Structured Query Language

Data Definition, Constraints, and Schema Changes

- Used to CREATE, DROP, and ALTER the descriptions of the tables (relations) of a database
- Syntax:
- CREATE DATABASE database_name ;
- CREATE TABLE table_name (

  column_name1 data_type,

  column_name2 data_type, ...)

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: Data Type

Data Type	Description

integer(size)
int(size)
smallint(size)
tinyint(size)
	Hold integers only. The maximum number of digits are specified in parenthesis.

decimal(size,d)
numeric(size,d)
	Hold numbers with fractions. The maximum number of digits are specified in "size". The maximum number of digits to the right of the decimal is specified in "d".

char(size)	Holds a fixed length string (can contain letters, numbers, and special characters). The fixed size is specified in parenthesis.
varchar(size)	Holds a variable length string (can contain letters, numbers, and special characters). The maximum size is specified in parenthesis.
date(yyyymmdd)	Holds a date

CREATE TABLE

- In SQL2, can use the CREATE TABLE command for specifying the primary key attributes, secondary keys, and referential integrity constraints (foreign keys).
- Key attributes can be specified via the PRIMARY KEY and UNIQUE phrases

```
CREATE TABLE   DEPT
(    DNAME           VARCHAR(10) NOT NULL,
     DNUMBER         INTEGER     NOT NULL,
     MGRSSN          CHAR(9),
     MGRSTARTDATE        CHAR(9),
     PRIMARY KEY (DNUMBER),
     UNIQUE (DNAME),
     FOREIGN KEY (MGRSSN) REFERENCES EMP  );
```

DROP TABLE

- Used to remove a relation (base table) *and its definition*
- The relation can no longer be used in queries, updates, or any other commands since its description no longer exists
- Example:

DROP TABLE DEPENDENT;

ALTER TABLE

- Used to add an attribute to one of the base relations
- The new attribute will have NULLs in all the tuples of the relation right after the command is executed; hence, the NOT NULL constraint is *not allowed* for such an attribute
- Example:

ALTER TABLE EMPLOYEE ADD JOB VARCHAR(12);

- The database users must still enter a value for the new attribute JOB for each EMPLOYEE tuple. This can be done using the UPDATE command.

Features Added in SQL2 and SQL-99

- **CREATE SCHEMA**
- **REFERENTIAL INTEGRITY OPTIONS**

CREATE SCHEMA

- the statement can include all the elements' definitions.
  - Schema elements include tables, constraints, views, domains, and other constructs (such as authorization grants)
- Alternatively, the schema can be assigned a name and authorization identifier. The elements can be defined later.
- EX: schema owned by the user with JSMITH
  - CREATE SCHEMA company AUTHORIZATION JSMITH;

Attributes Constraints

- Specify constraint on attribute:
  - DNUMBER INT NOT NULL **CHECK** (DNUMBER > 0 AND DNUMBER < 21)
- Alternatively
  - **CREATE DOMAIN** D_NUM AS INTEGER CHECK (D_NUM>0 AND D_NUM<21)
  - DNUMBER D_NUM

Additional Data Types in SQL2 and SQL-99

Has DATE, TIME, and TIMESTAMP data types

- **DATE:**
  - Made up of year-month-day in the format yyyy-mm-dd
- **TIME:**
  - Made up of hour:minute:second in the format hh:mm:ss
- **TIME(i):**
  - Made up of hour:minute:second plus i additional digits specifying fractions of a second
  - format is hh:mm:ss:ii...i
- **TIMESTAMP:**
  - Has both DATE and TIME components

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

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

Referential Integrity (RI)

- RI constraints can be violated when tuples are inserted or deleted, or when a foreign key or primary key is modified
- Default action
  - Reject the update operation that will cause the violation
- **Referential triggered actions**
  - SET NULL, SET DEFAULT, CASCADE
  - When ON DELETE or ON UPDATE

REFERENTIAL INTEGRITY OPTIONS

- We can specify **RESTRICT**, **CASCADE**, **SET NULL** or **SET DEFAULT** on referential integrity constraints (foreign keys)

```
CREATE TABLE   DEPT
 (    DNAME         VARCHAR(10)       NOT NULL,
      DNUMBER   INTEGER      NOT NULL,
      MGRSSN       CHAR(9),
      MGRSTARTDATE  CHAR(9),
      PRIMARY KEY (DNUMBER),
      UNIQUE (DNAME),
      FOREIGN KEY (MGRSSN) REFERENCES EMP
ON DELETE SET DEFAULT ON UPDATE
CASCADE   );
```

REFERENTIAL INTEGRITY OPTIONS (continued)

```
CREATE TABLE   EMP
    (          ENAME          VARCHAR(30) NOT NULL,
               ESSN    CHAR(9) primary key,
               BDATE DATE,
               DNO     INTEGER  DEFAULT 1 check (dno>0 and dno<9)
               SUPERSSN       CHAR(9),
   #           PRIMARY KEY (ESSN),
               FOREIGN KEY (DNO) REFERENCES DEPT
            ON DELETE SET DEFAULT ON UPDATE CASCADE,
               FOREIGN KEY (SUPERSSN) REFERENCES EMP
            ON DELETE SET NULL ON UPDATE CASCADE  );
```

If the tuples for a supervising employee is deleted, the value of SUPERSSN is set to NULL.

If SSN is updated, the new value is cascaded to SUPERSSN.

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 (cont.)

- Basic form of the SQL SELECT statement is called a *mapping* or a *SELECT-FROM-WHERE block*

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

  - <attribute list> is a list of attribute names whose values are to be retrieved by the query
  - <table list> is a list of the relation names required to process the query
  - <condition> is a conditional (Boolean) expression that identifies the tuples to be retrieved by the query

Relational Database Schema--Figure 5.5

http://web.ntnu.edu.tw/~samtseng/

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--Fig.5.6

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

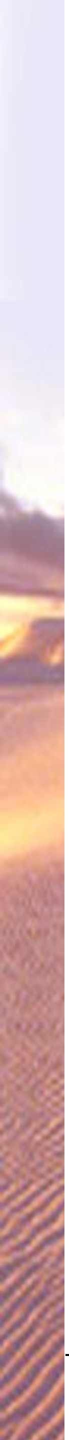
DEPENDENT	ESSN	DEPENDENT_NAME	SEX	BDATE	RELATIONSHIP
	333445555	Alice	F	1986-04-05	DAUGHTER
	333445555	Theodore	M	1983-10-25	SON
	333445555	Joy	F	1958-05-03	SPOUSE
	987654321	Abner	M	1942-02-28	SPOUSE
	123456789	Michael	M	1988-01-04	SON
	123456789	Alice	F	1988-12-30	DAUGHTER
	123456789	Elizabeth	F	1967-05-05	SPOUSE

Simple SQL Queries

- Basic SQL queries correspond to using the SELECT, PROJECT, and JOIN operations of the relational algebra
- All subsequent examples use the COMPANY database
- 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 (cont.)

- 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 (cont.)

- 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

<u>Example:</u>

- 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 (cont.)

– 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 (cont.)

- 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

Simple Examples

```
create database courses_students;
use courses_students;
# Table definition
create table courses (
  cid int(10)  NOT NULL auto_increment,
  cname varchar(30) NOT NULL,
  credit tinyint(2)  NOT NULL,
  croom varchar(10),
  primary key (cid)
);
create table students (
  sid int(10) unsigned NOT NULL
      auto_increment,
  sname varchar(30) NOT NULL default '',
  syear tinyint(2) unsigned,
  primary key (sid)
);
create table selected (
  cid int(10) unsigned,
  sid int(10) unsigned
);
```

```
# Data
insert into courses values (1, 'DBMS', 3, '307');
insert into courses values (2, 'OS', 3, '406');
insert into courses values (3, 'Algorithm', 3, '307');

insert into students values (1, 'Sam', 4);
insert into students values (2, 'Joe', 3);
insert into students values (3, 'Mary', 3);
insert into students values (4, 'John', 3);

insert into selected values (1, 1);
insert into selected values (1, 2);
insert into selected values (1, 4);
insert into selected values (2, 1);
insert into selected values (2, 3);
insert into selected values (2, 4);
insert into selected values (2, 2);
insert into selected values (3, 2);
insert into selected values (3, 4);
```

Join Operations

```
select * from
students;
+-----+-------+-------+
| sid | sname | syear |
+-----+-------+-------+
|   1 | Sam   |     4 |
|   2 | Joe   |     3 |
|   3 | Mary  |     3 |
|   4 | John  |     3 |
+-----+-------+-------+
```

```
select * from selected;
+------+------+
| cid  | sid  |
+------+------+
|    1 |    1 |
|    1 |    2 |
|    1 |    4 |
|    2 |    1 |
|    2 |    3 |
|    2 |    4 |
|    2 |    2 |
|    3 |    2 |
|    3 |    4 |
+------+------+
```

```
select selected.cid,  selected.sid, sname
from   selected, students
where  selected.sid = students.sid;
+------+------+-------+
| cid  | sid  | sname |
+------+------+-------+
|    1 |    2 | Joe   |
|    1 |    4 | John  |
|    1 |    1 | Sam   |
|    2 |    2 | Joe   |
|    2 |    3 | Mary  |
|    2 |    4 | John  |
|    2 |    1 | Sam   |
|    3 |    4 | John  |
|    3 |    2 | Joe   |
+------+------+-------+
```

If omitted, 36 rows will 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 (cont.)

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

```
Q4:  (SELECT  PNAME
      FROM    PROJECT, DEPARTMENT, EMPLOYEE
      WHERE   DNUM=DNUMBER AND MGRSSN=SSN
      AND     LNAME='Smith')
      UNION   (SELECT  PNAME
      FROM    PROJECT, WORKS_ON, EMPLOYEE
      WHERE   PNUMBER=PNO AND ESSN=SSN AND
              LNAME='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 (cont.)

- The nested query selects the number of the 'Research' department
- The outer query select an EMPLOYEE tuple if its DNO value is in the result of either nested query
- The comparison operator **IN** compares a value v with a set (or multi-set) of values V, and evaluates to **TRUE** if v is one of the elements in V
- In general, we can have several levels of nested queries
- A reference to an *unqualified attribute* refers to the relation declared in the *innermost nested query*
- In this example, the nested query is *not correlated* with the outer query

CORRELATED NESTED QUERIES

- If a condition in the WHERE-clause of a *nested query* references an attribute of a relation declared in the *outer query* , the two queries are said to be *correlated*
- The result of a correlated nested query is *different for each tuple (or combination of tuples) of the relation(s) the outer query*
- Query 12: Retrieve the name of each employee who has a dependent with the same first name as the employee.

```
Q12: SELECT     E.FNAME, E.LNAME
     FROM       EMPLOYEE AS E
     WHERE      E.SSN IN (SELECT     ESSN
                FROM  DEPENDENT
                WHERE         ESSN=E.SSN AND
                     E.FNAME=DEPENDENT_NAME)
```

CORRELATED NESTED QUERIES (cont.)

- In Q12, the nested query has a different result *for each tuple* 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
```

- 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

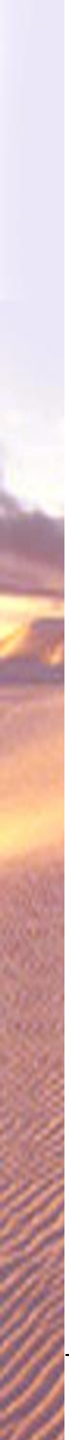
CORRELATED NESTED QUERIES (cont.)

- 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).
  - Query 3: Retrieve the name of each employee who works on *all* the projects controlled by department number 5.

```
Q3:     SELECT  FNAME, LNAME
        FROM    EMPLOYEE
        WHERE  ( (SELECT        PNO
                  FROM   WORKS_ON
                  WHERE         SSN=ESSN)
                  CONTAINS
                 (SELECT        PNUMBER
                  FROM   PROJECT
                  WHERE         DNUM=5) )
```

CORRELATED NESTED QUERIES (cont.)

- In Q3, the second nested query, which is <u>not correlated</u> 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 below

THE EXISTS FUNCTION (cont.)

- 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 (cont.)

- 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 <u>equality comparison is not appropriate</u> .
- <u>Query 14:</u> Retrieve the names of all employees who do not have supervisors.

```
Q14:    SELECT    FNAME, LNAME
        FROM      EMPLOYEE
        WHERE     SUPERSSN  IS  NULL
```

<u>Note:</u> If a join condition is specified, tuples with NULL values for the join attributes are not included in the result

Joined Relations Feature in SQL2

- Can specify a "joined relation" in the FROM-clause
- Looks like any other relation but is the result of a join
- Allows the user to specify different types of joins (regular "theta" JOIN, NATURAL JOIN, LEFT OUTER JOIN, RIGHT OUTER JOIN, CROSS JOIN, etc)

Joined Relations Feature in SQL2 (cont.)

- Examples:

```
Q8:  SELECT      E.FNAME, E.LNAME, S.FNAME, S.LNAME
     FROM        EMPLOYEE E S
     WHERE       E.SUPERSSN=S.SSN
```

can be written as: (Note: there is one row in difference)

```
Q8:  SELECT      E.FNAME, E.LNAME, S.FNAME, S.LNAME
     FROM  (EMPLOYEE E LEFT OUTER JOIN EMPLOYEE S
           ON  E.SUPERSSN=S.SSN)

Q1:  SELECT      FNAME, LNAME, ADDRESS
     FROM  EMPLOYEE, DEPARTMENT
     WHERE       DNAME='Research' AND DNUMBER=DNO
```

Joined Relations Feature in SQL2 (cont.)

- 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 (cont.)

- Another Example;
  - Q2 could be written as follows; this illustrates multiple joins in the joined tables

```
Q2:    SELECT    PNUMBER, DNUM, LNAME,
                  BDATE, ADDRESS
       FROM       ((PROJECT JOIN
                  DEPARTMENT ON
                  DNUM=DNUMBER) JOIN
                  EMPLOYEE ON
                  MGRSSN=SSN)
       WHERE      PLOCATION='Stafford’
```

AGGREGATE FUNCTIONS

- Include **COUNT**, **SUM**, **MAX**, **MIN**, and **AVG**
- Query 15: Find the maximum salary, the minimum salary, and the average salary among all employees.

```
Q15:        SELECT      MAX(SALARY),
                        MIN(SALARY), AVG(SALARY)
            FROM        EMPLOYEE
```

  – Some SQL implementations *may not allow more than one function* in the SELECT-clause

AGGREGATE FUNCTIONS (cont.)

- 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 (cont.)

- 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 (cont.)

- 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 (cont.)

- 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

- This type of selection is very useful.

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 (cont.)

- 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
```

- **So what is the difference between WHERE and HAVING?**
  - WHERE : before ; HAVING : after

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 (cont.)

- Query 25: Retrieve all employees whose address is in Houston, Texas. Here, the value of the ADDRESS attribute must contain the substring 'Houston,TX'.

```
Q25:    SELECT   FNAME, LNAME
        FROM         EMPLOYEE
        WHERE    ADDRESS LIKE
                 '%Houston,TX%'
```

SUBSTRING COMPARISON (cont.)

- 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 (cont.)

- 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

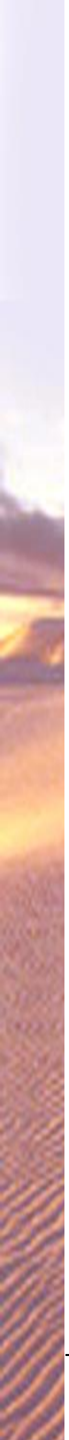
Summary of SQL Queries

- 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 (cont.)

- 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 (cont.)

- 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 (cont.)

- 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 (cont.)

– 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 ;
```

INSERT (cont.)

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

DELETE

- Removes tuples from a relation
- Includes a WHERE-clause to select the tuples to be deleted
- 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
- Referential integrity should be enforced

DELETE (cont.)

- 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 (cont.)

- 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 (cont.)

- 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

Views in SQL

- A view is a “virtual” table that is derived from other tables
- Allows for limited update operations (since the table may not physically be stored)
- Allows full query operations
- A convenience for expressing certain operations

Specification of Views

- SQL command: `CREATE VIEW`
  - a table (view) name
  - a possible list of attribute names (for example, when arithmetic operations are specified or when we want the names to be different from the attributes in the base relations)
  - a query to specify the table contents

SQL Views: An Example

- Specify a different WORKS_ON table

```
CREATE VIEW WORKS_ON_NEW AS
SELECT FNAME, LNAME, PNAME, HOURS
    FROM EMPLOYEE, PROJECT, WORKS_ON
    WHERE SSN=ESSN AND PNO=PNUMBER
    GROUP BY PNAME;
```

Using a Virtual Table

- We can specify SQL queries on a newly create table (view):

```
SELECT FNAME, LNAME FROM WORKS_ON_NEW
WHERE PNAME='Seena';
```

- When no longer needed, a view can be dropped:

```
DROP VIEW WORKS_ON_NEW;
```

Efficient View Implementation (1)

- Query modification: present the view query in terms of a query on the underlying base tables
  - disadvantage: inefficient for views defined via complex queries (especially if additional queries are to be applied to the view within a short time period)

Efficient View Implementation (2)

- View materialization: involves physically creating and keeping a temporary table
  - assumption: other queries on the view will follow
  - concerns: maintaining correspondence between the base table and the view when the base table is updated
  - strategy: incremental update

View Update

- Update on a single view without aggregate operations: update may map to an update on the underlying base table
- Views involving joins: an update *may* map to an update on the underlying base relations
  - not always possible

Un-updatable Views

- Views defined using groups and aggregate functions are not updateable
- Views defined on multiple tables using joins are generally not updateable
- `WITH CHECK OPTION`: must be added to the definition of a view if the view is to be updated
  - to allow check for updatability and to plan for an execution strategy