CS3402: Chapter 5
SQL: Structured Query Language

SQL: Structured Query Language

- Data Definition Language(DDL): define the structures in a database, i.e. create, modify, and remove database objects such as tables, indexes, and users. Commands include CREATE, ALTER, and DROP.
- Data Manipulation Language (DML): deal with the manipulation of data present in database. Commands include : INSERT, UPDATE , and DELETE.
- Data Query Language (DQL): make queries for data in databases. Commands include : SELECT.

Note:

- Each statement in SQL ends with a semicolon (;)
- SQL statements are case insensitive

DDL: Define database

CREATE Table

- Create Database:

  CREATE SCHEMA database_name AUTHORIZATION user-name;

- Create Table: CREATE TABLE table_name
  (column_name1 data_type(size),
  column_name2 data_type(size),....);

- Delete Table: DROP TABLE table-name;

- Update Table:

  ALTER TABLE table-name

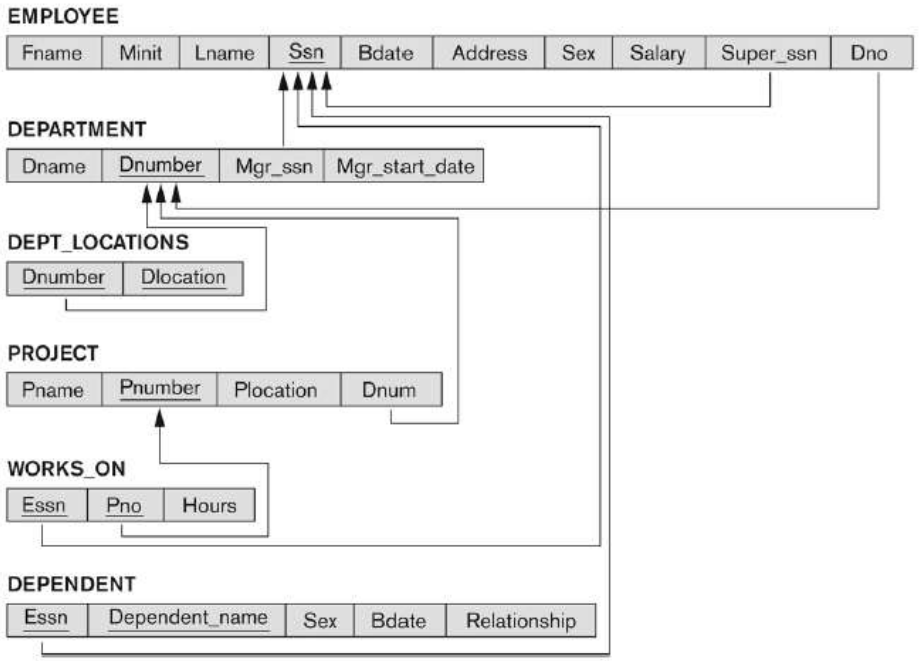
  ADD Aj, Dj

  (to add new attribute Aj with domain Dj to an existing table)

SQL CREATE TABLE data definition statements for defining the COMPANY schema

Standard data types

```
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) );
```



Data Types and Domains: Numeric

- **Numeric** data types include integer numbers of various sizes (**INTEGER** or **INT**, and **SMALLINT**) and floating-point numbers of various precision (**FLOAT** or **REAL**, and **DOUBLE PRECISION**).

- Formatted numbers can be declared by using **DECIMAL(i, j)** , where I (i.e., the precision) is the total number of decimal digits and j (i.e., the scale) is the number of digits after the decimal point. The default for scale is zero, and the default for precision is implementation-defined.

4

Data Types and Domains: Character string

- **Character string** data types are either fixed length **CHAR(n)** or **CHARACTER (n),** where n is the number of characters or varying length **VARCHAR (n)** or **CHAR VARYING(n)** or **CHARACTER VARYING(n),** where n is the maximum number of characters.

- For fixed length strings , a shorter string is **padded with blank characters** to the right. For example, if the value 'Smith' is for an attribute of type CHAR(10), it is padded with five blank characters to become 'Smith' if needed. Padded blanks are generally ignored when strings are compared.

- When specifying a string value, it is placed between single quotation marks (apostrophes), and it is case sensitive (a distinction is made between uppercase and lowercase)

Data Types and Domains: Date and Time

- The **DATE** data type has ten positions, and its components are YEAR, MONTH, and DAY in the form **YYYY-MM-DD**.
- The **TIME** data type has at least eight positions, with the components HOUR, MINUTE, and SECOND in the form **HH:MM:SS**.
- Literal values are represented by single-quoted strings preceded by the keyword **DATE** or **TIME**; for example, DATE '2014-09-27' or TIME '09:12:47'.
- Only valid dates and times should be allowed by the SQL implementation.

Data Types and Domains: Boolean

- A **Boolean** data type is defined as **Boolean** and has the traditional values of TRUE or FALSE. In SQL, because of the presence of NULL values, a three-valued logic is used, so a third possible value for a Boolean data type is UNKNOWN.

3-valued logic:

Not	
T	F
U	U
F	T

AND	T	U	F
T	T	U	F
U	U	U	F
F	F	F	F

OR	T	U	F
T	T	T	T
U	T	U	U
F	T	U	F

And

- Only T-T returns T
- And-ing F with anything results with F
- The rest is UNKNOWN

Or

- Only F-F returns F
- Or-ing T with anything results with T
- The rest is UNKNOWN

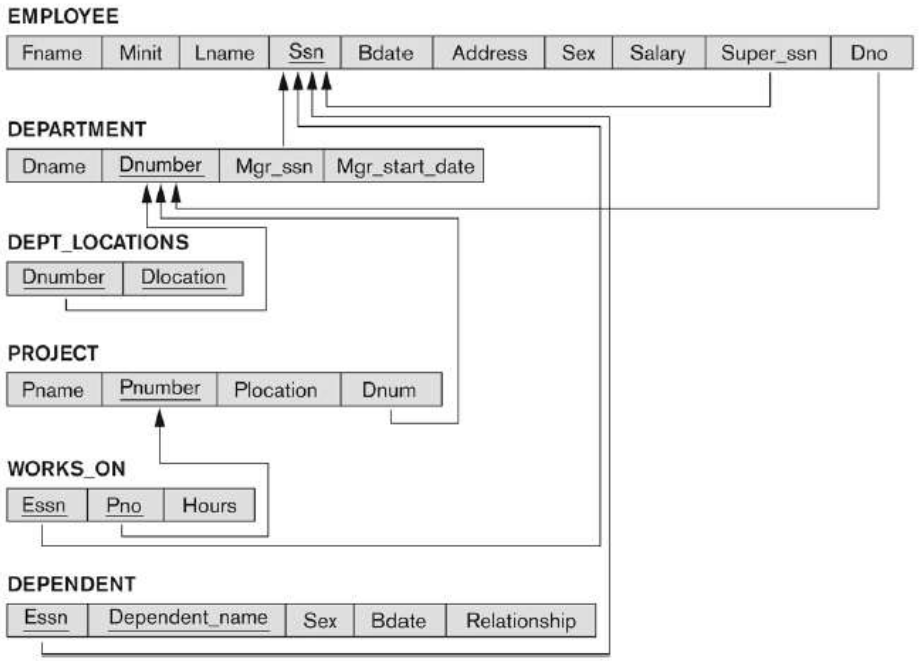
SQL CREATE TABLE data definition statements for defining the COMPANY schema

Indicate this column does not accept NULL value

Define primary key

ensures that all values in a column are different

```
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                                        2),
          Super_ssn
          Dno                                           NOT NULL,
        PRIMARY KEY
CREATE TABLE DEPAR
        ( Dname                                         NOT NULL,
          Dnumber                                       NOT NULL,
          Mgr_ssn                                       NOT NULL,
          Mgr_start_da                  TE,
        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) );
```



Define foreign key and its reference

Attribute Constraints

- Because SQL allows NULLs as attribute values, a constraint **NOT NULL** may be specified if NULL is not permitted for a particular attribute. This is always implicitly specified for the attributes that are part of the primary key, but it can be specified for any other attributes whose values are required not to be NULL

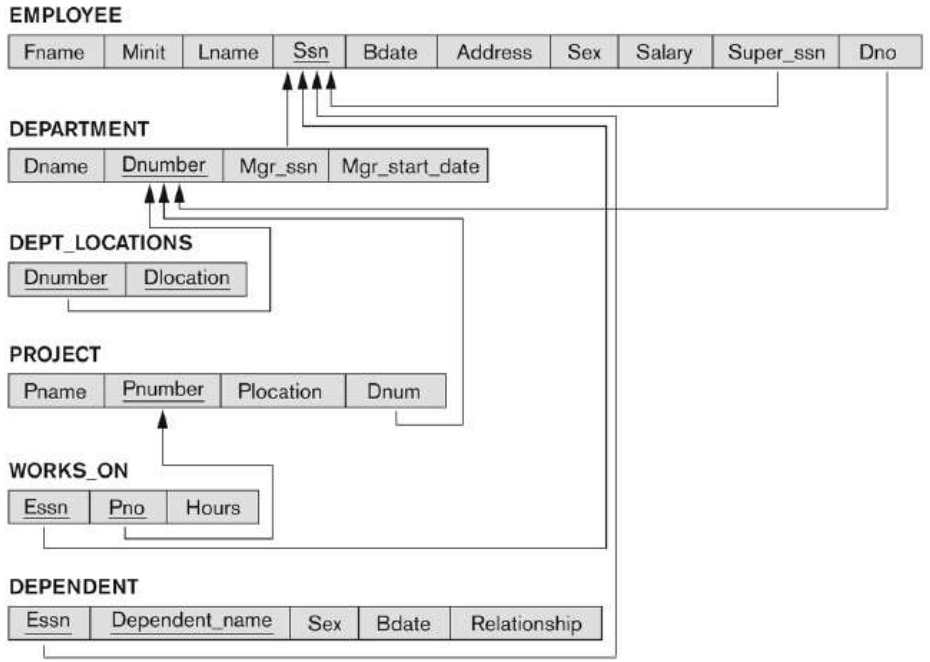
- The **PRIMARY KEY** clause specifies one or more attributes that make up the primary key of a relation.

- The **UNIQUE** clause specifies alternate (unique) keys, also known as candidate keys.

- Referential integrity is specified via the **FOREIGN KEY** clause.

SQL CREATE TABLE data definition statements for defining the COMPANY schema

```
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) );
```



Adding Constrains after creating table

- CREATE TABLE COUNTRY

```
ALTER TABLE COUNTRY  ADD CONSTRAINT PK_country PRIMARY KEY (cntry_cd);

ALTER TABLE EXCHANGE ADD CONSTRAINT PK_exchange PRIMARY KEY
(exchg_cd);

ALTER TABLE EXCHANGE ADD CONSTRAINT FK_exchg_cntry FOREIGN KEY
(cntry_cd) REFERENCES COUNTRY (cntry_cd)  ;
```

One possible database state for the COMPANY relational database schema

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

One possible database state for the COMPANY relational database schema

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

DQL: make query of data

The SELECT-FROM-WHERE Structure of Basic SQL Queries

- Queries in SQL can be very complex. We will start with simple queries.

- The basic form of the SELECT statement formed of the three clauses SELECT, FROM, and WHERE and has the following form:

```
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.

Specified attributes ↓

Satisfy the conditions →

Title	Year	Length	Type
Star War	1977	124	Color
Mighty Duck	1991	104	Color
Wayne's World	1992	95	Color

Retrieval from a single table

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';
```

Projection attributes

Selection conditions

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

- In SQL, the basic logical comparison operators for comparing attribute are =, <, <=, >, >=, and <>.
- Logic operator (AND, OR, NOT) can be used to connect multiple conditions. Priority is : NOT, AND, OR.
  E.g. A AND B OR NOT C equals to (A AND B) OR (NOT C)

Retrieval from two tables

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

```
Q1:   SELECT   Fname, Lname, Address
      FROM     EMPLOYEE, DEPARTMENT        <-- Two tables
      WHERE    Dname='Research' AND Dnumber=Dno;   <-- Join conditions
```

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

- The condition Dname='Research' is a **selection condition** that chooses the particular tuple of interest in the DEPARTMENT table, because Dname is an attribute of DEPARTMENT.
- The condition Dnumber=Dnois called a **join condition**, because it combines two tuples: one from DEPARTMENT and one from EMPLOYEE, whenever the value of Dnumberin DEPARTMENT is equal to the value of Dnoin EMPLOYEE.

Retrieval from two tables:Join Operation

A	B
ABC	DEF

X

JOIN

C	D	E	F
XYZ			
AAAA			
BBBB			
CCCC			

A	B	C	D	E	F
ABC	DEF	XYZ			
ABC	DEF	AAAA			
ABC	DEF	BBBB			
ABC	DEF	CCCCC			

Retrieval from three tables

(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';
```

Select-project-join query

Project joins Department

Department joins Employee

NULL Value Comparisons

- When a record with NULL in one of its attributes is involved in a comparison operation, the result is considered to be UNKNOWN (it may be TRUE or it may be FALSE).

```
SELECT Essn,
  FROM WORKS_ON
  WHERE HOURS > 0
   (UNKNOWN result will not return!)
```

- In most SQL-based DBMSs, the special keyword NULL may be used to test for a NULL value.
- E.g.,

```
SELECT c-name
    FROM Deposit
    WHERE balance IS NULL;
        (or balance IS NOT NULL;)
```

NULL Values Comparisons

Condition	Value of a	Evaluation
a IS NULL	10	FALSE
a IS NOT NULL	10	TRUE
a IS NULL	NULL	TRUE
a IS NOT NULL	NULL	FALSE
a = NULL	10	UNKNOWN
a = !NULL	10	UNKNOWN
a = NULL	NULL	UNKNOWN
a = !NULL	NULL	UNKNOWN
a = 10	NULL	UNKNOWN
a = 10	NULL	UNKNOWN

Substring Pattern Matching

- The **LIKE** comparison allows comparison conditions on only parts of a character string, using operator. This can be used for string pattern matching.

- Partial strings are specified using two reserved characters: percentage (%) replaces an arbitrary number of zero or more characters, and the underscore (_) replaces a single character.
  - *Find the names of all employees whose first name has the substring 'mm' included*

```
SELECT Fname, Minit, Lname
 FROM EMPOYEE
 WHERE Fname LIKE '%mm%';
```

(Note: if we use ' _ _ mm%', then it becomes a special case)

3rd character (case sensitive)

Ambiguous Attribute Names

- Same name can be used for two (or more) attributes in different relations, which may cause ambiguity.
  - Must qualify the attribute name with the relation name to prevent ambiguity
  - This is done by prefixing the relation name to the attribute name and separating the two by a period, e.g.,

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

Dnumber

Aliasing, and Renaming

- The ambiguity of attribute names also arises in the case of queries that refer to the same relation twice.
  - Must declare alternative relation, called aliases or tuple variables using AS
  - E.g. 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;
```

Aliasing, and Renaming

- We can use this mechanism to rename any table in the WHERE clause, whether or not the same relation needs to be referenced more than once. In fact, this practice is recommended since it results in queries that are easier to comprehend.

- The attribute names can also be renamed

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

- The “AS” may be dropped in most SQL implementations

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

Unspecified WHERE Clause

- Missing **`WHERE`** clause
  - Indicates no condition on tuple selection (select ALL)

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;
```

Values of all tuples

Ssn
123456789
333445555
999887777
987654321
666884444
453453453
987987987
888665555

All possible combinations

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

Use of the Asterisk

- 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;
```

EMPLOYEE: 100 tuples
DEPARTMENT: 10 tuples
Finally, 1000 tuples and all attributes

Ordering Tuples

- SQL allows the user to order the tuples in the result of a query by the values of one or more of the attributes that appear in the query result, by using the ORDER BY clause.

- List first name of all employees in alphabetic order

```
SELECT Fname
 FROM EMPOYEE
 ORDER BY Fname;
```

By default, in ascending order.

- List the employee names in descending order of last name, and if several employees have the same last name, order them in ascending order by the first name

```
SELECT Fname, Minit, Lname
 FROM EMPLOYEE
 ORDER BY Lname DESC, Fname ASC;
```

Tables as Sets in SQL

- SELECT does not automatically eliminate duplicate tuples (the attributes of two tuples have same values) in query results (NOT a set)
- 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;
```

ALL:

Salary
30000
40000
25000
43000
38000
25000
25000
55000

Distinct:

Salary
30000
40000
25000
43000
38000
55000

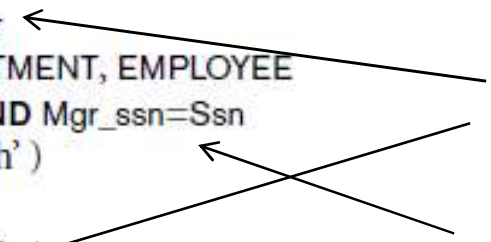
- Specifying SELECT with neither ALL nor DISTINCT is equivalent to SELECT ALL.

Tables as Sets in SQL

- Set operations
  - `UNION`, `INTERSECT`, `MINUS/EXCEPT` (difference)
  - These set operations apply only to type compatible relations , so we must make sure that the two relations on which we apply the operation have the same attributes and that the attributes appear in the same order in both relations.

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' );
```



Same attribute

The projects in the dept with "Smith" as manager

Tables as Sets in SQL

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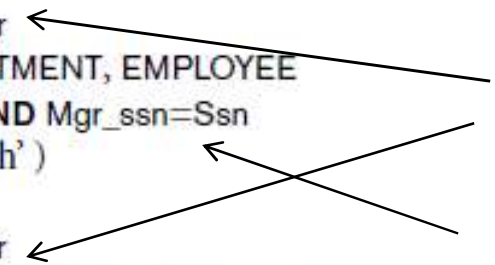
                 AND Lname='Smith' )
       UNION
      ( SELECT   DISTINCT Pnumber
       FROM      PROJECT, WORKS_ON, EMPLOYEE
       WHERE     Pnumber=Pno AND Essn=Ssn
                 AND Lname='Smith' );
```



Same attribute

The projects in the dept with "Smith" as manager

Tables as Sets in SQL

- The relations resulting from these set operations `UNION`, `INTERSECT`, `MINUS/EXCEPT` are sets of tuples; that is, duplicate tuples are eliminated from the result.

- If we do not want to eliminate the duplicate tuples, we should use multisets operations `UNION ALL`, `INTERSECT ALL`, `MINUS/EXCEPT ALL`.

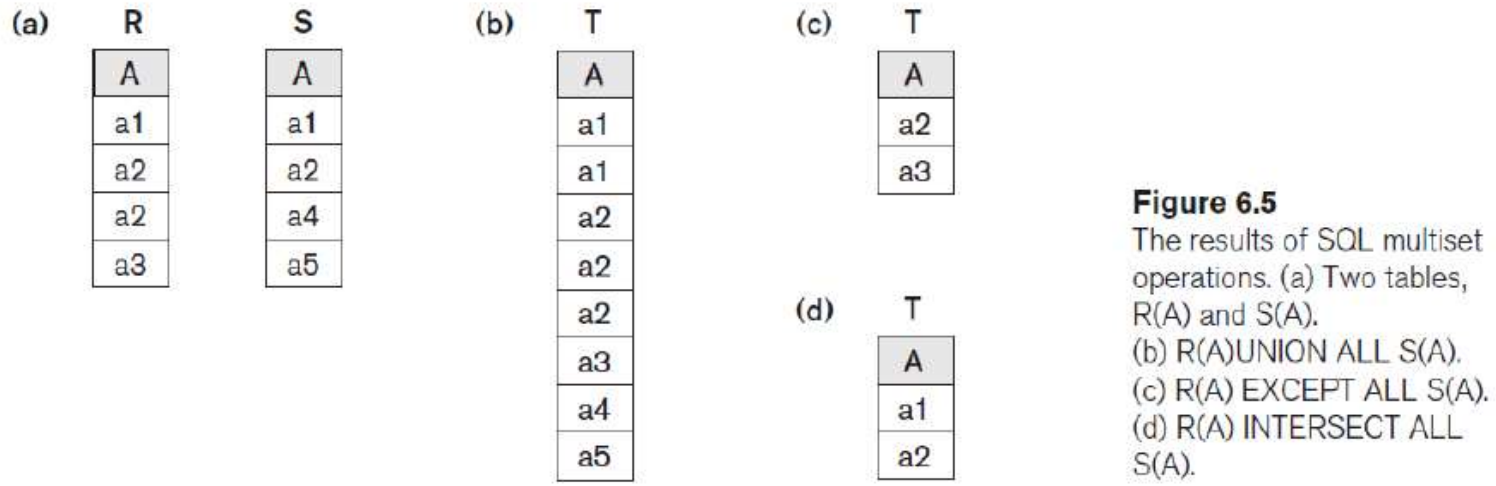


Figure 6.5
The results of SQL multiset operations. (a) Two tables, R(A) and S(A).
(b) R(A)UNION ALL S(A).
(c) R(A) EXCEPT ALL S(A).
(d) R(A) INTERSECT ALL S(A).

DML: Manipulate data

INSERT Command

- INSERT is used to add a single tuple (row) to a relation (table). We must 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 );
```

```
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 values for the attributes are obtained from the results of the SELECT statement

DELETE Command

- DELETE command removes tuples from a relation.

  DELETE FROM table-name;

  - (Note: this operation only deletes all tuples from the table and the table is still there)
  - 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;
```

UPDATE Command

- UPDATE command is used to modify attribute values of one or more selected tuples.

- Additional `SET` clause in the `UPDATE` command
  - Specifies attributes to be modified and new values

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

Views (Virtual Tables)

- Base table (base relation)
  - Relation and its tuples are actually (physically) created and stored as a file by the DBMS
  - The tables are stored in the secondary storage in the specified format

- Virtual table (view)
  - Single table derived from other base tables temporarily.
  - A view does not necessarily exist in physical form; it is just presented to the user through reconstruction (view) of base tables.

Views (Virtual Tables)

- `CREATE VIEW` command
  - In V1, attributes retain the names from base tables. In V2, attributes are assigned new names

```
V1:   CREATE VIEW   WORKS_ON1
      AS SELECT     Fname, Lname, Pname, Hours
          FROM      EMPLOYEE, PROJECT, WORKS_ON
          WHERE     Ssn=Essn AND Pno=Pnumber;

V2:   CREATE VIEW   DEPT_INFO(Dept_name, No_of_emps, Total_sal)
      AS SELECT     Dname, COUNT (*), SUM (Salary)
          FROM      DEPARTMENT, EMPLOYEE
          WHERE     Dnumber=Dno
          GROUP BY  Dname;
```

New attribute names

- We can think of a view as a way of specifying a table that we need to reference frequently, even though it may not exist physically.

Views (Virtual Tables)

- Once a View is defined, SQL queries can use the View relation in the FROM clause. Views can be regarded and retrieved as ordinary tables.

  E.g.,

```
SELECT Fname
FROM WORKS_ON1
WHERE HOURS > 5.0;
```

- View is always up-to-date
  - Responsibility of the DBMS and not the user
  - Change in base table will be reflected in the views

- `DROP VIEW` command
  - DROP VIEW WORKS_ON1;

Views (Virtual Tables)

- View has limits on data modification operations.

  e.g. Suppose we insert a tuple (“Mary”, “Black”, “ProjectX”, 10.0) into WORKS_ON1, it will cause other attribute has NULL value in the base table: (“Mary”, NULL, “Black”, NULL, ...) in EMPLOYEE, ….

- To avoid such problems and to simplify implementation, most SQL-based DBMSs restrict the following condition:

  “A modification is permitted through a view ONLY IF the view is defined in terms of ONE base relation.”