Salary AS Increased_sal
        FROM      EMPLOYEE AS E, WORKS_ON AS W, PROJECT AS P
        WHERE     E.Ssn=W.Essn AND W.Pno=P.Pnumber AND
                  P.Pname='ProductX';
```

Query 14. Retrieve all employees in department 5 whose salary is between $30,000 and $40,000.

```
Q14:    SELECT    *
        FROM      EMPLOYEE
        WHERE     (Salary BETWEEN 30000 AND 40000) AND Dno = 5;
```

Ordering of Query Results 39

Use **ORDER BY** clause

Keyword **DESC** to see result in a descending order of values

Keyword **ASC** to specify ascending order explicitly

```
ORDER BY D.Dname DESC, E.Lname ASC,
E.Fname ASC
```

Query 15. Retrieve a list of employees and the projects they are working on ordered by department and, within each department, ordered alphabetically by last name, then first name.

```
Q15:  SELECT    D.Dname, E.Lname, E.Fname, P.Pname
      FROM      DEPARTMENT D, EMPLOYEE E, WORKS_ON W,
                PROJECT P
      WHERE     D.Dnumber= E.Dno AND E.Ssn= W.Essn AND
                W.Pno= P.Pnumber
      ORDER BY  D.Dname, E.Lname, E.Fname;
```

Discussion and Summary of Basic SQL Retrieval Queries


```
SELECT      <attribute list>
FROM        <table list>
[ WHERE     <condition> ]
[ ORDER BY <attribute list> ];
```

INSERT, DELETE, and UPDATE Statements in SQL

Three commands used to modify the database:

`INSERT`, `DELETE`, and `UPDATE`

The INSERT Command

Specify the relation name and a list of values for the tuple

```
U1:   INSERT INTO   EMPLOYEE
      VALUES        ( 'Richard', 'K', 'Marini', '653298653', '1962-12-30', '98
                      Oak Forest, Katy, TX', 'M', 37000, '653298653', 4 );
```

```
U1A:  INSERT INTO   EMPLOYEE (Fname, Lname, Dno, Ssn)
      VALUES        ('Richard', 'Marini', 4, '653298653');
```

The INSERT Command


```
U3A:   CREATE TABLE     WORKS_ON_INFO
       ( Emp_name       VARCHAR(15),
         Proj_name      VARCHAR(15),
         Hours_per_week DECIMAL(3,1) );
```

```
U3B:   INSERT INTO  WORKS_ON_INFO ( Emp_name, Proj_name,
                    Hours_per_week )
       SELECT       E.Lname, P.Pname, W.Hours
       FROM         PROJECT P, WORKS_ON W, EMPLOYEE E
       WHERE        P.Pnumber=W.Pno AND W.Essn=E.Ssn;
```

The DELETE Command

Removes tuples from a relation

Includes a `WHERE` clause to select the tuples to be deleted

```
U4A:  DELETE FROM  EMPLOYEE
      WHERE        Lname='Brown';

U4B:  DELETE FROM  EMPLOYEE
      WHERE        Ssn='123456789';

U4C:  DELETE FROM  EMPLOYEE
      WHERE        Dno=5;

U4D:  DELETE FROM  EMPLOYEE;
```

The UPDATE Command

Modify attribute values of one or more selected tuples

Additional **SET** clause in the UPDATE command

Specifies attributes to be modified and new val

```
U5:   UPDATE   PROJECT
      SET      Plocation = 'Bellaire', Dnum = 5
      WHERE    Pnumber=10;
```

```
U6:   UPDATE   EMPLOYEE
      SET      Salary = Salary * 1.1
      WHERE    Dno = 5;
```

Additional Features of SQL

- Techniques for specifying complex retrieval queries
- Writing programs in various programming languages that include SQL statements
- Set of commands for specifying physical database design parameters, file structures for relations, and access paths
- Transaction control commands

Additional Features of SQL (cont'd.)

- Specifying the granting and revoking of privileges to users
- Constructs for creating triggers
- Enhanced relational systems known as object-relational
- New technologies such as XML and OLAP

Summary

SQL

- Comprehensive language
- Data definition, queries, updates, constraint specification, and view definition

Covered in Chapter 4:

- Data definition commands for creating tables
- Commands for constraint specification
- Simple retrieval queries
- Database update commands