CSc 134
Database Management Systems

6. SQL

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SQL History

- SQL-86 (SQL 1)
- SQL-92 (SQL 2)
- SQL-99 (SQL 3)
  - Core: supposed to be implemented by all RDBMS vendors
  - Extension: optional modules such as data mining, spatial data, temporal data, data warehousing
- Later updates:
  - 2003, 2006: Add XML features
  - 2008: incorporated more object database features

CREATE TABLE

- Specifies a new base relation by giving it a name, and specifying each of its attributes and their data types
- 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)
               );
```

Attribute Data Types and Domains in SQL

- Numeric
  - INTEGER or INT
  - FLOAT or REAL
  - DECIMAL(i,j), or DEC(i,j), or NUMBERIC(i,j)
    - i: total number of decimal digits
    - j: number of digits after the decimal point
- Character-string
  - fixed length
    - CHAR(n) or CHARACTER(n)
  - varying length
    - VARCHAR(n)

Attribute Data Types and Domains in SQL (Cont.)

- Boolean
  - TRUE, FALSE
- Date
  - DATE: year, month, day in the form YYYY-MM-DD
  - TIME: hour, minute, second in the form HH:MM:SS

CREATE TABLE (Cont.)

- Specify primary key
- Referential integrity constraints (foreign keys).
- Key attributes
  - PRIMARY KEY
  - UNIQUE phrases

```
CREATE TABLE   DEPARTMENT
(    DNAME  VARCHAR(10)   NOT NULL,
     DNUMBER          INTEGER          NOT NULL CHECK
                      (DNUMBER>0 AND DNUMBER <21),
     MGRSSN           CHAR(9),
     MGRSTARTDATE           DATE,
     PRIMARY KEY (DNUMBER),
     UNIQUE (DNAME),
     FOREIGN KEY (MGRSSN) REFERENCES EMPLOYEE(SSN)
   );
```

REFERENTIAL INTEGRITY OPTIONS

- We can specify CASCADE, SET NULL or SET DEFAULT on referential integrity constraints
- CREATE TABLE EMPLOYEE

```
(   ...
    DNO INT NOT NULL  DEFAULT 1,
    ...
    PRIMARY KEY (SSN),

    FOREIGN KEY (SUPERSSN) REFERENCES EMPLOYEE(SSN)
    ON DELETE SET NULL
    ON UPDATE CASCADE,

    FOREIGN KEY (DNO) REFERENCES DEPARTMENT(DNUMBER)
    ON DELETE SET DEFAULT
    ON UPDATE CASCADE  );
```

Giving Names to Constraints

```
CREATE TABLE   EMPLOYEE
(   SSN CHAR(9),
    ...
    CONSTRAINT EMPPK
    PRIMARY KEY (SSN),

    CONSTRAINT EMPDEPTFK
    FOREIGN KEY(DNO) REFERENCES DEPARTMENT (DNUMBER)
    ON DELETE SET DEFAULT ON UPDATE CASCADE
    ...
)
```

DROP TABLE

- Remove a relation (base table) and its definition
- The relation can no longer be used in queries, updates, or any other commands
- <u>Example:</u>

```
DROP TABLE  DEPENDENT;
DROP TABLE  DEPENDENT RESTRICT;
DROP TABLE  DEPENDENT CASCADE;
```

Drop Table (Cont.)

- Cascade
  - All constraints (e.g. foreign key definitions in another relation) and views reference the table are dropped automatically from the schema.
- Restrict
  - A table is dropped only if it is not referenced in any constraints.

ALTER TABLE
- Add column

- Add an attribute to one of the base relations
- New attribute=null automatically

- <u>Example:</u>

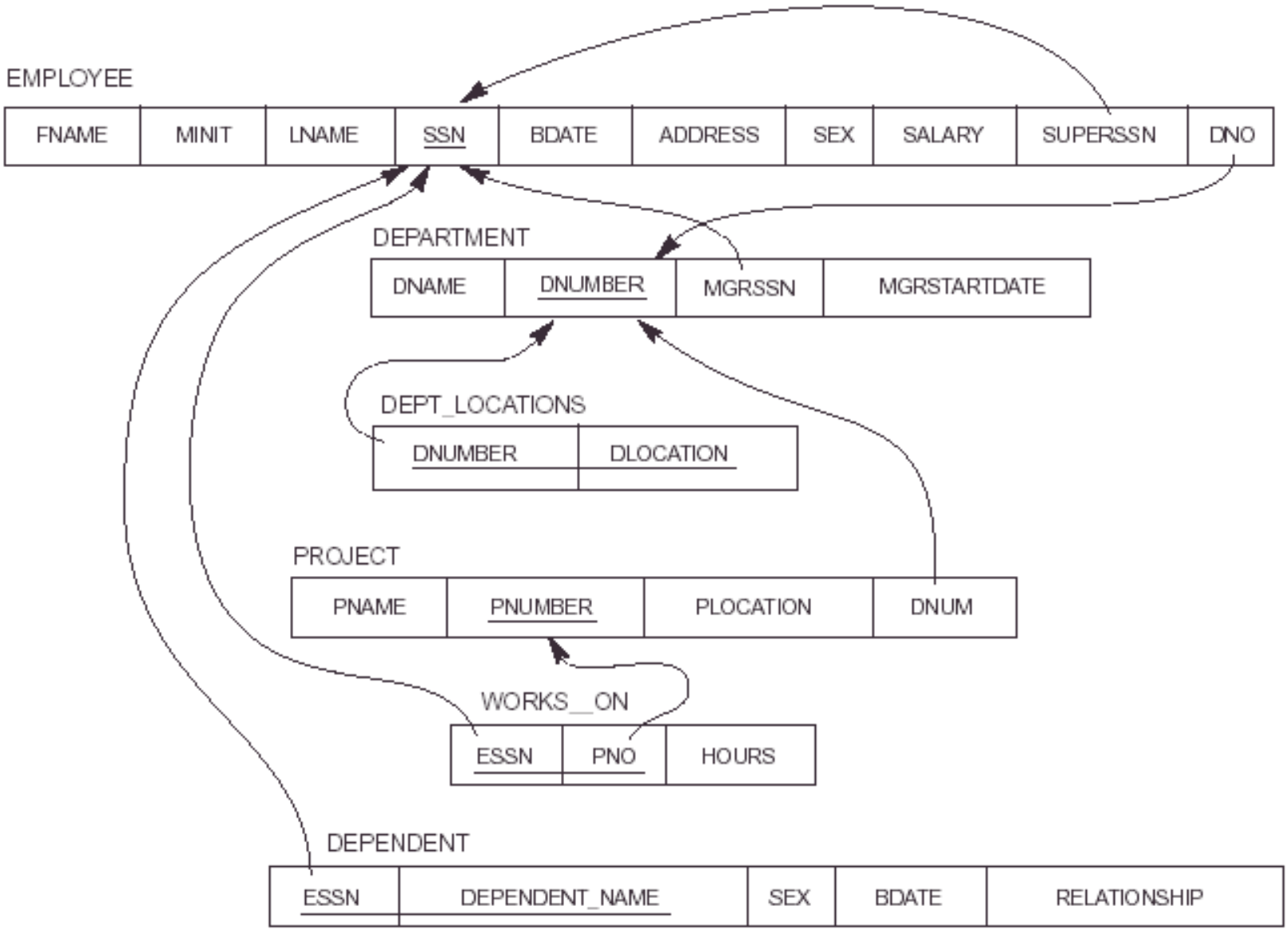
ALTER TABLE EMPLOYEE ADD JOB VARCHAR(12);

ALTER TABLE
- Drop column

- ALTER TABLE EMPLOYEE DROP ADDRESS;
- ALTER TABLE DEPARTMENT ALTER MGRSSN DROP DEFAULT;
- ALTER TABLE DEPARTMENT ALTER MGRSSN SET DEFAULT ‘122444444’;

Queries

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


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

Simple SQL Queries

<u>Query 0:</u> 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'
```

- SQL relation (table) is a *bag* of tuples; it *is not* a set of tuples.

Simple SQL Queries (cont.)

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

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, and birthdate.

Qualify attribute name

- Use the same name for two (or more) attributes as long as the attributes are in *different relations*
- *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

- 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
```

- We can think of E and S as two different copies of EMPLOYEE
  - E represents employees in role of *supervisees*
  - 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

- *All tuples* of the relations in the FROM-clause are selected
- = WHERE TRUE
- <u>Query 9:</u> Retrieve the SSN values for all employees.

Q9:	**SELECT**	**SSN**
	FROM	**EMPLOYEE**

UNSPECIFIED WHERE-clause (cont.)

- Example:

Q10:	**SELECT**	**SSN, DNAME**
	FROM	**EMPLOYEE, DEPARTMENT**

- *CARTESIAN PRODUCT* of employee and department is selected

USE OF DISTINCT

- **Q11:** **SELECT SALARY FROM EMPLOYEE**
- **Q11A:** **SELECT DISTINCT SALARY FROM EMPLOYEE**

Set Operations

- UNION, EXCEPT, INTERSECT
  - apply the operation have the same attributes
  - attributes appear in the same order
- Result: sets of tuples
- UNION ALL, EXCEPT ALL, INTERSECT ALL: bags of tuples

UNION Operation Example

- 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.

ARITHMETIC OPERATIONS

- +, -, *, /
- 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 AS INCREASED_SAL
FROM      EMPLOYEE, WORKS_ON, PROJECT
WHERE     SSN=ESSN AND PNO=PNUMBER AND
          PNAME='ProductX'
```

- Are the salaries different after execute the query?

Substring Pattern Matching

- **`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';

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 in a descending order, and within each department ordered alphabetically by employee last name, fname in an ascending order.

Q28:

```
SELECT      DNAME, LNAME, FNAME, PNAME
FROM        DEPARTMENT, EMPLOYEE,
            WORKS_ON, PROJECT
WHERE       DNUMBER=DNO AND SSN=ESSN AND
            PNO=PNUMBER
ORDER BY    DNAME DESC, LNAME ASC, FNAME ASC
```

NESTING OF QUERIES

- Nested query
- Outer query
- Query 11: Retrieve the name and address of all employees who work for the 'Research' department.

```
SELECT    FNAME, LNAME, ADDRESS
FROM      EMPLOYEE
WHERE     DNO IN  (SELECT    DNUMBER
                   FROM      DEPARTMENT
                   WHERE     DNAME='Research' )
```

Comparison operators

- ANY (or SOME)
- ALL
- List the names of employees whose salary is greater than the salary of all the employees in department 5.

THE EXISTS FUNCTION

- Check whether the result of a correlated nested query is empty
- Query 12: Retrieve the name of each employee who has a dependent with the same first name as the employee.

THE EXISTS FUNCTION (cont.)

- Retrieve the names of employees who have no dependents

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)
```

Renaming of Attributes

Rename an attribute that appears in the result of a query.

Q8A:Retrieve the last name of each employee and his or her supervisor, while renaming the resulting attribute names as Employee_name and Supervisor_name.

```
SELECT E.lname AS employee_name, s.lname AS superviosr_name
FROM EMPLOYEE AS E, EMPLOYEE AS S
WHERE E.super_ssn=S.ssn;
```

Joined Tables

- Join operation in the FROM clause
- Separate the selection and join conditions in the where clause

```
SELECT    FNAME, LNAME, ADDRESS
FROM      EMPLOYEE, DEPARTMENT
WHERE     DNAME='Research' AND
          DNUMBER=DNO;
SELECT    FNAME, LNAME, ADDRESS
FROM      EMPLOYEE JOIN DEPARTMENT
           ON DNUMBER=DNO
WHERE     DNAME='Research';
```

INNER and OUTER Joins

- INNER JOIN **(versus** OUTER JOIN**)**
  - Default type of join in a joined table
  - Tuple is included in the result only if a matching tuple exists in the other relation
- LEFT OUTER JOIN
  - Every tuple in left table must appear in result
  - If no matching tuple
    - Padded with NULL values for attributes of right table
- RIGHT OUTER JOIN
  - Every tuple in right table must appear in result
  - If no matching tuple
    - Padded with NULL values for attributes of left table

Outer join

- List all employee names and the departments they manage if they happen to manage a department; if they do not manage one, we can indicate it with a NULL value.

```
SELECT FNAME, LNAME, DNAME
FROM EMPLOYEE LEFT OUTER JOIN
   DEPARTMENT ON SSN=MGRSSN;
```

Outer Join

```
+---------+-----------+---------------+
| FNAME   | LNAME     | DNAME         |
+---------+-----------+---------------+
| Lisa    | Monroe    | Administration |
| Rahim   | Abdul     | NULL           |
| Lindsay | Fitzgerald | NULL          |
| Louis   | Duncan    | NULL           |
| Arnold  | Chan      | Research       |
| Niko    | Kurosawa  | NULL           |
| Claire  | Prince    | NULL           |
| Scott   | Cho       | NULL           |
| Mason   | Cronkite  | Marketing      |
| Cindy   | Rodriguez | NULL           |
+---------+-----------+---------------+
```

Inner Join

```
SELECT FNAME, LNAME, DNAME
FROM EMPLOYEE INNER JOIN
    DEPARTMENT ON SSN=MGRSSN;
```

```
+--------+----------+---------------+
| FNAME  | LNAME    | DNAME         |
+--------+----------+---------------+
| Lisa   | Monroe   | Administration |
| Arnold | Chan     | Research       |
| Mason  | Cronkite | Marketing      |
+--------+----------+---------------+
```

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
```

- NOTE: 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.

AGGREGATE FUNCTIONS (cont.)

- <u>Queries 17:</u> Retrieve the total number of employees in the company

```
Q17:    SELECT    COUNT (*)
        FROM      EMPLOYEE
```

- Returns the number of rows in the result of the query

AGGREGATE FUNCTIONS (cont.)

- SELECT COUNT(DISTINCT SALARY) FROM EMPLOYEE;
- SELECT COUNT(SALARY) FROM EMPLOYEE;

AGGREGATE FUNCTIONS (cont.)

- (Q18) Retrieve the number of employees in the 'Research' department.

AGGREGATE FUNCTIONS (cont.)

Q5: retrieve the names of all employees who have two or more dependents.

GROUPING

- 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

- 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
```

FNAME	MINIT	LNAME	SSN	. . .	SALARY	SUPERSSN	DNO
John	B	Smith	123456789		30000	333445555	5
Franklin		Wong	333445555		40000	888665555	5
Ramesh	K	Narayan	666884444		38000	333445555	5
Joyce	A	English	453453453	. . .	25000	333445555	5
Alicia	J	Zelaya	999887777		25000	987654321	4
Jennifer	S	Wallace	987654321		43000	888665555	4
Ahmad	V	Jabbar	987987987		25000	987654321	4
James	E	Bong	888665555		55000	null	1

DNO	COUNT (*)	AVG (SALARY)
5	4	33250
4	3	31000
1	1	55000

Result of Q24.

THE HAVING-CLAUSE

- Retrieve the values of these functions for only those groups *that satisfy certain conditions*
- The HAVING-clause
  - Specify a selection condition on groups (rather than on individual tuples)
- WHERE clause is executed before Having clause.

THE HAVING-CLAUSE (cont.)

- Query 22: For each department which has *more than two employees*, retrieve the department number, the number of employees in the department, and their average salary.

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>]
```

Specifying Updates in SQL

- There are three SQL commands to modify the database; INSERT, DELETE, and UPDATE

INSERT

- Example1:

  INSERT INTO EMPLOYEE
  VALUES ('Richard','K','Marini', '653298653',
  '30-DEC-52', '98 Oak Forest,Katy,TX', 'M',
  37000,'987654321', 4)

- Example 2:

  INSERT INTO EMPLOYEE (FNAME, LNAME, SSN, DNO)
  VALUES ('Richard', 'Marini', '653298653`, 4)

- Must include an attribute if the attribute is specified as NOT NULL and has no default value.
- Set to other attributes: DEFAULT, or NULL

INSERT (cont.)

- CREATE TABLE DEPTS_INFO
  (DEPT_NAME VARCHAR(10),
  NO_OF_EMPS INTEGER,
  TOTAL_SAL INTEGER);

- INSERT INTO DEPTS_INFO (DEPT_NAME,
  NO_OF_EMPS, TOTAL_SAL)
  SELECT DNAME, COUNT (*), SUM (SALARY)
  FROM DEPARTMENT, EMPLOYEE
  WHERE DNUMBER=DNO
  GROUP BY DNAME ;

DELETE

- **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

- 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')
```

These slides are based on the textbook and the notes of:

R. Elmaseri and S. Navathe, *Fundamentals of Database Systems*, 7th Edition, Addison-Wesley.