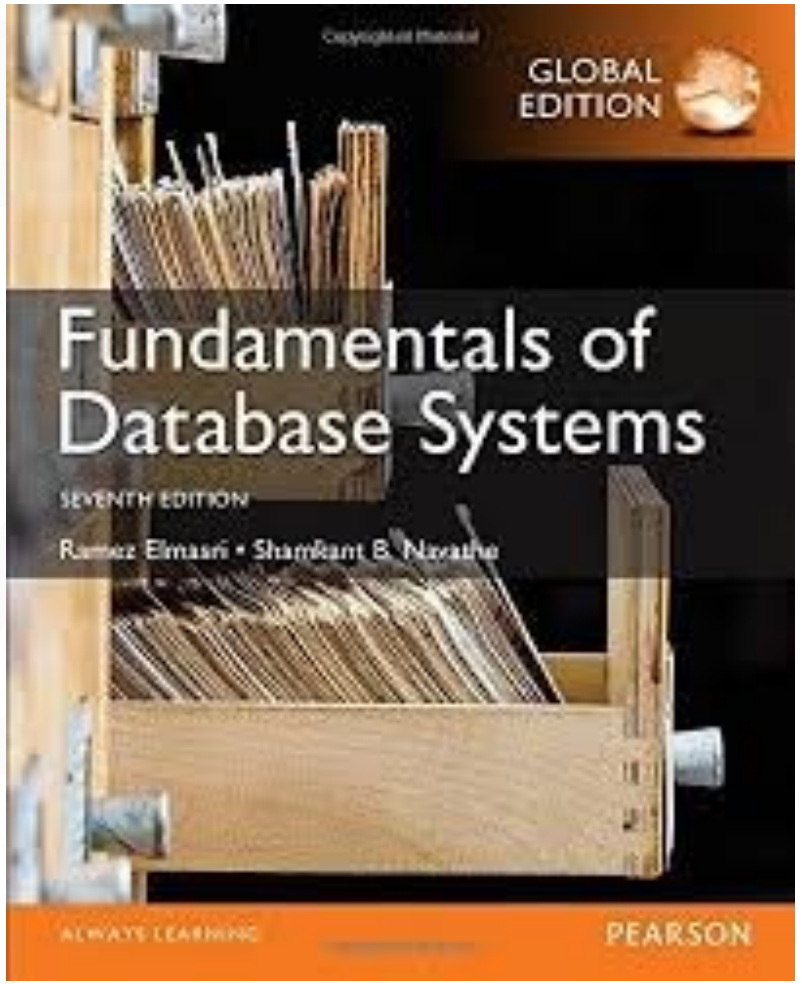
Database Systems

Program in Computer Engineering
Faculty of Engineering

King Mongkut's Institute of Technology Ladkrabang

Text

- Ramez Elmasri and Shamkant B. Navathe. "Fundamentals of Database Systems" 7th Edition., Pearson, 2017



Chapter 6

Basic SQL

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
  - Now popularly known as "Structured Query language".
  - SQL is an informal or practical rendering of the relational data model with syntax

SQL Data Definition, Data Types, Standards

- Terminology:
  - **Table**, **row**, and **column** used for relational model terms **relation**, **tuple**, and **attribute**
- **CREATE** statement
  - Main SQL command for data definition
- The language has features for :
  Data definition, Data Manipulation, Transaction control (Transact-SQL, Ch. 20), Indexing (Ch.17), Security specification (Grant and Revoke- see Ch.30), Active databases (Ch.26), Multi-media (Ch.26), Distributed databases (Ch.23) etc.

SQL Standards

- SQL has gone through many standards: starting with SQL-86 or SQL 1.A. SQL-92 is referred to as SQL-2.
- Later standards (from SQL-1999) are divided into **core** specification and specialized **extensions**. The extensions are implemented for different applications – such as data mining, data warehousing, multimedia etc.
- SQL-2006 added XML features (Ch. 13); In 2008 they added Object-oriented features (Ch. 12).
- SQL-3 is the current standard which started with SQL-1999. It is not fully implemented in any RDBMS.

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**

- **CREATE SCHEMA** statement
  - `CREATE SCHEMA COMPANY AUTHORIZATION 'Jsmith';`
- **Catalog**
  - Named collection of schemas in an SQL environment
- SQL also has the concept of a cluster of catalogs.

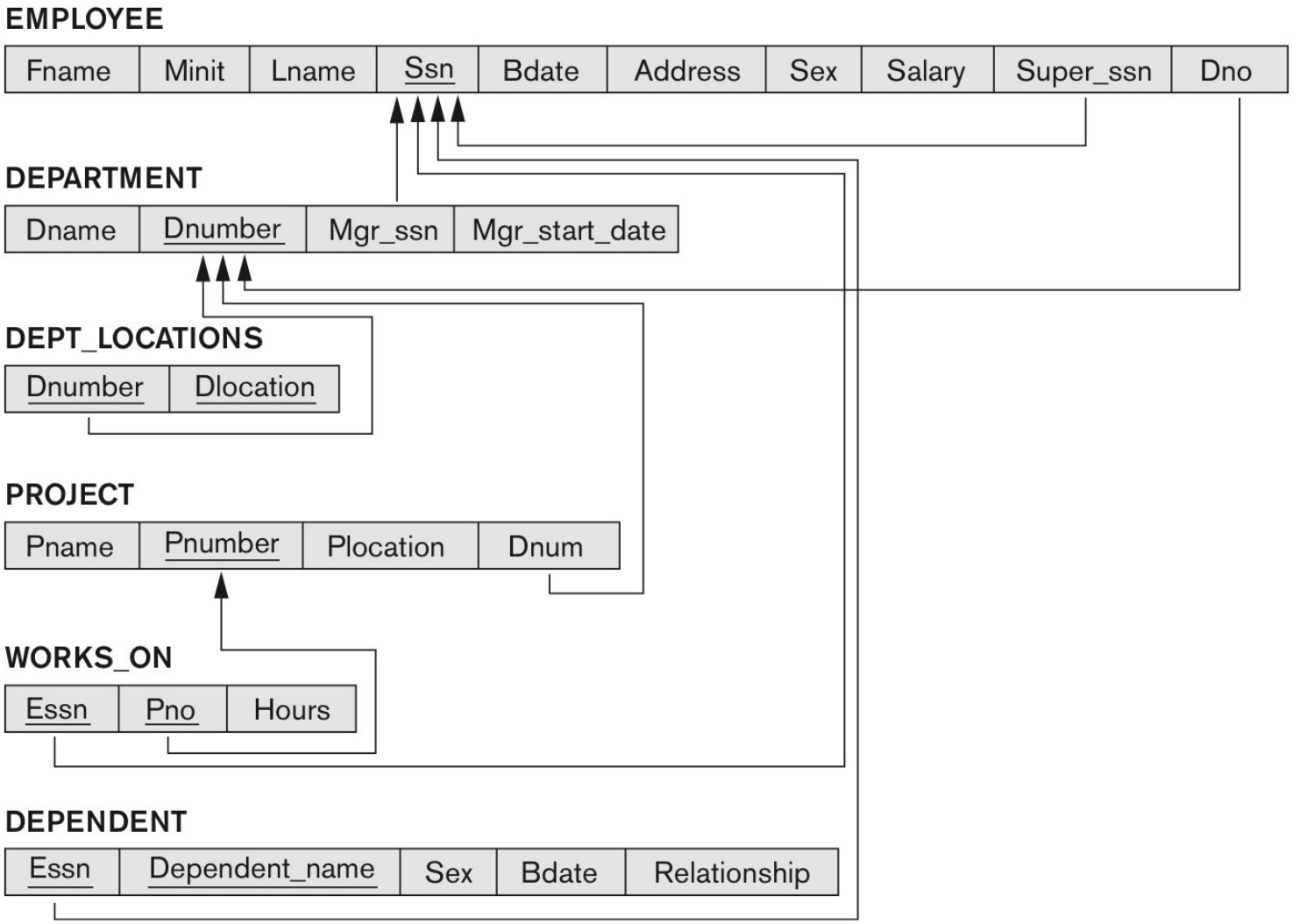
The CREATE TABLE Command in SQL

- Specifying a new relation
  - Provide name of table
  - Specify attributes, their types and initial constraints
- Can optionally specify schema:
  - `CREATE TABLE COMPANY.EMPLOYEE ...`

    or
  - `CREATE TABLE EMPLOYEE ...`

- **Base tables** (**base relations**)
  - Relation and its tuples are actually created and stored as a file by the DBMS
- **Virtual relations** **(views)**
  - Created through the `CREATE VIEW` statement.
    Do not correspond to any physical file.

COMPANY relational database schema (Fig. 5.7)



One possible database state for the COMPANY relational database schema (Fig. 5.6)

EMPLOYEE

Fname	Minit	Lname	Ssn	Bdate	Address	Sex	Salary	Super_ssn	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	1968-01-19	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

DEPARTMENT

Dname	Dnumber	Mgr_ssn	Mgr_start_date
Research	5	333445555	1988-05-22
Administration	4	987654321	1995-01-01
Headquarters	1	888665555	1981-06-19

DEPT_LOCATIONS

Dnumber	Dlocation
1	Houston
4	Stafford
5	Bellaire
5	Sugarland
5	Houston

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

SQL CREATE TABLE data definition statements for defining the COMPANY schema from Figure 5.7 (Fig. 6.1)

```
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),
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) );
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) );
```

- Some foreign keys may cause errors
  - Specified either via:
    - Circular references
    - Or because they refer to a table that has not yet been created
  - DBA's have ways to stop referential integrity enforcement to get around this problem.

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*`)`

- **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
  - Multiple mapping functions available in RDBMSs to change date formats

- Additional data types
  - **Timestamp** data type
    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
  - **DATE**, **TIME**, **Timestamp**, **INTERVAL** data types can be **cast** or converted to string formats for comparison.

- **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);`
- **TYPE**
  - User Defined Types (UDTs) are supported for object-oriented applications. (See Ch.12) Uses the command: `CREATE TYPE`

Specifying Constraints in SQL

Basic constraints:

- Relational Model has 3 basic constraint types that are supported in SQL:
  - **Key** constraint: A primary key value cannot be duplicated
  - **Entity Integrity** Constraint: A primary key value cannot be null
  - **Referential integrity** constraints : The "foreign key " must have a value that is already present as a primary key, or may be null.

Specifying Attribute Constraints

Other Restrictions on attribute domains:

- Default value of an attribute
  - **DEFAULT** <value>
  - **NULL** is not permitted for a particular attribute (NOT NULL)
- **CHECK** clause
  - Dnumber INT NOT NULL CHECK (Dnumber > 0 AND Dnumber < 21);

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 (called CANDIDATE keys in the relational model).
  - `Dname VARCHAR(15) UNIQUE;`

- **`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

- Using the keyword `CONSTRAINT`
  - Name a constraint
  - Useful for later altering

Default attribute values and referential integrity triggered action specification (Fig. 6.2)

```
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);
```

Specifying Constraints on Tuples Using CHECK

- Additional Constraints on individual tuples within a relation are also possible 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 (relational model is strictly set-theory based)
  - Multiset or bag behavior
  - Tuple-id may be used as a key

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.

- 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. Selection conditions include join conditions (see Ch.8) when multiple relations are involved.

Basic Retrieval Queries

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';
```

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

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;
```

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 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';
```

(c)

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

Ambiguous Attribute Names

- Same name can be used for two (or more) attributes in different relations
  - 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;
```

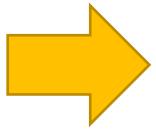
Fname	Lname	Address
John	Smith	731 Fondren, Houston, TX
Franklin	Wong	638 Voss, Houston, TX
Ramesh	Narayan	975 Fire Oak, Humble, TX
Joyce	English	5631 Rice, Houston, TX

Aliasing, and Renaming

- **Aliases** or **tuple variables**
  - Declare alternative relation names E and S to refer to the EMPLOYEE relation twice in a query:

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.

```
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

Note Recommended practice to abbreviate names and to prefix same or similar attribute from multiple tables.

- The attribute names can also be renamed

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

- Note that the relation EMPLOYEE now has a variable name E which corresponds to a tuple variable
- The "AS" may be dropped in most SQL implementations

Unspecified WHERE Clause and Use of the Asterisk

- Missing **WHERE** clause
  - Indicates no condition on tuple selection

```
Q9:     SELECT    Ssn
        FROM      EMPLOYEE;
```

- If more than one relation is specified in the FROM clause and there is no WHERE clause, effect is a **CROSS PRODUCT**
  - Result is all possible tuple combinations

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

- Specify an asterisk (*)
  - Retrieve all the attribute values of the selected tuples
  - The * can be prefixed by the relation name; e.g., EMPLOYEE *

```
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
- For aggregate operations (See sec 7.1.7) duplicates must be accounted for
- 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;
```

- Set operations
  - **UNION**, **EXCEPT** (difference), **INTERSECT**
  - Corresponding multiset operations: UNION ALL, EXCEPT ALL, INTERSECT ALL)
  - Type compatibility is needed for these operations to be valid

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
  - Examples:

```
WHERE Address LIKE '%Houston,TX%';
WHERE Ssn LIKE '_ _ 1_ _ 8901';
```

- **BETWEEN** comparison operator
  - E.g., in Q14 :

    WHERE (Salary **BETWEEN** 30000 **AND** 40000) **AND** Dno = 5

Arithmetic Operations

- Standard arithmetic operators:
  - Addition (+), subtraction (–), multiplication (*), and division (/) may be included as a part of **SELECT**

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

```
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';
```

Ordering of Query Results

- Use **`ORDER BY`** clause
  - Keyword **`DESC`** to see result in a descending order of values
  - Keyword **`ASC`** to specify ascending order explicitly
  - Typically placed at the end of the query

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

Basic SQL Retrieval Query Block

```
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**
  - **INSERT** typically inserts a tuple (row) in a relation (table)
  - **UPDATE** may update a number of tuples (rows) in a relation (table) that satisfy the condition
  - **DELETE** may also update a number of tuples (rows) in a relation (table) that satisfy the condition

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
- Constraints on data types are observed automatically
- Any integrity constraints as a part of the DDL specification are enforced

The INSERT Command

- Specify the relation name and a list of values for the tuple. All values including nulls are supplied.

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

- The variation below inserts multiple tuples where a new table is loaded values from the result of a query.

```
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;
```

BULK LOADING OF TABLES

- Another variation of **INSERT** is used for bulk-loading of several tuples into tables
- A new table TNEW can be created with the same attributes as T and using LIKE and DATA in the syntax, it can be loaded with entire data.

- EXAMPLE:

```
CREATE TABLE D5EMPS LIKE EMPLOYEE
(   SELECT      E.*
    FROM EMPLOYEE AS E
    WHERE       E.Dno=5                 )
WITH DATA;
```

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

The DELETE Command

- Removes tuples from a relation
  - Includes a `WHERE` clause to select the tuples to be deleted. The number of tuples deleted will vary.

```
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;
```

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 specified as part of DDL specification is enforced

- 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
```

- **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

Additional Features of SQL

- Techniques for specifying complex retrieval queries (see Ch.7)
- Writing programs in various programming languages that include SQL statements: Embedded and dynamic SQL, SQL/CLI (Call Level Interface) and its predecessor ODBC, SQL/PSM (Persistent Stored Module) (See Ch.10)
- Set of commands for specifying physical database design parameters, file structures for relations, and access paths, e.g., CREATE INDEX

- Transaction control commands (Ch.20)
- Specifying the granting and revoking of privileges to users (Ch.30)
- Constructs for creating triggers (Ch.26)
- Enhanced relational systems known as object-relational define relations as classes. Abstract data types (called User Defined Types- UDTs) are supported with CREATE TYPE
- New technologies such as XML (Ch.13) and OLAP (Ch.29) are added to versions of SQL

Summary

- SQL
  - A Comprehensive language for relational database management
  - Data definition, queries, updates, constraint specification, and view definition
- Covered :
  - Data definition commands for creating tables
  - Commands for constraint specification
  - Simple retrieval queries
  - Database update commands